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Baseline Forsmark – Geology

Updating of existing site descriptive models

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Abstract

In the near future, the Swedish Nuclear Fuel and Waste Management Company (SKB) intends to launch two repository projects at the Forsmark site in northern Uppland, a deep geological repository (DGR) for spent nuclear fuel (HLW) and an expansion of the existing final repository for low- and intermediate-level waste (LMLW, SFR). Before commencing surface contract works and underground construction, SKB has compiled an integrated description of the current natural conditions of the geosphere and biosphere at Forsmark, known as the Baseline Forsmark. This description is primarily based on extensive site descriptive models (SDM) developed over a decade ago, supplemented by additional information and insights from subsequent investigation campaigns.

This report outlines the geological baseline conditions in the Forsmark area, aiming to provide a foundation for baseline modelling in other geoscientific disciplines and for detailed repository design. The report focuses on the updates of the deterministic geological models for SDM-Site and SDM-PSU that was carried out using data obtained after 2010. It also presents the fundamental concepts and assumptions for modelling, along with condensed descriptions of the geometric models of Baseline Forsmark. Additionally, the report addresses sources of uncertainties and their potential magnitudes, offering recommendations for downstream users.

Although the geological models of Baseline Forsmark are based on the established structural concepts of the original site descriptive models and follow similar modelling methodologies, there has been a progressive refinement of both concepts and models to meet the needs of downstream users. The major components of the model changes and additions up to the release of Baseline Forsmark include:

- All modelled deformation zones of SDM-Site and SDM-PSU has been merged into a single master version, named DMS (*Deterministically Modelled Structures*) Forsmark, encompassing all deterministically modelled deformation zones regardless of size.
- The DMS version has been expanded beyond the SDM-Site regional volume to cover the extent of the future sub-catchment area at Forsmark site.
- The spatial understanding of sheet joints has gradually improved, enabling very localised deterministic modelling of individual sheet joints and further subdivision of the shallow fracture domain FFM02 of SDM-Site, based on a marked contrast in the occurrence of sheet joints with observable apertures.
- Local revision of deformation zone geometries of the DMS have been in two areas: near the planned accesses and operational area of the repository for spent nuclear fuel, and within the volume of the planned extension of the SFR facility.
- The truncation pattern of deformation zones located northeast of the SFR facility has been reassessed to eliminate artificial blind ends of previously modelled zones of SDM-PSU.

An appendix of the report provides an extensive update of the property tables for deformation zones included in the site descriptive models, along with property tables for 14 new deformation zones. In addition to previously published descriptions, these property tables offer revised presentations of fracture characteristics and extended confidence estimates, in line with the proposed approach of Hermanson and Petersson (2022).

Sammanfattning

Inom kort avser Svensk Kärnbränslehantering (SKB) att påbörja byggnationen av två förvarsprojekt i området kring Forsmark i norra Uppland, ett djupt geologiskt förvar (DGR) för använt kärnbränsle (HLW) och en utbyggnad av befintligt slutförvar för låg- och medelaktivt avfall (LMLW, SFR). Innan mer omfattande entreprenadarbeten påbörjas har SKB låtit sammanställa en integrerad beskrivning av de nuvarande naturförhållandena för geosfären och biosfären i Forsmark, vilken benämns Baseline Forsmark. Denna beskrivning är främst baserad på omfattande platsbeskrivande modeller (SDM) utvecklade för över ett decennium sedan, som sedan kompletterats med ytterligare information och insikter från efterföljande underökningskampanjer.

Denna rapport beskriver de geologiska baseline-förhållandena i Forsmarksområdet, i syfte att ge underlag för baseline-modellering inom andra geovetenskapliga discipliner och för detaljprojektering. Rapporten fokuserar i huvudsak på uppdateringen av de deterministiska geologiska modellerna för SDM-Site och SDM-PSU som gjorts baserat på data som erhållits efter 2010. Den presenterar också de grundläggande koncepten och antagandena för modellering, tillsammans med översiktliga beskrivningar av de geometriska modellerna i Baseline Forsmark. Dessutom tar rapporten upp källor till osäkerheter, deras potentiella omfattning, och ger rekommendationer för avnämare.

Även om de geologiska modellerna i Baseline Forsmark i grunden är baserade på etablerade strukturella koncept som tillämpats i de ursprungliga platsbeskrivande modellerna och följer liknande modelleringsmetodik, har det skett en progressiv förfining av både koncept och modeller för att möta behoven hos avnämare. De huvudsakliga ändringarna och tilläggen i modellerna fram till Baseline Forsmark inkluderar följande:

- Alla modellerade deformationszoner i SDM-Site och SDM-PSU har slagits samman till en samlad modellversion, kallad DMS (*Deterministically Modelled Structures*) Forsmark, som omfattar alla deterministiskt modellerade deformationszoner oavsett storlek.
- DMS har utökats bortom den regionala volymen för SDM-Site för att täcka hela det framtida delavrinningsområdet för Forsmarksområdet.
- Kunskapen kring bankningssprickor har gradvis förbättrats, vilket möjliggjort mycket lokal, deterministisk modellering av individuella bankningssprickor, samt en uppdelning av den grunda sprickdomänen FFM02 i SDM-Site, baserat på kontraster i förekomsten av bankningssprickor med observerbar apertur.
- Lokal revidering av deformationszonens geometrier i DMS har gjorts i två områden: nära de planerade tillfarterna och driftområdet till slutförvaret för använt kärnbränsle, och inom volymen för den planerade utbyggnaden av SFR.
- Trunkeringsmönstret för deformationszoner nordost om SFR har omprövats för att eliminera artificiella slut för tidigare modellerade zoner i SDM-PSU.

En bilaga till rapporten ger en omfattande uppdatering av egenskapstabellerna för de deformationszoner som ingår i de platsbeskrivande modellerna, tillsammans med egenskapstabeller för 14 nya deformationszoner. Utöver tidigare publicerade beskrivningar ger dessa egenskapstabeller reviderade presentationer av sprickegenskaper och utökade konfidensbeskrivningar, i linje med föreslagen metodik i Hermanson och Petersson (2022).

Contents

* Appendix 7 is not included in the printed report.

1 Introduction

1.1 Background

In 2011, SKB applied for a permit to build a deep geological repository (DGR) for spent nuclear fuel (HLW) at the Forsmark site. After review of the application by the Swedish Radiation Safety Authority (SSM), the Swedish Government approved the application in January 2022. In 2014, SKB submitted a license application to expand the existing final repository for low- and intermediate-level waste (LMLW, SFR) in Forsmark to also include disposal of waste from decommissioning of Swedish nuclear facilities. The Swedish Government granted permit for the expansion in December 2021.

The applications have been preceded by extensive site characterisation from several years of surface-based investigations and the use of a wealth of materials from the construction of both the nuclear power plants and the SFR facility. An integrating component in the characterisation work within the repository projects was the development of site descriptive models (SDM) that constitute descriptions of the site and its regional setting. The models address the current state of knowledge regarding the geosphere and the biosphere as well as the ongoing natural processes that affect their long-term evolution. The models associated with the two repository projects are referred to as SDM-Site (for the repository for spent nuclear fuel; SKB 2008a) and SDM-PSU (for SFR; SKB 2013). The overall strategy of the site descriptive modelling has been to develop discipline-specific models through interpretation and analyses of quality-assured primary data and to integrate these models into a unified site description. In this context, the geological models are fundamental components that provide the geometrical framework and geological basis for all discipline-specific modelling.

Since the compilation of the site descriptive models more than a decade ago, new data have become available from several investigation campaigns, while there has been a progressive refinement of geological concepts and models to meet the needs of downstream users. In 2017, all modelled deformation zones of the two site descriptive models were merged into one master version to include all deterministically modelled deformation zones regardless of their size. Three years later, the master model version was expanded to cover the future sub-catchment area at Forsmark site. In addition, the spatial understanding of sheet joints has gradually improved over time to allow local modelling of individual sheet joints and a further subdivision of the fracture domain model of SDM-Site.

The updated geological models described herein constitute elements of a baseline model, developed to describe the integrated understanding of geology, rock mechanics, hydrogeology, hydrogeochemistry, bedrock transport properties, and the surface system at the Forsmark site, prior to the construction of the two repositories (HLW and LMLW). The Baseline Forsmark model will serve as a starting point for future versions of the site descriptions, developed from a growing amount of subsurface data that will be acquired during the construction of the two repositories at Forsmark. The baseline modelling includes all available data in the SKB databases Sicada and SDE up to and including December 2023.

1.2 Scope and objective

The original purpose of the Baseline Forsmark was to provide a compilation of the current natural conditions at the site prior to the expansion of the SFR facility and the construction of the planned repository for spent nuclear fuel; a compilation that makes use of the knowledge and understanding described in previous site descriptive models, along with insights earned during the following investigation campaigns. The task was later extended to establish a basis that fulfils the needs for the safety assessment hydro-SÄK. Furthermore, the work serves as useful preparatory work for the coming update of the present site descriptive models SDM-Site and SDM-PSU into SDM Forsmark 2026. The specific aims of the geological work of Baseline Forsmark are as follows:

- To provide an updated interpretation of the geological conditions based on information acquired after the previous SDM reports to be used by all other geoscientific disciplines.
- Evaluation of established concepts and existing geometric models in the light of new data that emerged after 2010 for the Forsmark site.

- Updating of the deterministic models for geology of SDM-Site and SDM-PSU by considering new data obtained after 2010. A basic approach has been that all geometric revision requires new data; geometries solely based on older site investigation data remain fixed.
- Description of the sources of uncertainties and their potential magnitudes, with recommendations to downstream users.
- Application of the newly developed methodology for deterministic modelling by Hermanson and Petersson (2022) wherever possible. Since data from underground construction have not yet been acquired, application has been largely limited to aspects concerning confidence estimates and the introduction of object-based modelling.

The focus of the Baseline Forsmark report for geology is the model updates carried out after completion of Forsmark version 2.3 (Stephens and Simeonov 2015) and SFR version 1.0 (Curtis et al. 2011). The report also includes presentations of the fundamental concepts and assumptions for modelling, as well as condensed descriptions of the geometric models of Baseline Forsmark version 1.0. For details regarding the development of previous model versions and related analyses of underlying data, the reader is referred to Stephens et al. (2007, 2008b), Curits et al. (2011) and Stephens and Simeonov (2015).

1.3 Geological framework

Forsmark is situated in northern Uppland, in a part of the Fennoscandian Shield that was formed between 1.89 and 1.85 billion years ago during the Svecokarelian orogeny (Stephens et al. 2009). The bedrock in this orogen is dominated by Precambrian igneous rocks that were variably affected by complex ductile strain and metamorphism at predominantly mid-crustal levels. Structurally, the Forsmark area is characterised by large-scale, ductile high-strain belts, striking WNW−ESE or NW−SE and showing evidence of a dextral strike-slip component of movement (Stephens et al. 2008a). These belts define an anastomosing network, enveloping less deformed tectonic lenses (Figure 1-1). The volume proposed as the repository for spent nuclear fuel is located in the northwesternmost part of one of these lenses, the so-called Forsmark tectonic lens, where gneissic granite that formed at 1.87 Ga (Hermansson et al. 2008), pegmatite and amphibolite comprise the dominant rock types.

The final repository for low- and intermediate-level radioactive waste (SFR) is situated within the high-strain belt that forms the northeastern margin to the Forsmark tectonic lens (see Figure 1-1). The rock types and temporal relationship in the rock volume surrounding SFR are virtually identical to that of the rocks in the tectonic lens, but they are generally affected by a much higher degree of ductile strain. The predominant rock components in the SFR area consist of a heterogeneous package of mainly felsic to intermediate metavolcanic rocks intercalated with gneissic granite intruded by younger igneous suites comprising granite, pegmatitic granite and pegmatite.

The high-strain belts surrounding the tectonic lens show a distinct tectonic foliation, defined by intense planar grain-shape fabric or banding, dipping sub-vertically or steeply to the southwest; a mineral stretching lineation plunging moderately to the southeast is also present. Inside the tectonic lens, the tectonic foliation is less intense, and the fabric is dominated by the mineral stretching lineation and folds that plunge moderately to shallow towards the southeast.

Thus, the framework of the tectonic lens was initially developed under amphibolite-facies metamorphic conditions, at 1.87–1.86 Ga (Hermansson et al., 2008), whereas the timing of the later folding is less tightly constrained. Low-grade ductile deformation under dextral transpression continued within the shear belts to around 1.8 Ga, with the development of discrete, WNW–ESE to NW–SE striking deformation zones, such as the regionally important Singö, Örskär, Eckarfjärden and Forsmark shear zones. Ductile-brittle or brittle deformation prevailed at 1.8–1.7 Ga, with the subsequent establishment of sub-greenschist metamorphic conditions and sole brittle deformation at around 1.7 Ga (Söderlund et al. 2009).

As the effects of orogenic activity waned and shifted to a progressively more far-field realm during and after the Mesoproterozoic, the effects of loading and unloading, involving deposition and denudation of sedimentary or glacial material, started to play a more significant role. Far-field effects of the 1.1–0.9 Ga Sveconorwegian orogeny in southwestern Sweden have been recognised in the bedrock at Forsmark, both by brittle reactivation (Sandström and Tullborg 2007) and the development of a foreland sedimentary basin that covered central Sweden (Larsson et al. 1999). Following erosion established a sub-Cambrian peneplain that has been identified over a large part of southern Sweden, including the Forsmark area (Lidmar-Bergström 1996). The peneplain represents a relatively flat topographic surface with a gentle dip towards the east. The deposition of a sedimentary sequence, including oil-shales, covered the peneplain during the Palaeozoic and were probably not removed until after the Early Jurassic (Cederbom 2001; Larson et al. 1999; Söderlund et al. 2008). This resulted in burial and sedimentary loading followed by uplift and re-exhumation of the ancient sub-Cambrian unconformity.

Several cycles of glacial loading, removal of ice sheets and subsequent renewed exhumation of the same unconformity, with deposition of glacial and post-glacial sediment prevailed during the ongoing Quaternary (Sohlenius and Hedenström 2008). Indeed, the current ground surface, the maximum height of which in the Forsmark area is approximately +25 m above current sea level, corresponds more or less to the sub-Cambrian unconformity. Plate motion related to mid-Atlantic ridge push, in combination with glacial isostatic rebound following removal of the latest Weichselian ice sheet and crustal unloading, are the two geological processes that constrain current strain conditions in the crust in northern Europe (Muir Wood 1993, 1995).

The orientation and magnitude of the current stress field at Forsmark have been constrained by indirect observations of drill core and borehole damage (core disking and borehole breakouts, respectively) along with stress measurements (Glamheden et al. 2007; Martin 2007). Both horizontal stress components are larger than the vertical stress component and the bedrock at the proposed repository depth is currently affected by a thrust regime with horizontal compression in a NW–SE direction.

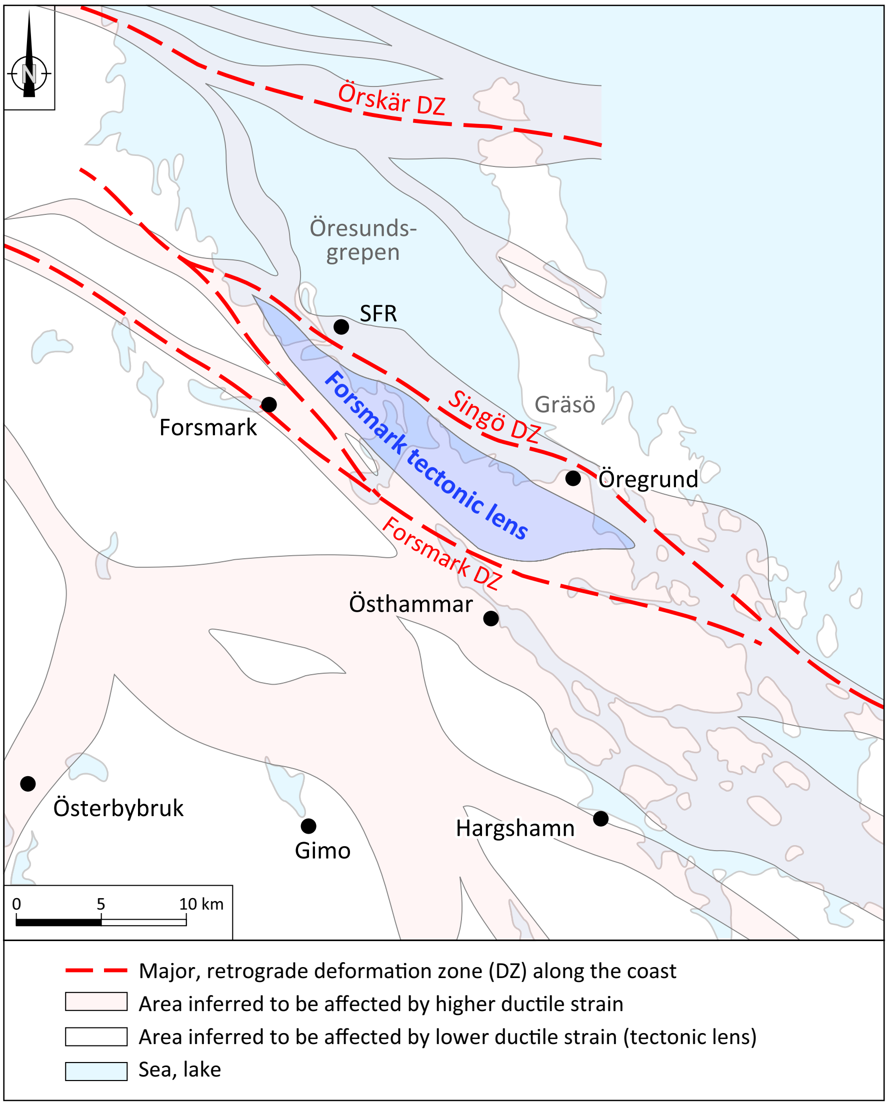


Figure 1-1. *Tectonic lens at Forsmark and areas affected by strong ductile deformation along the coastal deformation belt in northern Uppland. Modified after Stephens et al. (2007).*

2 Geological models and model volumes of Baseline Forsmark

2.1 Model overview

The integrated geological understanding of the Forsmark site is manifested by a series of deterministic models. Each model has a specific volume populated by a selection of three-dimensional geometries of geological objects with supplemental descriptions of their geological nature in property tables. Object types and volumes of all deterministic geological models included in Baseline Forsmark version 1.0 are listed in Table 2-1. The areal coverage of the models is presented in Figure 2-1.

The geological models of Baseline Forsmark are stored in the SKB model database SKBMod at the location *Forsmark/kärnbränsleförvaret/Projekt Kärnbränsleförvaret/Berggrundsgeologi/3D Modell*.

Table 2-1. Summary of all deterministic geological models included in Baseline Forsmark version 1.0.

Model	Object types	Volume
DMS	Deformation zones + deterministically modelled sheet joints	Future sub-catchment area + SDM-site regional model volume/area
RFM reg	Rock domains	SDM-Site regional model volume/area
RFM loc	Rock domains	SDM-Site local model volume/area
RFR loc	Rock domains	SDM-PSU local model volume/area
FFM	Fracture domains	SDM-Site local model volume/area

The current Baseline models rely heavily on the site descriptive models of SDM-Site (SKB 2008a) and SDM-PSU (2013), which were developed in several stages during the period 2002 to 2011. The geological basis for SDM-Site was models of deformation zones, rock domains and fracture domains of the Forsmark stage 2.2 modelling (Olofsson et al. 2007, Stephens et al. 2007), whereas geological models of the project SDM-PSU included deformation zones and rock domains presented by Curtis et al. (2011). The Forsmark stage 2.2 deterministic models for deformation zones has subsequently been updated to model version 2.3 (Stephens and Simeonov 2015), after taking account of the SDM-PSU deformation zone model of regional extent. Model version 2.3 was later revised on the basis of data from preparatory investigations conducted in shallow boreholes drilled in proximity of the planned accesses and operational area of the final repository (2011–2012). The revision included a minor deformation zone and slight geometrical adjustments of a few deformation zones (see Follin 2019).

Geometrical geological models were developed for two different volumes, termed regional and local, for each of the site descriptive models (i.e. SDM-Site and SDM-PSU). The model volumes have guided the selection of a minimum surface length for steeply dipping deformation zones. Thus, for SDM-Site, only deformation zones with inferred lengths at the ground surface of 3000 m or more are included in the regional volume model. For the local volume model of SDM-Site, limit was set at structures with trace lengths at the ground surface at 1000 m or more. Where the available high-resolution, surface magnetic data permitted, some minor zones that are shorter than 1000 m have been modelled deterministically and assigned properties, but these were not included in the local geometrical model of SDM-Site. Since sizes of gently dipping zones are difficult to estimate, and since these zones are significant from a hydrogeological point of view, it was decided to include all the identified gently dipping zones in both the local and regional models of SDM-Site. The resolution of the SDM-PSU regional model corresponds to the local model of SDM-Site, containing all modelled deformation zones with surface trace lengths of ≥ 1000 m or more, whereas the local SDM-PSU model contains all inferred deformation zones with trace lengths of ≥ 300 m or more.

The areal extent of the regional and local volumes described above is illustrated in Figure 2-1 and the geological models developed for each volume are listed in Table 2-2 along with the minimum trace length at the ground surface for steeply dipping deformation zones.

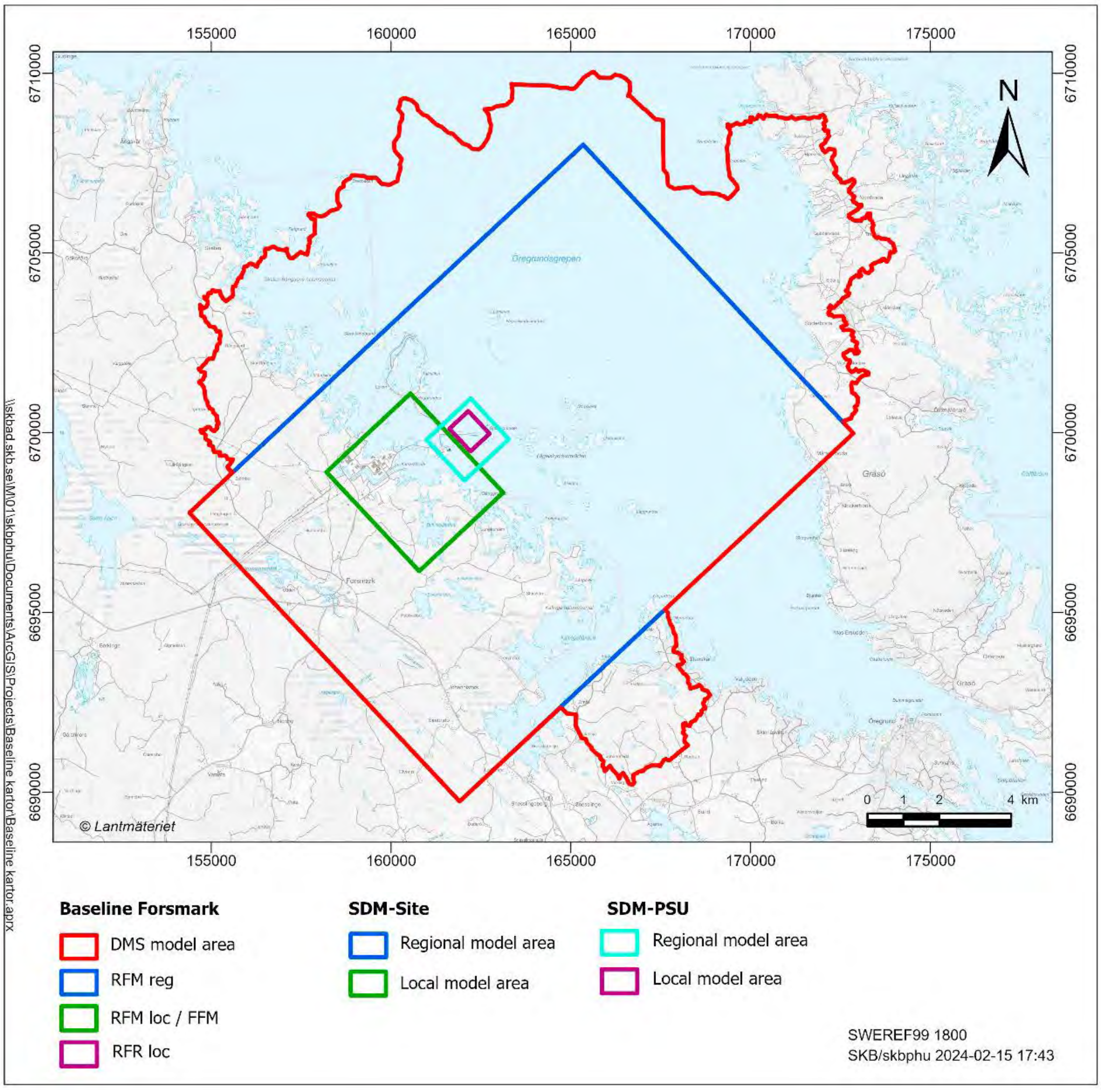


Figure 2-1. *The areal coverage of the deterministic geological models included in Baseline Forsmark relative to the models of SDM-Site and SDM-PSU (see Table 2-1 and Table 2-2 for further details).*

Table 2-2. Volumes and object types populating the various deterministic geological models of SDM-Site and SDM-PSU along with the bounding size for steeply dipping deformation zones.

Model and object types	Volumes/Areas	Trace length of deformation zones
SDM-Site		
Deformation zones	Regional and local	≥ 3 000 and ≥ 1 000 m, respectively
Rock domains	Regional and local	–
Fracture domains	Local	–
SDM-PSU		
Deformation zones	Regional and local	≥ 1 000 and ≥ 300 m, respectively
Rock domains	Local	–

2.2 DMS Baseline Forsmark

At the request of downstream users and especially the hydrogeologists, a master version of the deformation zone model has been developed by merging the individual deformation models listed in Table 2-3. This master version is named DMS (*Deterministically Modelled Structures*) and includes all deterministically modelled deformation zones in the Forsmark area, regardless of size. To attain consistency of the basic geometrical modelling principles, the merging entailed adjustments with regards to termination depth, extent, and thickness for some deformation zones, especially those of SDM-PSU.

The major changes and additions to the DMS model up to the release of Baseline Forsmark version 1.0 can be summarised as follows with further details in Chapter 5:

- Adjusted object geometries as an effect of the upgrading of SKB's modelling tool for geological visualization and modelling, RVS (*Rock Visualization System*).
- Revision of deformation zone geometries based on borehole data acquired from the preparatory investigations conducted after 2010 in proximity of the planned accesses and operational area of the final repository and the volume of the planned extension of the SFR facility.
- Addition of deterministically modelled sheet joints in shallow bedrock volumes with closely spaced boreholes.
- Extension and addition of regional deformation zones outside the SDM-Site regional volume to cover the extent of the future sub-catchment area.
- Reassessment of the truncation pattern of deformation zones northeast of the SFR facility to eliminate artificial blind ends of previously modelled zones.
- Introduction of confidence estimates for deformation zones in accordance with the proposed approach of Hermanson and Petersson (2022).

Baseline Forsmark version 1.0 have been preceded by three releases of the DMS model (Table 2-4); all three releases are strictly geometrical updates, without associated revision of property tables. Each release version includes two types of visualisations:

- Surface (hydrology) shows the origin surface of all structures.
- Volume (geology) shows the bounding surfaces of all structures.

An additional, interim delivery of geometries for deterministically modelled sheet joints was produced to support the DFN modelling group (see Table 2-4).

Table 2-3. Deformation zone models integrated into DMS Forsmark.

ID[1]	Model	Bounding size	Reference report
1492880	DZ modell regional PLU v2.3 Forsmark	≥ 3000 m	Stephens and Simeonov (2015)
1492438	DZ modell lokal PLU v2.3 Forsmark	≥ 1000 m	Stephens and Simeonov (2015)
1492088	Regional deformation zone model v.22 PLU v.22 Forsmark[2]	< 1000 m	Stephens et al. (2007)
2004361	489019_FPS_Forsmark	< 1000 m	Follin (2019)
1579543	SFR REG DZ v 1.0	≥ 1000 m	Curtis et al. (2011)
1579539	SFR LOC DZ v 1.0	≥ 300 m	Curtis et al. (2011)

[1] ID in SKBMod.

[2] Minor deformation zones.

Table 2-4. DMS model versions preceding the release of DMS Baseline Forsmark v1.0.

DMS version	Details
2018_1	Geometries (obj-exports) and notes (SKBMod 2047742)
2018_2	Geometries RVS v6 (SKBMod 1705366), geometries as stl- and dgn-exports, summary tables and notes (SKBMod 2047745)
Deterministic sheet joints	Geometries as stl-exports (SKBMod 2047747)
2020_1	Geometries as dgn-exports (SKBMod 1896141, 1896142) and summary tables (SKBMod 1896144)

2.3 RFM and RFR Baseline Forsmark

Baseline Forsmark comprises all three rock domain models developed during SDM-Site and SDM-PSU (see Table 2-5). Details on modelling methodology, assumptions and geological character of these models are presented in Stephens et al. (2007) and Curtis et al. (2011).

The rock domain models form a nestled system where the local volumes are sub-models within the regional model volume. Thus, rock domain boundaries of the regional model volume have identical geometrical representations in the local volumes. The difference between the volumes lies in a division of some regionally defined domains in the local volumes to support the work of downstream users and repository design. The division and equivalent naming of the domains are summarised in Table 2-6.

Table 2-5. Versions of the rock domain model that precede the release of RFM and RFR Baseline Forsmark v1.0.

Baseline Forsmark v 1.0	Preceding model	Project
RFM regional	RD modell regional PLU v.2.3, Forsmark (SKBMod 1492880)	SDM-Site
RFM local	RD modell lokal PLU v.2.3, Forsmark (SKBMod 1492607)	SDM-Site
RFR local	SFR_RD_LOC-v1.0_SWEREF99 (SKBmod 1989500)	SDM-PSU

Table 2-6. All regional rock domains which are divided and/or renamed in the local volumes.

Rock domain in regional volume	Corresponding rock domain(s) in local volume
RFM029R	RFM local – RFM029 and RFM045
RFM021	RFR local – RFR01, RFR02 and RFR03
RFM033	RFR local – RFR04

None of the data acquired after the completion of SDM-Site and SDM-PSU have entailed revision of the rock domain geometry from a geological point of view. However, with the release of Baseline Forsmark version 1.0 virtually all domains have been subjected to slight geometrical adjustments. The changes can be summarized as follows with further details in Chapter 6:

- Modelled surfaces were optimised using as sparse grid as possible in order to decrease the workload for the solid modelling engine in the RVS modelling tool.
- To avoid problems along the edges of the modelling volume, modelled surfaces were extrapolated to ensure full intersection.
- Adjustment of the intersections between domain boundaries and the inferred top surface (i.e. the bedrock surface) to increase the agreement with the rock type distribution of the bedrock map on the ground surface.

2.4 FFM Baseline Forsmark

The basis for FFM Baseline Forsmark is the fracture domains of SDM-Site, developed during the modelling stage 2.2. Details on modelling methodology, assumptions and geological character of this model are presented in Olofsson et al. (2007) and Stephens et al. (2007). Up to the release of the FFM Baseline Forsmark version 1.0 there has been one intermediate update of the fracture domain model, which included the following major changes:

- Representation of deformation zones as single, infinitely thin surfaces ("origin surfaces") instead of volumes defined by the bounding zone surfaces.
- Division of the rather shallow FFM02 into two subdomains, based on a marked contrast in the occurrence of sub-horizontal fractures (i.e. sheet joints) with observable aperture.

Additional changes introduced by the release of FFM Baseline Forsmark version 1.0 comprise:

- Changed object geometries as an effect of the upgrading of the RVS modelling software.
- Revision of the boundary between FFM01 and FFM02, based on borehole data acquired from the preparatory investigations conducted after 2010 in proximity of the planned accesses and operational area of the final repository.

Details regarding the various changes made to the fracture domain model posterior to the SDM-Site version are presented in Chapter 7. The two versions of the fracture domain model that precede the release of FFM Baseline Forsmark version 1.0 are listed in Table 2-7.

Table 2-7. Versions of the fracture domain model that precede the release of FFM Baseline Forsmark v1.0.

Fracture domain model	Details
Fracure domain FM 2.3	The SDM-Site stage 2.2 in RVS v6 format (SKBMod 1705617)
FD_2.3_separated FFM02_SWEREF99	Geometries – stl-exports (SKBMod 2047747) and dgn-export (SKBMod 1898920)

2.5 Model volumes

Table 2-8 presents the coordinates that define the modelling volumes inherited from SDM-Site and SDM-PSU after conversion to SWEREF 99 1800 and RH2000. Motivation for the selection of these volumes is provided by SKB (2006, p. 23–24) and Curtis et al. (2011, p. 18–19).

The volume of DMS Baseline Forsmark version 1.0 has been defined laterally by combining the SDM-site regional model area with the extent of the future sub-catchment area (cf. Earon 2022), including a peripheral buffer of 200 m around the sub-catchment area (Figure 2-2). The vertical extent of the volume is identical to that of the SDM-site regional model volume with an elevation from +100 down to −2 100 (RH2000).

Table 2-8. Coordinates and elevations defining relevant SDM-Site and SDM-PSU model volumes. SWEREF 99 1800 and RH2000.

Volume	SDM-Site regional		SDM-Site local		SDM-PSU local	
Elevation*	+100 to −2 100		+100 to −1 100		+100 to −300	
Coordinates	*Easting*	*Northing*	*Easting*	*Northing*	*Easting*	*Northing*
North	165 346	6 708 020	160 542	6 701 092	162 150	6 700 602
East	172 861	6 699 987	163 121	6 698 333	162 738	6 699 974
South	161 907	6 689 740	160 783	6 696 148	162 212	6 699 482
West	154 392	6 697 772	158 204	6 698 906	161 625	6 700 110

* Note that there is a 18 cm difference between elevations expressed in RH2000 and RHB70 used in SDM-Site and SDM-PSU.

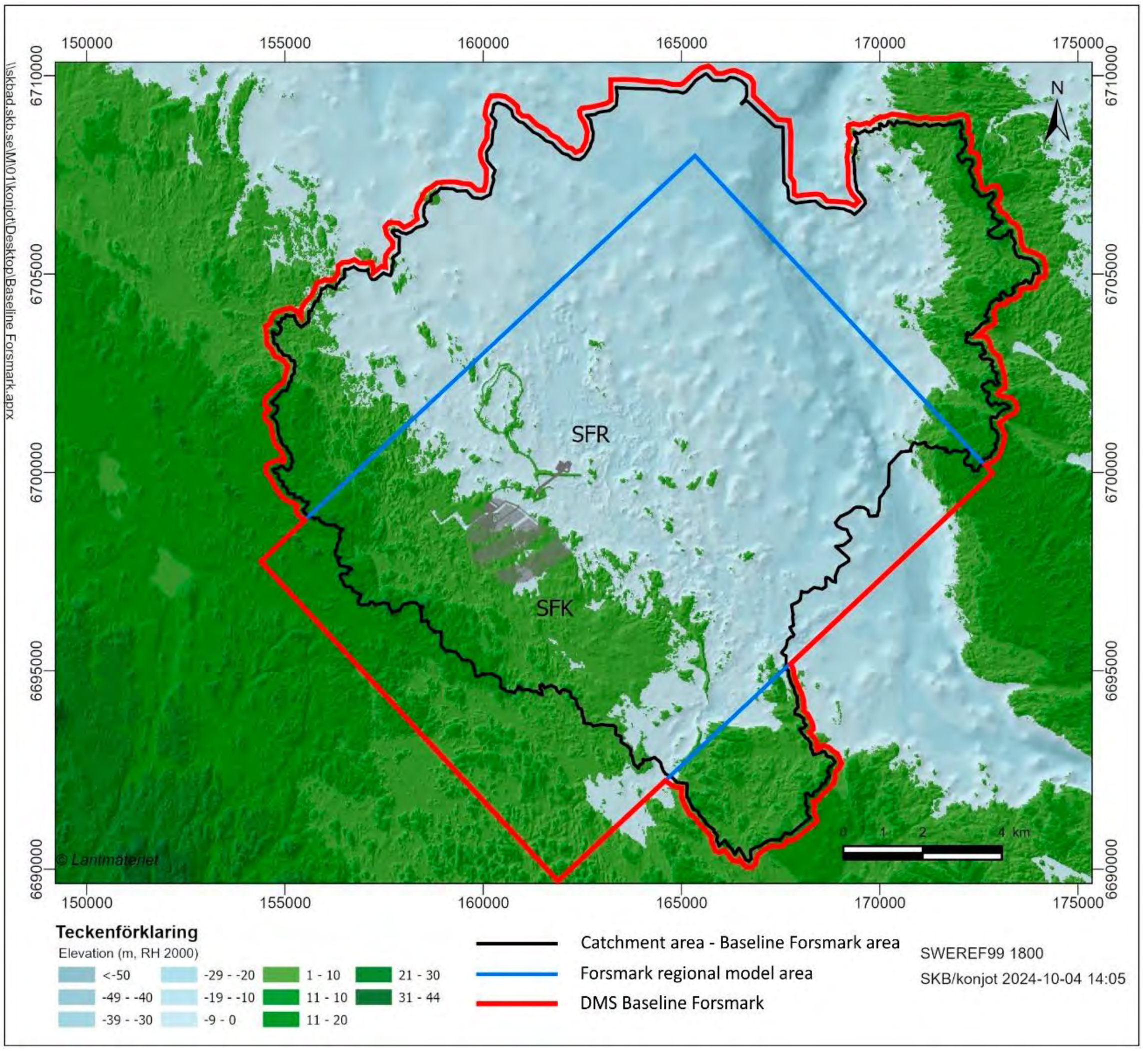


Figure 2-2. *Extent of the future sub-catchment area of Forsmark and SDM-Site regional model area relative to the DMS Baseline Forsmark.*

2.6 Bedrock surface

The bedrock surface used as model top surface is identical in all deterministic geological models of Baseline Forsmark version 1.0. It is based on the regolith depth model presented in Petrone et al. (2020). The surface denoted SDEADM.SVE_FM_GEO_20235 covers the defined sub-catchment area and corresponds to the lower limit of the till layer. The extraction method is presented by Earon (2022).

The surface that covers the sub-catchment area consists of a 20 m grid with a 20 m vertical point reduction introduced by RVS. To achieve surface coverage in the parts of the DMS model that are outside the sub-catchment area (i.e. the Forsmark regional model area protruding the sub-catchment area and a peripheral buffer of 200 m; Figure 2-2), a linear interpolation to elevation = 0 (RH2000) along the surface boundaries (Easting = 152 940 and 178 060, Northing = 6 687 940 and 6 713 060) has been applied. The result of the approach is illustrated in Figure 2-3.

The consequence of the reduction is that the surface mesh is disconnected from the original fix points along boreholes. Thus, the surface can deviate from the registered rock surface along a borehole by several meters. Another consequence is that some of the modelled/visualised sheet joints occur above the surface mesh, especially along the inlet channel to the nuclear power station.

All deformation zones and domains inferred to reach the ground surface have been truncated at the bedrock top surface. Since some modelled/visualised sheet joints occur above the modelled mesh, it was decided to leave all sheet joints untruncated.

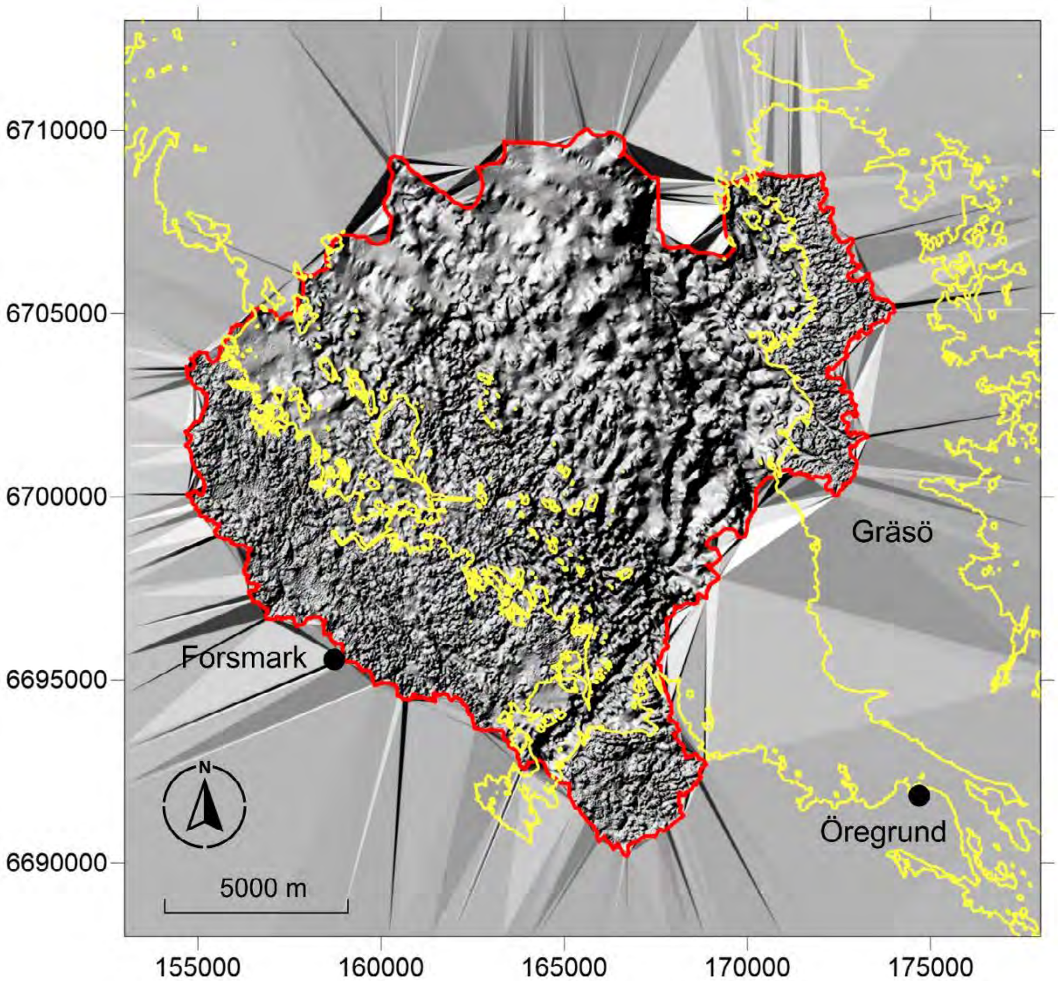


Figure 2-3. *The model top boundary used in all deterministic models of Baseline Forsmark version 1.0. The surface is based on the regolith depth model of Petrone et al. (2020) with a linear interpolation to elevation = 0 along the surface boundaries to achieve surface coverage in the DMS model area outside the sub-catchment area, where the latter is marked by a red line.*

2.7 Bedrock block model

With the purpose to identify and characterise Phanerozoic faulting of the Precambrian basement, Grigull et al. (2019) have developed a bedrock block model for a 112 × 112 km area which covers considerable parts of Uppland and Gästrikland, along with the future sub-catchment area of Forsmark (Figure 2-4). The modelling approach is an improvement of the methodology developed by Beckholmen and Tirén (2010a, b) for topographical data. The method builds on the assumption that the original relative relief of the sub-Cambrian peneplain in the model area was less than 20 m (Rudberg 1960, Olvmo 2010).

Based on a digital elevation model (DEM) achieved by combining LiDAR and bathymetric data, block boundaries were defined by interpretation of lineaments along topographic lows. Subtraction of the sedimentary cover from the DEM, yielded a bedrock elevation model that corresponds approximately to the faulted and glacially eroded sub-Cambrian peneplain. The topographic gradient was then removed from the bedrock elevation model and maximum elevation values were calculated for each rock block as indications of relative movement across the block boundaries. Further details are presented by Grigull et al. (2019).

The ArcGIS model is archived in SKBMod at the location *Forsmark/kärnbränsleförvaret/Projekt Kärnbränsleförvaret/Berggrundsgeologi/2D Modell*.

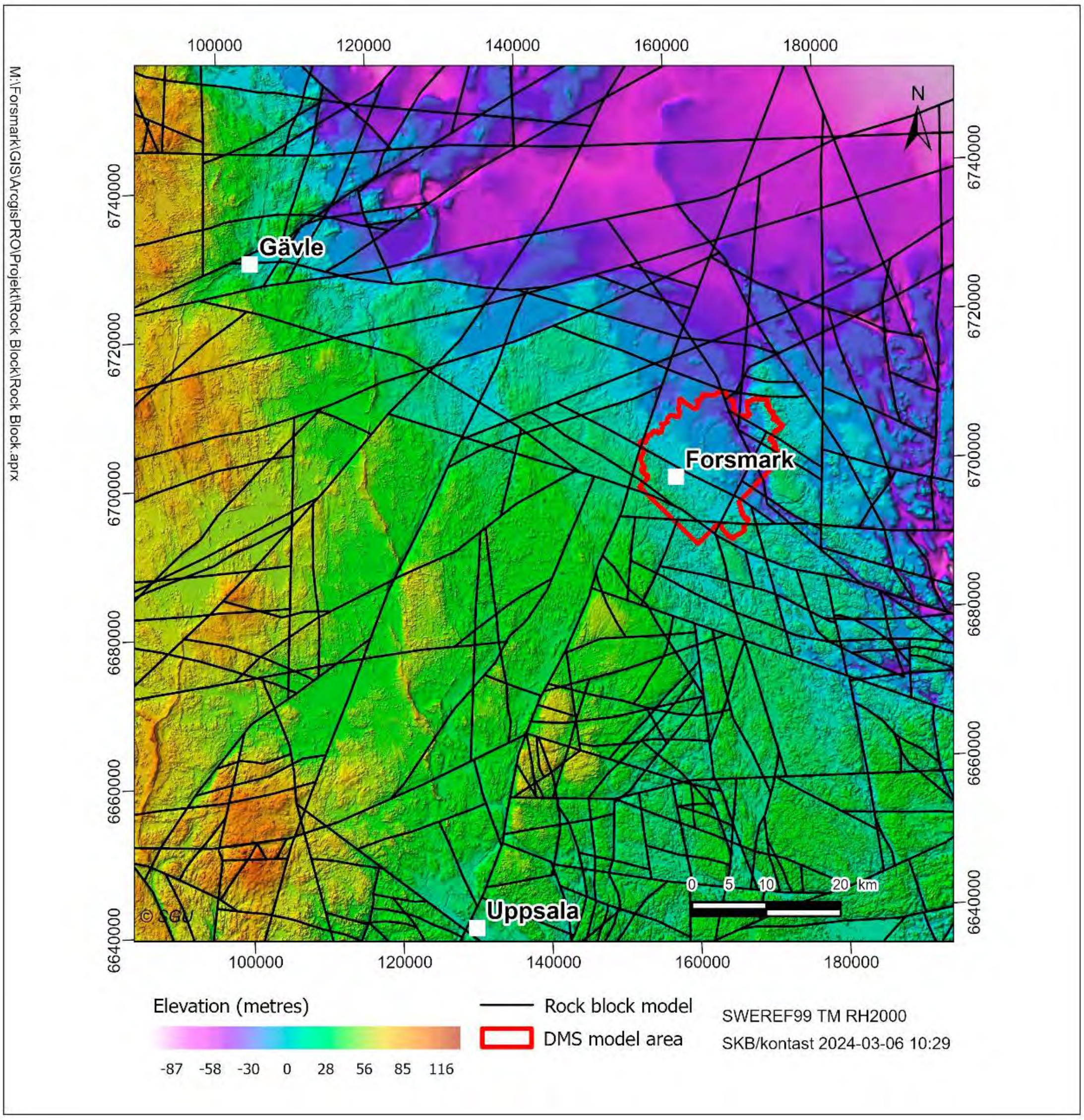


Figure 2-4. *Rock block model (blue lines) of Grigull et al. (2019) relative to the DMS model area. Background map is the combined DEM, which represents the relief of both the bedrock surface and the Quaternary cover sediments.*

3 Data acquired after 2010

3.1 Boreholes

The most recent geological models of SDM-Site, with the subsequent update of the deformation zone model to version 2.3, were developed by using data from ca 18 000 m of cored boreholes with a maximum depth of ca 1 000 m, and complementary data from ca 6 500 m of percussion drilled boreholes down to ca 300 m depth. References to acquisition data reports and analysis of these data can be found in the series of geological modelling reports produced during the site descriptive modelling (SKB 2004, 2005, Olofsson et al. 2007, Stephens et al. 2007, 2008b, Stephens and Simeonov 2015). The borehole data used to develop the geological models of SDM-PSU comprise ca 7 000 m of cored boreholes and ca 600 m of percussion drilled boreholes from the rock mass in proximity to the existing SFR facility and the volume for the planned SFR extension. Details regarding these data are provided by Curtis et al. (2011).

After conclusion of the investigations for SDM-Site and SDM-PSU, SKB has undertaken four separate drilling campaigns at Forsmark. Data from these drillings have provided essential input to the geological modelling work of Baseline Forsmark. The drilling campaigns can be summarised as follows:

- 2011–2012. Preparatory investigations of the shallow bedrock in proximity of the planned accesses and operational area of the final repository in the Söderviken area. The drilling activities included eleven cored boreholes, KFM13–KFM23, and three percussion-drilled boreholes, HFM39–HFM41, with individual lengths between 60 and 150 m. An evaluation of the borehole data focusing on the comparison with data from other boreholes located farther from the planned accesses are presented by Follin (2019).
- 2016. A ca 550 m long, subvertical borehole, KFM24, was drilled near the potential skip shaft of the planned repository with the main purpose to validate current geoscientific models and provide data for the access volume at depth. KFM24 is designed as a telescopic borehole, with ca 36 m of percussion drilling followed by core drilling to the full borehole length.
- 2018. The drilling included three cored boreholes, KFM25–KFM27, in proximity to the nuclear power plant (reactor Forsmark 1), two percussion drilled boreholes, HFM42 and HFM43, close to the planned accesses of the final repository and four percussion drilled boreholes, HFM44–HFM47, in the Stora Asphällan area (see Figure 3-2). All nine boreholes are steeply inclined (> 75°) with individual lengths of ca 100 m for the cored boreholes and ca 200 for the percussion drilled boreholes. KFM25–KFM27 were drilled with the aim to monitor the ground water level and the potential for subsidence along sub-horizontal fractures (e.g. sheet joints) with aperture and sediment fillings, whereas HFM42 was drilled for seismic monitoring and HFM43–HFM47 were drilled to perform hydraulic testing, including flow logging and water sampling.
- 2020. Four cored boreholes, KFR117–KFR120, and one telescopic borehole, KFR121, were drilled from the pier close to the SFR facility with an aim to investigate the possible existence of sub-horizontal fractures of hydraulic importance in the volume for the planned SFR extension. KFR117–KFR120 are steeply inclined (> 80°) with individual lengths of ca 176 m, whereas KFR121 has an inclination of ca 52° at the starting point with percussion drilling to ca 40 m length followed by core drilling to ca 362 m length.

Location of drill sites and borehole projection at the ground surface relative to the coastline, the Forsmark nuclear power plant and the SFR facility are presented in Figure 3-1 and Figure 3-2. Technical data concerning the drilling activities, including the coordinates of the drill sites, total length, length to inferred rock surface, bearing and inclination of the boreholes are presented in Appendix 1.

Data acquired from the standard SKB logging programmes of the boreholes include borehole TV-logging with the borehole image processing system BIPS (KFM13–KFM23 and HFM39–HFM41) and OP-TV (KFM24–KFM27, KFR117–KFR121 and HFM42–HFM47), geophysical logging and interpretation (KFM24 and KFR117–KFR121), hydraulic logging and geological logging of the drill cores (rock type, alteration phenomena and both ductile and brittle structures). Data from these programmes provide input to the integrated geological and geophysical single-hole interpretation discussed further in Section 4.1. Relevant data acquisition reports for the borehole investigations are listed in Appendix 2.

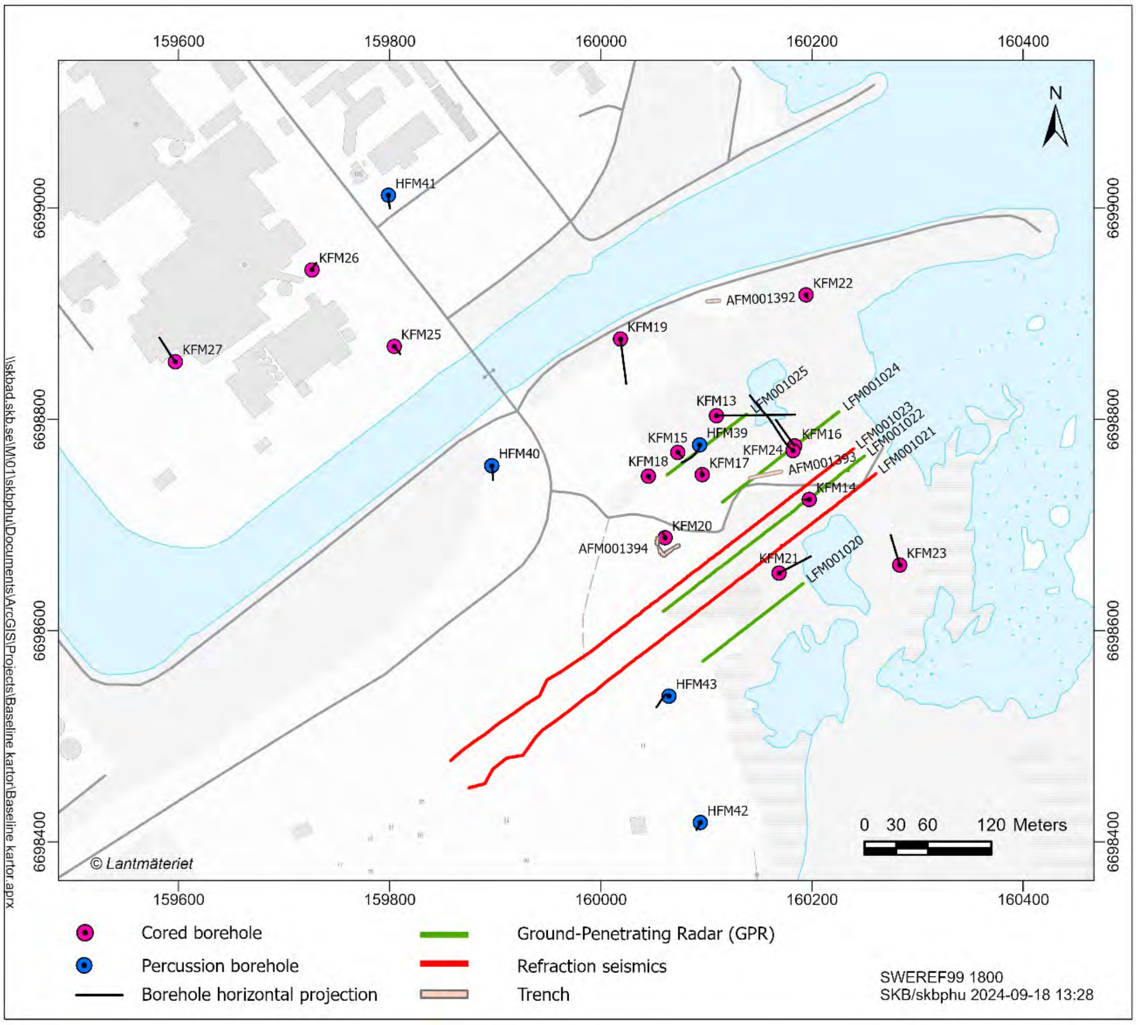


Figure 3-1. *Location of the cored boreholes KFM13–KFM27, the percussion drilled boreholes HFM39–HFM43, excavated trenches AFM001392–AFM001394 and the lines LFM001020–LFM001025 for ground penetrating radar (GPR) and seismic measurements in proximity of the planned accesses and operational area of the final repository in the Söderviken area.*

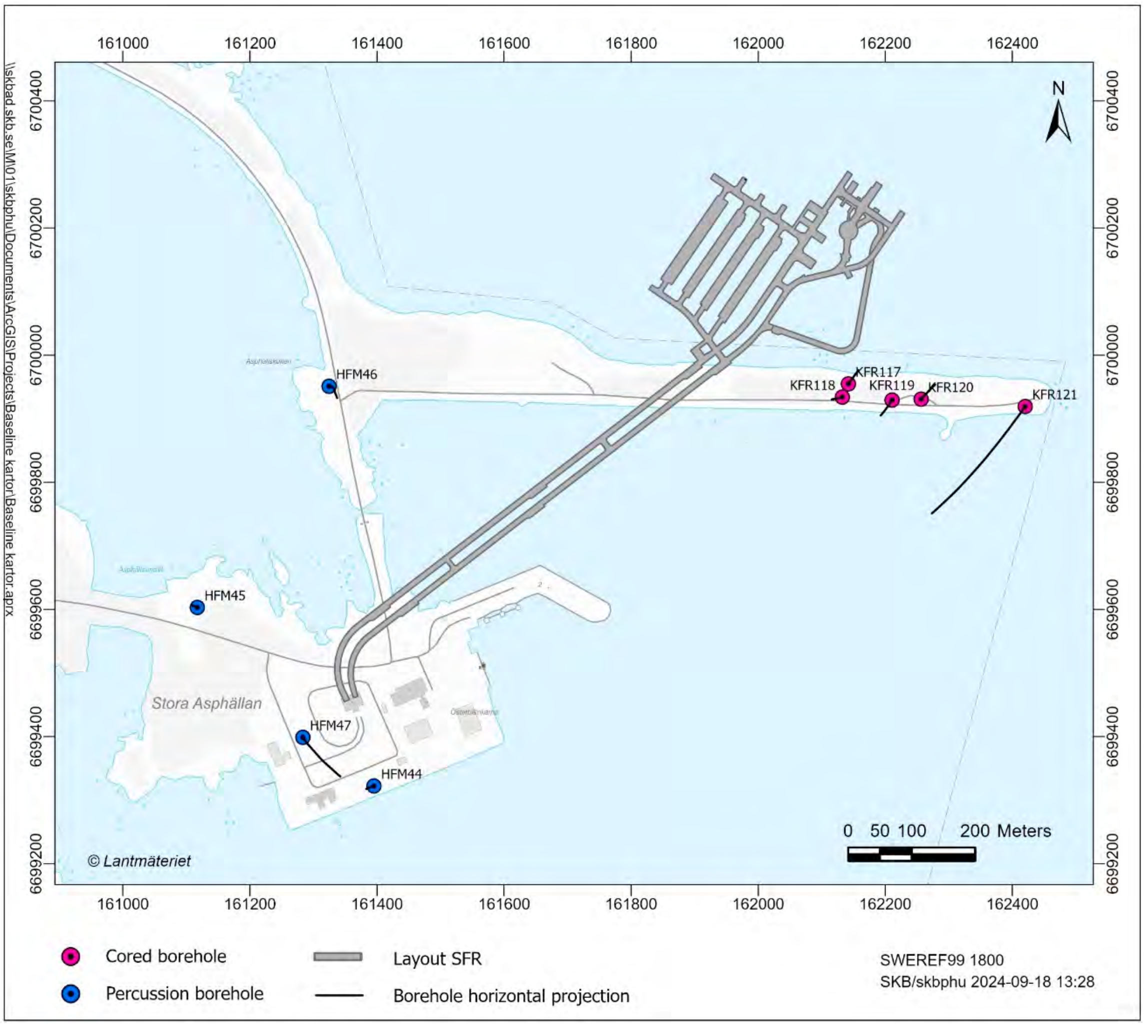


Figure 3-2. *Location of the cored boreholes KFR117–KFR121 and the percussion drilled boreholes HFM44–HFM47 in the SFR area.*

3.2 Trenches in the access area of the planned repository for spent nuclear fuel

During the subsequent preparatory investigations for the planned accesses and operational area of the final repository, SKB excavated two trenches in the Söderviken area, AFM001393 and AFM001394, to enable investigations of the regolith and the bedrock surface. Excavation of a third trench, AFM001392, had to be terminated before the bedrock surface was reached due to great regolith depths in combination with high inflow of groundwater. The locations of the trenches are presented in Figure 3-1.

The geological documentation of the two trenches can be summarised as follows:

AFM001393: Trenched outcrop of ca 26 m length excavated to investigate the nature of lineament MFM2168G with NNW–SSE trend. Deformation zone ZFMNNW1205B has been modelled along MFM2168G to transect this outcrop. The zone is manifested as two parallel, subvertical fault zones of 0.6–0.8 m width, separated by a 1.3 m thick slice of intact bedrock (Figure 3-3). Detailed fracture mapping of the outcrop was undertaken in accordance with the SKB method description 132.003e, *"Method description for detailed fracture mapping of rock outcrops"*.

Figure 3-3. *View towards NNW of the fault zones inferred to represent ZFMNNW1205B. Note the slice of intact bedrock between the faults. Width of view approximately 4.5 m. From Peterson et al. (2010).*

AFM001394: Excavated to acquire information of the rock mass properties and estimate soil depth at the planned start position of the repository ramp. Two trenched outcrops, each of ca 20 m length, arranged almost perpendicular towards each other, with one branch trending NNW–SSE and the other NE–SW. The geological documentation included a detailed fracture mapping in accordance with the SKB method description 132.003e, along with a detailed documentation of minor fracture zones and possible glacial tectonics. Investigations with ground penetrating radar (GPR) revealed extensive sub-horizontal fractures. Exposure of a more than 4 m high, almost vertical bedrock surface emphasizes that local variations in bedrock topography largely exceed indications by the ground surface topography.

Data acquisition reports for the outcrops AFM001393 and AFM001394 are listed in Table 3-1.

Table 3-1. acquisition reports for the outcrops AFM001393 and AFM001394.

Investigation	SKBdoc ID	Reference
Bedrock mapping	1338506	Petersson et al. (2015)
Detailed fracture mapping	1338599	Curtis et al. (2015)
Regolith mapping and GPR	1327863	Gustafsson and Hedman (2012)

3.3 Remote fracture mapping of islets and coastal outcrops

Remote fracture mapping based on photogrammetric models from drone imagery of ten islets and coastal outcrops at Forsmark and northwestern Gräsö was undertaken by Bakker et al.[1] during 2022–2023. The purpose of the mapping project was partly to provide input for DFN-modelling, and partly to test a new method for remote fracture mapping. The mapping was carried out using the Rock Characterisation System RoCS, a digital system developed by SKB for geological mapping of underground openings (tunnels, shafts and niches, etc.) based on photogrammetric 3D models.

[1] **Bakker A, Gåling J, Holmberg J, Andersson M.** Remote fracture mapping of ten outcrops in the Forsmark archipelago using RoCS. Methodology and results. Svensk Kärnbränslehantering AB. (In prep.)

All distinguished fractures with trace lengths of ≥ 1 m were digitised and described in terms of orientation, confidence in dip, trace length, termination and form. None of the islets and coastal outcrops were revisited subsequent to the mapping for verification by field control.

In general, the islets and outcrops show similar patterns with two predominant orientation sets of vertical to steeply dipping fractures striking NE–SW and NW–SE[1]. The latter typically follows the ductile structural trend revealed by tectonic banding and rock type boundaries. In addition to the dominant sets, other potential fracture sets of various relative intensities are visible in some outcrops. Subordinate sets of E–W and N–S striking fractures are defined in two of the most peripheral outcrops, where the ductile structures strike in N–S direction[1].

3.4 Outcrop observations in the sub-catchment area outside the regional model area

To provide geological support for the modelling of regional deformation zones within the future sub-catchment area situated outside the SDM-Site regional volume, a field survey was undertaken during 2020–2021 to examine the geological significance of lineaments interpreted by Isaksson and Johansson (2020) and characterise recognized deformation zones by structural analysis. For some outcrops of structural interest, drone photogrammetry was implemented. The survey was accomplished as a master's thesis by Bakker (2021). These data were not acquired according to the SKB QA system and were consequently not stored in the SKB database Sicada.

Where the exposure allowed, at least one outcrop was visited along each interpreted lineament; the majority are completely covered by water and regolith. In total 52 outcrops were visited, though the correspondence to deformation zones of inferred regional extent was only verified for five of the interpreted lineaments. Most of the remaining lineaments were attributed to ductile bedrock structures. Regardless of whether there are indications of significant deformation or not, a brief geological description has been compiled by Bakker (2021) for 33 of the visited outcrops.

The five verified deformation zones are found along the coast of central Gräsö and at the mainland, west of Öregrund. They are all steeply dipping and three of them strike NNW–SSE, whereas the other two strike NW–SE and E–W to ENE–WSW. All exhibit mylonitic fabric, which suggests an initial development under low-grade ductile deformational conditions with subsequent brittle reactivation.

Seven additional steeply dipping deformation zones were discovered in well-exposed coastal outcrops of central Gräsö and the Öregrund area (Figure 3-4). Despite of their proximity to the interpreted lineaments (see Figure 3-4), as a direct consequence of the predefined survey areas, there are no obvious connections, considering orientation, thickness and deformational character. Four of them strike E–W to ENE–WSW and three strike NNW–SSE. All seven are brittle deformation zones with inferred thicknesses in the range between 0.5 and 40 m. None of the geophysical or elevation data give convincing support for more extensive lateral continuations of these structures.

Outcrop locations in the southeastern part of the future sub-catchment are presented in Figure 3-4.

In early 2021, additional fieldwork was undertaken by the modelling team to investigate the geological significance of E–W trending lineaments at northern Gräsö. Geological information was acquired from almost 50 outcrops along three interpreted lineaments MFM3513, MFM3514 and MFM3518 from Isaksson and Johansson (2020) with associated splays. Notes from the fieldwork are presented in Appendix 3.

[1] **Bakker A, Gåling J, Holmberg J, Andersson M.** Remote fracture mapping of ten outcrops in the Forsmark archipelago using RoCS. Methodology and results. Svensk Kärnbränslehantering AB. (In prep.)

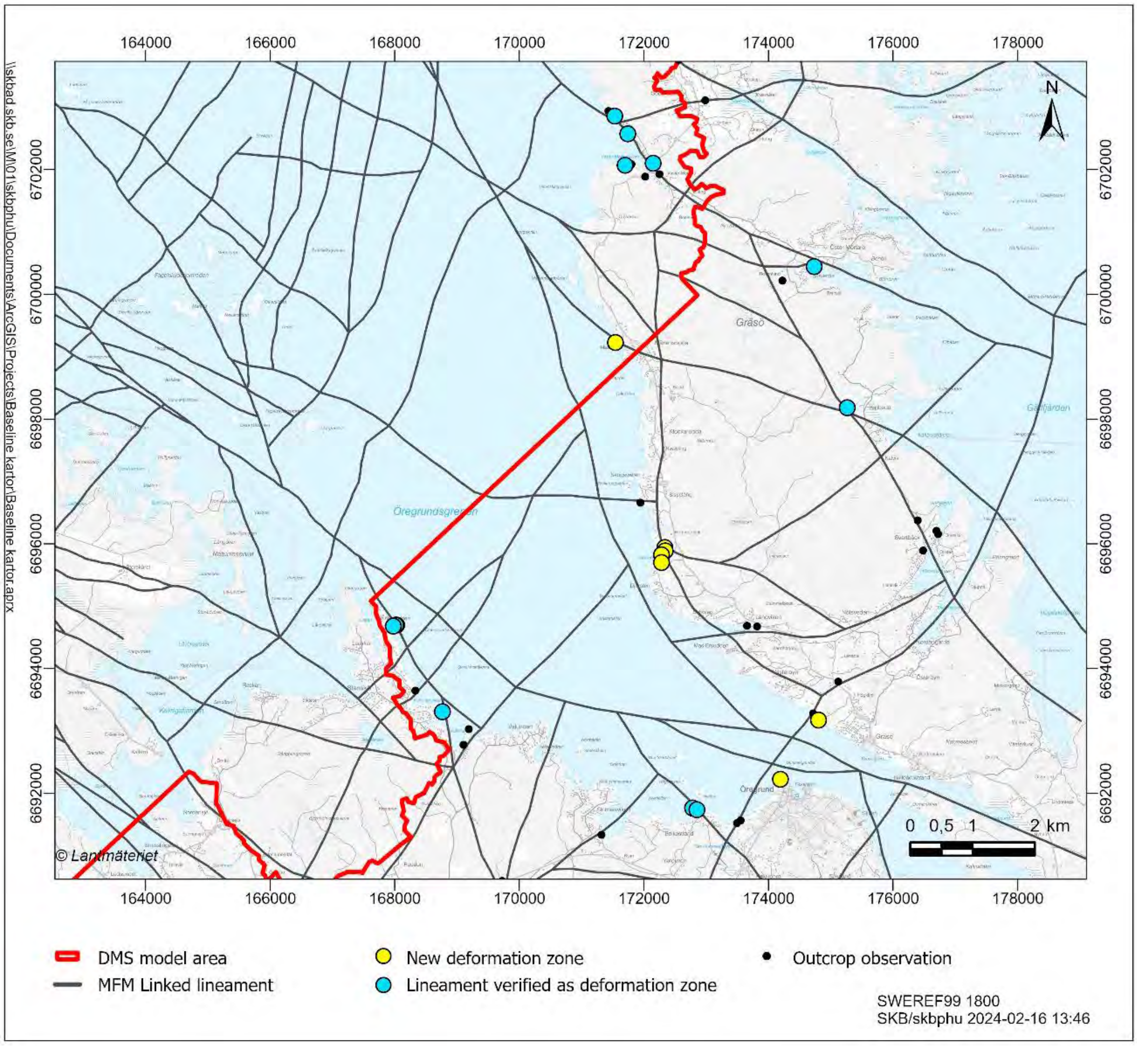


Figure 3-4. *Locations of outcrops visited by Bakker 2020–2021 in the south-eastern part of the DMS model area to examine the geological significance of lineaments interpreted by Isaksson and Johansson (2020). Outcrops that verify lineaments as deformation zones are coloured turquoise, whereas observations of deformation zones without obvious connection to interpreted lineaments are yellow. Outcrops where no deformation zones have been recognized are represented by black dots.*

3.5 Refraction seismics and GPR data

A campaign to acquire seismic and GPR data was accomplished in 2011, during preparatory investigations of the uppermost part of the bedrock in the Söderviken area. GPR measurements were carried out along six parallel lines, LFM001020–LFM001025, with a total length of 1.2 km (Figure 3-1). Complementary seismic data were acquired along two of these lines, LFM001021 and LFM001023, to obtain information on the near surface conditions by refraction seismic interpretation. However, close spacing between the receivers (2 m) and sources (6 m) also allows the data to be processed as reflection seismic data. The results of the GPR and refraction seismic survey are presented by Mattsson (2013), whereas the reflection seismic interpretation is presented in a separate report by Juhlin (2016).

Both methods have previously turned out to be less efficient for the identification of deformation zones and individual fractures at Forsmark (cf. Stephens et al. 2007). Plausible explanations for this are, for example, the high proportion of sealed fractures and sealed fracture networks along several zones, their inhomogeneous character and a fractured near-surface bedrock with narrow depressions.

4 Evaluation and interpretation of geological and geophysical data

4.1 The significance and usage of geological data from different sources

4.1.1 Borehole data – identification of rock units and possible deformation zones

The geological mapping and the supportive geophysical data from the boreholes completed after conclusion of the investigations for SDM-Site and SDM-PSU provide the key input to the geological modelling work of Baseline Forsmark. For some issues, such as identification and modelling of sheet joints (see Section 4.3.3), data from older boreholes have also been used after renewed evaluation. The inherently restricted quality of the data from the percussion boreholes, as discussed in SKB (2005), remains. For this reason, focus in the current model is on the cored borehole data, as in earlier model versions. Data from the percussion boreholes have primarily been used as support in the deterministic modelling work. An exception is the identification and modelling of sheet joints, where input is mainly provided by borehole imagery and information from percussion and cored boreholes has therefore been treated equally.

The terminology and procedures used in the acquisition of fracture data follows those summarised in Appendix 1 of Hermanson and Petersson (2022). Revision of the mapping methodology has occurred successively during the course of the different investigation campaigns at Forsmark, where more significant changes include:

- The term "sealed fracture network" with the purpose to handle highly fractured sections of the borehole was introduced after the mapping of boreholes KFM01A, KFM02A, KFM03A and KFM03B.
- A method to measure the orientation of ductile linear fabric was introduced 2006, but systematic measurements were not available until after Forsmark stage 2.2. However, the method is afflicted with significant uncertainties and therefore all these linear borehole data have been omitted from the Baseline modelling.
- Ambiguities concerning the recognition of fracture apertures in percussion boreholes, have as a precaution entailed registration of aperture for all fractures. Consistent application of this has been made for all percussion boreholes mapped after 2010, which include HFM39–HFM47.
- The term "fault rock" was introduced based on a simplified classification of Braaten et al. (2004) with the purpose of a more consistent documentation of deformational features such as breccia, cataclasite and mylonite. So far only used in the mapping of boreholes KFR117–KFR121.

The modelling efforts of the SDM-Site accentuated the need for a more rigorous treatment of uncertainties in borehole orientation data, which involve uncertainties in the geological mapping, the geometric position of boreholes in 3D space and the orientation of the borehole images. Based on this, SKB carried out a critical review to identify potential errors and to quantify uncertainties in the orientation of geological entities in boreholes (Munier and Stigsson 2007). Important consequences of this review include:

- Omission of all fractures not visible in the borehole image from the analyses of orientation data in the modelling work.
- Revisions in orientation data due to imprecisions of the BIPS-image orientation. The work includes virtually all cored and percussion boreholes from the site investigations at Forsmark and was completed in two steps: 22 prioritized (cored) boreholes revised during 2006–2007 (Döse et al. 2008) and 38 additional boreholes (mainly percussion drilled boreholes and cored boreholes in proximity to SFR) revised during 2017–2018 (Samuelsson and Winell 2022). Following the revisions, all structural orientation data in the Sicada database were recalculated and provided with numerical estimates of uncertainty.

- A reassessment of the analyses carried out in the deterministic modelling of rock domains and deformation zones during Forsmark stage 2.2, based on the revised orientation data (cf. Stephens et al. 2007).
- A geometrical update of all deformation zones during the modelling of Forsmark version 2.3, based on the revised deviation measurements and the resulting adjustments made with the position of boreholes in 3D space, following the delivery of Forsmark stage 2.2 (Stephens and Simeonov 2015). This did not include the minor deformation zones of Forsmark stage 2.2 (cf. Table 2-3).

A revision to match the adjusted borehole positions that included all modelled object geometries of Baseline Forsmark version 1.0, was carried out during the required model conversions after the upgrading of the RVS modelling tool in 2019 (see Sections 5.4.3, 6.2 and 7.4). However, there are still uncertainties in the spatial position of boreholes in all three dimensions, with a general increase towards depth (Munier and Stigsson 2007). The estimated uncertainty of borehole intersections with modelled objects does not exceed ca 30 m in the horizontal plane. In most cases, the uncertainty is less than 10 m in the horizontal plane and less than 6 m in the vertical dimension. These uncertainties are approximately of the same order of magnitude as the uncertainty in the position of lineaments defined by magnetic minima using airborne magnetic data and for seismic reflectors; all these uncertainties are considered relatively minor in character (Stephens and Simeonov 2015).

None of the orientation data acquired from boreholes drilled after conclusion of the investigations for SDM-Site and SDM-PSU, have been subject to revision due to imprecisions of the borehole image orientation. The underlying arguments for this are an introduction of new routines for BIPS-logging (applied to KFM13–KFM23 and HFM39–HFM41) and, a few years later, the implementation of a new, fully automatic borehole orientation system, OP-TV (used in KFM24–KFM27, HFM42–HFM47 and KFR117–KFR121). In this context, it is emphasized that the deterministic modelling work in geology has only used the orientation of geological structures in boreholes (e.g. fractures) as a support in the correlation of a large-scale geological or geophysical feature (e.g. a low magnetic lineament at the ground surface); not to define the orientation of the modelled zones (see Section 5.3.2).

Single-hole interpretation – 1D-model

The geological mapping and the supportive geophysical data have provided the input to single-hole interpretations, which is a 1D-model of a single borehole, that in turn forms a key link between the sub-surface data and 3D-modelling. A description of the procedures adopted during the various stages of the single-hole interpretation work is provided by for example Stephens et al. (2007) and Curtis et al. (2011). The method updates proposed by Hermanson and Petersson (2022) have not yet been applied in practice. The results of the interpretations for the boreholes completed after 2010 are presented in four separate data reports, one for each drilling campaign:

- KFM13–KFM23 and HFM39–HFM41 (Appendix C[2]),
- KFM24 (Dahlin et al. 2017),
- KFM25–KFM27 and HFM42–HFM47 (Rauséus and Petersson 2020),
- KFR117–KFR121 (Winell and Samuelsson 2022).

The single-hole interpretation adopted by SKB is carried out independently for each borehole in two stages (Stage 1 and 2 in Table 4-1). During the first stage of the single-hole interpretation, rock units and possible deformation zones in each borehole are identified and described by analysis of base data and inspection of drill cores. Furthermore, the interpretation of each geological feature is assigned a level of confidence. The second stage of the single-hole interpretation work involves a more detailed description of the characteristics of the possible deformation zones that are recognised with high confidence, with a special focus on kinematic data. Necessary information to accomplish the second stage interpretation was only available for boreholes completed during the site investigations that preceded the SDM-Site (cf. Nordgulen and Saintot 2006, 2008; Saintot and Nordgulen 2007). The remaining boreholes at Forsmark, including the HFR and KFR boreholes situated in proximity to the SFR, and the boreholes completed after 2010 (KFM13–KFM27 and HFM39–HFM47), have only been

[2] SKBdoc 1332706 ver 1.0 (Internal document, in swedish.)

subjected to the first stage of the single-hole interpretation, with identification and description of rock units and possible deformation zones. It should be noted that division into rock units was never done for boreholes KFM13–KFM23 and HFM39–HFM41.

Rock units are primarily characterized based on the composition, grain size and the inferred relative age of the dominant rock type. In some cases, rock units have been defined with guidance from, for example, the frequency of open and partly open fractures outside possible deformation zones, the degree of ductile deformation or the occurrence of the alteration referred to as albitization (see Section 4.2.2). Rock units extend over the total length in each borehole and, for this reason, include the borehole intervals where possible deformation zones have been recognised. The possible deformation zones identified at Forsmark are basically brittle in character, with subordinate low-grade ductile components along NW to WNW striking zones of more regional extent. Brittle deformation zones have been defined in the single-hole interpretation work primarily with guidance from the geological and geophysical data sets fracture frequency, rock alteration and focused resistivity. Other features, which have assisted in their identification, include the occurrence of low radar amplitude anomalies in the borehole radar data, low magnetic susceptibility and the occurrence of caliper anomalies.

Two additional varieties of the single-hole interpretation were implemented during the modelling work of SDM-Site and SDM-PSU, the extended single-hole interpretation (ESHI) and the simplified single-hole interpretation. The ESHI was introduced 2006 as a reassessment of existing data and drill cores in order to identify possible additional deformation zones below the resolution threshold applied during the preceding stages of the site investigation programme. The details and outcome of the ESHI are presented by Fox and Hermanson (2006). Data for these new minor zones, as well as some adjustments that emerged at the stage 2.2 modelling work to the boundaries of possible deformation zones identified in the original single-hole interpretation, are both stored in the Sicada database under a separate activity identification number, GE302. The simplified single-hole interpretation was introduced during the modelling that preceded SDM-PSU, with the purpose to enable incorporation of relevant information from older boreholes, completed during the construction of SFR, in the modelling work. This data deficiency prevented full application of the established process for single-hole interpretation, and the identification of possible deformation zones and rock units was based on direct visual inspection of the drill cores, rock code translations and the lithological overview mapping. Further details are given in Petersson et al. (2011) and results of the simplified interpretation is stored in the Sicada database under a separate activity identification number, GE299.

All available data from single-hole interpretations of boreholes at Forsmark have been of equal importance in the reappraisal process. A summary of the available data types from single-hole interpretations, which were the key components of the current model version, is presented in Table 4-1.

Table 4-1. Available data types from single-hole interpretations completed at boreholes in the Forsmark area.

Type of interpretation for each borehole	Stage 1	Stage 2
Extended single-hole interpretation (GE302)		
KFM01A–KFM01D, KFM02A, KFM02B, KFM03A, KFM03B, KFM04A, KFM05A, KFM06A–KFM06C, KFM07A–KFM07C, KFM08A–KFM08C, KFM09A, KFM09B, KFM10A	X	X
HFM01–HFM32, HFM38	X	–
Single-hole interpretation (GE300)		
KFM08D, KFM11A, KFM12A	X	X
HFM33–HFM37, HFM39–HFM41*, HFM42–HFM47, HFR101, HFR102, HFR105, HFR106, KFM13–KFM23*, KFM24–KFM27, KFR101, KFR102A, KFR102B, KFR103–KFR106, KFR117–KFR121	X	–
Simplified single-hole interpretation (GE299)		
KFR01–KFR05, KFR08–KFR14, KFR19, KFR20, KFR27, KFR31, KFR32, KFR34–KFR38, KFR51, KFR52, KFR54, KFR55, KFR57, KFR61–KFR72, KFR89, KFR7A–KFR7C	X	–

* No rock units for boreholes KFM13–KFM23 and HFM39–HFM41.

The major significance of data acquired from single-hole interpretations of boreholes completed after 2010 has been a confirmation of previous concepts and existing geological models. New data that contributed to the actual revision of, and additions to, the deterministic modelling and the characterisation of modelled deformation zones are limited to the following boreholes (see Section 5.4.4 and Appendix 7):

- KFM13 and KFM21: Geometrical modelling and assignment of properties for ZFMNNW1205B, as well as revised geometry and updating of geological properties for ZFMNNW1205A.
- KFM19 and KFM24: Revised geometry and updating of geological properties for ZFMENE1061A.
- KFM23: Revised geometry and updating of geological properties for ZFMENE2120.
- KFM26, KFM27 and HFM41: Revised geometry and updating of geological properties for ZFMENE2248.
- KFR118: Updating of geological properties for ZFMENE3115.
- KFR121: Revised geometries for ZFMWNW0835 and ZFMWNW8042, as well as updating of geological properties for ZFMWNW0835, ZFMWNW3262 and ZFMWNW8042.

All deterministic modelling of sheet joints is restricted to bedrock volumes where the borehole density allows reasonable confidence in interpolation (see Section 5.3.6), which basically means in proximity to the SFR facility and the planned accesses and operational area of the final repository. The primary input to this work is information from the boreholes concluded after 2010, but also older boreholes situated at drill site 7 and 8. Data from these boreholes are also the main basis for revision of the fracture domain model, including the division of FFM02 into two subdomains (see Section 7.5) and modification of the boundary between FFM02 and FFM01 (see Section 7.6).

4.1.2 Surface data from trenches and outcrops

The special studies concerned with the assembly of surface bedrock data after 2010 include:

- Bedrock mapping of trenches in the access area of the planned repository for spent nuclear fuel (Section 3.2); data provided in Sicada delivery SKBdata_24_020.
- Remote fracture mapping of islets and coastal outcrops (Section 3.3); data provided in Sicada delivery SKBdata_24_020.
- Outcrop observations in the sub-catchment area outside the regional model area (Section 3.4).

These data provide primarily support to the current site understanding by verification of established concepts and existing geological models. Only a small portion of the data have contributed directly to the deterministic modelling and the characterisation of modelled features. More specifically, data from the following trenches and outcrops have been of significance for the deformation zone modelling carried out after SDM-Site and SDM-PSU:

- AFM001393: Characterisation of lineament MFM2168G as well as modelling and assignment of properties for ZFMNNW1205B.
- ABR20002–ABR20005, ABR20007, ABR20008, ABR200020, ABR200021, ABR200034 (codes according to the thesis of Bakker 2021): Characterisation of lineament MFM3511 as well as modelling and assignment of properties for ZFMNW3511.

The outcrop observations by Bakker (2021) have proved the existence of additional deformation zones, but they are either outside the model boundary of DMS Baseline Forsmark (Figure 3-4) or inferred to be smaller than the minimum ground surface length for representation by deterministic modelling (see Section 5.4.5). However, uncertainties regarding the nature of most lineaments interpreted by Isaksson and Johansson (2020), and the field verification of those, remain and possible correlations with deformation zones cannot be ruled out solely from the work of Bakker (2021). Only three E–W trending lineaments at northern Gräsö have been rejected as surface expressions of regional deformation zones; a decision based on outcrop data from a dedicated field effort by the modelling team in early 2021 (see Section 3.4), which provide alternative explanations, including the trend of ductile bedrock structures and locally anthropogenic features such as power lines and roads.

The data from the remote fracture mapping of islets and coastal outcrops (Section 3.3) became available after the delivery of the deterministic geological models. Given the confidence level in geological data acquired by remote techniques, the application has been limited to support the evaluation of fracture statistics of borehole data.

The surface bedrock data acquired after 2010 have not provided incentive to update the bedrock geological map at the scale 1:10 000 that covers the mainland and the archipelago area at the Forsmark site (Bedrock geological map, Forsmark, version 1.2); nor to extend the map further to cover remaining parts of the future sub-catchment area. None of the surface data affect the current knowledge regarding the potential for metallic mineralisations and industrial mineral deposits (cf. Lindroos et al. 2004).

4.2 Comparison with geological data acquired before 2011

4.2.1 Rock type

The character and distribution of the rock types in the Forsmark area have previously been described in numerous reports (e.g. SKB 2005, 2008a; Stephens et al. 2005, 2007; Söderbäck 2008). Outcrop mapping during the initial site investigations enabled distinction of four major rock groups (Groups A to D), categorised based on their relative age relationships. An overview of the deformational character, composition, grain-size and relative age of individual rock types within the four groups is presented in Table 4-2. It should be emphasized that only a few of these rocks can be distinguished solely by their compositional character. Ocular distinction relies mainly on a combination of several properties, where the importance of texture and grain-size often outweigh mineralogical composition.

Table 4-2. Major groups of rock types at the Forsmark site after Stephens et al. (2005). SKB rock codes that distinguish individual rock types of each group are shown in brackets.

Rock groups	Rock types
All rocks are affected by brittle deformation. The fractures generally cut the boundaries between the different rock types. The boundaries are predominantly not fractured.	
Rocks in Group D are affected only partly by ductile deformation and metamorphism.	
Group D	• Fine- to medium-grained granite and aplite (111058). Pegmatitic granite and pegmatite (101061). Variable age relationships with respect to Group C. Occur as dykes and minor bodies that are commonly discordant and, locally, strongly discordant to ductile deformation in older rocks.
Rocks in Group C are affected by penetrative ductile deformation under lower amphibolite-facies metamorphic conditions.	
Group C	• Fine- to medium-grained granodiorite, tonalite and subordinate granite (101051). Occur as lenses (boudins) and dykes in Groups A and B. Intruded after some ductile deformation in the rocks belonging to Groups A and B with weakly discordant contacts to ductile deformation in these older rocks.
Rocks in Groups A and B are affected by penetrative ductile deformation under amphibolite-facies metamorphic conditions.	
Group B	• Biotite-bearing granite (to granodiorite) (101057) and aplitic granite (101058), both with amphibolite (102017) as dykes and irregular inclusions. Local albitization (104) of granitic rocks. • Tonalite to granodiorite (101054) with amphibolite (102017) enclaves. Granodiorite (101056). • Ultramafic rock (101004). Gabbro, diorite and quartz diorite (101033).
Group A	• Volcanic rock (103076), calc-silicate rock (108019) and subordinate sedimentary rocks (106001). • Iron oxide mineralization (109014) and sulphide mineralization, possibly epigenetic (109010).

Since the site investigations that preceded SDM-Site and SDM-PSU, new data on modal mineralogy and rock type distribution have been acquired from several cored boreholes. All these complementary data motivate primarily a comparison between the different data sets, but also updates regarding the mineralogical composition of the dominant rock types and quantitative estimates of the proportions of rock types in different rock domains.

The cored boreholes that succeed 2010 are located in two main areas: the northeastern part of RFM029 and the pier close to the SFR facility. Both areas were in focus of the previous site investigations, which thereby permits comparison with extensive borehole data from the immediate proximity. The assessment is therefore restricted to the rock domains RFM029, RFR01 and RFR02. The proportion of different rock types along the cored boreholes completed after 2010 and during the site investigations is presented separately for each domains in Figure 4-1 by merging the data sets rock type (> 1 m borehole length) and rock occurrence (< 1 m borehole length) in the Sicada delivery SKBdata_22_065 and SKBdata_23_022. The working procedure has involved the removal of a short interval of rock type for each inserted rock occurrence. The following features of this compilation merit attention:

- The proportion of rock type for RFM029 show a general agreement between boreholes completed during the site investigations and after 2010, with a strong dominance of medium-grained metagranite to granodiorite (101057). However, subordinate rock types are consistently less abundant in the borehole data acquired after 2010. This is due to variability in distribution of sub-ordinate rock types within rock domain RFM029.
- The borehole data acquired after 2010 from RFR01 show an anomalously high content of fine- to medium-grained granite (111058) relative to the data from older boreholes. Virtually all of this 111058 occurs along one borehole, KFR118. The rock type is generally more abundant in RFR02, with significant occurrences along boreholes situated further north (e.g. KFR04, KFR08 and KFR37) and the rock caverns of the SFR facility. Although significant local variability is to be expected, the quantity of 111058 along KFR118 provides incentive for a future revision of the boundary between RFR01 and RFR02.
- For RFR02, the proportion of rock types in the borehole data acquired after 2010 and equivalent data from SDM-PSU differs substantially, with an increase of pegmatitic granite and pegmatite (101061) at the expanse of felsic to intermediate metavolcanics (103076) and fine- to medium-grained granite (111058). Heterogeneity in the rock type distribution has been a primary criterion for distinction of this rock domain (see Curtis et al. 2011) and local variability is to be expected.

Quantitative estimates of the proportions of rock types in different rock domains with sufficient data is presented in Section 6.4.

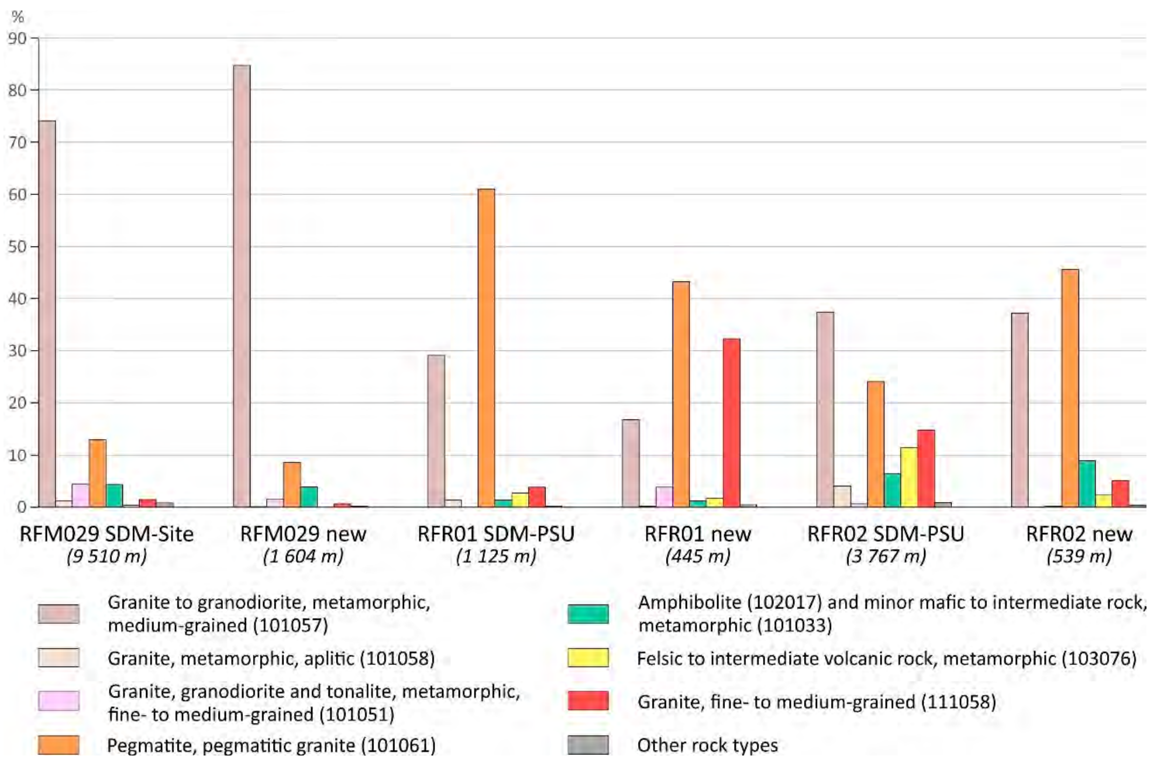


Figure 4-1. *Histograms illustrating the quantitative estimates of the proportions of different rocks for the three rock domains RFM029, RFR01 and RFR02 by a separation of borehole data acquired after 2010 (new) and the previous site investigations (SDM-Site and SDM-PSU). The compilation is based on geological data from cored borehole sections (Sicada delivery SKBdata_22_065 and SKBdata_23_022). All calculations take account of rock types and rock occurrences greater than and less than 1 m in borehole length, respectively.*

Modal, whole-rock geochemical and petrophysical analyses of samples of different rock types, from both outcrops at the ground surface and from boreholes, have been acquired during the site investigations that preceded the SDM-Site. In model version 1.2, these properties were determined for each rock type based on the analyses from the regional SDM-Site volume (SKB 2005). As more data became available, the estimates on the mineral composition and petrophysical properties were revised in model stage 2.2 with focus on analytical data from the local SDM-Site volume (Stephens et al. 2007; SKB 2008b). A final summary of the available data on modal mineral composition, whole-rock geochemistry, redox properties and porosity of different rock types in the Forsmark regional model volume was presented by Sandström and Stephens (2009). Corresponding analysis during the site investigations that preceded the SDM-PSU, was limited to the petrophysical parameters silicate density and magnetic susceptibility (Curtis et al. 2011); modal analysis of rock type composition was never acquired within the framework of SDM-PSU.

All modal data that have been produced after 2010 are for drill core samples of medium-grained metagranite to granodiorite (101057) and metagranodiorite (101056). One third of them has been acquired from samples affected by oxidation, which include all samples obtained in proximity to the SFR facility. After omission of these samples and duplicate analyses, twelve analyses of unaltered rock remain. In addition, there are modal data from the previous site investigation (SDM-Site) that were never used in the estimates, primarily from studies of thermal properties (Adl-Zarrabi 2004a, 2004b, 2006), but also some from the laboratory investigations of transport properties (Gustavsson 2006). These additional analyses have formed the basis for an upgrading of the mineralogical compositions presented by Stephens et al. (2007), by application of the following principles:

- Omission of samples affected by rock alteration (oxidation, albitization and quartz dissolution).
- Selection of a single analysis for thin-sections that have been analysed repeatedly (i.e. duplicate analyses).
- A minimum distance of 1 m of borehole length between individual samples; if closer, the sample with the lowest borehole length shall be omitted.
- Estimates of mineralogical compositions for 101051 and 101057 have been calculated by solely using analyses from the local SDM-Site volume. For the remaining rock types, where there are no or few samples from the local SDM-Site volume (i.e., 111058, 101061, 101058, 101056, 101054, 101033, 102017, 101004 and 103076), estimates have been calculated by using analyses from the regional model volume of SDM-Site.

A summary of the mineralogical composition of the different rock types at the Forsmark site is presented in Table 4-3. Estimates for 101057, 101056, 101054 and 103076 have been recalculated from the values presented by Stephens et al. (2007) according to the following revisions:

- *101057* – addition of 14 new analyses from Adl-Zarrabi (2004a, 2004b), Gustavsson (2006) and Petersson and Eliasson (2023).
- *101056* – addition of four new analyses from Adl-Zarrabi (2004b, 2006) and Petersson and Eliasson (2024).
- *101054* – addition of one new analysis from Gustavsson (2006).
- *103076* – two of the analyses used in the estimates presented by Stephens et al. (2007) could not be found in either Sicada or in any data report. With the addition of one new analysis from Adl-Zarrabi (2006), the current values in Table 4-3 is based on 16 instead of 17 analyses.

Table 4-3. Modal composition of the different rock types at the Forsmark site. SKB rock codes that distinguish individual rock types are defined in Table 4-2.

SKB code	No of samples	Quartz Min–max Mean ± std [vol.%]	K-feldspar Min–max Mean ± std [vol.%]	Plagioclase Min–max Mean ± std [vol.%]	Biotite* Min–max Mean ± std [vol.%]	Hornblende Min–max Mean ± std [vol.%]
Group D						
111058	5	25.4–42.8 32.4 ± 6.4	22.6–37.8 29.6 ± 5.6	22.0–46.2 33.0 ± 9.3	1.4–5.2 3.4 ± 1.4	–
101061	5	29.2–38.1 34.0 ± 3.7	19.2–45.0 31.3 ± 9.5	20.6–39.0 31.4 ± 7.4	0.7–5.2 2.2 ± 1.8	–
Group C						
101051	17	19.2–35.4 28.4 ± 4.1	1.4–32.4 11.8 ± 9.8	29.4–67.0 47.7 ± 9.8	3.4–14.4 8.4 ± 3.2	0–5.0 0.8 ± 1.4
Group B						
101058	6	30.8–44.4 37.4 ± 4.9	23.0–47.0 31.7 ± 8.6	18.8–31.2 26.4 ± 4.3	0.7–7.4 3.6 ± 3.0	–
101057	39	24.2–46.4 36.3 ± 5.0	12.6–36.0 22.2 ± 5.4	24.8–47.4 34.5 ± 4.8	3.6–11.6 5.8 ± 2.0	0–1.6 0.2 ± 0.4
101056	13	15.6–44.4 28.8 ± 8.1	6.3–16.6 11.4 ± 3.3	28.8–52.0 45.0 ± 6.7	6.4–12.4 9.2 ± 1.7	0–16.2 3.9 ± 5.7
101054	24	13.6–45.4 23.3 ± 7.4	0–11.4 5.1 ± 3.3	37.6–61.4 49.1 ± 5.3	2.6–15.8 10.5 ± 3.1	0–19.4 9.5 ± 6.2
101033	11	0–24.6 8.3 ± 7.7	In 2 samples	40.4–64.6 51.3 ± 7.0	0–15.2 8.4 ± 5.0	10.6–50.6 29.0 ± 11.8
102017	4	0–6.4 2.6 ± 2.9	In 1 sample	39.2–53.0 46.3 ± 6.4	In 1 sample	40.6–55.6 45.0 ± 7.2
101004	2	Quartz, K-feldspar and plagioclase feldspar are absent. 46.6–61.2 % pyroxene, 9.6–31.0 % hornblende (actinolite) and 0–35.2 % olivine (serpentine).				
Group A						
103076	16	5.2–39.2 28.0 ± 9.2	0–17.0 4.3 ± 5.2	29.2–58 47.3 ± 7.7	0–26.0 13.0 ± 8.5	0–35.6 No estimate

* Includes chlorite developed by retrograde alteration of biotite.

The values for all other rock types in Table 4-3 are identical to those listed by Stephens et al. (2007). However, a notable difference is that all values for biotite have been changed to include chlorite, which developed by retrograde alteration of biotite. A summary of all analyses used in the calculations is provided in Appendix 4.

In general, the new values for 101057, 101056, 101054 and 103076 are very close to those estimated previously by Stephens et al. (2007), with mean and standard deviations within 1 vol.% of the original values. However, there are two features that deserve further attention: the range for K-feldspar in 103076, which has increased from 0–12.6 to 0–17.0 vol.%, and the content of hornblende in 101057, which occurs in accessory amounts (< 1.6 vol.%) in approximately one third of the analyses. Other accessory phases in the granitoids of Group B and C (not included in Table 4-3) are epidote (< 3.6 vol.%), titanite (< 1.8 vol.%) and magnetite (1.2 vol.%), with a few grains of muscovite, allanite, apatite prehnite/pumpellyite, zircon, calcite and sulphides (primarily pyrite).

Following feedback from the transport modelling team, an attempt has been made to illustrate the variability of rock-forming minerals of particular importance for the thermal, mechanical and transport properties of the intact rock. The basic approach, as confirmed by data from Forsmark (SKB 2008a and references therein), is that the content of quartz has a critical impact on the thermal conductivity, whereas the content of biotite together with secondary chlorite may influence both the radionuclide sorption and the compressive strength.

Figure 4-2 illustrates the variability in the content of biotite (including chlorite) versus quartz for the different rock types at the Forsmark site. Data for the two rock types that dominates strongly within RFM029 and RFM045 (101057 and 101058, see Section 6.4) show largely overlapping ranges, with very similar quartz content and conspicuously lower biotite content in 101058. Some of the Group B granitic rocks, particularly in RFM045 where 101058 is a major component, have been affected by the alteration referred to as albitization (see Section 4.2.2). This alteration tends to raise the quartz content slightly and decrease the biotite content significantly. However, no such altered samples are included in the data set presented in Figure 4-2.

The petrophysical data acquired after the completion of SDM-Site are limited to the following data:

- Investigations preceding SDM-PSU: Analysis of density and magnetic susceptibility for samples from five boreholes: KFR04, KFR05, KFR20, KFR101 and KFR106 (Mattsson 2009, Mattsson and Keisu 2009, 2010).
- KFR24: Analysis of density, porosity, magnetic susceptibility and electric resistivity for 35 samples.

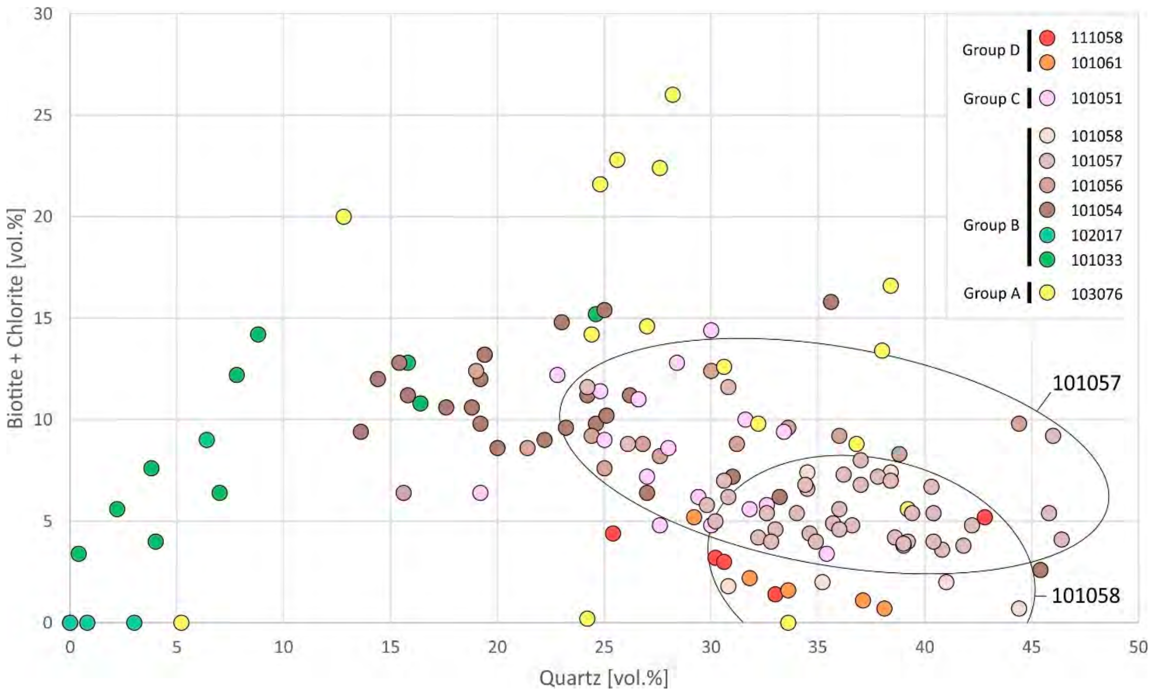


Figure 4-2. *Variability in the content of biotite (including chlorite) and quartz for the different rock types at the Forsmark site. SKB rock codes that distinguish individual rock types are defined in Table 4-2. Encircled fields include all analyses of 101057 and 101058, the dominant rock types in RFM029 and RFM045, respectively. The diagram is based on modal analyses presented in Appendix 4 (Sicada delivery SKBdata_23_036_02).*

A comparison between the new data for KFM24, the SFR boreholes and the petrophysical properties presented by Stephens et al. (2007) for different rock types at Forsmark is presented in Figure 4-3. Electric resistivity has been omitted, as the base frequencies differ between the new and old measurements. Also, natural exposure rate (natural gamma radiation) has been excluded, as no such data has been produced since 2005. The diagrams include only samples unaffected by rock alteration. The following features are noticeable in the diagrams of Figure 4-3:

- Samples from KFM24 show a systematically lower porosity than the samples from site investigations that preceded SDM-Site (Figure 4-3a). This consistent bias is inferred to be of analytical nature, rather than reflecting the actual porosity of the rock mass. Including these data in the two data sets should therefore be avoided.
- By visual inspection, the parameter density in Figure 4-3b, shows no difference between the data sets from KFM24, SDM-Site and the SFR boreholes. This confirms an excellent consistency between the field and borehole assessment of the rock type and the analytical data. The density range for 102017 and 103076 reflect significant compositional variability within the two groups.
- The parameter magnetic susceptibility in Figure 4-3c shows a general agreement between the data sets from KFM24, SDM-Site and the SFR boreholes. However, a feature that merit attention is the anomalously high magnetic susceptibility of the SFR samples, with a geometric mean of 0.0035 SI, whereas the values for the amphibolites in the Forsmark tectonic lens are consistently low, in the range 0.00051–0.00086 SI. This can be explained, at least partly, by a high content of magnetite in the amphibolite of the SFR area (cf. Curtis et al. 2011).

Following discussions with colleagues of other disciplines in the modelling group, two questions were recognised concerning the homogeneity of the dominant metagranite-granodiorite (101057) at Forsmark:

- Compositional and textural differences between the tectonic lens and the rock mass in proximity to the SFR facility.
- Scale-dependent variability versus analytical uncertainties related to the point-counting method.

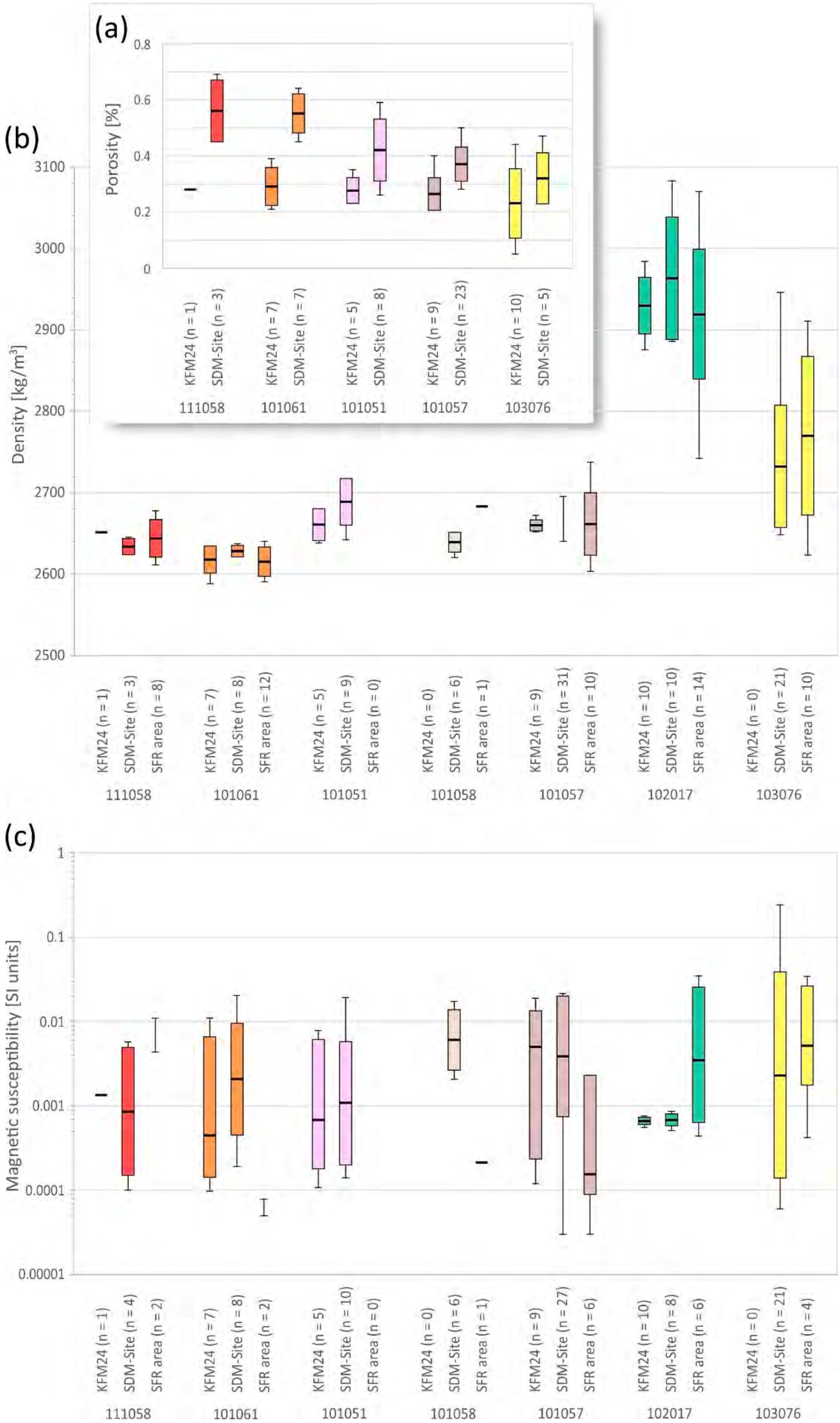


Figure 4-3. *A variety of classical box and whisker diagrams comparing the petrophysical properties for different rock types at Forsmark by separation of samples from KFM24, SDM-Site and SFR boreholes. (a) Porosity, (b) density and (c) magnetic susceptibility. The whisker is defined by the range (min–max), the box by the standard deviation and the thick line by the mean (arithmetic for porosity and density, geometric for magnetic susceptibility). Data for SDM-Site are presented in Table 4-3 in Stephens et al. (2007), whereas data for KFM24 and SFR boreholes were extracted from Sicada delivery SKBdata_23_036.*

A summary of the major differences between the metagranite-granodiorite (101057) of the tectonic lens and the rock mass around SFR is listed below. Since the only available thin-sections from the SFR volume are affected by oxidation (see Section 4.2.2), this comparison has been solely based on ocular inspection during the borehole mapping, aided by a magnifying lens.

- The typical texture of elongated monomineralic domains that characterise 101057 within the tectonic lens are less distinct in the rock mass in vicinity to the SFR (Figure 4-4).
- The grain-size is generally smaller in vicinity to the SFR than within the tectonic lens. An isolated example of a highly reminiscent variety within the lens occurs in the upper part of KFM05A (cf. Petersson et al. 2004b).
- Intensely deformed varieties of 101057 show strong similarities with the metavolcanic rocks of felsic to intermediate composition (103076), though the content of ferromagnesian phases is typically lower in 101057.
- The density is generally higher in the SFR varieties of 101057, with an arithmetic mean of ca 2 700 kg/m^3, which indicates a prevailing granodioritic composition with subordinate, granitic varieties.
- The occurrence of muscovite is a pervasive feature in parts of the rock mass in vicinity to the SFR, whereas the presence of muscovite within the tectonic lens is strictly limited to deformation zones. It is inferred that the muscovitization in proximity to the SFR has an origin that pre-dates the brittle deformation of the region.

The compositional variability of 101057 is significant, with standard deviations of 5–6 vol.% for the main salic minerals and approximately 2 vol.% for biotite (Table 4-3). Comparison between samples from the surface and the borehole, along individual boreholes and within a few metres of a borehole reveals similar variations at all scales. Even duplicate analyses completed by two different persons independently of the same thin-section yielded variations of such an extent that they outmatch the modal variability among samples from different localities (e.g. the modal analyses of KFM01A 109.66, KFM06A 636.34 and KFM08C 750.32; Petersson and Eliasson 2023, Petersson et al. 2004a, 2005). The mineralogy of 101057 would not provide difficulties in the distinction between the different components, especially not the ferromagnesian phases, considering the experience of all the analysing persons. An explanation for this discrepancy of the duplicate analyses, previously provided by Petersson and Eliasson 2023, is the mounting of the thin-sections in the point-counting stage in combination with the textural character of the rock type. The counted area does not cover the entire thin-section and an infinite ability to adjust the position of the area makes it problematic for two different persons to repeat the setup. The characteristic incipient gneissosity of 101057, with stretched monomineralic domains of quartz/feldspars and trails of ferromagnesian minerals, gives a heterogeneity at centimetre-scale that cannot always be captured by the limited point-counting area. Thus, the heterogeneity at centimetre-scale prevent quantification of more large-scale variations in the composition of 101057 solely based on modal data. However, whole-rock geochemistry and documentation from the geological borehole/outcrop mapping both provide evidence for the actual existence of more large-scale variations. The systematics of possible spatial anomalies and scale-dependent differences within the lens remains to be resolved. Considering the large number of analyses available, the calculated values presented in Table 4-3 are nevertheless judged to reflect the actual variations within the lens as such with high confidence.

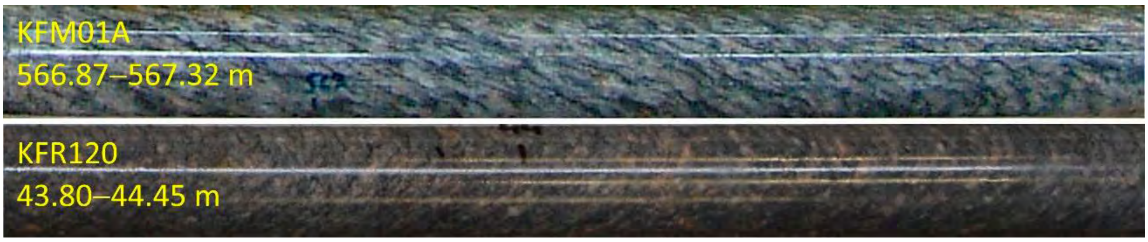


***Figure 4-4.** Examples of drill cores from the north-western central part of the tectonic lens (KFM01A) and the rock mass close to the SFR facility (KFR120), which illustrate the textural character of 101057.*

4.2.2 Rock alteration

The significance of rock alteration at the Forsmark site, in particular the relationship between alteration and deformation zones, has previously been summarised by Stephens et al. (2007). A more detailed characterisation of the three most conspicuous alteration types, referred to as oxidation, albitization and quartz dissolution, has been provided by Petersson et al. (2012). Considering the additional data acquired at Forsmark after 2010 and discussions with other modelling disciplines, it was deemed necessary to focus on the following aspects in the presentation and evaluation of data:

- Clarifications regarding nomenclature.
- Guidelines for mapping of alteration intensity.
- Description of subordinately occurring alteration types.
- Comparison between borehole data acquired after 2010 and during the previous site investigations (SDM-Site and SDM-PSU).
- Quantitative estimates of the proportions of alterations in different rock domains (presented in Section 6.4).
- The relative change in quartz content for rock types affected by oxidation, albitization and sericitization.

The nomenclature of the rock alterations in this report may differ from the established nomenclature in some earlier SKB-reports; possibly due to perceived shortcomings of the nomenclature, which not always reflect the actual changes an alteration has given rise to. To avoid future misunderstandings, Table 4-4 provides a summary that includes the current nomenclature, SKB code, basis for identification, alternative names and a brief description. The compilation is based on information presented by Möller et al. (2003), Petersson et al. (2005, 2012), Stephens et al. (2007) and Sandström et al. (2010).

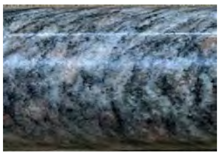
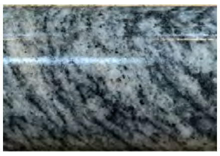
Table 4-4. Naming, SKB code, primary basis for identification and a brief description of the three most conspicuous alteration types at Forsmark, referred to as oxidation, albitization and quartz dissolution.

Alteration type	SKB code	Total length* [m]	Primary basis for identification	Alternative names
Oxidation	706	3535	Red-staining	Hematite dissemination, red-staining
Oxidation commonly occurs as a wall-rock alteration along fractures and is characterized by the development of a reddish colour due to hematite dissemination within feldspar grains, along grain boundaries and in microfractures, rather than by a significant oxidation (Sandström et al. 2010). Associated mineralogical changes include mainly saussuritization of plagioclase, chloritization of biotite and conversion of magnetite into martite.				
Albitization	104	1674	Bleaching or whitening	Epitonalite, whitened alteration
Albitization occurs extensively, but it is pronounced along contacts to amphibolite. The primary protoliths are metamorphosed, medium-grained or aplitic granites (101057 and 101058). The altered rocks show a marked decrease in K-feldspar and an increase in quartz relative to the unaltered equivalents, resulting in an epitonalitic composition. Plagioclase is metamorphic in character and generally richer in albite than in the unaltered rocks. It is inferred that albitization was triggered by the input of basic or intermediate melts into the crust during igneous activity close to the peak of regional metamorphism at 1.87–1.86 Ga (Petersson et al. 2012). Thus, the albitization lacks connection to brittle deformation.				
Quartz dissolution	700	151	Vugs replacing quartz giving the rock a sponge-like appearance	Vuggy rock, episyenite, desilicification
Quartz dissolution, which resulted in the formation of episyenite, are mainly located along fracture zones. The quartz dissolution process was also accompanied by pervasive albitization. Most of the vugs left after the removal of quartz are, to a variable extent, refilled by hydrothermal assemblages, including quartz, albite, K-feldspar, hematite, chlorite and calcite.				

* Total length refers to the total borehole length affected by the alteration type.

Most alteration types distinguished at Forsmark are characterised by microscopic or sub-microscopic alteration assemblages, often in combination with chemical changes of feldspars, which to the unaided eye is only revealed by colour changes. Intensity estimates for some alteration types, such as oxidation and albitization, relies hence heavily on colour. Such an approach is of course rather crude, as the colour intensity not just reflect the alteration degree but also depends on the actual content of the affected mineral phase (e.g. feldspar). Another issue is the ability to capture the various aspects of an alteration type. Oxidation for example, is without exception accompanied by chloritization of biotite and sericitization/saussuritization of plagioclase. However, the degree of chloritization and/or sericitization/saussuritization do not necessarily follow the hematite dissemination of feldspars, which gives the reddish discolouration. Despite the apparent weakness of the current intensity approach, it is considered to provide a general measure of the alteration intensity. To facilitate evaluation of intensity data for downstream users Table 4-5 present guidelines for intensity mapping of oxidation, albitization and quartz dissolution.

Table 4-5. Guidelines for intensity mapping of the three most conspicuous alteration types at Forsmark – oxidation, albitization and quartz dissolution.

Intensity	Oxidation	Albitization	Quartz dissolution
Faint		Faint bleaching with preserved texture and structure 	–*
Weak		Distinct bleaching with slightly blurred grain boundaries – texture affected 	–*
Medium		Intense bleaching with obliteration of the original texture 	Incomplete dissolution of quartz or partly refilled vugs 
Strong		Whitening with a distinct decrease of mafic minerals – protolith texture and structure are obliterated 	Total dissolution – no quartz observed and significant porosity 

* Faint and weak intensities are currently not applicable for quartz dissolution. However, approximately half of the total borehole length registered as quartz dissolution in the mappings completed until today (SKBdata_22_065) has been assigned faint to weak intensities. With the current guidelines, all these intervals would be assigned a medium intensity.

In addition to the three alteration types described above there are a number of subordinate alterations in the area, most of them with a preference to certain deformation zones or rock types. A compilation of the general occurrence and character of these alteration types are given in Table 4-6.

Table 4-6. General occurrence and character of subordinate alteration types identified along cored boreholes at Forsmark. Calculated lengths and proportions are based on delivery SKBdata_22_065.

Type (SKB-code)	Total length* [m]	Occurrence and character
Argillization (72)	66	Dissemination of clay minerals. About 80 % occurs along intersections with modelled deformation zones.
Carbonatization (712)	6	Calcite dissemination along intervals of ≤1 m in length. About 80 % occurs along intersections with modelled deformation zones.
Chloritization (701)	143	Typically affecting mafic rocks and about 65 % occurs along sections with amphibolites and metamorphic diorite, quartz diroite and gabbro. About 55 % occurs along intersections with modelled deformation zones.
Epidotization (702)	128	Locally associated with fracture networks sealed by epidote or with other alterations (e.g. chloritization and silicification). Includes subordinate intervals of inferred prehnitization. About 75 % occurs along intersections with modelled deformation zones, mainly in KFM11A and KFM12A along inferred intersections with with the Singö deformation belt (ZFMWNW0001, ZFMWNW0813 and ZFMWNW3259) and the Forsmark deformation zone (ZFMWNW0004).
Laumontization (721)	49	Typically associated with fracture networks sealed by laumontite. About 80 % occurs along intersections with modelled deformation zones.
Saussuritization (713)	33	Microscopic assemblage of epidote, sericite and albite formed by alteration of plagioclase. Gives the affected rock a dark greenish tint. A majority (> 19 m) is recognized along the inferred intersection between KFM12A and the Forsmark deformation zone (ZFMWNW0004). Identification is assigned a low degree of confidence.
Sericitization (714)	387	Generally muscovitization developed during low-grade metamorphism; lacks direct connection to brittle deformation, even if approximately 30 % of the length interval occurs in KFM11A at the inferred intersection with the Singö deformation belt (ZFMWNW0001, ZFMWNW0813 and ZFMWNW3259). Almost 60 % occurs in the cored boreholes in proximity to the SFR facility, where it primarily has affected metamorphic granite–granodiorite (101057).
Silicification (71)	28	The vast majority (> 21 m) occurs at 314–337 m length along KFM12A, typically in intimate association with epidotization. The interval coincides with the inferred intersection of the Forsmark deformation zone (ZFMWNW0004).
Steatitization (716)	12	Virtually all (> 10 m) are talc-rich intervals at 510–550 m length along KFM11A – the inferred intersection with the Singö deformation zone (ZFMWNW0001).

* Total length refers to the total borehole length affected by the alteration type.

To assess whether the borehole data acquired after 2010 on rock alteration are in accordance with the conceptual judgements of SDM-Site and SDM-PSU, a comparison has been performed based on spatial proximity. Considering the locations of the cored boreholes drilled after 2010, it seemed appropriate to limit the comparison to the following three rock domains, RFM029, RFR01 and RFR02, which also were the focus of the previous site investigations. Since several alteration types are strongly related to brittle deformation, the comparison has been further extended to a separation in alteration inside and outside modelled deformation zones. A summary of selected aspects of this comparison is visualised in Figure 4-5. In general, there is a consistency between data acquired after 2010 (denoted “new” in Figure 4-5) and the previous site investigations. However, there are a number of features in the figure that deserve further attention:

- The occurrence of albitization, sericitization and chloritization have no apparent connection with deformation zones.
- The occurrence of sericitization is virtually limited to the RFR domains, enclosing the SFR facility. This is also in accordance with modal analysis of thin sections from KFR121 within RFR02, which yielded muscovite contents of 2–3.5 vol.% (Petersson and Eliasson 2023, 2024), whereas samples from RFM029 contain only traces (< 1 vol.%) of muscovite/sericite Petersson et al. (2004a, 2005).
- Oxidation is consistently more abundant within than outside deformation zones. An exception is the borehole data for RFR01 acquired after 2010, where the bedrock within zones lack oxidation. An explanation is that the data are limited to a single intersection between KFR118 and ZFMENE3115 in combination with the typical non-pervasive character of alterations along deformation zones (cf. Stephens et al. 2007).

- In RFM029 and RFR02, albitization is slightly more abundant in borehole data acquired after 2010 than in data from previous site investigations. About 60 % of the albitised sections along the new boreholes within RFM029 occur in one borehole, KFM27, which is situated close to the boundary of the marginal domain RFM032. Occurrences of syn-metamorphic albitization in the northwesternmost part of RM029, close to reactor 1 and 2 of the nuclear power plant and RFM032, was previously noted in older boreholes by Stephens et al. (2007, pp. A14-31). Since the main criterion for separation between RFM029 and RFM032 is the intensity of ductile deformation, and not the presence of albitization, model changes are not considered necessary. The albitization along the new boreholes within RFR02 is mainly found along KFR121, where most albitization is of faint intensity and typically occurs adjacent to amphibolite. Thus, neither does this call for conceptual changes.

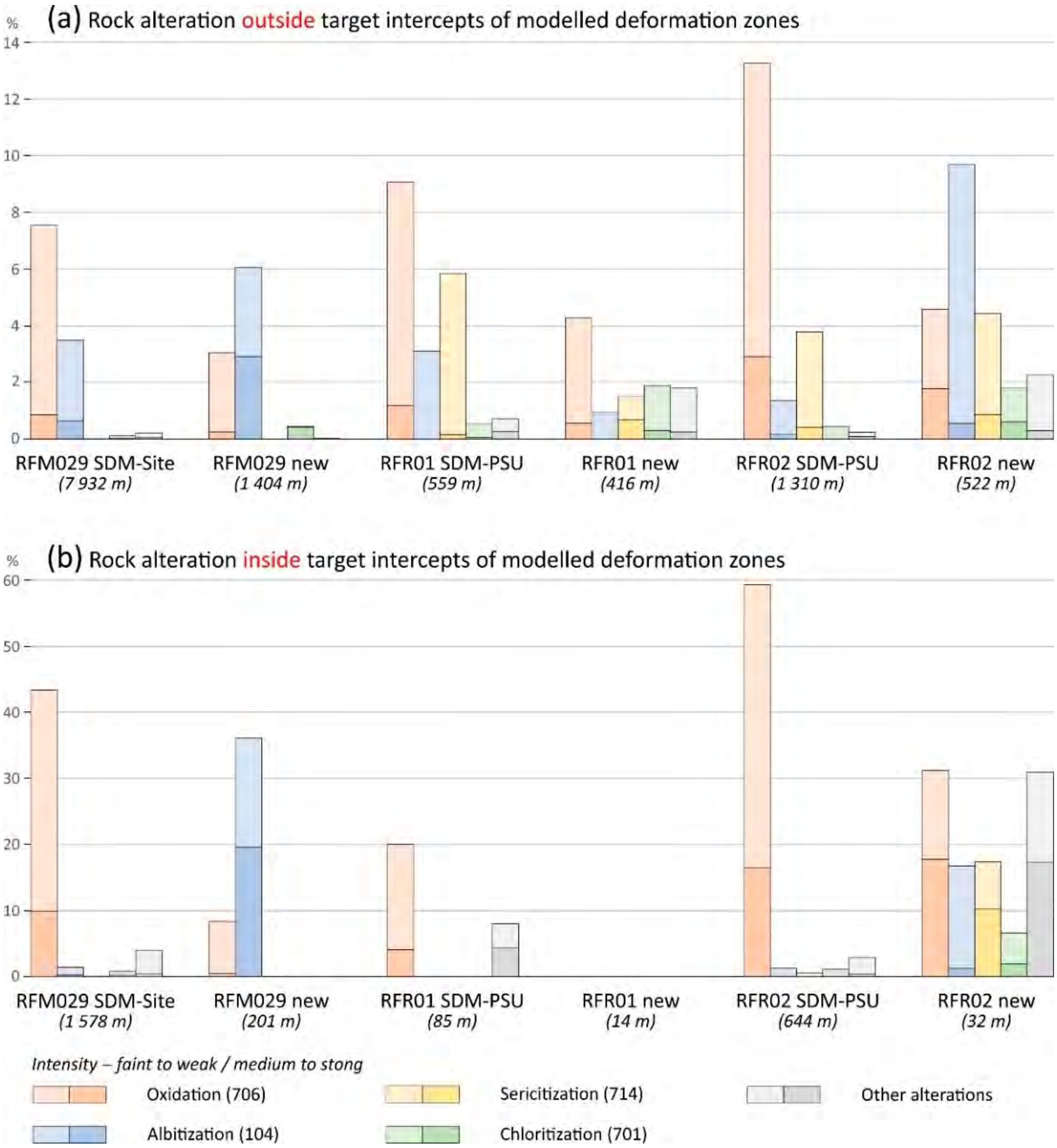


Figure 4-5. *Histograms illustrating the quantitative estimates of rock alteration (a) outside and (b) inside target intercepts of modelled deformation zones for the three rock domains RFM029 RFR01 and RFR02 by a separation of borehole data acquired after 2010 (new) and the previous site investigations (SDM-Site and SDM-PSU). "Other alterations" include argillization, carbonatization, epidotization, laumontization, quartz dissolution, saussuritization, silicification and steatitization. The compilation is based on geological data from cored borehole sections (Sicada delivery SKBdata_22_065). Total borehole lengths outside and inside modelled deformation zones of each rock domain, including both altered and unaltered sections are presented in brackets. Note the scale difference between the histograms outside and inside target intercepts of modelled deformation zones. Note also that different alteration types can overlap and the total proportion of altered rock is hence lower than the sum of individual alteration types.*

An issue of special interest, because of its impact on the bedrock thermal properties, is how the alteration effects the quartz content, since this mineral shows a thermal conductivity two- to three-times higher than that in other, common rock-forming minerals (Horai, 1971). The subject is mainly relevant when it comes to the more abundant alteration types that are not limited to deformation zones: oxidation, albitization and sericitization. However, an assessment of this, based on modal mineral analyses, suffers from two major difficulties, the lack of data for the alteration types of interest and the inhomogeneous quartz content of the unaffected metamorphic granite-granodiorite (101057 and 101058), as discussed in Section 4.2.1. A compilation of available modal data for rock samples affected by oxidation and albitization are summarised in Table 4-7. There are currently no data for serizitised samples specifically, but four of the oxidised samples from KFR121 show an incipient formation of muscovite (Petersson and Eliasson 2023, 2024), that is too insignificant to allow detection during the geological mapping of the borehole.

The quartz content of the oxidized samples does not differ significantly from the contents of the unaltered equivalents (i.e., metamorphic granite to granodiorite, 101057), with a mean ± standard deviation of 36.3 ± 5.8 vol.% (see Table 4-3). However, the spread in the sample set is considerable. The apparent stability of quartz during oxidation is supported by various petrographic studies of granites in southern Sweden (Eliasson 1993) and metamorphic granite-granodiorite at Forsmark (Sandström and Tullborg 2006; Petersson and Eliasson 2023, 2024). The studies further show that the content remains unaffected regardless of the oxidation intensity.

The mineralogical changes attributed to the syn-metamorphic albitization at Forsmark has been analysed by Petersson et al. (2005, 2012). Their conclusion is that the albitization was accompanied by a slight silicification. The enrichment of quartz is reflected in the high but variable modal quartz content, with an average of 40 vol.% in the albitized samples and 35 vol.% in the unaltered equivalents, in combination with a slightly increased whole-rock silica concentration, where the average SiO_2 content in the albitized samples exceeds that of the unaltered, metamorphosed granitic rocks by 3.1 wt.% (cf. Petersson et al. 2012).

Table 4-7. Modal content of quartz in metamorphic granite to granodiorite (101057 and 101058) affected by oxidation and albitization of medium to strong intensity.

Alteration	No of samples	Min–max [vol.%]	Mean ± std [vol.%]	References
Oxidation	11	19.8–41.7	35.5 ± 6.3	Sandström and Tullborg (2006), Petersson and Eliasson (2023, 2024)
Albitization	12	34.4–50.0	40.0 ± 5.7	Stephens et al. (2003, 2005), Petersson et al. (2005)

4.2.3 Ductile deformation

The Forsmark site has been affected by varying degrees of penetrative ductile deformation, followed by complex folding of the bedrock on different scales. This ductile strain developed at mid-crustal depths at amphibolite-facies metamorphic conditions. Later ductile strain occurred predominantly along more discrete deformation zones in the high-strain belts around the tectonic lenses (Stephens et al. 2007).

Thorough analysis and evaluation of structural data acquired during the preceding site investigations, including the bedrock mapping at the ground surface, the geological mapping of boreholes and laboratory measurements of the anisotropy of magnetic susceptibility (AMS), have previously been presented by SKB (2005), Stephens et al. (2007) and Curtis et al. (2011). Additional data archived at Forsmark after 2010 are largely restricted to tectonic foliation measured during the borehole mapping but include infrequent measurements of linear grain-shape fabric, veining and minor ductile and ductile-brittle shear zones. The only additional structural data from the ground surface are measurements of tectonic foliation in the trenches AFM001393 and AFM001394 (cf. Section 3.2).

These new data have been analysed in relation to the structural concepts of the SDM-Site and the SDM-PSU, with a major sheath fold present inside the tectonic lens and intense tectonic banding along its flanks (cf. Section 6.1). Conceptually, the bedrock with cored boreholes KFM13–KFM27 are situated close to the hinge of the major synform, which at the current level of erosion plunges to the southeast and SSE. Integrated surface and borehole data for ductile structures from the local model volume indicate a fold axis that plunges 170°/55° (Stephens et al. 2007). This is also consistent with the girdle distribution pattern established on a stereographic projection from orientations of rock contacts to amphibolites measured in cored boreholes (158°/43°); a relationship that signify that intrusion of the amphibolite dyke-like bodies occurred prior to the folding.

A stereographic presentation of the orientation data for ductile planar structures (primarily tectonic foliation) as well as contacts to amphibolites from the 15 boreholes KFM13–KFM27 display a similar, but less pronounced, girdle distribution pattern with a pole that plunges 173°/34° (Figure 4-6a). This is also supported by measurements of tectonic foliation in the two trenches and in excellent agreement with the orientation of the modelled major synform inside the tectonic lens. Thus, no model revision is considered necessary.

The corresponding structural concept proposed by Curtis et al. (2011) for the bedrock in proximity to the SFR facility is that the intense ductile structures generally follow the regional trend of the WNW–ESE striking high-strain belt, combined with major folding. Although confirmed by a crude, but yet distinguishable girdle pattern, with a best-fit pole at 110°/24°, the data scatter is considerable. The latter is to some extent inferred to rheological differences of an often very heterogeneous lithology. Another contributory cause might be that a fine-scale folding imparts variability in the planar fabric (cf. Curtis et al. 2011).

A stereographic presentation of the orientation data for ductile planar structures (primarily tectonic foliation) as well as contacts to amphibolites from the five boreholes KFR117–KFR121 yield a distribution along a broad girdle with an orientation of the best-fit pole at 107°/17° (Figure 4-6b). The data distribution strongly resembles the pattern that emerged from the site investigation data, which hence provides further support for the structural concept inferred by Curtis et al. (2011).

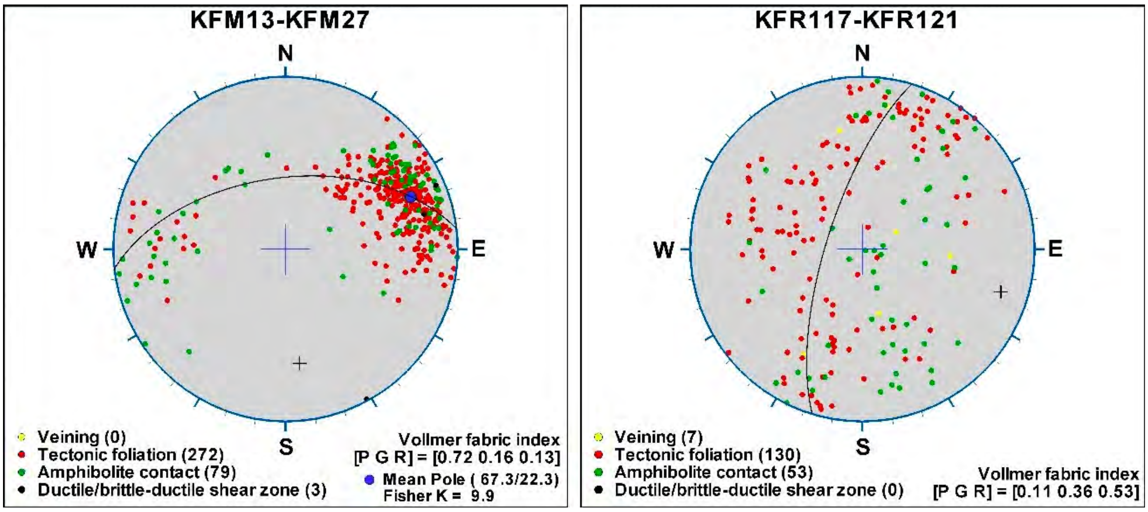


Figure 4-6. *Orientation of planar ductile structures and amphibolite contacts in cored boreholes completed after 2010 at Forsmark. KFM13–KFM27 situated in the north-western central part of the tectonic lens, and KFR117–KFR121 situated in close proximity to the SFR facility. An estimation of the degree of point, girdle or random distribution pattern (Vollmer fabric index, PGR) in the raw data is provided for each data set. The pole to each planar structure is plotted on the lower hemisphere of an equal-area stereographic projection. No Terzaghi correction has been applied. Only one contact (the upper) for each amphibolite occurrence has been included in the plots.*

4.2.4 Brittle deformation and fracture statistics for cored boreholes

Fracture orientation

Presentation of fracture orientation data in the modelling reports of SDM-Site and SDM-PSU (Stephens et al. 2007; Curtis et al. 2011), has consistently been based on a distinction between fractures outside and inside deformation zones. To facilitate comparison, this approach has also been adopted in the current analysis, by separation of fractures along possible deformation zones and target intercepts of modelled deformation zones (see Section 5.3.4) from fractures outside the zones. The fracture orientation along each modelled deformation zone, where borehole intercepts are available, is presented in Appendix 7. The assessment of fracture data outside zones follows generally the spatial considerations applied to other geological properties in Section 4.2, with a restriction to the rock domains RFM029, RFR01 and RFR02. However, since most new fracture data for RFM029 are derived from rather shallow boreholes (KFM13–KFM23 and KFM25–KFM27), the orientation analysis has been further refined by a distinction between fractures within fracture domains FFM01 and FFM02.

Available information on brittle deformation for cored boreholes include the following data sets:

- Fracture (Sicada table *p_fract_core* – division into open, partly open and sealed based on aperture; for the criteria see Figure A1-2 in Hermanson and Petersson 2022).
- Crush (Sicada table *p_fract_crush* – predominant fracture orientations provided by Strike3/Dip3 and Strike4/Dip4).
- Sealed network (Sicada table *p_fract_sealed_nw* – predominant fracture orientations provided by Strike3/Dip3 and Strike4/Dip4).
- Fault rocks, including breccia, cataclasite and brittle-ductile shear zone (Sicada table *p_fault_rock* for KFR117–KFR121 and *p_rock_struct_feat* for all other boreholes. Predominant structural orientations for *p_fault_rock* is provided by Strike3/Dip3 and Strike4/Dip4).

The orientation of brittle structures recorded in cored boreholes completed after 2010 and during the site investigations is presented as contoured pole data in a number of stereograms in Figure 4-7 through to Figure 4-10. Since the uncertainty in orientation is significantly higher for fractures not visible in the BIPS and OPTV imagery, such fractures have been excluded from the analysis.

A similar comparison between fracture orientation data from the cored boreholes KFM13–KFM24 completed during the preparatory investigations and the cored boreholes KFM01A–KFM10A from the site investigations that preceded SDM-Site has previously been presented by Follin (2019), with the purpose to distinguish possible anomalies in the rock mass of the planned repository accesses. The data sets of the current analysis differ from this previous comparison by the inclusion of both additional boreholes (KFM25–KFM27) and a broader spectrum of brittle structures.

In general, the fracture orientation data acquired outside deformation zones along the cored boreholes completed after 2010 and during the site investigations show similar patterns both in FFM02 (Figure 4-7) and FFM01 (Figure 4-8), with two dominant sets: a vertical to steeply dipping set that strike approximately NE and a subhorizontal set (dips < 20°). The relative concentration of open (and partly open) fractures is significantly higher in the subhorizontal set, whereas the NE-striking set is dominated by sealed fractures. A noticeable difference between the data acquired after 2010 and during the site investigations is the occurrence of vertical to steeply dipping fractures that strike NW to NNW (Figure 4-7 and Figure 4-8). These fractures are predominantly sealed, and clear concentrations of the set is largely restricted to the older boreholes, completed prior to 2010. A viable explanation for the difference is the bias in the borehole geometry; the boreholes completed after 2010 are mainly shallow (< 100 m) with steep plunges (cf. Appendix 1), whereas several of the more extensive, older boreholes reach deeper in the rock mass and have favourable directions for intersections with fractures of the NW- to NNW-striking set (e.g. KFM06C, KFM07A, KFM08C and KFM09A). The orientation patterns for crushes and sealed networks resemble the predominant intensities for open and sealed fractures, respectively, with subhorizontal orientations for crushes and variable, but mostly subhorizontal and NE-striking orientations, for sealed networks (Figure 4-7 and Figure 4-8). A majority of the tectonic breccias and brittle-ductile shear zones in FFM02 and FFM01 are vertical to steeply dipping with strikes to NE.

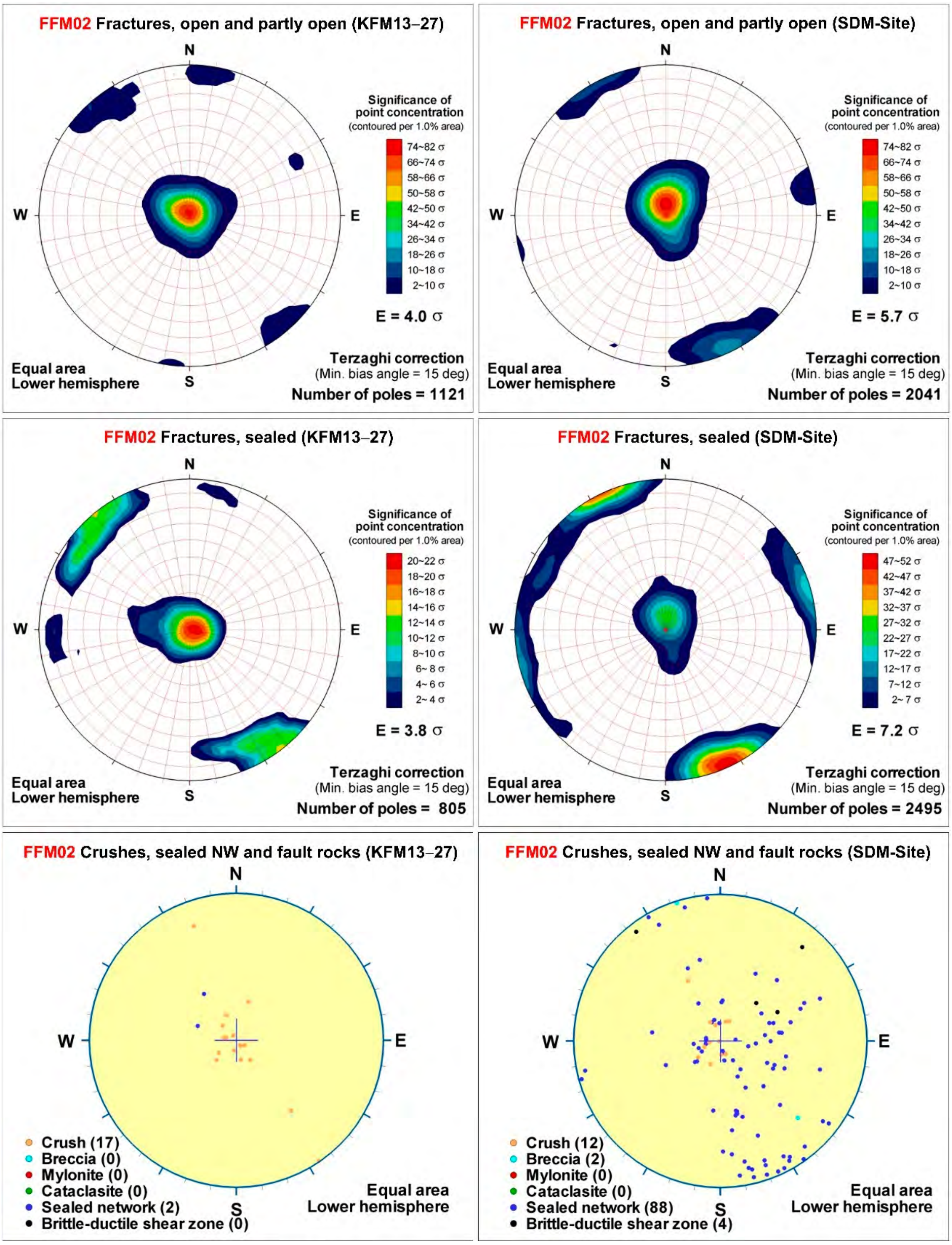


Figure 4-7. *Orientation of brittle structures (individual fractures, fractures within crushes and sealed networks, as well as fault rocks) outside deformation zones in fracture domain FFM02 by a separation of borehole data acquired after 2010 (new) and the previous site investigations (SDM-Site). Plots for individual fractures utilize a lower hemisphere, equal area projection, with a Terzaghi correction of the Kamb contouring. Poles for crushes and sealed networks are calculated as means of Strike3/Dip3 and Strike4/Dip4.*

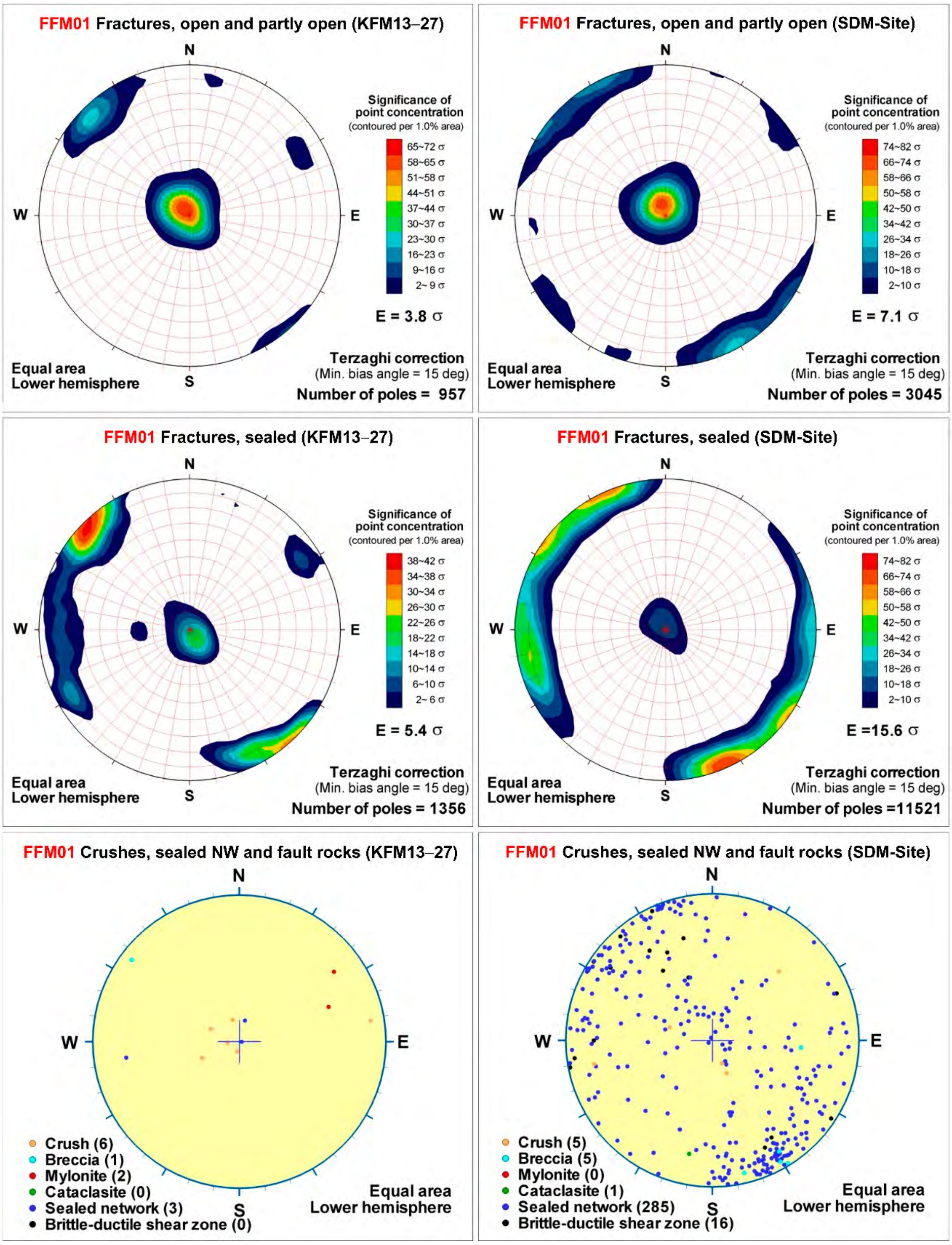


Figure 4-8. *Orientation of brittle structures (individual fractures, fractures within crushes and sealed networks, as well as fault rocks) outside deformation zones in fracture domain FFM01 by a separation of borehole data acquired after 2010 (new) and the previous site investigations (SDM-Site). Plots for individual fractures utilize a lower hemisphere, equal area projection, with a Terzaghi correction of the Kamb contouring. Poles for crushes and sealed networks are calculated as means of Strike3/Dip3 and Strike4/Dip4.*

A comparison between fracture orientation data acquired from the SFR boreholes KFR117–KFR121 and boreholes completed before SDM-PSU shows virtually identical patterns for the rock domains RFR01 and RFR02 outside deformation zones (Figure 4-9 and Figure 4-10). Open fractures are predominantly subhorizontal (dips < 20°), while sealed fractures are distributed among two vertically to steeply dipping orientation sets that strike NW to NNW and NE, where the latter is more clearly defined in data from the older boreholes. There is also a subordinate, moderately dipping orientation set with an E–W strike, which is populated by both sealed and open fractures.

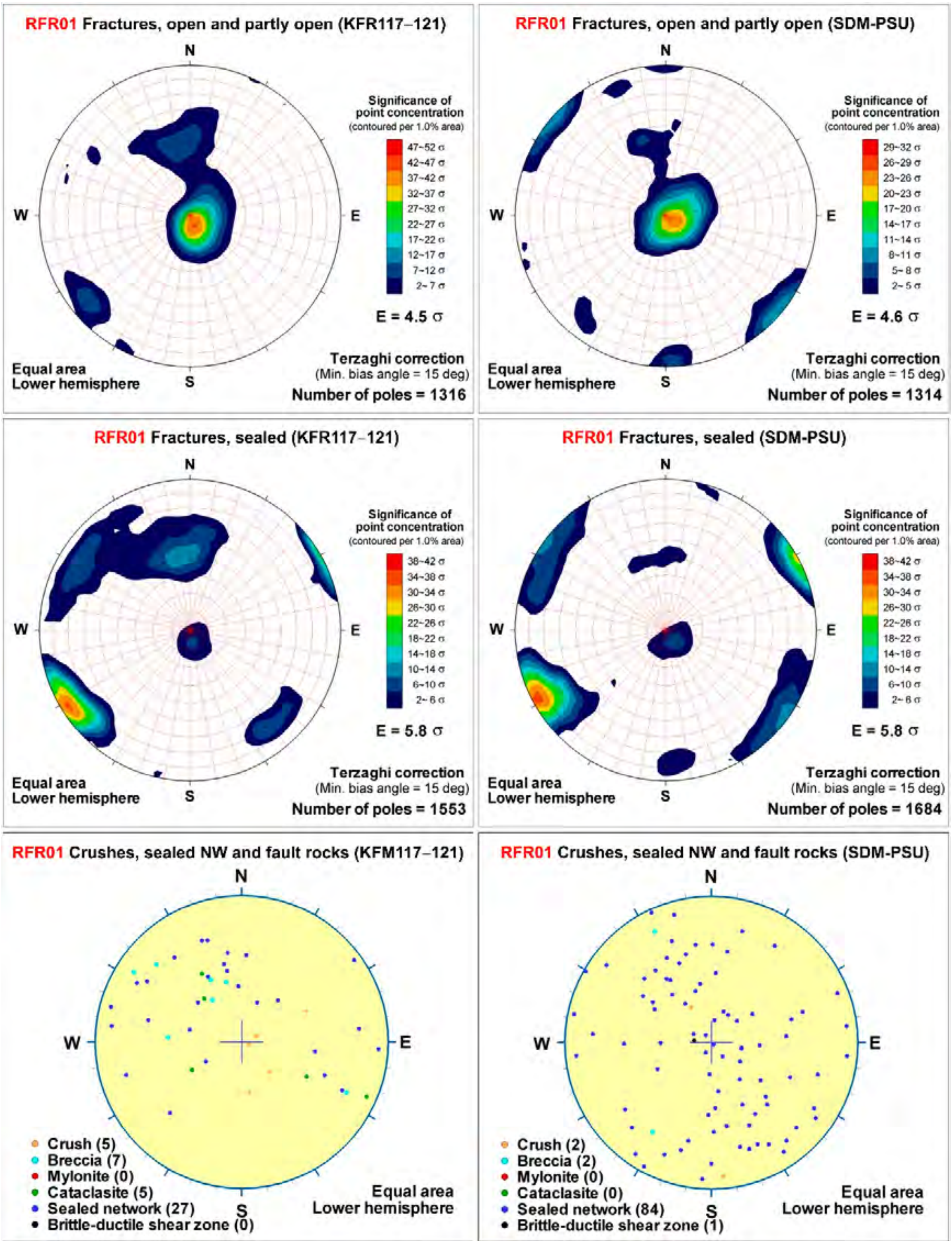


Figure 4-9. *Orientation of brittle structures (individual fractures, fractures within crushes and sealed networks, as well as fault rocks) outside deformation zones in rock domain RFR01 by a separation of borehole data acquired after 2010 (new) and the previous site investigations (SDM-PSU). Plots for individual fractures utilize a lower hemisphere, equal area projection, with a Terzaghi correction of the Kamb contouring. Poles for crushes, sealed networks, breccias and cataclasites are calculated as means of Strike3/Dip3 and Strike4/Dip4.*

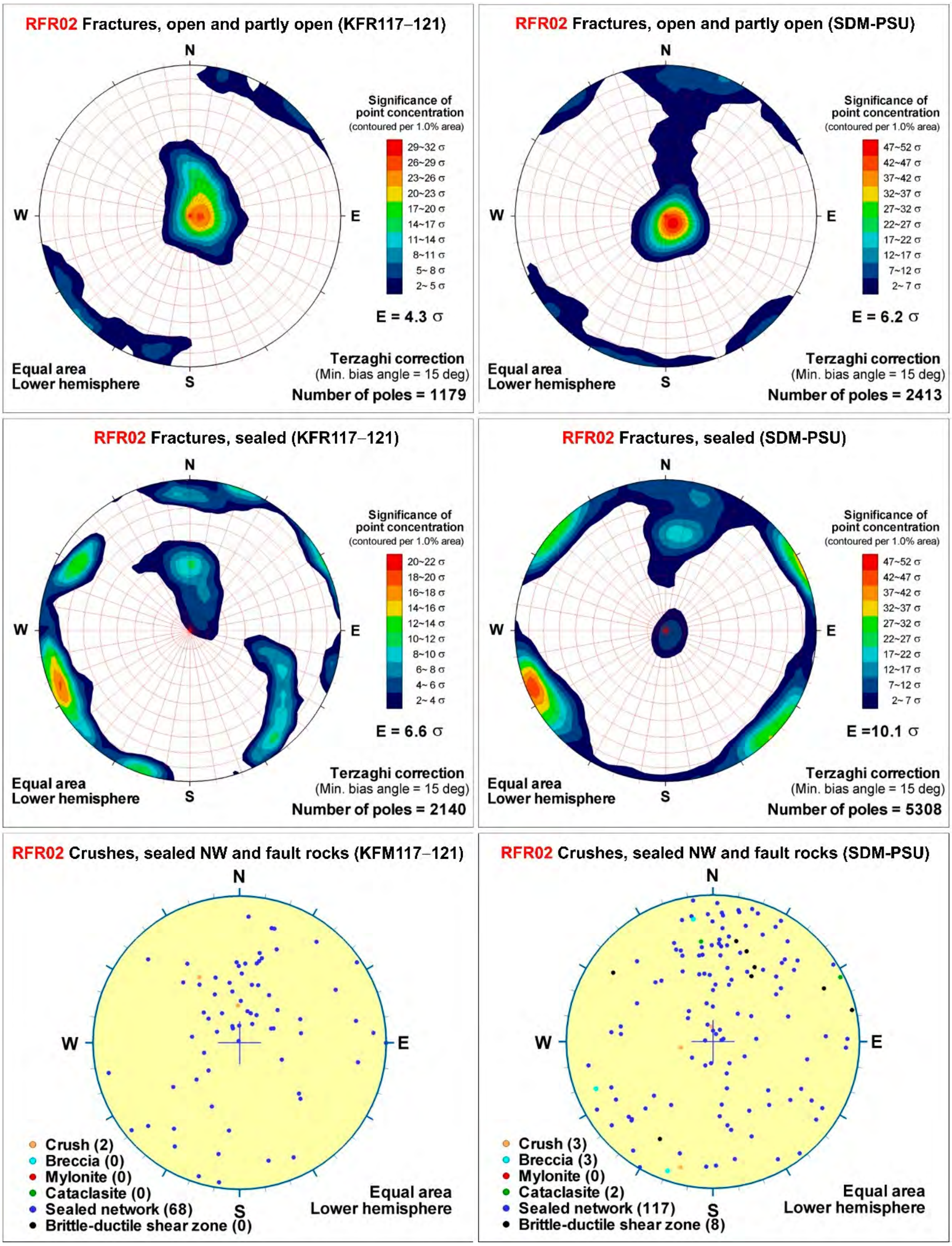


Figure 4-10. *Orientation of brittle structures (individual fractures, fractures within crushes and sealed networks, as well as fault rocks) outside deformation zones in rock domain RFR02 by a separation of borehole data acquired after 2010 (new) and the previous site investigations (SDM-PSU). Plots for individual fractures utilize a lower hemisphere, equal area projection, with a Terzaghi correction of the Kamb contouring. Poles for crushes and sealed networks are calculated as means of Strike3/Dip3 and Strike4/Dip4.*

The orientations of fractures inside modelled deformation zones (presented in Appendix 7) are strongly reminiscent of the orientation of fractures outside possible deformation zones. As a rule, the predominant fracture orientation set inside a zone is approximately coincident with the overall orientation of the zone. However, a characteristic feature is the frequent occurrence of additional, subordinate sets along many of the deformation zones, with a noteworthy proportion of gently dipping fractures. It is inferred that the different sets of fractures, including both steeply and gently dipping fractures, are genetically related and formed close in time during the geological history (cf. Stephens et al. 2007).

Fracture frequency (intensity)

A key component of the geological modelling work is the variability in fracture frequency (referred to as intensity or P_{10}). Table 4-8 presents an overview of the fracture data from the cored boreholes completed in Forsmark after 2010. The frequencies of open fractures (single open and partly open fractures) and sealed fractures are presented as P_{10} based on (1) all registered fractures, (2) fractures visible in the borehole image, and (3) fractures visible in the borehole image with Terzaghi corrections. In addition to individual fractures, this table includes data for highly fractured borehole sections, including the percentage of crushes, sealed fracture networks and fault rocks.

More than 80 % of the fractures are generally visible in the borehole image and in most boreholes more than 90 %. Terzaghi correction increases the frequencies for open fractures by approximately 50–250 % and sealed fractures by 35–150 %. The increase is least in boreholes with inclinations of about −52 to −65°, demonstrating that vertical to steeply dipping fractures are highly underestimated in the more steeply inclined boreholes.

The Terzaghi corrected frequency of open fractures for the shallow cored boreholes within RFM029 (KFM13–KFM23 and KFM25–KFM27) ranges between 2.3 and 9.6 fractures per metre. The deep borehole KFM24, on the other hand, exhibits a considerably lower frequency at 1.4 fractures per metre, which is comparable with the frequencies for several of the deep boreholes from the site investigations (see Table 3-11 of Stephens et al. 2007, but note that they are uncorrected). The observed borehole distribution of open fractures is inferred to reflect the influence of the near-surface fracture domain FFM02.

The SFR boreholes KFR117–KFR121 show similar Terzaghi corrected frequencies, ranging between 4.4 and 9.1 open fractures per metre. By contrast, these boreholes have significantly higher frequencies of partly open fractures, sealed fractures (both individual fractures and networks), and fault rocks (mainly breccia) than the boreholes inside the tectonic lens. Thus, the proportion of open to sealed fractures is generally lower in the SFR boreholes compared with the boreholes within the lens.

The intersection of deformation zones significantly affects the fracture intensity encountered along a given borehole. To accurately characterize background fracturing outside the deformation zones, it is necessary to remove intervals of possible deformation zones from the fracture intensity statistics. Table 4-9 presents revised frequencies after the removal of fractures within these intervals. Although the removal consistently yields lower intensities of open fractures along the boreholes in question, the decreases are rather limited, with a maximum drop of 25 % and in some boreholes small (< 5 %) increases. Most significantly, the occurrence of sealed fracture networks and breccias (fault rock) decreases with the removal of possible deformation zones. This change can be attributed to the fact that vertical to steeply dipping deformation zones at Forsmark are defined by elevated intensities of especially sealed fractures and sealed fracture networks.

Table 4-8. Frequency statistics of brittle structures in cored boreholes completed in Forsmark after 2010. Numbers are based on delivery SKBdata_22_065.

Cored boreholes	P_{10} – Open + partly open fractures			P_{10} – Sealed fractures			Fault rock [%]	Crush [%]	Sealed NW [%]
	All fractures	Visible in BIPS	Visible in BIPS, Terzaghi	All fractures	Visible in BIPS	Visible in BIPS, Terzaghi			
KFM13*	1.8	1.5	2.3	1.9	1.5	2.1	0.05	0.19	0.81
KFM14	1.7	1.5	4.7	0.8	0.4	1.1	0.00	0.00	0.00
KFM15*	2.4	2.0	6.1	2.9	2.3	4.5	0.00	0.84	0.00
KFM16	3.0	2.7	4.6	2.6	2.1	3.0	0.00	0.00	0.63
KFM17	2.6	2.1	6.6	3.5	3.3	7.1	0.00	0.23	0.74
KFM18	2.0	1.7	4.5	1.5	1.2	2.4	0.00	0.38	0.00
KFM19*	2.8	2.4	4.0	3.8	3.2	4.4	0.05	0.02	2.75
KFM20*	3.2	2.7	7.2	2.9	2.7	4.5	0.00	0.68	3.14
KFM21*	3.7	3.1	7.6	3.4	2.6	5.4	0.01	0.39	0.69
KFM22	4.1	3.0	9.6	1.9	1.5	3.6	0.00	0.49	0.00
KFM23*	4.1	3.5	9.4	2.9	2.5	4.9	0.05	0.46	0.00
KFM24	0.6	0.6	1.4	1.0	0.9	1.7	0.03	0.00	0.00
KFM25	1.9	1.9	6.4	2.2	2.0	4.1	0.00	0.02	0.00
KFM26	2.2	2.2	7.7	3.3	3.2	7.1	0.00	0.29	0.40
KFM27*	4.4	4.3	12.4	5.7	5.6	11.3	0.00	0.76	3.75
KFR117	3.7	3.6	8.5	4.4	4.3	7.1	1.44	0.08	0.49
KFR118*	4.4	4.4	9.1	5.4	5.3	8.1	0.50	0.10	13.34
KFR119*	2.3	2.2	5.3	2.9	2.8	4.3	0.47	0.00	6.19
KFR120*	3.7	3.5	8.7	6.4	6.1	10.4	0.23	0.11	12.92
KFR121*	3.1	2.9	4.4	5.6	5.3	7.3	0.22	0.39	17.64

* Borehole that intersects possible deformation zones identified in the SHI.

Table 4-9. Frequency statistics of brittle structures outside deformation zones in cored boreholes completed in Forsmark after 2010. Numbers are based on delivery SKBdata_22_065 with removal of data from intervals of possible deformation zones (defined by Sicada table p_shi).

Cored boreholes	P_{10} – Open + partly open fractures			P_{10} – Sealed fractures			Fault rock [%]	Crush [%]	Sealed NW [%]
	All fractures	Visible in BIPS	Visible in BIPS, Terzaghi	All fractures	Visible in BIPS	Visible in BIPS, Terzaghi			
KFM13*	1.5	1.3	2.0	1.6	1.3	1.6	0.05	0.19	0.45
KFM14	1.7	1.5	4.7	0.8	0.4	1.1	0.00	0.00	0.00
KFM15*	2.1	1.6	5.1	2.4	2.0	3.6	0.00	0.54	0.00
KFM16	3.2	2.8	4.8	2.7	2.2	3.2	0.00	0.00	0.63
KFM17	2.6	2.1	6.6	3.5	3.3	7.1	0.00	0.23	0.74
KFM18	2.0	1.7	4.5	1.5	1.2	2.4	0.00	0.38	0.00
KFM19*	Entire borehole inside deformation zone ZFMENE1061A								
KFM20*	3.2	2.7	7.3	3.0	2.7	4.6	0.00	0.68	3.14
KFM21*	3.0	2.5	6.5	2.2	1.8	3.8	0.01	0.00	0.69
KFM22	4.1	3.0	9.6	1.9	1.5	3.6	0.00	0.49	0.00
KFM23*	3.4	2.9	8.1	2.1	1.9	3.4	0.05	0.04	0.00
KFM24	0.6	0.6	1.4	1.0	0.9	1.7	0.03	0.00	0.00
KFM25	1.9	1.9	6.4	2.2	2.0	4.1	0.00	0.02	0.00
KFM26	2.2	2.2	7.7	3.3	3.2	7.1	0.00	0.29	0.40
KFM27*	3.1	3.1	9.2	3.6	3.6	6.9	0.00	0.03	0.00
KFR117	3.7	3.6	8.5	4.4	4.3	7.1	1.44	0.08	0.49
KFR118*	4.3	4.3	9.5	5.5	5.4	8.5	0.17	0.10	6.65
KFR119*	2.2	2.1	5.3	2.6	2.6	4.0	0.04	0.00	3.58
KFR120*	3.6	3.4	8.9	5.1	4.8	9.2	0.09	0.11	7.28
KFR121*	2.3	2.2	3.4	6.1	5.7	7.7	0.00	0.00	6.24

* Borehole that intersects possible deformation zones identified in the SHI.

The variation relative to depth for different types of fractures recorded in cored boreholes completed after 2010 and during the site investigations is presented in Figure 4-11 and Figure 4-12, as average Terzaghi corrected fracture frequencies (intensities, $P_{10\ corrected}$) over 10 m elevation intervals. Only fractures recorded outside sections identified as deformation zones have been included in the analysis. It should also be noted that the plots exclude the contribution from crushes and sealed networks. Follin (2019) presented a similar analysis, based on a comparison between data from the cored boreholes KFM13–KFM24 completed during the preparatory investigations and the older boreholes KFM01A–KFM10A. However, the current analysis is based on slightly different data sets and include additional boreholes from both the planned access area (KFM25–KFM27) and the pier above SFR.

The analysis is further supported by moving-average and cumulative-frequency plots for each of the cored boreholes; plots for boreholes used in Forsmark model stage 2.2 and 2.3 are presented by Stephens et al. (2007, 2008b), whereas corresponding plots for the more recent boreholes KFM13 to KFM23 and KFM25 to KFM27 are found in Appendix 6 of the current report. Such plots are one of the tools used in the single-hole interpretation work, as an aid in the identification of possible deformation zones (see Section 4.1.1). It has also formed the basis for the establishment of the fracture domain concept at the site (cf. Olofsson et al. 2007).

Starting the assessment with the frequency data for older cored boreholes within FFM01 and FFM02 (i.e. boreholes that were used in the SDM-Site, Figure 4-11), the following principal features have been recognised:

- The Terzaghi corrected frequency of sealed fractures is largely constant down to an approximate elevation of −800 m, with a tendency of higher frequencies in the upper part of the bedrock. The frequency decreases radically below −800 m, partly due to the scarcity of boreholes reaching greater depths.
- An anomalously high Terzaghi corrected frequency of open and partly open fractures in the upper part of the bedrock relative to the lower part. The frequencies of open (including partly open) and sealed fractures are essentially the same in the upper part of the bedrock, with a strong dominance of sealed fractures in the lower part down to approximately −1 000 m elevation.
- In the northwestern part of the Forsmark lens, the boundary between bedrock with an anomalously high frequency of open and partly open fractures (upper part), and bedrock with a strong dominance of sealed fractures (lower part), does not occur at the same elevation in the boreholes. The boundary varies between −30 to −40 m (e.g. drill site 8) and ca −200 m elevation (e.g. drill site 1).

The Terzaghi corrected fracture frequency for borehole data acquired after 2010 (i.e. KFM13–KFM27) is more variable but the overall distribution resembles that of the previous boreholes within FFM01 and FFM02 (Figure 4-11), with an anomalously high frequency of especially open and partly open fractures in the uppermost 100 m of the bedrock. The data set is strongly influenced by the deficiency of deep boreholes; only KFM24, of the totally 15 boreholes, reaches below −100 m elevation, and none of the new boreholes provide data below −550 m elevation.

A similar comparison between the Terzaghi corrected frequency data acquired from the SFR boreholes KFR117–KFR121 and boreholes completed within RFR01 and RFR02 before SDM-PSU, shows a contrasting distribution, with constant high Terzaghi corrected frequencies for both open and sealed fractures in the upper 300 m of the bedrock (Figure 4-12). Anomalously high Terzaghi corrected frequencies of sealed fractures, reaching > 15 fractures per metre, occur at the following depth ranges in the two data sets:

- Approximately 85–165 m depth in the cored boreholes of SDM-PSU.
- Approximately 195–215 m depth in the cored boreholes KFR117–KFR121.

It should be noted that of the boreholes in the new data set, only KFR121 reaches below −171 m elevation, and the anomalously high frequency of sealed fractures can be attributed to an interval of felsic to intermediate metavolcanic rock (103076) that occurs at 252–274 m borehole length along the borehole. These fractures are predominantly steeply dipping that strike NW–SE (i.e. parallel with ductile structural trend in the SFR area). In contrast, the more extensive depth range of anomalously high frequency in the boreholes that preceded SDM-PSU can neither be correlated with a specific lithological feature nor a particular fracture orientation set.

There are several possible combined explanations for the contrasting distributions between the frequency data acquired from the SFR boreholes and the boreholes within the Forsmark lens (i.e. FFM01 and FFM02), primarily relating to the differences in lithology, the intensity of the ductile deformation and the past and present stress conditions. An example is the horizontal to subhorizontal fractures (i.e. sheet joints) that occur in the shallow parts of the bedrock. These structures do occur in the SFR volume but show conspicuous concentrations inside the lens (FFM02), where the formation conditions are inferred to be more optimal, with a more isotropic bedrock (i.e. higher degree of lithologic homogeneity and less intense ductile fabric) in combination with significantly higher differential rock stresses (cf. Glamheden et al. 2007; SKB 2013).

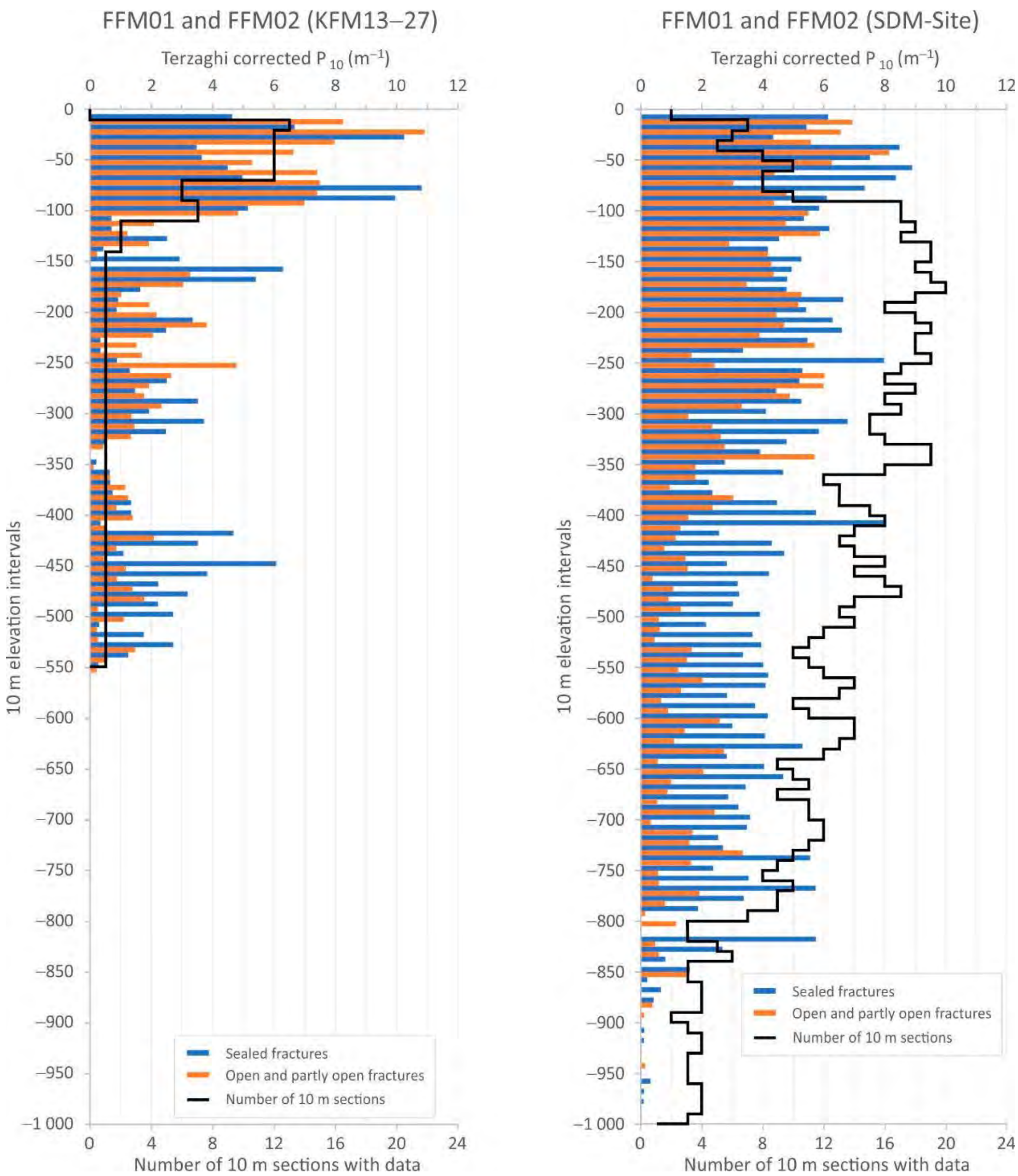


Figure 4-11. *Average Terzaghi corrected fracture frequencies ($P_{10\ corrected}$) of sealed and open (plus partly open) fractures over 10 m elevation intervals in fracture domain FFM01 and FFM02, outside borehole sections identified as deformation zones. The data excludes contribution from sealed networks and crushes. The uncertainty of fracture intensity increases towards depth and only one borehole completed after 2010 (KFM24) reaches deeper than −100 m elevation (see Appendices 1and 6).*

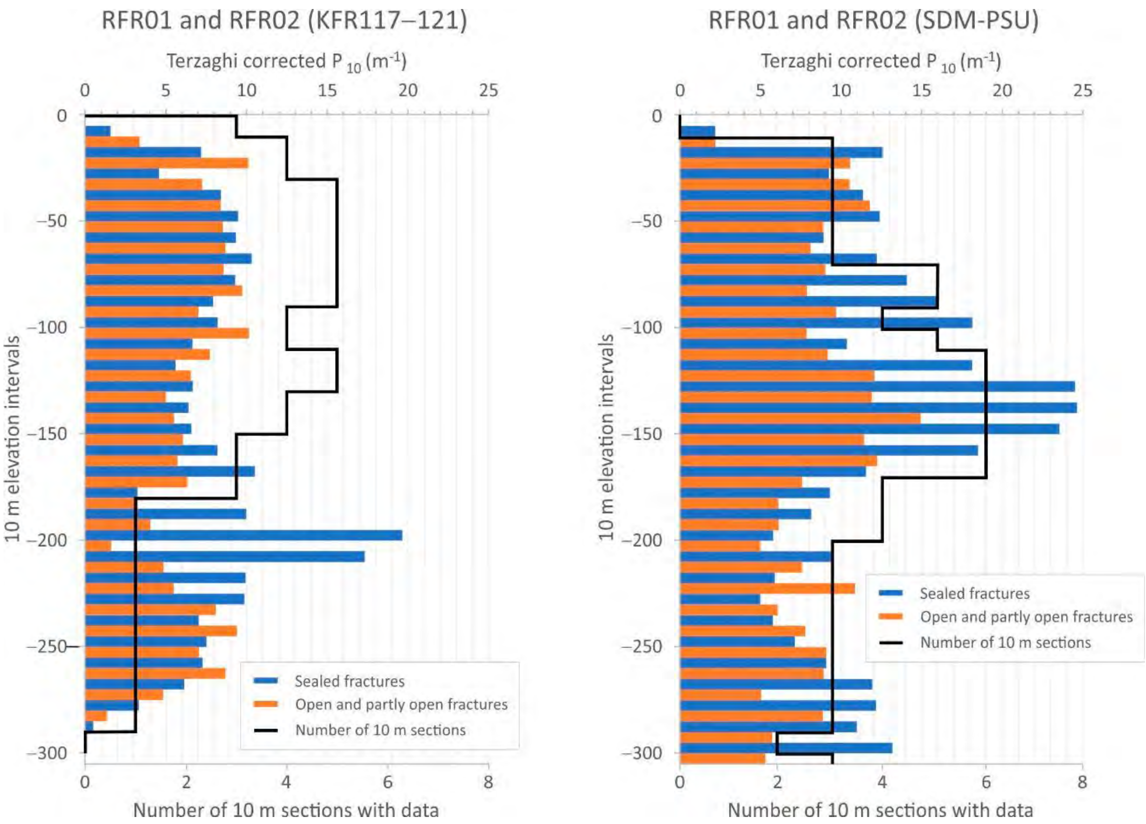


Figure 4-12. *Average Terzaghi corrected fracture frequencies ($P_{10\ corrected}$) of sealed and open (plus partly open) fractures over 10 m elevation intervals in the SFR rock domains RFR01 and RFR02, outside borehole sections identified as deformation zones. The data excludes contribution from sealed networks and crushes. The uncertainty of fracture intensity increases towards depth and only one borehole completed after 2010 (KFR121) reaches deeper than −171 m elevation (see Appendices 1and 6).*

Fracture mineralogy

Several detailed studies of mineral coatings and fillings in fractures were carried out during the site investigations that preceded SDM-Site. The primary basis for all these studies is drill cores acquired from within the tectonic lens; information from outcrops and excavations is sparse and of low confidence due to disturbance by surficial weathering and/or erosional processes (cf. SKB 2005). Initially, the focus involved mineral identification, verification of mapping results and the establishment of mineral paragenesis and relative age relationships. An overview that integrates the results of this work has been presented by Sandström et al. (2008). In addition, a number of complementary studies were carried out to shed light on the following aspects:

- Quantitative amount of different minerals along selected fractures (Eklund and Mattsson 2009; Löfgren and Sidborn 2010).
- Nature and origin of fractures lacking visible mineralisation, i.e. fractures mapped with no detectable mineral and/or classified as non-mineralised in Sicada (Claesson Liljedahl et al. 2011).
- Brittle tectono-thermal evolution in the Forsmark area, as recorded by $^{40}Ar/^{39}Ar$ geochronology, stable isotopes, rare earth elements and fluid inclusions of fracture minerals (Sandström and Tullborg 2009; Sandström et al. 2009).

Subsequent studies of fracture mineralogy within the investigation programme for the extension of SFR are more limited. With primary focus on borehole sections sampled for groundwater chemistry and redox potential (Eh) (Sandström and Tullborg 2011), identification of uranium phases present in the fractures (Sandström et al. 2011), the occurrence of iron hydroxide in bedrock fractures and the quantitative redox capacity provided by the fracture minerals (Sandström et al. 2014). Together with data from the geological borehole logging (summarised by Curtis et al. 2011), these studies strongly indicate that there are no major differences between the fracture mineralogy in the SFR area and the adjacent tectonic lens (Stephens et al. 2007; Sandström et al. 2008); an overview of the predominant fracture minerals in the two volumes is presented in Figure 4-13. Thus, the major events of fracture mineralisation that have been distinguished based on, for example, cross-cutting relations, stable isotopes and geochronology for fractures within the tectonic lens, are valid also for the SFR area. The current interpretation of fracture mineral generations is summarized below in decreasing relative age of formation:

Generation 1 (oldest) – Mainly epidote, chlorite and quartz in, preferably, steep WNW–ESE to NW–SE striking fractures and, more rarely, gently dipping fractures. Wall rock alteration and red staining by disseminations of hematite. Inferred formation at about 200–300 °C, during the Proterozoic between 1.8 and 1.1 Ga. More specifically, it is suggested that precipitation occurred close to 1.8–1.7 Ga, during the waning stages of the Svecokarelian orogeny, at conditions close to the ductile-brittle transition.

Generation 2 – Dominated by hematite-stained adularia and laumontite, together with albite, prehnite, calcite and chlorite; all preferentially precipitated along steep ENE–WSW to NNE–SSW and NNW–SSE striking fractures. Wall rock alteration and red staining by dissemination of hematite. Inferred formation at about 150–250 °C and $^{40}Ar/^{39}Ar$ ages of adularia in breccias indicate, at the very least, precipitation as a response to far-field effects from the Sveconorwegian orogeny, around 1.1–1.0 Ga. Both reactivation of older structures and formation of new fractures and breccias are inferred during this period. After precipitation of the generation 2 minerals a period with some dissolution of fracture minerals occurred, of which the age and cause is uncertain.

Generation 3 – Primarily quartz, calcite and pyrite with minor occurrences of, for example, asphaltite (black, highly viscous to solid hydrocarbons), analcime, corrensite, galena, adularia and fluorite. Preferential precipitation in steep ENE–WSW to NNE–SSW striking fractures and subhorizontal to gently dipping fractures. Inferred formation at about 60–190 °C (mainly < 100 °C) during several episodes in the Palaeozoic through significant reactivation of older fractures. $^{40}Ar/^{39}Ar$ ages of adularia indicate that the main stage of precipitation was between 460–277 Ma. Fluids emanating from an organic-rich sedimentary sequence overlying the basement during this period and mixing with a deep brine, is suggested to have promoted the precipitation. Further, it is suggested that the episodes are far-field effects from the Caledonian orogeny and/or elevated hydrostatic pressure due to the overburden of the Caledonian foreland basin.

Generation 4 (youngest) – Predominantly clay minerals and thin precipitates of calcite in open fractures in the upper part of the bedrock; minor occurrences of pyrite and goethite are also found. The generation is mostly found in sub-horizontal to gently dipping fractures, but also in steep NNE, ENE and NW striking fractures. Precipitation has probably occurred at low temperatures (< 50 °C) during a prolonged period, possibly since the late Palaeozoic until present, by groundwater circulation.

The new data acquired from drill core logging after 2010 provide satisfactory support to the established concept of paragenesis and relative age relationships among the fracture minerals. Thus, instead of comparing data from new and old boreholes, the remaining part of this section address the following aspects of the fracture mineralogy at Forsmark:

- Bias in the fracture mineral data collected during the routine logging of drill cores.
- Fractures lacking visible mineralisation.
- Variation of fracture mineralogy with depth.
- Mineralogy of fractures within possible deformation zones.
- Differences between the fracture mineralogy along drill cores within the tectonic lens and the SFR area.

To maintain consistency in the fracture mineralogy data collected during the routine logging, SKB has engaged a very limited number of mapping geologists with extensive knowledge of the Forsmark site. Nevertheless, feedback from the follow-up mineralogical work and increased experience, in combination with inevitable personnel changes, have had an impact on the data acquired during the course of the investigation programmes. The primary source of bias is that certain minerals are more challenging to distinguish/identify than other. A comparison with follow-up mineralogical work indicates that the occurrence of, for example, adularia, albite and analcime is underestimated. In many fractures, their presence is likely to be masked by other, more easily detectable minerals, including chlorite, red staining hematite and calcite; the latter revealed by the reaction with diluted hydrochloric acid. Detailed mineralogical studies have, on the other hand, shown that iron hydroxide, and to some extent clay minerals, have an overestimated occurrence. The minerals most often mistaken for iron hydroxide are iron-rich mixed layer clay, uranium-minerals and hematite-stained adularia and albite (cf. Sandström et al. 2014). Inferred clay minerals in some fractures are actually clay-fraction mud from the drilling process, though it is also likely that some clay is lost during the drilling and core recovery process, even though triple-tube barrel was used exclusively during the investigations. It should be noted that different clay minerals are not distinguished during the routine logging. Follow-up mineralogical analysis show that corrensite is a common clay mineral. Other clay minerals include illite, smectite and a mixed layer clay that is composed of illite and smectite.

Fractures without any visible minerals make up several percent of the total amount of fractures stored in the Sicada database. These are predominantly, but not exclusively sub-horizontal or gently dipping (Sandström et al. 2008) and their distribution decreases significantly with depth (cf. fracture domain FFM01 and FFM02 in Figure 4-13). Since the existence of these fractures could be taken to imply that fracturing is an ongoing process, SKB initiated a dedicated study to further clarify their nature and origin (Claesson Liljedahl et al. 2011). In this study a subset of 99 fractures was selected from Forsmark to reflect various depths and fracture domains; virtually all are interpreted as water-bearing (PFL) fractures, outside inferred deformation zones. Investigation of the fracture surfaces, including detailed visual inspection and SEM-EDS analysis, revealed that the vast majority of these fractures were actually coated by minerals or that they were drill-induced fractures. Nevertheless, Claesson Liljedahl et al. (2011) conclude that five of the fractures in this study were non-mineralised. Groundwater flow was detected in three of them and all are subhorizontal (dips < 20°) and occur at depth above −250 m.

Several processes that may have contributed to the origin of these non-mineralised fractures are discussed by Stephens et al. (2007) and Claesson Liljedahl et al. (2011): (1) drilling and subsequent handling of the core; (2) mechanical flushing and/or chemical dissolution of fracture coating; (3) fracturing due to ice segregation; (4) borehole intersection with fracture fronts; (5) tension induced sheet jointing (see Section 5.1.2); and (6) reactivation/opening of fractures/micro-fractures and/or non-connected, partly sealed, parts of a fracture plane. Of these, it is concluded that 2 is the least likely processes and 6 the most likely process, possibly in combination with other suggested processes. Tension induced sheet jointing (5) is also a viable mechanism to explain the existence of these fractures. Based on the knowledge of fracture mineral generations in Forsmark, it is suggested by Claesson Liljedahl et al. (2011) that the opening of these fractures is not older than Late Palaeozoic. Furthermore, it cannot be excluded that at least some of these fractures were opened up during the Quaternary glaciations or during the post-glacial Holocene period.

The variation in the occurrence of different fracture minerals with depth has been addressed by Stephens et al. (2007), while a more focused analysis of the variation of minerals along open fractures, in the upper 100 m of the bedrock, has been presented by Sandström et al. (2008). Common minerals such as chlorite and calcite, which belong to different parageneses, as well as the minerals that belong to generation 1 and 2 (e.g. epidote, adularia, laumontite, prehnite and red staining by dissemination of hematite) show no distinctive variation with depth. Their frequency of occurrence generally follows the variation in the frequency of occurrence of fractures. By contrast, the younger minerals asphaltite and goethite (generation 3 and 4) are restricted entirely to the uppermost part of the bedrock. In some boreholes, pyrite and to some extent clay minerals (generation 3 and 4), show a similar concentration in the upper part of the bedrock. Restricted occurrence of clay minerals along fractures at greater depth within and along the margins the tectonic lens is typically related to distinctive peaks in the fracture frequency, which are inferred to represent deformation zones (cf. Stephens et al. 2007 and Figure 4-13).

Since the current ground surface more or less coincides with the sub-Cambrian peneplain, the correlation with depth may have been established several hundred million years ago. The shallow distribution of asphaltite in combination with a confirmed organic origin, indicate formation by fluids emanating from the organic-rich Alum Shale of Cambrian to earliest Ordovician age that covered the crystalline bedrock at Forsmark during the earlier part of the Phanerozoic. Pyrite, precipitated during the same event, has remained in the fractures, indicating prevailing reducing conditions. However, an absence of pyrite in water conductive fractures in the uppermost 10–30 m of the bedrock in the SFR area, indicates limited intrusion of oxygenated waters during some period(s) (Sandström et al. 2011; 2014).

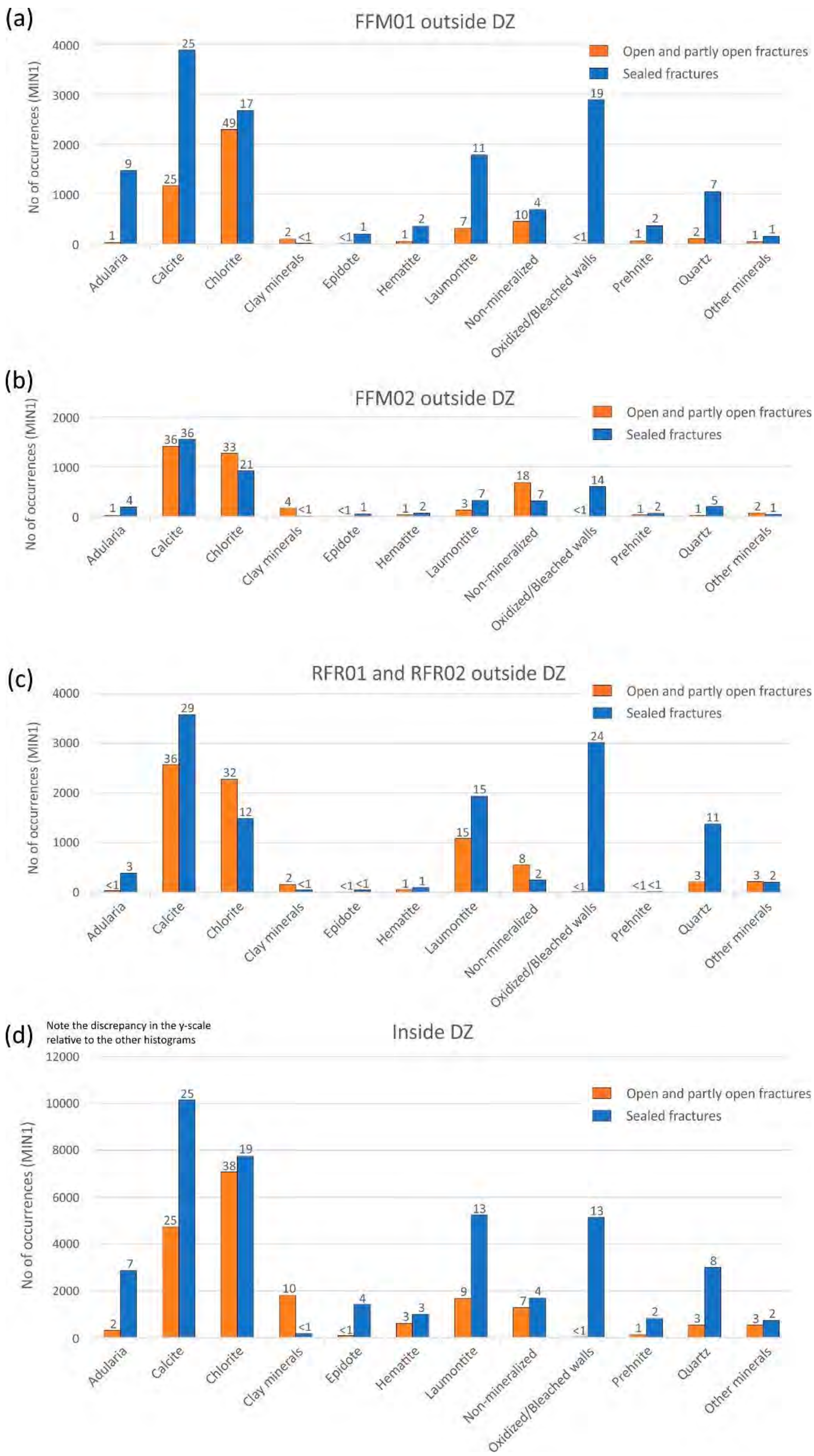


Figure 4-13. *Occurrence of predominant fracture minerals (represented by Min1 in Sicada table p_fract_core) in drill cores acquired (a–c) outside deformation zones in FFM01, FFM02 and RFR01+RFR02, and (d) inside deformation zones (all zones regardless of domain, size and orientation). The histograms include all fracture data from cored boreholes, regardless of whether the fractures are visible in the borehole images or not. The category "non-mineralized" includes both fractures where Min1 is left blank, and fractures where the code "no detectable minerals" has been used. The percentage of each mineral within open (and partly open) fractures and sealed fractures, respectively, is given above the bars.*

The identification and significance of different fracture minerals along possible deformation zones in the single-hole interpretations have previously been provided by Stephens et al. (2007). A summary of the fracture mineralogy along deformation zones is presented in Figure 4-13, whereas corresponding histograms for individual zones included in Baseline version 1.0 are presented in the property tables of Appendix 7. The key aspects addressed by Stephens et al. (2007) can be summarised as follows:

- The occurrence of similar minerals and wall-rock alterations along different fracture orientation sets within a single deformation zone provides support to the assumption that different sets are genetically related.
- Minerals from more than one generation can be present along a single fracture, suggesting a history of repeated zone reactivation. In this context, it needs to be emphasized that the temperature along the zones, with their hot hydrothermal fluids, can be higher than that in the surrounding bedrock.
- Minerals of older generations may have been affected by subsequent hydrothermal events along a zone; older minerals may have been replaced by the precipitation of a younger generation of minerals. Care must therefore be taken in the interpretation of contrasting mineral parageneses along zones, both during the establishment of a conceptual model for deformation zones and the correlation between zones in different boreholes.
- There is a clear concentration of gently dipping fractures without visible minerals along possible deformation zones in boreholes KFM02A and KFM03A, which are inferred to intersect the significant family of gently dipping zones beneath Bolundsfjärden (i.e., ZFMA2, ZFMA3 and ZFMF1, see Chapter 5).

As mentioned above, there are no indications of major differences between the fracture mineralogy in the SFR area and the adjacent tectonic lens. However, minor differences, some of which may be of significance for the understanding of past and present groundwater-mineral interaction, have been identified:

- Data from the drill core logging show that muscovite/sericite and illite are common fracture coatings in the SFR area, whereas there are very few (less than 50) observations along boreholes located south of the Singö deformation zone. The minerals are preferentially found in foliation parallel fractures (Figure 4-14) along borehole sections affected by sericitization, which in turn is inferred to have developed during low-grade metamorphism (see Table 4-6). The interpretation is that a significant proportion of these fractures represent breaks along weaknesses induced by an abundance of muscovite/sericite with preferred orientation (personal communication with Eva Samuelsson 2020). Muscovite in such fractures is part of the wall-rock and lack consequently direct connection with brittle deformation history.
- The set of moderately dipping fractures with an E–W strike that occur in the SFR area, is mainly filled/coated by minerals of generation 2 (i.e. hematite-stained adularia, laumontite, calcite and chlorite, together with red staining of wall rocks). The set is clearly distinguished by plotting fractures filled by, for example, laumontite on a stereographic projection (Figure 4-14).
- The relative abundance of different clay minerals; in the SFR area a mixed layer clay consisting of smectite-illite dominates, together with illite in the water conductive fractures. In contrast, corrensite predominates the clay minerals within the tectonic lens. There are also indications that the amounts of clay minerals are greater in the SFR drill cores compared with those from the tectonic lens (Sandström and Tullborg 2011).
- Uranium minerals have been detected in 20 % of the analysed samples from the SFR drill cores (Sandström et al. 2011). During the site investigations that preceded the SDM-Site Forsmark site investigation, only one uranium mineral (altered pitchblende) was identified in more than 200 sampled fractures along boreholes within the tectonic lens (Sandström and Tullborg 2005). The locally high content of uranium in the Group D rocks (cf. Stephens et al. 2007), in combination with the abundance of these rocks in the SFR area (see Figure 4-1) suggests that pegmatitic granite, pegmatite (101061) and associated fine- to medium-grained granite (111058) is probably a source for this type of fracture coating.
- REE-carbonates have been identified in many of the SFR drill core samples; no REE-carbonates have been identified within the tectonic lens (Sandström et al. 2011). The difference can possibly be explained by the contrasting lithology, with abundant pegmatitic and fine-grained granite in the SFR area.
- Barite is more common in the SFR drill cores; a few occurrences of a Sr-rich barite have also been identified (solid solution barite-celestine series) (Sandström et al. 2011).

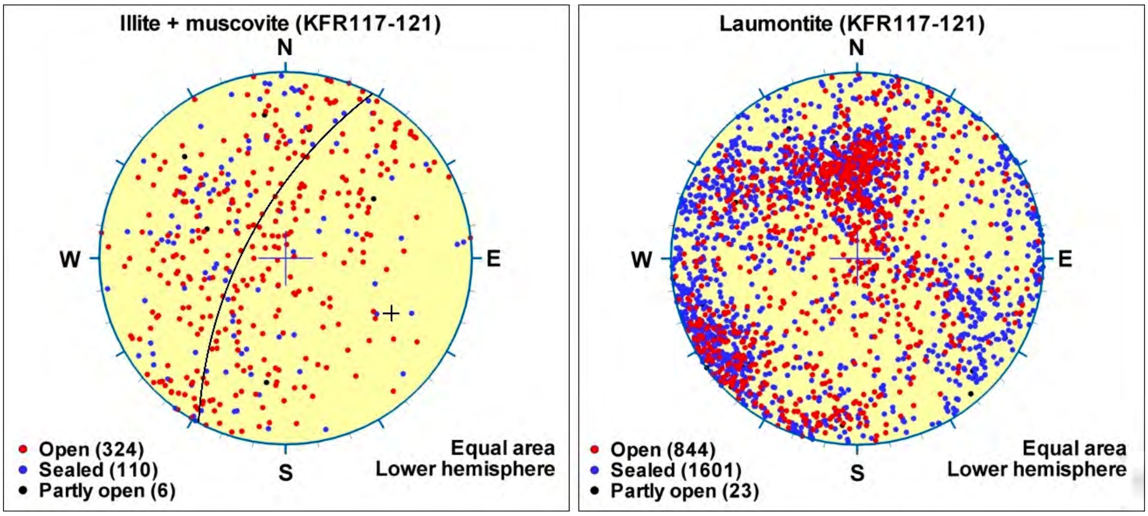


Figure 4-14. *Orientation of fractures with illite or muscovite (left) and laumontite (right), outside deformation zones in boreholes completed in the SFR area after 2010 (KFR117–KFR121). The pole to each planar structure is plotted on the lower hemisphere of an equal-area stereographic projection. No Terzaghi correction has been applied. Fractures with illite or muscovite are distributed along a broad girdle with an orientation of the best-fit pole at 118°/25°, which strongly resembles the pattern that emerged from planar ductile structures and amphibolite contacts in these boreholes (cf. Figure 4-6 and Curtis et al. 2011). As a key mineral of generation 2, laumontite has been selected to illustrate the moderately dipping orientation set with an E–W strike that occur in the SFR area.*

4.3 Sheet joints

4.3.1 Nomenclature

Integration work with hydrogeologists and DFN-modellers recognised the need for a common terminology associated with sheet joints. The term is used to describe tensile fractures (i.e. joints) developed essentially parallel to the topographic surface and divide the shallow part of the bedrock into thin layers with an increased spacing towards depth.

In 2019, SKB decided to use the term "sheet joint" instead of "sheeting joint", which is more widely invoked in the literature. The following nomenclature, along with the Swedish translation, is strongly recommended:

- **Sheet joints** (*Swedish: Bankningssprickor*): Fractures that bound sheet-like rock layers or plates. They exhibit generally the key kinematic qualities of joints and the term "sheet fractures" should be avoided.
- **Sheets** (*Swedish: Bankar*): The thin rock layers or plates.
- **Sheeting** (*Swedish: Bankning*): The process of development.

Avoid the ambiguous term "sheet structure" as it is unclear whether it refers to the sheets themselves or the joints between the sheets.

4.3.2 Observations at Forsmark site

With a rather flat topography in combination with local regolith filled depressions, observations of sheet joints in the Forsmark area are primarily limited to boreholes and the rock excavations made during the construction of the nuclear power plants. A documentation of the fracture character in the shallow rock mass in proximity to the nuclear power plants, with special focus on reactor block 3, is provided by Carlsson (1979). The study also presents details regarding the fracture distribution along an approximately 500 m continuous section of the inlet channel (Figure 4-15), located just north of the planned accesses and operational area of the repository for spent nuclear fuel. The maximum shaft height documented by Carlsson (1979) during the excavations is approximately 20 m.

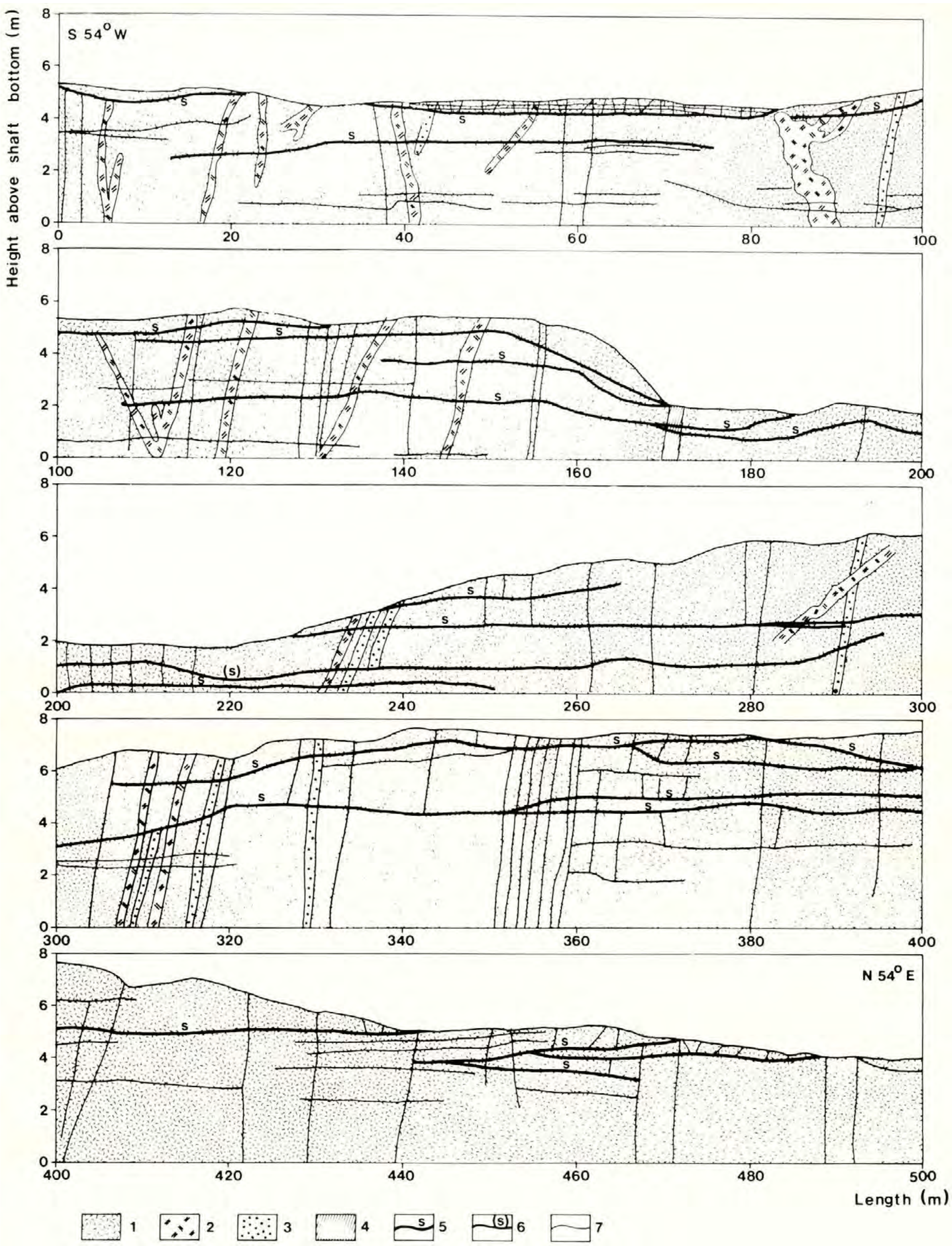


Figure 4-15. Fracture distribution and the occurrence of sediment fillings in a 500 m long section along the northwestern shaft of the inlet channel. 1. Gneiss granite, 2. Pegmatite, 3. Greenstone, 4. Crush zone, 5. Sediment-filled fracture, 6. Fracture partly filled with sediment, 7. Fracture without sediment filling. From Carlsson (1979).

Carlsson (1979) states that shallow horizontal to sub-horizontal fractures (i.e. what we here denote sheet joints) occur, more or less, throughout the construction area where the main rock type consists of gneiss granitic rock (equivalent to 101057, medium-grained metamorphic granodiorite-granite according to SKBs current nomenclature), but are lacking in areas with paragneiss (inferred to be equivalent with 103076, felsic to intermediate metavolcanics rock or intensely deformed rocks according to SKBs current nomenclature). However, core drilling in the shallow bedrock in proximity of the planned accesses and operational area of the final repository for spent nuclear fuel has revealed a considerable spatial variability in the occurrence horizontal to sub-horizontal fractures; as shown by KFM08B and KFM14, there are shallow rock volumes where these fractures are significantly more sparse than for example along the inlet channel.

Reported trace lengths for shallow horizontal to sub-horizontal fractures observed along shafts range up to a maximum length of 176 m (along the inlet channel, cf. Figure 4-15), though most of them are less than 100 m. Furthermore, Carlsson (1979) proposes that the most extensive horizontal to sub-horizontal fractures occur in the uppermost part of the rock mass, down to about 3 m beneath the rock surface, a conclusion that might be attributed to the limited height of the shafts. Along the outlet tunnel to reactor 3, horizontal and sub-horizontal fractures with a trace length of 60 m have been observed at a level of approximately 35 m below the rock surface. (cf. Carlsson 1979, p. 40).

A significant proportion of the inferred sheet joints displays conspicuous apertures and many of them are filled with glacial sediment (Figure 4-16) with a grain-size distribution corresponding to sandy silt or clayey silt. Inferred sheet joints filled with glacial sediments have also been reported from drill site 5 (Leijon 2005) and 7 (Forssberg et al. 2007). The largest aperture in the Forsmark area has been described by Carlsson (1979) with a sediment-filled joint along the inlet channel that amounts to 820 mm (Figure 4-17). The aperture is highly variable along most sheet joints, in one case from a few millimetres up to 190 mm within a horizontal distance of about 2 m (Carlsson 1979).

Figure 4-16. *Shaft wall along a water reservoir during the foundation of the nuclear power plant. A sediment-filled sheet joint with an aperture of approximately 0.5 m runs along the shaft. Photography by G. Hansson.*

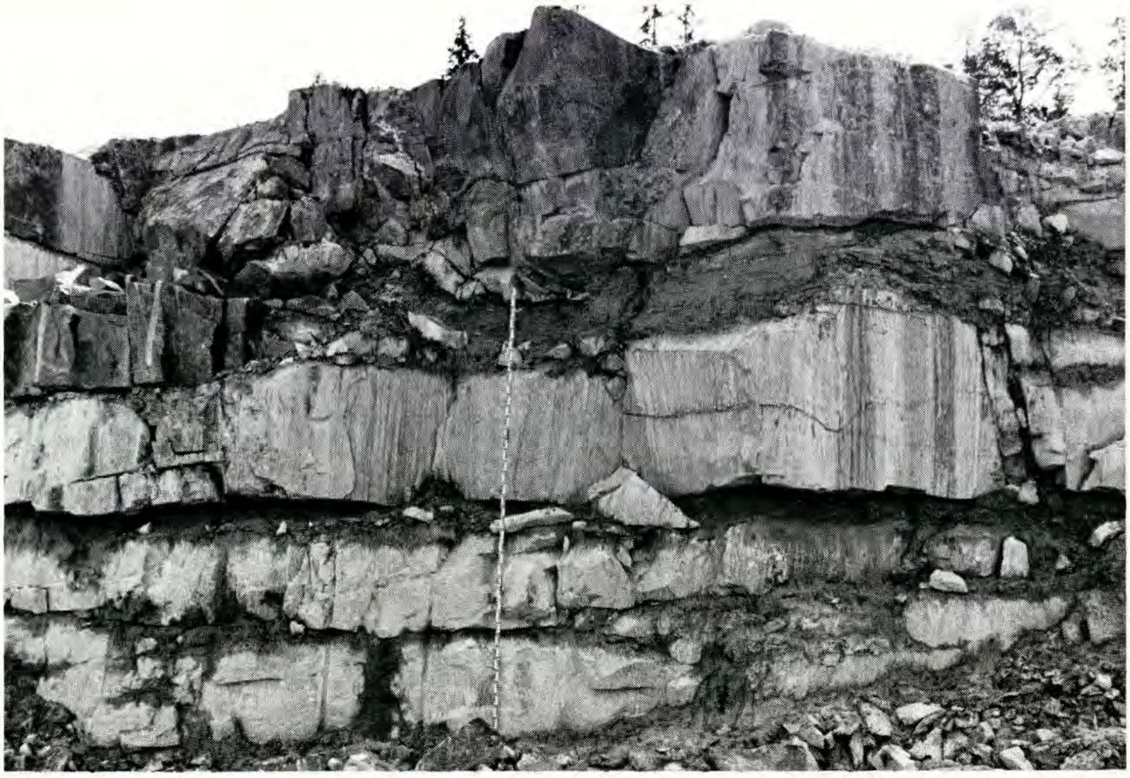


Figure 4-17. *Shaft wall along the inlet channel with several sediment-filled sheet joints. The uppermost joint has a maximum aperture of 820 mm. Length of the levelling staff is 4 m. From Carlsson (1979). Photography by G. Hansson.*

Carlsson (1979) concludes that horizontal to sub-horizontal fractures with distinct apertures, typically ranging up to 2 dm, are frequent in the uppermost 5 m of the rock mass. Boreholes from the subsequent site investigation confirm this pattern for substantial areas in the northern part of the Forsmark tectonic lens. Inferred sheet joints with apertures at 110–280 mm have been identified in five of the boreholes within the planned accesses and operation area of the repository for spent nuclear fuel. All of them occur in the uppermost 5 m of the rock mass, but in contrast to the joints observed at excavations none of them appears to be filled with unconsolidated material (Figure 4-18). Below that depth, joint apertures generally decrease, though intensely sheeted intervals with discernible apertures, occasionally up to tens of millimetres, are still frequent down to approximately −25 to −30 m in the northwestern part of the tectonic lens. The occurrence at greater depth is more sporadic. However, the distribution of inferred sheet joints with discernible aperture is rather heterogeneous and strikingly few in some boreholes, such as KFM14 and HFM41.

Sedimentary fillings are limited to the uppermost part of the rock mass, with the deepest observation 13 m below the rock surface (shaft walls at reactor block 3; Carlsson 1979). None of the boreholes drilled during the site investigations retain traces of sediment-filling, possibly due to an actual lack of sediments along the joints, but more likely as an effect of the drilling process, where the infilling has been worn or flushed away, although triple-tube barrel was used exclusively during entire site investigations. Accordingly, Carlsson (1979) noted that the sediment-filling frequently was flushed out of such joints during the drillings made in connection with the power plant foundation work.

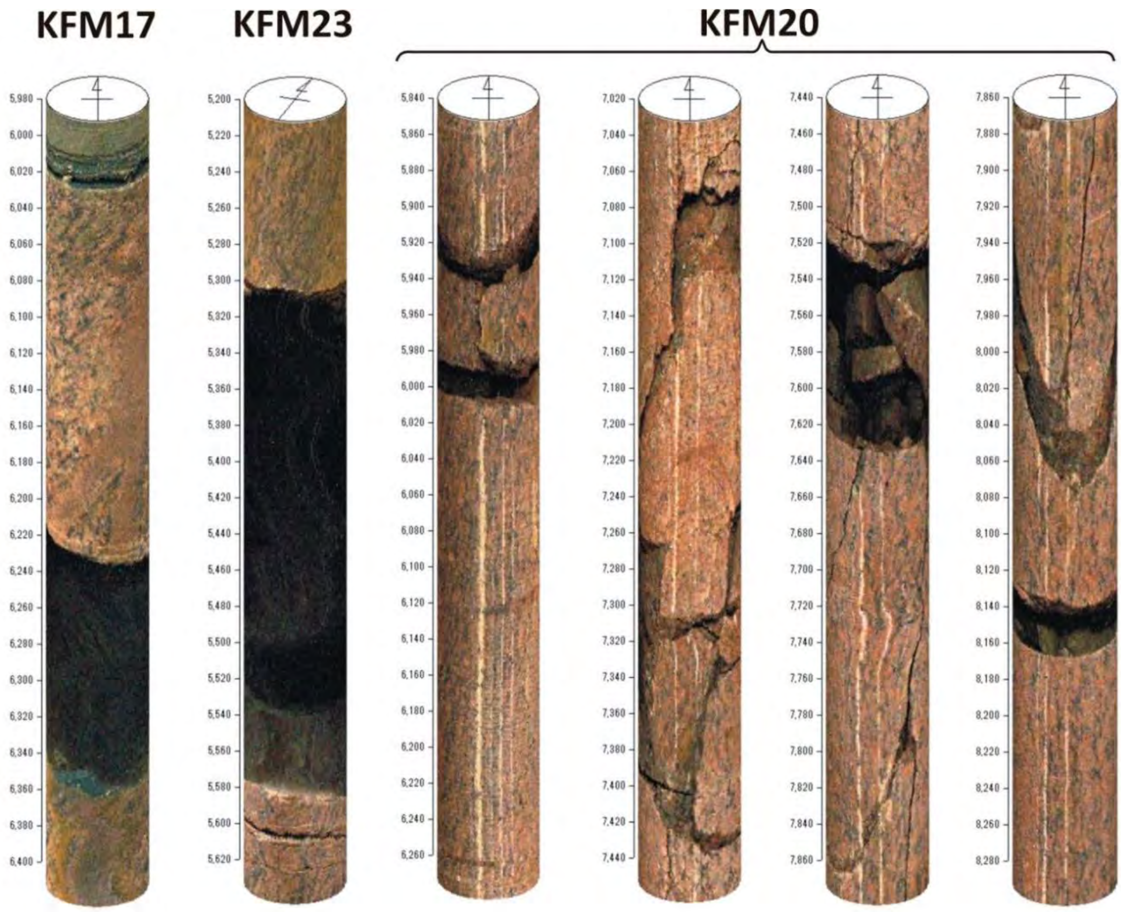


__Figure 4-18.__ BIPS images along sections of three boreholes KFM17, KFM20 and KFM23, in planned accesses and operational area of the repository. KFM17: Inferred sheet joint with an aperture of 125 mm at a level of −2.6 m (6.3 m borehole length). KFM23: Inferred sheet joint with an aperture of 280 mm at a level of −2.9 m (5.4 m borehole length). KFM20: Crushed interval with several fractures (some inferred sheet joints) with apertures of 15–30 mm between −3.8 and −6.3 m level (5.9–9.1 m borehole length). Distance between individual tick marks is 20 mm.

For the superficial horizontal to sub-horizontal fractures, Carlsson (1979) concludes that there are no obvious differences in orientation, length, spacing, aperture, filling material and roughness that can be related to the direction of the shaft walls. Moreover, the superficial horizontal to sub-horizontal fractures occur independently of all forms of discontinuities and cut as a rule across steeply dipping fractures, crush and fracture zones, dykes or other occurrences of amphibolite and pegmatite. All steeply dipping fractures in the shaft walls are intersected by the horizontal to sub-horizontal fractures (Figure 4-19). An assessment of the terminations of horizontal to sub-horizontal fractures conducted by Carlsson (1979) shows the following five types:

- Rock surface. Usually, the shallowest, sediment-filled fractures.
- Vertical to steeply dipping fractures (Figure 4-20a), but the horizontal to sub-horizontal fractures typically intersect the steeply dipping fractures.
- Branching into another horizontal to sub-horizontal fracture (Figure 4-20b).
- Crush or fracture zone.
- Rock mass, where the fracture gradually dies out (Figure 4-20c).

Figure 4-19. Shaft wall at reactor block 3, which displays a vertically dipping fracture zone (oriented 040°/90°) intersected by a set of sheet joints. Length of the levelling staff is 4 m. From Carlsson (1979). Photography by G. Hansson.

Carlsson (1979) has not recognised any spatial differences in the termination mode; most or all types of terminations are represented in each individual shaft. The vast majority of the shallowest horizontal to sub-horizontal fractures terminate against the bedrock surface, whereas the deeper fractures in most cases fade out in the rock mass. Sediment-filled fractures observed in the shaft walls intersect lithological contacts without displacement. However, uplifted and slightly rotated blocks, separated from the underlying bedrock by sub-horizontal fractures, are reported by Leijon (2005) from drill site 5.

4.3.3 Criteria for identification of sheet joints in boreholes

Sheet joints can be significant pathways to hydraulic modelling. The issue is to identify those sheet joints that are large enough to qualify for deterministic modelling. Information from the construction of the nuclear power plants in Forsmark (Carlsson 1979), suggests that aperture is the only reliable proxy for recognition of sheet joints with lateral size of several tens of meters or more. Based on this, sheet joints in Forsmark can be identified by using the following criteria for fractures and crushes in boreholes:

1. Dip of ≤ 30°.
2. Distinct aperture, i.e. ≥ 1 mm.
3. No noticeable slip/displacement.
4. No noticeable fracture coating or wall rock alteration.

Identification of sheet joints is not part of the regular core mapping procedure. Available mapping records may support the identification, but the final decision on whether a fracture is classified as a sheet joint, developed by extensional failure, requires a reassessment of the borehole image obtained by BIPS or OPTV.

Examples of typical sheet joints that fulfils the criteria are presented in Figure 4-21.

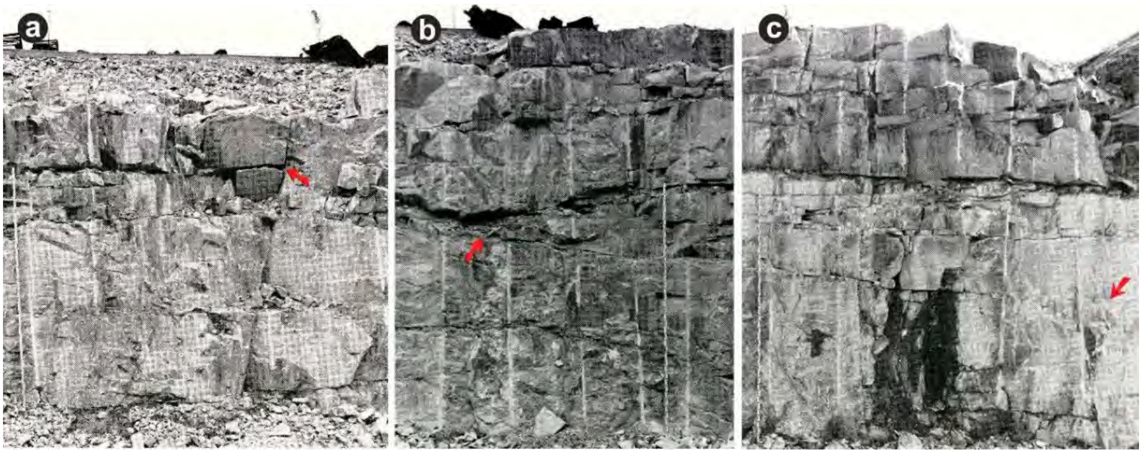


Figure 4-20. Shaft walls showing examples of terminations for sheet joints. a) Termination against a steeply dipping fracture. b) Branching into another sheet joint. c) Dead end in the rock mass. From Carlsson (1979). Photography by G. Hansson.

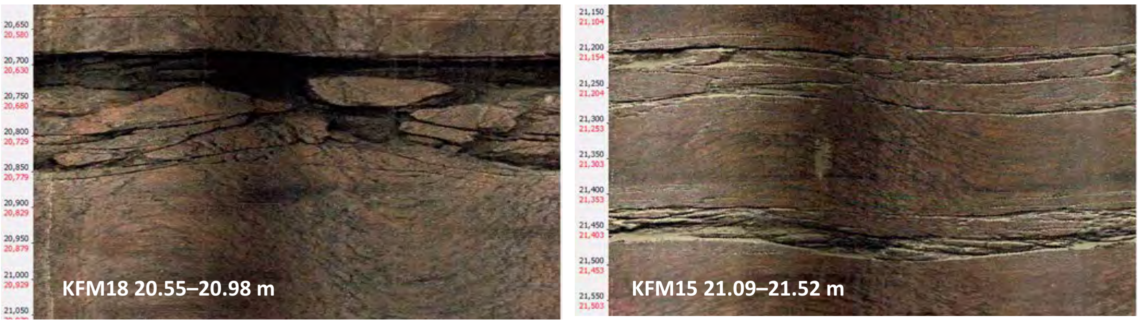


Figure 4-21. BIPS images showing examples of sheet joints with distinct aperture in two boreholes (KFM18 and KFM15) drilled in the planned accesses and operational area of the repository.

4.4 Complementary lineament interpretation

The complementary lineament interpretation work has been the primary basis for the following two modelling tasks:

- Extension and addition of regional deformation zones outside the SDM-Site regional volume for full coverage of the future sub-catchment area (Isaksson and Johansson 2020).
- Reassessment of the truncation pattern of deformation zones northeast of the SFR facility to eliminate artificial blind ends of previously modelled zones (cf. Curtis et al. 2011).

4.4.1 The DMS Baseline Forsmark area

At the request of downstream users and especially the hydrogeologists, the deformation zone model for Forsmark was expanded to include the future sub-catchment area, within the Site Descriptive Model – Safety Assessment Report (SDM-SAR) area. The DMS Baseline Forsmark area consists of a combination of the SDM-Site regional model area and the delineated future sub-catchment area (see Figure 4-22 and Section 2.5).

Identification of topographic and airborne geophysical lineaments has been carried out during the site investigations at Forsmark (Isaksson 2003; Isaksson et al. 2004, 2006a, 2006b, 2007; Korhonen et al. 2004; Isaksson and Keisu 2005; Johansson 2005). The lineaments have mainly been identified as magnetic lows. In several cases, lineaments have been verified by excavations and by drilling as representing deformation zones in the bedrock, whereas others have alternative geological explanations (Johansson and Isaksson 2006). Thus, an interpretation of lineaments, forming the base for further deformation zone modelling, was carried out within a delimited work area including the DMS Baseline Forsmark area (Figure 4-22).

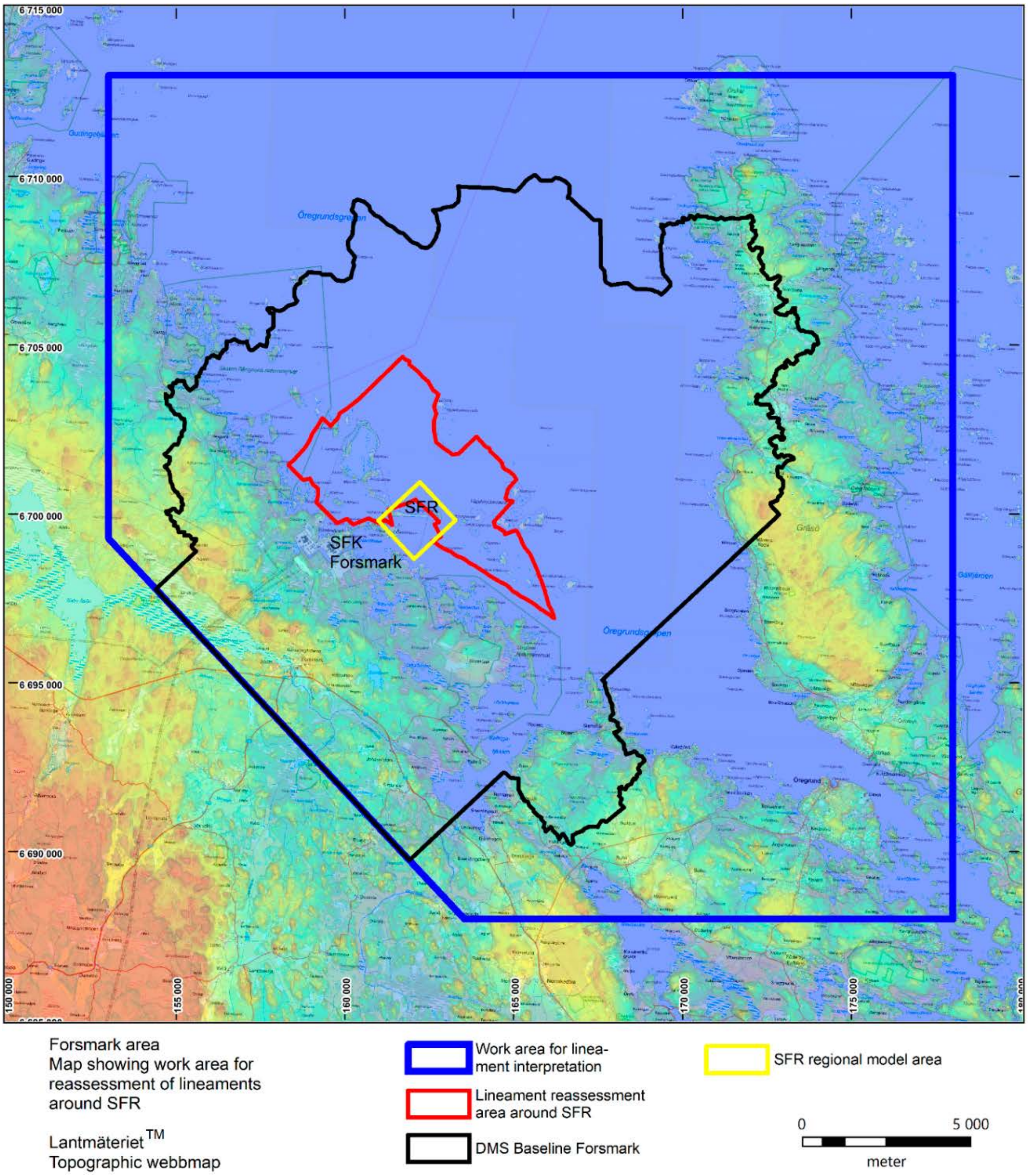


Figure 4-22. *Topographic location map showing the lineament interpretation work area (blue polygon) in relation to the area of DMS Baseline Forsmark (black line). The red polygon shows the supplementary area for the reassessment of the truncation pattern of deformation zones around the SFR facility. The SFR regional model area is presented as a yellow box. Revised from Isaksson and Johansson (2020).*

The minimum trace length at the ground surface for modelling of deformation zones outside the SDM-Site regional volume was set to 5 km (see Section 5.4.5). To be in accordance with previous work, the lineament interpretation thereof has a minimum trace length at the ground surface of approximately 3 km. Lineaments were determined by identification and outlining vectors using visualization of the various magnetic, VLF (very low frequency) and elevation datasets.

Available data

The area of interest is covered by low-altitude airborne geophysical surveys, predominantly generated by the Geological Survey of Sweden (SGU) as part of their standard mapping activities. Surveys have also been carried out by the Geological Survey of Norway (NGU) on behalf of SKB and by Boliden AB for exploration purposes. Table 4-10 presents the various surveys performed in the area and their respective survey parameters. Figure 4-23 illustrates the areal coverage for datasets that have been used for this lineament interpretation work.

VLF data have been available mainly through the SGU surveys. From 1998, SGU also provide VLF apparent electrical resistivity calculated according to a method by Becken and Pedersen (2003). The resistivity data constitute a new data set compared to previous work in the Forsmark/Östhammar region. However, this data is only available in the northern part of the work area (Figure 4-23).

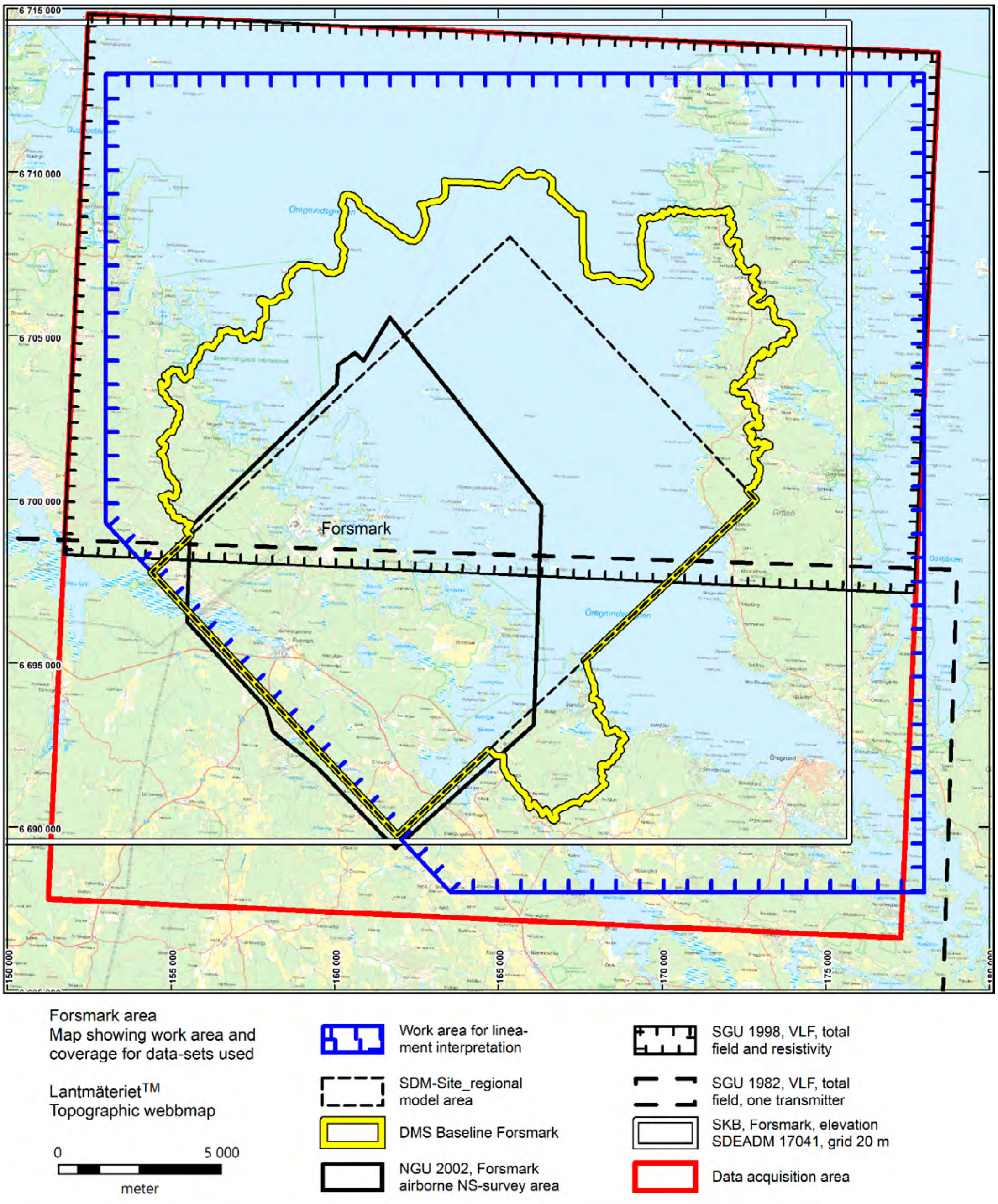


***Figure 4-23.** Available data coverages for the lineament interpretation work area. Revised from Isaksson and Johansson (2020).*

DEM data from the work area consist of the Land-survey GSD, grid 50+, covering the whole work area and a special 20 × 20 m grid provided by SKB. The latter is a mosaic of detailed land-based 1 × 1 m grid elevation data and bathymetric data from the sea (Figure 4-24).

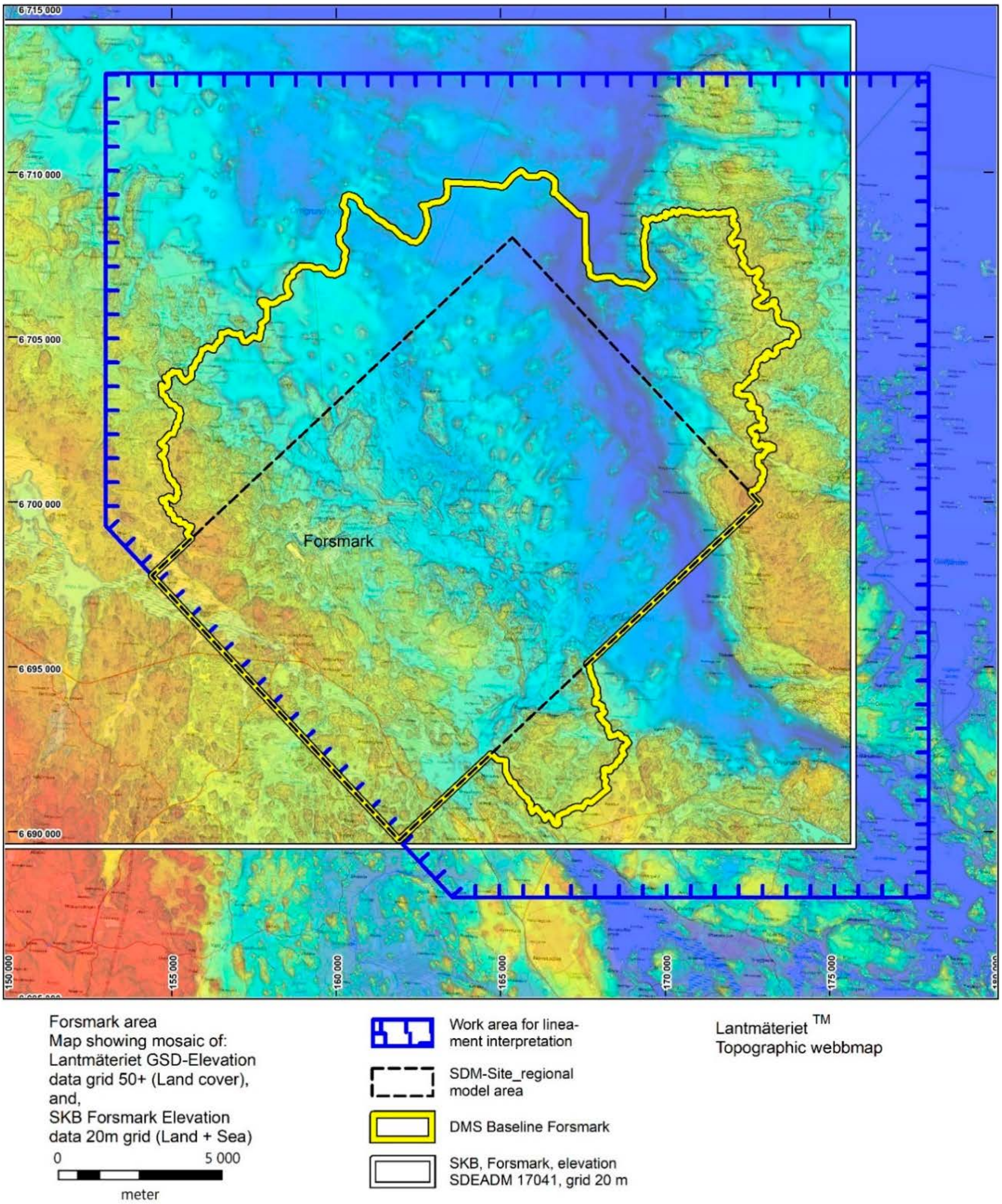


Figure 4-24. *Digital elevation data, GSD, grid 50+, Lantmäteriet™, covering the whole work area and an inset 20 m grid provided by SKB. The latter is a mosaic of detailed land-based elevation data and bathymetric data from the Sea. Figure revised from Isaksson and Johansson (2020).*

Table 4-10. Survey parameters for airborne geophysical surveys in the study area. All surveys have been carried out in the Swedish grid RT90, 2.5 gon W, 0: −15.

Survey area	Forsmark (power plant)	13I SV, NV Österlövsta	12I Östhammar	13I Österlövsta	Forsmark SDM-Site
Contractor	SGU	Boliden	SGU	SGU	NGU
Flight year	1977	1979	1982	1998	2002
Survey direction	35°	0°, S–N	90°, E–W	90°, E–W	0°, S–N
Line spacing	200 m	Ca 150 m	200 m	200 m	50 m
Grid cell size	40 m	40 m	40 m	40 m	10 m
Ground clearance	ca 30 m	ca 30 m	ca 30 m	ca 60 m	ca 45 m
Reference	(Bergman et al. 1999)	(Bergman et al. 1999)	(Bergman et al. 1999)	(Bergman et al. 1999)	(Stephens et al. 2007)

Processing

The magnetic data has been interpolated to regular 40 and 10 m grids (Stephens et al. 2007, 2008b; Isaksson and Johansson 2020). For data enhancement and to facilitate identification and mapping of geological structures, bedrock magnetic patterns and lineaments, a package of transformations and filters have been applied to the interpolated magnetic grids. For the magnetic field, a colour RGB-composite of processed data layers, is presented in Figure 4-25.

For the 1982 VLF data, the total field is interpolated to a 40 × 200 m grid and for the 1998 VLF data, the resistivity is interpolated to a 40×40 m grid. To enhance the resistivity data from 1998, a so called "Peaker"-functions has been applied according to Persson and Daniels (2002).

The DEM grid data has been enhanced by gradient calculations and other regular grid data or image enhancement algorithms.

Interpretation

Interpretation of lineaments has been carried out in accordance with the methodology and strategy previously used in the Forsmark site modelling. The methodology for interpretation and documentation of lineaments has previously been well described by Isaksson and Keisu (2005). From experiences during the site descriptive modelling Forsmark version 2.1, lineaments identified in topographic data showed major uncertainties, with the ground surface inconclusive in expressing the bedrock morphology. Electromagnetic methods such as active and passive (VLF) EM exhibited similar uncertainties, due to large topographic dependence and the proximity to coastal marine saltwater. Both topography and electromagnetic data also have poor spatial resolution and reproduction in the area covered by oceans and lakes, while airborne and ground magnetic data provide a more uniform basis for assessment. In short, it is assumed that magnetic data is considered a more reliable source for identifying deformation zones from mainly low magnetic lineaments (cf. SKB 2006; Stephens et al. 2007).

For the DMS Baseline Forsmark area, some specific conditions apply. The lineament interpretation was carried out to enable modelling of deformation zones with a minimum ground surface trace length of 5 km, up to the boundary of the future sub-catchment area. This also includes an extension of all previously modelled zones that are truncated along the boundary for the SDM-Site regional area. This regardless of whether the ground surface trace length of the zone exceed 5 km or not. Thus, there should be no artificial truncation of a lineament between the SDM-Site regional area and the surrounding sub-catchment area. However, in accordance with previous similar interpretations, the lineaments in this work have a minimum ground surface trace length of 3 km. Lineaments shorter than 3 km may, in exceptional cases, be included in the case where they constitute a termination of a longer lineament or if they, for a short distance, constitute an alternate or parallel route to the main lineament.

The methodology included identification, description and documentation of the spatial occurrence of lineaments primarily in magnetic data. Topographic and airborne geophysical VLF data were used as a backing for the identification, for descriptions and for support of tracking location and propagation of a magnetic lineament. In exceptional cases, a topographic or VLF lineament may be included if it is suspected to correspond to a gently dipping zone.

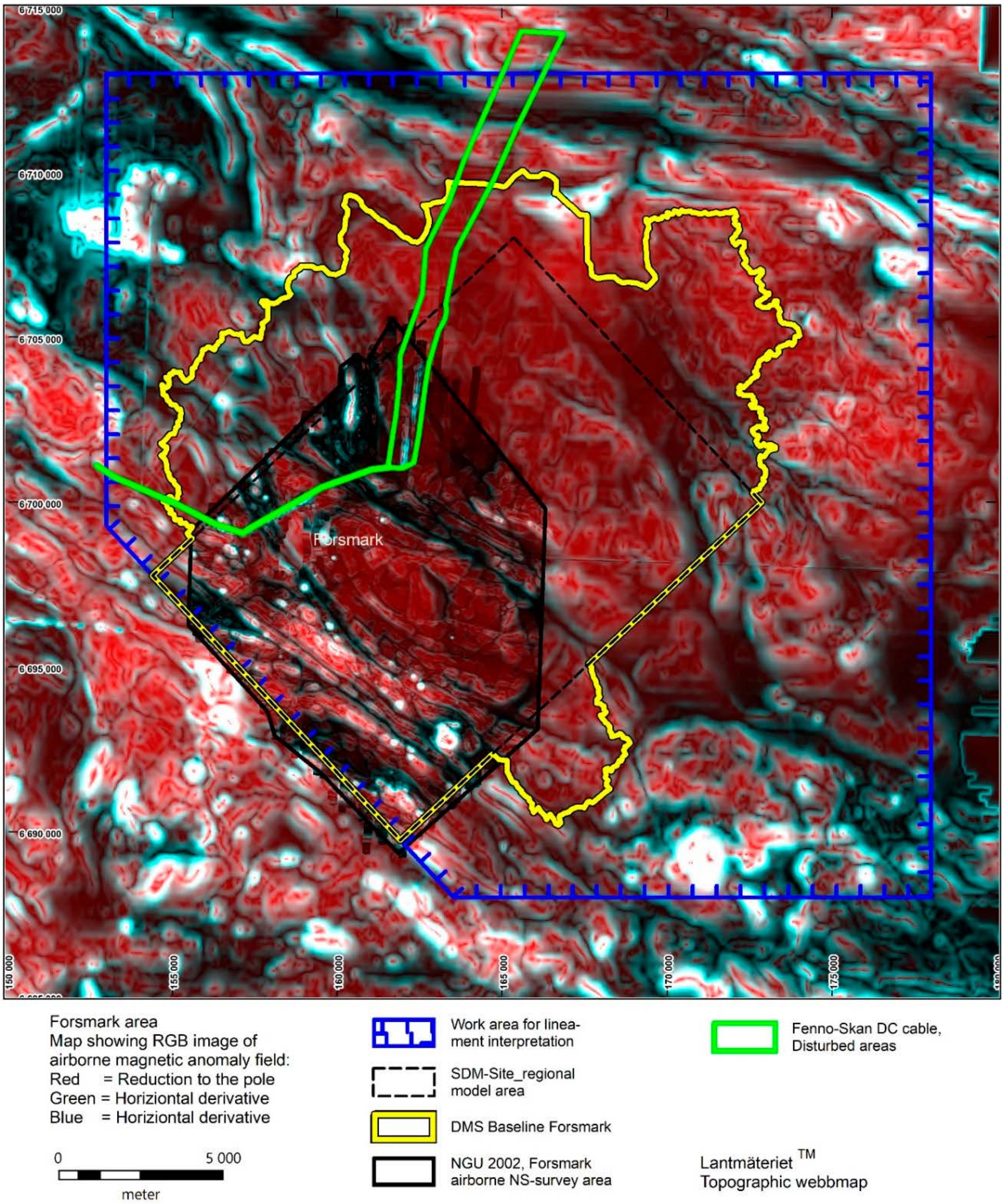


Figure 4-25. *Airborne magnetic anomaly field from "Förstudie Tierp" and an inset map with magnetic total field from NGU Forsmark 2002. Red-green-blue (RGB) colour composite of reduction to the pole (in red) and horizontal derivative (in green and blue). Revised from Isaksson and Johansson (2020).*

The identified magnetic lineaments were graded in low, medium, and high uncertainty mainly with respect to the clarity in which they appear but also through judgement regarding the specific geological and geophysical character of the lineament (e.g. Isaksson and Keisu 2005). In this work, two major groups of magnetic lineaments were distinguished by their magnetic nature:

- Magnetic minima, discordant to geological and geophysical trends.
- Magnetic minima connection, concordant to geological and geophysical trends.

A third group of lineaments typically distinguished as “magnetic maxima with dyke-like character” (Stephens et al. 2007), were not identified in this work.

The lineaments were described with attribute data in a table with the same content that was used in previous work (SKB 2006). Notable is attributes such as character, uncertainty, length, and mean orientation, as well as from which data-type a lineament has been identified. A weight attribute considered the degree of uncertainty and the number of methods in which a lineament has been identified. The weight attribute assessment yields an indication of the confidence of a lineament, which is also exemplified by the lineament visualisation in Figure 4-26.

The initially identified magnetic lineament segments (i.e. method specific/co-ordinated lineaments, Figure 4-26), were subsequently linked together into linked lineaments. At this stage, linked lineaments from previous work (Forsmark stage 2.2; Stephens et al. 2007), were also included, Figure 4-27. The identity and naming followed the previous nomenclature with the prefix plus its serial number. Lineaments that connect/link to previously interpreted lineaments of Forsmark stage 2.2 were given the same identity.

From this work, in total 96 linked lineaments was generated, to compare with 44 linked lineaments in the previous Forsmark stage 2.2 (Stephens et al. 2007). Fifty of the lineaments being completely new along their full extension. Twenty-six of the previously linked lineaments have not been affected by this work and are hence keeping their previous identity and extent. Twenty of the previously identified lineaments were extended outside the SDM-Site regional model area and was in some cases also modified within the SDM-Site regional area. For the latter, earlier identities were retained. Of all linked lineaments, 24 are classified as regional (length > 10 km) and 72 as local major (1–10 km in length).

Both the method-specific/co-ordinated lineaments and linked lineaments identified and outlined in this work was delivered to the SKB databases, along with the original and processed data (delivery SKBdata_22_093_2). Further details, data and results of the work is presented in Isaksson and Johansson (2020).

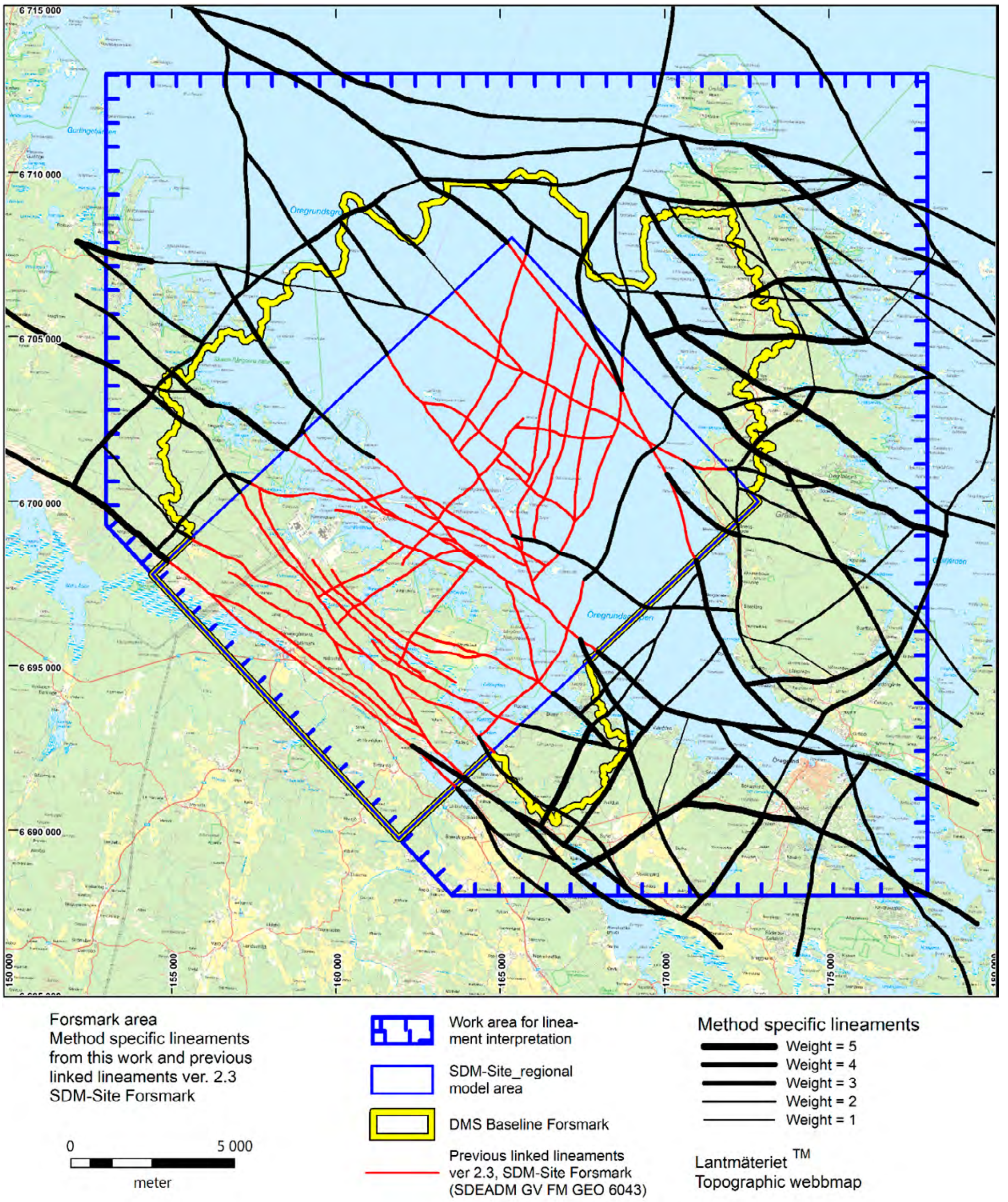


Figure 4-26. *Method specific lineaments identified and outlined in this work. Revised from Isaksson and Johansson (2020).*

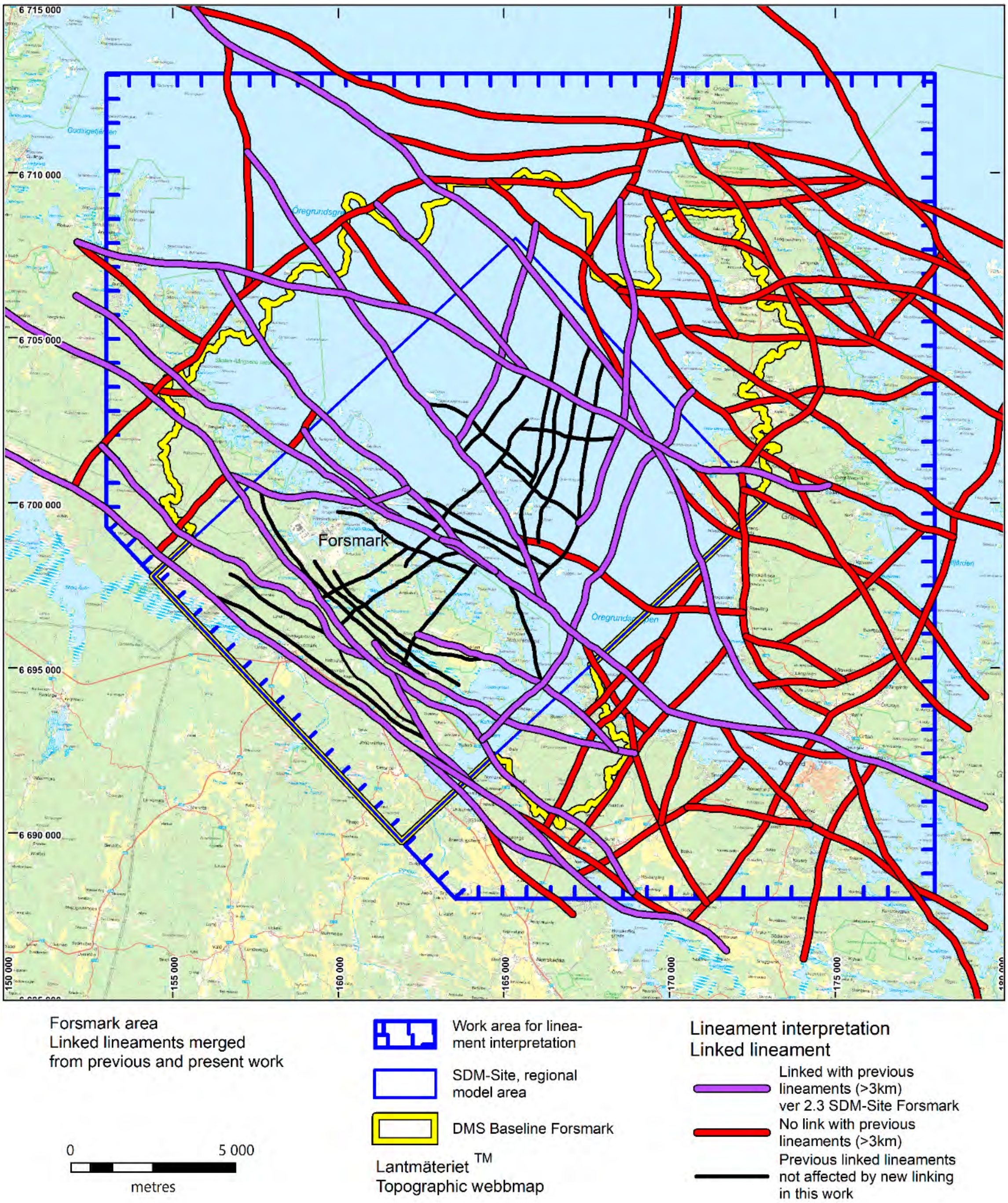


***Figure 4-27.** Linked lineaments identified and outlined in this work. Revised from Isaksson and Johansson (2020).*

4.4.2 The area northeast of the SFR facility

In the deformation zone model for SDM-PSU, a few lineaments with artificial truncation occur at the regional model boundary (see Curtis et al. 2011). Thus, a supplementary lineament interpretation was carried out in the area around and adjacent to the SFR facility (Figure 4-22) as a basis for handling deformation zones modelled with artificial terminations. Basically, these discrepancies mostly occur in the near shore sea area, where detailed ground geophysical magnetometry data is lacking.

Available data and processing

As mentioned in Section 4.4.1 (sub-section Interpretation), magnetic data in general is considered a more reliable source for identifying deformation zones from mainly low magnetic anomalies. However, specifically in the area around the SFR facility, the various magnetic data are disturbed by the Fennoscandia DC power cable, (cf. Figure 4-25). In this work, a single flightline from the NGU airborne magnetic survey (2002), parallel (~ south–north) to the DC power cable and about 1.4 km towards east, was also recognized with an additional and probable line error (Figure 4-28).

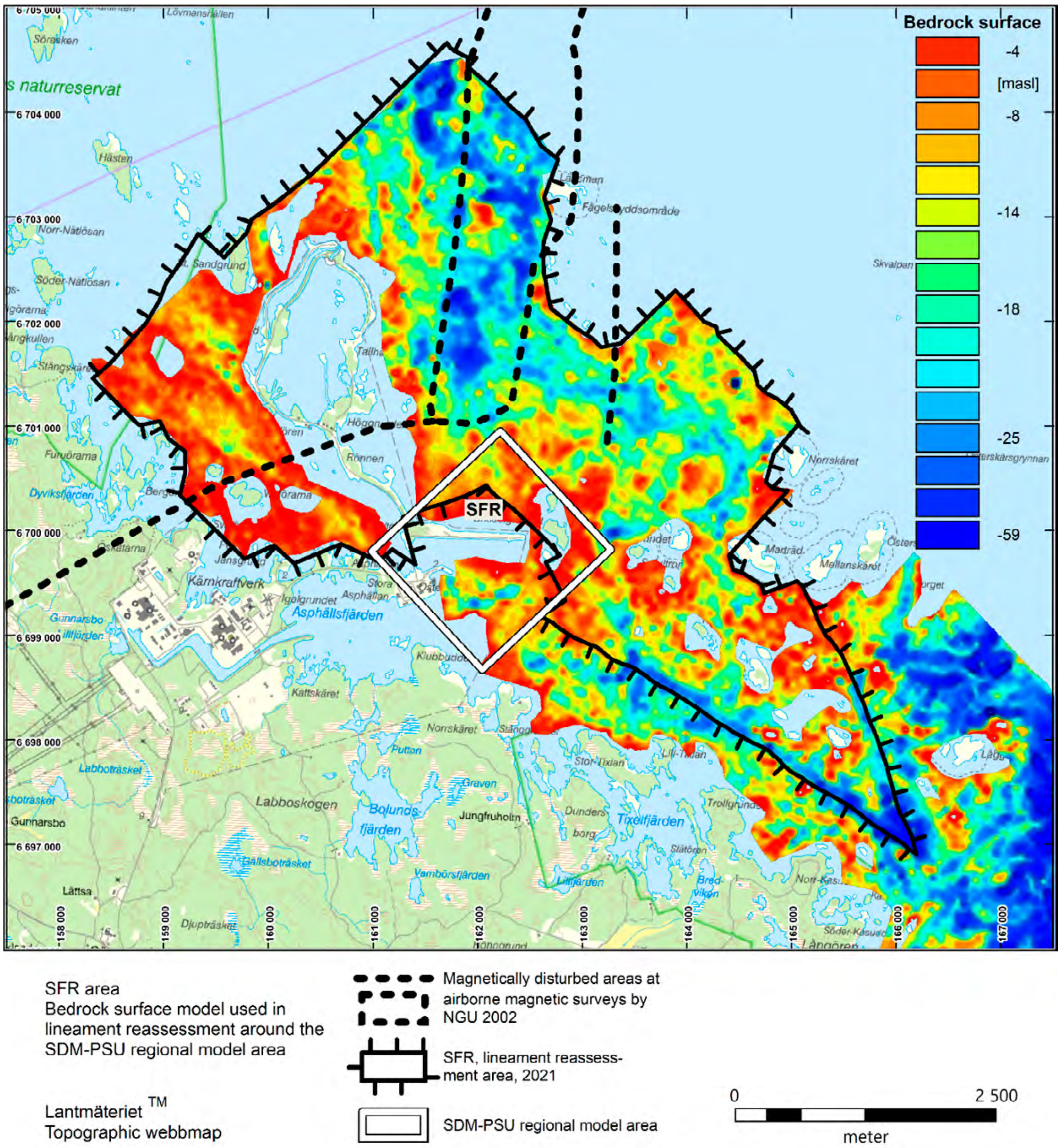


Figure 4-28. *The lineament reassessment area around the SFR facility and the SDM-PSU regional model, with the near shore, Sea bedrock surface model (Petrone et. al. 2020).*

With this as background, it was decided to utilize bedrock surface data from a regolith depth model (RDM), presented by Petrone et.al. (2020), as a complement (see Section 2.6). This RDM model visualises the present spatial distribution of the regolith, as well as a model of the surface of the bedrock (Figure 4-29). In the absence of reliable magnetic data in this area, the bedrock model was used to support lineament interpretation. The bedrock surface DEM, 20 × 20 m grid data, was enhanced by calculations of gradients and other regular image and grid enhancement algorithms.

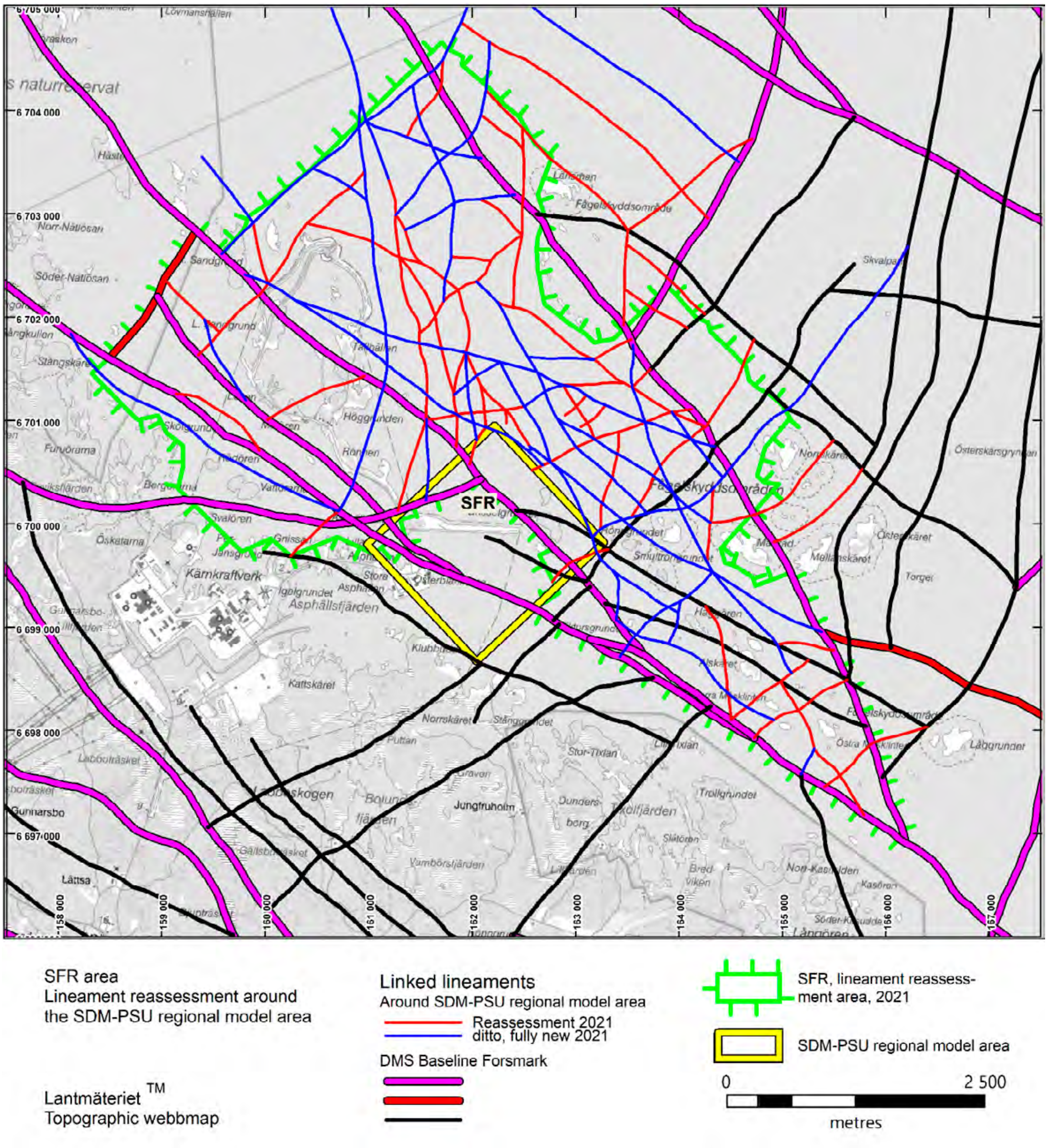


Figure 4-29. *Reassessment lineaments around the SFR area and the SDM-PSU regional model, within the network of linked lineaments presented in Figure 4-27 (cf. Isaksson and Johansson 2020). For legend text contents to DMS Baseline Forsmark, see Figure 4-27. For layout and clarity reasons, lineaments are not included within the SDM-PSU regional model area.*

Interpretation

The supplementary lineament interpretation in connection with the SFR area was carried out under the following conditions, in general like the procedures described in Section 4.4.1 (sub-section Interpretation):

- Decisions on structural relationships between, and linking of, individual lineaments rely largely on the tectonic concepts adopted for development of deformation zones in Forsmark (see Section 5.1.1).
- A minimum lineament length of approximately 300 m was applied. Shorter lineaments were allowed to be included in the case where they constitute a termination of a longer lineament or if they, for a short distance, constitute an alternative or parallel route to the main lineament.
- Focus on the area north and northeast of the SDM-PSU regional area, which did not exclude additions and adjustments within the adjacent outside areas defined by the red polygon in Figure 4-22.
- Addition of new lineaments and adjustments of existing lineaments if required.
- Regional lineaments from the DMS Baseline Forsmark area, as outlined and described in Section 4.4.1, were not adjusted (Figure 4-29).
- At the boundary to SDM-PSU regional area, lineaments in the reassessment area were adjusted and adapted to the lineaments within the SDM-PSU regional area.
- Basis for interpretation was primarily the inferred rock surface below the seabed, bathymetric, refraction seismic and, high-resolution ground and airborne magnetometry data. The latter described in Section 4.4.1.
- Lineament identity according to Section 4.4.1 (sub-section Interpretation). New lineaments were named with consecutive numbers starting with "MFM3550".

From this work, in total 93 linked lineaments was generated or revised; 42 of the lineaments were completely new along their full extension (Figure 4-29). Of all linked lineaments, 43 were classified as local major (1–10 km in length), 50 as local minor (< 1 km) and none as regional (length > 10 km).

Both the method-specific/co-ordinated lineaments and linked lineaments identified and outlined in this work were delivered to the SKB databases, along with the basic and processed data (delivery SKBdata_22_093_2).

4.4.3 Geological significance

Low magnetic lineaments may represent different geological features. The assumption that they are expressions of steeply dipping fracture zones relies on the frequent association with bedrock oxidation, characterised by martitization of magnetite and development of hematite dissemination within feldspars (cf. Table 4-4). The alteration type is commonly coincident with decreased magnetic susceptibility, which in turn gives rise to a minima in the magnetic total field.

During the site investigations that preceded SDM-Site, extensive efforts were taken to investigate the nature of low magnetic lineaments of different character and orientation (cf. SKB 2006; Stephens et al. 2007). Observations both along zone intersections in boreholes and trenched outcrops excavated across interpreted lineaments, provide undisputed support to the use of low magnetic lineaments in the identification of steeply dipping fracture zones. Although the majority of the excavations across low magnetic lineaments inside the Forsmark tectonic lens show that they represent steeply dipping zones, there are exceptions. Based on previous conclusions presented in various modelling reports (e.g. SKB 2006; Stephens et al. 2007), the geological significance of the low magnetic lineaments in Forsmark can be summarised as follows:

- Lineaments defined by discordant magnetic minima primarily represent steeply dipping zones. However, the lineament model does not always match the inferred structural concepts, which means that the extent of steeply dipping zones can deviate locally from the lineament pattern. Furthermore, excavations show that dykes that are composed of Group D granite and pegmatite have magnetic signatures that are similar to those observed along fracture zones, which therefore, introduces some element of uncertainty in the interpretation of such lineaments.

- The high-resolution data indicates that the strike-slip displacement along the steeply dipping fracture zones is minor.
- Inside the Forsmark tectonic lens, lineaments classified as magnetic minima connections are inferred to be related primarily to lithological contrasts that are aligned parallel to the ductile tectonic foliation in the bedrock (Stephens et al. 2007). However, the occurrence of minor fracture zones along the tectonic foliation cannot be excluded as a contributory factor.
- Along the margins or in the ductile high-strain belts outside the tectonic lens, where all structures are concordant, it is generally impossible to distinguish magnetic minima connections that are simply related to lithological contrasts from those that are related to deformation zones with an initial ductile development. The uncertainty in the interpretation of such lineaments is significant, especially regarding their length (see Section 8.2).
- Areas with low magnetic intensity and with low relief can be related to intersections of discordant, low magnetic lineaments. Areas of diffuse magnetic patterns may indicate a deeper bedrock source and/or the presence of fractured and altered surface rock.

Furthermore, a field effort was undertaken by the modelling team in early 2021 to investigate the geological significance of E–W trending lineaments at northern Gräsö. Outcrops along three interpreted lineaments MFM3513, MFM3514 and MFM3518 of Isaksson and Johansson (2020) with associated splays were visited (cf. Figure 3-4). At this scale, segments of the lineaments are largely defined by regolith-filled, topographic depressions, with some support from VLF data. However, the degree of bedrock exposure in some areas along the lineaments would definitely be sufficient to reveal the existence of regional deformation zones, especially the low-grade ductile components typically associated with such zones. None of the outcrops show structures with obvious relation to deformation zones of regional extent. Instead, the lineaments are attributed to the trend of penetrative ductile deformation and local anthropogenic features such as power lines and roads.

4.5 Seismic processing

The seismic data acquired along LFM001021 and LFM001023 indicate a frequently occurring, 2–3 m thick, transition zone between the bedrock and the Quaternary cover material, with velocities ≤ 4 000 m/s (Mattsson 2013). Considering the known distribution of sheet joints at Forsmark, with the highest frequencies down to about 3 m beneath the rock surface (cf. Carlsson 1979), it is inferred that this low velocity layer is a result of fractured near-surface bedrock, locally in combination with the presence of till.

Several minor sections of low rock velocity, including one 10 m section, has been identified by Mattsson (2013) as possible minor fracture zones. However, a comparison with magnetic minima and modelled deformation zones shows poor correlation. Both ZFMNNW1205A and ZFMNNW1205B intersects LFM001021, but no associated low velocity anomalies can be distinguished. The only possible match is between ZFMNNW1205A and one of the minor low velocity sections along LFM001023. The limited correlation rate is in accordance with the outcome of a previous study presented by Isaksson (2007) on the correlation between the refraction seismic data, low magnetic lineaments and deformation zones of Forsmark, model stage 2.2.

Low velocity anomalies that do not match low magnetic lineaments and/or modelled zones may represent the following features:

- Unidentified fracture zones, preferentially minor zones or/and zones without associated wall rock oxidation.
- Narrow depressions in the bedrock surface filled with Quaternary cover material.
- Local variabilities in the vertical extent of the more intensely fractured layer of near-surface bedrock (see Figure 4-30).

Figure 4-30. *Examples from shaft walls along the inlet channel that illustrate the local variability in the fracture intensity in the near-surface bedrock. The distance between the two localities is ca 20 m. Length of the levelling staff is 4 m. From Carlsson (1979). Photography by G. Hansson.*

As previously summarised by Stephens et al. (2007), the refraction seismic data acquired at Forsmark can identify low velocity anomalies in brittle deformation zones, which contain sections of open fractures or crushed bedrock that are 5 m or wider. The method is less efficient for the identification of brittle deformation zones defined by sealed fractures and sealed fracture networks. Another problem is the often inhomogeneous character of deformation zones, as well as the large number of low velocity anomalies without direct relation to geologically verified fracture zones.

The GPR data along the six lines LFM001020–LFM001025 have generally poor signal penetration. Thus, the measurements provide very limited complementary information regarding the near-surface bedrock conditions (cf. Mattsson 2013).

Based on reflection seismic processing of the refraction seismic data acquired from LFM001021 and LFM001023, Juhlin (2016) has identified a sub-horizontal reflection (G8) at about 60 m depth that can be traced under much of the survey area. Since no boreholes penetrate the reflecting interface, it has not been possible to give a definite answer to the cause of the reflection. A conceivable possibility is that the reflector represents the transition from the more fractured bedrock of FFM02 to the underlying, more intact FFM01. Significantly higher apparent velocities on the farthest offset data support this suggestion (Juhlin (2016). However, borehole data acquired in the proximity to the G8 reflection show that the boundary between the domains is shallow in this part of the lens and lies at about 25–40 m depth (cf. Section 7.6). Other potential sources to the G8 reflection are lithological changes, a gently dipping fracture zone or a concentration of deep-seated sheet joints. An interpretation where the G8 reflection represent a northwestern continuation of deformation zone ZFM1203 can be rejected, both due to differences in depth and the lack of geological indications along boreholes situated northwest of ZFMENE0159A (cf. Section 5.4.4). Thus, drilling of the reflector in locations where it is most clearly observed on the seismic data is essential to determine its origin.

5 Deterministic model for structures (DMS)

5.1 Conceptual model

5.1.1 Deformation zones

Structural observations with bearing on character of deformation in combination with the truncation pattern of lineaments and previous modelling work, indicate that four distinctive sets of deformation zones are present at the Forsmark site. A conceptual model for the formation and reactivation of the different sets of deformation zones has successively grown in confidence as progressively more data have been available (SKB 2005, 2006; Juhlin and Stephens 2006; Stephens et al. 2007). A key component in this work was the use of low-temperature geochronological data that provided insights in the exhumation and cooling history, the relative time relationships and absolute age determinations of fracture minerals. For an overview and evaluation of these data, the reader is referred to Söderbäck (2008). No new information from subsequent analytical work contradicts the conceptual understanding that was presented earlier, and the model was consequently adopted both for the deformation zone modelling of SDM-PSU and Baseline Forsmark.

The conceptual fundaments of the model can be summarised as follows:

- The spatial distribution and geometric relationships between the deformation zones have largely been steered by the pronounced ductile anisotropy in the bedrock, with contrasting crustal segments of the tectonic lenses surrounded by broader high-strain belts.
- All four sets of deformation zones have been formed in the same tectonic regime and the geometric relationships between the different sets are consistent with their formation in a strike-slip tectonic regime.
- The oldest discrete structures in the area are the steeply dipping, WNW–ENE and NW–SE striking zones (e.g. Singö deformation zone) with an initial development in the ductile regime.
- Brittle multiphase reactivation of different sets of deformation zones in response to changes in the stress situation during the subsequent tectonic evolution.
- Reactivation with local shear failure and dip-slip normal displacement in connection with loading and unloading cycles around and after ca 1.45 Ga.

The current model for the Proterozoic (post-1.85 Ga) tectonic evolution at Forsmark is illustrated schematically in Figure 5-1 as a strike-slip fault system. The structural hierarchy reflects a variation in both the regional significance and relative timing of formation of these structures. Regionally important, WNW striking deformation zones (Forsmark, Singö and Örskär), and the NW splays from these zones (e.g. Eckarfjärden deformation zone), are ranked as first and second order R-Riedel structures, respectively. It is proposed that these structures formed by dextral strike-slip displacement in response to bulk crustal shortening in a N–S to NNW–SSE direction, during the latter part of the Svecokarelian orogeny (stage 1 and 2 in Figure 5-1). The activation of some steeply dipping NNW striking structures with sinistral strike-slip displacement is also inferred to have occurred at this stage in the tectonic evolution. Steeply dipping ENE to NNE striking structures are inferred to be initiated as third order antithetic Riedel structures with sinistral strike-slip displacement (stage 2 in Figure 5-1). In the same system, gently SE- and S-dipping structures are developed as fourth order structures as thrust faults sandwiched between the first and second order structures. By this, a framework for truncation of zones has been established.

All the four sets of deformation zones underwent significant reactivation during younger transpressional tectonic events, involving bulk crustal shortening in both NE–SW (possibly Gothian) and WNW–ESE (Sveconorwegian) directions. Documented sinistral strike-slip displacement along the WNW–ENE and NW–SE striking zones can be ascribed to these changed stress regimes. It is further suggested that a conjugate relationship between steeply dipping ENE striking structures and NNE to N–S striking structures, with sinistral and dextral strike-slip displacements, respectively, are related to these episodes, as well as dextral horizontal movement along the steeply dipping NE striking structures (stage 3 and 4 in Figure 5-1). During these reactivations, gently dipping zones were subjected to reverse dip-slip or strike-slip compressive deformation. According to the tectonic model, it can be expected that the gently dipping zones in the southeastern part of the Forsmark lens follow boudinaged layers of amphibolite (see Section 5.5) and both truncate against the steeply dipping ENE to NNE striking structures and are displaced by them.

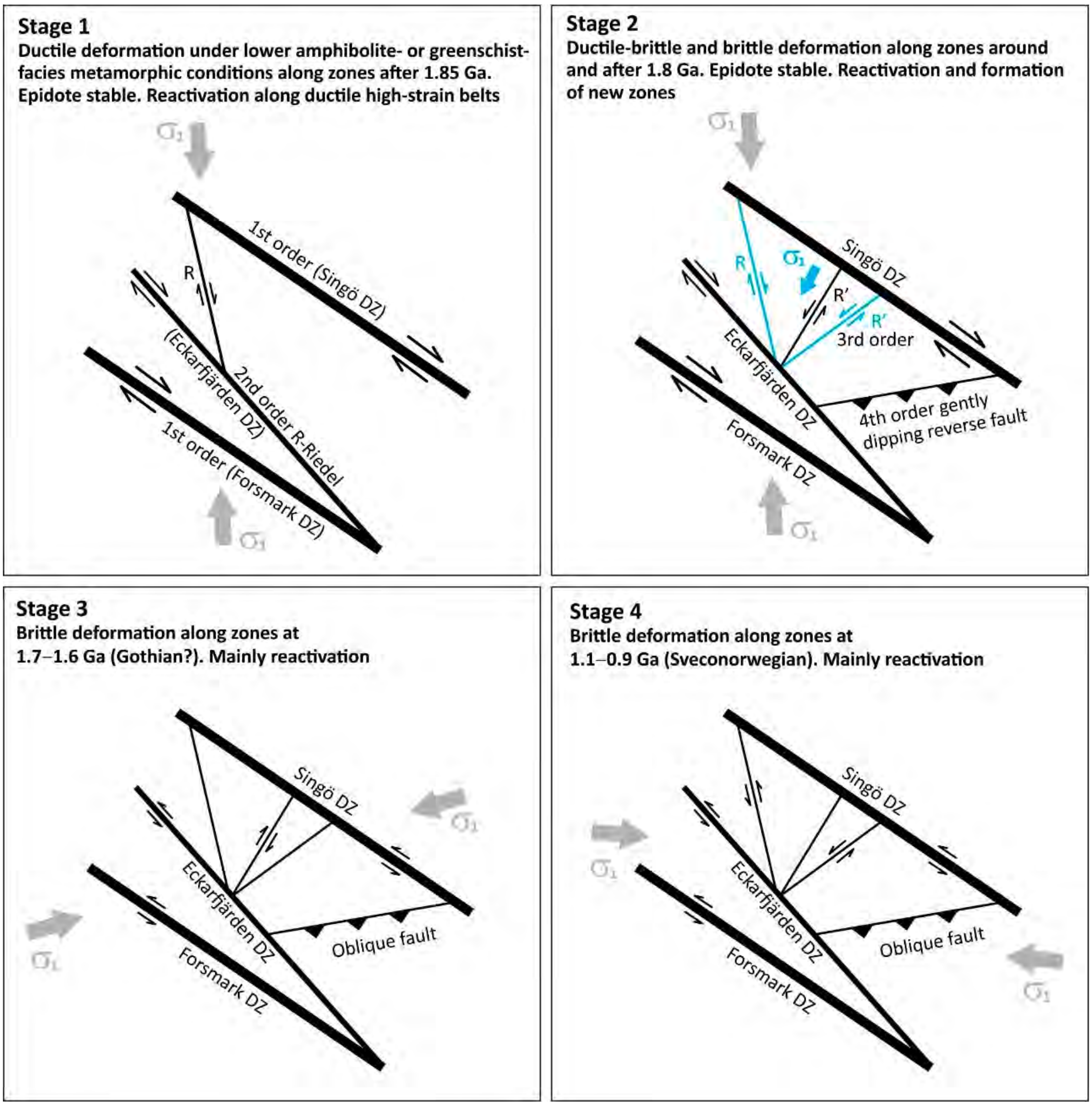


Figure 5-1. *Two-dimensional illustrations of the Proterozoic (post-1.85 Ga) tectonic evolution at Forsmark, with the inferred maximum principal paleostress (σ1) (Saintot et al. 2011) shown in grey. Transpressive deformation with a regional NNW–SSE σ_1 axis, combined with clockwise stress deviation inside the Forsmark tectonic lens between the Eckarfjärden and Singö DZ with a more NNE–SSW direction for the σ_1 axis (blue symbols), resulted in dextral strike-slip along regionally significant WNW–ESE and NW–SE deformation zones during the waning stages of the Svecokarelian orogenesis (stages 1 and 2). Younger transpressional tectonic events with NE–SW and nearly E–W σ_1 axes at 1.7–1.6 and 1.1–0.9 Ga (stage 3 and 4) resulted, for example, in sinistral reactivation along the WNW–ESE and NW–SE zones. The size of the arrows indicates an inferred variable degree of activity along the zones. Modified after Stephens et al. (2015).*

Around and after c. 1.45 Ga, loading and unloading cycles related to the deposition and denudation, respectively, of sedimentary rocks or glacial material have provided a significant impact on the geodynamic evolution in the Forsmark area. Based on kinematic data, it is suggested that the loading of sediments is related temporally with the reactivation of steeply dipping zones in the form of minor shear failure and dip-slip normal displacement. By contrast, unloading resulted in the reactivation of especially gently dipping structures, in the form of extensional failure and the development of dilatational joints. These loading and unloading cycles also invoked the driving mechanisms behind the formation of sheet joints, which is further discussed in Section 5.1.2. Sedimentary loading, besides tectonic events, was also a process of inferred significance for the build-up of high rock stress, a feature that presently characterises the northwestern part of the Forsmark tectonic lens down to ca 500 m depth (SKB 2008a).

Another relevant aspect to the deterministic modelling is the complex architecture of individual deformation zones. The current concept of brittle deformation zones (i.e. fracture zones) makes use of the generally accepted division of zones into undeformed host rock, transition or damage zone, and fault core (cf. summary in Hermanson and Petersson 2022 based on Munier et al. 2003), as well as the site-specific characterisation by the single-hole interpretation (Figure 5-2). At Forsmark, parts defined as transition or damage zones can range in thickness from a few metres up to several tens of metres. Relative to the unaffected host rock, these parts generally exhibit higher fracture frequencies and a more conspicuous hydrothermal alteration. The latter is defined by red-staining (see Section 4.2.2) due to sub-microscopic hematite dissemination of the minerals along the wall rock adjacent to fractures. Both sealed and open fractures usually increase in abundance inside the damage zones. In addition, damage zones can enclose segments of bedrock reminiscent of the unaffected host rock outside the actual deformation zone.

Based on the zone characterisation completed during the second stage of the single-hole interpretation (only available for boreholes from the site investigations that preceded the SDM-Site, see Section 4.1.1), fault cores have been recognised in approximately 50 % of the possible deformation zones identified with high confidence (SKB 2008a). These fault cores are typically intensely fractured with the occurrence of especially sealed fractures in complex networks, in combination with rock alteration. Cohesive breccia or cataclasite are also frequent along some fault cores. The thickness of the fault core ranges from a few centimetres up to a few metres. None of the studied zones contain fault gouge.

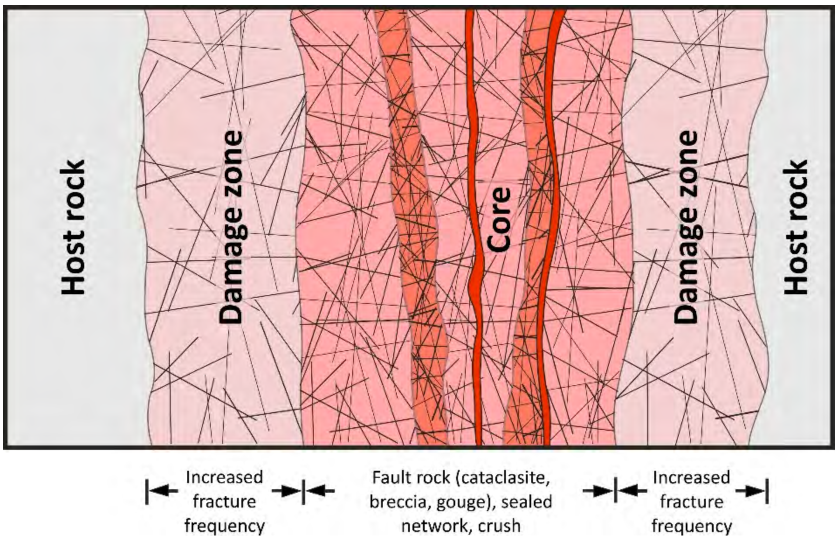


__Figure 5-2.__ Schematic illustration of a brittle deformation zone, showing various segments of undeformed host rock, damage zone, and fault core. Modified after Munier et al. (2003) and Hermanson and Petersson (2022).

5.1.2 Sheet joints

Sheet joints are evidently tensile structures thought to develop parallel to the two greatest principal compressive stresses in the rock mass. Perhaps the most widely invoked explanation for the origin of sheet joints is pressure release due to erosion of overburden (e.g. Thornbury 1954). This hypothesis is, however, inconsistent with some crucial field observations reported in the literature (e.g. Holzhausen 1989; Twidale 1973), and has consequently been abandoned during recent years by several workers in favour of an alternative mechanism involving compression parallel to a convex bedrock surface (Twidale et al. 1996; Martel 2011, 2017).

The basic principles of the mechanism are provided by Martel (2011, 2017), with a starting point in the variation of tensile stress normal to the ground surface (T) as a function of depth (z). Under the prime influence of gravitational stresses, this function has a straight, negative slope (Figure 5-3a, dashed curve). Other quantities with bearing on the function are the compressive stress parallel to the ground surface and the surface shape. Strong compressive stresses parallel to the ground surface in combination with a convex surface curvature can yield a positive slope (Figure 5-3a, solid curve), with a resulting tensile stress normal to the surface at shallow depths.

The next step to illustrate the essential physics of the mechanism, is by a thin element bounded by a convex, traction-free upper surface, which can be considered as a "skin" of a bedrock outcrop (Figure 5-3b). Compressive stresses acting parallel to the convex surface yield a net outward radial force on the element. If this overcomes the inwardly directed net force of gravity and the tensile strength of the material at the base, the element is brought into disequilibrium and would separate from its substrate.

Martel (2011, 2017) has expressed this by a re-formulation of the static equilibrium equations for a traction-free surface in a curvilinear reference frame, with two contributions from curvature-stress products and a contribution from gravity (see Figure 5-3c):

$$\left.\frac{\partial T}{\partial z}\right|_{z=0} = \phi = \sigma_{11} k_1 + \sigma_{22} k_2 - \rho g \cos\beta \qquad (5\text{-}1)$$

φ = slope in Figure 5-3a

k_1 and k_2 = the most positive and least positive curvature, respectively, at a point on the surface

σ_{11} and σ_{22} = stresses parallel to the surface in the directions of k_1 and k_2, respectively

ρ = density of the bedrock

g = gravitational acceleration

β = slope of the surface (cf. Figure 5-3b)

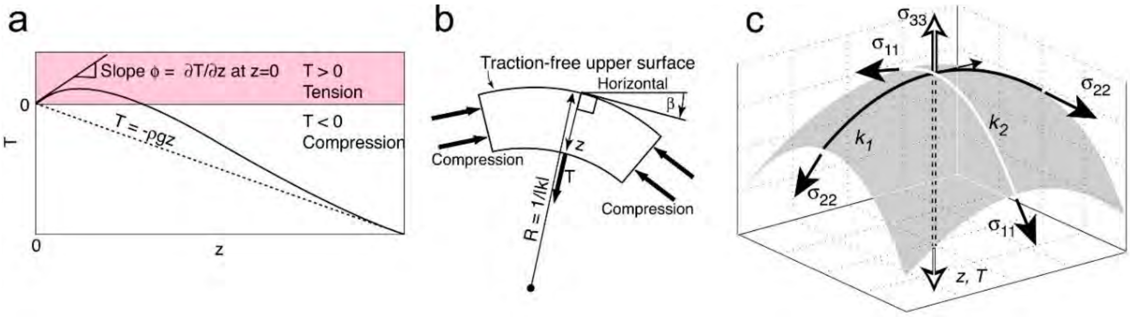


Figure 5-3. A series of figures from Martel (2011) to illustrate the mechanism of sheet jointing. (a) Curves showing the tension normal to a traction-free surface (T) as a function of normal depth (z) below the ground surface. The solid curve has a positive slope (φ > 0) in the shallow depths, whereas the dashed curve has a linear negative slope with progressively more compressive stresses with depth. (b) Cross-section showing compressive stresses (unlabelled bold arrows) parallel to a thin concave element of a traction-free surface with a tensile stress (T) at the base of the element. R = radius of surface curvature. (c) Curvilinear local reference frame with its origin at the surface of a convex body, with axes aligned along directions of the principal curvatures.

Where the sum of the two stress-curvature products exceeds the negative contribution from gravity, φ will be positive and a resulting tensile stress arises perpendicular to the surface at shallow depths; a necessary criterion for the formation of sheet joints.

An important aspect of this equation is that the penetration depth of the curvature-induced tension is fully dependent on k_1 and k_2 with principal radii of $R = 1/|k|$ (cf. Figure 5-3b). The consequence is that the penetration depth increase as the surface curvature decreases. Thus, sheet joints beneath broad, gently curved surfaces would extend to greater depths than those beneath small highly curved bumps (Martel 2011).

An additional positive contribution to the driving pressure gradient is water pressure, which expands and deepens the regions where sheet joints can develop substantially.

Rock type properties, in terms of unconfined compressive strength and density, are also decisive for the development of sheet joints, which explains frequent reports from massive rocks, such as granites, with an ability to sustain high compressive stresses. Accordingly, sheet joints are conspicuously absent in intensely fractured rocks (e.g. Jahns 1943) and weak rocks such as shales, which fail in shear under large differential stresses (e.g. Nygård et al. 2006).

Since the mechanism of Martel (2011, 2017) fails to account for the formation of sheet joints in non-convex bedrock morphologies, Ziegler (2013) argues for an alternative approach with formation as extensional fractures in an anisotropic, compressive stress field, analogue to longitudal (axial) splitting. Accordingly, the joint onset is dependent on the crack initiation threshold and the development into a macroscopic sheet joint requires a maximum/minimum principal stress ratio (σ_H/σ_v) that exceeds approximately 10 (Ziegler 2013). The mechanism finds primary support in joint surface morphologies (fractographic markings), laboratory experiments and the in situ stress state with high in situ compressive stresses in the shallow rock mass. A problem is that the crack initiation threshold for the competent, often granitic rocks, in which sheet joints tend to occur, generally is far too high (approximately 30–60 % of the uniaxial compressive strength, e.g. Martin 1997) to allow the initial joint formation. Thus, either the sheet joint propagation depends on pre-existing microcracks or a process such as stress corrosion (cf. Ziegler 2013 and references therein) that might allow crack initiation at a lower differential stress.

According to the formation mechanism proposed by Martel (2011; 2017), the key parameters responsible for sheet joints are:

- large surface-parallel compressive stresses, typically several MPa or greater, and
- a convex topographic bedrock surface with the ability to deflect the near-surface stresses.

The current stress magnitudes yielded by the proposed stress model for the shallow rock mass in Forsmark (Glamheden et al. 2007) are largely equivalent with the high compressive surface-parallel stresses in most sheeted rock masses (cf. Martel 2017), especially in FFM02. The conditions appear less favourable in FFM03, with considerably lower stress magnitudes in addition to stress-release through a package of gently dipping fracture zones (i.e., ZFMA4–A7, ZFMB1 and ZFM866) is to be expected (see Figure 5-4).

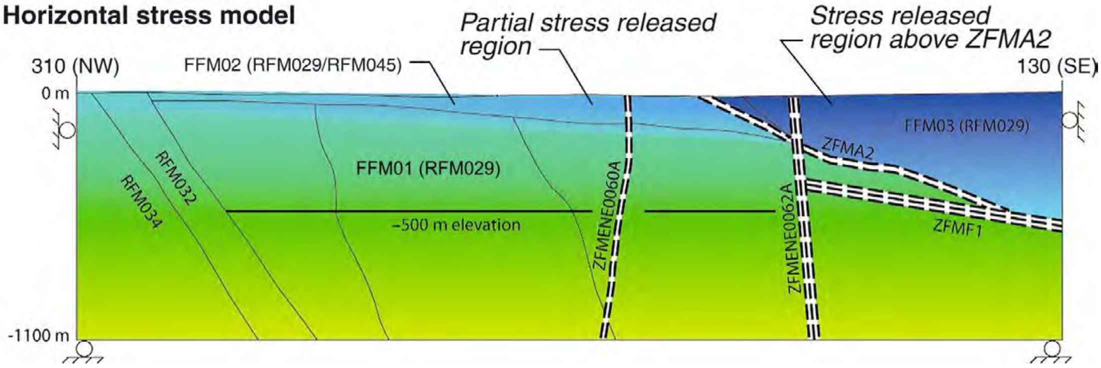


Figure 5-4. *Distribution of maximum horizontal stress models along a NW–SE striking profile in the north-western part of the tectonic lens. Blue shades represent reduced stress magnitudes caused by stress release in FFM02 and FFM03 compared with the "normal" stress magnitudes shaded green. From SKB (2008a).*

The second parameter of significance is the curvature of the bedrock surface. The current bedrock topography of Forsmark combined with a low-gradient shoreline do not appear to possess sufficient curvature to account for the systematic appearance of sheet joints described in Section 4.3. However, turning to the recent tectonic history of the Forsmark area, loading and unloading cycles in connection with burial/denudation of sedimentary rocks and glaciations/deglaciations have provided a profound impact on the stress situation in the near-surface realm, which in turn influence the potential to develop sheet joints. In addition to stress build-up, such loading tends to produce an elastic upward bending of the lithosphere peripheral to the sedimentary basin or glaciated area. The phenomenon is known as flexural or peripheral forebulge and could produce an uplift that amounts to 3–4 % of the maximum depression, independent of the mantle rheology (e.g. Brotchie and Silvester 1969; Crampton and Allen 1995). The wavelength of such forebulges may range up to several hundreds of kilometres, whilst the amplitude is estimated to a maximum of several hundred meters. During the emplacement, the sedimentary or glacial load creates a radial crustal extension within the upper crust of the uplifted forebulge (Figure 5-5a); an unfavourable situation for the development of sheet joints. A collapse and simultaneous migration of the maximum forebulge during the phase of isostatic rebound, as the displaced mantle flows back into the area beneath the former load, give however rise to compression in the forebulge region (Figure 5-5b). The flexural stresses imposed by such a rebound may typically match or even exceed the magnitude of the prevailing tectonic stress field (e.g. Stein et al. 1989), with an inferred net horizontal compression of sufficient magnitude to promote formation or propagation of sheet joints.

With several loading-unloading cycles, it seems plausible that the majority of the sheet joints occurred as soon as the stress situation permit their development, perhaps already in connection with the exhumation of the sub-Cambrian peneplain or some Palaeozoic loading-unloading event, such as the sedimentary erosion of the foreland associated with the Caledonides (cf. Cederbom et al. 2000). Most of these sheet joints, inferred to have formed in response to early loading-unloading cycles, were hence already present at the time of the Late Cenozoic glaciations-deglaciations. As such they are available for reactivation and possibly glacially induced hydraulic jacking (cf. Hall et al. 2019), which is implied by the frequent occurrence of compacted sediment fillings and re-deposited pollen with pre-Holocene signature in the more surficial sheet joints at the Forsmark site (e.g. Carlsson 1979; Leijon 2005).

The general lack of mineral coating, filling or wall rock alteration in the sheet joints provide a scanty input to these speculations, since the deficiency can be attributed to near-surface processes of dissolution during the last c. 500 million years, as well as a recent origin during the Quaternary. However, there are actually a few inferred sheet joints that evidently have mineral coatings and/or wall rock alteration such as reddening (Figure 5-6). This suggests that at least some sheet joints have been attributed to hydrothermal activity and consequently were formed in response to or predate a major burial by sedimentary rocks, presumably during the Palaeozoic. Interestingly, Lidmar-Bergström (1997) proposes that sheet joints in the Jungfrun granite, in southeastern Sweden, are of Cambrian age or older, based on findings of sandstone infillings by Mattsson (1962).

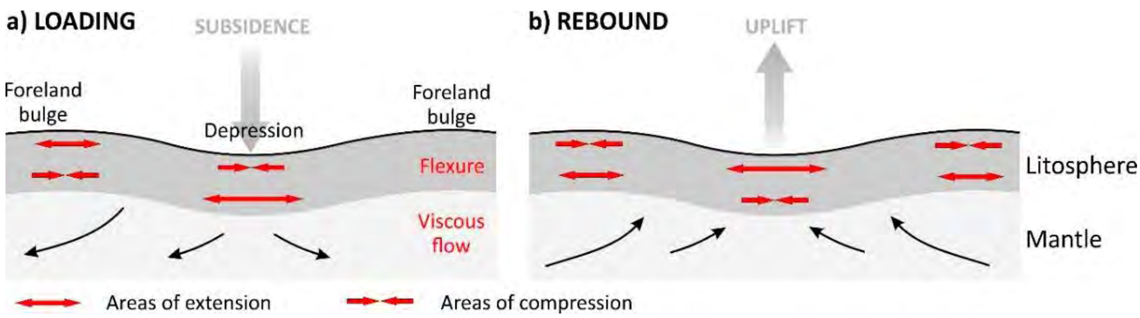


***Figure 5-5.** Schematic illustration of flexural stress field in the lithosphere during the (a) loading and (b) unloading in connection with burial and removal of sedimentary rocks or ice sheets. Redrawn from Shaw (2012).*

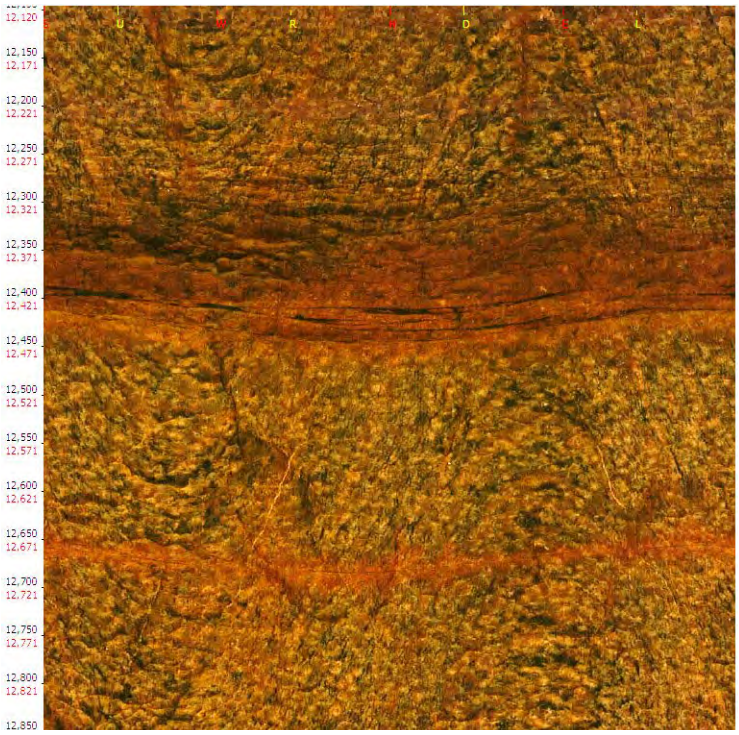


Figure 5-6. *BIPS image showing a swarm of inferred sheet joints at 12.3–12.7 m length in percussion borehole HFM42. The character is typical for dilatational joints formed by extensional failure. Distinct reddening reveals hydrothermal oxidation along all joints. The main fracture swarm is located at ca 10 m below the bedrock surface.*

The local spatial variability in the occurrence of sheet joints, as shown in the northwestern part of the Forsmark tectonic lens, can primarily be attributed to heterogeneities in tensile strength of the material (lithology, ductile fabric, etc.) in combination with the shallow stress conditions, where the latter is highly dependent of the shape of the bedrock surface. Another contributing factor may be differential glacial erosion.

5.2 Definition and naming of modelled objects

Definitions of the terms deformation zone and sheet joint are provided by Hermanson and Petersson (2022), with further details in Munier et al. (2003) and Stephens et al. (2007).

Deterministically modelled deformation zones and sheet joints are identified as ZFM and JFM, respectively, where Z = zone, J = joint and FM = Forsmark site. The abbreviations are followed by two to six letters or digits according to the following principles:

- Sheet joints – a three-digit serial number starting at 001 (e.g. JFM004).
- Gently dipping (≤ 45°) deformation zones – those based on inferred seismic reflectors inherit the name of the reflector (e.g. ZFMA3), whereas the remaining gently dipping zones are labelled by three to four digits (e.g. ZFM871). Zones divided into two separate segments (east and west), due to limitations of the RVS modelling tool, are denoted by the suffixes -e and -w (e.g. ZFMA6-e).
- Moderately dipping (> 45° to < 70°) deformation zones – currently no such zones in the Baseline model.
- Vertical to steeply dipping (≥ 70°) deformation zones – Two to three letters providing information about the strike of the zone, followed by four digits, typically inherited from the name of the primary lineament upon which the zone is based (e.g. ZFMNNW0999). Association between primary zones and subordinate splays and subsections are denoted by the suffixes A (primary zone), B and C (subordinate zones).

The letters that give information about the strike of vertical to steeply dipping zones are strictly applied according to the nomenclature introduced by Stephens et al. (2007) to name fracture clusters along deformation zones, but do not follow the right-hand-rule convention. Applied acronyms with corresponding strike values are as follows:

EW 085–095° and 265–275°

WNW 095–125° and 275–305°

NW 125–145° and 305–325°

NNW 145–175° and 325–355°

NS 175–185° and 355–005°

NNE 185–215° and 005–035°

NE 215–235° and 035–055°

ENE 235–265° and 055–085°

5.3 Methodology and assumptions

5.3.1 Heterogeneous zone resolution throughout the model volume

Before merging, the resolution of modelled deformation zones was different in the local and regional model volumes. Each volume contained all modelled deformation zones down to a certain size, based on the measured lineament trace length on the ground surface. Following the principle that a zone is represented by one geometry regardless of the model volume, the regional zones were identical in both the local and regional model volumes.

By merging, all modelled deformation zones are included in one single volume regardless of size. However, such a representation must be used with caution since it mixes sub-volumes of different data density within a single model boundary; heterogeneity in data density does not allow for deterministic modelling of small-size zones throughout the model volume. This in turn can have major implications to modelling of hydraulic connectivity or transport within the rock mass, as well as the rock stress modelling. In the current version of the Baseline Forsmark model, such uncertainties in the deterministic heterogeneity are addressed by alternative representations using stochastic DFN models (cf. Hartley et al. 2024).

5.3.2 Interpolation and extrapolation of zones

The low magnetic lineaments provide the starting point for the identification of steeply dipping (> 70°) or vertical deformation zones at the ground surface. More uncertain, topographic lineaments based on depressions in the ground surface have been used locally in the areas where the magnetic data are of poorer quality, for example in the vicinity of the nuclear power plant (SKB 2005). The zone projection towards depth is achieved by matching the lineament to possible deformation zones identified along boreholes in the single-hole interpretation. The matching process is largely geometrical, but correlation is further supported by the overall geological character in the borehole, in particular the analysis of the orientation of fractures and brittle-ductile structures along the zone. Thus, the structural orientation in each zone is used as guidance to link a particular borehole section to a suitably oriented lineament. For modelled zones that intersect the SFR facility, the matching between lineaments and borehole data have been broadened to involve available geological information from the tunnels. Although scarce, outcrop data have also been considered in the modelling of a few zones.

Guidance for the truncation pattern along the strike direction of these zones, are provided by the lineament model in combination with conceptual understanding. Thus, generally the length of steeply dipping zones at the ground surface is represented by the length of the corresponding lineament. However, the overall continuity of the lineaments has been continually reviewed during the modelling and the background data re-examined. Alternative alignments and extents for individual lineaments have been considered, often driven by geological information from boreholes or tunnel mapping and some have been implemented after a joint review by both the geologists and geophysicists.

The strike of steeply dipping zones is assumed to be determined by the trend of the matching lineaments, whereas the dip of the zones is determined by matching of lineaments to particular borehole and tunnel intervals. Strike and dip are denoted as the average angles along the entire extent of a zone. Deformation zones that are observed only at the ground surface and lack information on their sub-surface extents from boreholes and tunnels intersections and geometry, are generally estimated by comparison with the dip of zones that intersect one or more boreholes and show a similar strike. However, in the SDM-PSU these zones are assumed to be vertical.

Termination of zones at depth is made according to the following principles:

- The termination depth is equal to the trace length of the deformation zone at the ground surface (elevation = 0), if the length is less than 2 100 m.
- Zones with trace lengths exceeding 2 100 m terminate at the base of the model volume (i.e. −2 100).
- The extent of subordinate splays and subsections (i.e. B and C) is controlled by the termination depth of the main deformation zone (i.e. A; see examples in Figure 5-7).
- Rounding is based on the ground surface trace lengths, where trace length > 1 000 m is rounded to the nearest 50 m elevation, and trace length < 1 000 m is rounded to the nearest 10 m elevation.
- Departure from the principles of termination depth is allowed where a shorter zone is used for truncation of a longer zone; then the termination depth of the shorter zone has been increased to match the truncated zone.

Gently dipping deformation zones (< 45°) have been detected by an integration of more distinct seismic reflectors and possible deformation zones identified along boreholes in the single-hole interpretation. As for the steeply dipping and vertical zones, the matching of a reflector to a possible deformation zone follows the same analytical procedure with guidance from especially fracture orientation data along the zone. The orientation of the gently dipping zones is provided by the inferred orientation of the corresponding seismic reflector and not the orientation of the fractures inside the zone.

In accordance with the conceptual understanding of the site, the modelled extent of the gently dipping zones has been constrained by the lateral extent of the supporting investigation evidence with an assumed truncation, both along their strike and dip, against the nearest regional or major deformation zone with steep to vertical dip. This approach has also steered the splay relationship between the gently dipping zones (Figure 5-8). However, there are some exceptions, as illustrated in Figure 5-8.

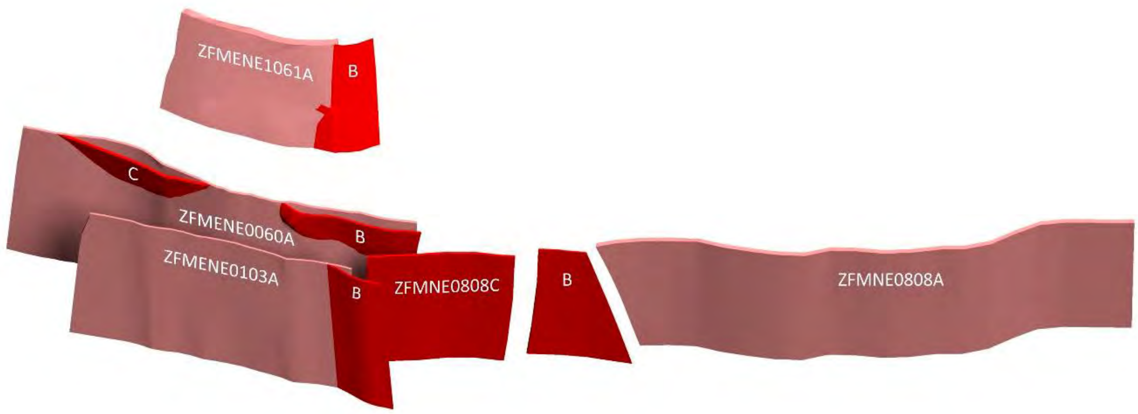


Figure 5-7. *Examples of splays and subsections of deformation zones (red – B and C) where the termination depth is controlled by that of the main deformation zone (light red – A). View towards the northwest. Trace lengths at ground surface for ZFMENE1061A and ZFMNE0808A are 1 200 and 4 077 m, respectively.*

Figure 5-8. *Illustration of the splay relationship between some of the major gently dipping zones of the site where ZFM866, ZFMB1 and ZFMF1 are truncated against ZFMA3, whereas ZFMA2 and ZFMA8 are truncated against ZFMA3 and ZFMF1. View towards the ENE. Trace lengths at ground surface for ZFMA2 and ZFMA3 are 4031 and 3196 m, respectively.*

5.3.3 Zone length

Similar to lineaments, deformation zone length is related to the scale of assessment and the elevation of measurement. Thus, length estimates only give a rough indication of deformation zone size.

The entity refers to a projection of the overall traceable zone length along the ground surface to elevation = 0 (RH2000). Zones that fail to reach the ground surface have hence no length indication. Estimated lengths take account of the continuation of a zone outside the model volume of DMS Baseline Forsmark.

5.3.4 Zone thickness

Brittle deformation zones (i.e. fracture zones) may in reality have very complex architecture with various segments of damage zone, fault core and parts virtually unaffected by the brittle deformation within the zone (see Section 5.1.1). As illustrated in the conceptual sketch of Figure 5-9, both the zone thickness and the proportions of the various segments may vary considerably along a zone, and consequently from one borehole to another. However, zones are modelled with constant thickness to include the internal variability, without distinction between damage zone, fault core and more unaffected parts (cf. Figure 5-9). This is because of the inability to interpolate structural details and variability over the distance of adjacent borehole (or tunnel) intersections. If ductile deformation is present along the zone, this is also included in the thickness estimate. However, the occurrence of intense ductile is largely limited to deformation zones of regional extent along the margins of the tectonic lens and the volume in proximity to the SFR facility.

Modelled zone thickness is primarily estimated based on borehole intersections, as supporting tunnels and outcrop observations are scarce. Where more than one borehole intersection exists, the thickness has either been defined as a mean value of the estimated thicknesses in all intersecting boreholes or by the estimated thickness in one or more borehole intercepts, judged to be most reliable. By this approach, parts of an inferred zone intercept along a borehole can occur outside the modelled zone boundaries and vice versa (Figure 5-9).

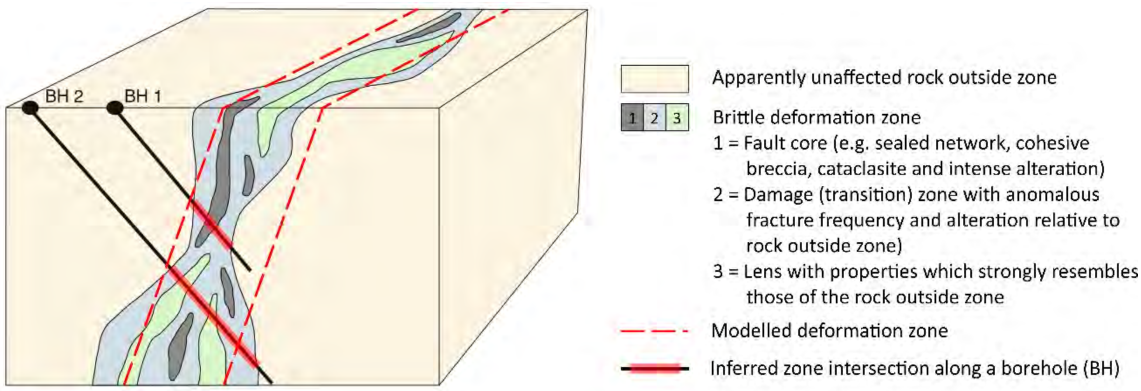


Figure 5-9. *Simplified illustration of a brittle deformation zone divided into three different segments: fault rock (e.g. Cane et al. 1996), damage zone (e.g. Gudmundsson et al. 2001) and parts virtually unaffected by the brittle deformation along the zone. Red dashed lines outline modelled zone with constant thickness. Note the variable character and thickness of the zone along the two borehole intersections (BH1 and BH2). Redrawn after Cane et al. 1996 and Stephens et al. 2007.*

Two specific borehole related terms are quoted in the deformation zone descriptions and accompanying property tables (Appendix 7), *target intercept* and *geometrical intercept*:

- A target intercept is the interpreted position of a deformation zone along a borehole essentially based on anomalously high fracture frequency (both open and sealed fractures) in combination with the existence of brittle-ductile deformation and hydrothermal rock alteration. In general, target intercepts conform to the intercepts of possible deformation zone identified during the geological SHI (see Figure 5-10), in certain cases with adjustments based on complimentary information. A target intercept is described by an upper and lower borehole length (sec_up/sec_low).
- A geometrical intercept is the intersection between a modelled zone and an individual borehole as they are modelled with the RVS modelling tool (see Figure 5-10). The intercept is described by an upper and lower borehole length (sec_up/sec_low) provided by the intersection of the bounding surfaces of the modelled zone.

Technically, deformation zones are modelled by fitting of a single origin surface to interpreted lineaments/reflectors and target intercepts along boreholes. Volumetric geometries or thicknesses to capture the target intercepts are achieved by perpendicular transposition of clones to the origin surface (Figure 5-10). For most deformation zones the origin surface is located centrally between the bounding surfaces with equal thickness values on each side. However, for the deformation zones of SDM-Site, the origin surfaces were modelled to reflect the inferred position of the zone core. Several of the zones inherited from SDM-Site (about one third of all zones in the Baseline version) have therefore origin surfaces with asymmetrical positions between the bounding surfaces (Figure 5-10).

Difficulties arise in the deformation zones where thickness data from boreholes, tunnels and outcrops are lacking. With support from the literature and a foregoing discussion of the serious limitation of the approach, Stephens et al. (2007) solved this by introducing a thickness-length correlation chart based on deformation zones where both thicknesses and lengths are "known". Since the length of gently dipping zones is highly uncertain, only vertical and steeply dipping deformation zones were included in the thickness-length correlation chart. The thicknesses of gently dipping zones that lack supportive geological and geophysical data were estimated simply by a comparison with the thickness of appropriate high confidence, gently dipping zones (see Stephens et al. 2007).

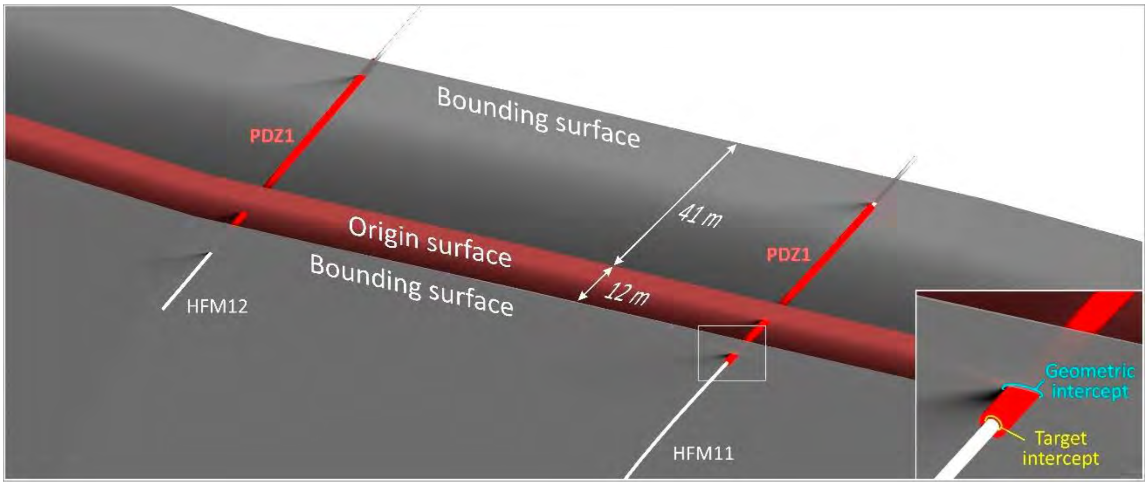


Figure 5-10. *Detail of the origin and bounding surfaces (brownish red and grey, respectively) of deformation zone ZFMNW0003 relative to possible deformation zones (PDZ1, red) identified along the intersecting boreholes HFM11 and HFM12. The origin surface has been modelled with an asymmetric position relative to the bounding surfaces to reflect the inferred zone core. Inset – enlargement to illustrate the terms target and geometrical intercept.*

With reservations for high degrees of uncertainties, the power law function $T = 0.2L^{0.6}$ yielded by the thickness-length correlation chart presented in Figure 5-11 has been used to estimate the following two parameters for vertical and steeply dipping deformation zones of SDM-Site, where direct geological information was lacking:

- The thickness of deformation zones where only the ground surface length is known form associated lineaments. Calculated thicknesses are rounded off to the nearest 5 m.
- The possible range in thickness that might be expected along each deformation zone.

Although the function was established already during the Forsmark stage 2.2 modelling work (SDM-Site), it was subsequently applied to deformation zones of Forsmark version 2.3 (Stephens and Simeonov 2015) and all zones that were added or remodelled after the merging of SDM-Site and SDM-PSU. The basic arguments for this are:

- A reluctance to change of thicknesses of zones modelled during preceding stages where the underlying data for the specific zone remain unchanged.
- Consistency in the thickness estimate regardless of the stage during which the zones were modelled.
- Subsequent addition of zones (mainly local minor zones from the SFR area) and changes in thicknesses and lengths for zones of Forsmark stage 2.2 (cf. Figure 5-11), have rather limited effect on the power law function.

Regression analysis made by Curtis et al. (2011) to investigate possible zone thickness-length relationships of SDM-PSU revealed an inability at describing the aggregate data by a single relationship with any real statistical power. Therefore, an alternative approach has been applied to deformation zones of SDM-PSU without supporting geological information, where the assigned thickness is 1 % of the zone's trace length at the ground surface, rounded off to the nearest 5 m.

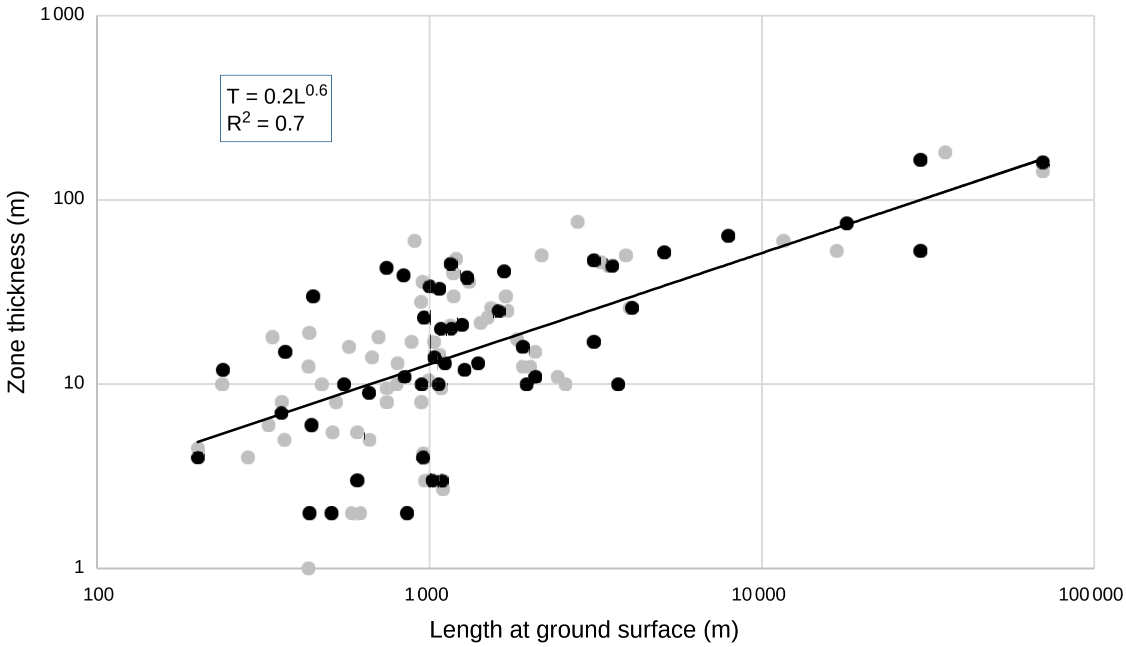


Figure 5-11. *Power law correlation diagram between thickness and length at ground surface of deterministic deformation zones, based on model stage 2.2 data from Stephens et al. (2007). Corresponding data for the Baseline model are shaded; these are uncoupled to the power law regression.*

In general, the possible range in thickness that can be predicted along each steeply dipping zone is estimated on the basis of five different length classes, as presented in Table 5-1. The maximum variability in thickness along each zone is defined by the thinnest and thickest zones within each length class. This means that virtually all steeply dipping zones within a specific length class have the same range in thickness. However, there are exceptions, which include the majority of the zones inherited from SDM-PSU. Thickness spans for these zones are instead based on a general assessment of available borehole and tunnel data for a particular zone.

Table 5-1. The length classes used to define possible thickness spans for the majority of deformation zones included in SDM Baseline Forsmark version 1.0.

Length [m]	Estimated thickness span [m]
< 500	2–30
500–1 000	2–43
1 000–3 000	3–50
3 000–10 000	15–64
> 10 000	50–200

5.3.5 Assignment of geological properties

The geological properties assigned to each deformation zone are given in Table 5-2. These are identical to those presented in the deformation zone property tables provided by Stephens et al. (2007), Curtis et al. (2011) and Stephens and Simeonov (2015) for SDM-Site and SDM-PSU. Except for an increased occurrence of borehole intersections along some deformation zones in proximity to the planned access volume of the final repository and immediately southeast of the SFR facility, the geological properties have been assigned using the same type of data as for SDM-Site and SDM-PSU.

Table 5-2. Properties assigned to deterministic deformation zones of the Baseline Forsmark model.

Property	Comment
Deformation style	Brittle, brittle-ductile or ductile, including the possible presence of fault rocks (e.g. cohesive breccia and mylonite).
Sense of displacement	Described in terms of slip direction (e.g. normal, reverse, sinistral and dextral).
Alteration	Type and degree of alteration.
Fracture character	Main fracture character, including fracture types (open, sealed, crushes, sealed networks, etc). Due to the intrinsic limitations of the data on fractures from percussion boreholes, such data are generally only used when data on fractures from cored boreholes are lacking.
Orientation	Strike/dip, right-hand-rule method. Based on evaluation of Terzaghi-corrected fracture stereograms. Only fractures visible in BIPS are included. Open/partly open and sealed fractures are differentiated. Clustering has been analysed by the definition of soft sectors (see Appendix 15 in Stephens et al. 2007 for further details).
Frequency	Terzaghi-corrected P10 fracture frequencies. Open and sealed fracture frequencies are presented separately. Includes crushes and sealed networks, where the fracture frequency is calculated on the basis of the piece length of the rock fragments inside the structure. A direct count of fractures has not been made.
Filling	Mineral coating or filling are specified for open/partly open and sealed fractures. In data from older SFR boreholes, this information differentiates between 'broken' or 'unbroken', in accordance with the limitations of the mapping technique applied at that time.

Each geological property is assigned a property confidence level based on a three-level scale. Where geological data from borehole, tunnel or surface investigations are available, the properties of the zones are relatively well-constrained and, in many cases, a property is assigned a high level of confidence. However, properties are most commonly derived from a restricted number of borehole intersections and, only in a few cases, from tunnel investigations, surface outcrops or a single surface excavation. Thus, the estimated properties need to be treated with care when extrapolating to the bedrock beyond borehole and tunnel intersections. For that reason, some geological properties have been assigned a medium or low level of confidence, even if geological data from borehole, tunnel or surface investigations are present. The adjustment from a high to a lower level of confidence, for a particular geological property, includes:

- Medium level of confidence to the estimates of fracture character (orientation, frequency, and filling) in virtually all deformation zones, since these data emanate from a restricted number of borehole intersections.
- Low level of confidence to the assessment of the style of deformation and fracture frequency in zones intersected solely by percussion boreholes, due to insufficient data quality.
- Low or medium level of confidence to the estimates of the sense of displacement along zones, when shear striae data emanate from a restricted number of borehole intersections; less than nine measurements from one or more boreholes = low level of confidence, higher quantity of shear striae data from one or more boreholes = medium level of confidence.

Where geological data are lacking, general information about deformation style and alteration has been obtained by comparison with zones of similar orientation and size. Such estimates are assigned a low to medium level of confidence. No information regarding fracture character and sense of displacement is given for these zones.

5.3.6 Strategy for modelling of sheet joints

The dilatational nature of the sheet joints has significant implications for both the identification and modelling approaches. One issue is to identify individual joints of such extent that they allow deterministic modelling. Information from the construction of the nuclear power plants in Forsmark (Carlsson 1979), suggests that aperture is the only reliable proxy for recognition of sheet joints with lateral size of several tens of meters or more. Provided that there is an absence of sealing sediments, aperture is also the only geological parameter with the ability to suggest whether a joint may be of importance as flow path. Based on this, it was decided to focus the modelling work on sub-horizontal joints with distinct aperture.

Once sheet joints with distinct apertures have been selected, questions regarding the deterministic modelling approach remains; is it possible to single out a specific joint in several boreholes or might the spatial distribution be handled volumetrically, by a domain concept? Contrary to structures developed by shear failure, sheet joints lack kinematic support for interpolation. Also, the possibility of extrapolation and the mode of termination differ from those of shear structures. Briefly speaking, sheet joints are less predictable than shear structures with increasing distance from the observation points. With a reasonable confidence in the validity of interpolation, individual sheet joints can therefore only be modelled deterministically in rock volumes where observation points are closely situated. The consequence of this is that some parts of the rock mass, with few or no observation points remains undescribed, which would be a violation of the "space filling" principles, which states that the geometrical model needs to be described at all points (Munier et al. 2003). A possible approach is to describe volumes with too few observation points to allow reliable deterministic modelling by coupled stochastic simulations. By using this approach, deterministic representations of individual sheet joints will serve as input to the stochastic modelling (cf. Hermanson and Petersson 2022).

Based on the argumentation in the preceding paragraph, it was decided to provide deterministic representations of individual sheet joints with distinct aperture, in those cases where available data permit modelling of acceptable confidence. This modelling principle relies primarily on assumptions established by Hermanson and Petersson (2022) for modelling of sheet joints based on observations from the excavation for the inlet channel to the nuclear power plants (Carlsson 1979) and details in the literature on sheet joints. Concerning orientation and extent, the following two assumptions are used to steer the modelling procedure:

- Due to the long-wave, flat topography of the bedrock surface in Forsmark, all sheet joints are inferred to be horizontal to sub-horizontal (dips ≤ 3°).
- The largest individual sheet joints can have dimensions of a few hundred meters laterally (i.e. the approximate size of the longest joint trace mapped by Carlsson along the inlet channel).

In accordance with these assumptions, the following approach has been used:

- To allow interpolation, observation points must be located at approximately the same elevation, ± 1 m.
- Whether an observation point is of hydraulic significance or not is irrelevant for interpolation.
- The aperture of individual observation points is irrelevant for the size (horizontal extent).
- A modelled surface must be based on three or more observation points.
- Surfaces are modelled by constant thickness with a minimum of 0.1 m.
- Interpolation based on geological observations is limited to a horizontal distance of 100 m, which is the approximate radius of the longest joint trace along the inlet channel (cf. Carlsson 1979). Additional interpolation up to 150 m is possible with support from hydraulic responses.

Analysing the borehole data, it became obvious that the modelling of individual sheet joints is incapable of describing the systematic distribution of sheet joints with aperture in the near-surface realm. Instead, it was decided to handle this by a further subdivision of FFM02 by introducing a horizontal boundary between an upper and a lower slab (see Section 7.5).

Thus, the deterministic representation of individual sheet joints at the Forsmark site is based on the mapping along the inlet channel by Carlsson (1979) and interpolation observation points in boreholes. Joints that fail to fulfil the criteria for individual representation are omitted (e.g. three or more observation points and observations separated by a horizontal distance of ≤ 100 m), irrespective of their actual extent.

Based on their dilatational nature, the termination mode of sheet joints differs to that of the shear-induced deformation zones. Sheet joints are expected to cross both steep geological structures and lithological boundaries, though they are assumed to interact with gently dipping deformation zones. Terminations can also occur due to a decreasing stiffness of the rock mass. However, the vast majority fade out without any obvious structural or lithological explanation. This has implications for the distance of confident extrapolation and individual sheet joints are extended to a horizontal distance that corresponds to 1/3 of the maximum distance between nearby observations. Additional details of the method used during extrapolation are provided by Hermanson and Petersson (2022).

5.4 Adjustments to deformation zones after merging the models

5.4.1 Naming

Extensions and shortenings along the strike of several deformation zones inherited from SDM-Site and SDM-PSU zones have affected their strike direction. These changes are typically limited to a few degrees, with a maximum of 6°. However, strictly applying the acronyms that give information about the strike of vertical to steeply dipping zones (cf. Section 5.2), requires revised naming for twelve of the modelled zones. For some of these zones, the discrepancy between the acronym and the actual strike dates back to the time before the models were merged. The zones with revised naming are listed in Table 5-3.

Table 5-3. Deformation zones with revised naming due to changed strike or a less strict application of the acronyms for strike in previous model versions.

Original zone name (SDM-Site and SDM-PSU)	Zone name in Baseline Forsmark version 1.0
ZFMENE0810	ZFMNE0810
ZFMEW0137	ZFMWNW0137
ZFMEW1156	ZFMWNW1156
ZFMNNE2308	ZFMNE2308
ZFMNNE2309	ZFMNE2309
ZFMNNE3266	ZFMNE3266
ZFMNW0806	ZFMNNW0806
ZFMWNW0016	ZFMNW0016
ZFMWNW0036	ZFMNW0036
ZFMWNW0851	ZFMNW0851
ZFMWNW0974	ZFMNW0974
ZFMWNW8043	ZFMNW8043

5.4.2 Geometric adjustments due to mering the models

Deformation zone doublets and thickness

Several deformation zones occurred in both SDM-Site and SDM-PSU. The majority are steeply dipping, NW- to WNW-striking zones, belonging to the deformation belts of Singö (i.e. ZFMWNW0001 with splays) and ZFMNW0805A. During the upgrading of Forsmark stage 2.2 to version 2.3, all deformation zones in the SDM-PSU regional model volume have been integrated (cf. Stephens and Simeonov 2015). It was consequently decided to select the geometric representations from the Forsmark version 2.3 as input to the Baseline model where there are doublets in the two models. However, three zone representations (ZFM871, ZFMENE3115 and ZFMNW0805A) from SDM-PSU replace those with the same name in the SDM-site.

Although the regional SDM-PSU model and the local model of Forsmark version 2.3 have identical size limits for deformation zones (see Section 2.1), the modelled thickness differs slightly between the two models for some of the zone doublets. The choice of zone geometry has affected the thickness for three zones ZFMNNE0725, ZFMNNE2308 and ZFMWNW0001, which all are adopted from Forsmark version 2.3. In addition, the thickness of the SFR-zone ZFMENE3115 has been reduced from 28 to 10 m, based on the following text from the zone's property table in Curtis et al. (2011): *"It should be noted that the modelled zone thickness of 28 m is based on KFR102A DZ3. An alternative interpretation of DZ3 is that it represents more than one zone, and this would result in a reduction of ZFMENE3115 thickness to around 10 m."*

In connection with merging the models, changes were also made to ZFMNNE2312, a local minor deformation zone in proximity to the access volume of the planned repository for spent nuclear fuel (see Section 5.4.4). The thickness was reduced from 43 m to 19 m by using SHI DZ2 (the second possible deformation zone from the start of the borehole) of KFM08C and ignoring the data from percussion borehole HFM38.

Termination depth

During the merging process, individual deformation zones underwent a reassessment of the termination depth with strict application of the principles presented in Section 5.3.2. Departure from the principles of termination depth is allowed where a zone truncates a slightly deeper zone. On this basis, the termination depth has been extrapolated to a lower elevation for five deformation zones: ZFMENE3115, ZFMENE3135, ZFMNE3137, ZFMNNW0101 and ZFMNNW0404.

Application of the principles has resulted in changed cut-off depth for a total of 50 zones: 23 in SDM-Site, 21 in SDM-PSU and six minor zones with surface trace length < 1 000 m in Forsmark stage 2.2. The revised termination is typically within 200 m of the original depths, although additional extrapolation of zones that were originally terminated against the base of the local model volume of SDM-Site can reach significantly larger depths, in one case (ZFMENE0401A) to the base of the regional model volume.

Extension, truncation and removal of deformation zones

ZFMNNE3130 of SDM-PSU is a medium confidence deformation zone, based on a single magnetic lineament. It was not modelled in SDM-Site and was consequently omitted from the merged model.

Extrapolation beyond the regional volume boundary of SDM-PSU has resulted in considerable changes in the lengths along the ground surface for two of the deformation zones, ZFMENE8034 and ZFMWNW1035. In addition, there are a few zones of SDM-PSU that have been subjected to minor changes, in the order of tenths of meters, in their ground surface trace lengths. The reason is primarily the use of truncating deformation zones from SDM-Site in favour of those in SDM-PSU. Another explanation is the abovementioned removal of ZFMNNE3130, which has given rise to blind ends for three deformation zones, ZFMWNW3267, ZFMWNW3268 and ZFMNNW1034.

5.4.3 Upgrading of the RVS modelling tool

SDM-Site and SDM-PSU were merged in the modelling tool RVS v6. Before the release of DMS 2020_1 (see Table 2-4) the model was converted to RVS v7, which was introduced during the autumn of 2019. The RVS v7 allows for full application of object-based deterministic modelling, introduced by Hermanson and Petersson (2022) to meet the foreseen complexity beyond the Baseline modelling work. Through the conversion, each modelled geological object (deformation zone and sheet joint) is stored with its specified geometry and position in the RVS central object library. The Baseline geological model is an assemblage of all these objects in their final form, extracted from the central object library for downstream usage.

RVS v7 provides several additional advantages over RVS v6, of which the most important items are:

- Introduction of active constraints, which means that a zone that is cut against another is automatically adapted to the new geometry of the cutting zone if this is remodelled.
- Ability to acquire volumetric representations of geological objects without the previous time-consuming step of block modelling.

Since the introduction of RVS, there have been problems where unevenly distributed data has caused the geometry engine to generate meshes with strongly elongated triangles. However, with RVS v7 there is a change for the better, resulting in softer surface geometries and smoother folds. This change influences clearly the object geometries, not in the fix points along borehole, tunnel and ground surface intersections, but in inter- and extrapolated parts of the object surfaces. For deformation zones based solely on lineaments, the deviation is insignificant, reaching a few decimetres. However, the deviations for zones with subsurface borehole or tunnel intersections can locally amount to tens of meters in volumes without fix points, as illustrated for ZFMNNW1209 and ZFMNNE2273 in Figure 5-12. Even if the object geometries have changed significantly *between* the fix points, it needs to be emphasized that the new representations by RVS v7 are “as true as” the representations by v6.

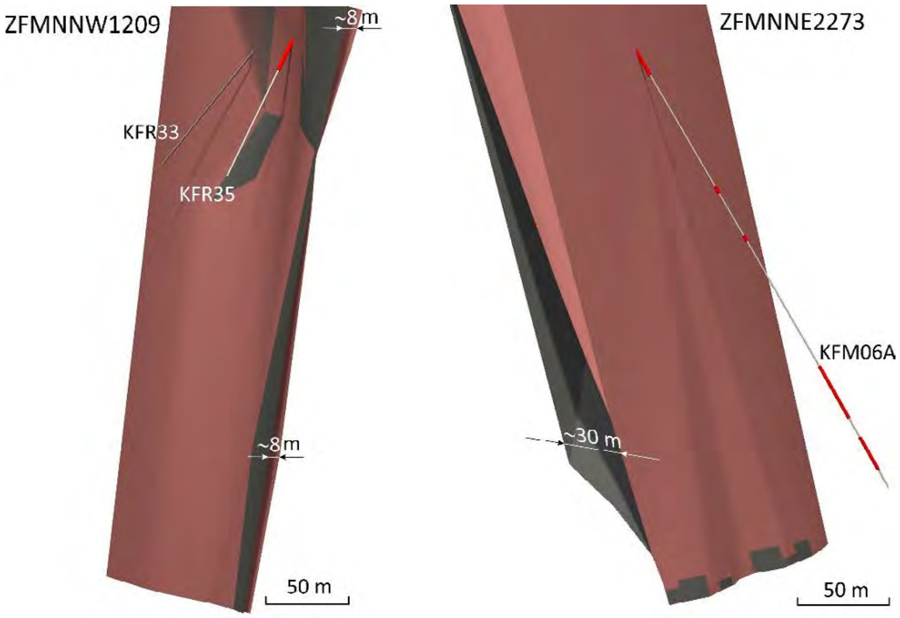


***Figure 5-12.** Examples of geometric changes due to the conversion from RVS v6 to RVS v7. Origin surfaces for ZFMNNW1209 and ZFMNNE2273 in RVS v6 (grey) and v7 (pale red).*

Another change is the technique to truncate deformation zones. In RVS v6, the volume of a truncated zone ends against the origin surface of another zone, but in v7 the volume ends at the bounding surface of the truncating zone (Figure 5-13). As a consequence, it is possible that borehole intercepts actually used for modelling of a specific zone (attached to the origin surface as points), fall outside the bounding surfaces of the same zone (Figure 5-14). However, the intercept is still contributing as an input to the geometry of the zone.

5.4.4 Revision based on data acquired after 2010

The access volume of the planned repository for spent nuclear fuel

Data from excavation trench AFM001393 and borehole investigations conducted in KFM13–KFM27 and HFM39–HFM47 have provided information that require updated geometries for several of the deformation zones in the vicinity to the planned accesses of the final repository and the nuclear power plant (reactor Forsmark 1 and 2). Deformation zones with revised geometries relative to Forsmark version 2.3 are illustrated in Figure 5-15 and a summary of the geometrical changes are presented in Table 5-4. ZFMNNE2312 is also included among the revised zones, even if the geometrical changes were not justified by new data.

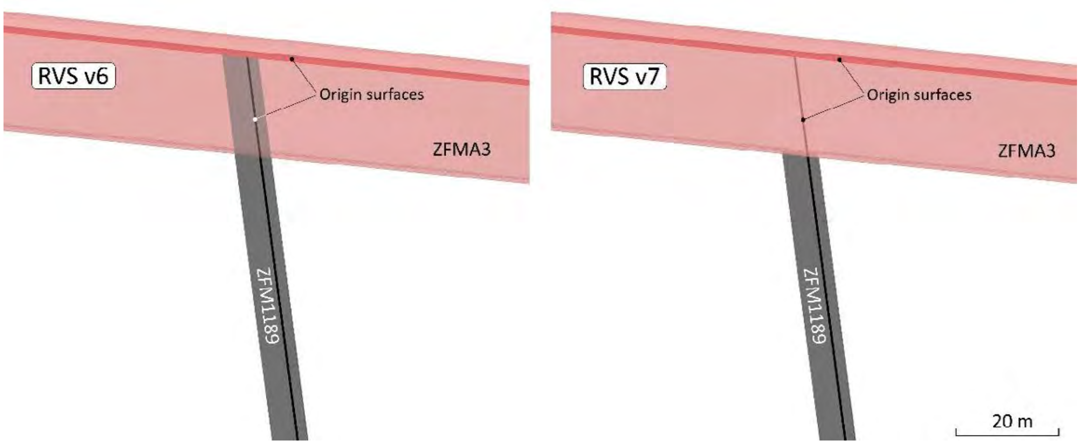


***Figure 5-13.** The truncation of ZFM1189 (grey) against ZFMA3 (red). RVS v6: Truncation against the origin surface of ZFMA3. RVS v7: Truncation against the bounding surface of ZFMA3.*

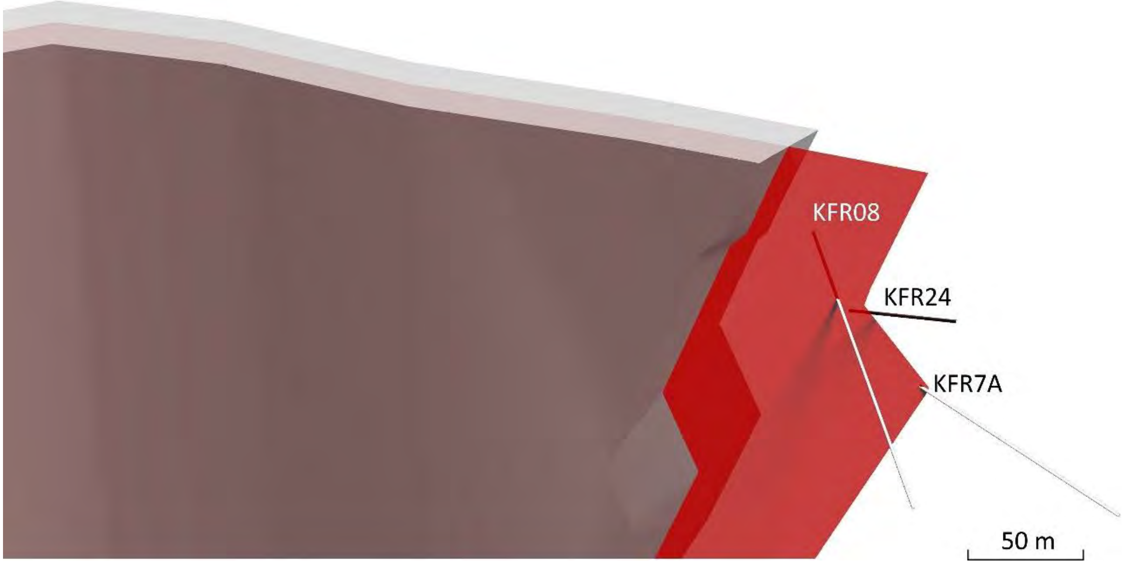


Figure 5-14. *The truncation of ZFMNNW0999 against ZFMNW0805A (not shown) illustrating the extent of he origin surface (red) and the volumetric zone representation (grey) relative to three boreholes. Two of the boreholes (KFR08 and KFR7A) intersect the origin surface, but all occur outside the grey volume.*

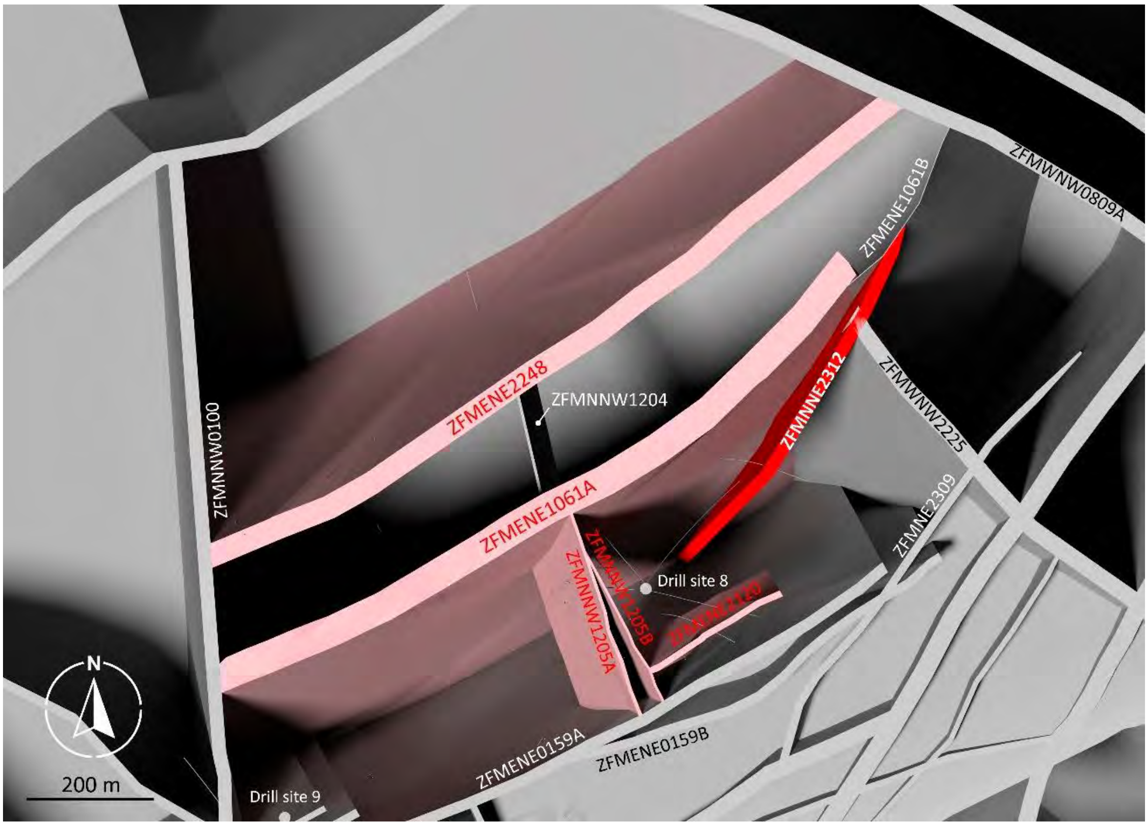


Figure 5-15. *Top view of the relationship between modelled deformation zones in the vicinity to the planned accesses of the final repository and the nuclear power plant. Deformation zones with revised geometries based on data acquired after 2010 are pale red, whereas ZFMNNE2312, which has been changed by ignoring the data from percussion borehole HFM38, are red.*

Table 5-4. Summary of the geometrical differences between deformation zones of Forsmark version 2.3 and the DMS Baseline Forsmark version 1.0 in the vicinity of the access volume of the planned repository for spent nuclear fuel.

Zone ID	Forsmark version 2.3			DMS Baseline Forsmark version 1.0		
	Strike [°]	Dip [°]	Thickness [m]	Strike [°]	Dip [°]	Thickness [m]
ZFMENE1061A	56	81	48	58	82	48
ZFMENE2120	237	82	12	238	79	10
ZFMENE2248	234	80	37	236	80	36
ZFMNNE2312	202	84	43	208	87	19
ZFMNNW1205A	159	78	15	161	77	5
ZFMNNW1205B	–	–	–	155	79	4

The modelling approach used to achieve the preferred geometries for the six zones are described briefly below.

ZFMENE1061A – Based on single-hole interpretations (Dahlin et al. 2017) it is inferred that the zone geometry must be adjusted to avoid intersection with KFM24 and HFM40 but include the entire KFM19. However, intercepts of the two original boreholes (i.e. KFM08A and KFM08C) shall, as far as possible, remain unchanged. Furthermore, the zone thickness, as defined by the intercept with KFM08A, shall be left unadjusted at 48 m. To achieve the preferred geometry, the following changes were implemented:

- A slight modification of low magnetic lineament MFM2054G0 in proximity to HFM40.
- The fix point of the deformation zone core in KFM08A was moved from 277 to 282 m borehole length (see Figure 5-16). The target intercept of the zone boundaries remains at 244–315 m.
- A fix point for the zone plane was added in the lowermost end of KFM08C at 947 m length.
- A fix point for the zone plane was added at 700 m length along a fictitious extrapolation of KFM24.

ZFMENE2120 – Adjustment of ZFMENE2120 based on an intersection with KFM23 and a decrease of the thickness from 12 to 10 m.

ZFMENE2248 – Revised geometry based on the drillings down to approximately 200 m depth north of the inlet channel, in proximity to reactor block 1 and 2. The single-hole interpretations of Dahlin et al. (2017) and Rauséus and Petersson (2020) indicate that the southwestern part of the zone geometry must be adjusted to avoid intersection with KFM26 and HFM41 but include PDZ1 (30–92 m borehole length) of KFM27. However, the intercept of the original borehole, KFM08A shall remain unchanged to include PDZ5 between 775–843 m borehole length. Both KFM27 PDZ1 and KFM08A PDZ5 were assigned a medium confidence level. The preferred geometry of ZFMENE2248 was achieved by the following changes:

- The inferred southwestern continuation of low magnetic lineament MFM2248G, in the disturbed area around the nuclear power plant, has been modified by moving the trace line slightly southward, closer to the ground surface trace of ZFMENE1061A.
- The thickness of the zone was decreased by 1 m from 37 to 36 m.

ZFMNNW1205A – A renaming ZFMNNW1205, and an accompanying geometrical adjustment based on intersections with KFM13 and KFM23. The thickness of the zone was decreased by 10 m from 15 to 5 m. For additional details, see Follin (2019).

ZFMNNW1205B – An inferred splay to ZFMNNW1205A added by Follin (2019). The surface manifestation is the magnetic lineament MFM2168G and data from excavation trench AFM001393. The zone is modelled to intersect KFM08B, KFM13 and KFM21.

With the additional drillings in the vicinity to the planned accesses of the final repository, an issue of further examination is whether the gently dipping ZFM1203 continues north of its current truncation against ZFMENE0159A. However, comprehensive data review provides no geological indications to support a continuation of ZFM1203 on the northwestern side of ZFMENE0159A.

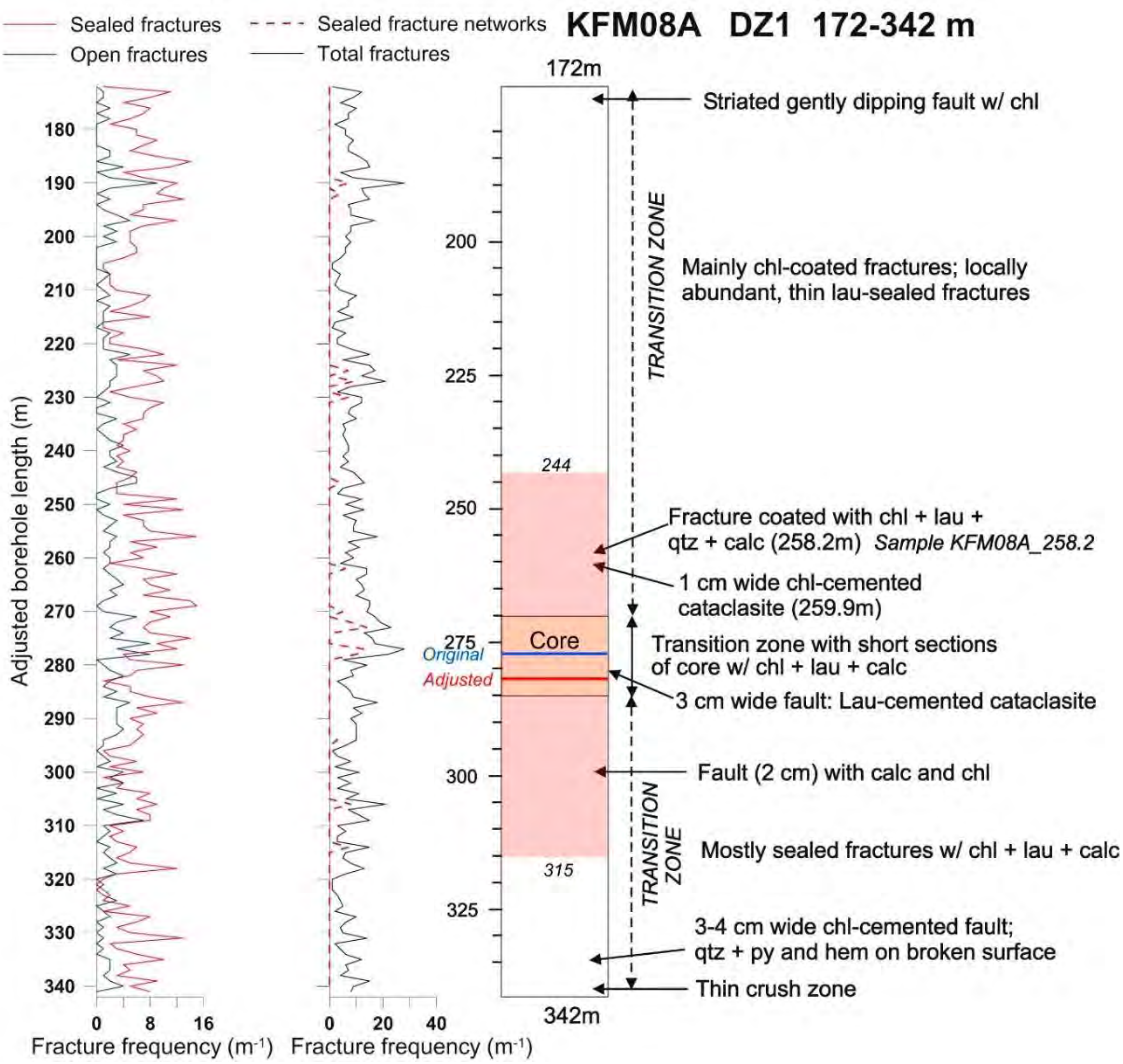


Figure 5-16. *Simplified log of brittle deformation features along SHI PDZ1 in KFM08A, showing the target intercept of ZFMENE1061A (pale red interval at 244–315 m length) and the location of the zone plane fix point (blue = original at 277 m, red = adjusted at 282 m) within the inferred core. Modified from Nordgulen and Saintot (2006).*

The rock volume southeast of SFR

The drillings of KFR117–KFR121, immediately southeast of the SFR facility, have yielded data for geometrical adjustments of two deformation zones ZFMWNW0835 and ZFMWNW8042. Two additional zones (ZFMENE3115 and ZFMWNW3262) intersected by the boreholes have been left geometrically unmodified, as their borehole intersections are in accordance with the results from the SHI (cf. Winell and Samuelsson, 2022). Deformation zones with revised geometries relative to SFR version 1.0 are illustrated in Figure 5-17 and a summary of the geometrical changes are presented in Table 5-5. Note that ZFMENE3115 is included among the revised zones, due to the thickness reduction introduced during the merging of Forsmark version 2.3 and SFR version 1.0 (see Section 5.4.2).

The adjustment of ZFMWNW0835 is based on an intersection with SHI DZ3 (the third possible deformation zone from the start of the borehole) along KFR121 (cf. Winell and Samuelsson, 2022). The judgement is that this intersection provides a better estimate of the zone properties than the only other intersecting borehole, KFR27, which is situated close to the northern end of the zone and runs subparallel with the zone. Based on this the thickness has been reduced from 21 to 10 m (Table 5-5).

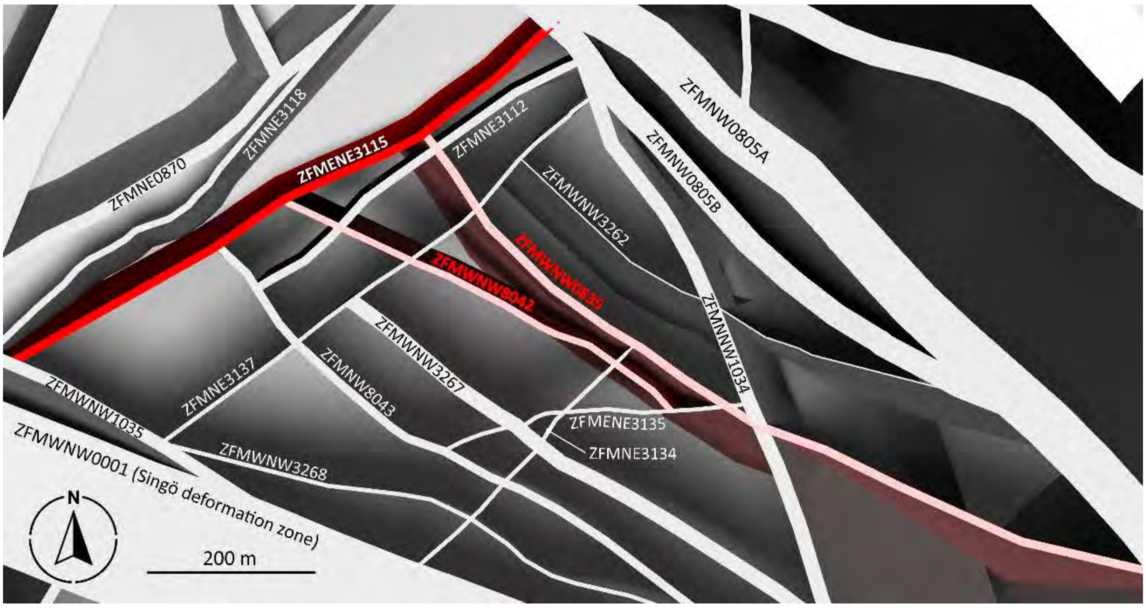


Figure 5-17. *Top view of the relationship between modelled deformation zones in the rock volume situated southeast of the SFR facility. Deformation zones with revised geometries based on data acquired after 2010 are pale red, whereas ZFMENE3115, which has been changed during the merging of models are red.*

The dip and thickness of ZFMWNW8042 has been revised to obtain full intersection with the inferred zone core of SHI PDZ4 along KFR121, located at 289.8–303.1 m borehole length (cf. Winell and Samuelsson, 2022). An effect of the changed dip direction is a truncation against ZFMWNW0835.

Table 5-5. Summary of the geometrical differences between deformation zones of SFR version 1.0 and the DMS Baseline Forsmark version 1.0 in the volume southeast of the SFR facility.

Zone ID	SFR version 1.0			DMS Baseline Forsmark version 1.0		
	Strike [°]	Dip [°]	Thickness [m]	Strike [°]	Dip [°]	Thickness [m]
ZFMENE3115	236	84	28	238	84	10
ZFMWNW0835	118	88	21	120	88	10
ZFMWNW8042	116	89	5	298	88	8

5.4.5 Extension of regional deformation zones into the sub-catchment area

A selection of the lineaments interpreted by Isaksson and Johansson (2020) was investigated as part of a geological field study by Bakker (2021) to verify whether they correspond to actual deformation zones (see Section 3.4). The study focuses on the well-exposed outcrops along coastal areas of central Gräsö and west of Öregrund. Additional information regarding potential deformation zones at Gräsö are presented by Svenonius (1887) and Bergman et al. (1998).

All lineaments inferred to represent deformation zones with a minimum ground surface trace length of 5 km (in practice down to about 4 km) have been modelled in the Baseline Forsmark sub-catchment area, outside the SDM-Site regional model volume. This also includes an extension of all previously modelled zones that are truncated along the boundary of the SDM-Site regional model volume; this is regardless of whether the ground surface trace length exceeds 5 km or not. Thus, artificial truncation of deformation zones along the SDM-Site regional model volume has not been allowed.

Similar to the SDM-Site, the bedrock in the Baseline Forsmark sub-catchment area is characterised structurally by ductile high-strain belts (striking WNW−ESE or NW−SE) that define an anastomosing network enveloping the less deformed tectonic lenses. As part of the same tectonic domain, it seems reasonable to expand the conceptual model of Stephens et al. (2007) to the entire sub-catchment area by proposing that the composite ductile and brittle, steeply dipping WNW and NW zones formed in response to transpressive deformation. This resulted in dextral strike-slip displacement and an R-Riedel shear relationship between regionally significant WNW and NW zones as presented in Figure 5-18. The framework is given by the regionally significant Forsmark, Singö and Örskär deformation zones. The development of steeply dipping NNW structures with sinistral strike-slip displacement is also inferred to have occurred later in the tectonic evolution. The strong anisotropy in the bedrock, related to older ductile deformation under higher-grade metamorphic conditions, is a critical factor that controls the location and orientation of these older deformation zones.

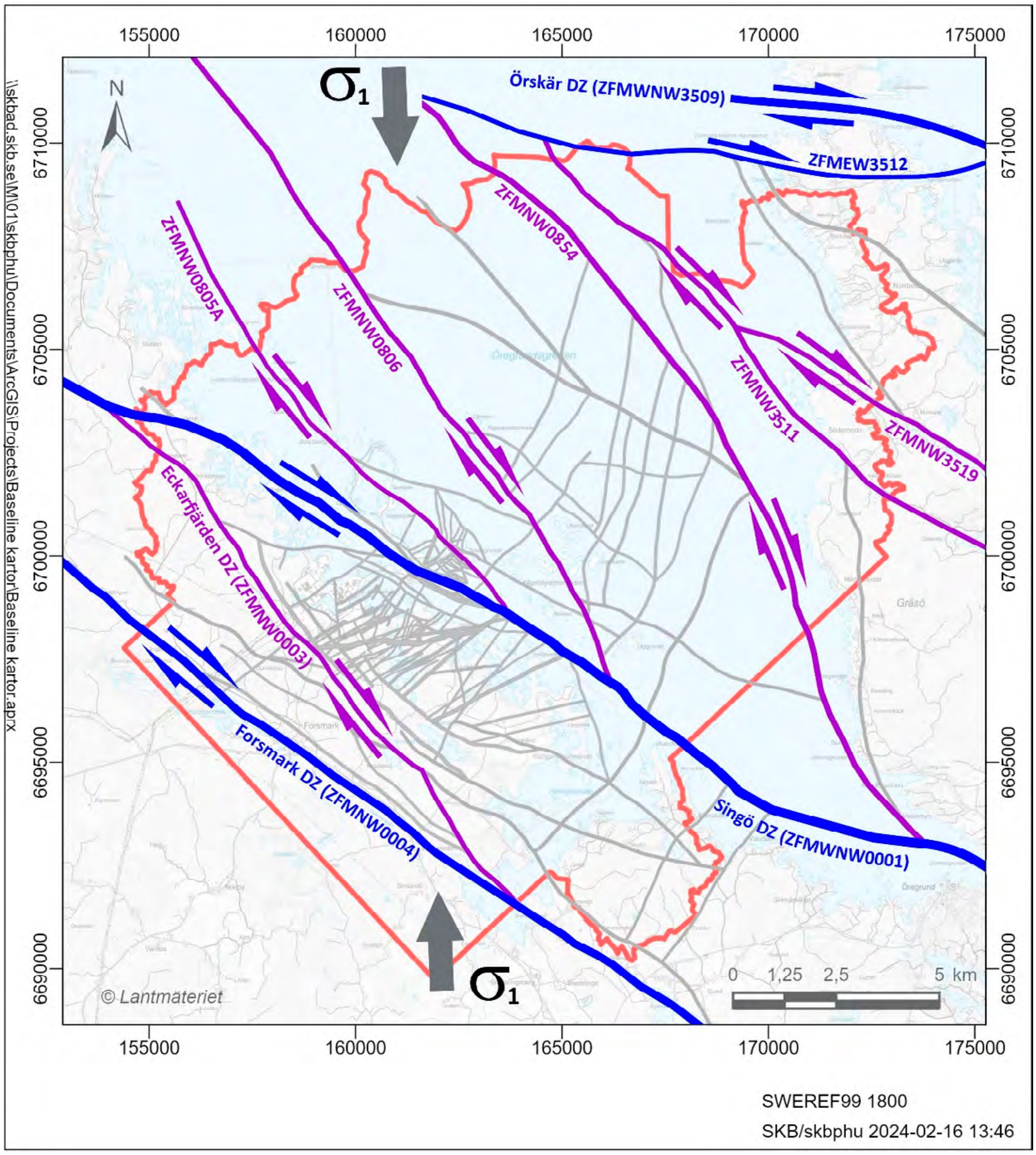


Figure 5-18. *The large-scale tectonic framework of the DMS Baseline Forsmark model area (red line) showing the concept where regionally significant WNW and NW zones evolved by dextral strike-slip displacement in response to transpressive deformation. Note that Örskär DZ (ZFMWNW3509) is not included in the model area.*

Accepting this, an approach identical to that of Stephens et al. (2007) was used to estimate orientation and thickness for zones that lack borehole intersections:

- The strike of a zone is assumed to be determined by the trend of the matching lineament.
- The dip of the zone is estimated by comparison with the dip of high confidence zones that intersect one or more boreholes and show a similar strike. In general, this means 80° for the sub-set referred to as ENE (NE) and NNE and 90° for all other sub-sets referred to as WNW, NW, NNW and EW.
- The thickness of the zone has been calculated with the help of the length-thickness correlation diagram presented in Figure 5-11, according to the power law function $T = 0.2\ L^{0.6}$, rounded to the nearest 5 m. Note that the changed trace lengths along the ground surface for some of the existing deformation zones (ZFMNNE0828, ZFMNW0016, ZFMNW0036, ZFMWNW0023 and ZFMWNW0836) resulted in thickness changes.

In total 15 of the existing deformation zones have been extended beyond the SDM-Site regional model volume and eleven new deformation zones have been added within the Baseline Forsmark sub-catchment area. Geological support for the actual existence of the newly added zones is only provided for two of them, ZFMNW3511 and ZFM3519 (Bakker 2021). Three rather well-defined lineaments on the northern part of Gräsö were omitted as possible deformation zones based on field control (MFM3513, MFM3514 and MFM3518), see Section 3.4. It shall be emphasized that there is currently no deterministic approach to handle the possible existence of gently dipping zones; such zones inferred to occur throughout the sub-catchment area, but deterministic modelling requires drillings and seismic data for identification.

5.4.6 Reassessment of the deformation zone truncation pattern northeast of SFR

In the SDM-PSU deformation zone model there are six deformation zones with blind ends (ZFMNNE3264, ZFMNNE3265, ZFMNNE3266, ZFMNNW0999, ZFMNNW3113 and ZFMNS3154) immediately northeast of deformation zone ZFMNW0805A (Figure 5-19). The truncation is apparently artificial, but the reason is somewhat ambiguous. The most obvious reason is the resolution of the magnetic data, which is the primary basis for the lineament interpretation. In addition, there are disturbances in the magnetic total field data due to the Fenno-Skan HVDC (high voltage, direct current) cable, which prevent confident identification of lineaments at the appropriate scale in the area north of ZFMNNW0999, ZFMNNW3113 and ZFMNS3154 (Figure 5-19).

With deficiencies in the magnetic data, it was decided to do a reassessment of the lineament interpretation in the area between ZFMNW0805A and ZFMNW0806. The primary basis for this work was the inferred bedrock surface (lower surface of layer Z5, generated from the regolith depth model), with varying support from the magnetic data. For details regarding the interpretation, see Section 4.4). Several new lineaments were added during the work and the reassessment showed the need to adjust some of the magnetic lineaments from previous interpretations. These adjustments included the lineaments used as surface traces for the blind end zones ZFMNNW0999, ZFMNNW3113 and ZFMNS3154, which based on bedrock topography were extended further to the north into the magnetically disturbed area.

The lineaments used as surface traces for ZFMNNE3264, ZFMNNE3265 and ZFMNNE3266 in SDM-PSU bend in a northeastward direction immediately outside the area covered by the high-resolution ground magnetic data (Figure 5-19). With further analysis, it appears that the northeast striking parts of these lineaments are all magnetic minima connections, and the interpretation is that they have a lithological origin.

To achieve natural terminations of these zones after modification, two deformation zones were added (ZFMNW0997 and ZFMWNW3571) based on lineaments from the renewed interpretation (Figure 5-20). The current conceptual thinking is that the six modified zones were formed as second order synthetic and antithetic Riedels due to dextral strike-slip displacement along ZFMNW0805A and ZFMNW0997 (Figure 5-21). Truncation against ZFMNW0997 has led to an elongation of the three northern zones (ZFMNNW0999, ZFMNNW3113 and ZFMNS3154) and a shortening of the three southern zones (ZFMNNE3264, ZFMNNE3265 and ZFMNNE3266). This in turn has affected the orientations and thicknesses of the zones, which in the absence of geological data are based on the length-thickness correlation (Figure 5-11); consequently, ZFMNNE3266 has been renamed to ZFMNE3266.

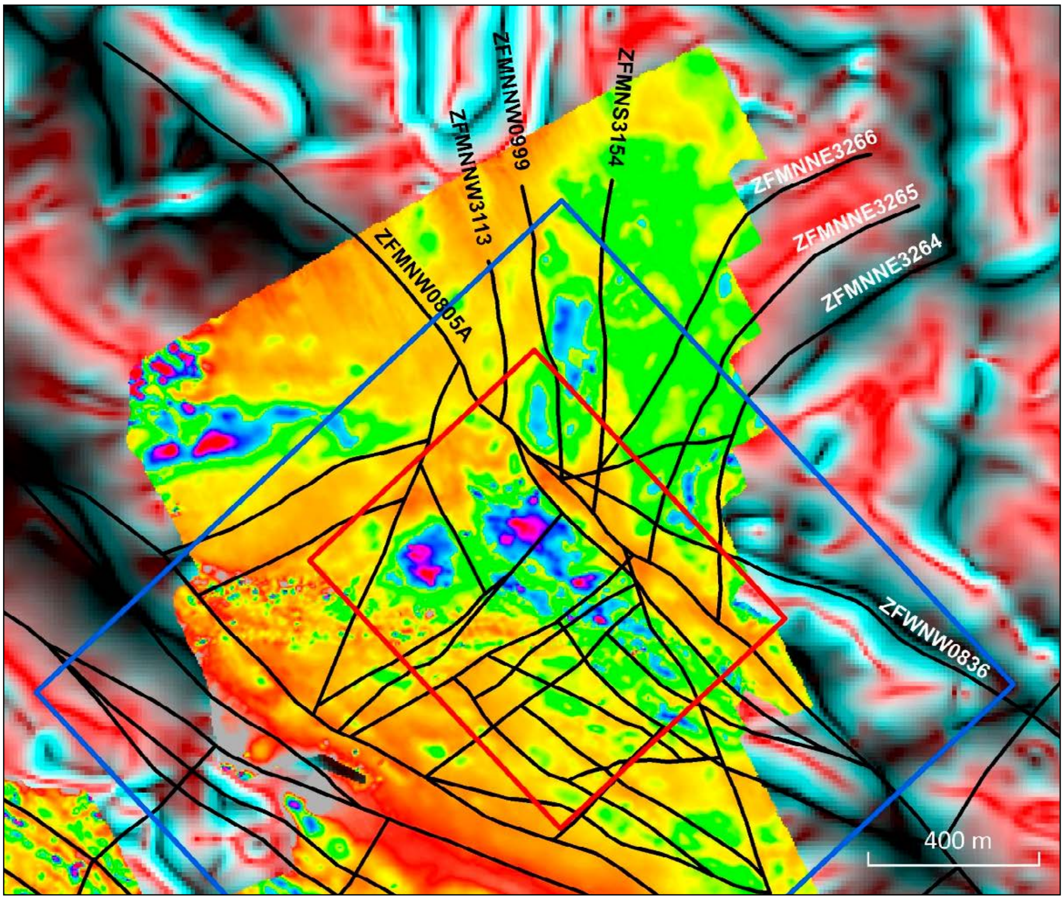


Figure 5-19. *Ground surface trace lines of modelled deformation zones in SDM-PSU overlain on a combined magnetic map, which illustrates the extent of the high-resolution ground magnetic survey (land and sea) relative to the NS-directed helicopter survey (red, turquoise and black layer). SDM-PSU local and regional model areas a marked in red and blue, respectively.*

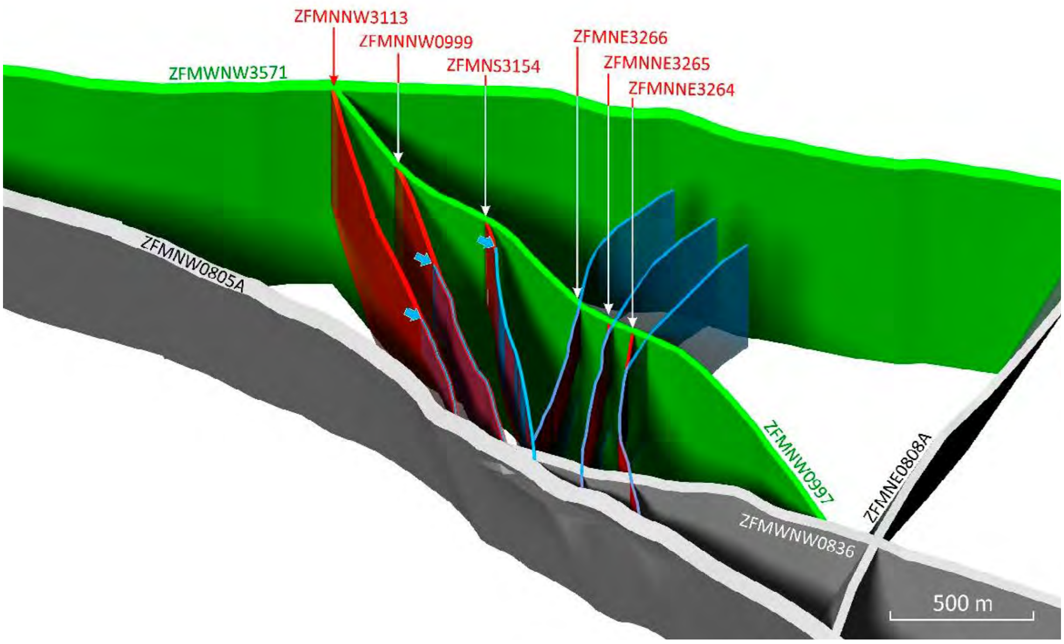


Figure 5-20. *Extract from DMS Baseline Forsmark version 1.0 illustrating the changes in the deformation zones pattern relative to SFR version 1.0, immediately northeast of ZFM0805A. Zones with changed geometries are red with their former geometry shown in blue (blue arrows show original ends). New zones are shown in green and the previous, unchanged zones are grey. Oblique view towards the north.*

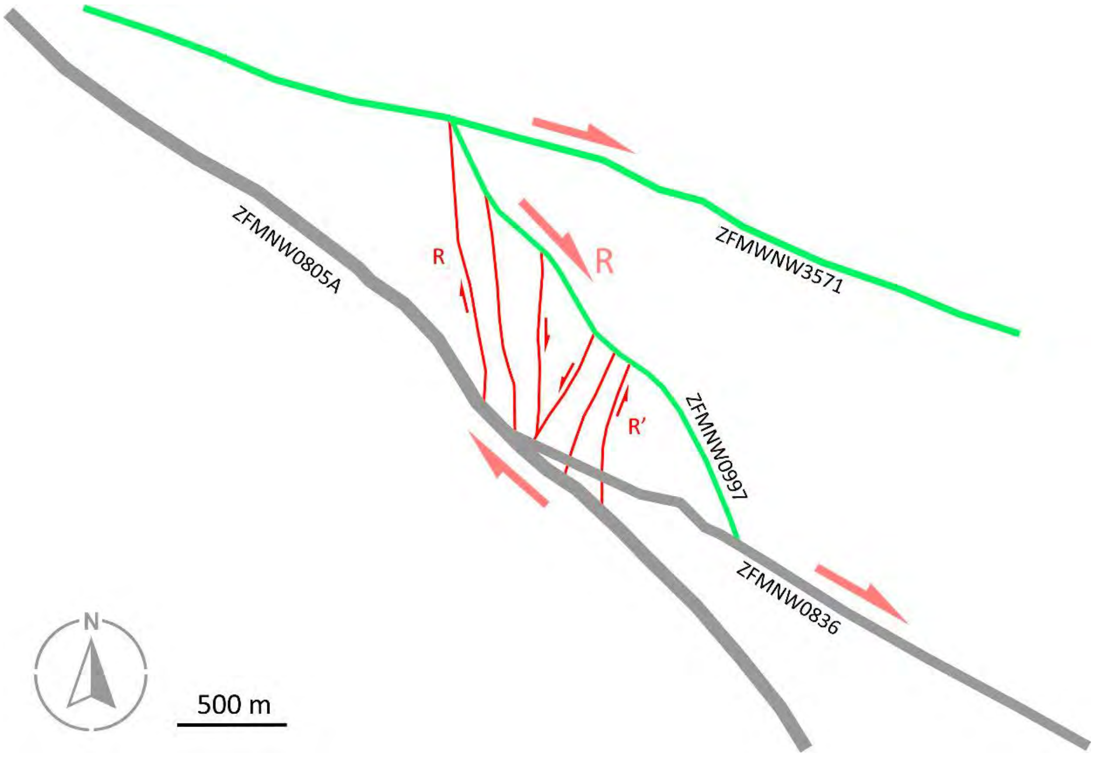


***Figure 5-21.** Conceptual model of the tectonic origin for the deformation zones with former artificial blind ends northeast of the SFR facility. Zone colours are as in Figure 5-20.*

5.5 Geometric model and object properties

One hundred fifty-nine deformation zones have been modelled deterministically in the DMS Baseline Forsmark version 1.0. Of these, 135 are vertical and steeply dipping (≥ 70°) structures, which all except one (ZFMNNW1204) intersect the ground surface. The remaining zones are gently dipping (≤ 45°) zones and 14 of these also intersect the ground surface. Based on orientation, the modelled zones can be divided into three main sets:

- Vertical and steeply dipping fracture zones with sub-sets referred to as ENE (NE) and NNE (72 zones).
- Vertical and steeply dipping deformation zones with sub-sets referred to as WNW and NW (47 zones).
- Gently dipping fracture zones with dips to the south and SE (24 zones).

In addition, there are 16 vertical and steeply dipping deformation zones that belong to the sub-sets referred to as NNW and EW. A division based on trace length along the ground surface (Figure 5-22) shows that the proportion of vertical and steeply dipping zones in the WNW and NW sub-sets increases significantly with trace length, from 10 % of the zones that are shorter than 1 000 m to about 60 % of the zones whose length exceeds 3 000 m. This correlation between specific orientation and trace length is strongly related to the spatial distribution of zones, and consequently to the tectonic anisotropy of the high-strain belt in which the Forsmark area is located. In accordance with the current understanding, vertical and steeply dipping zones of the WNW and NW sub-sets are largely restricted to the margins of and to the high-strain areas outside the Forsmark tectonic lens, whereas the fracture zones of the other sub-sets mainly have developed in volumes of less intense strain, as second order structures, in response to displacements along these more extensive zones.

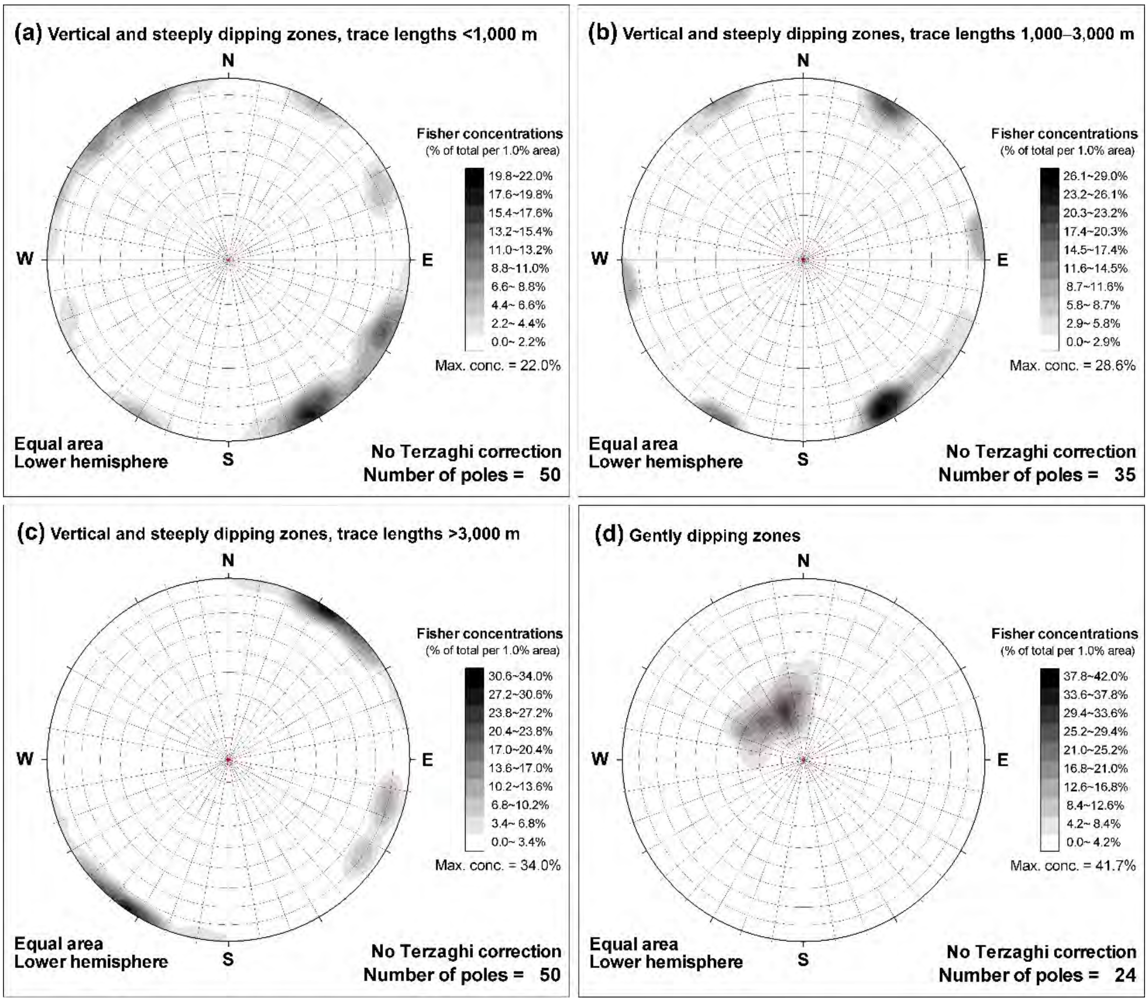


Figure 5-22. *Orientation of deformation zones in DMS Baseline Forsmark version 1.0. Vertical and steeply dipping deformation zones with ground surface trace lengths (a) less than 1 000 m (including ZFMNNW1204), (b) 1 000–3 000 m and (c) exceeding 3 000 m. (d) Gently dipping zones. The orientations of zones in the stereographic projections (equal-area, lower hemisphere) are shown as contours with no Terzaghi correction.*

The distribution of data for modelling is a crucial consideration when covering zones with specific orientations and trace lengths. This inherent bias becomes more significant due to the merging of models that have varying minimum zone lengths and the extension of the model volume to encompass the future sub-catchment area. Using the current methodology, modelling of vertical to steeply dipping zones of local extent requires access to high-resolution ground magnetic data, while modelling of gently dipping zones relies on reflection seismics. Such data are limited to the local model volumes of SDM-Site and SDM-PSU. The heterogeneous distribution of deterministically modelled structures that is related to the lack of data needs to be handled by stochastic methods (cf. Selroos et al. 2022).

The bias related to the spatial lack of data and hence the lower cut-off lengths applied in the various model volumes is also reflected in a logarithmic trace length frequency plot (Figure 5-23). Artificially induced trace length bias is visible where the slope coincides with the lower cut-off lengths of SDM-Site and SDM-SFR (i.e., 1 000 and 3 000 m, see Table 2-2 and Table 2-3) and the sub-catchment area outside the SDM-Site regional model volume (i.e., 5 000 m, see Section 5.4.5).

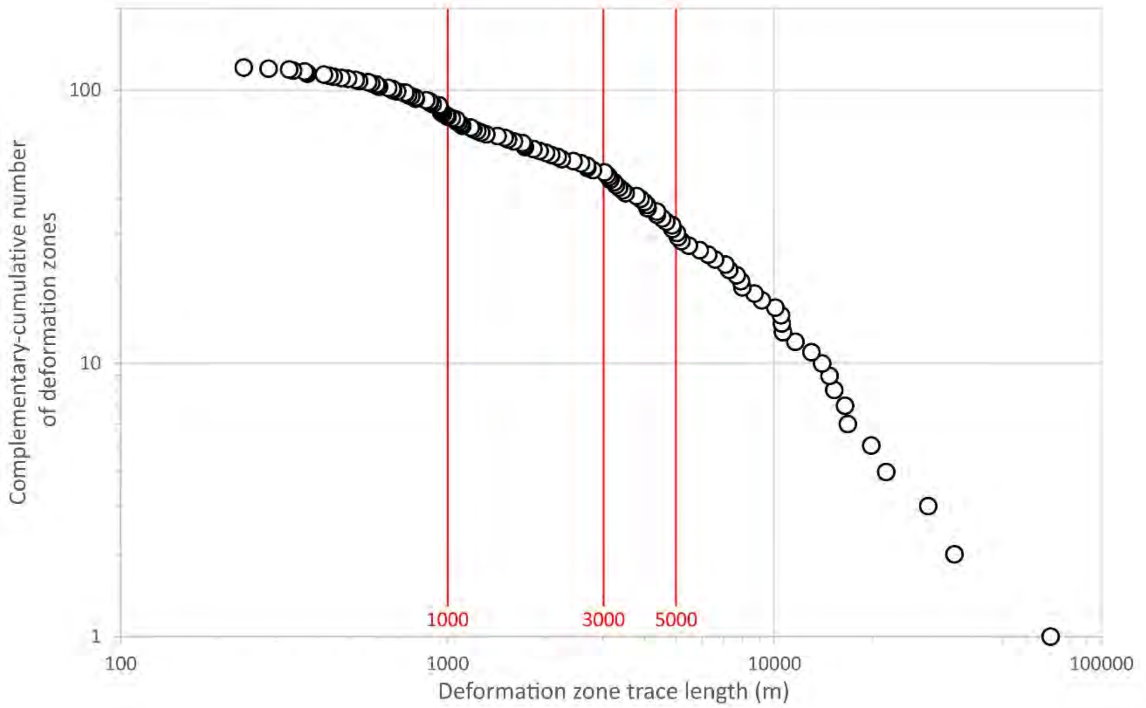


***Figure 5-23.** Distribution of surface trace length of vertical and steeply dipping deformation zones in DMS Baseline Forsmark version 1.0. Estimated trace lengths include continuations outside the inferred sub-catchment area. Splays or attached branches, which are modelled to belong to a particular zone and strike more or less parallel to the zone (e.g. ZFMENE0401B that is a branch related to ZFMENE0401A), are not included in the data set.*

Most of the vertical and steeply dipping zones in the WNW and NW sub-sets follow the general structural trend defined by rock contacts and the ductile planar grain-shape fabric. The subordinate set of vertical and steeply dipping fracture zones referred to as NNW also follows the ductile bedrock fabric. Vertical or steeply dipping zones in the other sub-sets are concentrated in three areas: the Forsmark tectonic lens, the SFR area and centrally in Öregrundsgrepen (see Figure 5-18). Inside the tectonic lens, where the ductile fabric is folded and more variable in orientation (cf. Stephens et al. 2007), the bedrock is intersected exclusively by vertical or steeply dipping zones of the ENE (NE) and NNE sub-sets. The zones are typically distributed in clusters.

The majority of gently dipping deformation zones are situated in the southeastern, central part of the tectonic lens, where several zones appear to splay off each other in an integrated mesh (Figure 5-8). In particular, ZFMA2 defines the hanging-wall of the volume that has been identified as potentially suitable for the excavation of a repository. Conceptually Stephens et al. (2007) proposes that these gently dipping zones mainly follow arrays of amphibolite boudins. For this reason, the more frequent occurrence of gently dipping zones in this part of the tectonic lens is related to the gentler, southeast dip of the amphibolite occurrences, the tectonic foliation and the mineral stretching lineation (see orientation data from KFM03A presented in Figure 5-6 of Stephens et al. 2007). Gently dipping zones are also inferred to occur outside the tectonic lens and the rock volume close to the SFR facility, but with a lack of drillings and seismic data it has not been possible to identify them.

Deterministic modelling of local minor deformation zones, with trace lengths at the ground surface shorter than 1 000 m, is limited to the local model volumes of SDM-Site and SDM-PSU. The zones have been identified primarily along boreholes as SHI deformation zones, which were correlated with lineaments recognised in the interpretation of the high-resolution ground magnetic data. One minor zone (ZFMNNW1204) has been modelled entirely based on borehole data.

An atypical feature among the deterministically modelled structures is ZFM1189. It represents a fractured alteration pipe of vuggy, quartz-deficient rock referred to as episyenite, sandwiched between the gently dipping zones ZFMA2 and ZFMA3 at drill site 2. An assessment of surface seismic, VSP (vertical seismic profile) and borehole radar data indicates that the episyenite pipe and associated fracture zones in KFM02A (borehole interval 240–310 m, including DZ4 and DZ5) has a steep orientation and trends more or less parallel with the borehole KFM02A.

The properties of deformation zones included in the merged deterministic models have been compiled into property tables, presented in the following reports:

- Forsmark version 2.3 (trace lengths > 1 000 m) Stephens and Simeonov (2015)
- Forsmark stage 2.2 (trace lengths < 1 000 m) Stephens et al. (2007)
- SFR version 1.0 Curtis et al. (2011)

Property tables which also gives hydraulic and engineering characteristics for deformation zones within and in close proximity to the volume of the planned repository for spent nuclear fuel (SKB 2008a, 2009) and the SFR facility (SKB 2013) have also been presented.

Property tables for the current versions of the deformation zones included in DMS Baseline Forsmark version 1.0 are stored in SKBmod (cf. Section 2.2). A summary of some key aspects of the three dominant orientation sets of deformation zones at Forsmark is presented in Table 5-6. Further details of the various sub-sets are given by Stephens et al. (2007, 2015) and Curtis et al. (2011). Hydrothermal alteration along brittle deformation zones at Forsmark are described in more detail in Sandström et al. (2008) and Petersson et al. (2012), whereas kinematic data for the zones are presented in Saintot et al. (2011).

Table 5-6. Summary of the geological properties of the three dominant orientation sets of deformation zones at Forsmark. Slightly modified from Stephens et al. (2015).

Dip **Strike**	**Vertical and steeply dipping** **WNW and NW**	**Vertical and steeply dipping** **ENE (NE) and NNE**	**Gently dipping** **–**
Deformation style	Both ductile and brittle. High frequency of especially sealed fractures and sealed fracture networks.	Only brittle. High frequency of especially sealed fractures.	Only brittle. High frequency of especially open fractures.
Fault core	Mylonite, protomylonite, cataclastic rock and cohesive breccia in structures of regional size.	Highly elevated fracture frequency with sealed networks, locally cohesive breccia and cataclasite.	Highly elevated fracture frequency with sealed networks or non-cohesive rock, cohesive breccia and cataclasite.
Alteration	Hematite dissemination, locally quartz dissolution, development of muscovite- and talc-rich rocks.	Hematite dissemination, locally quartz dissolution.	Hematite dissemination, locally quartz dissolution.
Fracture orientation	Vertical to steep dips, striking NW–SE, NE–SW and NNE–SSW. Also gently dipping to sub-horizontal fractures.	Vertical to steep dips, striking ENE–WSW (dominant) to NNE–SSW (subordinate). Also gently dipping to sub-horizontal fractures.	Gently dipping to sub-horizontal and vertical to steeply dipping that strike ENE–WSW to NNE–SSW.
Fracture filling	Calcite, chlorite, adularia and hematite. Clay minerals, laumontite, quartz, prehnite, pyrite and epidote are locally present.	Calcite, chlorite, laumontite, adularia and hematite. Pyrite quartz, clay minerals, prehnite and epidote are locally present.	Calcite, chlorite, adularia, hematite and fractures with no apparent mineral coating. Clay minerals, laumontite, pyrite, prehnite, asphaltite and epidote are locally present.
Sense of displacement	Strike-slip displacement with both dextral and sinistral sense of shear.	Strike-slip displacement with both sinistral and dextral sense of shear.	Reverse sense of shear.

5.6 Unassigned possible deformation zones identified in the SHI

Less than one third of the possible deformation zones (PDZ's) identified during the SHI lack correlation with any of the modelled deformation zones. This group of PDZ's are denoted "unassigned deformation zones". In total, there are 97 unassigned deformation zones distributed among 11 percussion and 49 cored boreholes. Relative to the modelled PDZ's, the unassigned deformation zones typically occur along rather short borehole intervals and a considerable proportion of them were defined with a low or medium confidence level during the SHI work (Figure 5-24). Although uncertainty remains related to the nature of the unassigned zones, especially in terms of size and orientation, it is judged from these features that they predominantly represent intersections with minor zones (see Section 8.4), too small to allow deterministic representation.

The possible orientation of the unassigned deformation zones has been evaluated by analysis of orientations for fractures, sealed networks, crushes and fault rocks along the defined zone interval. All fractures not visible in BIPS were eliminated from this analysis due to larger uncertainty in orientation. The general distribution pattern on an equal-area stereographic projection for the structural data in each zone is used as a guideline for the orientation of the unassigned zones. However, the data set for about one third of the unassigned deformation zones is too limited or shows too much scatter to allow orientation estimates. For the remaining 66 unassigned zones, a predominant structural orientation has been estimated, but some of them include also distinct subordinate sets. The estimated general orientations among the unassigned deformation zones, based on the predominant structural set, are illustrated in Figure 5-25.

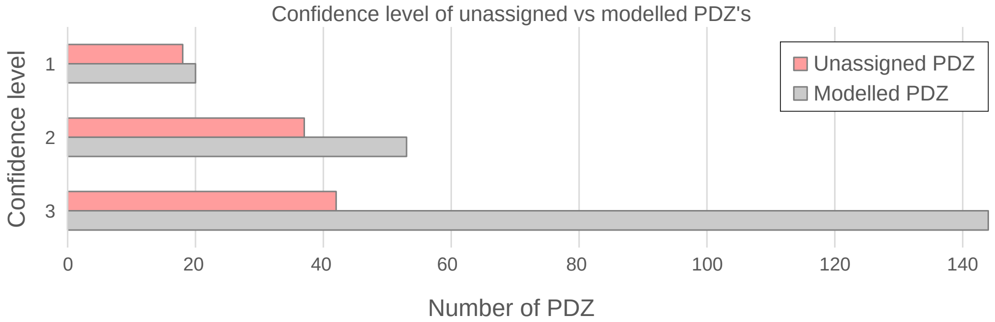


Figure 5-24. *Histogram showing the relative distribution of confidence levels for modelled and unassigned PDZ's in the Forsmark baseline model version 1.0.*

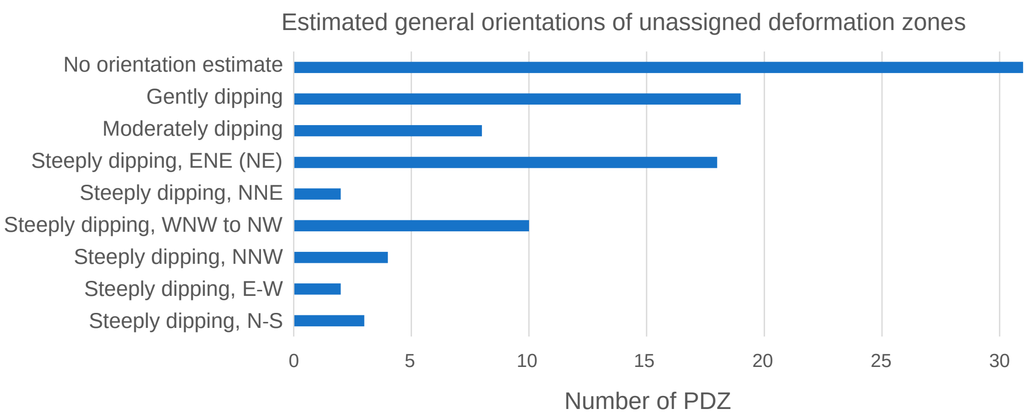


Figure 5-25. *Histogram showing the relative distribution of estimated general orientations for unassigned PDZ's in the Forsmark baseline model version 1.0.*

A considerable proportion of the unassigned zones is inferred to be gently dipping. Except for two, they are all situated in the uppermost 150 m of the rock mass, which strongly suggest that they primarily represent intersections with swarms of sheet joints. The estimated orientations of vertical to steeply dipping unassigned zones is in line with the orientations of the modelled zones, with the two main sets that strike ENE (NE) to NNE and WNW to NW.

5.7 Quantification of confidence for deformation zones

A new approach to quantify confidence for deterministically modelled deformation zones is presented by Hermanson and Petersson (2022). Although the approach focuses on subsurface modelling of structures only identified in underground openings and boreholes, it was proposed that the methodology can be applicable to already established deformation zones of the DMS Baseline Forsmark, where zone geometries primarily are derived from lineaments and seismic reflectors in combination with data from boreholes. However, the usefulness of the approach remains to be verified by further investigations of deformation zones included in the DMS Baseline Forsmark.

The basic principle of the approach comprises four categories, each divided into two subcategories and with the purpose to reflect various modelling decisions that affect the object geometry. Each subcategory is assigned a confidence estimate according to the scale 1–3 (low, medium, high). A total relative confidence for a zone is then achieved by summing the confidence estimates for each individual subcategory, which hence ranges between 8 and 24.

Following the proposed methodology, confidence estimates for each deformation zone in DMS Baseline Forsmark version 1.0 are presented in the property tables of Appendix 7. This work was completed after the delivery of the 3D model version 1.0 to visualise the assembled confidence estimate for each zone by means of colour coding. An upgraded 3D model version 1.1 was released in late 2023 (see Chapter 9). In this model, the confidence range (8–24) is declared by an RGB colour scheme programmed in the RVS modelling tool (Table 5-7). Note that gently dipping zones separated into two parts to facilitate geometric modelling in RVS (ZFMA6, ZFMB5 and ZFMB23) are treated as unbroken surfaces and are consequently assigned identical confidence levels.

Full implementation of the methodology outlined by Hermanson and Petersson (2022) to the already established deformation zones included in the DMS Baseline turned out to require both some further development and additional clarification of the principles. The adjustments and complements used during the work of confidence assignment are captured and summarized in Table 5-8.

Table 5-7. RGB colour scheme programmed in the RVS modelling tool to visualise the total relative confidence estimate for deformation zones.

Color code	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
R	255	255	255	255	255	255	255	255	255	234	213	191	170	149	127	106	84
G	0	31	63	95	127	159	191	223	255	240	224	209	193	177	162	146	130
B	0	0	0	0	0	0	0	0	0	6	13	19	26	33	39	46	53

Table 5-8. Adjustments and complements applied to the categories and sub-categories for quantification of confidence for deterministically modelled deformation zones according to Hermanson and Petersson (2022).

Interpretation

Data source

No deviations from or additions to the guidelines presented by Hermanson and Peterson (2022); the confidence level has been based on the source with the highest degree of confidence.

Results of interpretation

The confidence level has been based on the interpretation with the best quality of the source data, with the following amendments to the methodology of Hermanson and Peterson (2022):

Lineaments – Each interpreted lineament has been given an uncertainty ranging from 1 to 3, where 1 = low, 2 = medium and 3 = high (see e.g. Isaksson and Johansson 2020). These values have been directly adopted as confidence levels. Uncertainties given with decimal precision have been rounded to the nearest integer.
Where a deformation zone is modelled based on multiple lineaments, average values have been used.

Boreholes – Only borehole intersections defined as target intercepts (see Section 5.3.4) have been considered as observation points. Thus, intersections with absence of supporting geological indications/evidence, and boreholes where no SHI has been completed, have been omitted.

Information density

Number of observation points

Implementation of the guidelines presented by Hermanson and Petersson (2022), with the clarification that observations along boreholes are limited to target intercepts (see the subcategory data source above).

Distribution of observation points

Large distance between points and/or two observation points or less will result in low confidence according to Hermanson and Petersson (2022). However, the meaning of "large distance" in this subcategory is not further defined by Hermanson and Petersson (2022). Regional scale deformation zone may have a lateral extent of several kilometres in length, while local deformation zones may have a lateral extent less than 1000 m. Therefore, the term "large distance" has a different weight on regional deformation zones and those of more local extent. Henceforth, the notion of "large distance" has been neglected within the subcategory-distribution of observation points in the current work. Lineaments that comprise several segments has been considered as a continued observation point. Examples of the confidence assignment for this subcategory are illustrated in Figure 5-26.

Interpolation

Geometry

The trend of lineaments and the conceptual understanding of the deformation, in combination with the structural trend obtained by analysis of the orientation patterns of the natural fractures along boreholes and tunnels (where avaliable) has been regarded as the key parameter in this category.

Geological indicators

No deviations from or additions to the guidelines presented by Hermanson and Peterson (2022).

Extrapolation/Truncation – Vertical and steeply dipping deformation zones

Strike direction

Since a lineament is considered an observation point, there is a high confidence in the assumption that a modelled zone continues along the lineament. Thus, a modelled zone within confinement of an interpreted lineament has been given a high confidence in the subcategory extrapolation in strike direction. If a zone is extrapolated further, beyond the lineament, the conceptual understanding of the deformation and the pattern of surrounding lineaments/zones have been considered; such zones have been assigned a medium confidence.

Dip direction

Zones with trace lengths exceeding 2100 m at the ground surface terminate at the base of the model volume (see Section 5.3.2). These deformation zones have automatically been assigned a high confidence level for extrapolation in the dip direction, extending an equal distance to their ground surface trace length.

Deformation zones with trace lenghts less than 2100 m at the ground surface are extended to a depth that is approximately the same as its trace length at the surface. In such case, the uncertainty remains from the point of the lowest geological observation (borehole, tunnel) to the base of the model volume; Such zones with target intercepts along boreholes have been given a medium confidence in the dip direction.

Deformation zones based solely on lineaments and with a surface trace length less than 2100 m have been assigned a low confidence level in the dip direction.

Extrapolation/Truncation – Gently dipping deformation zones

Strike and dip direction

Quantifying the confidence for the extrapolation of the gently dipping zones involves firm understanding of the proposed structural concepts, limitations and assumptions of the underlying data. In this regard, the general approach has been as follows (Figure 5-27):

– Low confidence – Zones that have been terminated prior to truncation against other modelled zones (i.e. zones with dead ends). No geometrical control by tunnels/boreholes outside the modelled extent of the zone.
– Medium confidence – Inferred truncation against vertical to steeply dipping zones in agreement with the conceptual understanding of the deformation.
– High confidence – Strong geometrical control by observation along tunnels/boreholes/outcrops outside the modelled extent of the zone, in combination with inferred truncation against vertical to steeply dipping zones, in agreement with the conceptual understanding of the deformation.

__Figure 5-26.__ Simplified examples of the distribution of observation points along the deformation zones. Grey rectangles represent deformation zones, brown line represents lineaments and a black dots represent geological observation points. Modified after Hermanson and Petersson (2022). Regardless of the distance, the distribution pattern of the observation points forms the basis for confidence assignment. A) A single lineament. B) A lineament and a single observation point. C) A lineament and two observation points. D) A lineament and three clustered observation points. E) A lineament and three observation points that are equally distributed along the entire horizontal length of the modelled deformation zone. F) Three observation points that are equally distributed along the entire horizontal length of the modelled deformation zone. No lineament.

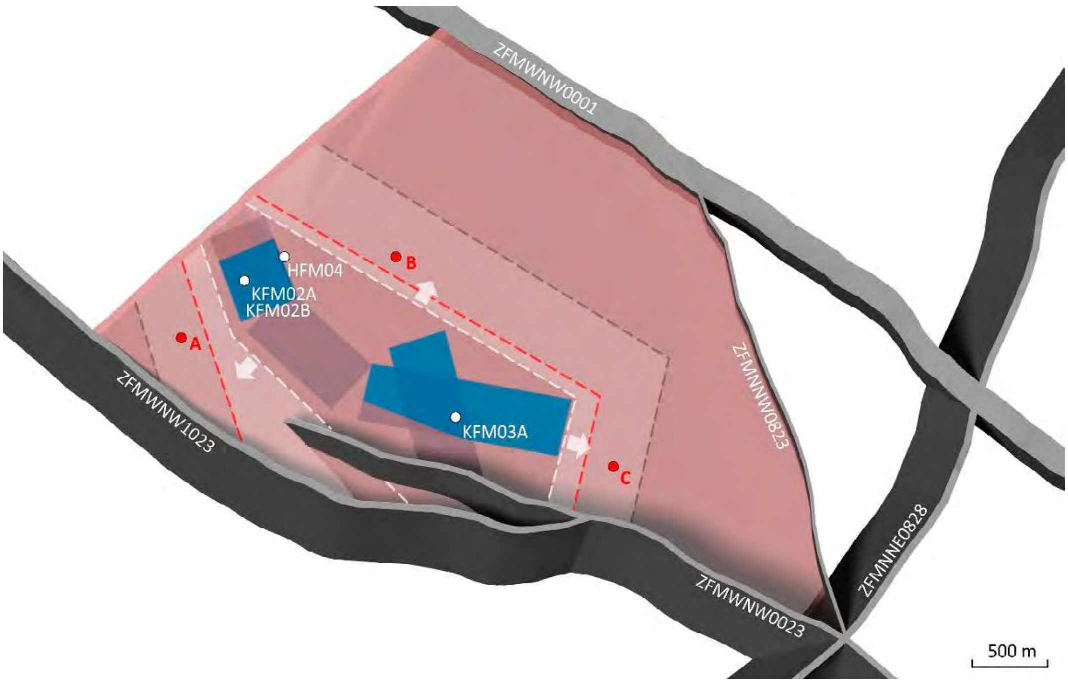


__Figure 5-27.__ The general principles of confidence assignment for extrapolation/truncation of gently dipping deformation zones; exemplification with ZFMA3 (light red). The existence of the zone is based on observations along HFM04, KFM02A, KFM02B and KFM03A (white points), in combination with a number of seismic reflectors (blue). Observations are limited to the area encircled by the white dashed line and parts beyond this line are the results of extrapolation. Oblique view towards north. Three hypothetical varieties of extrapolation are illustrated: 1) High confidence, where three fictitious boreholes (red points) that lack indication of the zone´s existence give a strong geometrical control for extrapolation in the direction of strike (A and B) and dip (C) to the approximate position of the red dashed line. 2) Low confidence, where the lack of geometrical control by observations or concepts limits the extrapolation to the grey dashed line (according to the methodology of Hermanson and Petersson (2022) a distance equivalent to 1/3 of the maximum distance between observation intercepts). 3) Medium confidence, with truncation against surrounding vertical to steeply dipping zones in agreement with the current conceptual understanding of the deformation.

5.8 Deterministic sheet joints

The geometric representation of deterministically modelled sheet joints includes the following two main components:

- Three-dimensional visualisations of sheet joints along the inlet channel to the nuclear power plants, based on the mapping of joint traces made by Carlsson (1979).
- Geometries of individual sheet joints modelled based on interpolation between observation points in boreholes.

All representations are restricted to the SFR area and an area of approximately 0.5 km^2 in proximity of the planned accesses and operation area of the final repository, where the borehole density allows reasonable confidence in interpolation. Additional sheet joints of significant extent are inferred to exist in the Forsmark area (cf. Bono et al. 2010), but available borehole data do not allow confident deterministic modelling. In total eleven individual sheet joints have been modelled based on borehole observation points, distributed among the following three subareas illustrated in Figure 5-28:

1. The planned accesses and operational area of the repository, including drill site 8.
2. Drill site 7, including HFM43.
3. The drill sites of KFR117–120 in the SFR area.

A summary of the basic geometrical properties for each of these sheet joints are presented in Table 5-9.

The 39 most extensive sheet joints along the inlet channel are represented by horizontal discs with diameters provided by the trace length of each joint in the profile. Except for two of the discs (JFM003 and JFM015), they are all named JFM001, with a suffix from 1 to 38 (e.g. JFM001_23). The joint traces are typically undulating, and the discs are placed at the level of the trace line centre, relative to a reference level established from photographs of the channel length-section. Individual fractures range up to a maximum diameter of 176 m, but most are less than 100 m. The largest disc, named JFM003, has been extended to include an observation point in KFM19 at 7.5 m borehole length (level −3.8 m), located at the southeastern part of the of the inlet channel. An additional disc (JFM001_16, renamed to JFM015), has been extended to include an observation point in KFM25 at 6.6 m borehole length (level −3.9 m). While the channel length-section is restricted to 500 m, the discs provide valuable insights into the potential extent and size distribution of sheet joints within the uppermost eight meters of the bedrock.

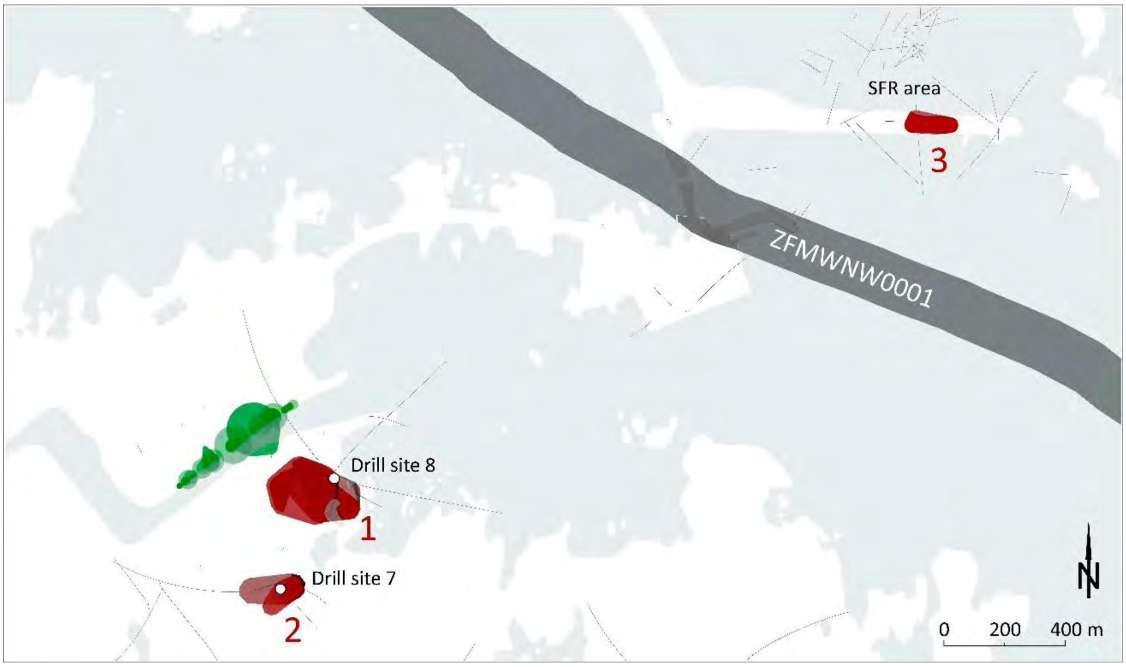


__Figure 5-28.__ Top view of the three subareas with deterministically modelled sheet joints (red) together with a visualization of the sheet joints documented by Carlsson (1979) along the inlet channel (green). Water is shaded and horizontal borehole projections marked by thin black lines.

Table 5-9. Geometry of sheet joints with aperture, modelled based on borehole observation points in the Forsmark area.

ID	Z [−m]	Strike [°]	Dip [°]	Max diameter [m]	Thickness [m]	No of observation points	Comments
Subarea 1							
JFM004	2–7	284	0.1	237	0.1	10	–
JFM005	15–17	148	1.1	177	0.1	4	–
JFM006	17–18	342	0.6	149	0.2	4	–
JFM007	20–21	298	0.7	248	0.1	5	Splay to JFM008
JFM008	22–24	023	0.2	219	0.1	6	Splay to JFM007
JFM009	50–51	169	0.3	215	0.1	5	–
Subarea 2							
JFM010	5–8	323	0.4	161	0.1	4	–
JFM011	19–20	157	1.6	69	0.1	3	–
JFM012	35–37	284	1.4	78	0.1	3	–
JFM014	151–153	340	0.9	220	0.1	3	–
Subarea 3							
JFM016	8–9	279	0.3	176	0.1	4	–

5.8.1 Subarea 1

For deterministic modelling, this subarea serves as the most dependable foundation, where a sequence of six distinct sheet joints has been identified down to an elevation of approximately −50 m (Figure 5-29). The most well-defined joints occur immediately beneath the bedrock surface and at approximately −20 to −24 m elevation. The latter coincides with the lowermost part of FFM02U and includes two sheet joints (JFM007 and JFM008), which are inferred to splay into each other. The joint immediately beneath the bedrock surface (JFM004) follows largely the elevation of the bedrock surface (Figure 5-30). Two joints of more subordinate size have been defined at −15 to −18 m elevation (JFM005 and JFM006); a close spatial relationship as splays is also inferred for these two joints.

The sheet joints of subarea 1 lies between the steeply dipping deformation zones ZFMENE0159A and ZFMENE1061A and has been modelled to crosscut three subordinate deformation zones (ZFMNNW1205A, ZFMNNW1205B and ZFMENE2120) with trace lengths at the ground surface of less than 400 m (Figure 5-15). No mutual dependencies are inferred to exist between the sheet joints and the deformation zones.

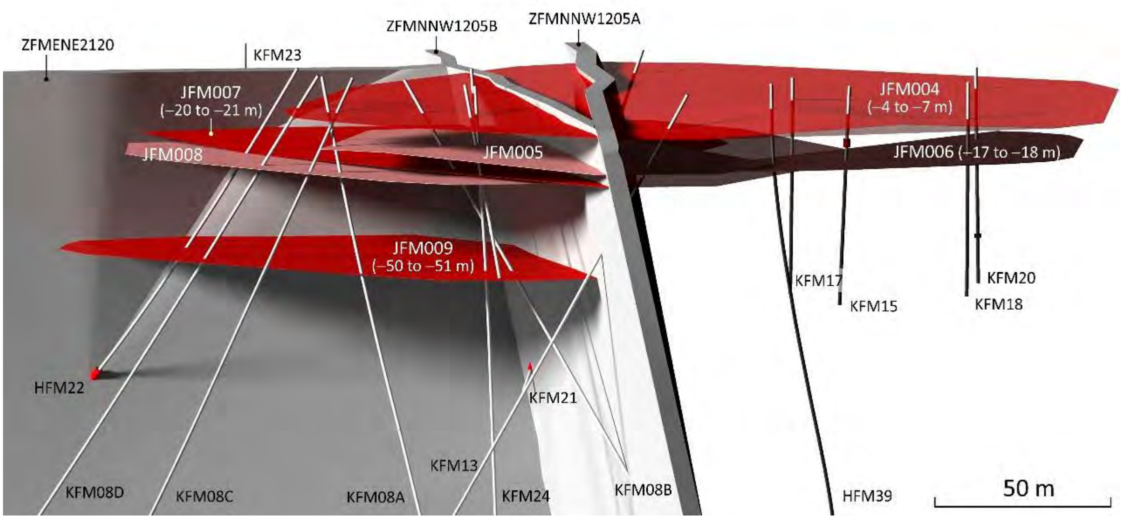


Figure 5-29. *Oblique side view towards southeast showing the sequence of deterministically modelled sheet joints in subarea 1 relative to the three subordinate deformation zones ZFMNNW1205A, ZFMNNW1205B and ZFMENE2120.*

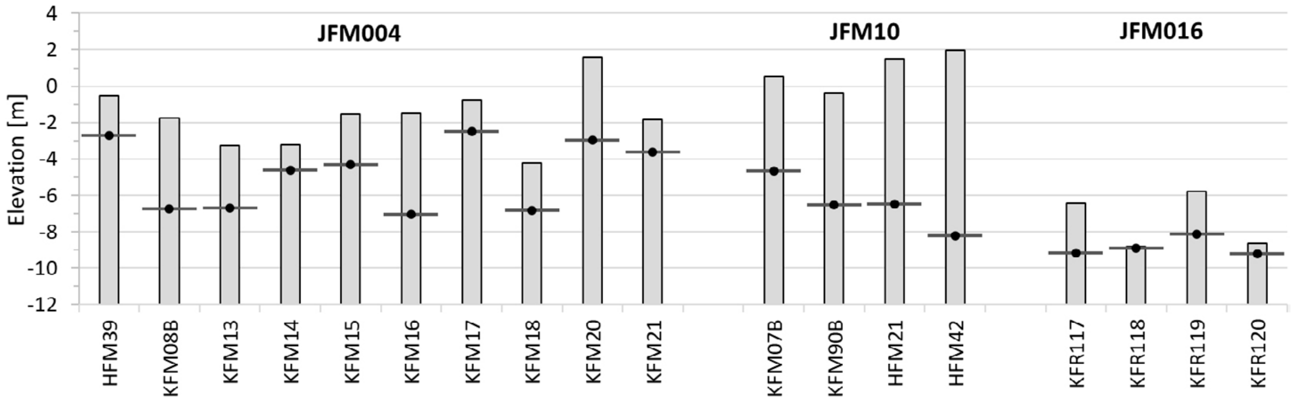


***Figure 5-30.** Histogram showing the inferred borehole elevations for the bedrock surface (grey staples) relative to the uppermost sheet joints (filled circles with intersecting line) modelled in each subarea. Intersecting boreholes without BIPS- or OPTV-images at the section of interest are omitted from the diagram.*

5.8.2 Subarea 2

The sequence of deterministically modelled sheet joints in subarea 2 includes four individual joints, all based on 3–4 observation points along boreholes (Figure 5-31). The two uppermost joints (JFM010 and JFM011) occur at approximately the same level as the most well-defined joints in subarea 1. Similar to the shallowest joints in subarea 1, JFM010 undulates parallel with and immediately beneath the bedrock surface (Figure 5-30). The lowermost joint (JFM014) is defined at a depth (−150 m) with few equivalents in the scientific literature (e.g. Jahns 1943; Twidale 1973) and alternative interpretations, where the fractured intersections represent separated structures, cannot be ruled out. However, all the observation points fulfil the sheet joint criteria listed in section "criteria for identification of sheet joints" and none of them appears to differ from inferred sheet joints at more shallow depths.

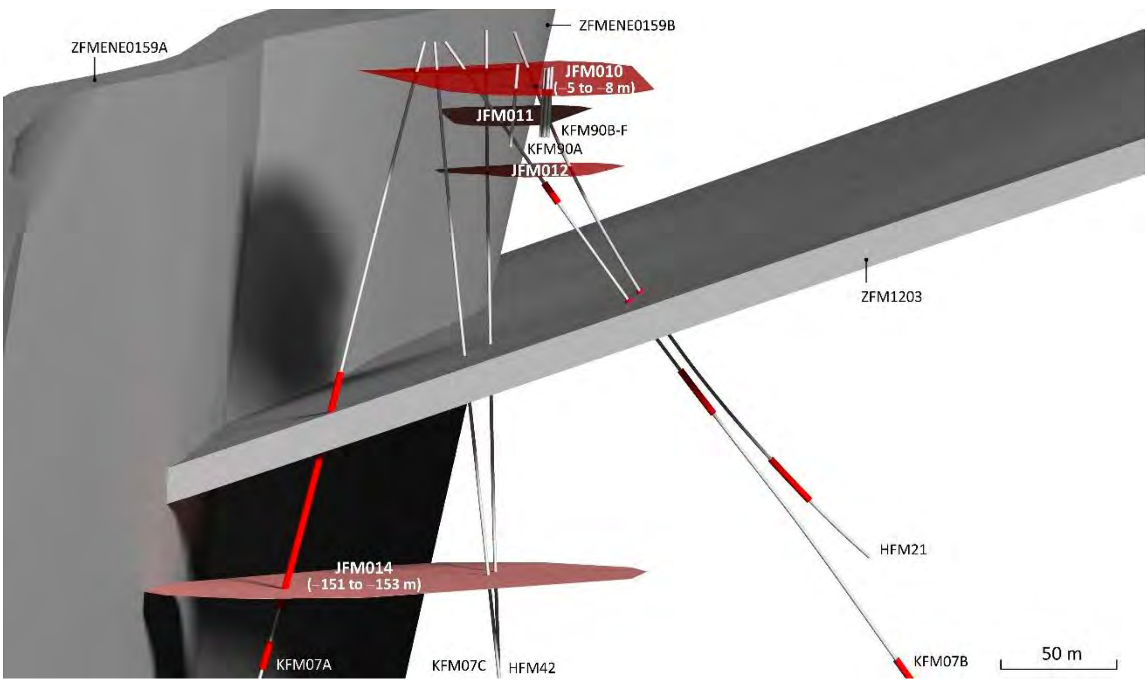


***Figure 5-31.** Oblique side view towards northeast showing the stack of deterministically modelled sheet joints in subarea 2 relative to the three deformation zones ZFMENE0159A, ZFMENE0159B and ZFM1203.*

5.8.3 Subarea 3

One sheet joint (JFM016) has been modelled deterministically in subarea 3. The joint is based on four observation points and occurs immediately beneath the bedrock surface (Figure 5-30). The joint has been modelled to intersect three steeply dipping deformation zones (ZFMENE3115, ZFMNE3112 and ZFMWNW0835), without mutual dependencies.

5.8.4 Shallow bedrock aquifer (SBA) structures

The modelled joint JFM016 is situated immediately south of SFR, in close proximity to the rock volume where Curtis et al. (2009, 2011) defined three horizontal to sub-horizontal structures, H1+H3, H5 and H6, based on fracture observations in boreholes and indications of hydraulic connections. These structures were inferred to occur at approximately −25, −110 and −130 m elevation, respectively. All of them were included as so-called shallow bedrock aquifer (SBA) structures in the hydrogeological model of SDM-PSU (Section 7.4.3 in SKB 2013), with further details in Öhman and Follin (2010).

H1+H3 corresponds to SBA7 of Öhman and Follin (2010) and was originally introduced by Carlsson et al. (1985) as two separate structures H1 and H3 of more limited extent above the silo in SFR (Figure 5-32). Their existence is based on sections with increased fracture frequency and local occurrence of clay minerals along eleven boreholes from the construction of SFR. Curtis et al. (2011) concluded that H1+H3 is the same type of structure as the sheet joints that occur in the shallow rock mass of the northwestern part of the tectonic lens. The modelled surface has a lateral extent of 250 × 400 m (Figure 5-32), which is almost twice as large as the longest trace length Carlsson (1979) registered along the inlet channel.

Although there is no substantial argument to reject the structure, it has been omitted from DMS Baseline Forsmark version 1.0 based on the following facts:

- Lateral distances of more than 100 m between some of the borehole observations.
- None of the boreholes have been filmed by BIPS or OPTV and it is therefore not possible to verify whether the fractures are horizontal to sub-horizontal and exhibit substantial aperture.

H5 and H6 have been modelled by Curtis et al. (2011) as possible sheet joints for further assessment and consideration by the hydrogeology modelling team. Support for interpolation is provided by an increased frequency of horizontal or sub-horizontal fracturing with a certain amount of hydraulic connection as indicated by testing in and between various boreholes.

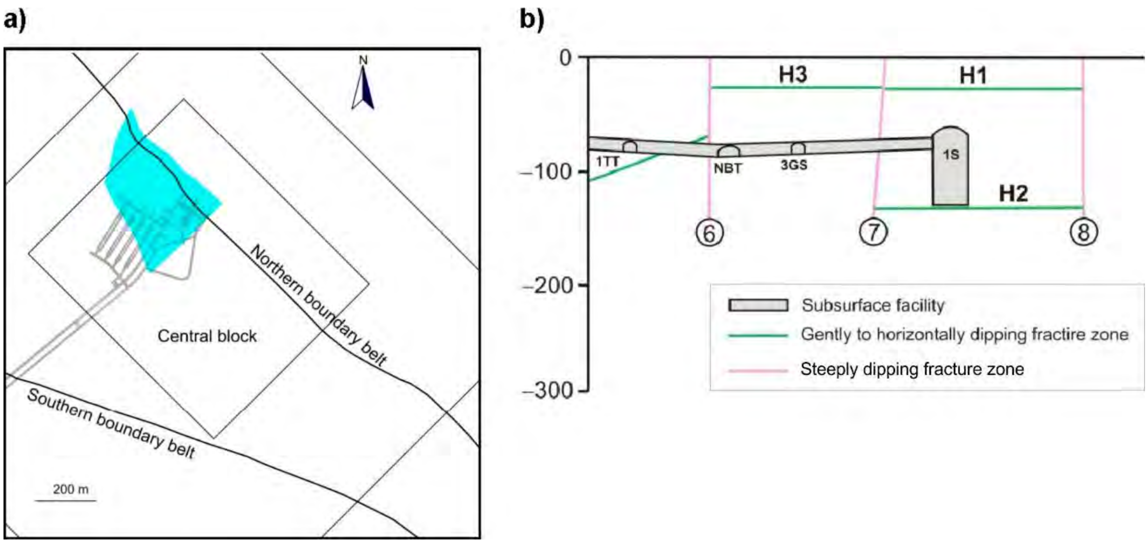


Figure 5-32. *a) a) Plan view of H1+H3. b) Representation of H1 and H3 as represented in the earlier model by Carlsson et al. (1985). From Curtis et al. (2011).*

H5 is based on fracture observations in nine boreholes together with a radar reflector, which runs subparallel with KFR105. All boreholes are filmed with BIPS and a reassessment has been made of the character of the inferred intercepts. Four of the boreholes (HFM102, KFR101, KFR103 and KFR106) show sub-horizontal fractures and crushes with significant apertures, whereas the geological indications in the other five boreholes are more questionable or completely absent, as in HFR106 and KFR102B. For example, the crushed section in HFM105 is situated at −104 m, whilst the inferred intercepts in the other boreholes (e.g. KFR101, KFR103 and KFR106) occur between −143 and −145 m, a difference of approximately 40 m. All five boreholes drilled from the pier during 2020 (KFR117–KFR121) have theoretical intercepts with H5, but only KFR117 exhibit a crushed section with significant aperture at the same elevation (−142 m) as the observations in KFR101, KFR103 and KFR106. However, the distance between the observation in KFR117 and the inferred intercept in KFR103, which is the closest of the three boreholes, exceeds 290 m. Moreover, there are no observations in boreholes situated between KFR117 and KFR103.

Thus, there is no geological support for a continuous structure of the extent that the modelled geometry of H5 indicates, with a lateral size of 650 × 1 000 m (Figure 5-33a). A plausible interpretation is that the inferred surface involves several structures of more limited extent. It is geometrically possible to join the observed joints/crushes in KFR101, KFR103 and KFR106 into one continuous, horizontal plane, but the distance between the intercepts exceeds 200 m for KFR101 and KFR103, and more than 300 m for KFR103 and KFR106. Considering the size of the documented sheet joints along the inlet channel (cf. Carlsson 1979), such an interpolation seems highly uncertain. Furthermore, observations of a corresponding structure are lacking in HFM106, which is located between KFR103 and KFR106.

H6 is modelled to occur at an approximate elevation of −110 m with an extent of 100 × 200 m (Figure 5-33b). The geological input to the surface is limited to fracture observation along two boreholes, KFR27 and KFR102B. Both boreholes are filmed with BIPS, which allows for a reassessment of the fracture character along the inferred intercepts. Several sub-horizontal fractures with distinct apertures occur on the level of interest (−118.5 m) in KFR102B, but the indications in KFR27 are less obvious. The same applies to KFR120, which has a theoretical intersection with H6. A reasonable conclusion is that H6 is also more limited in its extent.

The overall picture is that these structures are considerably more limited in their lateral extent than what is modelled geometrically. The hydraulic connection that the boreholes exhibit is rather a result of a more complex fracture network of steeply dipping structures that enable hydraulic contact between a number of smaller horizontal and sub-horizontal structures located at different levels in the rock mass.

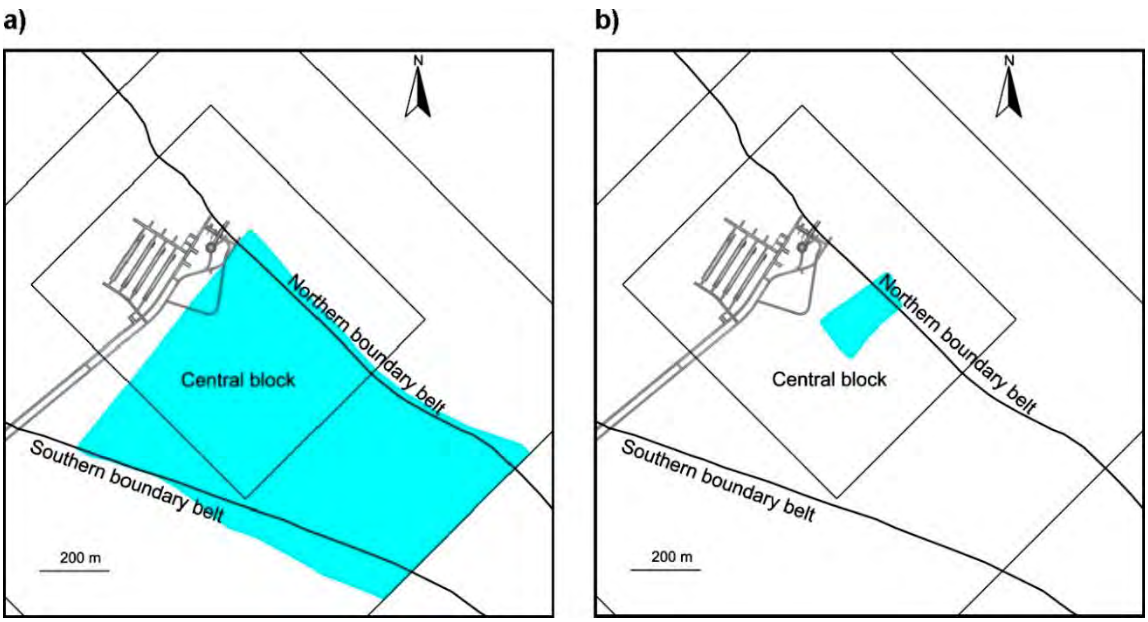


Figure 5-33. *Plan view of a) H5 and b) H6 as delivered by Curtis et al. (2011) for further evaluation by hydrogeological modelling.*

6 Rock domain models

6.1 Conceptual model

Forsmark is situated in a major deformation belt of the Fennoscandian Shield, which extends several tens of kilometres in WNW–ESE to NW–SE direction along the coast of northern Uppland. This high-strain belt was developed under amphibolite-facies metamorphic conditions and includes intervening lens-shaped volumes where the bedrock is folded and, in general, affected by less intense ductile strain. The Forsmark tectonic lens represents one such volume, with a size of ca 25 km length and up to ca 4 km in width, from the nuclear power plant in the northwest to Öregrund in the southeast (Figure 1-1). Regionally important, discrete deformation zones of retrograde character, such as the Singö, Eckarfjärden and Forsmark deformation zones, form an anastomosing network outside the tectonic lenses. Borehole data support the conceptual model that the lens is a major geological structure that can be traced from the surface to at least ca 1 000 m depth.

Folding of an older ductile fabric and a generally lower degree of ductile strain are inferred to be present inside the Forsmark tectonic lens. By contrast, the surrounding rocks are inferred to be affected by a higher degree of ductile strain and a conspicuous WNW to NW structural trend. The ductile structures at the site are characteristic of regions where variable degrees of ductile strain, folding and stretching are intimately related during strong, progressive, non-coaxial deformation. This structural anisotropy, with crustal segments of contrasting ductile strain, has important implications for an understanding of the spatial distribution of younger deformation zones and for uncertainties in the modelling of such zones (see Section 5.5).

Compressive deformation in the Forsmark region was absorbed initially by dextral strike-slip shear along the high-strain segments of the deformation belt, combined with shortening across these segments expressed by grain-shape fabric development. As the ductile strain progressed, these structures were folded at different scales. The transpressive deformation was accompanied by continuous extrusion of material in a southeasterly direction. Folding developed initially with a normal cylindrical shape, but, to variable extent, the folds were progressively drawn out in the stretching direction into tubular-shaped sheath folds. A major sheath fold is inferred to be present inside the Forsmark tectonic lens (Figure 6-1).

The bedrock inside the Forsmark tectonic lens is relatively homogeneous and is dominated by medium-grained, equigranular granite. Between 1.87 and 1.86 Ga, both this granite and the surrounding rocks were affected by penetrative ductile deformation at mid-crustal depths under high-temperature metamorphic conditions (Söderbäck 2008). Amphibolite and fine- to medium-grained granitoid intruded syn-tectonically as dykes and minor bodies during this time interval and, locally, at least the amphibolites gave rise to alteration (albitization) in the older granitic rocks. Ductile deformation with folding continued to affect the younger intrusive rocks, including amphibolite, under lower metamorphic conditions, prior to 1.85 Ga (Hermansson et al. 2008). Subsequently, until at least 1.8 Ga, the ductile strain continued to affect the bedrock, predominantly along the margins of the tectonic lens along discrete zones (Söderbäck 2008).

The conceptual model, which involves a tectonic lens and marginal domains with their different styles of ductile deformation, has provided a firm basis for the modelling of rock domains in the Forsmark area. In the modelling procedure, all the isolated bodies of metamorphosed intrusive rocks have been treated as major constrictional, rod-like structures that extend at depth sub-parallel to the mineral stretching lineation. A body of metatonalite (RFM017) that is situated in the southeastern part of the tectonic lens (Figure 6-5) is inferred to be a mega-xenolith inside the metagranite. The geochronological data by Hermansson et al. (2008) support this concept. A younger granite body (RFM022) that is situated in the archipelago northeast of the tectonic lens, has been treated conceptually as a laccolith. It shows a broad extension at the surface, but a rapidly decreasing extension at depth. This geological feature has not been drilled and remains as an unconfirmed concept.

Relative to the adjacent Forsmark tectonic lens, rocks inside the SFR central block were affected by a generally higher degree of ductile strain and a well-defined WNW–ESE to NW–SE structural trend. The most strongly deformed rocks in the area consist of a heterogeneous package of mainly felsic to intermediate metavolcanic rock intercalated with metagranodiorite (to granite) and minor amphibolite. All these rocks display moderate to strong foliation, locally along with banding and gneissosity. These rocks have been intruded by considerable amounts of younger granite and pegmatitic granite, which locally form bodies of significant volume, within which the older rocks occur as xenoliths. The rheological heterogeneity of the rock mass in the SFR area has resulted in irregular folding at all scales (cf. Curtis et al. 2011). A structural concept, with the development of major sheath folds, similar to that of the Forsmark tectonic lens, is therefore not fully applicable in the SFR area. Due to this structural uncertainty, the use of borehole and tunnel intercepts marking gross compositional changes, as well as the magnetic anomaly signature have been the primary input to the modelling work, instead of structural measurements. However, projections of the rock domain boundaries were modelled to avoid conflict with the general ductile structural trend, oriented roughly NW–SE.

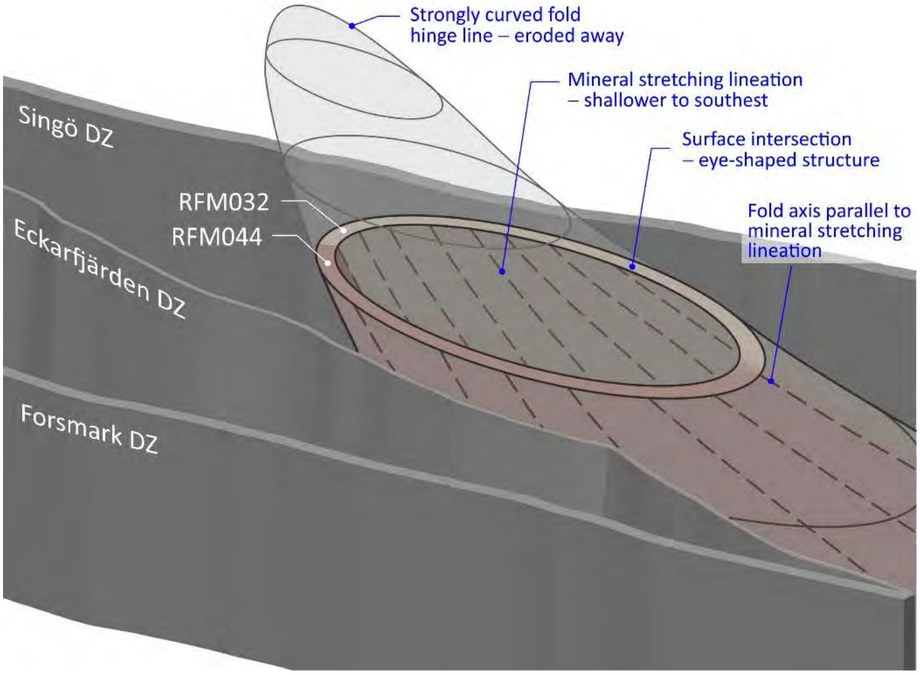


Figure 6-1. *Conceptual model for the development of major, sheath folding inside the Forsmark tectonic lens, with fold axes sub-parallel to the mineral stretching lineation. Redrawn after figure in Stephens et al. (2007).*

6.2 Upgrading of the RVS modelling tool

When the rock domain models were created in an earlier version of RVS, most rock boundary surfaces were created outside RVS and imported as ready-made geometries terminated against the modelling volume boundaries. When importing such objects into RVS v7 the object's edges coincides with the modelling volume boundary. This is unfavourable as rounding errors will create very long and very narrow triangles near the edges, which cannot be handled by the solid modelling engine. Also, imported geometries cannot be remodelled or otherwise updated using RVS tools, which is a serious limitation for further revision. Since the RVS modelling tools have been upgraded to make it possible to create the desired geometries, all objects were re-created using the RVS modelling tools.

To avoid problems along the edges, the modelled surfaces were extrapolated to reach outside the modelling volume (see Figure 6-2). The surfaces were also optimised using as sparse grid as possible, without simplifying the objects too much, to decrease the workload for the solid modelling engine.

This means that the rock boundary surfaces after the move to RVS v7 were not identical to previous versions of the model, but the overall appearance and geometry follows the original surfaces fairly close. All borehole intersections were kept unchanged.

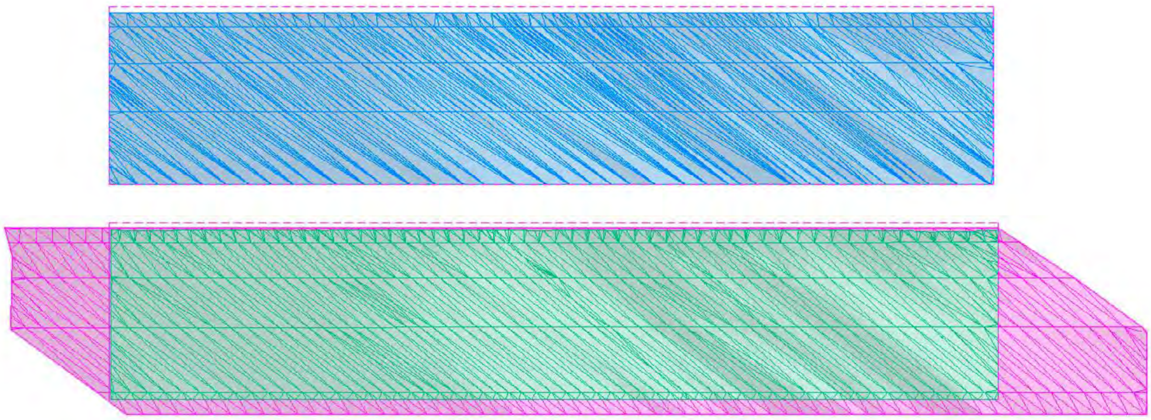


Figure 6-2. *The modelled rock boundary surface RUB18_12-29. On the top is the* ***entire*** *surface modelled in RVS v6 as it is cut by the modelling volume boundary. In the bottom the* ***visible*** *part of the surface modelled in RVS v7 is shown in green and its* ***entirety*** *is shown in purple. The upper part of the surface does not extend above the modelling boundary, but above the topographic surface.*

6.3 Adjustment of domain boundaries along the top surface

When evaluating the imported surfaces against the outcrop map and the interpreted rock boundaries on the ground surface, a known systematic error in the original modelling of the surfaces was discovered. When the surfaces were modelled in the original model, all rock domain traces on the surface, plotted in 2D at z = 0, were lifted 27 m vertically to ensure that all rock domain boundaries would extend above the topography. They were then modelled from that position, down through the modelling volume with the evaluated inclination. The reason for that was due to lack of function in RVS, at the time for modelling, for draping the 2D rock boundaries on topographic a surface. For boundaries with a non-vertical inclination this meant that the modelled surface intersected the top surface with a non-negligible displacement from the original interpretation (Figure 6-3).

To rectify this, the upper profile of several rock domain boundaries was adjusted or moved to make the intersection follow the interpreted rock boundaries as closely as possible. Boundary surfaces without borehole intersections below surface were moved, keeping the shape of the surfaces intact, meaning that these surfaces were moved through the entire volume, see Figure 6-3a. However, for boundary surfaces with borehole intersections below ground, these intersections had to be kept unchanged. So, for these surfaces only the uppermost profile was changed, meaning that these surfaces will have a slightly altered geometry above the uppermost borehole intersection, but will be more or less unaltered below this intersection, see Figure 6-3b.

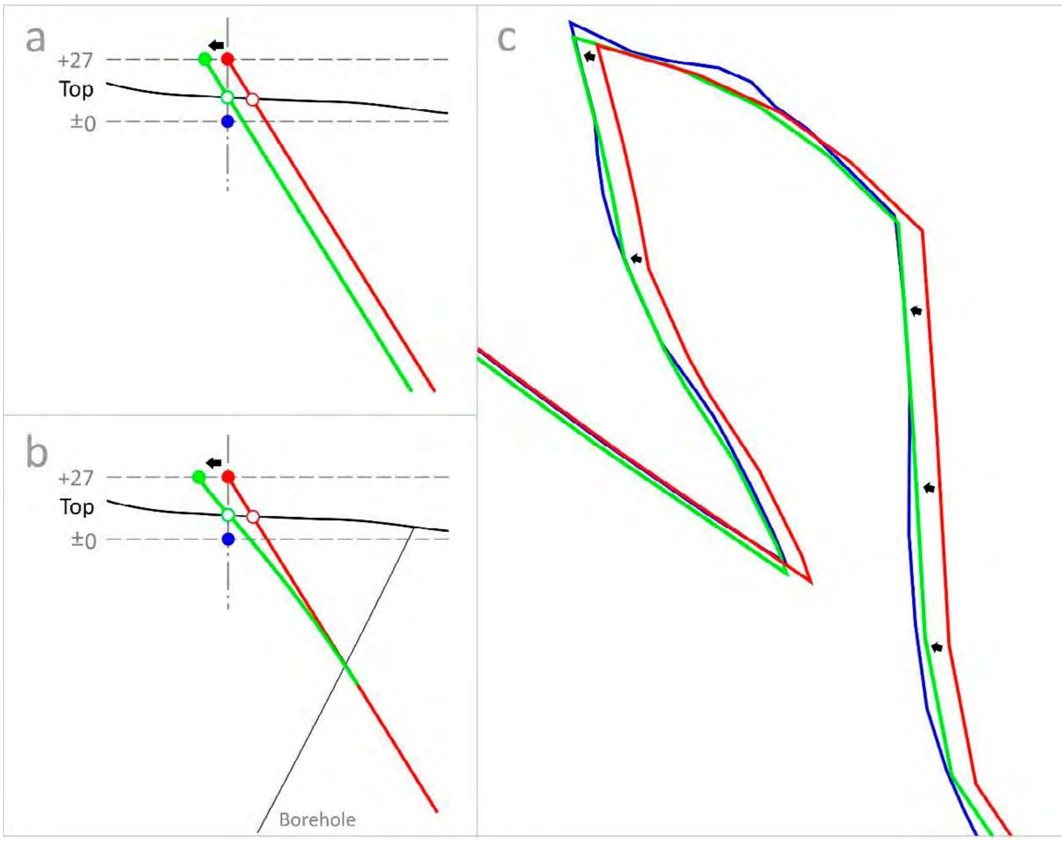


Figure 6-3. *(a and b) Cross-sections perpendicular to a rock domain trace on the ground surface plotted on a plane at z = 0 is shown as a filled blue circle. The same trace lifted 27 m vertically is shown as a filled red circle, and the boundary surface modelled from this position as a red line. The intersection between the modelled boundary surface and the topography is shown as an unfilled red circle. The desired position of this intersection is shown as an unfilled green circle. To achieve the anticipated intersection boundary surfaces with no observation point below ground (a) were moved in their entirety to make the intersection with the topography fit with the position projected on the z = 0 plane (left). For boundary surfaces with borehole intersections below ground (b), the uppermost part was adjusted, but the boundary surface was unchanged below the uppermost borehole intersection. (c) Top view of a rock domain trace in blue, the intersection between the topography and the modelled rock boundary surface from the RVS v6 model in red and the intersection between the topography and the adjusted rock boundary surface from the RVS v7 model in green.*

6.4 Division into rock domains, geometries and property assignment

The three rock domain models of Baseline Forsmark form a nestled system where RFM and RFR local are sub-models within volume of the RFM regional model. The number of domains in each model volume and the division of some regionally defined domains in the local model volumes are listed in Table 6-1. The inferred relationship between the domains of the local volumes and regional model volumes is illustrated in Figure 6-4.

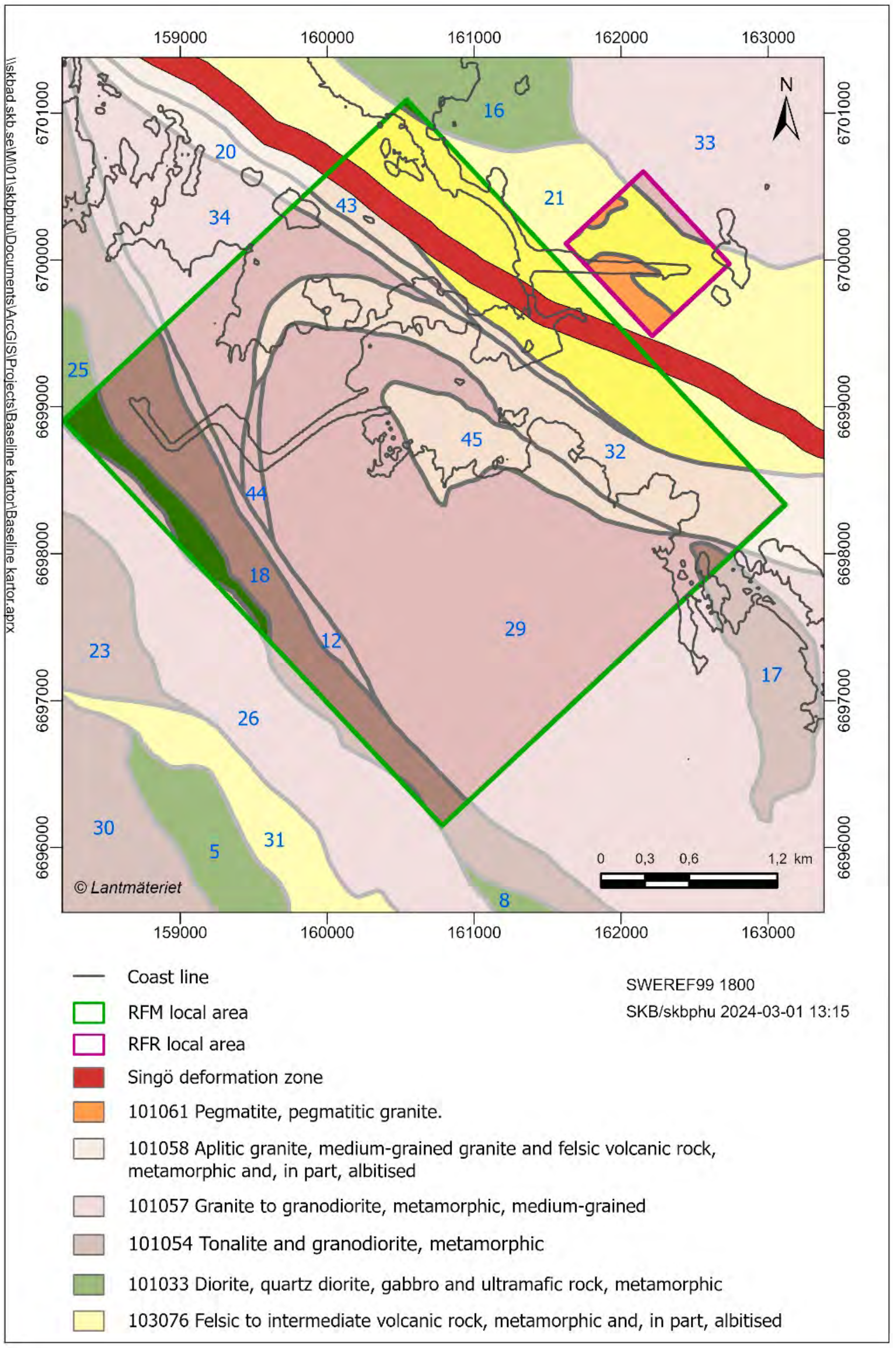


Figure 6-4. *Two-dimensional representation of the distribution of rock domains included in Baseline Forsmark version 1.0 at the ground surface. Domains immediately outside the local model volumes (RFM and RFR) are in paler colours. The different colours represent the dominant rock type in each domain.*

Data acquired after conclusion of the investigations for SDM-Site and SDM-PSU have provided satisfactory support to the previously established rock domain models. Thus, none of the new data have prescribed revision of the domain boundaries. However, the new borehole data set have resulted in minor adjustments to the properties of rock domains compared with the three models developed during SDM-Site and SDM-PSU.

Table 6-1. The number of rock domains in each of the three model volumes included in Baseline Forsmark version 1.0, along with information about the division of two regionally defined domains in the local models.

Model volume	Number of domains	Comments on division
RFM regional	38	–
RFM local	14	RFM029R of the regional volume divided into RFM029 and RFM045
RFR local	4	RFM021 divided into three sub-domains: RFR01–RFR03 RFM033 = RFR04

In the RFM models, the identification of rock domains was initiated at the surface with a subsequent correlation with geological data along especially cored boreholes from the SHI. Due to the lack of outcrops in the SFR area, the initial recognition of the RFR domains has been based on the geological tunnel mapping of the SFR facility and SHI results of cored boreholes, which were correlated with interpretations of high-resolution ground magnetic data (see Curtis et al. 2011). Rock domains were established based on two distinct types of rock units (cf. Stephens et al. 2007):

- Composition and, to some extent, the grain size of the dominant rock type.
- Degree of bedrock homogeneity in combination with the style and degree of ductile deformation.

The principles for the identification of rock units are largely the same both for the surface mapping and the SHI of boreholes, with the advantage to permit correlation between the different data sets. The division into rock domains makes use of all the combinations in the two types of rock units. For example, separate domains can be defined based solely on an anomalous degree of ductile strain even if other properties of the bedrock are similar.

The Forsmark tectonic lens is represented by a limited number of rock domains (RFM029, RFM045, RFM044, RFM032, RFM034, RFM020 and RFM017), of which the volumetrically most important is RFM029. Domains situated immediately outside the tectonic lens are stretched along the southwestern (RFM026, RFM025, RFM018 and RFM012) and northeastern (RFM043, RFM021 and RFM016) limbs of the synform that is part of the inferred major sheath fold. All these marginal domains dip steeply towards the southwest, following the trend of the coastal deformation belt. The geometry of the synform is constrained by the boundary between rock domain RFM029 and the marginal domains RFM032 and RFM044 (Figure 6-5). Ductile structures in outcrops and boreholes situated in this volume prove that the synform plunges moderately to steeply (55–60°) to the southeast. Domain RFM045 has a constricted rod-like geometry steered by the proximity to the hinge of the synform (Figure 6-5). Rock domain RFM034 is located structurally beneath the two folded marginal domains, RFM032 and RFM044.

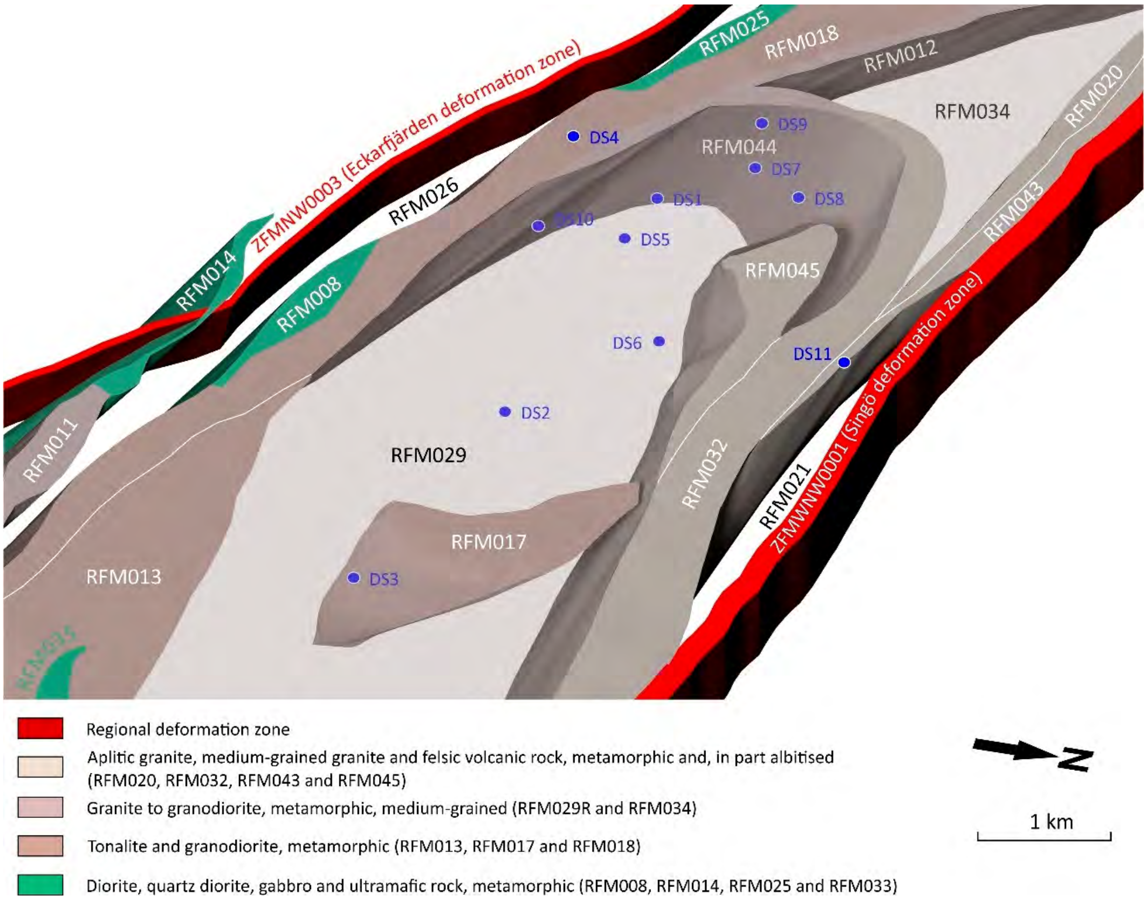


Figure 6-5. *Detail of the RFM regional volume showing the northwestern part of the tectonic lens. The model is viewed to the WSW and includes RFM045 from the RFM local model and the regionally significant Singö and Eckarfjärden deformation zone. RFM029R and RFM034 are shaded, whereas others are unshaded (RFM021 and RFM026) in order to display the structural trend at the Forsmark site. Note especially the moderately to steeply plunging synform that is defined by the boundary between domain RFM029R and domains RFM032 and RFM044. The dominant rock type in each domain is depicted by different colours (see legend). Drill sites (DS) 1–11 are marked by blue circles.*

In general, linear (L) ductile mineral fabrics, including folding, dominate over planar (S) equivalents (LS-tectonites) in the domains that belong to the tectonic lens. They are inferred to be affected by a lower degree of ductile strain relative to the domains outside the tectonic lens even if the intensity of tectonic foliation increases somewhat towards the margins of the lens. However, the rocks in domains RFM032 and RFM044 are more strongly deformed and inferred to be folded by the major synform.

The rock volume with the RFR domains is situated in domains RFM021 and RFM033 (Figure 6-4), where the former is inferred to be part of the coastal deformational belt and composed predominantly of felsic metavolcanic rocks with abundant pegmatite and pegmatitic granite. Domains RFR01–RFR03 are sub-domains of RFM21, whereas RFR04 is equal to RFM033. The concept for modelling of the two domains RFR01 and RFR03 has involved irregular folding of compositionally heterogeneous rock volumes dominated by pegmatitic granite.

Quantitative estimates of the proportions of different rock types and alteration types are presented in Figure 6-6 and Figure 6-7 for the domains RFM012, RFM044, RFM045, RFM029, RFM029R, RFR01 and RFR02. Quantitative borehole data for the other domains are either insufficient to carry out a reliable estimate (RFM032 and RFM034) or are lacking.

Granites affected by amphibolite-facies metamorphism and, to some extent also by syn-metamorphic albitization, form the dominant rock component inside the tectonic lens. The rock domains that lie outside the tectonic lens are dominated by different types of granitoids, predominantly felsic volcanic rocks and quartz-poor or quartz-deficient diorite to gabbro, all of which are affected by amphibolite-facies metamorphism. More inhomogeneous bedrock is common in domains RFM018 and RFM021, on both sides of the tectonic lens.

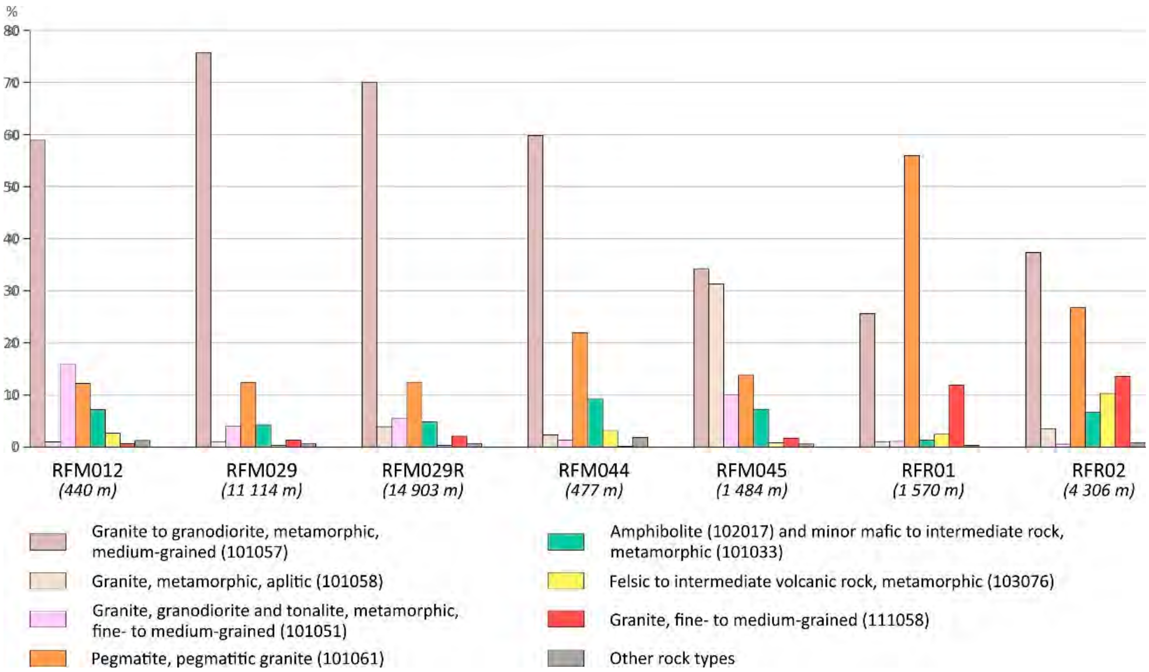


Figure 6-6. *Histograms illustrating the quantitative estimates of the proportions of different rocks in rock domains RFM012, RFM029, RFM029R, RFM044, RFM045, RFR01 and RFR02. The compilation is based on geological data from cored borehole sections (Sicada delivery SKBdata_22_065 and SKBdata_23_022). All calculations take account of both rock types and rock occurrences. Rock types with codes 101057 and 101058 in domain RFM045 are more or less altered to a fine-grained, quartz-plagioclase feldspar-(biotite) rock; the alteration is referred to as albitization (code 104 in the Sicada database).*

A considerable proportion of the bedrock within RFM045 is affected by syn-metamorphic albitization, whereas more extensive occurrences of sericitization (muscovitization) generally are restricted to the RFR domain.

Property tables for the current versions of the rock domains included in Baseline Forsmark version 1.0 are stored in SKBmod (cf. Section 2.3). Property tables and information regarding the modelling procedure for the previously established model versions are provided by SKB (2005, 2006), Stephens et al. (2007) and Curtis et al. (2011). More detailed descriptions of the key domains in the target volumes for the planned repositories are presented by Stephens et al. (2007) and Curtis et al. (2011).

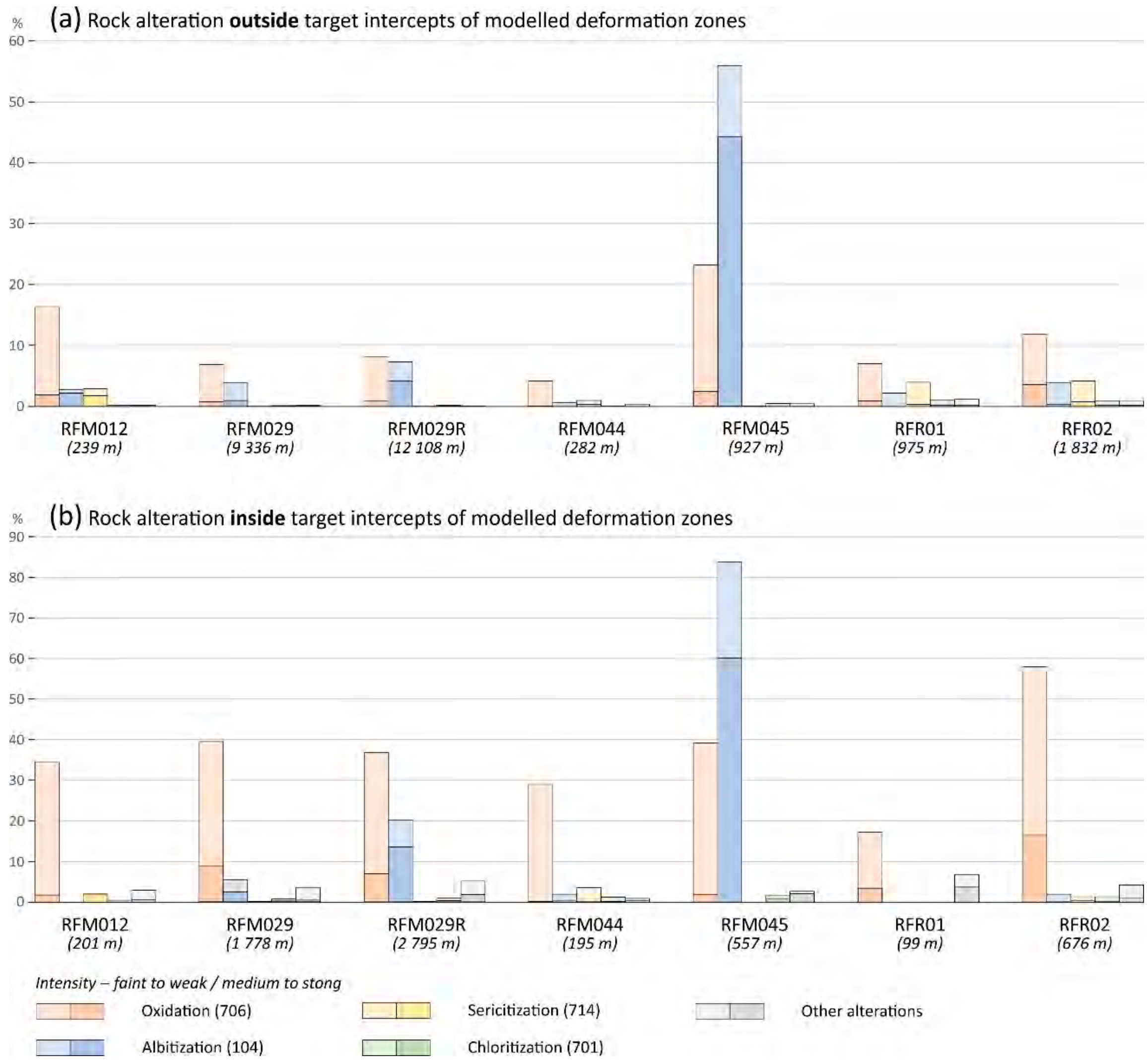


Figure 6-7. *Histograms illustrating the quantitative estimates of rock alteration (a) outside and (b) inside target intercepts of modelled deformation zones for the rock domains RFM012, RFM029, RFM029R, RFM044, RFM045, RFR01 and RFR02. "Other alterations" include argillization, carbonatization, epidotization, laumontization, quartz dissolution, saussuritization, silicification and steatitization. The compilation is based on geological data from cored borehole sections (Sicada delivery SKBdata_22_065). Total borehole lengths outside and inside modelled deformation zones of each rock domain, including both altered and unaltered sections are presented in brackets. Note the scale difference between the histograms outside and inside target intercepts of modelled deformation zones. Note also that different alteration types can overlap, and the total proportion of altered rock is hence lower than the sum of individual alteration types.*

7 Fracture domain model

7.1 Conceptual model

During the work with the SDM-Site, a need was recognised to divide the Forsmark site into fracture domains as a prerequisite for the development of an updated model for discrete fracture networks (DFN). For this purpose, Olofsson et al. (2007) identified and described a number of fracture domains at the site by using an integrated assessment of especially hydrogeological and hydrogeochemical data to support the development of a fracture domain concept.

A systematic assessment of the variation in the frequency of particularly open and partly open fractures with depth along each borehole (cf. Olofsson et al. 2007; Stephens et al. 2007) contributed significantly to the division of the bedrock into fracture domains. The following four considerations presented by Olofsson et al. (2007) control the identification and conceptual understanding of fracture domains at the site:

- Boreholes in the northwestern and southeastern parts of the investigated volume of the tectonic lens show a marked contrast in the fracture frequency distribution patterns with depth, particularly in the frequency of open and partly open fractures. It is suggested that this feature is essentially related to the corresponding contrast in the frequency of gently dipping deformation zones between the two sub-volumes. Since such zones are far less frequent beneath the combined zones ZFMA2 and ZFMF1 (cf. Figure 5-8), which merge southeast of drill site 2, different fracture domains are anticipated above and beneath these zones.
- The fracture frequency distribution patterns with depth also show that the bedrock beneath zone ZFMA2 displays different fracture characteristics close to the surface and at depth. This feature motivates separate fracture domains at different depths beneath this zone.
- There is a significant contrast in both the degree and character of the ductile strain and, to a large extent, the compositional homogeneity in the rock domains that form the margins of the tectonic lens, compared to the rock domains inside the lens. It is suggested that this contrast motivates the inclusion of the former as separate fracture domains. This strategy is also supported by the results of the DFN model version 1.2 (La Pointe et al. 2005). Two separate fracture domains are proposed, corresponding to the combined rock domains RFM012 and RFM018 and the combined rock domains RFM032 and RFM044.
- Rock domain RFM045, inside the tectonic lens, is dominated by fine-grained, altered (albitised) granitic rock. It is judged that both the finer grain size and the somewhat higher quartz content of this rock, as compared to unaltered granitic rock, may be significant for fracture characterization. The rock domain is consequently identified as a separate fracture domain.

7.2 Division into fracture domains, geometries and property assignment

Based on the considerations presented in the preceding section, six separate fracture domains have been recognised within the RFM local volume (Olofsson et al. 2007). However, borehole data that allow satisfactory characterisation are only available for four of the domains – FFM01, FFM02, FFM03 and FFM06. The inferred relationship between the domains is illustrated in Figure 7-1.

Data acquired after conclusion of the investigations for SDM-Site prescribes slight modifications for one of the domains, described further in Sections 7.5 and 7.6, but the framework and overall concept remains unchanged. A brief description of the four fracture domains is presented below. Further details regarding the fracture character, modelling procedures and uncertainties for the previously established model version are provided by Olofsson et al. (2007), with summaries in Stephens et al. (2007) and SKB (2008a). Property tables for the current versions of the fracture domains included in Baseline Forsmark version 1.0 are stored in SKBmod (cf. Section 2.4).

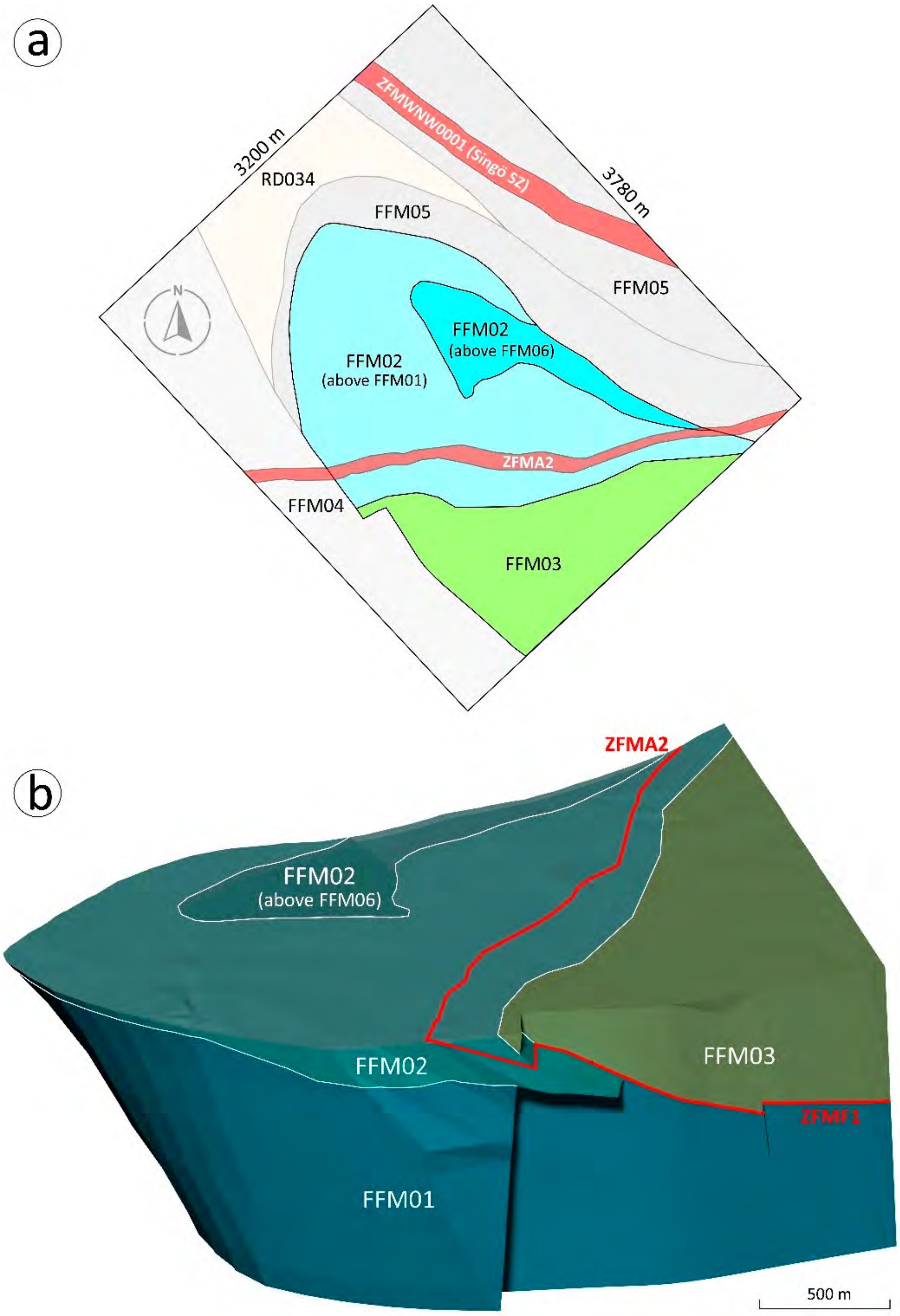


Figure 7-1. *(a) Top view of FFM Baseline Forsmark version 1.0 at the ground surface. Volumetric representations of deformation zones ZFMA2 and ZFMWNW0001 are shown as references; they are not part of the current version of the fracture domain model. (b) Three-dimensional model for fracture domains FFM01, FFM02 and FFM03 viewed towards the ENE. FFM06 is enclosed by FFM01 and situated beneath FFM02 and is for this reason not visible. Origin surfaces for the gently dipping zones ZFMA2 and ZFMF1 also shown in red.*

Fracture domain FFM01 is situated within rock domain RFM029. It lies beneath the gently dipping zones ZFMA2, ZFMA3 and ZFMF1 and northwest of the steeply dipping zone ZFMNE0065, at an elevation that varies from ca −40 m (large distance from ZFMA2) to ca −200 m (close to ZFMA2). Relative to the overlying fracture domain FFM02, the bedrock in this domain shows a lower frequency of open and partly open fractures. Gently dipping or sub-horizontal deformation zones are not common inside this domain, based on current available data and understanding of the site. It is suggested that local accumulation of high in situ rock stresses have occurred at one or more times during geological history, in connection with, for example, sedimentary loading processes (SKB 2006; Stephens et al. 2007).

Fracture domain FFM02 is situated close to the surface, directly above fracture domain FFM01 and FFM06. It is characterized by a complex network of gently dipping and sub-horizontal, open and partly open fractures, which, conceptually, are considered to merge into minor fracture zones. Several of the fractures are evidently extensional structures (i.e. sheet joints), developed parallel to the current ground surface and to the two greatest principal compressive stresses in the rock mass. The transition depth to the less fractured bedrock of FFM01 increase as the distance from zone ZFMA2 decreases. A viable explanation for this is provided by the numerical stress simulations of Glamheden et al. (2007), which reveals that ZFMA2 perturbs all the stresses in the rock mass above the zone, and to limited extent below the zone (Figure 7-2). This deflection of the near-surface stresses is proposed to mimic the effect of a convex topographic surface and might have the ability to induce tension. Furthermore, the numerical modelling of the current stress conditions, implies significantly higher stress magnitudes below ZFMA2 and ZFMF1 than in the hanging wall (i.e. FFM03), where release of stress has reached deeper levels relative to that in FFM02. The stress magnitudes yielded by Glamheden et al. (2007) are largely equivalent with the high compressive surface-parallel stresses in most sheeted rock masses (cf. Martel 2017), especially in FFM02. FFM03 yields considerably lower stress magnitudes, likely due to stress-release facilitated by gently dipping fracture zones (i.e. ZFMA4–A7, ZFMB1 and ZFM866). This behaviour aligns with expectations.

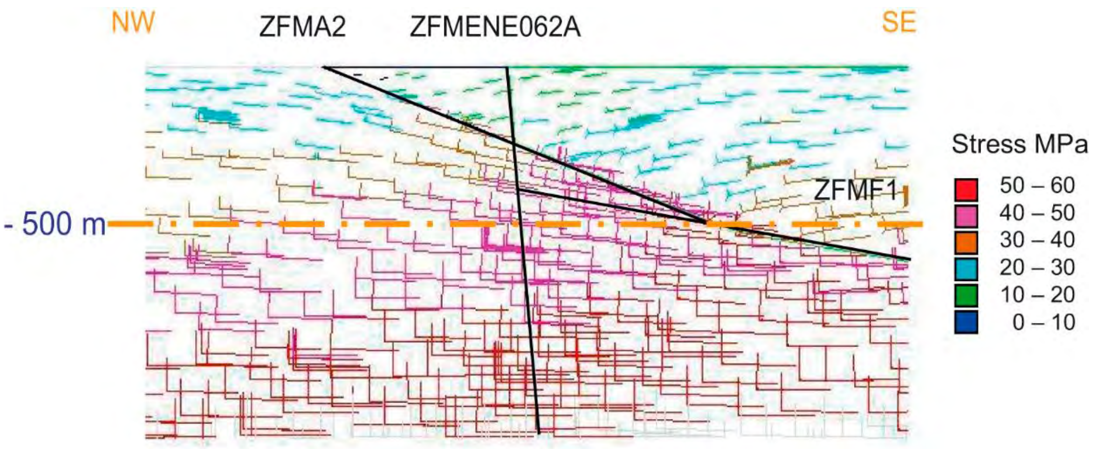


Figure 7-2. Principal stress tensors along NW–SE vertical section obtained from 3DEC numerical simulation to assess the impact of major deformation zones; ZFMA2, ZFMF1 and ZFMENE062A. Note the rotation of principal stress tensors above and around ZFMA2 and ZFMF1. From Glamheden et al. (2007, Figure 6-26).

Fracture domain FFM03 is situated within rock domains RFM017 and RFM029. Structurally, the domain lies above the shallow dipping zones ZFMA2, ZFMA3 and ZFMF1. The domain is characterised by a high frequency of gently dipping fracture zones containing both open and sealed fractures. It is suggested that this sequence of gently dipping zones inhibited the build-up of rock stresses in connection with, for example sedimentary loading processes (cf. Stephens et al. 2007). The development of sheet joints is hence less conspicuous than in FFM02.

Fracture domain FFM06 is situated within rock domain RFM045. It resembles fracture domain FFM01 in the sense that it lies beneath both zone ZFMA2 and fracture domain FFM02. It is distinguished from domain FFM01 based on lithological characteristics of the widespread occurrence of fine-grained, altered (albitized) granitic rock, with slightly higher contents of quartz compared with unaltered granitic rock.

7.3 Changed representation of deformation zones

Up to Fracture domain FM version 2.3 (cf. Table 2-7), the rock volume was divided into fracture domains, comprising of the volume included in the rock domains minus the volume of rock occupied by deformation zones. Thus, all deformation zones were represented by volumes between their bounding surfaces and as such treated as separate domains in a space filling model, which is illustrated in Figure 7-3a.

Regarding the FFM Baseline Forsmark, on the other hand, it was decided to represent each deformation zone by a single, infinitely thin surface – the origin surface, which generally corresponds to the centre of the zone (Figure 7-3b). If the end-users have a need for volumetric representations of deformation zones this can easily be achieved by superposition of deformation zone boundary geometries in DMS Baseline Forsmark (Figure 7-3c).

The advantage of the latter approach, with zones as single surfaces, is that the downstream users can decide whether to include a zone or not, depending on the purpose and modelling tool. With the former approach, the downstream users were forced to handle zones as separate domains, otherwise there were gaps that required extrapolations of adjacent domains to retain the connectivity.

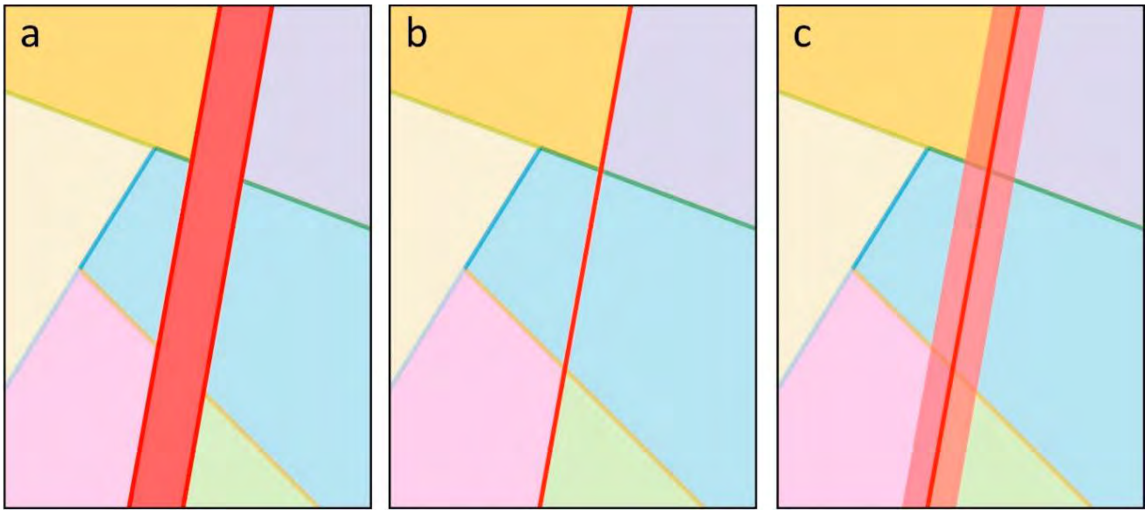


***Figure 7-3.** Simplified figure showing alternative representations of deformation zones in a fracture domain model. Deformation zones can be handled as (a) separate domains in a space filling model or (b) single, infinitely thin surfaces (the origin surface). In the latter case volumetric representations of deformation zones can be achieved by later superposition of the bounding zone surfaces, as illustrated in alternative c.*

7.4 Upgrading of the RVS modelling tool

The fracture domain model that preceded the release of FFM Baseline Forsmark version 1.0 (cf. Table 2-7) was produced in RVS v6. To achieve full concordance with the revised geometries of the other deterministic geological models of Baseline Forsmark, which were introduced by the conversion to RVS v7 (see Sections 5.4.3, 6.2 and 6.3), it was also necessary to generate a new fracture domain model. The major changes that affected the geometries of the fracture domain boundaries are as follows:

- The meshing of the domain boundaries was optimised by a general point reduction. Although this change has affected the geometric details, the overall geometric appearance remains indistinguishable from the boundaries of the original model (see Section 6.2).
- Adjustments of domain boundaries to achieve a better matching between ground surface intersections and the inferred rock boundaries derived from outcrop data. Boundaries without borehole intersections retained their original geometries, but with a slight shift in the position. For boundaries with borehole intersections, only the uppermost surface profile was adjusted to limit the geometrical changes to the part above the uppermost borehole intersection (se Section 6.3).

7.5 The division of FFM02 into subdomains

The frequency of sub-horizontal fractures with aperture displays a marked contrast between the upper and lower part of fracture domain FFM02 along the boreholes in the planned accesses and operation area of the final repository for spent nuclear fuel. The transition from a shallow rock mass, sheeted by sub-horizontal fractures with aperture, and the underlying part of FFM02 is rather distinct at −18 to −28 m elevation in most of the boreholes in proximity to the repository access volume (Figure 7-4). A similar depth-dependent trend is also revealed along other boreholes within fracture domain FFM02, especially those at drill sites 1, 5, 6 and 7. However, the feature is usually less conspicuous in these boreholes and tends to be vague to non-existent along most of the possible deformation zones identified during the single-hole interpretation process (e.g. boreholes at drill site 9 which are inferred to intersect ZFMENE1208A). The trend is also obscured by shallow level intersections of ZFMA2, where sub-horizontal fractures with significant aperture instead are attributed to ZFMA2. Thus, horizontal to sub-horizontal fractures close to ZFMA2 can be splays rather than superficial sheet joints.

Although there are local difficulties in the identification, this transition has been defined in approximately two thirds of all boreholes with images (BIPS and OP-TV images) covering the level of interest in FFM02. On this basis, fracture domain FFM02 has been divided into two subdomains:

- FFM02U (upper) – A shallow rock mass sheeted by horizontal to sub-horizontal fractures with distinct aperture and, in some cases, anomalously high transmissivities. The subdomain has a rather constant thickness, mainly ranging from 17 to 27 m, unaffected by the distance to ZFMA2, and a lower boundary that dips 0.3° towards the west.
- FFM02L (lower) – In principle, the underlying (remaining) part of fracture domain FFM02, down to the transition to the less fractured bedrock of FFM01 (and FFM06). The subdomain is characterised by an increasing spacing with depth between horizontal to sub-horizontal fractures with distinct aperture, relative to the shallow rock mass of FFM02U. The origin of the horizontal to sub-horizontal fractures with distinct aperture at great depth can be different than at shallow depth, with a genetic relationship to the other fracture sets in the area.

The distribution of inferred sheet joints with aperture relative to the defined boundary between the subdomains FFM02U and FFM02L are presented in Figure 7-4, as logs for boreholes in the planned accesses and operational area of the final repository and drill site 7. The extent of FFM02U and FFM02L, is shown in Figure 7-5. A similar depth-dependent contrast in the frequency of sub-horizontal fractures with aperture is also revealed along some of the boreholes outside fracture domain FFM02, such as in HFM32 in FFM03. But most of the boreholes show no such distribution pattern, even if inferred sheet joints are rather common. These observations, together with the sparse drillings outside of fracture domain FFM02 do not provide sufficient support for a deterministic extension of a shallow rock slab with frequent sheet joints beyond FFM02.

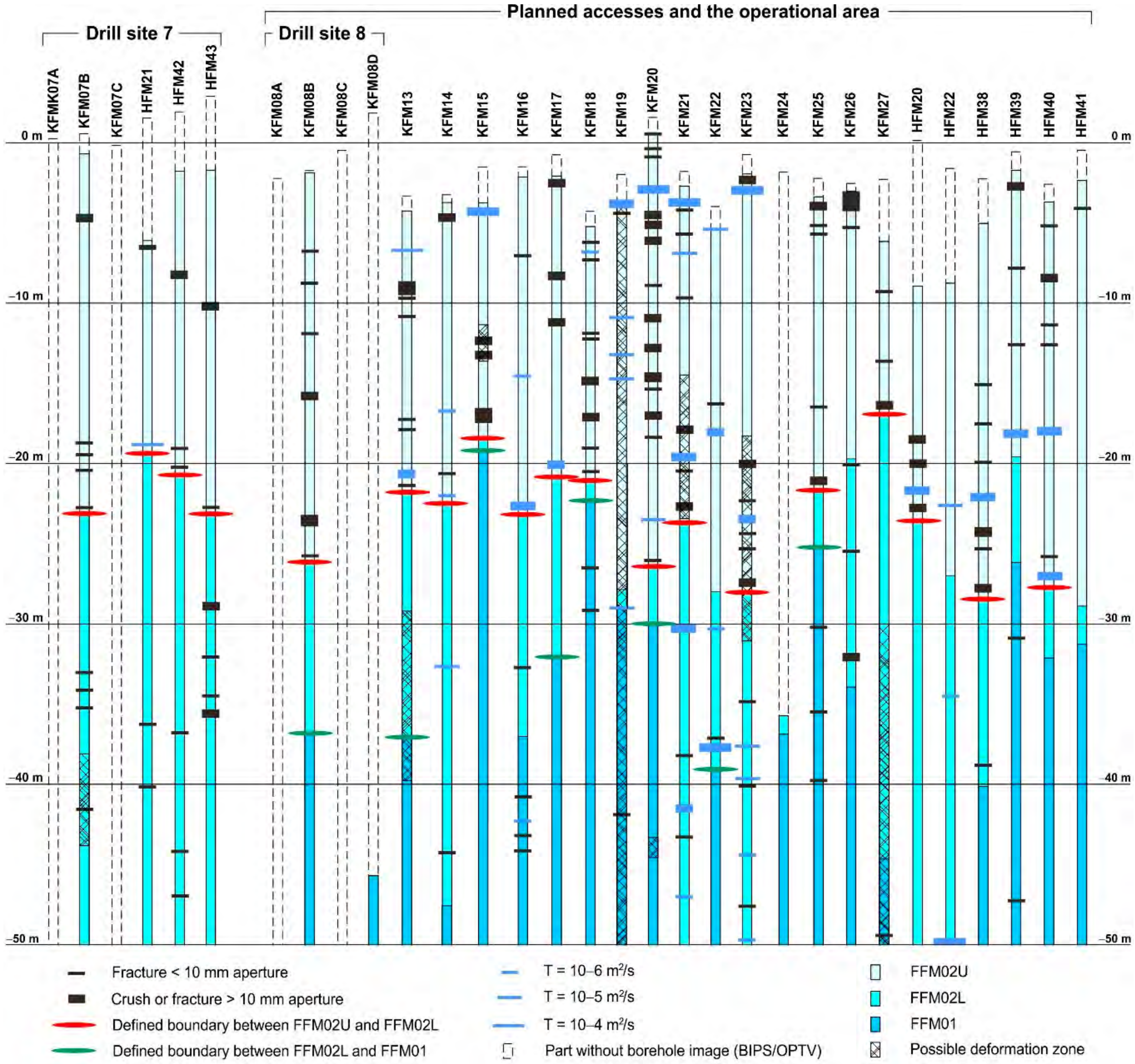


Figure 7-4. *Borehole logs covering drill site 7, 8 and the planned accesses and operation area of the final repository down to a depth of approximately −40 m. The logs show the distribution of inferred sheet joints with aperture along individual boreholes relative to the extent of fracture domains FFM02U, FFM02L and FFM01. Inferred sheet joints are divided based on aperture and transmissivity (T).*

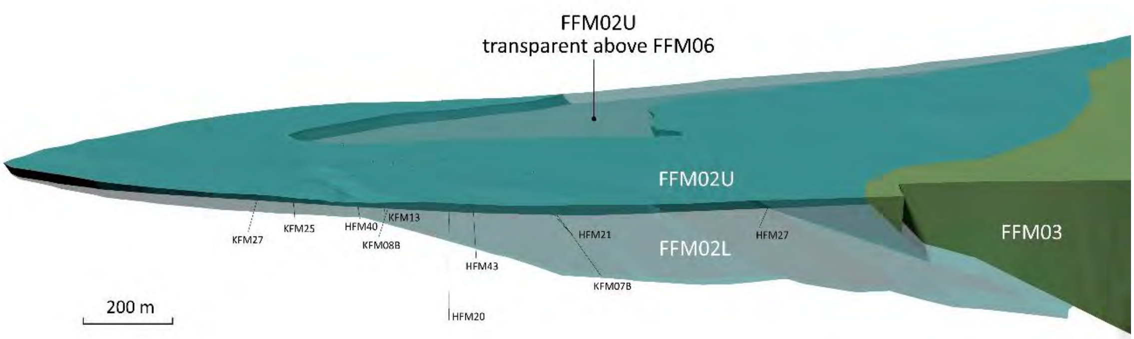


Figure 7-5. *Oblique view to northeast showing the relationship between fracture domains FFM02U, FFM02L and FFM03 relative to the boreholes used to define the boundary between FFM02U and FFM02L. FFM02U are transparent above FFM06 in order to display the geometry of the latter. Note that several of the boreholes are hidden by FFM02U in the current view.*

It is important to emphasise again that the distribution of horizontal to sub-horizontal fractures within FFM02L is highly variable, with an increased spacing towards depth. The boreholes completed after 2010 provide very limited information to the issue, as they all are located in a part of FFM02, where the transition depth to the underlying fracture domain FFM01 is close to the minimum. Also, the fracture data in the southeastern part, where the transition depth increases to a maximum of ca 200 m, are rather sparse with mainly deep telescopic boreholes, locally affected by the gently dipping zone ZFMA2.

7.6 Local revision of the boundary between FFM01 and FFM02

In the previous fracture domain FM 2.3 (cf. Table 2-7), the primary basis for the separation of fracture domain FFM02 from the underlying FFM01/FFM06 along cored boreholes is "an anomalously high frequency of open and partly open fractures" (Olofsson et al. 2007). The borehole intersection fix-points used for modelling of the boundary between the two domains are listed in Table 5-2 of Olofsson et al. (2007). However, the actual surface was achieved by Gaussian process regression with subsequent import to RVS. Olofsson et al. (2007) also present diagrams of the variation in the fracture frequency at depth for each cored borehole included at model stage 2.2 of SDM-Site. These diagrams have been designed to provide an initial assessment of significant variations in fracture frequency in the bedrock outside the influence of geological anomalies such as deformation zones. Due to the lower quality of geological data in the percussion boreholes, the lower confidence level in the single-hole interpretation and the limited length of these boreholes, data from the percussion boreholes have not been used to define fracture domains at the site.

The drilling programme conducted in the shallow part of the access volume during 2011–2012 with the drilling of KFM13 to KFM23, as well as the subsequent drilling of KFM25 to KFM27, have provided information for an updated geometry of the boundary between FFM01 and FFM02. The approach used to define the revised boundary is virtually the same as the one used by Olofsson et al. (2007), who basically relied on cumulative frequency plots of open and partly open fractures for each individual borehole. Cumulative fracture frequency plots for the boreholes KFM13 to KFM27 and KFR117 to KFR121 are presented in Appendix 6.

Except for the increased fracturing along intervals of inferred deformation zones, two typical fracture distribution patterns can be distinguished along the boreholes:

1. Virtually constant frequency along the entire borehole, even if the absolute frequency differs among the boreholes. Examples: KFM14 (Figure 7-6) and KFR16.
2. High and often variable frequency in the uppermost 20–40 m of the rock mass, with a change into lower and more constant frequency towards depth. Examples: KFM15, KFM17, KFM18 and KFM20 (Figure 7-6). KFM13, KFM21 and KFM23 show to some extent a similar distribution pattern, but with interference from intersecting deformation zones. This change in the distribution pattern of open and partially open fractures towards depth, has been taken to represent the boundary between FFM02 and FFM01. As illustrated by KFM20 in Figure 7-6, this change occurs at an approximate elevation of −30 m, with a shift from a rather high and variable frequency of 6.2 open and partially open fractures per metre in the upper part to an average of 1.4 in the remaining, lower part of the borehole.

Only boreholes with a distinct change in the fracture distribution pattern have been used to define the fracture domain boundary. Several of the older, cored boreholes from the site investigations situated close to the access volume are of telescope type (i.e. percussion drilled upper part of the borehole), and the cored parts do normally start at approximately 60–100 m depth. Within the planned access volume, the boundary between FFM02 and FFM01 is defined at an approximate elevation of –40 m in the previous model Fracture domain FM 2.3. The depth was defined along KFM08B during an extended SHI where the boundary between the two domains was identified at 46 m borehole length (Olofsson et al. 2007). The difference in the frequency of open and partially open fractures along the borehole is not obvious and there is more of a rather high, constant distribution (Figure 7-7) reminiscent of that in KFM14 (Figure 7-6) and KFM16. However, further support has been provided by the existence of fractures with aperture and especially differences in SPR (single point resistivity) and fluid resistivity (Michael Stephens, personal communication).

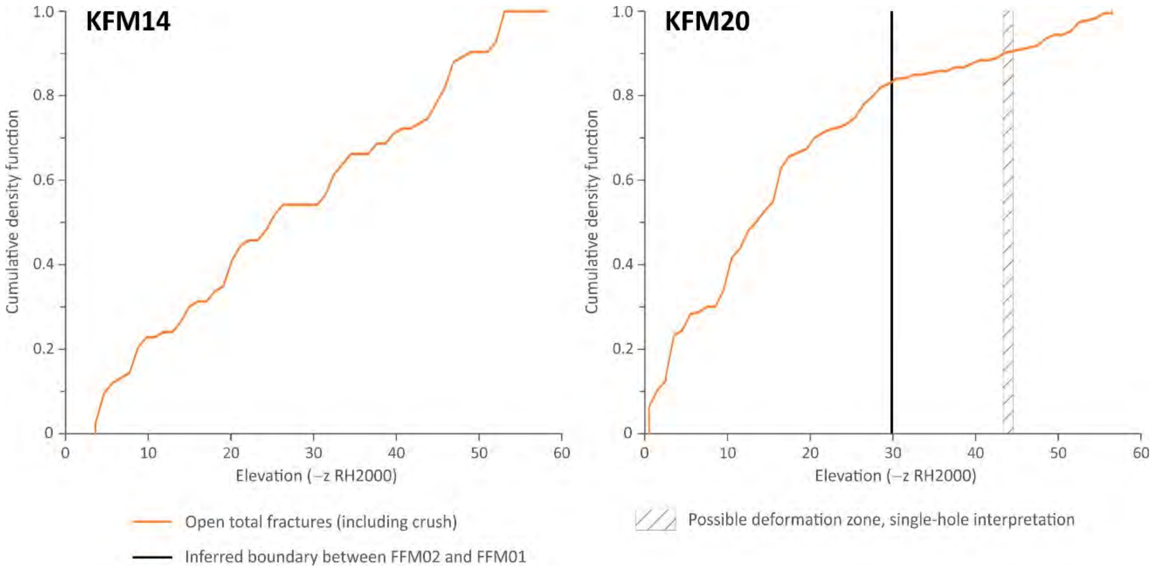


***Figure 7-6.** Two typical distribution patterns for open fractures (including partly open fractures and crushes) towards depth, exemplified by KFM14 and KFM20. Fracture frequencies are shown cumulatively. Note that the diagrams are based on elevation (not borehole length).*

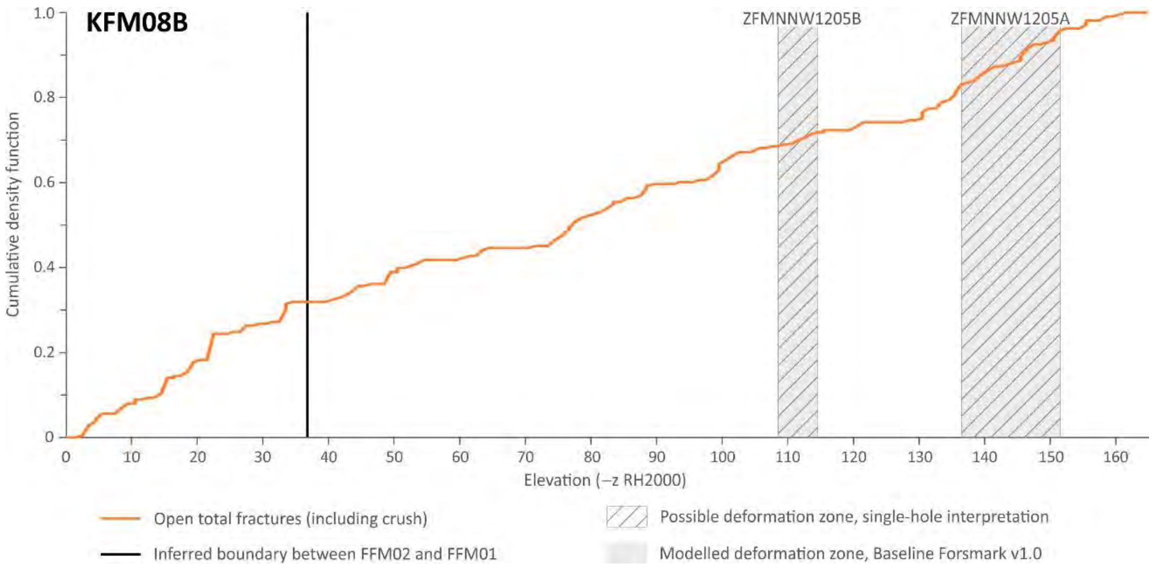


***Figure 7-7.** Cumulative frequency of open fractures (including partly open fractures and crushes) in KFM08B. Note that the diagram is based on elevation (not borehole length).*

Based on the frequency distribution of open and partly open fractures, the boundary between FFM02 and FFM01 has been possible to identify in about half of the cored boreholes situated in or close to the shallow part of the access volume (cf. Figure 7-4). In the remaining boreholes, there are either a disturbance by intersecting deformation zones (KFM19, KFM21, KFM23 and KFM27) or a rather constant frequency distribution along the entire borehole length (KFM14 and KFM16). Defined boundary intercepts, listed in Table 7-1, have been used as targets or fix points for revision of the surface geometry in the access volume. Following the modelling approach for Fracture domain FM 2.3, it was decided to exclude data from the percussion boreholes in this work. Target borehole intercepts used for modelling of the FFM02/FFM01 boundary in Fracture domain FM 2.3 (cf. Table 5-2 of Olofsson et al. 2007) have been left unchanged. However, kriging fix points situated close to target intercepts listed in Table 7-1, have been omitted to achieve a smooth shape of the boundary geometry. With this update, the boundary between FFM02 and FFM01 has been moved upward, closer to the ground surface, by about 5 m in the volume of the added borehole fix points.

Table 7-1. Target intercepts along boreholes for revision of the boundary between FFM02 and FFM01. See Appendix 6 for cumulative frequency diagrams.

Borehole	BH length [m]	BH depth [−m]	Comment
KFM13	46	37.2	Distinct change in the frequency of open and partly open fractures close to sec_low of PDZ1
KFM14	–	–	Low, rather constant frequency of open and partly open fractures throughout the borehole
KFM15	23	19.2	Distinct change in the frequency of open and partly open fractures
KFM16	–	–	Constant frequency of open and partly open fractures
KFM17	36	32.1	Distinct change in the frequency of open and partly open fractures
KFM18	26	22.3	Distinct change in the frequency of open and partly open fractures
KFM19	–	–	Constant frequency of open and partly open fractures. The borehole is almost completely included in ZFMENE1061A
KFM20	33	29.9	Distinct change in the frequency of open and partly open fractures
KFM21	–	–	–
KFM22	42	39.0	Distinct change in the frequency of open and partly open fractures
KFM23	–	–	Difficult to define a boundary since the borehole is almost completely inside ZFMENE2120
KFM24	–	–	Percussion drilled down to 35.68 m borehole length
KFM25	28	25.2	Rather weak change in the frequency of open and partly open fractures
KFM26	–	–	Constant frequency of open and partly open fractures
KFM27	–	–	Disturbance of the fracture frequency pattern by ZFMENE2248, which occurs along the entire borehole

8 Model validity, uncertainties and recommendations

Increased confidence and successive reduction of uncertainties in the six versions of the site descriptive models have, besides improvement of the conceptual understanding, been the main driving forces of the surface-based investigations at Forsmark. A recurring question has been whether remaining uncertainties are acceptable for the purpose of engineering design of the repository for spent nuclear fuel and post-closure safety assessment or could be further reduced by additional investigations. Assessments of uncertainties and confidence have, consequently, been essential components in all previous versions of the geological models. These include whether all data are considered and understood, identification of the main uncertainties and their causes, possible alternative models and their handling, and conceptual consistency between disciplines, which in turn forms the basis for an overall confidence statement. Remaining uncertainties at completion of SDM-Site and SDM-PSU are summarised in SKB (2008a) and SKB (2013), respectively, with a more systematic, multi-disciplinary compilation for SDM-Site in SKB (2008b). Further notes on uncertainties in the Forsmark deformation model version 2.3 are presented by Stephens and Simeonov (2015).

The overall confidence level concerning the geological evolution and the broad tectonic framework of the region is judged to be high, based on the detailed work associated with the site investigations and the associated modelling work as reported in Stephens et al. (2007) and Curtis et al. (2011). More specifically, this confidence in the deterministic models rely on a comprehensive site understanding, as a basis for well-founded modelling concepts, but also the consistency between different model versions, the wealth and quality of available data and support from other disciplines. The predictability of the occurrence and character of both deformation zones and rock domains has proven to be high (Stephens et al. 2008b) and no new deformation zones with trace lengths exceeding 3 000 m at the ground surface have emerged in the proximity to the SFR facility or the local model volume of SDM-Site since model stage 2.2. However, the confidence in the deterministic modelling is naturally scale-related, with high confidence in existence for zones of regional extent and lower levels as increasingly smaller structures are considered. The predictability of the region is inferred to be strongly related to the bedrock anisotropy that was established over 1 850 million years ago, when the bedrock was situated at mid-crustal depths and was affected by penetrative, ductile deformation.

Geometries of modelled objects are highly dependent on the spatial positioning of the underlying data, which mostly consist of boreholes and geophysical entities, such as seismic reflectors and low magnetic lineaments. The estimated uncertainty in the position is generally less than 10 m, with a minimum accuracy of approximately 30 m (cf. Cosma et al. 2003; Isaksson and Keisu 2005; Isaksson et al. 2006a; Munier and Stigsson 2007). The negative impact on the geometric models of these uncertainties is judged to be relatively minor in significance compared to other more interpretative factors, such as the coherence between different geological observations and their interpolation or extrapolation (see Hermanson and Petersson 2022). The intrinsic weaknesses in the modelling procedure of vertical to steeply dipping deformation zones, including the matching between lineaments and possible deformation zones identified in a single-hole interpretation, and assumptions concerning the downdip extension (see Section 5.3.2), affect the modelled zone geometries significantly. The consequence of this is that the geometric constellations of zones in the current models are non-unique, as alternative geometries cannot be excluded. This is even more striking when it comes to deterministic modelling of sheet joints, which basically requires complimentary semi-stochastic modelling to fully describe the uncertainties in occurrence and spatial extent (cf. Hermanson and Petersson 2022).

Uncertainties outside the bedrock volumes, which were the focus of the previous site investigations, are significant, but are judged to be of less importance for post-closure safety assessment and repository design. The most noticeable example of this data bias is the absence of gently dipping zones in large parts of the volume of DMS Baseline Forsmark version 1.0, where no reflection seismic data exist. Such deterministic gaps need to be addressed by the stochastic DFN modelling work.

After the compilation and revision of the deterministic geological models covered by Baseline Forsmark version 1.0, there remains several more specific uncertainties; the majority of which were identified already at the completion of SDM-Site and SDM-PSU:

- Size of gently dipping deformation zones, which are currently extended to the nearest steeply dipping zone.
- Lateral extent of vertical to steeply dipping deformation zones that are largely defined by magnetic minima connections (e.g. ZFMWNW0123).
- The truncation pattern of vertical to steeply dipping deformation zones outside areas of high-resolution magnetic measurements or in magnetically disrupted areas.
- Orientation and size of unresolved deformation zones identified in the single-hole interpretation.
- The existence and geological character of gently dipping zones beneath the final repository.
- The presence of additional deformation zones not captured in the deterministic Baseline model, such as gently dipping zones in areas that lack reflection seismics and drillings.
- Size, occurrence and frequency of sheet joints in the upper part of the crystalline bedrock.
- Size and spatial distribution of subordinate rock types, especially for anomalously thick amphibolite bodies in domain RFM045.

8.1 Size of gently dipping deformation zones

The estimated size of the gently dipping zones is based on the modelling of surface seismic reflection data and intersections along boreholes, in combination with the conceptual understanding of the tectonic evolution at Forsmark (see Section 5.1.1). Current knowledge is judged satisfactory where it concerns occurrence, orientation and geological properties in the volumes covered by the site investigations. Information from boreholes in these volumes provide constraints on the along-strike and down-dip extension for a few of the zones, such as ZFM1203 (see Section 5.4.4) and ZFM871, but uncertainties remain for the vast majority.

In the adopted modelling approach, it is judged that the uncertainty is sufficiently bounded by extending gently dipping zones to the nearest steeply dipping zone, even if there are uncertainties regarding the truncation towards depth. In addition, the significance of this uncertainty has been reduced somewhat through the selection of potential volumes for both the final repository and the expansion of the SFR facility. Though the uncertainty does still influence the modelling work of other disciplines, and hence the post-closure safety assessment.

The uncertainty can be reduced through complimentary surface-based investigations, such as boreholes and seismic reflection data in a tighter network of two-dimensional profiles (cf. SKB 2008b), but the significance in the near-repository volumes of the bedrock is judged to be limited.

8.2 Lateral extent of deformation zones largely defined by magnetic minima connections

Lineaments referred to as magnetic minima connections are related primarily to lithological contrasts that are aligned parallel to the ductile tectonic foliation in the bedrock. However, along or close to the high-strain margins of the Forsmark tectonic lens, lineaments defined by concordant magnetic minima are typically inferred expressions of vertical to steeply dipping, WNW–ESE and NW–SE striking zones with an initial ductile development. Whether a lineament defined by magnetic minima connections represent a possible deformation zone or lithological variability is not always obvious, and the occurrence of minor deformation zones along the tectonic foliation cannot be excluded as a contributory factor to these lineaments (e.g. ZFMNNW0404, ZFMNNW1204 and ZFMNNW1205A/B). This condition introduces some element of uncertainty in the interpretation of such lineaments, especially regarding their length.

Uncertainties regarding the length for some low magnetic lineaments has also been accentuated in the model review by the Swedish Radiation Safety Authority (SSM) through the following quotation: *"SKB's high-resolution ground magnetic measurements show that several steeply dipping deformation zones can be extended, which is particularly notable for zone ZFMWNW0123 which has been extended into the edge of the western part of the preliminary depositional area"* (GLS question 137). The example is highly relevant, given the possible impact on the preliminary layout of the repository, if a zone of such size (trace length at the ground surface is ca 5 km) were to be extended towards the NNW (cf. Figure 1-3 in Fälth 2022).

In the DMS Baseline Forsmark, ZFMWNW0123 terminates against ZFMENE0060A. A continuation further NNW of ZFMENE0060A cannot be completely excluded, based on the following information:

- Borehole data indicate that ZFMWNW0123 initially was developed by low-grade ductile deformation, whereas ZFMENE0060A shows only brittle strain. Thus, ZFMWNW0123 has at least locally existed before the development of ZFMENE0060A. Nevertheless, the conceptual model with a process of multiple reactivations and successive growth does not exclude the current truncation of ZFMWNW0123.
- The available high-resolution magnetic data provide basis for additional lineaments in the continuation of ZFMWNW0123, north of ZFMENE0060A (written communication with Hans Isaksson, dated 2019-12-19, see Figure 8-1).
- The northwestern part of ZFMWNW0123 instead follows lineament MFM0123G, which continues an additional 480 m northwest of ZFMENE0060A (Figure 8-1). Another possibility is that this part of the lineament represents a splay to the current interpretation of ZFMWNW0123; data from intersecting boreholes allow for both alternatives.
- None of the existing boreholes intersect a possible NNW continuation before it reaches KFM07A (Figure 8-1).
- The modelling team visited a number of outcrops in the area in early 2020 to shed further light on a possible continuation of ZFMWNW0123, though none of the outcrops provided any decisive input to the issue.

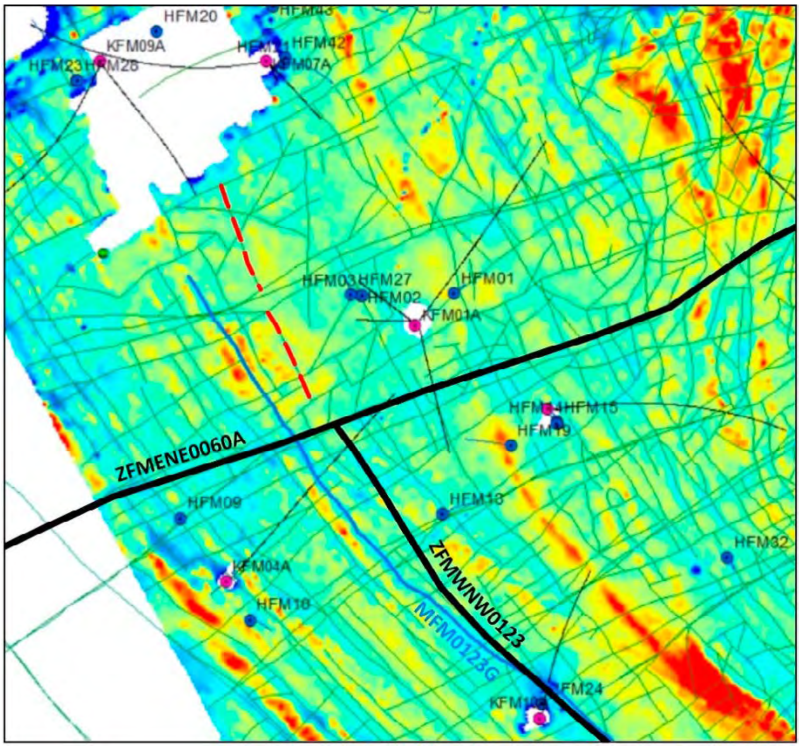


Figure 8-1. *High-resolution ground magnetic data relative to interpreted lineaments (thin blue and green lines) and boreholes with surface projections in the area of truncation between ZFMWNW0123 and ZFMENE0060A (solid black lines). Inferred lineaments in the northern continuation of ZFMWNW0123 are marked by dashed red lines, whereas lineament MFM0123G is marked by a blue solid line.*

A possible continuation of ZFMWNW0123 can be investigated both by boreholes and trenches positioned immediately north of ZFMENE0060A. Given the depth of the regolith in some depressions (e.g. AFM001243, Cronquist et al. 2005), it is recommended that such investigations are restricted to surface-based drillings.

There is also some uncertainty about the total extent of the zone and especially its southern part, which gradually receives an approximately east–west strike before truncation towards ZFMWNW0023. The question is whether the zone has a more limited extent or follows an alternative lineament in the south. Further analysis is recommended through a reassessment of the underlying data and the inferred lineaments in the light of current tectonic concepts.

8.3 The truncation pattern of vertical to steeply deformation zones

Uncertainties in the truncation patterns of vertical to steeply dipping zones are primarily of significance outside of areas covered by high-resolution ground magnetic measurements and in magnetically disturbed areas. The issue can be illustrated by Figure 8-2 from Stephens et al. (2008b), which compare the deterministic deformation zones in Forsmark stage 2.2 with modified zone traces implied by a revised interpretation of low magnetic lineaments that emerged from new high-resolution ground magnetic data (Isaksson et al. 2007). Based on this, the extent of individual lineaments, as well as the truncation pattern, is strongly dependent on the resolution of the underlying data, with a higher degree of uncertainty in areas outside of detailed ground magnetic surveys.

Although of a more local character, magnetically disturbed areas with low relief also exhibit significant uncertainties in lineament interpretation. Such disturbances occur close to man-made installations, including the Fennoscandian high-voltage DC cable, residence areas, landfill areas (e.g. the pier above the SFR facility), drill sites and water tubes. Furthermore, there are no measurements around the nuclear power plant. In these areas, the interpretations instead rely on alternative data sources (cf. SKB 2005), with strong support from the adopted tectonic concept.

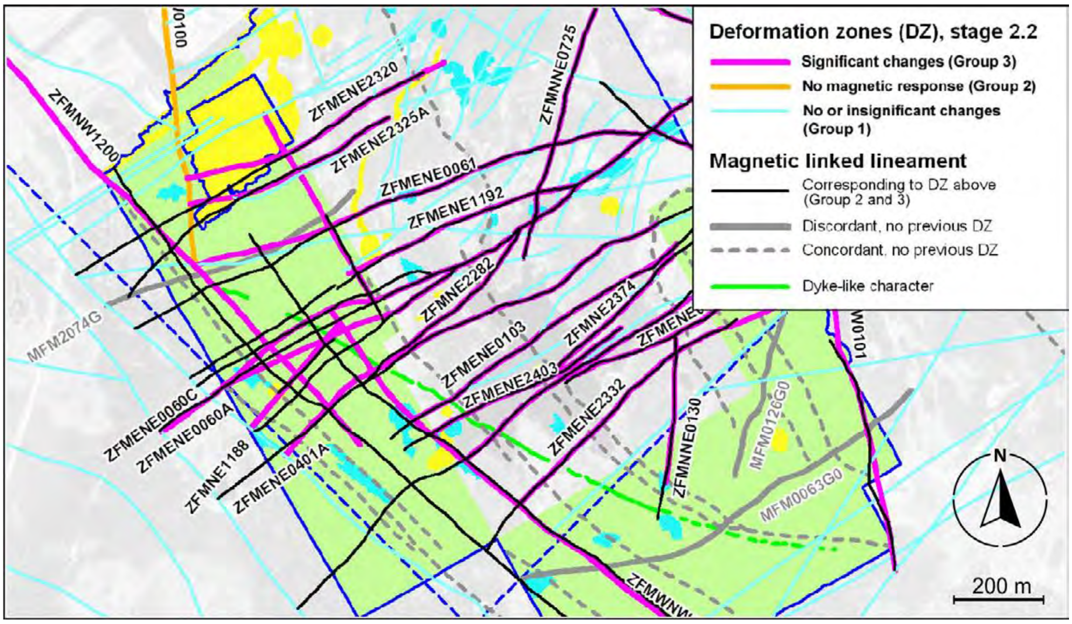


Figure 8-2. Detail of Figure 2-3 in Stephens et al. (2008b), showing deterministic deformation zones in Forsmark stage 2.2 (Stephens et al. 2007) compared with magnetic lineaments inferred from new high-resolution ground magnetic data (light green areas) and previous lineaments (Isaksson et al. 2007). The modification implied by the new high-resolution data in the western area is for some zones significant (magenta coloured, Group 3). The local model area of SDM-Site is marked with a blue dashed line. Magnetically disturbed areas are marked with yellow. © Lantmäteriverket Gävle 2007. Consent I 2007/1092.

Available high-resolution ground magnetic data cover, by a significant margin, the areas above the potential volumes of both the final repository and the expansion of the SFR facility. In these areas, it is judged that uncertainty in the truncation pattern of vertical to steeply dipping deformation zones is limited. The uncertainty outside these areas, which largely covers the local model areas of SDM-Site and SDM-PSU, has primarily been handled by an increase of the bounding size for modelled zones (e.g. from 1 to 3 km in SDM-Site). Nevertheless, the inferred spatial relations between zones in these areas of low-resolution airborne data rely to a greater extent on the conceptual understanding. Although significantly reduced, uncertainties in the details of the zone truncation largely remains. The impact on particularly the hydrogeological modelling is obvious, but the uncertainties are judged to have limited importance for post-closure safety and repository engineering.

8.4 Orientation and size of unresolved deformation zones

Possible deformation zones from the single-hole interpretation, which have not been modelled deterministically, are in this report denoted unresolved deformation zones. The confidence and possible orientation of these zones have been evaluated in Section 5.6.

Some of these zones could be transmissive and therefore of interest from a hydrogeological point of view. It is judged that these structures are either minor zones (cf. Stephens et al. 2007), branches from already modelled deformation zones or, considering the often low or medium confidence level in identification, brittle features of more local nature, such as fracture step-overs or results of small-scale rheological anomalies. Based on this, it is questionable whether these structures are sufficiently important to warrant further investigation.

Both the occurrence and geological character of the unresolved deformation zones are known. Uncertainty concerns how to link the zones with geophysical anomalies (e.g. a magnetic minimum), to establish their orientation and size. Such a link may simply not be possible using the geophysical data available at the ground surface due to limited penetration towards depth.

The lack of confidence has been handled by providing bounding estimates through stochastic modelling, on the assumption that they are minor zones (cf. Hartley et al. 2024). From the absence of geophysical anomalies, it can be concluded that all these sections correspond to zones that are less than 3 km in trace length at the ground surface, but it cannot be ruled out that some of them have surface trace lengths larger than 1 km.

8.5 Gently dipping zones beneath the final repository.

A main concern for the safety assessment is the existence and nature of gently dipping deformation zones beneath the final repository. This relies on the basic view that the maximum induced displacements associated with seismic reactivation of such structures in a reverse stress regime are generally significantly larger in the hanging wall than in the foot wall (see Hökmark et al. 2019). This means that the critical radii, defined as the smallest radius for any given combination of fracture orientation and distance to fault that can host a single slip exceeding the canister shear failure threshold (Munier 2006), are typically much smaller in the hanging wall.

The current available information from deep boreholes and seismic reflection processing provide support for the existence of one gently dipping zone beneath the planned repository, ZFMA1. Other gently dipping zones, such as ZFMB7 and ZFMB8, are inferred to terminate before they reach the footprint of the repository, though continuation beneath part of the repository cannot be excluded. Furthermore, since no boreholes penetrate seismic reflector A1/A0 there are uncertainties regarding the geological character of this feature. An alternative interpretation of the reflector, as provided by Stephens et al. (2007), is that it is related, wholly or partly, to compositional variations in the bedrock inside rock domain RFM032.

It is suggested that these uncertainties concerning the nature of seismic reflector A1/A0, as well as the possible existence of deformation zones with gentle dips towards the southeast beneath the planned repository, could be reduced by additional surface-based drillings in the northern to northwestern parts of rock domain RFM032.

8.6 Additional deformation zones not captured by the deterministic model

The main conclusions concerning the presence of undetected deformation zones at the completion of the preceding site descriptive modelling can be summarised as follows:

- Inside the repository target volume (i.e., the central part of the Forsmark local model volume), the existence of previously unknown deformation zones that are significantly longer than 3000 m is highly unlikely (Stephens et. al. 2007). This view has not been altered by the investigations conducted after 2010.
- There is a high confidence that no, previously unknown, local major (1–10 km length) or larger deformation zone exists in the SFR local model volume (Curtis et al. 2011).

The essence of these statements is that all deformation zones of critical importance for post-closure safety and the overall repository layout have been identified. However, there are no guarantees that *all* deformation zones down to the bounding size of the local models of SDM-Site and SDM-PSU (see Table 2-3) have been identified.

Outside the local volumes of SDM-Site and SDM-PSU, where the support from direct geological observations is sparser, the uncertainties are larger. This means that only a few of the lineaments have been verified as deformation zones by actual observations and that there might exist undetected deformation zones, which exceed the bounding size of the specific volume (see Table 2-3). Uncertainties are most significant for WNW–ESE to NW–SE striking zones along magnetic minima connections (see Section 8.2) and gently dipping zones, which require either boreholes or seismic reflection data for detection. Such deterministic gaps because of data deficiencies need to be stochastically addressed using DFN modelling (cf. Selroos et al. 2022). However, the usage of the DMS Baseline Forsmark without a complementary DFN model would transfer these uncertainties to the modelling work of downstream users, with significant impact on the hydrogeological and mechanical modelling.

8.7 Size, occurrence and variability of sheet joints

There is considerable variation and uncertainty in the size and intensity of sheet joints in the upper part of the crystalline bedrock at Forsmark. The structures are often highly conductive and can affect the rock mass stability. Thus, the variation and uncertainty affect assessment of stability and groundwater conditions (inflows and drawdown).

Current knowledge is based on a number of percussion and cored boreholes, together with the documentation of Carlsson (1979) from the earlier construction of the nuclear power plant. The issue of sheet joints has been the focus in most of the borehole investigations conducted after 2010, and their occurrence in the immediate proximity to the planned accesses of the final repository and extension of the SFR facility is judged to be rather well-described. The information outside these areas is, on the other hand, more sporadic and the uncertainty is significant.

In SDM-Site this uncertainty was handled and quantified by assigning the upper part of the bedrock in rock domain RFM045 and the northern part of rock domain RFM029 to a separate fracture domain (FFM02), within which the fracture character was modelled stochastically (cf. SKB 2008a). This concept was further refined in the Baseline Forsmark by a local revision of the boundary between the two fracture domains FFM02 and FFM01 (see Section 7.6), and a division of fracture domain FFM02 into two subdomains, based on a marked contrast in the occurrence of inferred sheet joints with observable aperture (see Section 7.5). Baseline Forsmark also includes deterministic representations of individual sheet joints in a few limited areas, with the sole purpose to provide basis for conditional probability simulations in the DFN modelling work. By this semi-deterministic approach, it is judged that the uncertainty is sufficiently bounded in the upper part of the bedrock, in areas of planned exploitation. However, the uncertainty in the nature of these structures increase with depth, and even if inferred occurrences exist at greater depths, there are no indications concerning size. It is questionable whether this uncertainty could successfully be further reduced by additional surface-based investigations; explorations with special focus on this issue are instead advisable during the construction of the repository access.

8.8 Size and spatial distribution of subordinate rock types

The rock domain model of SDM-Site relies heavily on the accuracy of the bedrock geological map at the surface (two-dimensional model) and the positioning of boreholes at depth (three-dimensional model). For the two key rock domains RFM029 and RFM045 in the local model volume, the extension of domain boundaries at depth and the quantitative estimates of the proportions of different rock types are judged to be sufficiently well-defined for the basis of engineering design and post-closure safety assessment. Corresponding details are still lacking for all other rock domains, though the uncertainty is not judged to be of major significance.

The uncertainties in size and spatial distribution of subordinate rock types, on the other hand, remain for all rock domains of SDM-Site, including RFM029 and RFM045. An issue of concern for both the thermal and rock mechanical modelling is the anomalously thick amphibolite bodies in rock domain RFM045. Borehole data indicate that amphibolites thicker than 1 m are uncommon in rock domain RFM029 but are more plentiful in domain RFM045. The modelling scale and the spatial density of borehole data have not permitted a deterministic approach to this uncertainty, which is a direct result of the high degree of lithological heterogeneity. The simulations of the size and spatial distribution of subordinate rock bodies have been optimised for thermal modelling at the canister scale. For other scales, the uncertainties are greater, which means that the distributions of both larger and smaller bodies are less well described (cf. SKB 2008b). Advisable, this is handled stochastically by extending the thermal modelling to reflect additional scales.

Considering the rock domain model of SDM-PSU, geological data are virtually limited to the key domains RFR01 and RFR02. Both domains, and especially RFR02, exhibit a considerable heterogeneity in the rock type distribution compared with the domains within the Forsmark tectonic lens. Despite some spatial variability, the uncertainty in both the geometric boundary between the two domains and the quantitative estimate of the proportions of different rock types are judged to be low to moderate (cf. Curtis et al. 2011). The lack of data in the rock domains that are peripheral to the volume of interest for the extension of SFR (i.e., RFR03 and RFR04), is not judged to be of any major significance for either engineering design or post-closure safety assessment.

9 Quality assurance, model deliveries and supporting tables

The quality assurance (QA) system of SKB provides a number of procedures and instructions to ensure that the models are:

– derived from qualified data acquired prior to a fixed date,
– correctly reviewed and approved by expert groups and responsible modellers,
– correctly delivered to, and employed by, the downstream users.

Peer-review of model changes introduced after the release of SDM-Site and SDM-PSU have been conducted by SKB's own experts. Review records are archived in SKBdoc in the folder:
Avdelningar – Enheter/Forskning och utveckling/Enhet RP/Platsmodellering/Geologi

Deterministic geological models included in Baseline Forsmark version 1.0 were delivered to the SKB model database SKBmod during the spring of 2022. Details for the delivery are listed in Table 9-1. All models have been approved by the person who is responsible for the geological modelling at SKB. The only models that are allowed for further use by the geology team and downstream users are the approved versions downloaded from SKBmod. The database is also used for internal deliveries.

Table 9-1. Details for the geological models and supporting tables of Baseline Forsmark version 1.0 in SKBmod.

ID*	Name	Format	Approval date
1968355	DMS Baseline Forsmark v1 Surface	Microstation DGN	2022-02-03
1968356	DMS Baseline Forsmark v1 Volumetric	Microstation DGN	2022-02-03
1981496	FFM Baseline Forsmark v1	Microstation DGN	2022-05-12
1981497	RFM loc Baseline Forsmark v1	Microstation DGN	2022-05-12
1981498	RFM reg Baseline Forsmark v1	Microstation DGN	2022-05-12
1981499	RFR loc Baseline Forsmark v1	Microstation DGN	2022-05-12
1990410	1967948 – Summary tables – geological models Baseline Forsmark v1	MS Excel 2010	2022-09-26

ID in SKBMod.

The delivery includes the file *1967948 – Summary tables – geological models Baseline Forsmark v1*, which comprises supporting tables with information concerning intercepts between boreholes and modelled objects, geometries and underlying data for modelled deformation zones, as well as inferred orientations for unresolved possible deformation zones (see Section 5.6). The meaning of the data presented in these tables (spreadsheets) are described in Table 9-2 to Table 9-5.

The bedrock surface, used as top surface in all deterministic geological models of Baseline Forsmark version 1.0 (see Section 2.6), was uploaded to SKBmod in mid-November 2023 with the identity *2028629 – Topo 40m grid Max error 20m.dgn*.

Table 9-2. Description of data presented in the spreadsheet *DZ – Geometry* in the file *1967948 – Summary tables – geological models Baseline Forsmark v1*, stored in SKBmod.

Column heading	Description
ID	Name of the deformation zone
Old ID	Name of the deformation zone in Forsmark version 2.3 and SFR version 1.0
Version	Object version extracted from RVS
Strike	According to the right-hand-rule method. Extracted from RVS
Dip	Extracted from RVS
Thickness, total	The sum of "*Thickness, dipdir*" and "*Thickness, opposite dipdir*". Extracted from RVS
Thickness, dipdir	The thickness of the zone on the right hand side (in the strike direction) of the origin surface (cf. Figure 5-10). Identical to "*Thickness, opposite dipdir*" for symmetrical zones. Extracted from RVS
Tickness, opposite dipdir	The thickness of the zone on the left hand side (in the strike direction) of the origin surface (cf. Figure 5-10). Identical to "*Thickness, dipdir*" for symmetrical zones. Extracted from RVS
Constant (C) or variable (V) thickness	All zones in DMS Baseline Forsmark version 1.0 are modelled with constant thickness
Thickness based on length-thickness correlation (Y/N)	Indicates whether the zone thickness has been defined on the basis of geological information (N) or the power law function $T = 0.2\ L^{0.6}$ yielded by the thickness-length correlation chart presented in Figure 5-11 (Y)
Projected horizontal length	The horizontal trace length at the ground surface inside the model volume. Zones that fail to reach the ground surface have hence no length indication (see Section 5.3.3). Extracted from RVS
Total length	The entire horizontal trace length at the ground surface, including parts that occur outside the future sub-catchment area (see Section 5.3.3). Values are only provided for zones that continue outside the model boundary of the future sub-catchment area. Extracted from RVS
Max depth	The zone termination depth. Zones with "*Max depth*" of −2 100 reach the base of the model volume. Extracted from RVS
Terminates against other objects	Modelled objects that the zone terminates against. "*Topo 40m grid Max error 20m*" is the bedrock surface (see Section 2.6) – all zones inferred to reach the ground surface terminates against this. "*Surface Planar Cut(s)*" denotes terminations made by the RVS trimming function, with no relations to other modelled objects. Extracted from RVS
Terminations caused by the zone	Other zones that terminate against the zone in question. Extracted from RVS

Table 9-3. Description of data presented in the spreadsheets *DZ – Borehole, FFM – Borehole*, *RFM reg – Borehole*, *RFM loc – Borehole*, *RFR – Borehole* in the file *1967948 – Summary tables – geological models Baseline Forsmark v1*, stored in SKBmod.

Column heading	Description
Geometrical intercept	The intersection between a modelled zone and an individual borehole as they exist in the RVS modelling tool (see Figure 5-10). The intercept is described by an upper and lower borehole length (sec_up/sec_low) provided by the intersection of the bounding surfaces of the modelled zone. Note that the geometrical sec_up along some boreholes represent intersections with the bedrock surface used as model top surface. In such boreholes, the geometrical sec_up can deviate from the position of the rock surface registered in the SKB database Sicada by several meters; the reason is the vertical point reduction introduced by RVS (see Section 2.6), eoh = end of borehole. Extracted from RVS
Target intercept	The interpreted position of a deformation zone or domain boundary along a borehole essentially based on geological indications, often with support from geophysical information. Consequently, if there is a geometrical intercept but no target intercept, there is nothing to support the existence of the zone or domain boundary along that specific borehole. In general, the target intercept conform to the intercept of a possible deformation zone or rock unit boundary identified during the geological SHI (see Figure 5-10), in certain cases with adjustments based on complimentary information. A target intercept is described by an upper and lower borehole length (sec_up/sec_low)
Intercept defined by SHI	The position of possible deformation zones or rock units inferred to represent a specific deformation zone or domain, respectively. Note that the target intercepts can include several possible deformation zones along a borehole; in such case geometrical and target sec_up/sec_low are identical for all included possible deformation zones. Based on data delivery SKBdata_22_065
RVS fix point	Fix point that define the intercept between a borehole and the origin surface of a modelled zone (see Figure 5-10). For deformation zones inherrited from the SDM-Site, the borehole fix points were positioned to reflect the inferred intercept of zone cores. Extracted from RVS

Table 9-4. Description of data presented in the spreadsheets *Sheet joint – Borehole* in the file *1967948 – Summary tables – geological models Baseline Forsmark v1*, stored in SKBmod.

Column heading	Description
Version	Object version extracted from RVS
Strike	According to the right-hand-rule method. Extracted from RVS
Dip	Extracted from RVS
Target intercept	The interpreted position of a sheet joint based on the criteria listed in Section 4.3.3. A target intercept is described by an upper and lower borehole length (sec_up/sec_low), typically defined by the aperture of the joint
RVS fix point	Fix point that define the intercept between a borehole and the origin surface of a modelled sheet joint. Extracted from RVS

Table 9-5. Description of data presented in the spreadsheets *PDZ – unresolved* in the file *1967948 – Summary tables – geological models Baseline Forsmark v1*, stored in SKBmod.

Column heading	Description
PDZ defined by SHI	Possible deformation zones defined in the single-hole interpretation. Each possible deformation zone is described by an upper and lower borehole length (sec_up/sec_low). Confidence level assigned in the single-hole interpretation, according to a three-level scale where 3 = high, 2 = medium and 1 = low. Based on data delivery SKBdata_22_065
Orientation	Estimated on the basis of the general distribution pattern of structural data presented on an equal-area stereographic projection (see Section 5.6). Orientations are not specified in those cases where the data set is too limited or shows too much scatter. Analysis is based on delivery SKBdata_22_065

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SKBdoc documents will be submitted upon request to document@skb.se.

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Technical data for cored and percussion drilled boreholes completed in Forsmark after 2010

Table A1-1. Technical borehole data (Coordinate system SWEREF99 1800)[1].

BH ID	Total length [m]	Bedrock surface[2] [m]	Northing	Easting	Inclination [°]	Bearing [°]
KFM13	150.21	7.20	6698803.40	160109.53	−60.57	89.85
KFM14	60.18	5.40	6698724.07	160197.44	−85.42	267.27
KFM15	62.30	5.20	6698768.62	160072.88	−83.62	137.90
KFM16	60.35	3.70	6698774.81	160183.63	−59.65	323.30
KFM17	60.45	4.60	6698747.58	160096.08	−85.92	346.72
KFM18	60.46	7.90	6698746.19	160045.06	−86.70	156.48
KFM19	102.37	5.45	6698875.99	160018.61	−64.76	172.42
KFM20	60.50	1.40	6698687.89	160060.90	−85.42	339.07
KFM21	101.06	4.90	6698654.41	160168.87	−70.93	62.12
KFM22	60.26	6.95	6698917.75	160194.37	−85.50	157.58
KFM23	100.64	3.38	6698662.00	160283.10	−73.02	342.88
KFM24	550.17	3.08	6698770.32	160182.02	−83.44	314.45
KFM25	100.72	4.90	6698868.99	159804.37	−84.27	140.00
KFM26	100.74	5.50	6698941.42	159726.47	−84.88	17.00
KFM27	100.64	5.00	6698854.47	159597.05	−74.97	322.00
KFR117	176.01	6.40	6699954.80	162141.98	−80.59	34.05
KFR118	175.48	9.30	6699934.01	162132.41	−85.59	236.00
KFR119	176.47	7.40	6699929.31	162210.71	−80.79	210.48
KFR120	176.91	9.20	6699930.77	162256.47	−79.88	37.41
KFR121	362.53	9.20	6699919.24	162420.29	−52.45	215.97
HFM39	151.20	4.90	6698775.72	160093.56	−85.82	164.64
HFM40	101.70	5.10	6698756.04	159896.74	−85.16	168.17
HFM41	101.50	4.10	6699012.09	159798.80	−84.84	175.46
HFM42	195.30	2.25	6698418.32	160094.17	−89.12	176.19
HFM43	200.00	1.44	6698537.92	160064.53	−85.21	303.79
HFM44	199.60	5.95	6699322.21	161395.20	−83.19	255.72
HFM45	200.30	0.30	6699603.14	161117.22	−84.98	291.20
HFM46	200.00	0.00	6699951.07	161324.55	−85.41	108.14
HFM47	200.40	9.92	6699398.78	161283.40	−84.42	150.00

[1] Data deliveries: SKBdata_20_069 and SKBdata_22_056.

[2] Length to inferred bedrock surface from top-of-casing.

Appendix 2

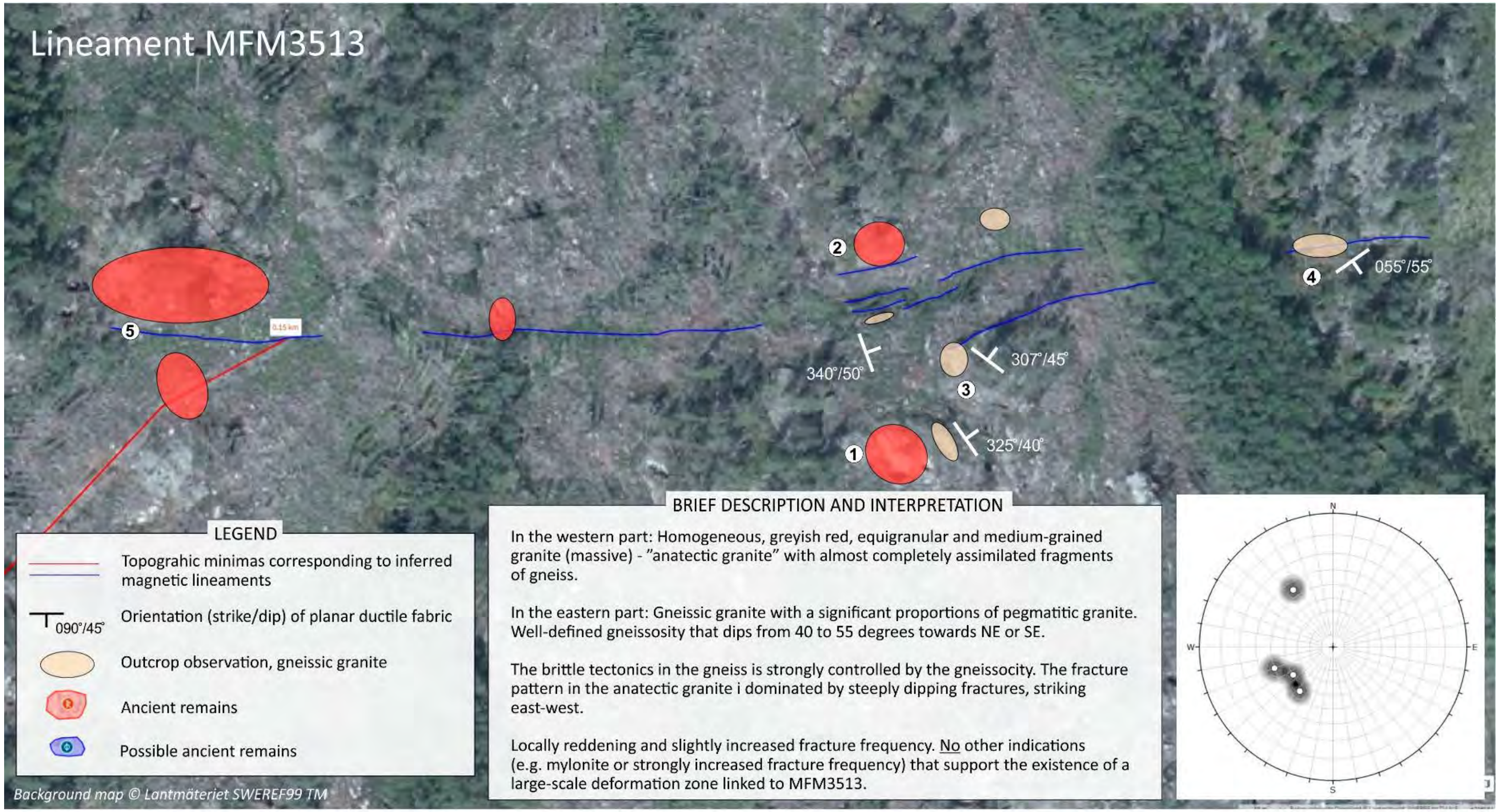
Data acquisition reports for geological and geophysical investigations completed after 2010

Data specification	Report	SKBdoc ID
Technical data in connection with drilling		
KFM13–KFM23 and HFM39–HFM41	–	1338601
KFM24	SKB P-16-32	1528493
HFM42–HFM46	SKB P-18-09	1686826
KFM25–KFM27 and HFM47	SKB P-19-25	1860464
KFR117–KFR121	SKB P-20-32	1923690
Boremap mapping		
KFM13–KFM23 and HFM39–HFM41	–	1327873, 1338831, 1338835
KFM24	SKB P-16-28	1536007
HFM42–HFM47	–	1678353*, 1909182*
KFM25–KFM27	SKB P-19-26	1865774
KFR117–KFR121	SKB P-21-24	1963160, 1988720, 1994749
Single-hole interpretation		
KFM13–KFM23 and HFM39–HFM41	–	1332706
KFM24	SKB P-16-29	1536007
KFM25–KFM27 and HFM42–HFM47	SKB P-20-13	1886598, 1898425
KFR117–KFR121	SKB P-21-25	1914790, 1994760
Surface-based data		
Geological mapping of AFM001392–AFM001394	–	1338506
Detailed fracture mapping of AFM001392–AFM001394	–	1338599
GPR and regolith mapping of AFM001392–AFM001394	–	1327863
Refraction seismics and GPR along LFM001020–LFM001025	–	1318988
Reflection seismic processing (LFM001021 and LFM001023)	–	1327865
Bedrock mapping – outcrop data in the sub-catchment area outside the regional model area	MSc thesis Bakker (2021)	–
Remote fracture mapping of islets and coastal outcrops	SKB P-23-02	1914643
Modal analysis and petrography		
KFM01A, KFM02A, KFM08C, KFM08D and KFR121	–	1982389, 2020832
KFM08C and KFR121	–	2020833

* Preliminary, not yet approved.

Appendix 3

Notes from the fieldwork to investigate E–W trending lineaments at northern Gräsö



Lineament MFM3514, western part

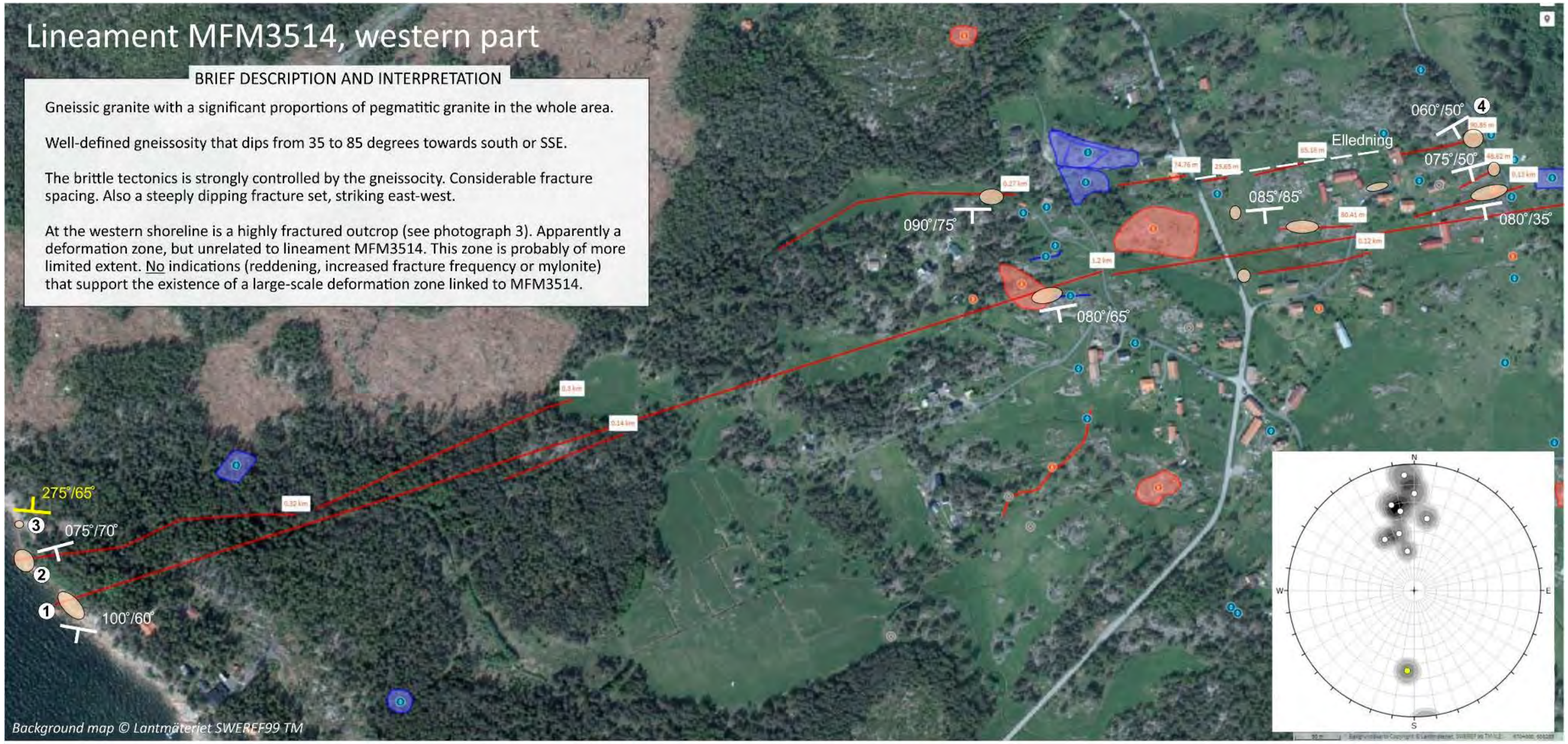
BRIEF DESCRIPTION AND INTERPRETATION

Gneissic granite with a significant proportions of pegmatitic granite in the whole area.

Well-defined gneissosity that dips from 35 to 85 degrees towards south or SSE.

The brittle tectonics is strongly controlled by the gneissocity. Considerable fracture spacing. Also a steeply dipping fracture set, striking east-west.

At the western shoreline is a highly fractured outcrop (see photograph 3). Apparently a deformation zone, but unrelated to lineament MFM3514. This zone is probably of more limited extent. No indications (reddening, increased fracture frequency or mylonite) that support the existence of a large-scale deformation zone linked to MFM3514.



LEGEND

- Topograhic minimas corresponding to inferred magnetic lineaments
- 090°/45° Orientation (strike/dip) of planar ductile fabric
- Outcrop observation, gneissic granite
- Ancient remains
- Possible ancient remains

LEGEND

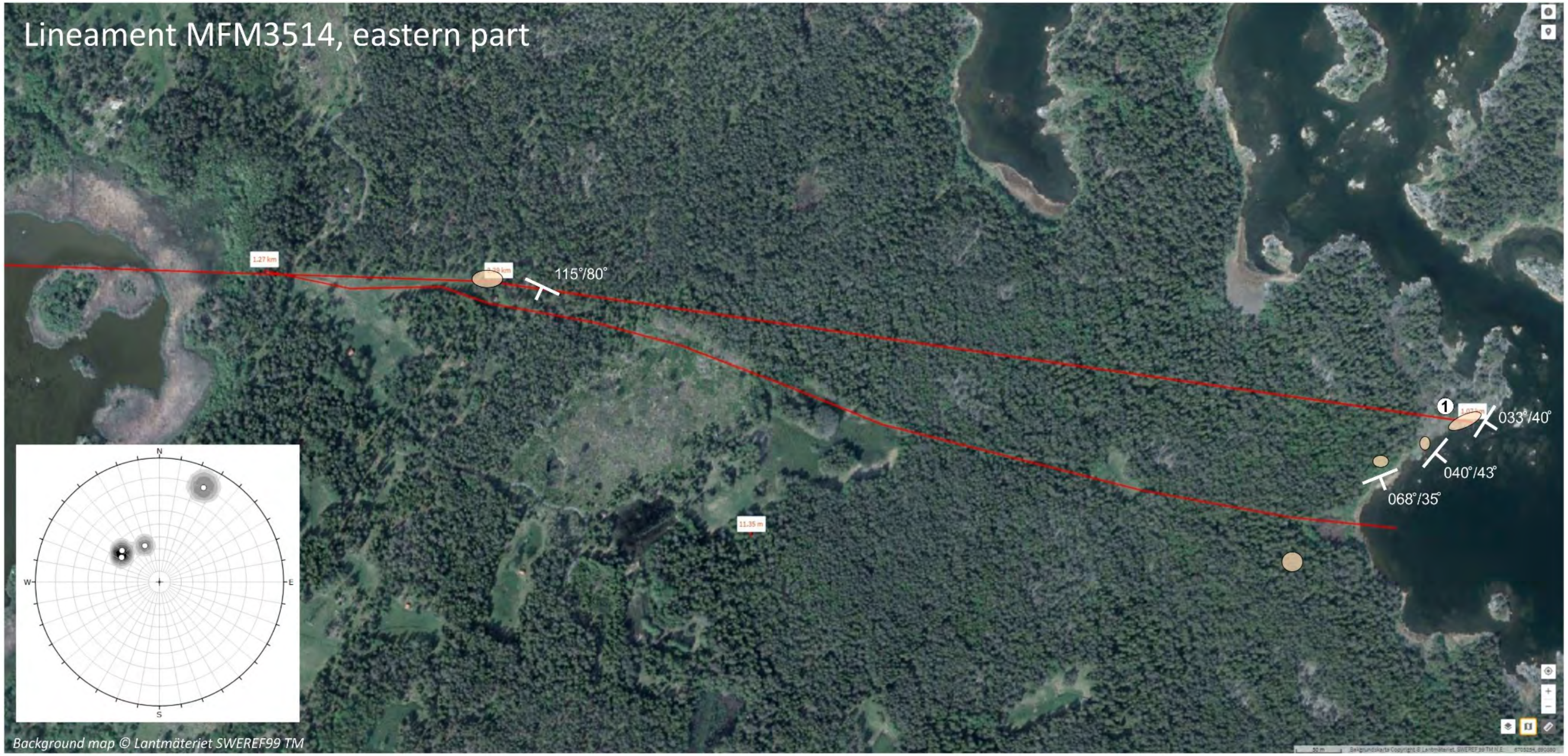
- Topograhic minimas corresponding to inferred magnetic lineaments
- 090°/45° Orientation (strike/dip) of planar ductile fabric
- Outcrop observation, gneissic granite

BRIEF DESCRIPTION AND INTERPRETATION

Gneissic granite, locally pegmatitic. Locally heterogeneous, almost migmatitic character, but there are volumes with more homogeneous, massive granite (geyish red, equigranular and medium-grained).

Well-defined gneissosity that dips from 45 to 70 degrees towards SE or SSE.

The brittle tectonics is strongly controlled by the gneissocity. Considerable fracture spacing; no reddening, increased fracture frequency or mylonite that support the existence of a large-scale deformation zone.



LEGEND

Topograhic minimas corresponding to inferred magnetic lineaments

090°/45° Orientation (strike/dip) of planar ductile fabric

Outcrop observation, gneissic granite

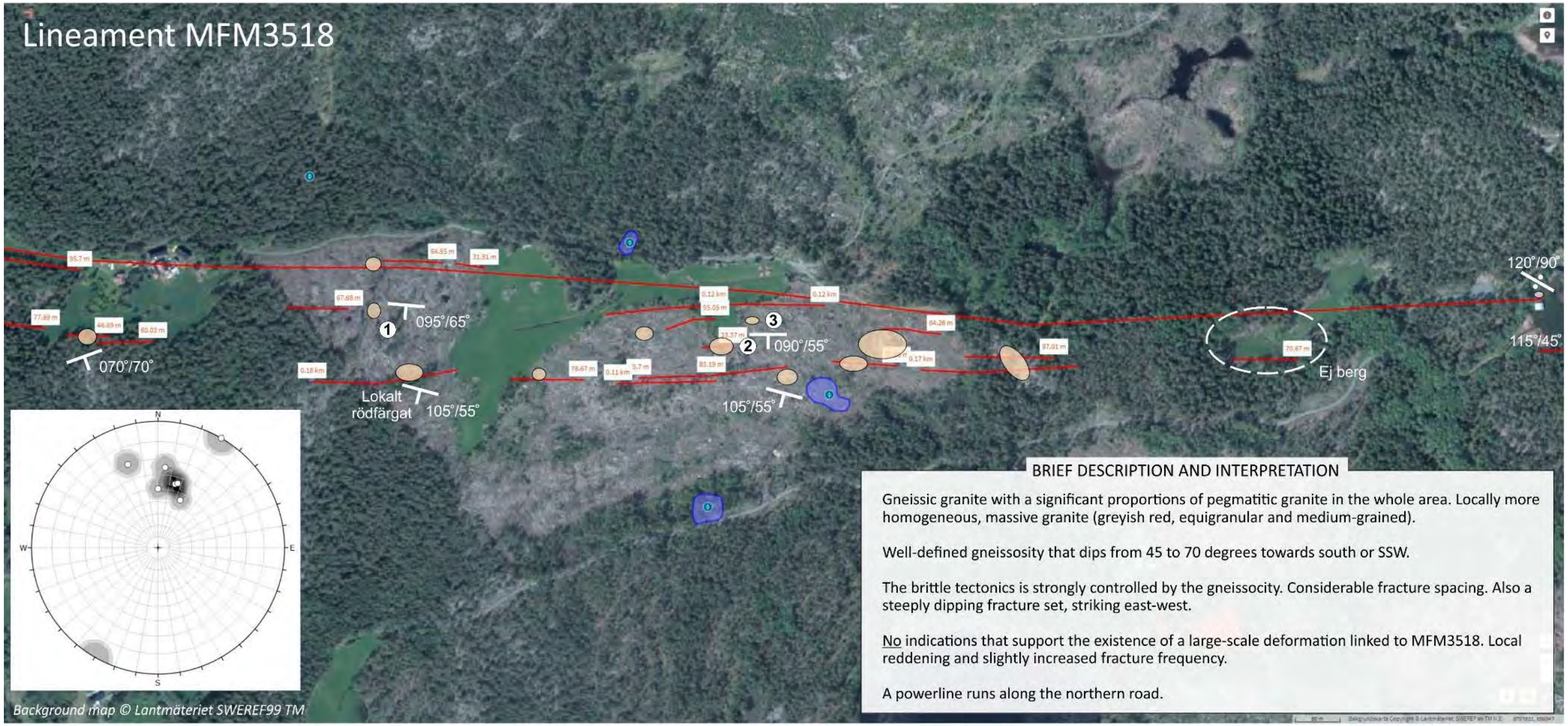
BRIEF DESCRIPTION AND INTERPRETATION

Pegmatitic granite and gneissic granite in the whole area.

Well-defined gneissosity that dips from 33 to 80 degrees towards SE or SSW.

The brittle tectonics is strongly controlled by the gneissocity. Considerable fracture spacing; no reddening, increased fracture frequency or mylonite that support the existence of a large-scale deformation zone.

Lineament MFM3518



BRIEF DESCRIPTION AND INTERPRETATION

Gneissic granite with a significant proportions of pegmatitic granite in the whole area. Locally more homogeneous, massive granite (greyish red, equigranular and medium-grained).

Well-defined gneissosity that dips from 45 to 70 degrees towards south or SSW.

The brittle tectonics is strongly controlled by the gneissocity. Considerable fracture spacing. Also a steeply dipping fracture set, striking east-west.

No indications that support the existence of a large-scale deformation linked to MFM3518. Local reddening and slightly increased fracture frequency.

A powerline runs along the northern road.

LEGEND

- Topograhic minimas corresponding to inferred magnetic lineaments
- 090°/45° Orientation (strike/dip) of planar ductile fabric
- Outcrop observation, gneissic granite
- Ancient remains
- Possible ancient remains

Appendix 4

Modal analyses used to estimate mineralogical composition of rock types

Estimated mineralogical compositions for unaltered rock types presented in Table 4-3 and Figure 4-2 are based on a selection originally made by Stephens et al. (2007), with complimentary data from studies of thermal properties (Adl-Zarrabi 2004a, 2004b, 2006), the laboratory investigations of transport properties (Gustavsson 2006) and petrographic studies of Petersson and Eliasson (2023, 2024).

The complete data set used in the upgrading of the compositions is listed in Table A3-1, by the use of Sicada delivery SKBdata_23_036_02 (activity identification numbers GE200 and GE202).

Table A3-1. Modal analyses used to estimate mineralogical composition of the rock types at the Forsmark site.

BH or outcrop ID	Sec_up [m]	Sec_low [m]	Report*	Qtz [vol.%]	K-fsp [vol.%]	Pl [vol.%]	Bt [vol.%]	Chl [vol.%]	Hbl [vol.%]
111058 Granite, fine- to medium-grained									
PFM000530B	–	–	P-03-75	33.0	28.0	36.8	1.4	–	–
PFM000651A	–	–	P-04-87	42.8	28.4	22.0	4.0	1.2	–
PFM002210A	–	–	P-03-75	30.2	37.8	27.0	3.0	0.2	–
PFM005245A	–	–	P-04-87	25.4	22.6	46.2	4.4	–	–
KFM03A	157.40	157.45	P-04-103	30.6	31.4	33.2	0.6	2.4	–
101061 Pegmatite, pegmatitic granite									
PFM000198A	–	–	P-03-75	33.6	27.0	37.2	1.6	–	–
PFM000656A	–	–	P-03-75	38.1	19.2	39.0	0.3	0.4	–
PFM001163A	–	–	P-03-75	37.1	31.8	28.4	0.6	0.5	–
PFM001243B	–	–	P-04-87	29.2	33.6	31.8	5.2	–	–
KFM03B	62.32	62.36	P-04-103	31.8	45.0	20.6	0.6	1.6	–
101051 Granite, granodiorite and tonalite, metamorphic, fine- to medium-grained									
PFM000529A	–	–	P-03-75	22.8	3.0	57.8	11.8	0.4	–
PFM000657B	–	–	P-03-75	29.4	27.2	35.4	6.0	0.2	–
PFM000712A	–	–	P-03-75	19.2	2.2	67.0	6.4	–	2.6
PFM001161A	–	–	P-04-87	30.0	13.2	48.4	4.6	0.2	–
PFM001220A	–	–	P-03-75	27.6	15.8	50.0	4.8	–	–
PFM001246B	–	–	P-03-75	35.4	2.4	54.8	–	3.4	–
PFM002206A	–	–	P-03-75	31.6	23.0	34.4	9.8	0.2	–
PFM002213A	–	–	P-03-75	27.0	10.6	53.0	6.0	1.2	0.2
PFM002214A	–	–	P-03-75	32.6	24.0	35.0	5.8	–	–
KFM01A	242.44	242.44	P-04-103	25.0	8.0	49.0	9.0	–	5
KFM01A	521.27	521.27	P-04-103	33.4	5.6	46.4	9.4	–	1.2
KFM01A	838.06	838.06	P-06-233	31.8	16.0	44.6	5.6	–	–
KFM01A	970.35	970.35	P-04-103	28.0	32.4	29.4	8.4	0.2	–
KFM05A	686.94	686.99	P-06-233	26.6	3.2	52.4	11.0	–	1.6
KFM05A	691.78	691.82	P-05-156	24.8	6.4	53.2	11.2	0.2	0.8
KFM05A	708.40	708.45	P-06-233	28.4	1.4	56.2	12.8	–	–
KFM06A	588.64	588.68	P-06-233	30.0	6.6	44.2	14.2	0.2	0.2
101058 Granite, metamorphic, aplitic									
PFM000278B	–	–	P-03-75	30.8	47	18.8	1.8	–	–
PFM001106A	–	–	P-04-87	35.2	35.6	26.0	2.0	–	–
PFM001160A	–	–	P-04-87	44.4	27.7	25.4	0.6	0.1	0.1
PFM005205B	–	–	P-04-87	41.0	26.2	29.8	2.0	–	–
KFM06A	636.34	636.37	P-05-156	34.5	30.7	27.2	6.9	0.5	–
KFM09A	443.32	443.35	P-06-233	38.4	23.0	31.2	7.4	–	–

Table A3-1. Continued.

BH or outcrop ID	Sec_up [m]	Sec_low [m]	Report*	Qtz [vol.%]	K-fsp [vol.%]	Pl [vol.%]	Bt [vol.%]	Chl [vol.%]	Hbl [vol.%]
101057 Granite to geanodiorite, meamorphic, medium-grained									
PFM000289A	–	–	P-03-75	36.0	30.8	27.2	5.6	–	–
PFM000319A	–	–	P-03-75	39.4	27.4	27.0	5.4	–	–
PFM000658A	–	–	P-03-75	32.6	36.0	24.8	5.4	–	–
PFM001159A	–	–	P-03-75	34.5	27.1	30.2	6.5	0.1	–
PFM001159B	–	–	P-03-75	30.2	30.0	33.8	5.0	–	–
PFM001164A	–	–	P-03-75	40.3	17.7	33.6	6.6	0.1	–
PFM001216A	–	–	P-03-75	41.8	19.6	34.2	3.8	–	0.2
PFM002207A	–	–	P-03-75	36.6	24.2	34.2	4.8	–	–
PFM002214B	–	–	P-03-75	33.0	29.0	31.8	4.6	–	–
KFM01A	103.46	103.65	P-06-186	24.2	25.1	38.1	11.6	–	0.2
KFM01A	109.66	109.66	P-04-103	34.6	22.8	37.6	4.4	–	–
KFM01A	312.20	312.50	P-06-186	38.4	21.6	30.4	7.0	–	–
KFM01A	317.79	317.79	P-04-103	45.8	12.8	34.4	5.4	–	0.4
KFM01A	231.28	231.28	P-04-159	42.2	24.0	28.6	4.8	–	0.2
KFM01A	235.23	235.23	P-04-159	40.4	19	35.6	4.0	–	0.4
KFM01A	389.68	389.68	P-04-159	37.0	17.6	36.6	8.0	–	0.2
KFM01A	477.30	477.30	P-04-103	46.0	12.6	32.0	8.8	0.4	–
KFM01A	487.10	487.50	P-06-186	26.1	22.2	40.5	8.6	0.2	–
KFM01A	494.82	494.82	P-04-159	30.8	25.8	36.2	6.2	–	0.8
KFM01A	692.02	692.02	P-04-159	37.0	16.2	39.0	6.8	–	0.8
KFM01A	698.35	698.35	P-04-159	38.6	19.4	37.6	4.2	–	–
KFM01A	705.88	705.88	P-04-103	32.2	13.2	47.4	4.2	–	–
KFM01A	908.18	908.36	P-06-186	36.2	14.2	41.3	7.3	–	–
KFM01A	947.70	947.70	P-04-103	37.8	23.2	30.8	7.2	–	–
KFM01B	397.41	397.76	P-06-209	46.4	16.6	30.3	3.6	0.5	0.2
KFM04A	186.65	186.70	P-05-156	40.4	19.8	32.8	5.2	0.2	–
KFM04A	271.40	271.44	P-05-156	29.8	21.0	42.6	5.8	–	–
KFM04A	581.05	581.10	P-04-199	32.8	29.6	36.6	4.0	–	–
KFM04A	816.76	816.81	P-04-199	34.0	18.4	42.0	5.4	–	–
KFM05A	152.66	152.70	P-05-156	39.2	21.0	35.0	3.8	0.2	–
KFM05A	272.11	272.15	P-05-156	40.8	24.4	30.6	3.4	0.2	0.2
KFM05A	299.19	299.23	P-05-156	34.4	18.6	38.2	6.8	–	0.2
KFM06A	440.13	440.60	P-06-186	39.0	29	27.0	3.4	0.4	–
KFM07A	387.47	387.87	P-06-186	30.8	20.4	36.6	11.6	–	–
KFM08C	750.32	750.44	2020833	39.0	21.2	31.3	3.0	0.9	1.6
KFM08C	751.95	752.06	2020833	34.9	20.6	39.5	3.0	1.0	–
KFM08C	837.20	837.32	2020833	35.7	24.7	33.1	4.9	–	0.8
KFM08C	839.87	840.00	2020833	36.0	22.3	35.2	3.8	0.8	1.1
KFM09A	583.00	583.03	P-06-233	30.6	28.2	32.6	6.8	0.2	–
101056 Granodiorite, metamorphic, medium-grained									
PFM000614A	–	–	P-04-87	31.2	11.0	46.8	8.8	–	1.2
PFM000650A	–	–	P-04-87	25.0	14.8	51.4	7.6	–	–
PFM000692A	–	–	P-03-75	30.0	11.6	42.6	12.4	–	–
PFM001198A	–	–	P-03-75	33.6	14.8	39.0	9.4	0.2	–
PFM001255A	–	–	P-03-75	24.4	8.6	44.4	9.2	–	13.4
PFM001580A	–	–	P-04-87	36.0	16.6	37.2	9.2	–	–
PFM005282A	–	–	P-04-87	26.8	9.8	50.8	8.8	–	–
KFM01A	477.50	477.61	1982389	38.8	6.3	46.1	8.1	0.2	–
KFM04A	108.76	108.80	P-04-199	21.4	12.8	47.4	8.6	–	9.8
KFM04A	109.05	109.09	P-04-199	27.6	11.0	48.8	8.2	–	4.4
KFM04A	117.70	117.74	P-05-156	15.6	7.2	49.6	2.2	4.2	16.2
KFM09A	719.13	719.16	P-06-233	19.0	8.2	52.0	12.4	–	5.2
KFM09A	761.89	761.92	P-06-233	44.4	15.4	28.8	5.2	4.6	–

Table A3-1. Continued.

BH or outcrop ID	Sec_up [m]	Sec_low [m]	Report*	Qtz [vol.%]	K-fsp [vol.%]	Pl [vol.%]	Bt [vol.%]	Chl [vol.%]	Hbl [vol.%]
101054 Tonalite to granodiorite, metamorphic, medium-grained									
PFM000207A	–	–	P-03-75	45.4	7.4	45.4	2.6	–	–
PFM000465A	–	–	P-03-75	35.6	1.6	37.6	15.6	0.2	4.6
PFM000557A	–	–	P-04-87	23.0	5.8	44.4	14.8	–	9.4
PFM000621A	–	–	P-04-87	31.0	5.0	56.2	7.2	–	–
PFM000729A	–	–	P-03-75	33.2	9.2	48.6	6.2	–	1.8
PFM000730A	–	–	P-03-75	22.2	6.0	60.4	9.0	–	0.8
PFM000778A	–	–	P-04-87	19.4	1.2	48.8	13.2	–	14.6
PFM000794A	–	–	P-03-75	19.4	6.2	50.8	13.2	–	9.8
PFM000827A	–	–	P-04-87	26.2	4.4	45.0	11.2	–	10.0
PFM000837A	–	–	P-04-87	25.0	2.6	53.4	15.4	–	–
PFM001157A	–	–	P-04-87	13.6	2.8	44.8	–	9.4	18.4
PFM001162A	–	–	P-03-75	17.6	10.6	45.2	10.6	–	9.4
PFM001217A	–	–	P-03-75	24.6	7.4	46.0	9.8	–	11.4
PFM001253A	–	–	P-03-75	27.0	1.8	61.4	6.4	–	2.8
PFM001518A	–	–	P-03-75	20.0	8.0	49.2	8.4	0.2	12.0
PFM001573A	–	–	P-04-87	23.2	3.6	46.6	9.6	–	12.0
PFM001574A	–	–	P-03-75	15.4	6.2	49.0	12.8	–	14.0
PFM001582A	–	–	P-03-75	24.2	2.8	45.6	11.2	–	14.2
PFM001874A	–	–	P-04-87	19.2	1.4	52.4	–	9.8	16.0
PFM002217A	–	–	P-03-75	19.2	11.4	47.2	12.0	–	8.6
PFM005172A	–	–	P-04-87	14.4	–	53.4	12.0	–	19.4
KFM03A	242.93	243.13	P-06-186	25.1	10.4	47.7	10.2	–	6.6
KFM03A	239.84	239.89	P-04-103	18.8	1.2	52.4	10.4	0.2	15.4
KFM09A	797.98	798.01	P-06-233	15.8	5.6	45.8	10.8	0.4	16.6
101033 Diorite, quartz diorite and gabbro, metamorphic, medium-grained									
PFM000782A	–	–	P-04-87	3.8	–	60.0	7.6	–	25.8
PFM000825B	–	–	P-04-87	7.0	0.2	55.4	6.4	–	28.0
PFM000842A	–	–	P-04-87	24.6	–	46.6	15.0	0.2	10.6
PFM000858A	–	–	P-03-75	4.0	–	40.4	4.0	–	50.6
PFM000865A	–	–	P-03-75	0.4	–	64.6	3.4	–	28.8
PFM001158A	–	–	P-04-87	2.2	–	43.8	4.6	1.0	43.0
PFM001204A	–	–	P-04-87	–	–	50.8	–	–	42.8
PFM001579A	–	–	P-04-87	7.8	–	54.4	12.2	–	24.6
PFM001906A	–	–	P-04-87	16.4	–	48.0	10.8	–	23.8
PFM005206A	–	–	P-04-87	8.8	–	52.2	14.2	–	21.0
PFM005209A	–	–	P-04-87	15.8	–	48.2	12.6	0.2	20.0
102017 Amphibolite									
PFM001010A	–	–	P-04-87	6.4	–	42.8	9.0	–	40.6
PFM001183B	–	–	P-03-75	–	–	39.2	–	–	55.6
KFM04A	737.61	737.65	P-05-156	3.0	2.0	50.0	–	–	41.0
KFM05A	356.07	365.11	P-05-156	0.8	–	53.0	–	–	42.6
103076 Felsic to intermediate volcanic rock, metamorphic									
PFM000350A	–	–	P-03-75	25.6	0.6	48.4	22.8	–	–
PFM000352A	–	–	P-03-75	24.4	10.6	50.8	14.2	–	–
PFM000352B	–	–	P-03-75	24.8	0.8	49.8	21.2	0.4	–
PFM001156A	–	–	P-03-75	33.6	1.0	52.2	–	–	10.0
PFM001200A	–	–	P-03-75	32.2	12.6	29.2	9.6	0.2	1.4
PFM001222A	–	–	P-03-75	38.4	1.6	43.4	16.6	–	–
PFM001229A	–	–	P-03-75	12.8	2.2	49.4	20	–	13.8
PFM001236A	–	–	P-03-75	27.6	0.8	48.6	22.4	–	–
PFM001908A	–	–	P-04-87	30.6	4.8	50.8	12.6	–	–
PFM001956A	–	–	P-04-87	27.0	1.2	55.0	14.2	0.4	–

Table A3-1. Continued.

BH or outcrop ID	Sec_up [m]	Sec_low [m]	Report*	Qtz [vol.%]	K-fsp [vol.%]	Pl [vol.%]	Bt [vol.%]	Chl [vol.%]	Hbl [vol.%]
PFM002163B	–	–	P-03-75	5.2	–	53.2	–	–	35.6
PFM002163C	–	–	P-03-75	24.2	0.8	58.0	0.2	–	15.2
PFM005217A	–	–	P-04-87	36.8	7.0	45.4	8.8	–	–
PFM005236A	–	–	P-04-87	39.2	7.2	47.0	5.6	–	–
KFM09A	786.79	786.82	P-06-233	38.0	17.0	31.2	12.6	0.8	–
KFM04A	124.56	124.60	P-05-156	28.2	0.4	44.8	25.6	0.4	–

* P-03-75 Stephens et al. (2003), P-04-87 Stephens et al. (2005), P-04-103 Petersson et al. (2004a), P-04-159 Adl-Zarrabi (2004a), P-04-199 Adl-Zarrabi (2004b), P-05-156 Petersson et al. (2005), P-06-186 Gustavsson (2006), P-06-233 Adl-Zarrabi (2006), 1982389 Petersson and Eliasson (2024), 2020833 Petersson and Eliasson (2023).

Appendix 5

Identified sheet joints with distinctive aperture along boreholes

Based on the criteria presented in Section 4.3.3, potential sheet joints with distinctive aperture have been identified along boreholes completed during the different drilling campaigns in Forsmark. The identification process has been based on a reassessment of the borehole image obtained by BIPS or OPTV down to an elevation of approximately −200 m (RH2000), with support from geological borehole data (Sicada delivery SKBdata_22_065 and SKBdata_23_029). Fractures identified as sheet joints are listed in Table A4-1.

The criteria for identification are as follows for fractures and crushes in boreholes:

1. Dip of ≤ 30°.
2. Distinct aperture, i.e. ≥ 1 mm.
3. No noticeable slip/displacement
4. No noticeable fracture coating or wall rock alteration.

It is important to emphasize that strict application of the identification criteria has only been possible with respect to orientation (dip < 30°) and aperture. The remaining two criteria, i.e. deficiency of discernible slip and mineral coating, have been of secondary importance, since a strict fulfilment requires verification through examination of drill cores. Another aspect is that neither slip nor mineral precipitation can be excluded as a result of later reactivation (cf. Section 5.1.2). Even if a considerable proportion of the fractures identified as sheet joints in the cored boreholes are classified as non-mineralised, the majority exhibits faint mineral coating. However, the mapping data give no information of the quantities. Frequent coatings are clay minerals, calcite, chlorite and hematite. Small quantities of all these minerals may possibly originate from the drilling activity and core handling procedures. Other minerals, such as quartz and muscovite, may be part of the wall rock (cf. Section 4.2.4).

Even if a fracture fulfils all four criteria, it is not necessarily a sheet joint sensu stricto, which has been formed by extensional failure. For example, the fractures that predominate the gently dipping deformations zones within the Forsmark tectonic lens are virtually indistinguishable from the sheet joins. Consequently, Table A4-1 includes several fractures that have been used to define the gently dipping deformations zones ZFM1203, ZFMA2, ZFMA4 and ZFMA8.

A more subtle feature to support identification is the relationship with other fractures. Typical dilatational joints often occur in swarms of parallel joints, separated by millimetres or a few centimetres.

Further, it should be noted that the quality and the resolution of the borehole image is crucial for identification of sheet joints. As a rule of thumb, images for percussion boreholes are of lower quality and resolution than those for cored boreholes, and images acquired by OPTV are generally of better quality and have significantly better resolution than those produced up to 2014 by the BIP system.

Table A4-1. Identified sheet joints with distinctive aperture down to approximately −200 m elevation along selected boreholes.

Boremap data			Revised	JFMxxx	Comment
Sec_up [m]	Sec_low [m]	Aperture [mm]	aperture [mm]		
HFM01 – mapping starts at 31.95 m [−29.39 m]					
35.447	35.447	2	10	–	Inside target intercept of ZFMA2 (PDZ1)
42.671	42.865	–	–	–	Mapped as crush. Inside target intercept of ZFMA2 (PDZ1)
99.389	99.389	1	2	–	–
HFM02 – mapping starts at 25.40 m [−22.14 m]					
28.186	28.186	0	2	–	Mapped as unbroken, sealed fracture
43.330	43.519	–	–	–	Mapped as crush. Inside target intercept of ZFMA2 (PDZ1)
44.878	44.878	1	4	–	Inside target intercept of ZFMA2 (PDZ1)
45.991	45.991	1	2	–	Inside target intercept of ZFMA2 (PDZ1)
HFM03 – mapping starts at 13.10 m [−9.75 m]. Very poor image quality					
15.493	15.788	–	–	–	Mapped as crush
21.216	21.326	–	–	–	Mapped as crush
22.566	22.566	20	–	–	–
HFM04 – mapping starts at 12.09 m [−7.99 m]					
No identified sheet joints with distinctive aperture					
HFM05 – mapping starts at 11.87 m [−3.97 m]					
No identified sheet joints with distinctive aperture					
HFM06 – mapping starts at 12.01 m [−5.14 m]					
53.378	53.378	10	–	–	Amphibolite contact
53.573	53.573	3	–	–	–
56.943	56.943	6	–	–	–
HFM07 – mapping starts at 18.01 m [−11.96 m]					
No identified sheet joints with distinctive aperture					
HFM08 – mapping starts at 18.00 m [−10.63 m]					
No identified sheet joints with distinctive aperture					
HFM09 – mapping starts at 17.01 m [−10.56 m]					
19.723	19.723	0.5	1	–	Interval of several fractures at 19.723 to 19.761 m. Mapped as partly open fracture. Inside target intercept of ZFMENE0060A (PDZ1)
19.741	19.741	0.5	1	–	Mapped as partly open fracture. Inside target intercept of ZFMENE0060A (PDZ1)
19.761	19.761	0.5	1	–	Mapped as partly open fracture. Inside target intercept of ZFMENE0060A (PDZ1)
22.368	23.134	–	–	–	Mapped as crush. Inside target intercept of ZFMENE0060A (PDZ1)
25.854	27.330	–	–	–	Mapped as crush. Inside target intercept of ZFMENE0060A (PDZ1)
HFM10 – mapping starts at 11.75 m [−5.83 m]					
26.026	26.026	0.5	2	–	–
47.567	47.567	0.5	1	–	–
HFM11 – mapping starts at 12.00 m [−1.33 m]					
37.970	37.970	0.5	1	–	–
HFM12 – mapping starts at 14.90 m [−4.15 m]					
No identified sheet joints with distinctive aperture					

Table A4-1. Continued.

Boremap data			Revised	JFMxxx	Comment
Sec_up [m]	Sec_low [m]	Aperture [mm]	aperture [mm]		
HFM13 – mapping starts at 14.91 m [−7.00 m]					
20.319	20.349	–	–	–	Mapped as crush
162.353	162.353	19	–	–	Inside target intercept of ZFMENE0401A (PDZ1)
HFM14 – mapping starts at 3.05 m [−1.45 m]					
3.422	3.809	–	–	–	Mapped as crush
7.684	7.684	1.7	8	–	Two fractures at 7.684 and 7.791 m
7.791	7.791	1.2	8	–	
21.151	21.151	36	–	–	–
25.036	25.036	12	–	–	–
49.602	49.638	–	–	–	Mapped as crush
68.113	68.113	24	–	–	Inside target intercept of ZFMA2 (PDZ1)
68.503	68.503	1	2	–	Inside target intercept of ZFMA2 (PDZ1)
71.368	71.368	15	–	–	Interval of several fractures at 71.368 to 71.465 m. Inside target intercept of ZFMA2 (PDZ1)
71.419	71.419	1	–	–	Inside target intercept of ZFMA2 (PDZ1)
71.465	71.465	0.5	–	–	Inside target intercept of ZFMA2 (PDZ1)
72.027	72.027	7	–	–	Inside target intercept of ZFMA2 (PDZ1)
72.845	72.845	0.5	2	–	Inside target intercept of ZFMA2 (PDZ1)
87.237	87.237	1	2	–	–
93.792	93.792	0.5	2	–	Inside target intercept of ZFMA2 (PDZ2)
98.644	98.780	–	–	–	Mapped as crush. Inside target intercept of ZFMA2 (PDZ2)
100.573	100.868	–	–	–	Mapped as crush. Inside target intercept of ZFMA2 (PDZ2)
101.911	101.970	–	–	–	Mapped as crush. Inside target intercept of ZFMA2 (PDZ2)
102.738	103.053	–	–	–	Mapped as crush. Inside target intercept of ZFMA2 (PDZ2)
HFM14B – No borehole image available					
HFM15 – mapping starts at 6.02 m [−0.15 m]					
23.276	23.276	5	12	–	–
23.653	23.653	0.5	6	–	–
26.281	26.281	1	10	–	–
66.447	66.471	–	–	–	Mapped as rock occurrence
67.192	67.215	–	–	–	Mapped as rock occurrence
HFM16 – mapping starts at 12.05 m [−8.55 m]					
12.455	12.455	0.5	3	–	Inside target intercept of ZFMA8 (PDZ1)
19.753	19.753	0.5	1	–	Inside target intercept of ZFMA8 (PDZ1)
24.280	24.372	–	–	–	Mapped as crush. Inside target intercept of ZFMA8 (PDZ1)
35.123	35.211	–	–	–	Mapped as crush. Inside target intercept of ZFMA8 (PDZ1)
41.310	41.408	–	–	–	Mapped as crush. Inside target intercept of ZFMA8 (PDZ1)
59.814	60.156	–	–	–	Mapped as crush. Inside target intercept of ZFMA8 (PDZ1)
61.425	61.425	0.5	10	–	Inside target intercept of ZFMA8 (PDZ1)
69.200	69.528	–	–	–	Mapped as crush. Inside target intercept of ZFMA8 (PDZ1)
70.358	70.529	–	–	–	Mapped as crush. Inside target intercept of ZFMA8 (PDZ1)
HFM17 – mapping starts at 8.01 m [−4.04 m]					
31.096	31.548	–	–	–	Mapped as crush

Table A4-1. Continued.

Boremap data			Revised	JFMxxx	Comment
Sec_up [m]	**Sec_low [m]**	**Aperture [mm]**	**aperture [mm]**		
HFM18 – mapping starts at 8.99 m [−2.47 m]					
23.948	23.948	2	3	–	–
37.563	37.778	–	–	–	Mapped as crush. Inside target intercept of ZFMA4 (PDZ2)
46.706	46.897	–	–	–	Mapped as crush. Inside target intercept of ZFMA4 (PDZ2)
HFM19 – mapping starts at 12.23 m [−6.57 m]					
13.4	13.4	0.5	2	–	–
20.373	20.373	2	–	–	–
52.206	52.206	1	2	–	Interval of several fractures at 52.206 to 52.296 m
52.240	52.240	0.5	–	–	–
52.296	52.296	1	–	–	–
101.231	101.231	0.5	6	–	–
101.794	101.794	1	2	–	–
168.915	168.915	0.5	3	–	Inside target intercept of ZFMA2 (PDZ2)
170.425	170.771	–	–	–	Mapped as crush. Inside target intercept of ZFMA2 (PDZ2)
HFM20 – mapping starts at 12.10 m [−8.90 m]					
21.775	21.839	–	–	–	Mapped as crush
23.220	23.288	–	–	–	Mapped as crush
24.818	24.918	–	–	–	Mapped as crush
25.991	25.991	2	8	26.01	Crushed interval mapped as two individual fractures at 25.991 and 26.014
26.014	26.014	0.5	3	–	–
64.590	64.590	0	2	–	Mapped as unbroken, sealed fracture
78.037	78.037	0.5	2	–	–
87.474	87.474	0	1	–	Mapped as unbroken, sealed fracture
115.202	115.202	0	1	–	Interval of several fractures at 115.241 to 115.338 m. Mapped as unbroken, sealed fracture
115.241	115.241	0.5	2	–	
115.297	115.297	0	1	–	Mapped as unbroken, sealed fracture
115.338	115.338	0	1	–	Mapped as unbroken, sealed fracture
118.831	118.831	1	2	–	Crushed interval mapped as two individual fractures at 118.831 and 118.868
118.868	118.868	5	10	–	
137.431	137.431	0	6	–	Mapped as unbroken, sealed fracture
147.651	147.651	0	3	–	Mapped as unbroken, sealed fracture. Rather a crushed interval at 146.65–146.71 m
168.422	168.422	0	3	–	Interval of several fractures at 168.422 to 168.60 m. Mapped as unbroken, sealed fracture
168.498	168.498	0	1	–	Mapped as unbroken, sealed fracture
168.535	168.535	0	1	–	Mapped as unbroken, sealed fracture
168.596	168.596	0	1	–	Mapped as unbroken, sealed fracture
197.049	197.049	0	2	–	Mapped as unbroken, sealed fracture
198.433	198.433	0	1	–	Mapped as unbroken, sealed fracture
HFM21 – mapping starts at 12.05 m [−6.06 m]					
12.564	12.564	0.5	4	JFM010	–
12.641	12.641	0.5	2	–	–
27.210	27.210	1	2	JFM011	–
48.081	48.081	0	2	JFM012	Mapped as unbroken, sealed fracture
52.764	52.764	0	2	–	Mapped as unbroken, sealed fracture
96.435	96.815	–	–	–	Mapped as crush. Inside target intercept of ZFM1203 (PDZ1)
99.094	99.170	–	–	–	Mapped as crush. Inside target intercept of ZFM1203 (PDZ1)

Table A4-1. Continued.

Boremap data			Revised	JFMxxx	Comment
Sec_up [m]	Sec_low [m]	Aperture [mm]	aperture [mm]		
168.589	168.589	0	2	–	Mapped as unbroken, sealed fracture
182.789	182.789	0	2	–	Mapped as unbroken, sealed fracture
184.900	184.900	0	2	–	Mapped as unbroken, sealed fracture
HFM22 – mapping starts at 12.05 m [−8.54 m]					
28.854	28.854	0.5	–	JFM007 JFM008	–
62.228	62.273	–	–	JFM009	Mapped as crush
85.181	85.220	–	–	–	Mapped as crush
HFM23 – mapping starts at 20.80 m [−13.14 m]					
21.175	21.175	1	5	–	–
36.395	36.395	2.5	–	–	Inside target intercept of ZFMENE1208A (PDZ1)
52.037	52.099	–	–	–	Mapped as crush
54.197	54.197	0.5	1	–	–
89.23	89.23	0.5	1	–	Inside target intercept of ZFMNNW0100 (PDZ2)
HFM24 – mapping starts at 18.05 m [−11.57 m]					
18.439	18.439	0.5	1	–	Inside target intercept of ZFMWNW0123 (PDZ1)
29.737	29.737	0.5	1	–	Two fractures at 29.737 and 29.786 m. Inside target intercept of ZFMWNW0123 (PDZ1)
29.786	29.786	0.5	1	–	Inside target intercept of ZFMWNW0123 (PDZ1)
43.847	43.847	0.5	1	–	Inside target intercept of ZFMWNW0123 (PDZ2)
46.549	46.549	0.5	1	–	Inside target intercept of ZFMWNW0123 (PDZ2)
47.825	47.825	0.5	1	–	Two fractures at 47.825 and 47.845 m. Inside target intercept of ZFMWNW0123 (PDZ2)
47.845	47.845	1	–	–	Inside target intercept of ZFMWNW0123 (PDZ2)
49.412	49.412	2	–	–	Two fractures at 49.412 and 49.446 m. Inside target intercept of ZFMWNW0123 (PDZ2)
49.446	49.446	1	2	–	Inside target intercept of ZFMWNW0123 (PDZ2)
HFM25 – mapping starts at 9.00 m [−3.56 m]					
No identified sheet joints with distinctive aperture					
HFM26 – mapping starts at 12.03 m [−6.72 m]					
No identified sheet joints with distinctive aperture					
HFM27 – mapping starts at 12.04 m [−8.52 m]					
19.924	19.967	–	–	–	Mapped as crush
27.793	28.491	–	–	–	Mapped as crush. Inside target intercept of ZFMA2 (PDZ1)
49.399	49.553	–	–	–	Mapped as crush
50.712	50.712	1	2	–	Interval of several fractures at 50.712 to 50.746 m.
50.733	50.733	0.5	–	–	–
50.746	50.746	1.5	–	–	–
51.142	51.142	1.5	–	–	Two fractures at 51.142 and 51.162 m
51.162	51.162	1	–	–	–
54.672	54.672	0.5	1	–	–
66.058	66.058	0.5	–	–	Two fractures at 66.058 and 66.067 m
66.067	66.067	1	2	–	–
118.705	118.771	–	–	–	Mapped as crush
121.468	121.468	1	3	–	–
122.458	122.458	16	–	–	–
HFM28 – mapping starts at 12.10 m [−7.59 m]					
112.412	112.412	1	2	–	–
145.587	145.587	0.5	1	–	–

Table A4-1. Continued.

Boremap data			Revised	JFMxxx	Comment
Sec_up [m]	Sec_low [m]	Aperture [mm]	aperture [mm]		
HFM29 – mapping starts at 9.05 m [−3.07 m]					
16.380	16.400	–	–	–	Mapped as crush
HFM30 – mapping starts at 18.00 m [−11.55 m]					
69.239	69.239	0.5	1	–	Two fractures at 69.239 and 69.288 m
69.288	69.288	0.5	1	–	–
90.981	90.981	0.5	2	–	Inside target intercept of ZFMNW0017 (PDZ1)
94.914	94.914	1	3	–	Inside target intercept of ZFMNW0017 (PDZ1)
159.346	159.405	–	–	–	Mapped as crush. Inside target intercept of ZFMNW0017 (PDZ1)
178.520	178.520	1	4	–	Inside target intercept of ZFMNW0017 (PDZ1)
190.241	190.241	0.5	1	–	Inside target intercept of ZFMNW0017 (PDZ1)
HFM31 – mapping starts at 9.00 m [−2.16 m]					
20.812	20.812	0.5	1	–	–
52.927	52.927	0.5	3	–	–
69.777	69.777	2	3	–	–
83.389	83.389	0	1	–	Interval of several fractures at 83.389 to 83.530 m. Mapped as unbroken, sealed fracture
83.405	83.405	0	1	–	Mapped as unbroken, sealed fracture
83.530	83.530	0.5	1	–	–
HFM32 – mapping starts at 6.03 m [−4.82 m]					
10.35	10.35	0.5	–	–	Interval of several fractures at 10.350 to 10.710 m.
10.393	10.393	0.5	–	–	–
10.438	10.438	0.5	–	–	–
10.454	10.454	0.5	–	–	–
10.511	10.511	0.5	–	–	–
10.545	10.545	0.5	–	–	–
10.572	10.572	0.5	–	–	–
10.633	10.633	0.5	–	–	–
10.644	10.644	0.5	–	–	–
10.664	10.664	0.5	–	–	–
10.680	10.680	0.5	–	–	–
10.704	10.704	0.5	–	–	–
10.710	10.710	0.5	–	–	–
15.336	15.463	–	–	–	Mapped as crush
18.087	18.229	–	–	–	Mapped as crush
27.979	27.979	–	2	–	Not registered in Boremap
HFM33 – mapping starts at 12.06 m [−7.49 m]					
77.715	77.715	0.5	2	–	–
77.957	77.957	0.5	2	–	–
79.387	79.387	0.5	2	–	–
81.065	81.065	4	–	–	–
127.079	127.079	2	–	–	–
136.537	136.537	8	–	–	
136.559	136.559	4	–	–	Two fractures at 136.537 and 136.559 m
HFM34 – mapping starts at 12.08 m [−7.68 m]					
16.463	16.463	50	–	–	–
23.186	23.186	1	–	–	–
27.857	27.857	1	–	–	–
28.581	28.581	1	2	–	–
30.953	30.953	1	–	–	–
86.013	86.013	5	–	–	Inside target intercept of ZFMWNW0001 (PDZ1)

Table A4-1. Continued.

Boremap data			Revised	JFMxxx	Comment
Sec_up [m]	Sec_low [m]	Aperture [mm]	aperture [mm]		
120.182	120.433	–	–	–	Uncertain due to poor image quality. Inside target intercept of ZFMWNW0001 (PDZ1)
HFM35 – mapping starts at 12.04 m [−8.17 m]					
25.439	25.542	–	–	–	Mapped as crush. Inside target intercept of ZFMWNW0001 (PDZ1)
48.759	48.775	–	–	–	Mapped as crush. Inside target intercept of ZFMWNW0001 (PDZ1)
50.703	51.132	–	–	–	Mapped as crush. Inside target intercept of ZFMWNW0001 (PDZ1)
118.116	118.116	0.5	2	–	–
143.829	143.829	3	–	–	–
154.384	154.448	–	–	–	Mapped as crush
154.878	154.975	–	–	–	Mapped as crush
HFM36 – mapping starts at 12.06 m [−1.71 m]					
27.504	27.585	–	–	–	Mapped as crush
32.575	32.575	0.5	1	–	Interval of several fractures at 32.575 to 32.639 m
32.614	32.614	0.5	1	–	–
32.639	32.639	0.5	1	–	–
41.464	41.464	0.5	1	–	Mapped as partly open
43.433	43.433	1	2	–	–
46.367	46.367	1.5	–	–	–
47.023	47.023	0.5	6	–	–
51.373	51.462	–	–	–	Mapped as crush
51.682	51.682	4	–	–	–
56.937	56.937	1	–	–	–
59.642	59.642	1	–	–	–
HFM37 – mapping starts at 9.07 m [−4.64 m]					
16.204	16.204	2	–	–	Inside target intercept of ZFMWNW0004 (PDZ1)
16.277	16.277	1.5	–	–	Inside target intercept of ZFMWNW0004 (PDZ1)
17.108	17.108	0	2	–	Mapped as unbroken, sealed fracture. Inside target intercept of ZFMWNW0004 (PDZ1)
37.693	37.693	2	–	–	
37.727	37.727	2	–	–	Two fractures at 37.693 and 37.727 m
HFM38 – mapping starts at 9.14 m [−5.03 m]					
21.557	21.557	0.5	2	–	–
24.619	24.619	0.5	5	–	–
27.641	27.641	0.5	7	–	–
30.044	30.526	–	–	–	Mapped as crush
32.068	32.068	0.5	11	–	Mapped as partly open
33.236	33.236	0.5	4	–	–
34.498	34.498	0.5	5	–	–
37.566	37.566	0.5	10	–	–
53.193	53.193	0.5	5	–	–
185.361	185.361	0.5	2	–	–
186.808	186.808	1	2	–	–
HFM39 – mapping starts at 6.05 m [−1.69 m]					
7.066	7.066	200	–	JFM004	–
12.201	12.201	0.5	5	–	–
16.959	16.959	0.5	5	–	–
22.514	22.720	–	–	JFM006	Crushed interval or fracture swarm. Not registered in Boremap
35.442	35.442	0.5	4	–	–

Table A4-1. Continued.

Boremap data			Revised	JFMxxx	Comment
Sec_up [m]	Sec_low [m]	Aperture [mm]	aperture [mm]		
52.093	52.093	0.5	1.5	–	–
57.271	57.271	0.5	2	–	–
66.261	66.261	0.5	1	–	Interval of several fractures at 66.261 to 66.771 m
66.363	66.363	0.5	1	–	–
66.379	66.379	0.5	1	–	–
66.522	66.522	0.5	1	–	–
66.579	66.579	0.5	1	–	–
66.771	66.771	0.5	1	–	–
81.23	81.23	0.5	1	–	Interval of several fractures at 81.230 to 81.737 m
81.29	81.29	0.5	1	–	–
81.331	81.331	0.5	1	–	–
81.465	81.465	0.5	1	–	–
81.517	81.517	0.5	1	–	–
81.653	81.653	0.5	1	–	–
81.737	81.737	0.5	1	–	–
97.073	97.073	0.5	1	–	Interval of several fractures at 97.073 to 97.342 m
97.254	97.254	0.5	1	–	
97.342	97.342	0.5	1	–	
107.445	107.445	0.5	1	–	Interval of several fractures at 107.445 to 108.479 m
107.535	107.535	0.5	1	–	–
107.999	107.999	0.5	1	–	–
108.142	108.142	0.5	1	–	–
108.305	108.305	0.5	1	–	–
108.479	108.479	0.5	1	–	–
139.181	139.181	0.5	1	–	Interval of several fractures at 139.181 to 139.546 m
139.27	139.27	0.5	1	–	–
139.546	139.546	0.5	1	–	–
140.134	140.134	0.5	3	–	–
HFM40 – mapping starts at 6.26 m [−3.70 m]					
7.767	7.767	0.5	2	–	–
10.945	11.000	–	4	–	Not registered in Boremap
13.817	13.817	0.5	1	1	Interval of several fractures at 13.817 to 13.980 m
13.928	13.928	0.5	1	–	–
13.980	13.980	0.5	1	–	–
15.161	15.161	0.5	1	–	–
20.654	20.654	0.5	8	–	Character of a minor crush
28.474	28.474	0.5	1	–	–
29.727	29.727	0.5	12		Character of a minor crush
65.795	65.795	0.5	2	–	Two fractures at 65.795 and 65.902 m
65.902	65.902	0.5	2	–	–
HFM41 – mapping starts at 6.04 m [−2.38 m]					
7.755	7.755	0.5	2	–	Two fractures at 7.755 and 8.076 m
8.076	8.076	0.5	2	–	–
HFM42 – mapping starts at 6.03 m [−1.82 m]					
12.394	12.454	–	–	JFM010	Mapped as crush
23.227	23.227	2	–	JFM011	–
23.297	23.297	3	–	JFM011	–
24.422	24.422	4	–	–	–
40.72	40.72	0.7	–	JFM012	Interval of several fractures at 40.720 to 41.032 m
40.798	40.798	0.7	–	JFM012	–

Table A4-1. Continued.

Boremap data			Revised	JFMxxx	Comment
Sec_up [m]	Sec_low [m]	Aperture [mm]	aperture [mm]		
40.912	40.912	0.7	–	JFM012	–
41.001	41.001	0.7	–	JFM012	–
41.032	41.032	0.7	–	JFM012	–
88.555	88.555	20	–	–	Amphibolite contact. Inside target intercept of ZFM1203
90.503	90.503	18	–	–	Amphibolite contact. Inside target intercept of ZFM1203
96.335	96.335	10	–	–	Two fractures at 96.335 and 96.373 m. Inside target intercept of ZFM1203
96.373	96.373	15	–	–	Inside target intercept of ZFM1203
157.853	157.853	5	–	JFM014	Two fractures at 157.853 and 157.859 m
157.859	157.859	5	–	JFM014	–
HFM43 – mapping starts at 6.03 m [−1.69 m]					
14.440	14.563	–	–	–	Mapped as crush
33.201	33.383	–	–	–	Mapped as crush
40.220	40.333	–	–	–	Mapped as crush
79.104	79.104	0.7	2	–	Two fractures at 79.104 and 79.181 m
79.181	79.181	0.7	2	–	–
88.162	88.162	0.7	–	–	Interval of several fractures at 88.162 to 88.255 m
88.190	88.190	0.7	–	–	–
88.221	88.221	0.7	–	–	–
88.255	88.255	0.7	–	–	–
90.730	90.730	0.7	–	–	Two fractures at 90.730 and 90.753 m
90.753	90.753	0.7	1.5	–	–
95.239	95.363	–	–	–	Mapped as crush
106.799	106.799	40	–	–	Rather a crush
121.405	121.513	–	–	–	Mapped as crush
173.805	173.805	1	2	–	–
HFM44 – mapping starts at 9.12 m [−6.14 m]					
50.411	50.411	2	–	–	Two fractures at 50.411 and 50.428 m
50.428	50.428	2	–	–	–
73.444	73.444	40	–	–	–
113.592	113.592	2	–	–	–
HFM45 – mapping starts at 6.30 m [−2.43 m]					
14.908	15.030	–	–	–	Mapped as crush
68.758	68.758	2	–	–	–
73.008	73.008	0.7	2	–	–
122.452	122.452	4	–	–	Two fractures at 122.452 and 122.480 m
122.480	122.480	2	–	–	–
136.145	136.145	2	–	–	–
HFM46 – mapping starts at 6.12 m [−4.40 m]					
32.890	32.890	2	–	–	–
33.516	33.516	0.7	–	–	Interval of several fractures at 33.516 to 33.813 m
33.615	33.615	0.7	–	–	–
33.695	33.695	0.7	–	–	–
33.813	33.813	0.7	–	–	–
169.096	169.096	2	–	–	–
184.632	184.769	–	–	–	Mapped as crush
HFM47 – mapping starts at 12.09 m [−8.53 m]					
No identified sheet joints with distinctive aperture					

Table A4-1. Continued.

Boremap data			Revised	JFMxxx	Comment
Sec_up [m]	Sec_low [m]	Aperture [mm]	aperture [mm]		
HFR101 – mapping starts at 8.04 m [−4.74 m]					
70.996	70.996	1	–	–	Interval of several fractures at 70.996 to 71.406 m
71.374	71.374	1	–	–	–
71.406	71.406	1	–	–	–
HFR102 – mapping starts at 9.04 m [−5.22 m]					
No identified sheet joints with distinctive aperture					
HFR105 – mapping starts at 21.12 m [−24.11 m]					
23.107	23.107	2	–	–	Inside target intercept of ZFMWNW0001 (PDZ1)
30.448	30.448	20	–	–	Inside target intercept of ZFMWNW0001 (PDZ1)
HFR106 – mapping starts at 9.03 m [−6.32 m]					
39.143	39.143	6	–	–	–
KFM01A – mapping starts at 101.00 m [−97.20 m]					
105.295	105.295	1	–	–	Two fractures at 105.295 and 105.324 m
105.324	105.324	1	–	–	–
122.578	122.578	1	2	–	Two fractures at 122.578 and 122.591 m
122.591	122.591	1.5	–	–	–
158.599	158.599	3	–	–	–
178.394	178.394	4	–	–	–
187.749	187.749	2	–	–	Two fractures at 187.749 and 187.869 m
187.869	187.869	2	–	–	–
194.669	194.669	1	–	–	Two fractures at 194.669 and 194.673 m
194.673	194.673	1	–	–	–
KFM01B – mapping starts at 15.50 m [−11.93 m]					
16.321	16.321	1.5	–	–	Inside target intercept of ZFMA2 (PDZ1)
17.543	17.543	3	–	–	Inside target intercept of ZFMA2 (PDZ1)
18.547	18.627	–	–	–	Mapped as crush. Inside target intercept of ZFMA2 (PDZ1)
20.591	20.654	–	–	–	Mapped as crush. Inside target intercept of ZFMA2 (PDZ1)
21.025	21.025	25	–	–	Inside target intercept of ZFMA2 (PDZ1)
21.085	21.135	–	–	–	Mapped as crush. Inside target intercept of ZFMA2 (PDZ1)
21.197	21.218	–	–	–	Mapped as crush. Inside target intercept of ZFMA2 (PDZ1)
27.592	27.592	1	–	–	Interval of several fractures at 27.592 to 28.015 m. Inside target intercept of ZFMA2 (PDZ1)
27.641	27.641	1	–	–	Inside target intercept of ZFMA2 (PDZ1)
27.838	27.838	1.5	–	–	Inside target intercept of ZFMA2 (PDZ1)
27.872	27.872	1.5	–	–	Inside target intercept of ZFMA2 (PDZ1)
28.015	28.015	1	–	–	Inside target intercept of ZFMA2 (PDZ1)
28.316	28.316	3	–	–	Inside target intercept of ZFMA2 (PDZ1)
28.527	28.617	–	–	–	Mapped as crush. Inside target intercept of ZFMA2 (PDZ1)
29.895	29.943	–	–	–	Mapped as crush. Inside target intercept of ZFMA2 (PDZ1)
39.784	39.813	–	–	–	Mapped as crush. Interval of several crushes and fractures at 39.784 to 41.861 m. Inside target intercept of ZFMA2 (PDZ1)
40.574	40.623	–	–	–	Mapped as crush. Inside target intercept of ZFMA2 (PDZ1)
40.832	40.860	–	–	–	Mapped as crush. Inside target intercept of ZFMA2 (PDZ1)
41.015	41.077	–	–	–	Mapped as crush. Inside target intercept of ZFMA2 (PDZ1)

Table A4-1. Continued.

Boremap data			Revised	JFMxxx	Comment
Sec_up [m]	Sec_low [m]	Aperture [mm]	aperture [mm]		
41.838	41.861	–	–	–	Mapped as crush. Inside target intercept of ZFMA2 (PDZ1)
45.590	45.590	1	2		Interval of several fractures and crushes at 45.590 to 46.925 m. Inside target intercept of ZFMA2 (PDZ1)
45.597	45.597	0.5	2	–	Inside target intercept of ZFMA2 (PDZ1)
45.722	45.722	0.5	8	–	Inside target intercept of ZFMA2 (PDZ1)
46.210	46.210	0.5	2	–	Inside target intercept of ZFMA2 (PDZ1)
46.245	46.245	0.5	4	–	Inside target intercept of ZFMA2 (PDZ1)
46.270	46.270	0.5	2	–	Inside target intercept of ZFMA2 (PDZ1)
46.295	46.295	0.5	2	–	Inside target intercept of ZFMA2 (PDZ1)
46.487	46.487	0.5	2	–	Inside target intercept of ZFMA2 (PDZ1)
46.517	46.517	0.5	8	–	Inside target intercept of ZFMA2 (PDZ1)
46.644	46.644	0.5	2	–	Inside target intercept of ZFMA2 (PDZ1)
46.816	46.925	–	–	–	Mapped as crush. Inside target intercept of ZFMA2 (PDZ1)
47.740	47.968	–	–	–	Interval of several crushes at 47.740 to 50.517 m. Inside target intercept of ZFMA2 (PDZ1)
48.971	49.426	–	–	–	Inside target intercept of ZFMA2 (PDZ1)
49.687	50.268	–	–	–	Inside target intercept of ZFMA2 (PDZ1)
50.503	50.517	–	–	–	Inside target intercept of ZFMA2 (PDZ1)
53.562	53.562	1.5	–	–	Inside target intercept of ZFMA2 (PDZ1)
69.870	69.891	–	–	–	Mapped as crush
78.876	78.893	–	–	–	Mapped as crush
89.868	89.903	–	–	–	Mapped as crush
92.993	92.993	2.5	–	–	–
94.513	94.513	1	–	–	Two fractures at 94.513 and 94.543 m
94.543	94.543	4	–	–	–
97.085	97.104	–	–	–	Mapped as crush
122.018	122.018	1	–	–	Two fractures at 122.018 and 122.030 m
122.030	122.030	1	–	–	–
123.796	123.796	6	–	–	–
138.755	138.772	–	–	–	Mapped as crush
KFM01C – mapping starts at 11.80 m [−5.90 m]					
12.366	12.366	1	3	–	Two fractures at 12.366 and 12.402 m
12.402	12.402	2	6	–	
16.82	16.82	1.8	–	–	–
18.061	18.061	4	6	–	–
18.432	18.432	2.5	–	–	–
26.022	26.022	0.5	2	–	Inside target intercept of ZFMA2 (PDZ1)
34.259	34.259	2.5	4	–	Inside target intercept of ZFMA2 (PDZ1)
40.455	40.560	–	–	–	Mapped as crush. Inside target intercept of ZFMA2 (PDZ1)
40.978	41.006	–	–	–	Mapped as crush. Inside target intercept of ZFMA2 (PDZ1)
43.037	43.583	–	–	–	Mapped as crush. Inside target intercept of ZFMA2 (PDZ1)
46.144	46.144	2	3	–	Inside target intercept of ZFMA2 (PDZ1)
52.122	52.122	2	–	–	–
59.562	59.562	1.2	–	–	–
79.044	79.044	3	–	–	Inside target intercept of ZFMA2 (PDZ2)
80.999	80.999	1.5	3	–	Inside target intercept of ZFMA2 (PDZ2)
84.384	86.095	–	–	–	Mapped as crush. Uncertain orientation. Inside target intercept of ZFMA2 (PDZ2)
91.581	91.581	0.5	3	–	Inside target intercept of ZFMA2 (PDZ2)

Table A4-1. Continued.

Boremap data			Revised	JFMxxx	Comment
Sec_up [m]	Sec_low [m]	Aperture [mm]	aperture [mm]		
93.010	93.010	1.5	4	–	Inside target intercept of ZFMA2 (PDZ2)
98.491	98.491	4.5	15	–	Inside target intercept of ZFMA2 (PDZ2)
105.019	105.019	1.5	–	–	–
146.230	146.230	1	2	–	–
196.184	196.184	1.5	–	–	–
KFM01D – mapping starts at 91.60 m [−71.78 m]					
106.029	106.029	1.5	–	–	Interval of several fractures at 106.029 to 106.088 m
106.053	106.053	1	–	–	–
106.088	106.088	3	–	–	–
111.161	111.161	2	–	–	–
120.901	120.901	1.5	–	–	–
121.897	121.897	2.5	–	–	–
122.355	122.355	1	–	–	Two fractures at 122.355 and 122.382 m
122.382	122.382	2	–	–	–
122.762	122.762	2	–	–	Interval of several fractures at 122.762 to 122.827 m
122.795	122.795	1	–	–	–
122.827	122.827	1	–	–	–
144.842	144.842	2	–	–	–
145.553	145.553	2	–	–	–
147.005	147.005	2	–	–	–
168.814	168.814	2	–	–	–
KFM02A – mapping starts at 12.00 m [−4.42 m]. Poor to very poor image quality down to 101.75 m					
88.659	88.659	3	–	–	–
118.307	118.345	–	–	–	Mapped as crush. Inside target intercept of ZFM866 (PDZ2)
118.858	119.437	–	–	–	Mapped as crush. Inside target intercept of ZFM866 (PDZ2)
120.182	120.182	2	–	–	Inside target intercept of ZFM866 (PDZ2)
121.003	121.003	15	–	–	Inside target intercept of ZFM866 (PDZ2)
121.255	121.255	3	–	–	Interval of several fractures at 121.255 to 121.646 m. Inside target intercept of ZFM866 (PDZ2)
121.401	121.401	1	–	–	Inside target intercept of ZFM866 (PDZ2)
121.438	121.438	1	–	–	Inside target intercept of ZFM866 (PDZ2)
121.445	121.445	1	–	–	Inside target intercept of ZFM866 (PDZ2)
121.492	121.492	1	–	–	Inside target intercept of ZFM866 (PDZ2)
121.565	121.565	2	–	–	Inside target intercept of ZFM866 (PDZ2)
121.606	121.606	3	–	–	Inside target intercept of ZFM866 (PDZ2)
121.611	121.611	1	–	–	Inside target intercept of ZFM866 (PDZ2)
121.646	121.646	1	–	–	Inside target intercept of ZFM866 (PDZ2)
122.207	122.207	1	–	–	–
137.068	137.068	2	–	–	–
162.611	162.611	3	–	–	Inside target intercept of ZFMA3 (PDZ3)
163.106	163.133	–	–	–	Mapped as crush. Inside target intercept of ZFMA3 (PDZ3)
KFM02B – mapping starts at 88.56 m [−79.59 m]. Locally very poor image quality					
137.664	137.664	2	–	–	–
138.423	138.423	1	–	–	–
158.099	158.099	1	–	–	Interval of several fractures at 158.099 to 158.175 m. Inside target intercept of ZFMA3 (PDZ2)
158.144	158.144	1	–	–	Inside target intercept of ZFMA3 (PDZ2)

Table A4-1. Continued.

Boremap data			Revised	JFMxxx	Comment
Sec_up [m]	**Sec_low [m]**	**Aperture [mm]**	**aperture [mm]**		
158.149	158.149	2	–	–	Inside target intercept of ZFMA3 (PDZ2)
158.165	158.165	2	–	–	Inside target intercept of ZFMA3 (PDZ2)
158.175	158.175	1	–	–	Inside target intercept of ZFMA3 (PDZ2)
KFM03A – mapping starts at 102.05 m [−93.36 m]					
108.676	108.676	2	–	–	–
KFM03B – mapping starts at 5.15 m [−3.52 m]					
5.830	5.830	8	–	–	–
8.502	8.502	0	1	–	Two fractures at 8.502 and 8.518 m
8.518	8.518	0	1	–	–
24.668	24.668	1	–	–	Inside target intercept of ZFMA5 (PDZ1)
55.592	55.592	1.5	–	–	–
KFM04A – mapping starts at 11.699 m [−1.19 m]. Very poor image quality down to 108.60 m. An unstable, fractured section was encountered at about 100 m. The fractured interval is interpreted to represent a subhorizontal fracture zone.					
103.686	103.686	4	–	–	–
112.564	112.564	9	–	–	Inside target intercept of ZFM1200 (PDZ1)
116.200	116.200	2	–	–	Inside target intercept of ZFM1200 (PDZ1)
181.919	181.919	2	–	–	–
192.064	192.064	4	–	–	–
193.473	193.473	2	–	–	Two fractures at 193.473 and 193.494 m
193.494	193.494	2	–	–	–
202.744	202.744	2	–	–	Interval of several fractures at 202.744 to 202.852 m. Inside target intercept of ZFMA2 (PDZ2)
202.760	202.760	5	–	–	Inside target intercept of ZFMA2 (PDZ2)
202.852	202.852	6	–	–	Inside target intercept of ZFMA2 (PDZ2)
207.058	207.058	6	–	–	Inside target intercept of ZFMA2 (PDZ2)
208.184	208.184	3	–	–	Inside target intercept of ZFMA2 (PDZ2)
232.585	232.730	–	–	–	Mapped as crush. Inside target intercept of ZFMA2 (PDZ3)
233.316	233.316	10	–	–	Inside target intercept of ZFMA2 (PDZ3)
233.413	233.413	4	–	–	Inside target intercept of ZFMA2 (PDZ3)
233.865	233.865	3	–	–	Inside target intercept of ZFMA2 (PDZ3)
235.525	235.525	10	–	–	Inside target intercept of ZFMA2 (PDZ3)
KFM04B – image starts at 11.70 m [−1.18 m]. No geological mapping has been carried out for this borehole. Very poor image quality. An unstable, fractured section was encountered at about 80 m. The fractured interval is interpreted to represent a subhorizontal fracture zone.					
62.095	62.095	–	2	–	Possible fracture
69.612	69.612	–	2	–	Possible fracture
81.107	81.107	–	3	–	Possible fracture
81.664	81.733	–	–	–	Possible crush
93.775	93.863	–	–	–	Possible crush
97.577	97.577	–	2	–	Two possible fractures at 97.577 and 97.800 m
97.800	97.800	–	2	–	–
KFM05A – mapping starts at 109.00 m [−88.79 m]					
109.096	109.349	–	–	–	Mapped as crush. Inside target intercept of ZFMA2 (PDZ1)
110.079	110.079	2	–	–	Inside target intercept of ZFMA2 (PDZ1)
110.133	110.133	10	–	–	Inside target intercept of ZFMA2 (PDZ1)
110.458	110.458	3	–	–	Interval of several fractures at 110.458 to 110.728 m. Inside target intercept of ZFMA2 (PDZ1)
110.517	110.517	1	–	–	Inside target intercept of ZFMA2 (PDZ1)

Table A4-1. Continued.

Boremap data			Revised	JFMxxx	Comment
Sec_up [m]	Sec_low [m]	Aperture [mm]	aperture [mm]		
110.554	110.554	1	–	–	Inside target intercept of ZFMA2 (PDZ1)
110.728	110.728	2	–	–	Inside target intercept of ZFMA2 (PDZ1)
111.485	111.485	0.5	–	–	Interval of several fractures at 111.485 to 111.803 m.
111.498	111.498	1	–	–	Inside target intercept of ZFMA2 (PDZ1)
111.532	111.532	3	–	–	Inside target intercept of ZFMA2 (PDZ1)
111.601	111.601	1	–	–	Inside target intercept of ZFMA2 (PDZ1)
111.687	111.687	1	–	–	Inside target intercept of ZFMA2 (PDZ1)
111.803	111.803	1.5	–	–	Inside target intercept of ZFMA2 (PDZ1)
112.313	112.313	2	–	–	Interval of several fractures at 112.313 to 112.374 m. Inside target intercept of ZFMA2 (PDZ1)
112.326	112.326	0.5	–	–	Inside target intercept of ZFMA2 (PDZ1)
112.349	112.349	1	–	–	Inside target intercept of ZFMA2 (PDZ1)
112.374	112.374	1	–	–	Inside target intercept of ZFMA2 (PDZ1)
112.575	112.575	2	–	–	Inside target intercept of ZFMA2 (PDZ1)
112.86	112.86	2	–	–	Inside target intercept of ZFMA2 (PDZ1)
116.489	116.489	1	–	–	Interval of several fractures at 116.489 to 116.568 m.
116.499	116.499	0.5	–	–	–
116.536	116.536	1	–	–	–
116.555	116.555	1	–	–	–
116.568	116.568	3	–	–	–
119.657	119.657	1.5	–	–	–
120.582	120.582	2	–	–	–
124.382	124.382	1	2	–	–
125.935	125.935	1	2	–	–
142.315	142.315	1	–	–	–
163.769	163.769	3	–	–	–
163.803	163.803	1	–	–	–
KFM06A – mapping starts at 13.11 m [−18.02 m]. Very poor image quality down to 100.00 m.					
115.277	115.277	1.5	–	–	–
123.113	123.113	1.5	–	–	–
125.982	125.982	5	–	–	–
126.896	126.896	2	–	–	–
128.386	128.386	1	–	–	Interval of several fractures at 128.386 to 128.412 m.
128.394	128.394	1.5	–	–	–
128.412	128.412	2	–	–	–
129.321	129.321	1.5	–	–	Interval of several fractures at 129.321 to 129.423 m.
129.326	129.326	1	–	–	–
129.332	129.332	1	–	–	–
129.423	129.423	1	–	–	–
130.269	130.318	–	–	–	Mapped as crush
181.161	181.161	2	–	–	–
206.214	206.214	2.5	4	–	Inside target intercept of ZFMENE0060B (PDZ2)
220.386	220.386	1.5	–	–	Two fractures at 220.386 and 220.409 m. Inside target intercept of ZFMENE0060B (PDZ2)
220.409	220.409	3	–	–	Inside target intercept of ZFMENE0060B (PDZ2)
220.627	220.627	5	–	–	Inside target intercept of ZFMENE0060B (PDZ2)
KFM06B – mapping starts at 5.70 m [−1.35 m]					
6.509	6.509	2	7	–	–
9.701	9.730	–	–	–	Mapped as crush
17.110	17.130	–	–	–	Mapped as crush
17.277	17.291	–	–	–	Mapped as crush

Table A4-1. Continued.

Boremap data			Revised	JFMxxx	Comment
Sec_up [m]	Sec_low [m]	Aperture [mm]	aperture [mm]		
18.572	18.572	3	–	–	Two fractures at 18.572 and 18.626 m.
18.626	18.626	2	–	–	–
20.757	20.757	1.5	–	–	–
21.149	21.149	7	–	–	–
34.009	34.009	1	–	–	Interval of several fractures at 34.015 to 34.256 m
34.015	34.015	3	–	–	–
34.051	34.051	1	–	–	–
34.256	34.256	1.5	–	–	–
35.303	35.303	7	–	–	–
35.558	35.558	4	–	–	–
43.470	43.470	1.5	–	–	–
45.502	45.502	1.5	–	–	–
55.269	55.388	–	–	–	Mapped as crush. Inside target intercept of ZFMA8 (PDZ1)
55.666	56.255	–	–	–	Mapped as crush. Inside target intercept of ZFMA8 (PDZ1)
61.225	61.225	1	–	–	Two fractures at 61.225 and 61.234 m. Inside target intercept of ZFMA8 (PDZ1)
61.234	61.234	2	–	–	Inside target intercept of ZFMA8 (PDZ1)
64.857	64.857	1.5	–	–	Inside target intercept of ZFMA8 (PDZ1)
KFM06C – mapping starts at 101.00 m [−82.69 m]					
124.450	124.450	1.5	–	–	–
143.103	143.103	2	–	–	–
143.338	143.338	1.5	–	–	–
144.262	144.262	0.5	–	–	Two fractures at 144.262 and 144.278 m.
144.278	144.278	4	–	–	–
145.400	145.400	2	–	–	–
154.298	154.345	–	–	–	Mapped as crush
166.544	166.544	3	–	–	Two fractures at 166.544 and 166.577 m.
166.577	166.577	3	–	–	–
168.746	168.746	1	–	–	–
172.617	172.617	2	–	–	Two fractures at 172.617 and 172.652 m.
172.652	172.652	2	–	–	–
174.082	174.082	2	–	–	–
176.48	176.48	2	–	–	–
182.245	182.245	2.5	–	–	–
205.025	205.025	1.5	–	–	–
205.335	205.335	1.5	–	–	–
214.153	214.153	2	–	–	–
217.443	217.443	3	–	–	–
236.578	236.578	1.5	–	–	–
KFM07A – mapping starts at 100.40 m [−83.14 m]					
111.253	111.253	1.5	–	–	Two fractures at 111.253 and 111.313 m. Inside target intercept of ZFM1203 (PDZ1)
111.313	111.313	1	–	–	Inside target intercept of ZFM1203 (PDZ1)
112.076	112.443	–	–	–	Mapped as crush. Inside target intercept of ZFM1203 (PDZ1)
116.579	116.592	–	–	–	Mapped as crush. Inside target intercept of ZFM1203 (PDZ1)
116.958	116.958	1.5	–	–	Inside target intercept of ZFM1203 (PDZ1)
119.330	119.330	2	–	–	Two fractures at 119.330 and 119.404 m. Inside target intercept of ZFM1203 (PDZ1)
119.404	119.404	1	–	–	Inside target intercept of ZFM1203 (PDZ1)

Table A4-1. Continued.

Boremap data			Revised	JFMxxx	Comment
Sec_up [m]	Sec_low [m]	Aperture [mm]	aperture [mm]		
120.146	120.198	–	–	–	Mapped as crush. Inside target intercept of ZFM1203 (PDZ1)
120.350	120.350	1	–	–	Inside target intercept of ZFM1203 (PDZ1)
120.573	120.573	1.5	–	–	Inside target intercept of ZFM1203 (PDZ1)
121.296	121.296	3	–	–	Inside target intercept of ZFM1203 (PDZ1)
121.647	121.647	1	–	–	Interval of several fractures at 121.647 to 121.822 m. Inside target intercept of ZFM1203 (PDZ1)
121.667	121.667	1	–	–	Inside target intercept of ZFM1203 (PDZ1)
121.801	121.801	1	–	–	Inside target intercept of ZFM1203 (PDZ1)
121.822	121.822	1	–	–	Inside target intercept of ZFM1203 (PDZ1)
122.752	122.764	–	–	–	Mapped as crush. Inside target intercept of ZFM1203 (PDZ1)
123.666	123.666	1.5	–	–	Inside target intercept of ZFM1203 (PDZ1)
124.503	124.503	3.5	–	–	Inside target intercept of ZFM1203 (PDZ1)
133.564	133.671	–	–	–	Mapped as crush. Inside target intercept of ZFM1203 (PDZ1)
143.844	143.844	3			Inside target intercept of ZFM1203 (PDZ1)
178.495	178.528	–	–	JFM014	Mapped as crush
KFM07B – mapping starts at 5.19 m [−0.69 m]					
10.018	10.018	30	35	JFM010	–
28.081	28.081	2	3	–	–
29.307	29.307	2	–	JFM011	
32.172	32.172	1.5	2	–	–
44.725	44.725	6	–	–	–
46.056	46.056	1.5	–	–	–
47.465	47.465	3	–	JFM012	–
79.75	79.75	1.5	–	–	Two fractures at 79.750 and 79.761 m.
79.761	79.761	0.5	–	–	–
KFM07C – mapping on image starts at 98.46 m [−94.46 m]					
144.08	144.08	1.5	–	–	–
156.294	156.294	0.5	–	JFM014	Interval of several fractures at 156.294 to 156.386 m
156.303	156.303	2	–	JFM014	–
156.319	156.319	0.5	–	JFM014	–
156.33	156.33	0.5	–	JFM014	–
156.349	156.349	0.5	–	JFM014	–
156.386	156.386	2	–	JFM014	–
163.729	163.729	1.5	–	–	–
KFM08A – mapping starts at 102.46 m [−85.54 m]					
116.632	116.632	1.5	–	–	Two fractures at 116.632 and 116.845 m.
116.845	116.845	1	–	–	–
119.854	119.854	1.5	–	–	–
124.353	124.353	1.5	–	–	–
130.242	130.242	2	–	–	–
134.973	134.973	2	–	–	–
189.730	189.730	2	–	–	–
193.539	193.539	1.5	–	–	–
197.707	197.707	2	–	–	Interval of several fractures at 197.707 to 197.808 m
197.797	197.797	4	–	–	–
197.808	197.808	1	–	–	–
214.187	214.187	1.5	–	–	–

Table A4-1. Continued.

Boremap data			Revised	JFMxxx	Comment
Sec_up [m]	Sec_low [m]	Aperture [mm]	aperture [mm]		
KFM08B – mapping starts at 5.72 m [−1.83 m]					
10.769	10.769	0.5	2	JFM004	–
13.187	13.187	4	–	–	–
16.855	16.855	2	–	–	–
21.365	21.389	–	–	JFM005	Mapped as crush
30.278	30.278	5	–	–	–
30.955	30.989	–	–	JFM008	Mapped as crush
33.121	33.121	2	–	–	–
61.892	61.892	0.5	2	JFM009	Two fractures at 61.892 and 61.923 m.
61.923	61.923	0.5	2	JFM009	–
106.945	106.945	1	2	–	–
KFM08C – mapping starts at 102.23 m [−85.7 m]					
No identified sheet joints with distinctive aperture					
KFM08D – mapping starts at 59.00 m [−45.7 m]					
82.004	82.004	0.5	2	–	–
107.352	107.352	0.5	2	–	Two fractures at 107.352 and 107.561 m.
107.561	107.561	1	–	–	–
109.109	109.109	1.5	–	–	–
116.993	116.993	2	4	–	–
125.528	125.528	2	–	–	Two fractures at 125.528 and 125.537 m.
125.537	125.537	0.5	–	–	–
131.090	131.090	2	3	–	–
149.779	149.779	1	2	–	–
KFM09A – mapping starts at 7.80 m [−2.23 m]					
9.372	9.372	3	–	–	–
19.421	19.480	–	–	–	Mapped as crush. Inside target intercept of ZFMENE1208A (PDZ1)
41.352	41.352	5	–	–	–
48.682	48.682	2	–	–	–
53.897	53.897	3	–	–	–
67.881	67.881	1.5	–	–	–
108.442	108.442	2	–	–	Inside target intercept of ZFMENE1208B (PDZ2)
113.003	113.003	1.5	–	–	Inside target intercept of ZFMENE1208B (PDZ2)
121.611	121.611	2	–	–	–
122.355	122.355	0.5	2	–	–
131.495	131.495	2	–	–	–
134.155	134.155	2	–	–	–
135.667	135.667	5	–	–	–
149.121	149.121	0.5	1	–	Two fractures at 149.121 and 149.329 m.
149.329	149.329	2	–	–	–
160.076	160.115	–	–	–	Mapped as crush
170.244	170.244	1.5	–	–	–
KFM09B – mapping starts at 9.22 m [−3.08 m]					
50.012	50.012	5	–	–	–
51.536	51.536	1.5	–	–	–
61.405	61.405	1.5	–	–	Two fractures at 61.405 and 61.419 m. Inside target intercept of ZFMENE1208B (PDZ1)
61.419	61.419	1.5	–	–	Inside target intercept of ZFMENE1208B (PDZ1)
62.532	62.532	2	–	–	Inside target intercept of ZFMENE1208B (PDZ1)
64.341	64.341	1.5	–	–	Inside target intercept of ZFMENE1208B (PDZ1)
68.775	68.775	1.5	–	–	Inside target intercept of ZFMENE1208B (PDZ1)

Table A4-1. Continued.

Boremap data			Revised	JFMxxx	Comment
Sec_up [m]	**Sec_low [m]**	**Aperture [mm]**	**aperture [mm]**		
76.328	76.328	2	–	–	Two fractures at 76.328 and 76.383 m. Inside target intercept of ZFMENE1208B (PDZ1)
76.383	76.383	1.5	–	–	Inside target intercept of ZFMENE1208B (PDZ1)
77.665	77.665	2.5	–	–	Inside target intercept of ZFMENE1208B (PDZ1)
82.489	82.489	2	–	–	–
114.646	114.646	2	–	–	Inside target intercept of ZFMENE0159A (PDZ1)
117.621	117.621	2	–	–	Inside target intercept of ZFMENE0159A (PDZ1)
119.816	119.816	1.5	–	–	Inside target intercept of ZFMENE0159A (PDZ1)
147.393	147.393	2	–	–	Two fractures at 147.393 and 147.429 m.
147.429	147.429	1.5	–	–	–
165.772	165.772	1.5	–	–	–
166.841	166.841	2	–	–	–
219.364	219.364	1.5	–	–	–
KFM10A – mapping starts at 62.92 m [−43.16 m]					
72.799	72.799	1.5	–	–	Inside target intercept of ZFMWNW0123 (PDZ1)
76.201	76.201	0.5	–	–	Two fractures at 76.201 and 76.209 m. Inside target intercept of ZFMWNW0123 (PDZ1)
76.209	76.209	1.5	–	–	Inside target intercept of ZFMWNW0123 (PDZ1)
85.707	85.849	–	–	–	Mapped as crush. Inside target intercept of ZFMWNW0123 (PDZ1)
87.904	87.904	2	3	–	Inside target intercept of ZFMWNW0123 (PDZ1)
KFM11A – mapping starts at 71.50 m [−60.05 m]					
No analysis of the borehole image.					
KFM12A – mapping starts at 61.40 m [−42.42 m]					
No analysis of the borehole image.					
KFM13 – mapping starts at 8.30 m [−4.25 m]					
11.013	11.013	7	–	JFM004	–
11.158	11.158	6	–	JFM004	–
13.639	13.639	5	15	–	–
13.910	13.973	–	–	–	Mapped as crush
14.536	14.536	1	3	–	–
15.823	15.823	1.5	–	–	–
23.110	23.110	1.5	–	JFM005	–
23.192	23.192	1.5	–	JFM005	–
23.936	23.936	2	3	–	–
27.062	27.228	–	–	JFM007	Mapped as crush
27.945	27.945	3	4	–	–
129.140	129.140	1.5	–	–	–
KFM14 – mapping starts at 5.91 m [−3.74 m]					
6.786	6.786	0.5	3	JFM004	–
18.905	18.905	2	5	JFM005	–
22.787	22.787	1	2	JFM007	–
24.165	24.165	2	6	JFM008	–
34.946	34.946	1	2	–	Several parallel fractures
46.534	46.534	1	2	–	–
46.551	46.551	1	4	–	–
53.249	53.249	1	–	JFM009	–
KFM15 – mapping starts at 7.48 m [−3.78 m]					
7.965	7.965	30	–	JFM004	
7.879	8.020	–	–	JFM004	Mapped as crush

Table A4-1. Continued.

Boremap data			Revised	JFMxxx	Comment
Sec_up [m]	**Sec_low [m]**	**Aperture [mm]**	**aperture [mm]**		
16.027	16.081	–	–	–	Mapped as crush
16.921	16.976	–	–	–	Mapped as crush
20.537	20.625	–	–	–	Mapped as crush
21.142	21.229	–	–	JFM006	Mapped as crush
KFM16 – mapping starts at 4.42 m [−2.13 m]					
10.090	10.090	5	–	JFM004	–
18.612	18.612	0.5	1	JFM005	Interval with several fractures at 18.612 to 18.652 m
18.615	18.615	0.5	1	JFM005	–
18.632	18.632	0.5	1	JFM005	–
18.652	18.652	1	–	JFM005	–
28.147	28.147	10	–	JFM007 JFM008	Interval with several fractures at 28.147 to 28.424 m
28.218	28.218	0.5	1	JFM007 JFM008	–
28.347	28.347	3	–	JFM007 JFM008	–
28.400	28.400	1	–	JFM007 JFM008	–
28.424	28.424	1.5	–	JFM007 JFM008	–
39.968	39.968	9	–	–	–
49.251	49.251	3.5	–	–	–
51.095	51.095	2.5	–	–	–
52.048	52.048	1.5	–	–	–
53.130	53.130	2	4	–	–
KFM17 – mapping starts at 5.98 m [−2.14 m]					
6.25	6.25	125	–	JFM004	–
12.180	12.215	–	–	–	Mapped as crush
14.954	15.060	–	–	–	Mapped as crush
23.969	23.969	10	–	JFM007	–
KFM18 – mapping starts at 8.89 m [−5.22 m]					
9.826	9.826	1	2	–	–
10.469	10.469	2.5	–	JFM004	–
10.998	10.998	1.5	–	–	–
15.573	15.573	3	7	–	Mapped as partly open
15.925	15.925	1.5	3	–	–
18.548	18.577		–	–	Mapped as crush
20.616	20.766		–	JFM006	Mapped as crush
21.035	21.084		–	JFM006	Mapped as crush
22.718	22.718	1	2	–	223/18
24.209	24.209	3	–	–	–
30.242	30.242	3	–	–	–
32.865	32.865	1.5	–	–	–
KFM19 – mapping starts at 7.25 m [−3.60 m]					
7.525	7.525	150	–	JFM003	Inside target intercept of ZFMENE1061A (PDZ1)
8.177	8.177	5.5	–	–	Inside target intercept of ZFMENE1061A (PDZ1)
15.297	15.297	3	–	–	Inside target intercept of ZFMENE1061A (PDZ1)
17.797	17.797	5.5	–	–	Inside target intercept of ZFMENE1061A (PDZ1)
19.430	19.430	2	4	–	Inside target intercept of ZFMENE1061A (PDZ1)
35.263	35.263	3	7	–	Inside target intercept of ZFMENE1061A (PDZ1)
49.490	49.490	1	2	–	Inside target intercept of ZFMENE1061A (PDZ1)

Table A4-1. Continued.

Boremap data			Revised	JFMxxx	Comment
Sec_up [m]	Sec_low [m]	Aperture [mm]	aperture [mm]		
KFM20 – mapping starts at 2.33 m [0.66 m]					
2.466	2.466	7	–	–	–
3.386	3.386	5	–	–	–
3.410	3.410	6	–	–	–
3.923	3.923	3	–	–	–
5.906	5.906	15	–	JFM004	–
5.965	5.965	1	–	JFM004	–
5.987	5.987	15	–	JFM004	–
7.503	7.610	–	–	–	Mapped as crush
8.128	8.128	20	–	–	–
9.098	9.098	30	–	–	–
11.927	11.927	1.5	–	–	–
13.947	14.022	–	–	–	Mapped as crush
14.785	14.872	–	–	–	Mapped as crush
17.512	17.512	2.5	–	–	–
18.182	18.182	5	15	–	–
18.895	18.895	1.5	–	–	–
18.907	18.907	1.5	–	–	–
20.054	20.195	–	–	JFM006	Rather steeply dipping, but includes inferred sheet joints
21.440	21.440	2	–	–	Two fractures
26.586	26.586	6	–	–	–
29.106	29.106	5	–	–	–
KFM21 – mapping starts at 5.82 m [−2.70 m]					
6.803	6.803	110	–	JFM004	–
7.417	7.417	4.5	–	–	–
7.447	7.447	4.5	–	–	–
8.944	8.944	3	–	–	–
10.352	10.352	4	–	–	–
10.407	10.407	2.5	–	–	–
13.183	13.183	1.5	–	–	–
21.792	22.023	–	–	–	Mapped as crush. Inside target intercept of ZFMNNW1205A (PDZ1)
23.625	23.717	–	–	JFM007	Mapped as crush. Inside target intercept of ZFMNNW1205A (PDZ1)
24.652	24.652	4	–	–	Interval with several fractures at 24.652 to 25.112 m. Inside target intercept of ZFMNNW1205A (PDZ1)
24.765	24.765	1	–	–	Inside target intercept of ZFMNNW1205A (PDZ1)
24.773	24.773	1	–	–	Inside target intercept of ZFMNNW1205A (PDZ1)
24.819	24.819	0.5	–	–	Inside target intercept of ZFMNNW1205A (PDZ1)
24.834	24.834	0.5	–	–	Inside target intercept of ZFMNNW1205A (PDZ1)
24.894	24.894	0.5	–	–	Inside target intercept of ZFMNNW1205A (PDZ1)
24.986	24.986	1	–	–	Inside target intercept of ZFMNNW1205A (PDZ1)
24.994	24.994	1	–	–	Inside target intercept of ZFMNNW1205A (PDZ1)
25.106	25.106	1	–	–	Inside target intercept of ZFMNNW1205A (PDZ1)
25.112	25.112	1	–	–	Inside target intercept of ZFMNNW1205A (PDZ1)
26.994	26.994	7	15	JFM008	Inside target intercept of ZFMNNW1205A (PDZ1)
34.900	34.900	5			Interval with several fractures at 34.900 to 35.377 m
35.073	35.073	0.5	–	–	–
35.107	35.107	1.5	–	–	–
35.212	35.212	0.5	–	–	–
35.257	35.257	4	–	–	–
35.355	35.355	3	–	–	–
35.377	35.377	0.5	–	–	–

Table A4-1. Continued.

Boremap data			Revised	JFMxxx	Comment
Sec_up [m]	Sec_low [m]	Aperture [mm]	aperture [mm]		
43.391	43.391	5	–	–	–
46.925	46.925	20	–	–	–
48.871	48.871	1.5	–	–	–
52.825	52.825	1	2	–	–
94.166	94.166	5	–	–	Inside target intercept of ZFMNNW1205B (PDZ3)
KFM22 – mapping starts at 8.40 m [−5.44 m]					
19.254	19.254	1.5	–	–	–
20.998	20.998	6	10	–	–
40.149	40.149	2.5	–	–	–
KFM23 – mapping starts at 4.60 m [−1.94 m]					
4.971	4.971	25	–	–	–
5.440	5.440	280	–	–	–
23.533	23.678	–		JFM007	Mapped as crush. Inside target intercept of ZFMENE2120 (PDZ1)
25.944	25.944	2	–	–	Inside target intercept of ZFMENE2120 (PDZ1)
27.068	27.119	–	–	JFM008	Mapped as crush
28.076	28.076	1.5	–	–	Inside target intercept of ZFMENE2120 (PDZ1)
29.023	29.023	1.5	–	–	Inside target intercept of ZFMENE2120 (PDZ1)
31.203	31.288	–	–	–	Mapped as crush. Inside target intercept of ZFMENE2120 (PDZ1)
38.994	38.994	1.5	–	–	–
41.914	41.914	2	–	–	–
44.479	44.479	2	–	–	–
49.030	49.030	2	–	–	–
52.307	52.307	1.5	–	–	–
54.490	54.490	1.5	–	JFM009	
60.520	60.520	2	–	–	–
63.859	63.859	1.5	–	–	–
64.958	64.958	1.5	–	–	–
67.786	67.786	0.5	–	–	Interval with several fractures at 67.786 to 67.923 m
67.793	67.793	0.5	–	–	–
67.923	67.923	0.5	–	–	–
74.891	74.891	1.5	–	–	–
75.766	75.766	3.5	–	–	–
98.629	98.629	1.5	–	–	–
KFM24 – mapping starts at 37.18 m [−35.71 m]					
51.848	51.848	3	–	JFM009	–
126.669	126.669	2	–	–	–
184.939	184.939	1	–	–	Very limited interval with several fractures
195.058	195.058	1	–	–	Very limited interval with several fractures
KFM25 – mapping starts at 6.06 m [−3.37 m]					
6.629	6.629	29	–	JFM015	–
7.842	7.842	4.5	–	–	–
8.420	8.420	1.5	–	–	–
19.209	19.209	3.5	–	–	–
23.83	23.83	11.5	–	–	–
33.012	33.012	0.5	–	–	Interval with several fractures at 33.012 to 33.045 m
33.023	33.023	0.5	–	–	–
33.045	33.045	0.5	–	–	–
38.300	38.300	2	–	–	–
42.600	42.600	0.5	–	–	Two fractures at 42.600 and 42.613 m

Table A4-1. Continued.

Boremap data			Revised	JFMxxx	Comment
Sec_up [m]	Sec_low [m]	Aperture [mm]	aperture [mm]		
42.613	42.613	1	–	–	–
61.524	61.524	2	1	–	–
61.861	61.861	2	–	–	Two fractures at 61.861 and 61.875 m
61.875	61.875	2	–	–	–
66.535	66.553	–	–	–	Mapped as crush
73.852	73.852	0.5	–	–	Interval with several fractures at 73.852 to 73.948 m
73.884	73.884	0.5	–	–	–
73.900	73.900	0.5	–	–	–
73.948	73.948	1	–	–	–
74.004	74.004	0.5	–	–	–
KFM26 – mapping starts at 6.03 m [−3.01 m]					
6.313	6.313	44.5	–	–	–
6.563	6.563	55	–	–	–
6.616	6.616	8	–	–	–
7.036	7.036	10	–	–	–
8.318	8.318	1	2	–	–
23.152	23.152	0.5	1	–	Two fractures at 23.152 and 23.165 m
23.165	23.165	1	1.5	–	–
28.539	28.539	1	1.5	–	–
35.157	35.213	–	–	–	Mapped as crush
70.108	70.108	0.5	–	–	Interval with several fractures at 70.108 to 70.127 m
70.118	70.118	0.5	–	–	–
70.127	70.127	0.5	–	–	–
85.927	85.927	1	3	–	–
87.830	87.830	1.5	–	–	–
91.833	91.833	3.5	–	–	Interval with several fractures at 91.833 to 91.901 m
91.838	91.838	2.5	–	–	–
91.901	91.901	0.5	–	–	–
94.496	94.496	1	–	–	Two fractures at 94.496 and 94.506 m
94.506	94.506	2	–	–	–
98.706	98.787	–	–	–	Mapped as crush
99.815	99.815	1	4	–	–
KFM27 – mapping starts at 9.03 m [−6.16 m]					
12.236	12.236	0.5	–	–	Interval with several fractures at 12.236 to 12.257 m
12.248	12.248	0.5	–	–	–
12.257	12.257	0.5	–	–	–
16.741	16.741	1	8	–	Two fractures at 16.741 and 16.759 m
16.759	16.759	1.5	–	–	
19.526	19.561	–	–	–	Mapped as crush
53.923	53.923	1.5	–	–	Inside target intercept of ZFMENE2248 (PDZ1)
55.090	55.090	1	2	–	Inside target intercept of ZFMENE2248 (PDZ1)
66.447	67.025	–	–	–	Revised length 66.81–66.87 m. Inside target intercept of ZFMENE2248 (PDZ1)
73.052	73.052	0.5	–	–	Interval with several fractures at 73.052 to 73.218 m. Inside target intercept of ZFMENE2248 (PDZ1)
73.071	73.071	0.5	–	–	Inside target intercept of ZFMENE2248 (PDZ1)
73.218	73.218	1	–	–	Inside target intercept of ZFMENE2248 (PDZ1)
73.803	73.803	0.5	–	–	Interval with several fractures at 73.803 to 73.850 m. Inside target intercept of ZFMENE2248 (PDZ1)
73.814	73.814	0.5	–	–	Inside target intercept of ZFMENE2248 (PDZ1)
73.828	73.828	0.5	–	–	Inside target intercept of ZFMENE2248 (PDZ1)
73.850	73.850	0.5	–	–	Inside target intercept of ZFMENE2248 (PDZ1)

Table A4-1. Continued.

Boremap data			Revised	JFMxxx	Comment
Sec_up [m]	Sec_low [m]	Aperture [mm]	aperture [mm]		
86.702	86.739	–	–	–	Mapped as crush. Inside target intercept of ZFMENE2248 (PDZ1)
87.849	87.921	–	2	–	Mapped as crush. Inside target intercept of ZFMENE2248 (PDZ1)
88.316	88.358	–	6	–	Mapped as crush. Inside target intercept of ZFMENE2248 (PDZ1)
KFM90B – mapping starts at 1.60 m [−1.95 m]					
6.211	6.211	0.5	1	JFM010	–
15.102	15.102	0.5	1	–	Interval with several fractures at 15.102 to 15.172 m
15.165	15.165	0.5	–	–	–
15.172	15.172	0.5	1	–	–
KFM90C – mapping starts at 1.58 m [−2.16 m]					
5.847	5.847	1	–	–	Two fractures at 5.847 and 5.863 m
5.863	5.863	2	–	–	–
14.625	14.625	1	–	–	Two fractures at 14.625 and 14.637 m
14.637	14.637	1	–	–	–
KFM90D – mapping starts at 1.60 m [−1.76 m]					
No identified sheet joints with distinctive aperture					
KFM90E – mapping starts at 1.59 m [−1.82 m]					
5.627	5.627	0.5	1	–	–
6.247	6.247	1	–	–	–
15.364	15.364	0.5	1	–	Interval with several fractures at 15.364 to 15.451 m
15.372	15.372	0.5	1	–	–
15.38	15.38	0.5	1	–	–
15.402	15.402	0.5	1	–	–
15.451	15.451	0.5	1	–	–
17.466	17.466	0.5	1	–	Two fractures at 17.466 and 17.475 m
17.475	17.475	0.5	1	–	–
KFM90F – mapping starts at 1.59 m [−2.01 m]					
5.762	5.762	0.5	1	–	–
KFR27 – mapping starts at 11.82 m [−8.76 m]					
23.457	23.457	0	1	–	Mapped as unbroken, sealed fracture
23.488	23.488	0	1	–	Mapped as unbroken, sealed fracture
28.361	28.361	0.5	1	–	–
44.284	44.284	1	–	–	–
50.174	50.174	2	–	–	–
54.743	54.743	6	–	–	–
60.312	60.312	0.5	–	–	Interval with several fractures at 60.312 to 60.334 m
60.322	60.322	0.5	–	–	–
60.334	60.334	1	–	–	–
65.515	65.515	1	–	–	–
87.240	87.240	1	–	–	–
89.036	89.036	5	–	–	–
98.691	98.691	1	–	–	Two fractures at 98.691 and 98.695 m
98.695	98.695	1	–	–	–
144.052	144.052	1	–	–	Two fractures at 144.052 and 144.070 m
144.070	144.070	0.5	–	–	
189.041	189.041	1	–	–	In interval with core loss.
192.506	192.707	–	–	–	Mapped as crush

Table A4-1. Continued.

Boremap data			Revised	JFMxxx	Comment
Sec_up [m]	Sec_low [m]	Aperture [mm]	aperture [mm]		
KFR101 – mapping starts at 13.72 m [−8.67 m]					
16.815	16.815	1	–	–	Inside target intercept of ZFMNNW1034 (PDZ1)
19.201	19.201	1.5	–	–	Inside target intercept of ZFMNNW1034 (PDZ1)
25.291	25.291	1	–	–	Inside target intercept of ZFMNNW1034 (PDZ1)
28.385	28.385	1	–	–	Two fractures at 28.385 and 28.408 m. Inside target intercept of ZFMNNW1034 (PDZ1)
28.408	28.408	1	–	–	Inside target intercept of ZFMNNW1034 (PDZ1)
32.775	32.775	1	8	–	Inside target intercept of ZFMNNW1034 (PDZ1)
53.394	53.394	0.5	1	–	Inside target intercept of ZFMNNW1034 (PDZ1)
59.421	59.421	0.5	1	–	Inside target intercept of ZFMNNW1034 (PDZ1)
62.644	62.644	1	–	–	Inside target intercept of ZFMNNW1034 (PDZ1)
64.224	64.224	1.5	–	–	Inside target intercept of ZFMNNW1034 (PDZ1)
64.840	64.840	1	–	–	Inside target intercept of ZFMNNW1034 (PDZ1)
141.135	141.135	1	–	–	Two fractures at 141.135 and 141.139 m
141.139	141.139	1	–	–	–
180.948	181.006		–	–	–
KFR102A – mapping starts at 71.95 m [−62.83 m]					
100.482	100.482	0.5	1	–	Interval with several fractures at 11.482 to 100.576 m
100.504	100.504	0.5	1	–	–
100.551	100.551	0.5	1	–	–
100.576	100.576	0.5	1	–	–
144.857	144.857	1	3	–	–
147.507	147.507	0.5	1	–	–
161.787	161.787	0.5	1	–	–
188.303	188.321	–	–	–	Mapped as crush
188.766	188.766	0.5	2	–	–
200.814	200.814	1.5	3	–	–
205.892	205.892	3	–	–	–
215.920	215.920	3	–	–	Two fractures at 215.920 and 215.929 m
215.929	215.929	0.5	2	–	–
235.486	235.486	1	–	–	–
240.697	240.697	1	2	–	–
KFR102B – mapping starts at 13.95 m [−8.70 m]					
26.420	26.420	1	–	–	–
48.620	48.620	3	–	–	Two fractures at 48.620 and 48.652 m
48.652	48.652	1	–	–	–
54.062	54.062	1	–	–	–
172.598	172.598	1	–	–	–
KFR103 – mapping starts at 13.34 m [−8.28 m]					
14.049	14.049	2	12	–	–
16.343	16.343	2	10	–	–
20.384	20.384	5	–	–	–
64.003	64.003	3	–	–	–
84.579	84.579	0.5	2	–	–
85.668	85.708	–	–	–	Mapped as crush
86.609	86.740	–	–	–	Mapped as crush
164.013	164.013	1	–	–	–
180.689	180.725	–	–	–	Mapped as crush. Inside target intercept of ZFMWNW3262 (PDZ3)
181.293	181.293	0.5	1	–	Two fractures at 181.293 and 181.301 m. Inside target intercept of ZFMWNW3262 (PDZ3)

Table A4-1. Continued.

Boremap data			Revised	JFMxxx	Comment
Sec_up [m]	Sec_low [m]	Aperture [mm]	aperture [mm]		
181.301	181.301	0.5	1	–	Inside target intercept of ZFMWNW3262 (PDZ3)
181.894	182.010	–	–	–	Mapped as crush. Inside target intercept of ZFMWNW3262 (PDZ3)
KFR104 – mapping starts at 8.74 m [−4.14 m]					
10.821	10.821	2	–	–	–
14.364	14.364	3	–	–	–
19.396	19.396	1	–	–	–
20.291	20.291	1	–	–	Interval with several fractures at 20.291 to 20.365 m
20.299	20.299	1	–	–	–
20.334	20.334	1	–	–	–
20.365	20.365	1	–	–	–
25.384	25.384	3	–	–	–
41.309	41.309	3	–	–	Inside target intercept of ZFMNE3118 (PDZ1)
49.977	49.977	0.5	1	–	Two fractures at 49.977 and 49.994 m
49.994	49.994	0.5	1	–	–
52.457	52.457	1.5	–	–	–
54.646	54.646	1.5	–	–	–
64.523	64.523	3.5	–	–	–
73.363	73.363	0.5	1	–	Interval with several fractures at 73.363 to 73.397 m
73.38	73.23	0.5	1	–	–
73.397	73.25	0.5	1	–	–
73.841	73.841	3	–	–	Two fractures at 73.841 and 73.885 m
73.885	73.885	4	–	–	–
93.515	93.515	2	–	–	–
121.558	121.558	1	–	–	–
KFR105 – mapping starts at 4.02 m [−107.34 m]					
No analysis of the borehole image.					
KFR106 – mapping starts at 9.11 m [−7.33 m]					
9.736	9.736	2	–	–	Two fractures at 9.736 and 9.750 m
9.750	9.750	0.5	–	–	–
41.239	41.239	1.5	–	–	–
50.766	50.766	1	–	–	–
60.199	60.199	0.5	1	–	–
61.884	61.884	0.5	1	–	–
61.909	61.909	0.5	1	–	–
68.241	68.241	14	–	–	Inside target intercept of ZFMWNW3262 (PDZ3)
72.996	72.996	0.5	1	–	Two fractures at 72.996 and 73.017 m. Inside target intercept of ZFMWNW3262 (PDZ3)
73.017	73.017	1	–	–	–
85.246	85.246	2	–	–	Interval with several fractures at 85.246 to 85.397 m
85.262	85.262	0.5	–	–	–
85.308	85.308	6	–	–	–
85.37	85.37	1.5	–	–	–
85.397	85.397	1	–	–	–
100.385	100.385	5	–	–	–
100.647	100.647	1	–	–	Interval with several fractures at 100.647 to 100.753 m
100.668	100.668	1	–	–	–
100.677	100.677	3	–	–	–
100.696	100.696	2	–	–	–
100.723	100.723	1	–	–	–
100.74	100.74	1.5	–	–	–

Table A4-1. Continued.

Boremap data			Revised	JFMxxx	Comment
Sec_up [m]	Sec_low [m]	Aperture [mm]	aperture [mm]		
100.753	100.753	0.5	–	–	–
117.524	117.524	2	–	–	–
126.056	126.056	1.5	–	–	–
155.944	155.944	2	–	–	Interval with one crush and several fractures at 155.944 to 156.235 m
155.969	155.969	1.5	–	–	–
155.995	155.995	6	–	–	–
156.079	156.079	1	–	–	–
156.081	156.237	–	–	–	Mapped as crush
156.235	156.235	5	–	–	–
KFR117 – mapping starts at 9.00 m [−6.45 m]					
9.482	9.482	1.5	–	–	Two fractures at 9.482 and 9.586 m.
9.586	9.586	1	–	–	–
11.074	11.074	1	–	–	–
11.737	11.775	–	–	JFM016	Mapped as crush
12.881	12.881	25	–	–	–
13.373	13.373	10	–	–	Two fractures at 13.373 and 13.12 m.
13.412	13.412	5	–	–	–
14.260	14.260	2	–	–	–
22.932	22.932	2	–	–	–
28.710	28.710	2.5	–	–	Two fractures at 28.710 and 13.725 m.
28.725	28.725	2.5	–	–	–
30.799	30.799	1.5	–	–	–
36.314	36.314	1	–	–	–
80.560	80.560	1	–	–	–
86.291	86.291	1	–	–	–
145.938	146.037	–	–	–	Mapped as crush
KFR118 – mapping starts at 12.03 m [−8.83 m]					
12.123	12.123	11		JFM016	–
14.165	14.266	–	–	–	Mapped as crush
16.755	16.801	–	–	–	Mapped as crush
18.420	18.451	–	–	–	Mapped as crush
21.440	21.440	3	–	–	Two fractures at 21.440 and 21.471 m.
21.471	21.471	3	–	–	–
22.083	22.083	1	–	–	Two fractures at 22.083 and 22.099 m.
22.099	22.099	1	–	–	–
37.495	37.495	1	–	–	–
41.530	41.530	1	–	–	Two fractures at 41.53 and 41.55 m.
41.55	41.55	5	–	–	
42.244	42.244	2	–	–	Two fractures at 42.244 and 42.260 m.
42.260	42.260	4	–	–	–
43.385	43.385	1.5	–	–	Two fractures at 43.385 and 43.398 m.
43.398	43.398	5	–	–	–
47.240	47.240	2	–	–	–
52.125	52.125	5.5	–	–	–
52.135	52.135	9.5	–	–	–
62.376	62.376	1	–	–	Two fractures at 62.376 and 62.389 m.
62.389	62.389	5	–	–	–
69.233	69.233	1	–	–	Two fractures at 69.233 and 69.247 m.
69.247	69.247	1	–	–	–
98.352	98.352	1	–	–	–

Table A4-1. Continued.

Boremap data			Revised	JFMxxx	Comment
Sec_up [m]	**Sec_low [m]**	**Aperture [mm]**	**aperture [mm]**		
KFR119 – mapping starts at 9.02 m [−5.78 m]					
10.504	10.504	1	–	–	–
11.376	11.376	89	–	JFM016	–
11.756	11.756	6	–	JFM016	Two fractures at 11.756 and 11.781 m.
11.781	11.781	2	–	JFM016	–
22.267	22.267	1	–	–	–
31.455	31.455	1	–	–	Two fractures at 31.455 and 31.461 m.
31.461	31.461	0.5	–	–	–
34.178	34.178	1.5	–	–	–
45.615	45.615	0.5	–	–	Two fractures at 45.615 and 45.628 m.
45.628	45.628	1	–	–	–
47.180	47.180	2.5	–	–	–
69.207	69.207	2.5	–	–	–
142.183	142.183	1	–	–	–
158.942	158.942	1	–	–	–
KFR120 – mapping starts at 9.02 m [−5.78 m]					
12.531	12.719	–	–	JFM016	Mapped as crush
15.008	15.008	2	–	–	–
15.313	15.313	6	–	–	–
20.328	20.328	1	–	–	–
27.720	27.720	1	–	–	Two fractures at 27.720 and 27.729 m.
27.729	27.729	1	–	–	–
34.448	34.448	1	–	–	–
38.165	38.165	1	–	–	Interval with several fractures at 38.165 to 38.182 m
38.176	38.176	2	–	–	–
38.182	38.182	1.5	–	–	–
39.756	39.756	2	–	–	–
41.043	41.043	1	–	–	–
43.616	43.616	1.5	–	–	Two fractures at 43.616 and 43.623 m.
43.623	43.623	2.5	–	–	–
46.788	46.788	1	–	–	–
56.576	56.576	3	–	–	Two fractures at 56.576 and 56.582 m.
56.582	56.582	2	–	–	–
60.640	60.640	1.5	–	–	–
65.265	65.265	2	–	–	–
92.879	92.879	1	–	–	Two fractures at 92.879 and 92.959 m.
92.959	92.959	2.5	–	–	
94.980	94.980	1	–	–	Two fractures at 94.980 and 95.005 m.
95.005	95.005	2.5	–	–	–
96.523	96.523	2.5	–	–	–
104.035	104.035	4	–	–	–
105.094	105.094	2	–	–	Interval with several fractures at 105.094 to 105.118 m
105.108	105.108	4	–	–	–
105.118	105.118	4	–	–	–
110.623	110.623	2	–	–	Two fractures at 110.623 and 110.640 m.
110.640	110.640	1.5	–	–	–
112.903	112.903	1.5	–	–	Two fractures at 112.903 and 112.926 m.
112.926	112.926	2	–	–	–
118.734	118.734	2.5	–	–	Two fractures at 118.734 and 118.757 m.
118.757	118.757	2	–	–	–

Table A4-1. Continued.

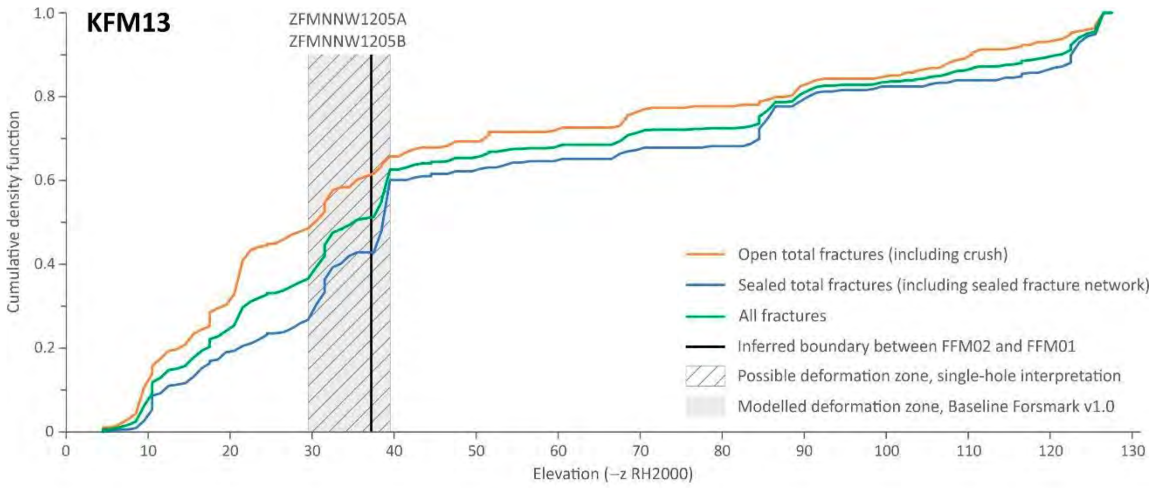
Boremap data			Revised	JFMxxx	Comment
Sec_up [m]	Sec_low [m]	Aperture [mm]	aperture [mm]		
KFR121 – mapping starts at 41.13 m [−29.52 m]					
41.328	41.328	4.5	–	–	–
46.384	46.384	1	–	–	–
61.905	61.905	2.5	–	–	–
68.737	68.737	1	–	–	–
97.149	97.149	1.5	–	–	Inside target intercept of ZFMWNW3262 (PDZ1)
100.494	100.494	1	–	–	–
155.451	155.451	3	–	–	–

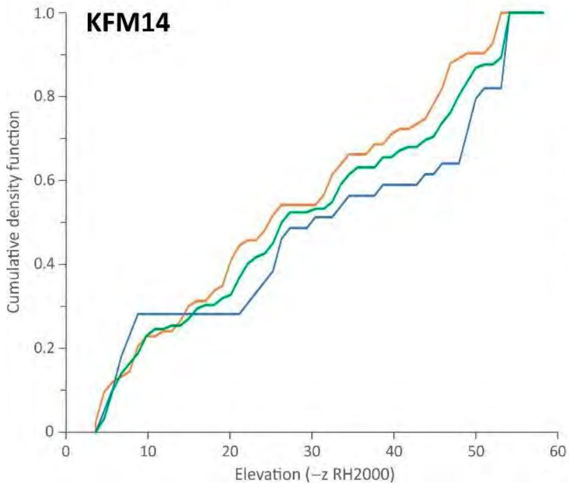
Appendix 6

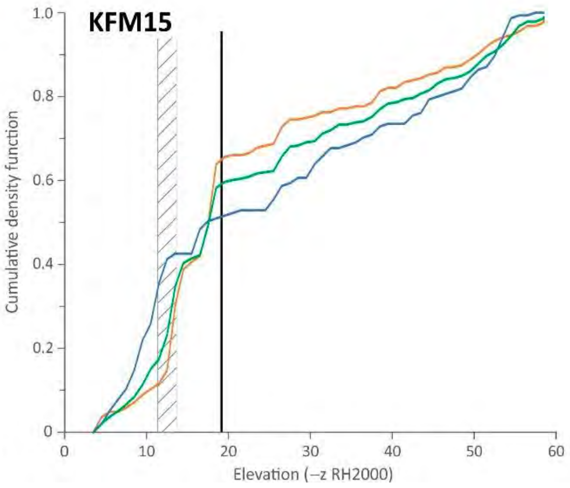
Cumulative fracture frequency diagrams for the cored boreholes KFM13 to KFM27 and KFR117 to KFR121

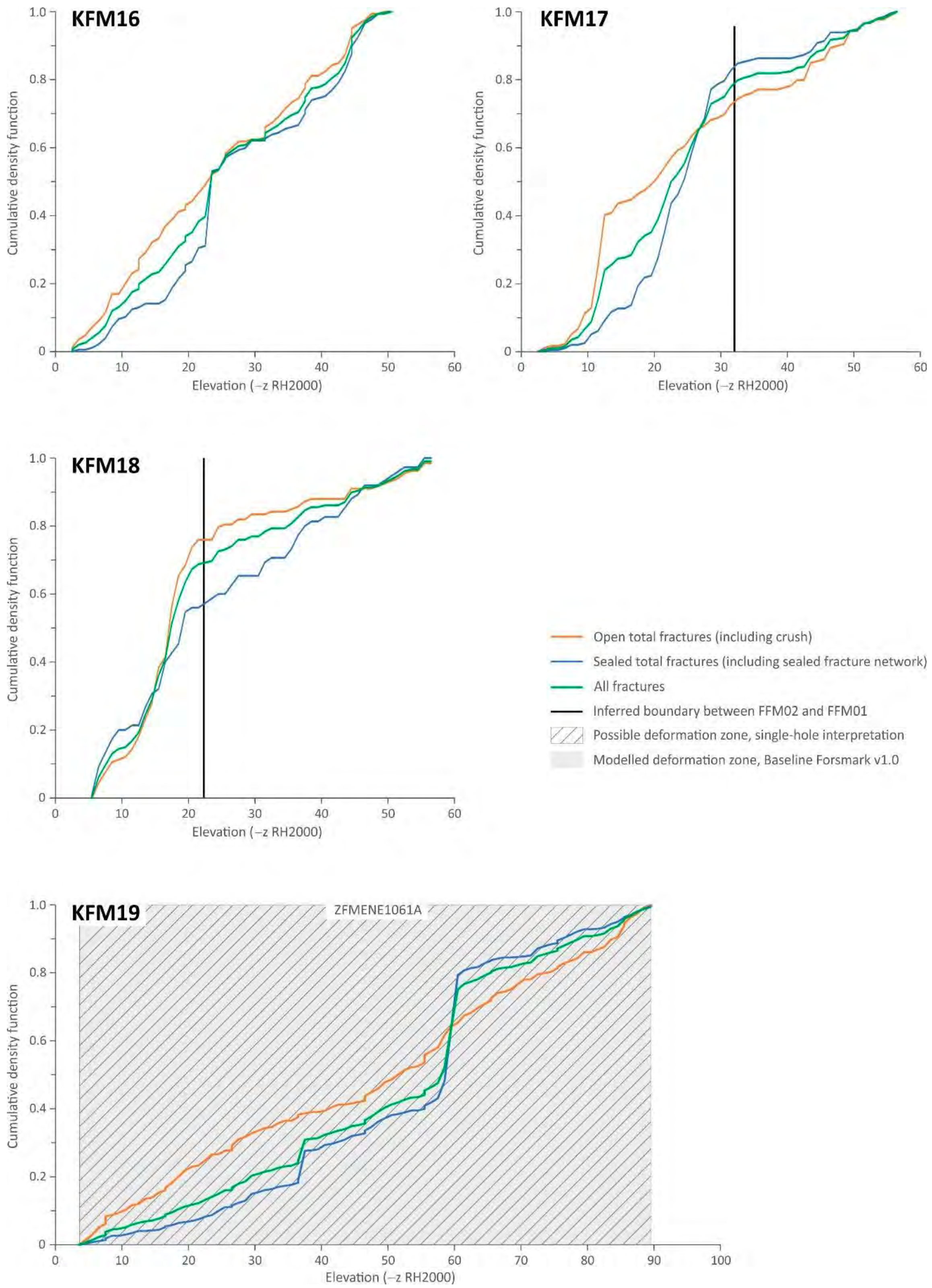
This appendix presents fracture distribution plots for the boreholes KFM13 to KFM27 and KFR117 to KFR121. These plots have been the basic input for an updated geometry of the boundary between FFM01 and FFM02 in the proximity to the repository access volume. The plots include open, partly open and sealed fractures, together with crushes and sealed network converted to individual fractures based on recorded piece lengths. Fracture frequency is illustrated cumulatively for each individual borehole. The plots are based at elevation, not borehole length. Additional information presented in the plots are:

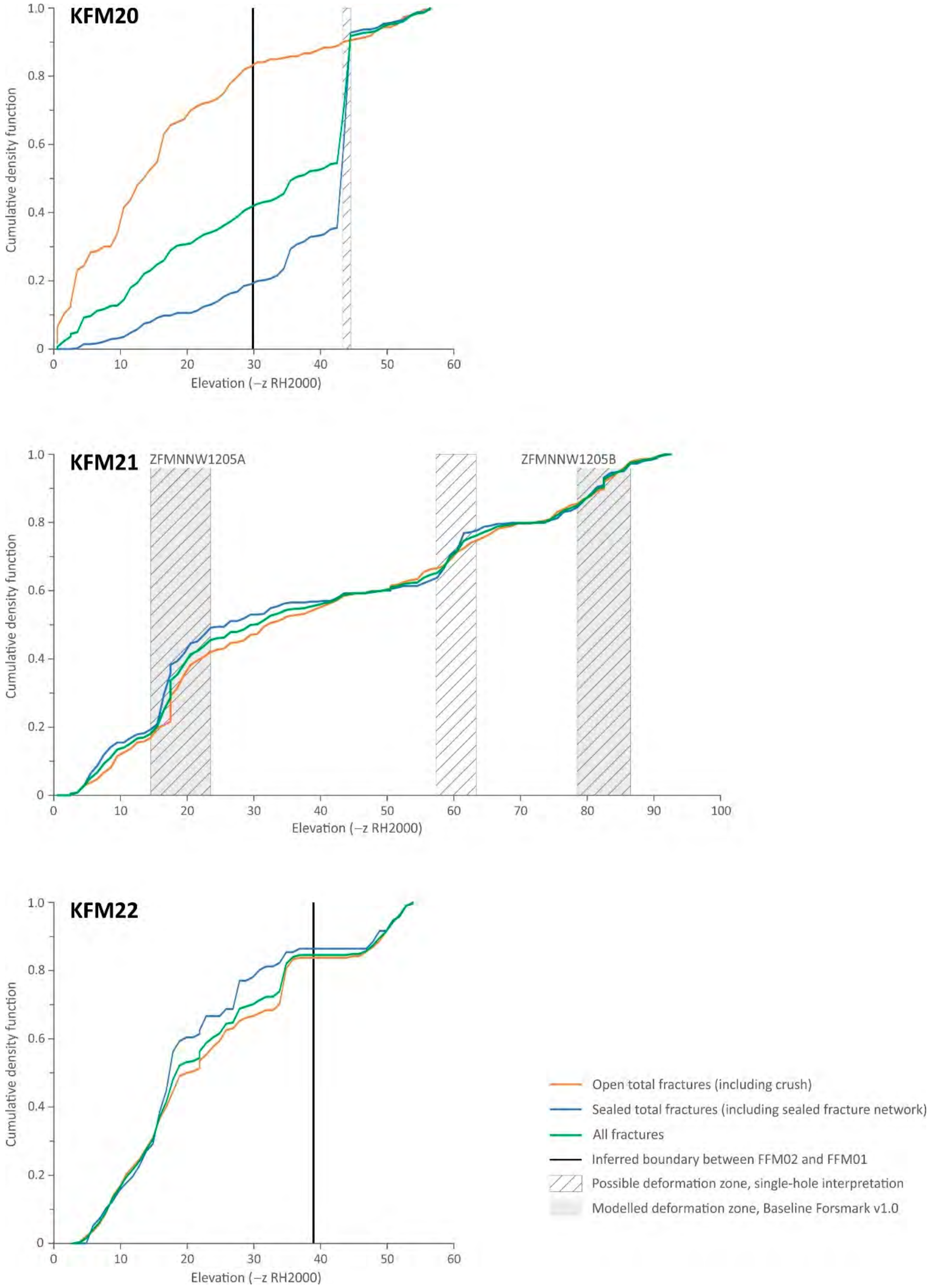
- Intersections with possible deformation zones (PDZ) identified during single-hole interpretations; marked by hatching.
- Intersections with modelled deformation zones; target intercepts (cf. Figure 5-10) marked as shaded areas.
- The target (if defined) position of the boundary between FFM02 and FFM01; marked by solid vertical, black lines.

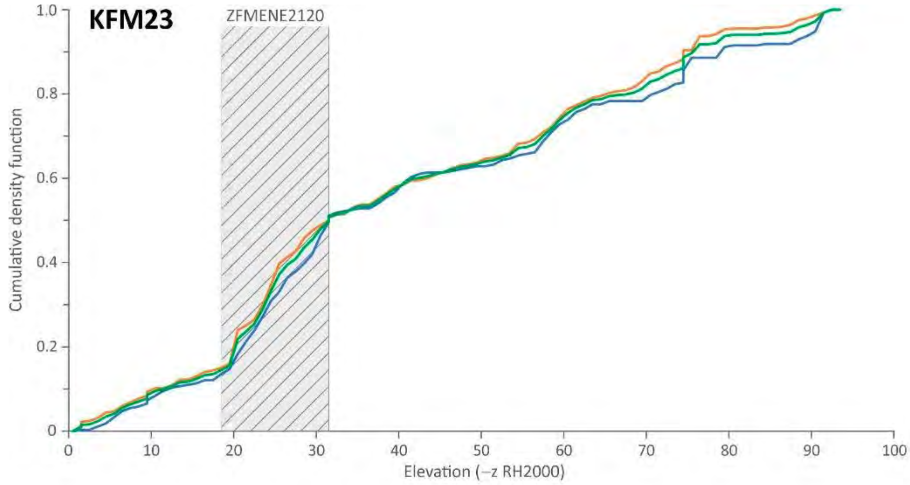


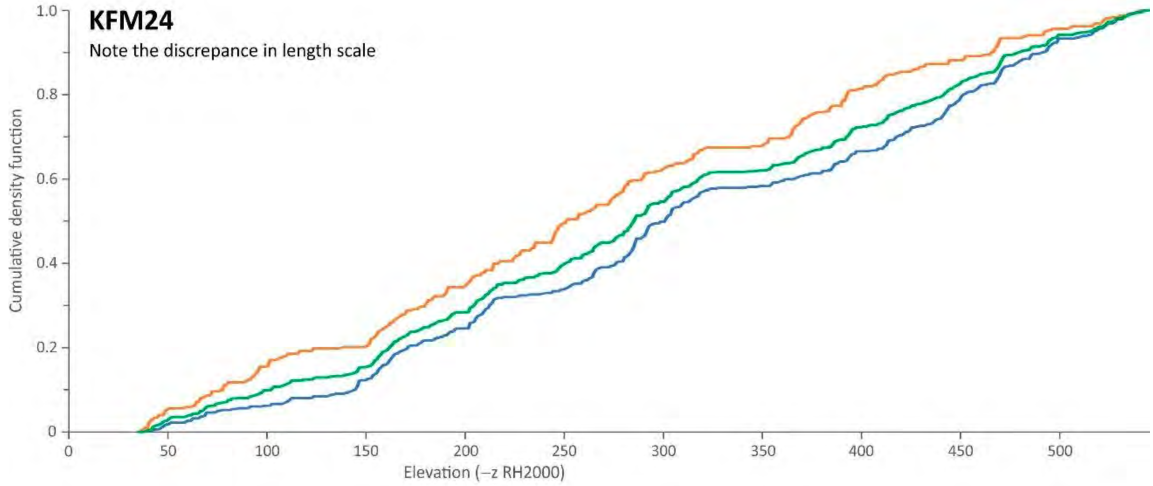


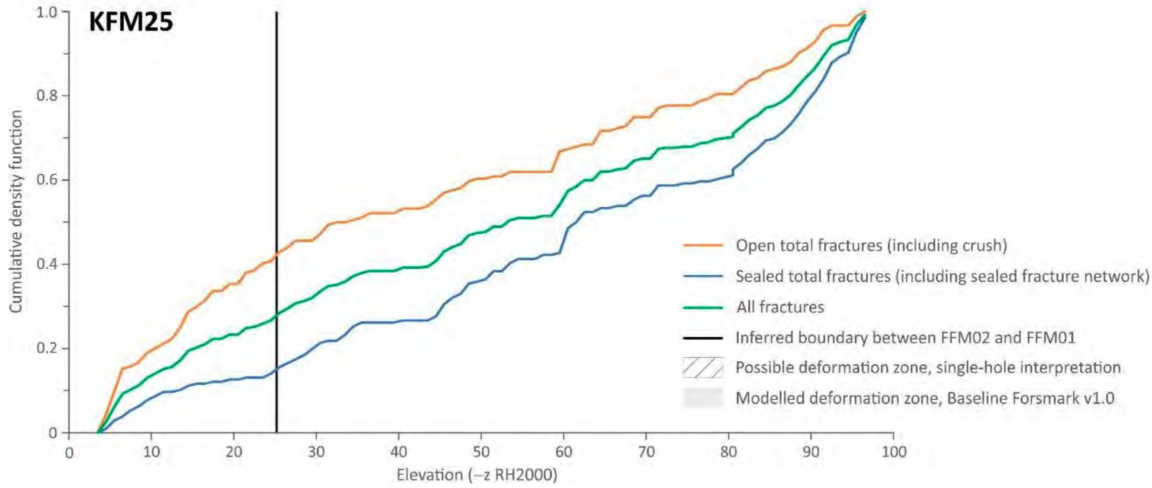


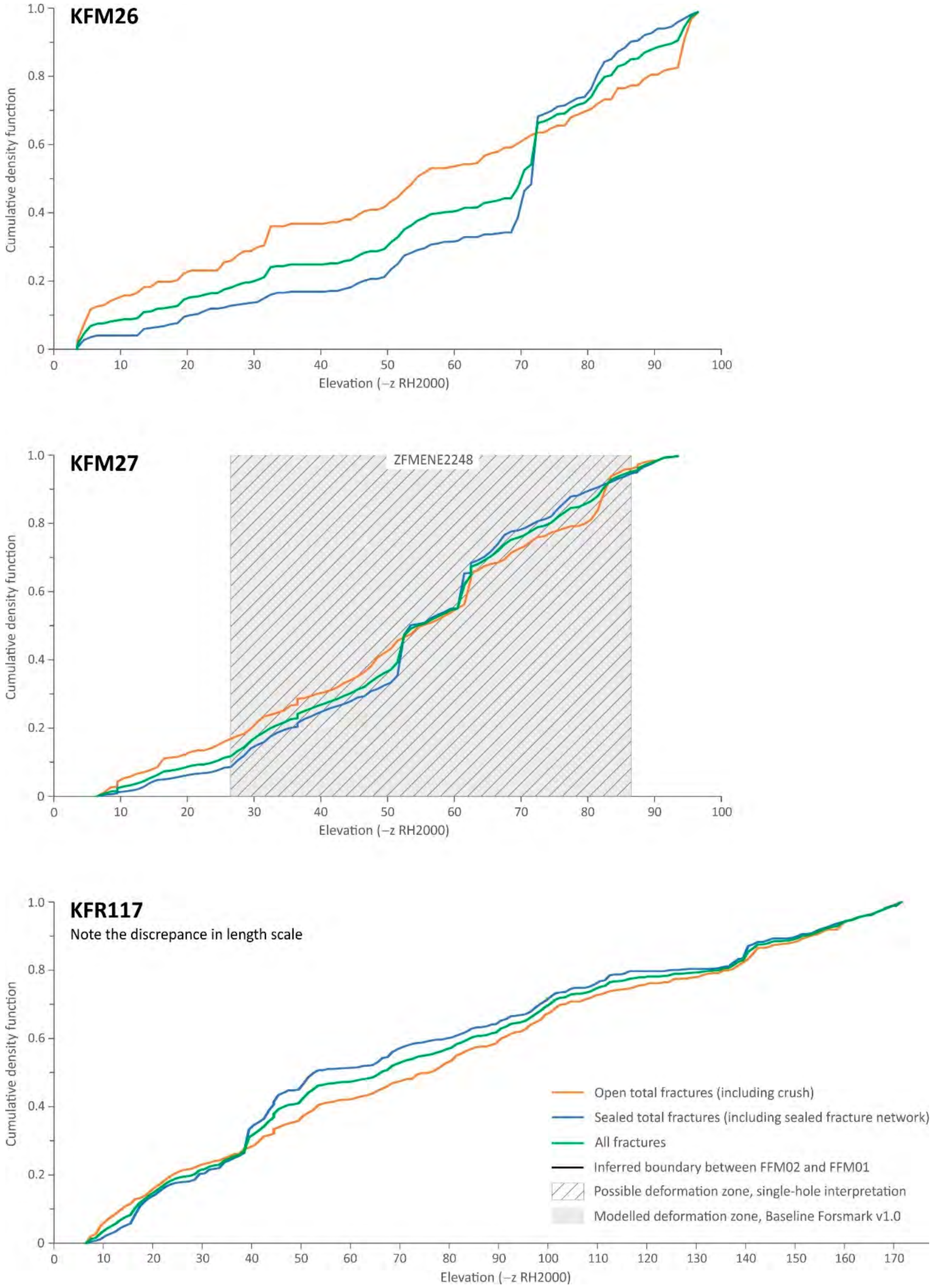

KFM16
KFM17
KFM18
KFM19
ZFMENE1061A
Cumulative density function
Elevation (–z RH2000)
Open total fractures (including crush)
Sealed total fractures (including sealed fracture network)
All fractures
Inferred boundary between FFM02 and FFM01
Possible deformation zone, single-hole interpretation
Modelled deformation zone, Baseline Forsmark v1.0

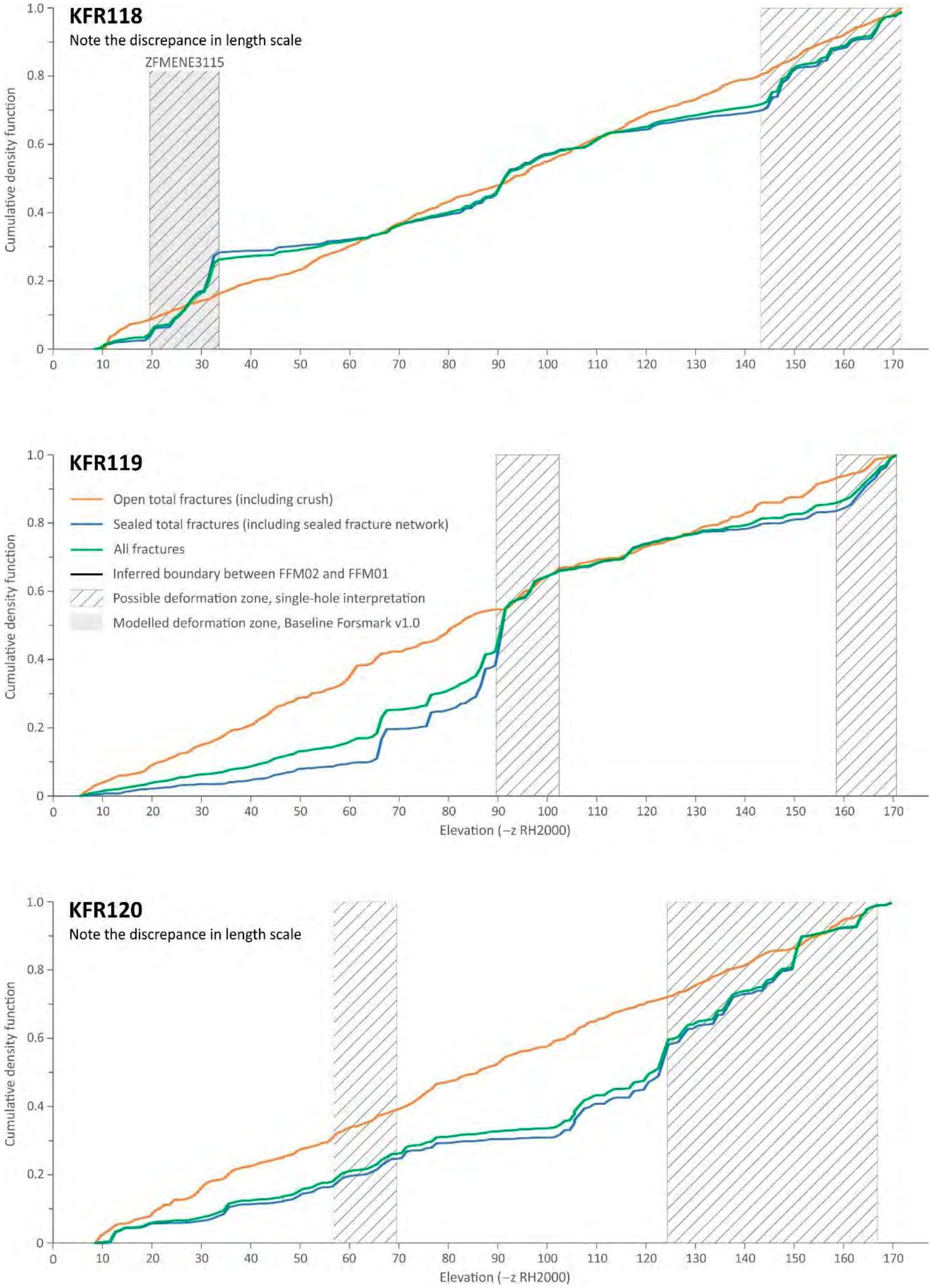

KFM20
KFM21
ZFMNNW1205A
ZFMNNW1205B
KFM22
Cumulative density function
Elevation (−z RH2000)
Open total fractures (including crush)
Sealed total fractures (including sealed fracture network)
All fractures
Inferred boundary between FFM02 and FFM01
Possible deformation zone, single-hole interpretation
Modelled deformation zone, Baseline Forsmark v1.0

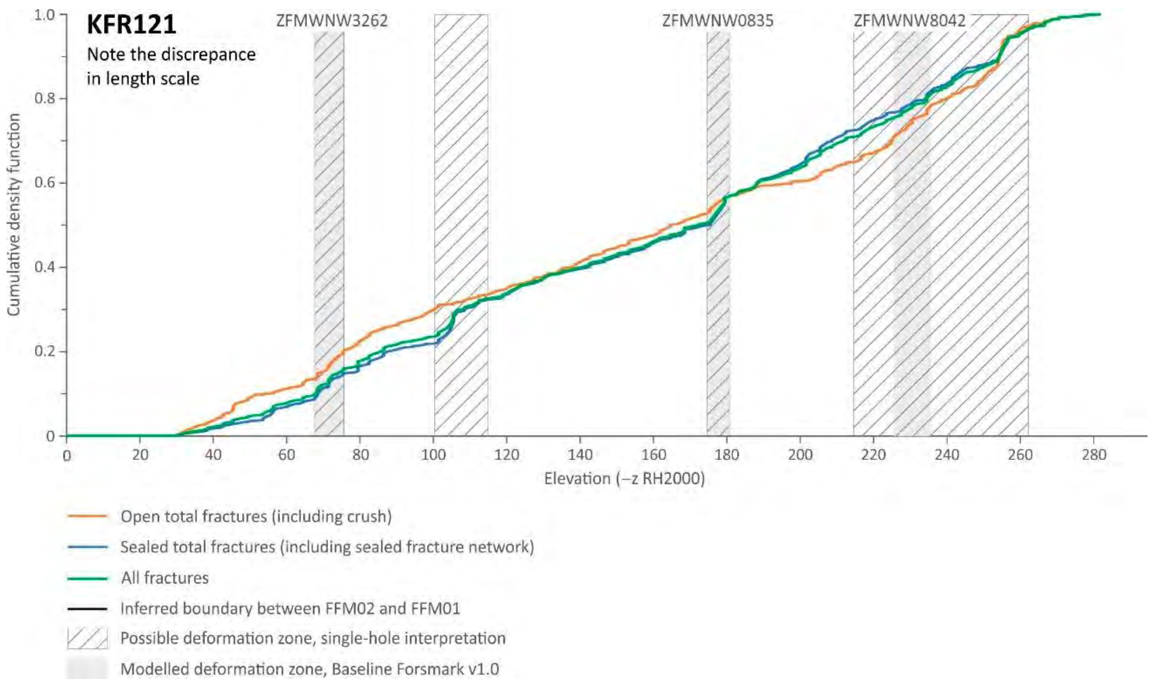

KFM23
ZFMENE2120
Cumulative density function
Elevation (–z RH2000)


KFM24
Note the discrepance in length scale
Cumulative density function
Elevation (–z RH2000)


KFM25
Cumulative density function
Elevation (–z RH2000)
Open total fractures (including crush)
Sealed total fractures (including sealed fracture network)
All fractures
Inferred boundary between FFM02 and FFM01
Possible deformation zone, single-hole interpretation
Modelled deformation zone, Baseline Forsmark v1.0


KFM26
KFM27
ZFMENE2248
KFR117
Note the discrepance in length scale
Cumulative density function
Elevation (–z RH2000)
Open total fractures (including crush)
Sealed total fractures (including sealed fracture network)
All fractures
Inferred boundary between FFM02 and FFM01
Possible deformation zone, single-hole interpretation
Modelled deformation zone, Baseline Forsmark v1.0


KFR118
Note the discrepance in length scale
ZFMENE3115
Cumulative density function
KFR119
Open total fractures (including crush)
Sealed total fractures (including sealed fracture network)
All fractures
Inferred boundary between FFM02 and FFM01
Possible deformation zone, single-hole interpretation
Modelled deformation zone, Baseline Forsmark v1.0
Elevation (−z RH2000)
KFR120
Note the discrepance in length scale
Elevation (−z RH2000)


KFR121
Note the discrepance in length scale
ZFMWNW3262
ZFMWNW0835
ZFMWNW8042
Cumulative density function
1.0
0.8
0.6
0.4
0.2
0
0
20
40
60
80
100
120
140
160
180
200
220
240
260
280
Elevation (−z RH2000)
Open total fractures (including crush)
Sealed total fractures (including sealed fracture network)
All fractures
Inferred boundary between FFM02 and FFM01
Possible deformation zone, single-hole interpretation
Modelled deformation zone, Baseline Forsmark v1.0

Appendix 7

Properties of deformation zones included in Baseline Forsmark version 1.0

A7.1 Content and structure

The procedure of the modelling work for deterministically modelled deformation zones (DZ) is presented in series of tables below. Properties of the deformation zones from SFR version 1.0 and Forsmark version 2.3 are inherited and reconstructed as precisely as possible using the application for visualisation and interpretation (AVI) tool developed by SKB.

Deterministically modelled deformation zones are arranged in the property tables, firstly, in the order of the orientation set to which the zone belongs and, secondly, in numerical order according to ID number (ZFMxxxxxxx).

The terminology used for zones orientation sets or fracture clusters in stereographic projections is inherited from Stephens et al. (2007) and presented in Table A7-1. Six sets of vertical or steeply (≥ 45°) dipping zones with different strike are present in the models: WNW–ESE, NW–SE, NNW-SSE abbreviated to WNW, NW and NNW respectively; and ENE–WSW, NNE–SSW and NE–SW abbreviated to ENE, NNE and NE respectively. A seventh orientation set where the dip is less than 45°, referred to as “Gently dipping”, is also present. Overview of the deformation zones (DZ) included in the Baseline Forsmark version 1.0 is presented in Table A7-2.

Table A7-1. Terminology used for vertical or steeply (≥ 45) dipping orientation sets in deformation zones and fracture clusters. If the structural feature dips less than 45°, the set is referred to as “gently dipping.

Name of vertical or steeply (≥ 45°) dipping orientation set	Strike [°]
N	355–005
NNE	005–035
NE	035–055
ENE	055–085
E	085–095
ESE	095–125
SE	125–145
SSE	145–175
S	175–185
SSW	185–215
SW	215–235
WSW	235–265
W	265–275
WNW	275–305
NW	305–325
NNW	325–355

Table A7-2. Summary of deformation zones in the Baseline Forsmark volume version 1.0. Presented in the same order as they occur in the property section A7.3. CL refers to total confidence level for the deformation zone (see explanation in Table A7-3).

DZ orientation group	Zone ID	Total CL	Page
Steep alteration pipe	ZFM1189	12	215
Gently dipping	ZFM1203	20	220
Gently dipping	ZFM866	19	226
Gently dipping	ZFM871	22	230
Gently dipping	ZFMA1	10	235
Gently dipping	ZFMA2	21	237
Gently dipping	ZFMA3	20	252
Gently dipping	ZFMA4	17	258
Gently dipping	ZFMA5	18	265
Gently dipping	ZFMA6-e	13	269
Gently dipping	ZFMA6-w	13	271
Gently dipping	ZFMA7	17	274
Gently dipping	ZFMA8	16	278
Gently dipping	ZFMB1	13	283
Gently dipping	ZFMB4	13	290
Gently dipping	ZFMB5-e	11	293
Gently dipping	ZFMB5-w	11	294
Gently dipping	ZFMB6	11	295
Gently dipping	ZFMB7	16	296
Gently dipping	ZFMB8	10	301
Gently dipping	ZFMB10	10	286
Gently dipping	ZFMB23-e	11	288
Gently dipping	ZFMB23-w	11	289
Gently dipping	ZFME1	10	303
Gently dipping	ZFMF1	18	460
Gently dipping	ZFMJ1	10	465
Gently dipping	ZFMJ2	10	467
Gently dipping	ZFMK1	11	469
Vertical or steeply dipping, ENE strike	ZFMENE0060A	22	304
Vertical or steeply dipping, ENE strike	ZFMENE0060B	15	309
Vertical or steeply dipping, ENE strike	ZFMENE0060C	15	314
Vertical or steeply dipping, ENE strike	ZFMENE0061	20	318
Vertical or steeply dipping, ENE strike	ZFMENE0062A	20	323
Vertical or steeply dipping, ENE strike	ZFMENE0062B	12	328
Vertical or steeply dipping, ENE strike	ZFMENE0062C	10	330
Vertical or steeply dipping, ENE strike	ZFMENE0103A	15	332
Vertical or steeply dipping, ENE strike	ZFMENE0103B	11	336
Vertical or steeply dipping, ENE strike	ZFMENE0159A	22	338
Vertical or steeply dipping, ENE strike	ZFMENE0159B	15	346
Vertical or steeply dipping, ENE strike	ZFMENE0168	14	350
Vertical or steeply dipping, ENE strike	ZFMENE0169	11	354
Vertical or steeply dipping, ENE strike	ZFMENE0401A	21	356
Vertical or steeply dipping, ENE strike	ZFMENE0401B	15	361
Vertical or steeply dipping, ENE strike	ZFMENE1061A	20	365
Vertical or steeply dipping, ENE strike	ZFMENE1061B	15	373
Vertical or steeply dipping, ENE strike	ZFMENE1192A	18	377
Vertical or steeply dipping, ENE strike	ZFMENE1192B	11	383
Vertical or steeply dipping, ENE strike	ZFMENE1208A	18	385
Vertical or steeply dipping, ENE strike	ZFMENE1208B	18	394
Vertical or steeply dipping, ENE strike	ZFMENE2120	21	402
Vertical or steeply dipping, ENE strike	ZFMENE2248	17	408
Vertical or steeply dipping, ENE strike	ZFMENE2254	14	415
Vertical or steeply dipping, ENE strike	ZFMENE2320	22	420

Table A7-2. Continued.

DZ orientation group	Zone ID	Total CL	Page
Vertical or steeply dipping, ENE strike	ZFMENE2325A	15	429
Vertical or steeply dipping, ENE strike	ZFMENE2325B	14	433
Vertical or steeply dipping, ENE strike	ZFMENE2383	14	437
Vertical or steeply dipping, ENE strike	ZFMENE2403	13	442
Vertical or steeply dipping, ENE strike	ZFMENE3115	22	446
Vertical or steeply dipping, ENE strike	ZFMENE3135	10	452
Vertical or steeply dipping, ENE strike	ZFMENE3151	10	454
Vertical or steeply dipping, ENE strike	ZFMENE8031	10	456
Vertical or steeply dipping, ENE strike	ZFMENE8034	10	458
Vertical or steeply dipping, NE strike	ZFMNE0065	17	471
Vertical or steeply dipping, NE strike	ZFMNE0808A	14	476
Vertical or steeply dipping, NE strike	ZFMNE0808B	14	478
Vertical or steeply dipping, NE strike	ZFMNE0808C	14	480
Vertical or steeply dipping, NE strike	ZFMNE0810	12	482
Vertical or steeply dipping, NE strike	ZFMNE0842	14	484
Vertical or steeply dipping, NE strike	ZFMNE0870	21	486
Vertical or steeply dipping, NE strike	ZFMNE1188	19	494
Vertical or steeply dipping, NE strike	ZFMNE2282	15	500
Vertical or steeply dipping, NE strike	ZFMNE2308	13	504
Vertical or steeply dipping, NE strike	ZFMNE2309	15	508
Vertical or steeply dipping, NE strike	ZFMNE2332	11	511
Vertical or steeply dipping, NE strike	ZFMNE3112	19	513
Vertical or steeply dipping, NE strike	ZFMNE3118	21	520
Vertical or steeply dipping, NE strike	ZFMNE3134	10	525
Vertical or steeply dipping, NE strike	ZFMNE3137	20	527
Vertical or steeply dipping, NE strike	ZFMNE3266	10	532
Vertical or steeply dipping, NE strike	ZFMNE3542	9	534
Vertical or steeply dipping, NNE strike	ZFMNNE0725	16	536
Vertical or steeply dipping, NNE strike	ZFMNNE0828	11	540
Vertical or steeply dipping, NNE strike	ZFMNNE0860	12	542
Vertical or steeply dipping, NNE strike	ZFMNNE0869	21	544
Vertical or steeply dipping, NNE strike	ZFMNNE0929	12	551
Vertical or steeply dipping, NNE strike	ZFMNNE1132	11	553
Vertical or steeply dipping, NNE strike	ZFMNNE1133	12	555
Vertical or steeply dipping, NNE strike	ZFMNNE1134	12	557
Vertical or steeply dipping, NNE strike	ZFMNNE1135	10	559
Vertical or steeply dipping, NNE strike	ZFMNNE2008	14	561
Vertical or steeply dipping, NNE strike	ZFMNNE2255	14	565
Vertical or steeply dipping, NNE strike	ZFMNNE2263	15	569
Vertical or steeply dipping, NNE strike	ZFMNNE2273	15	574
Vertical or steeply dipping, NNE strike	ZFMNNE2280	15	578
Vertical or steeply dipping, NNE strike	ZFMNNE2293	14	582
Vertical or steeply dipping, NNE strike	ZFMNNE2300	15	585
Vertical or steeply dipping, NNE strike	ZFMNNE2312	18	589
Vertical or steeply dipping, NNE strike	ZFMNNE3264	10	595
Vertical or steeply dipping, NNE strike	ZFMNNE3265	11	597
Vertical or steeply dipping, NNE strike	ZFMNNE3546A	11	599
Vertical or steeply dipping, NNW strike	ZFMNNW0100	22	601
Vertical or steeply dipping, NNW strike	ZFMNNW0101	11	609
Vertical or steeply dipping, NNW strike	ZFMNNW0404	22	611
Vertical or steeply dipping, NNW strike	ZFMNNW0806	13	619
Vertical or steeply dipping, NNW strike	ZFMNNW0823	14	621
Vertical or steeply dipping, NNW strike	ZFMNNW0999	10	623
Vertical or steeply dipping, NNW strike	ZFMNNW1034	20	625
Vertical or steeply dipping, NNW strike	ZFMNNW1204	13	632

Table A7-2. Continued.

DZ orientation group	Zone ID	Total CL	Page
Vertical or steeply dipping, NNW strike	ZFMNNW1205A	20	636
Vertical or steeply dipping, NNW strike	ZFMNNW1205B	21	642
Vertical or steeply dipping, NNW strike	ZFMNNW1209	22	648
Vertical or steeply dipping, NNW strike	ZFMNNW3113	9	652
Vertical or steeply dipping, NNW strike	ZFMNNW3524	13	654
Vertical or steeply dipping, NNW strike	ZFMNNW3534	11	656
Vertical or steeply dipping, NNW strike	ZFMNNW3550	10	658
Vertical or steeply dipping, NNW strike	ZFMNS3154	9	660
Vertical or steeply dipping, NW strike	ZFMNW0002	22	662
Vertical or steeply dipping, NW strike	ZFMNW0003	22	666
Vertical or steeply dipping, NW strike	ZFMNW0016	13	673
Vertical or steeply dipping, NW strike	ZFMNW0017	16	675
Vertical or steeply dipping, NW strike	ZFMNW0029	13	679
Vertical or steeply dipping, NW strike	ZFMNW0036	14	681
Vertical or steeply dipping, NW strike	ZFMNW0805A	22	683
Vertical or steeply dipping, NW strike	ZFMNW0805B	22	690
Vertical or steeply dipping, NW strike	ZFMNW0851	11	695
Vertical or steeply dipping, NW strike	ZFMNW0854	11	697
Vertical or steeply dipping, NW strike	ZFMNW0974	11	699
Vertical or steeply dipping, NW strike	ZFMNW0997	11	701
Vertical or steeply dipping, NW strike	ZFMNW1173	13	703
Vertical or steeply dipping, NW strike	ZFMNW1200	23	705
Vertical or steeply dipping, NW strike	ZFMNW3511	21	712
Vertical or steeply dipping, NW strike	ZFMNW3552	12	714
Vertical or steeply dipping, NW strike	ZFMNW8043	10	716
Vertical or steeply dipping, WNW strike	ZFMWNW0001	24	718
Vertical or steeply dipping, WNW strike	ZFMWNW0004	24	733
Vertical or steeply dipping, WNW strike	ZFMWNW0019	13	744
Vertical or steeply dipping, WNW strike	ZFMWNW0023	13	746
Vertical or steeply dipping, WNW strike	ZFMWNW0024	12	748
Vertical or steeply dipping, WNW strike	ZFMWNW0035	12	750
Vertical or steeply dipping, WNW strike	ZFMWNW0044	14	752
Vertical or steeply dipping, WNW strike	ZFMWNW0123	20	756
Vertical or steeply dipping, WNW strike	ZFMWNW0137	14	764
Vertical or steeply dipping, WNW strike	ZFMWNW0809A	14	766
Vertical or steeply dipping, WNW strike	ZFMWNW0809B	13	768
Vertical or steeply dipping, WNW strike	ZFMWNW0813	16	770
Vertical or steeply dipping, WNW strike	ZFMWNW0835	16	776
Vertical or steeply dipping, WNW strike	ZFMWNW0836	13	784
Vertical or steeply dipping, WNW strike	ZFMWNW0853	13	786
Vertical or steeply dipping, WNW strike	ZFMWNW1035	18	788
Vertical or steeply dipping, WNW strike	ZFMWNW1053	14	792
Vertical or steeply dipping, WNW strike	ZFMWNW1068	11	795
Vertical or steeply dipping, WNW strike	ZFMWNW1156	12	797
Vertical or steeply dipping, WNW strike	ZFMWNW2225	15	799
Vertical or steeply dipping, WNW strike	ZFMWNW3259	22	803
Vertical or steeply dipping, WNW strike	ZFMWNW3262	20	808
Vertical or steeply dipping, WNW strike	ZFMWNW3267	17	813
Vertical or steeply dipping, WNW strike	ZFMWNW3268	9	819
Vertical or steeply dipping, WNW strike	ZFMWNW3512	13	821
Vertical or steeply dipping, WNW strike	ZFMWNW3519	13	823
Vertical or steeply dipping, WNW strike	ZFMWNW3520	13	825
Vertical or steeply dipping, WNW strike	ZFMWNW3538	13	827
Vertical or steeply dipping, WNW strike	ZFMWNW3571	13	829
Vertical or steeply dipping, WNW strike	ZFMWNW8042	17	831

A7.2 Geological properties of modelled deformation zones

The geological properties assigned to each deformation zone are shown in Table A7-3.

Table A7-3. Explanation of properties shown in the deformation property tables.

Property	Description
Deformation zone ID	ZFMxxxxxxx
Version number	Geometrical version of the deformation zone (from RVS).
Total confidence level (CL)	The sum of the four confidence categories: interpretation, information density, interpolation and extrapolation according to the methodology presented in Hermanson and Petersson (2022).
Geological character	Describes the general geological character of the modelled deformation zone.
Deformation style	Description of the structural characterisation. Only presented if information/data exist.
Deformation description	Style of the kinematics and sense of displacement. Only presented if information/data exist.
Alteration	First, second and third order of alteration associated with the zones. Type of alteration presented only if information/data exists.
Fracture orientation and type	Description of fracture orientation, character and style of occurrence i.e. if sealed or open are dominant.
Fracture comment	Additional information related to fractures e.g. information regarding fracture aperture, alteration etc.
Fracture fill mineralogy	Type of mineral occurrences within fractures. Mineral coating or filling specified only if information/data exist.
Property confidence level	Quantitative judgement of the confidence level in each of the categories: Deformation style, deformation description, alteration, fracture orientation and type and fracture fill mineralogy. Also presented for lineaments and seismic reflectors.
Object geometry	Describes the geometry of the modelled deformation zone.
Strike/dip	The orientation of each zone is recorded as strike and dip using the right-hand-rule method, i.e. a zone with orientation 118/77 means that the zone strikes N62°W and dips 77° to the SSW. With numerical estimate of uncertainty.
Length	Length refers to the inferred total trace length of the deformation zone at the ground surface. No length is provided for the deformation zones that fail to intersect the ground surface. See also section 5.3.3 in the main report.
Mean thickness	Thickness refers to the total zone thickness, i.e. damage zone and fault core. If ductile deformation is present along the zone, this is also included in the thickness estimate. If there are data from boreholes, the modelled thickness reflects the value calculated from the borehole intersection (single intersection) or from the borehole intersection judged to be most reliable (more than one intersection). Mean thickness provided with numerical estimate of uncertainty. Min-Max thickness within brackets. See also section 5.3.4 in the main report.
Max depth	Zones with trace lengths exceeding 2 100 m at the ground surface terminate at the base of the model volume i.e. – 2 100 m. Less extensive deformation zones extended to a depth that is approximately the same as its trace length at the ground surface. See also section 5.3.2 in the main report.
Geometrical constraints	Truncation against other zones, open ends and surface planar cuts are specified if present.
Basis for modelling	Specification of type of data used as a basis for the modelling work.
Outcrops	Outcrop ID specified if present.
Boreholes	Borehole ID, possible deformation zones interpreted during single hole interpretation (SHI), target and geometrical intercepts and additional comments specified, if present. The degree of detail given in the geometric and target intervals (two decimals) is an effect that originates from the digital CAD modelling tool, RVS. The real uncertainty where a deformation zone may intersect a borehole is possibly within several meters. However, the level of detail of the CAD calculated intersections have been retained so changes to the geometric model can be identified.
Tunnels	Tunnel ID and chainage specified, if present.
Lineament and or seismic indications	Lineament and or seismic reflector ID specified, if present.

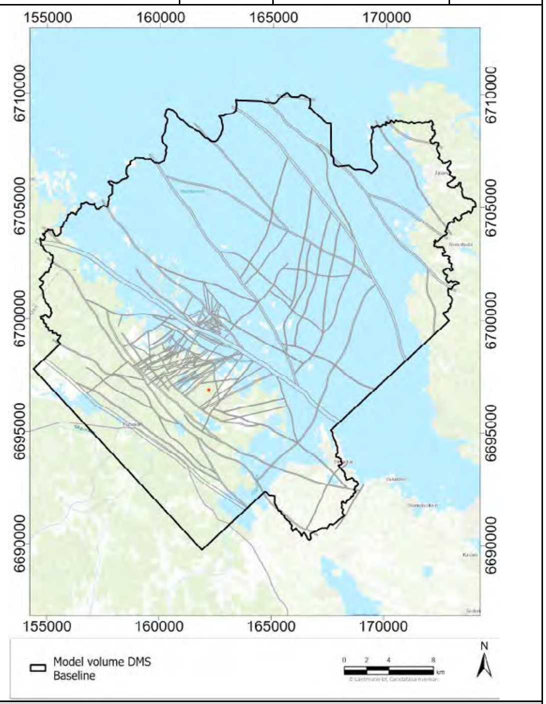
Property	Description
Modelling procedure	Description of the modelling procedure and the source data used in the development of the 3D geometry, truncations against surrounding zones and use of general geological concept.
Object confidence estimate	Quantitative object confidence estimates for the four categories: interpretation, information density, interpolation and extrapolation according to the methodology presented in Hermanson and Petersson (2022). See also section 5.7 in the main report.
Fracture character	Describes the general character of observed fractures in the modelled deformation zone.
Orientation	The mean orientation of each set of fractures along a zone is recorded as strike and dip using the right-hand-rule method. Previously interpretation presented by Stephens et al. (2007) and Stephens and Simeonov (2015) was followed as precisely as possible, however minor adjustments have been implemented in a few cases where data adjustments have occurred in SICADA or new borehole data have been added.
Fracture frequency	Sealed fracture networks and crush zones are included in the estimation of total fracture frequency along each zone. The frequency of fractures in such structures is calculated on the basis of the size of the rock fragments (i.e. the piece length) inside the network or crush zone and the length of the borehole occupied by the structure, both of which have been recorded during the mapping work. A direct count of fractures has not been made. Data from percussion boreholes are omitted due to the intrinsic limitations of the data on fractures from these boreholes.
Rock quality designation (RQD)	The percentage of the drill core in lengths of 10 cm or more.
Fracture fill mineralogy	Number of occurrences of identified minerals in the deformation zone target sections of core drilled boreholes.
Individual intercepts	Lists of all intercepts with cored and percussion drilled boreholes. Detailed information of individual intercepts in the existing tunnels in SFR and the cooling water tunnels to the powerplant are listed in Curtis et al. (2011).
Stereoplot	Fracture clusters are presented in an inferred, ranked order of interest and plotted consistently in the following colours: Primary cluster (red); Secondary cluster (blue); Third cluster (green); Fourth cluster (purple); Unassigned fractures (grey). The mean orientation of each set of fractures along a zone is recorded as strike and dip using the right-hand-rule method. Where data are available, the mean pole and Fisher k value for each fracture set have been calculated according to the methodology used in Stephens and Simeonov (2015).
Borehole log properties:	
– Length	Borehole length, measured from start of casing.
– Elevation	Measured from RH2000 elevation model., from the start of casing.
– Open fractures	Frequency of fractures designated as open or partly open (in p_fract_core).
– Sealed fractures	Frequency of fractures designated as sealed (in p_frac_core).
– Open total fractures	Frequency of fractures designated as open, partly open and crush.
– Sealed total fractures	Frequency of fractures designated as sealed, including sealed network.
– Total fractures	Frequency of fractures designated as open, partly open, crush and sealed fractures, including sealed network.
– Crushed zone	Highly fractured sections of the drill core where individual open fractures cannot be mapped and the distance between fractures are less than about 5 cm in the core.
– Sealed network	Highly fractured sections of the drill core where individual sealed fractures cannot be mapped and the distance between fractures are less than about 5 cm in the core.
– RQD	Summed length of all rock segments ≥ 10 cm per meter of drill core.
– Fracture open frac orientation	Tadpole plot of fractures designated as open (red) and partly open (green). Direction of tadpole tail indicates dip direction, and tadpole indicates dip.
– Fracture sealed frac orientation	Tadpole plot of fractures designated as sealed (grey). Direction of tadpole tail indicates dip direction, and tadpole indicates dip.
– Open aperture	Measured fracture aperture in millimetre.
– Core loss	Borehole sections without recovered drill core.

A7.3 Geological properties of modelled deformation zones

Date and time: 2024-11-18 21:17:41
Database version: skbdata_v_014

G	ZFM1189	Version number	6	Total object CL	12

GEOLOGICAL CHARACTER		Property CL
Deformation style:	Brittle	3
Deformation description:	No data available.	
Alteration:		3
- First order:	Quartz dissolution	
- Second order:	Oxidation	
- Third order:	Albitization	
Fracture orientation and type:	No data available.	2
Fracture comment:	Alteration pipe.	
Fracture fill mineralogy:	Calcite, hematite, chlorite, quartz, clay minerals, pyrite.	



OBJECT GEOMETRY	
Strike/dip:	120°/83°
Length:	-
Mean thickness:	7 m
Max depth:	-444 m
Geometrical constraints:	ZFMA3, ZFMA2, Topo 40m grid Max error 20m, 1 UNIVERSE Planar Cut(s).

BASIS FOR MODELLING

Zone based on borehole observations and pattern of surrounding deformation zones. ZFM1189 does not extend to the surface.

Outcrops:	-

Boreholes:

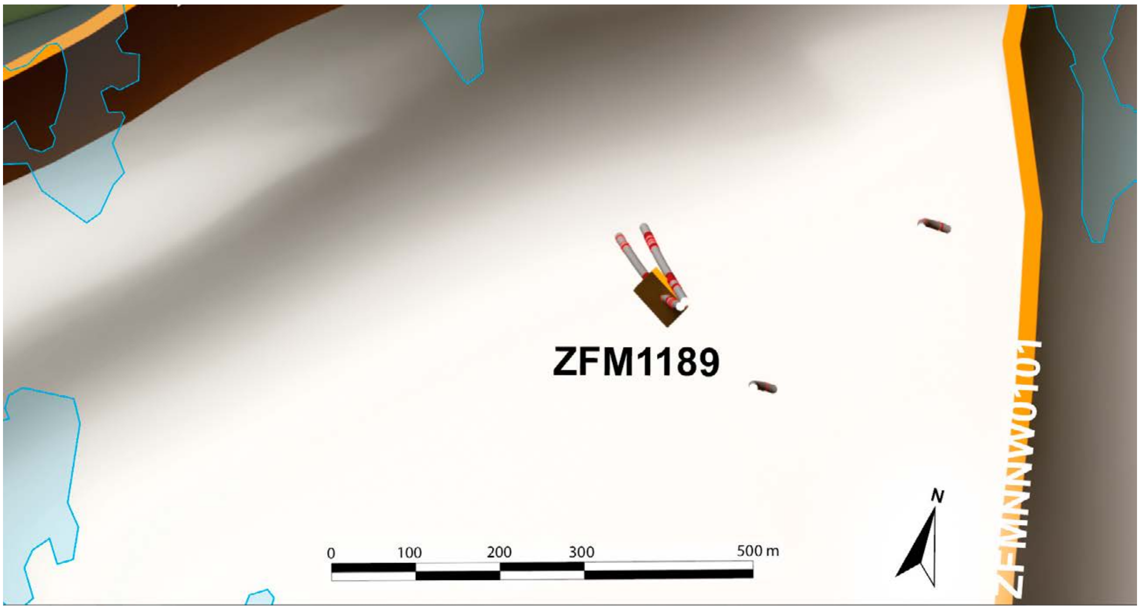
Borehole	PDZ	Target intercept		Geometric intercept		Comment
		Sec_up [m]	Sec_low [m]	Sec_up [m]	Sec_low [m]	
KFM02A	DZ4	240.00	310.00	248.76	309.00	Target intercept defined by RU3, composed of vuggy metagranite subjected to a strong albite-hematite-chlorite alteration.
KFM02A	DZ5	240.00	310.00	248.76	309.00	Target intercept defined by RU3, composed of vuggy metagranite subjected to a strong albite-hematite-chlorite alteration.

Tunnels:	-
Lineament and/or seismic indications:	-

MODELLING PROCEDURE

Modelled as a steeply plunging alteration pipe that occurs between the two gently dipping zones ZFMA2 and ZFMA3 beneath drill site 2. Fixed point placed at 266 m along DZ4. Model supported by the occurrence of a borehole radar reflector that is parallel to KFM02A along 180-240 m borehole length and an analysis of surface and borehole seismic reflection data. These data indicate that the altered vuggy rock associated with DZ4 and DZ5 in KFM02A (borehole interval 240-302 m) is steeply inclined and more or less parallel with the borehole. Pipe-like geometry supported by the lack of identification in KFM02B.

G	ZFM1189	Version number	6	Total object CL	12

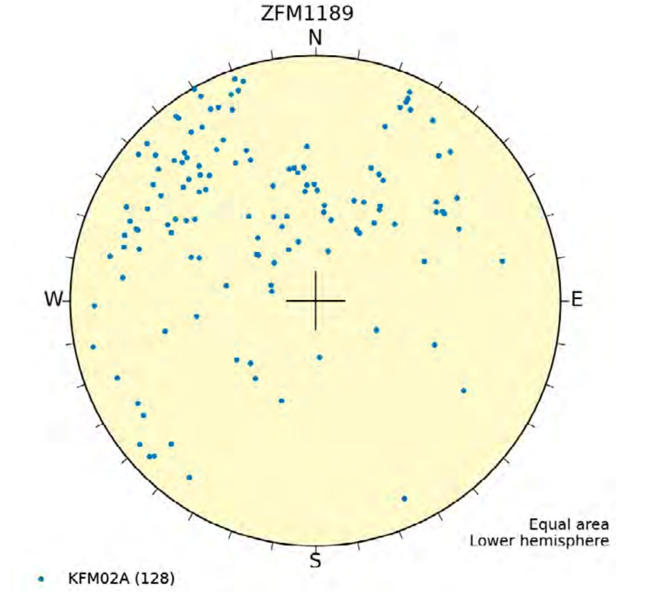
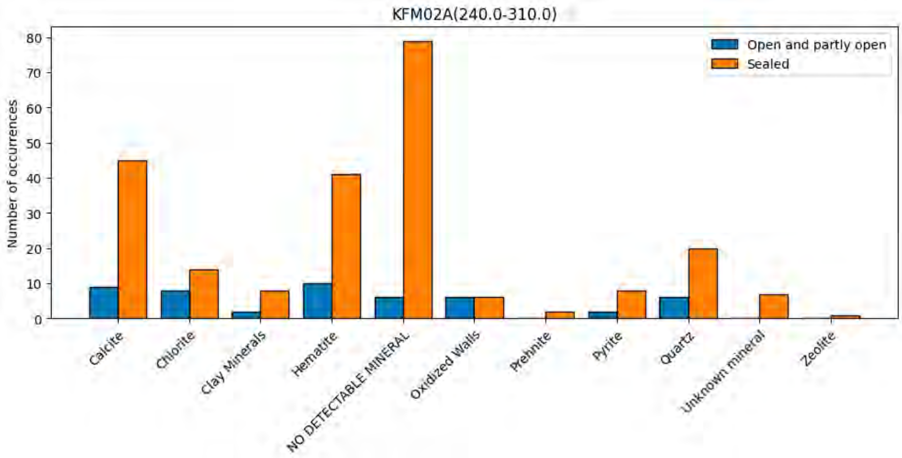


OBJECT CONFIDENCE ESTIMATE

Category	Object CL	Comment
INTERPRETATION		
Data source	2	KFM2A
Results of interpretation	3	High confidence observation in KFM2A.
INFORMATION DENSITY		
Number of observation points	1	1
Distribution of observation points	1	Single observation point at depth.
INTERPOLATION		
Geometry	1	Information from a single sub-surface obs. point is not enough/sufficient to put constrains on the geometry of the entire zone. At least one more observation point is required to enable interpolation. The zone not intersected by KFM02B provide some constraints on the vertical extent of the zone.
Geological indicators	1	Single observation point at depth. Zone modelled mainly based on surface geophysical data.
EXTRAPOLATION		
Dip direction	2	ZFM1189 does not extend to the surface. Truncated against ZFMA2 and ZFMA3.
Strike direction	1	Extrapolation along strike based on geophysical data and a single borehole intercept.

G	ZFM1189	Version number	6	Total object CL	12

FRACTURE CHARACTER

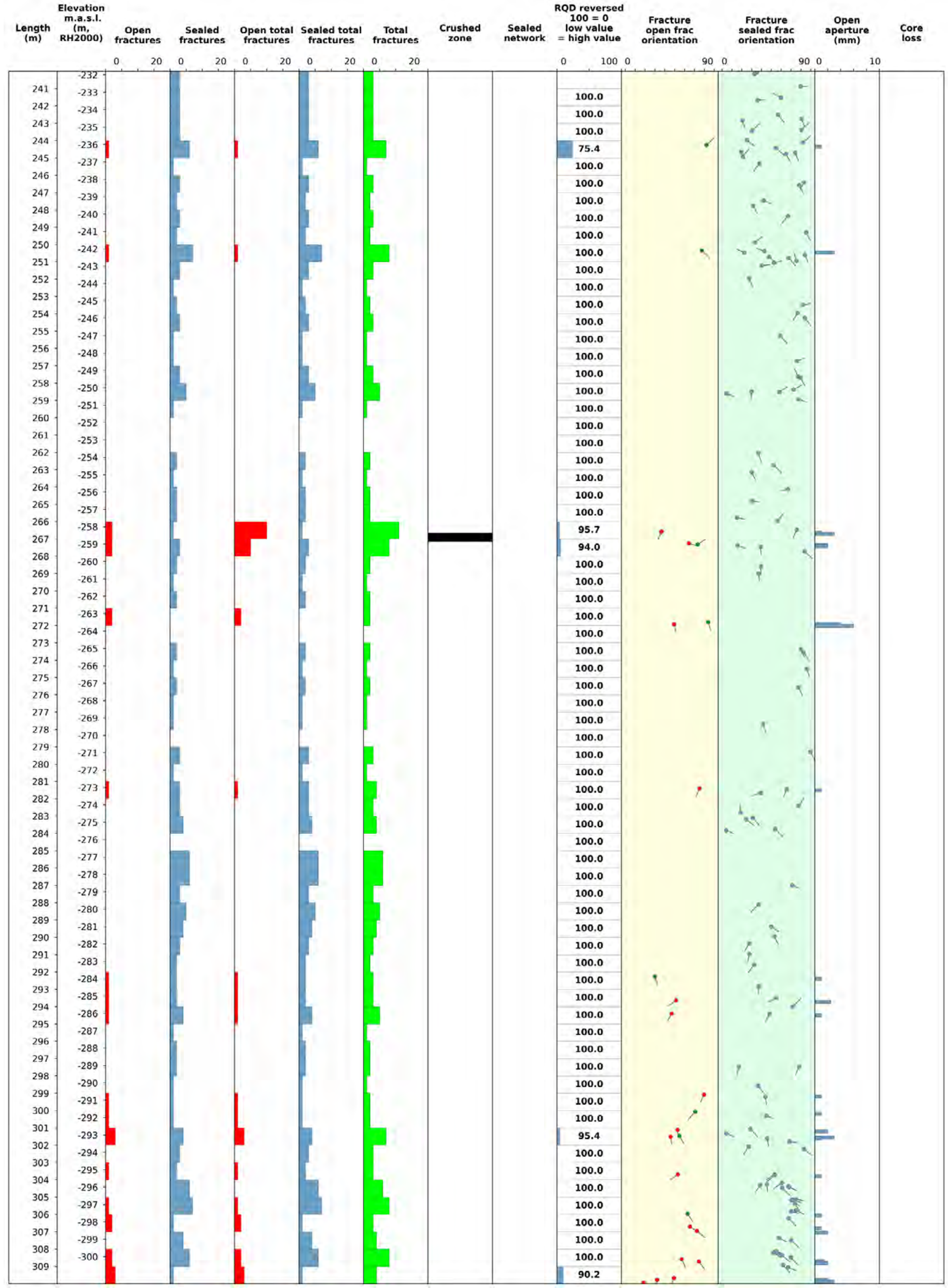
Orientation: (strike/dip right-hand-rule)	--	
Frequency:	Boreholes: KFM02A	
RQD:	min:75, max:100, mean:99	
Fracture fill mineralogy:		

FRACTURE TYPE	TERZAGHI-WEIGHED P10
Open and partly open	0.9 m-1
Sealed	4.7 m-1
Sealed network	0.0 % of DZ intercept
Crush	0.7 % of DZ intercept

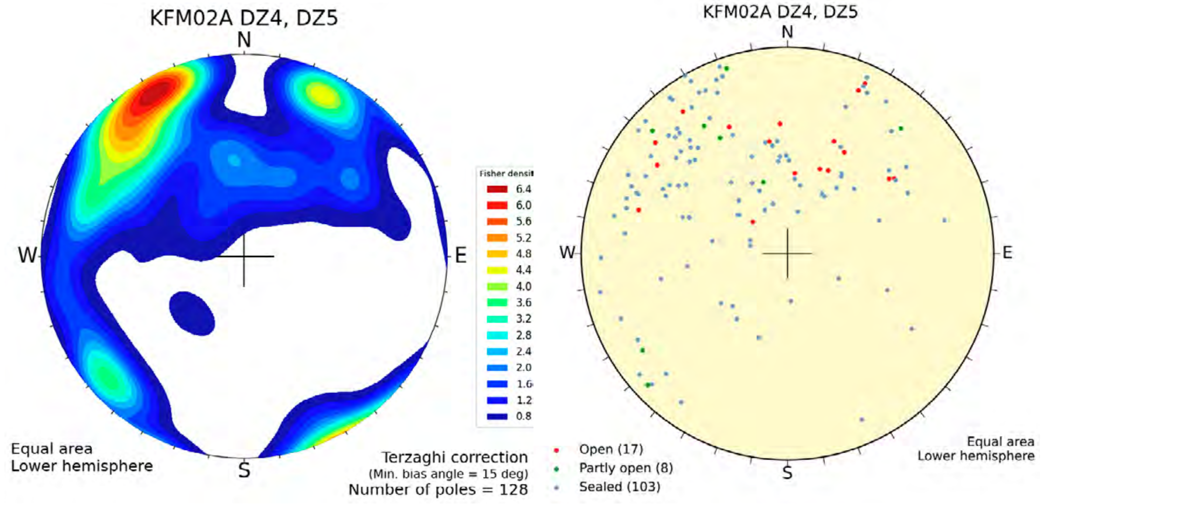
G	ZFM1189	Version number	6	Total object CL	12

INDIVIDUAL INTERCEPTS

KFM02A DZ4, DZ5 (240.0-310.0 m)

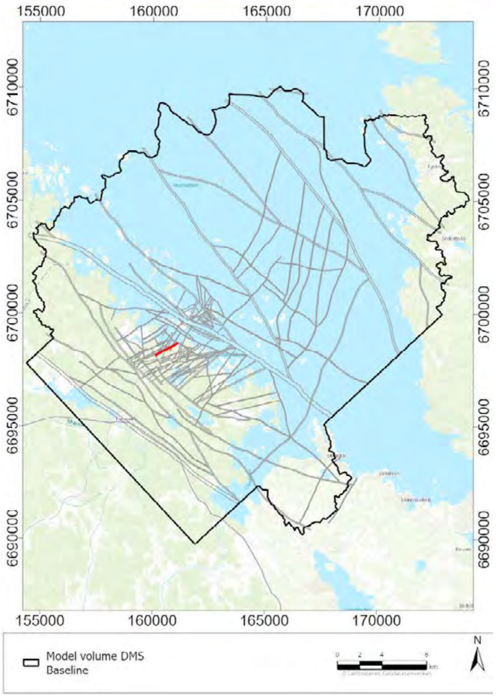


G	ZFM1189	Version number	6	Total object CL	12



G	ZFM1203	Version number	3	Total object CL	20

GEOLOGICAL CHARACTER		Property CL
Deformation style:	Brittle	3
Deformation description:	Faults dipping gently to the north show reverse dip-slip or reverse sinistral strike-slip components of movement. Steep WSW faults show strike-slip displacement, both dextral and sinistral. A steep NNW fault shows a predominantly dextral sense of shear.	
Alteration:		3
- First order:	Oxidation	
- Second order:	Not observed	
- Third order:	Not observed	
Fracture orientation and type:	Gently dipping fractures dominates. Steeply dipping fractures are also present. Open and sealed fractures. Quantitative estimate and span include crush zones and sealed fracture networks.	2
Fracture comment:	No data available.	
Fracture fill mineralogy:	No data available.	



OBJECT GEOMETRY	
Strike/dip:	242°/19°
Length:	1127 m
Mean thickness:	10 m (8 - 10 m)
Max depth:	-145 m
Geometrical constraints:	Topo 40m grid Max error 20m, ZFMWNW2225, ZFMNNE2280, ZFMENE0159A, Trunc ZFM1203, ZFMNE2309, ZFMNNW0404.

BASIS FOR MODELLING

Zone based on borehole observations and radar data and pattern of surrounding deformation zones.

Outcrops:	-

Boreholes:

Borehole	PDZ	Target intercept		Geometric intercept		Comment
		Sec_up [m]	Sec_low [m]	Sec_up [m]	Sec_low [m]	
HFM21	DZ1	94.00	102.00	94.89	105.94	
HFM42		88.50	96.30	91.52	101.98	Several sub-horizontal fractures with conspicuous apertures in the interval 88,5-96,3 m.
KFM07A	DZ1	108.00	183.00	120.68	133.80	ZFMNNW0404 also intersects DZ1 and its extension in KFM07A (lower part).
KFM07B	DZ2	93.00	102.00	93.94	104.51	
KFM07C	DZ1	92.00	103.00	91.98	102.23	

Tunnels:	-
Lineament and/or seismic indications:	-

MODELLING PROCEDURE

Modelled by combining the upper part of DZ1 and its extension (108-185 m) in KFM07A with a fixed point at 122 m, with the borehole intervals 93-102 m in KFM07B with a fixed point at 95 m (DZ2), 92-103 m in KFM07C with a fixed point at 93 m (DZ1) and 94-102 m in HFM21 with a fixed point at 96 m (DZ1). Low radar amplitudes also observed at 118-121 m in KFM07A and 95-102 m in KFM07B. Modelled as a near-surface, sub-horizontal fracture zone with support from the orientation of near-surface fractures in the borehole intersections. Termination against ZFMENE0159A, ZFMNNW0404, ZFMNNE2309, ZFMWNW2225 and ZFMNNE2280. However, zone ZFMNNW0404 also intersects DZ1 and its extension in KFM07A (lower part). Can explain the complex interference between gently and steeply dipping structures (see Nordgulen and Saintot 2006).

G	ZFM1203	Version number	3	Total object CL	20

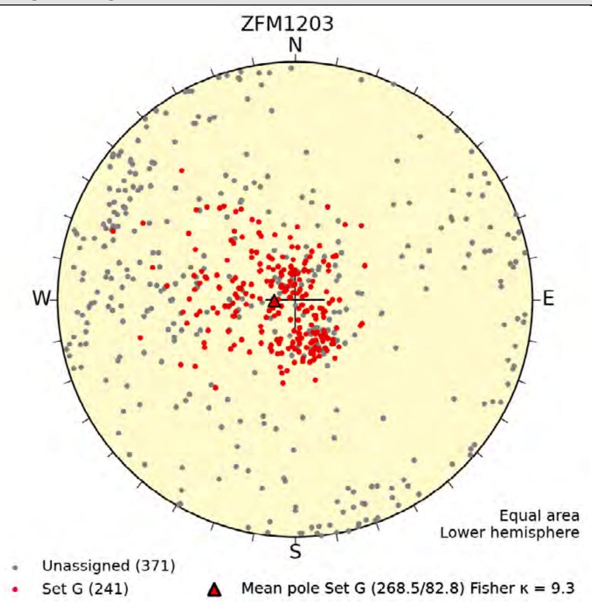
OBJECT CONFIDENCE ESTIMATE

Category	Object CL	Comment
INTERPRETATION		
Data source	2	HFM21, HFM42, KFM07A, KFM07AB, KFM07AC.
Results of interpretation	3	High confidence observation in KFM7A, KFM7B, KFM7C.
INFORMATION DENSITY		
Number of observation points	3	>4
Distribution of observation points	2	A group of cluster and no outlier, evenly distributed.
INTERPOLATION		
Geometry	3	Multiple observation points in the western area contribute to relative high conf. of interpolated geometry between the obs. points.
Geological indicators	2	Some discrepancies in the geological data.
EXTRAPOLATION		
Dip direction	3	Boreholes at the NW side of ZFMENE0159A, which lack indication of a gently dipping zone at the level of linear extrapolation.
Strike direction	2	Conceptual constraints. Truncated by ZFMWNW225, ZFMNNE2280, ZFMENE0159A, ZFMNE2309, ZFMNNW0404.

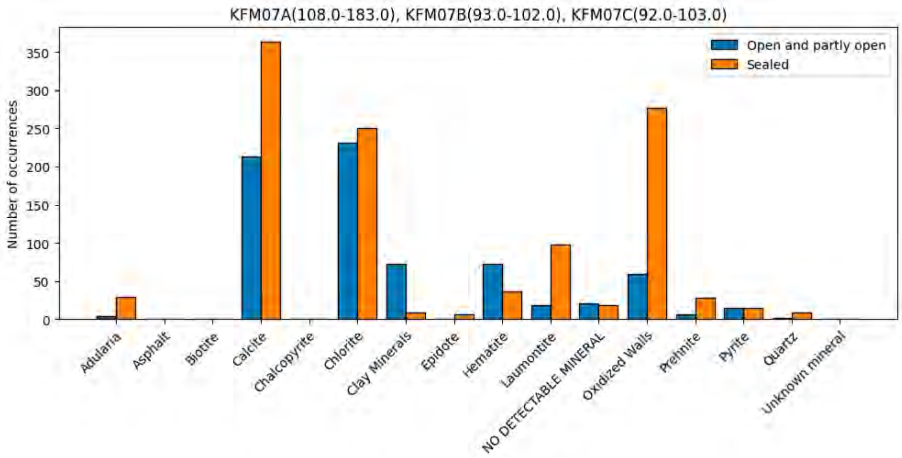
FRACTURE CHARACTER

Orientation: (strike/dip right-hand-rule)	Set G: 358.5°/7.2°	
Frequency:	Boreholes: KFM07A, KFM07C, KFM07B	
RQD:	min:62, max:100, mean:95	

FRACTURE TYPE	TERZAGHI-WEIGHED P10
Open and partly open	6.0 m-1
Sealed	12.9 m-1
Sealed network	2.2 % of DZ intercept
Crush	1.3 % of DZ intercept

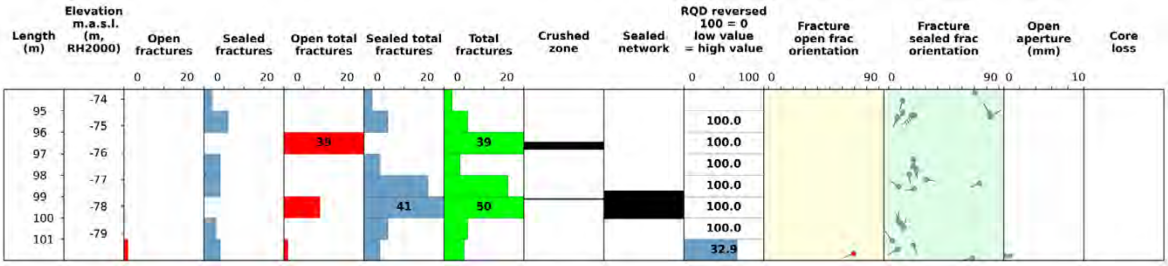


G	ZFM1203	Version number	3	Total object CL	20
Fracture fill mineralogy:					

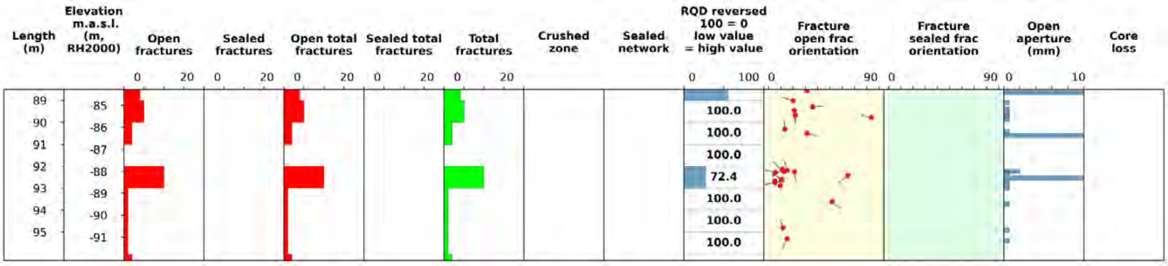


INDIVIDUAL INTERCEPTS

HFM21 DZ1 (94.0-102.0 m)

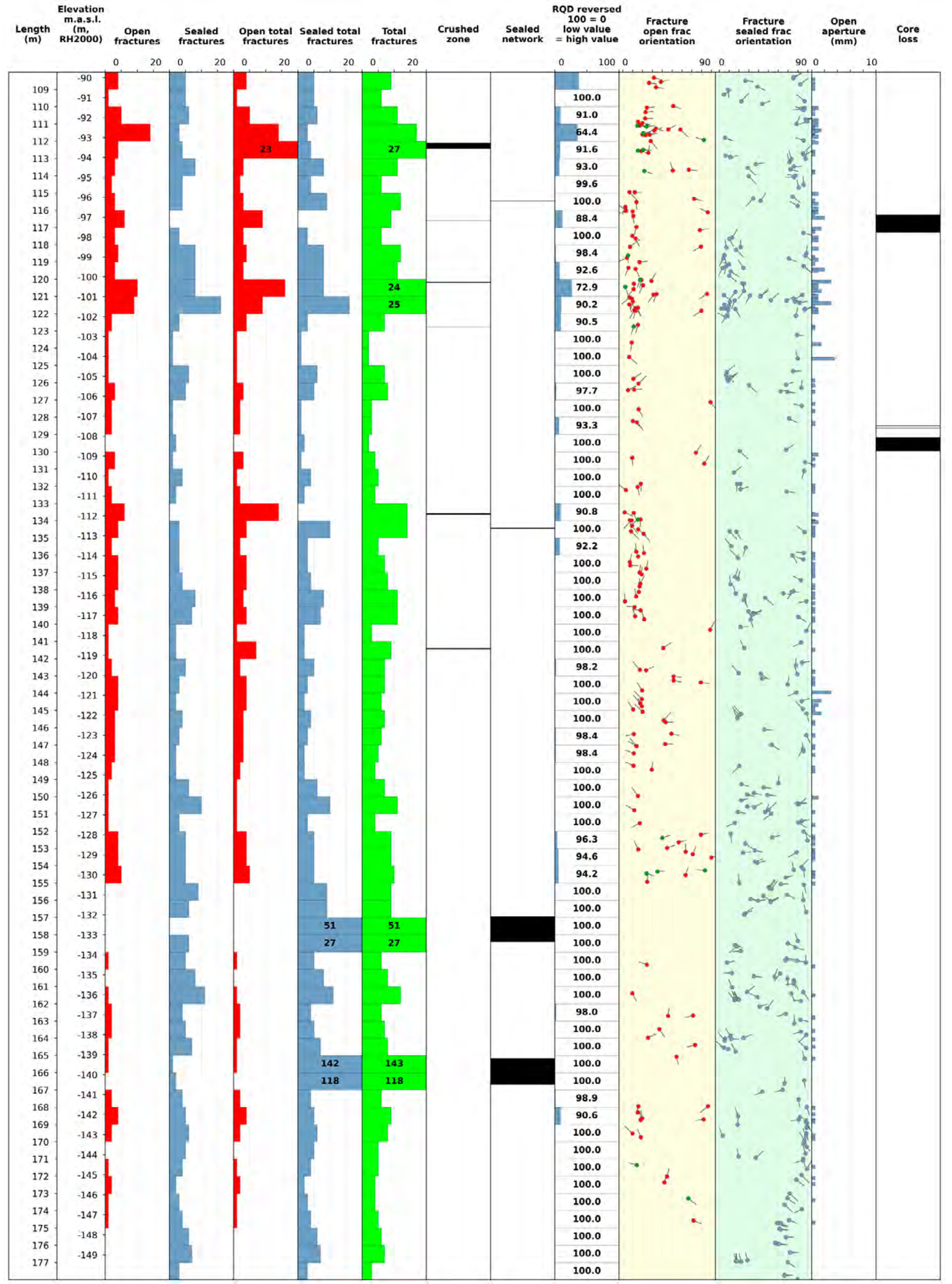


HFM42 (88.5-96.3 m)

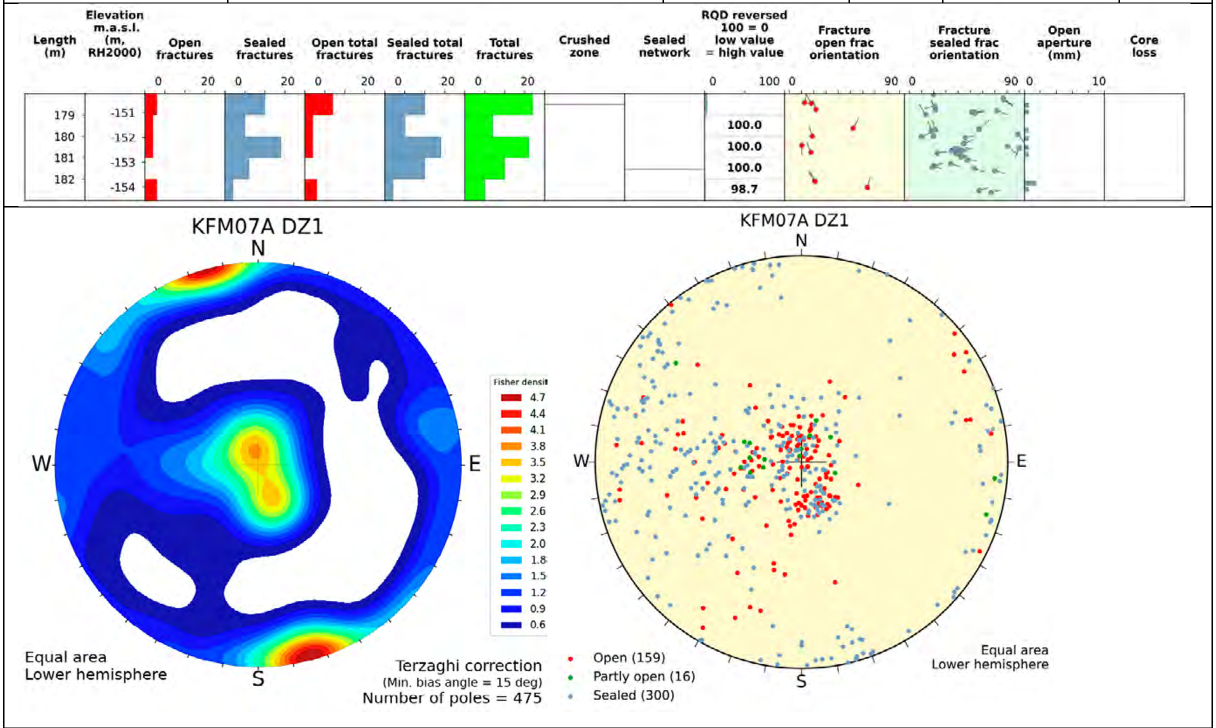


G	ZFM1203	Version number	3	Total object CL	20

KFM07A DZ1 (108.0-183.0 m)

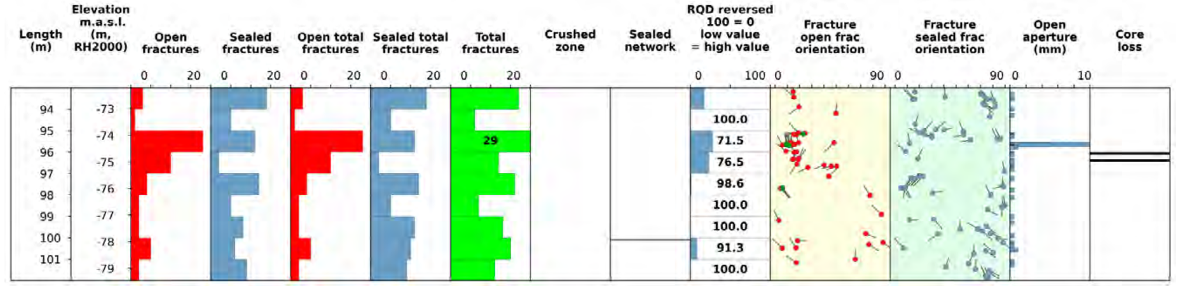


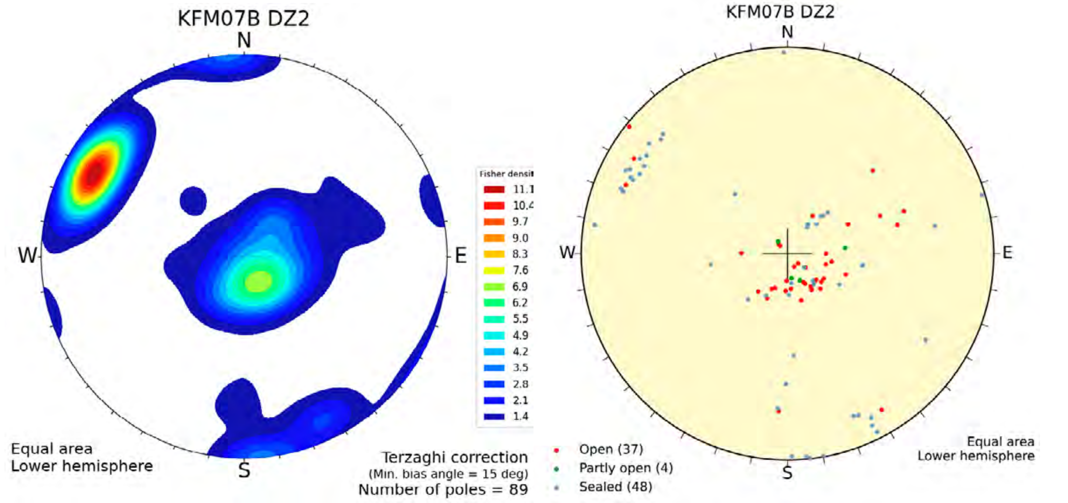
G	ZFM1203	Version number	3	Total object CL	20



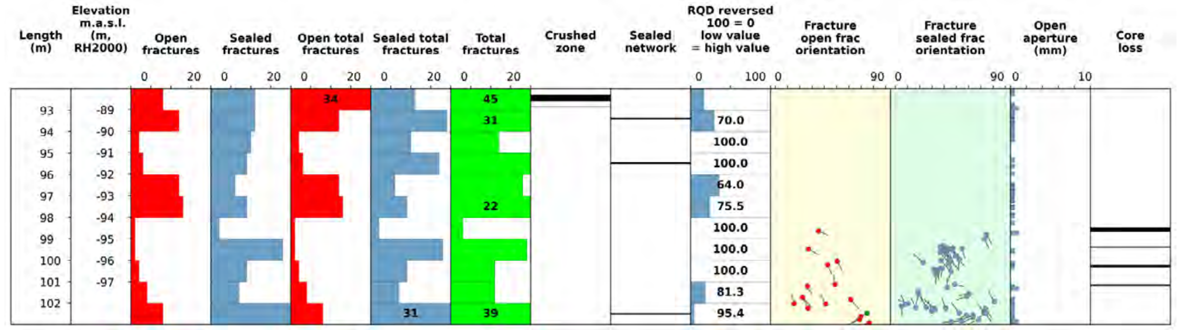
G	ZFM1203	Version number	3	Total object CL	20

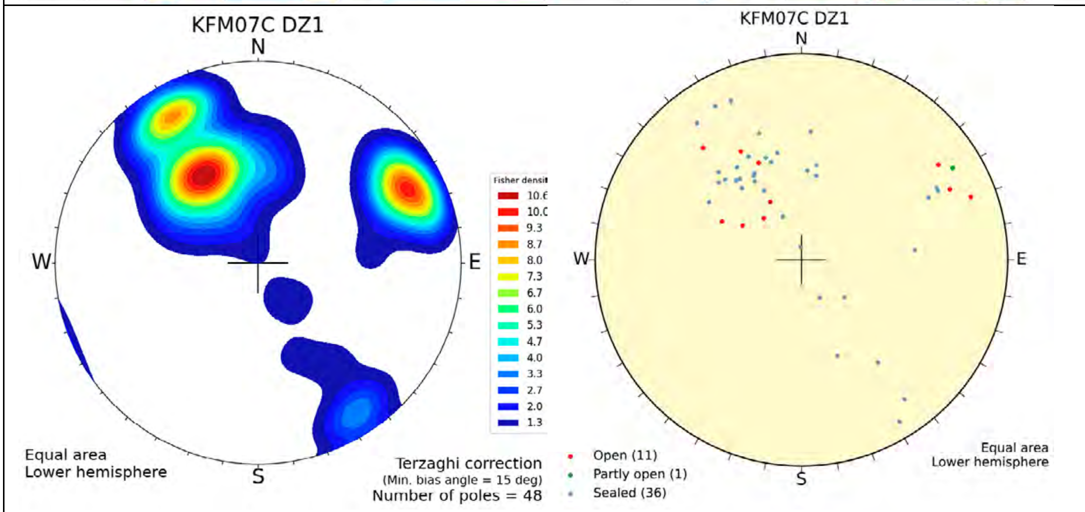
KFM07B DZ2 (93.0-102.0 m)





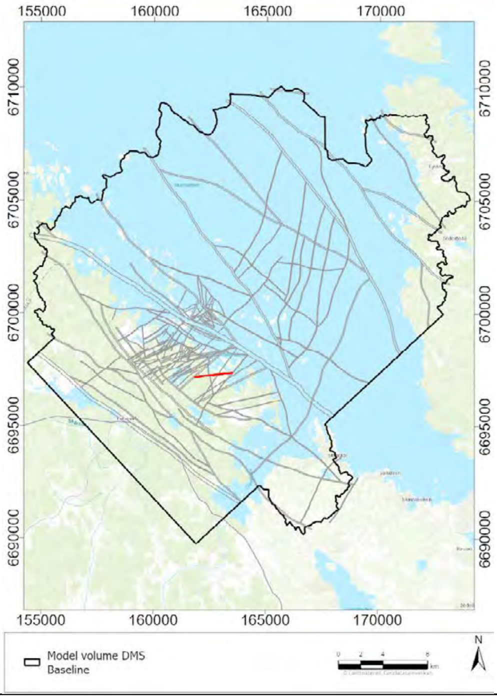
KFM07C DZ1 (92.0-103.0 m)





G	ZFM866		Version number	3	Total object CL	19

GEOLOGICAL CHARACTER		Property CL
Deformation style:	Brittle	3
Deformation description:	Reverse dip-slip displacement along several gently dipping faults that dip to the north-east and south-east. Minor faults along DZ2 in KFM02A. Chlorite striae.	
Alteration:		3
- First order:	Oxidation	
- Second order:	Argillization	
- Third order:	Chloritization	
Fracture orientation and type:	Gently dipping fractures dominates. Sealed and open fractures.	2
Fracture comment:	No data available.	
Fracture fill mineralogy:	Calcite, clay minerals, chlorite. High frequency of fractures with no mineral coating/filling.	



OBJECT GEOMETRY	
Strike/dip:	82°/23°
Length:	1710 m
Mean thickness:	11 m (11 - 17 m)
Max depth:	-596 m
Geometrical constraints:	ZFMNE0065, ZFMA3, Topo 40m grid Max error 20m.

BASIS FOR MODELLING

Zone based on combining borehole data and pattern of surrounding deformation zones.

Outcrops: -

Boreholes:

Borehole	PDZ	Target intercept		Geometric intercept		Comment
		Sec_up [m]	Sec_low [m]	Sec_up [m]	Sec_low [m]	
HFM04	DZ1	61.00	64.00	53.51	65.19	
HFM05	DZ1	153.00	154.00	145.10	157.34	
KFM02A	DZ2	110.00	122.00	110.40	122.22	
KFM02B	DZ1	98.00	115.00	104.74	116.22	

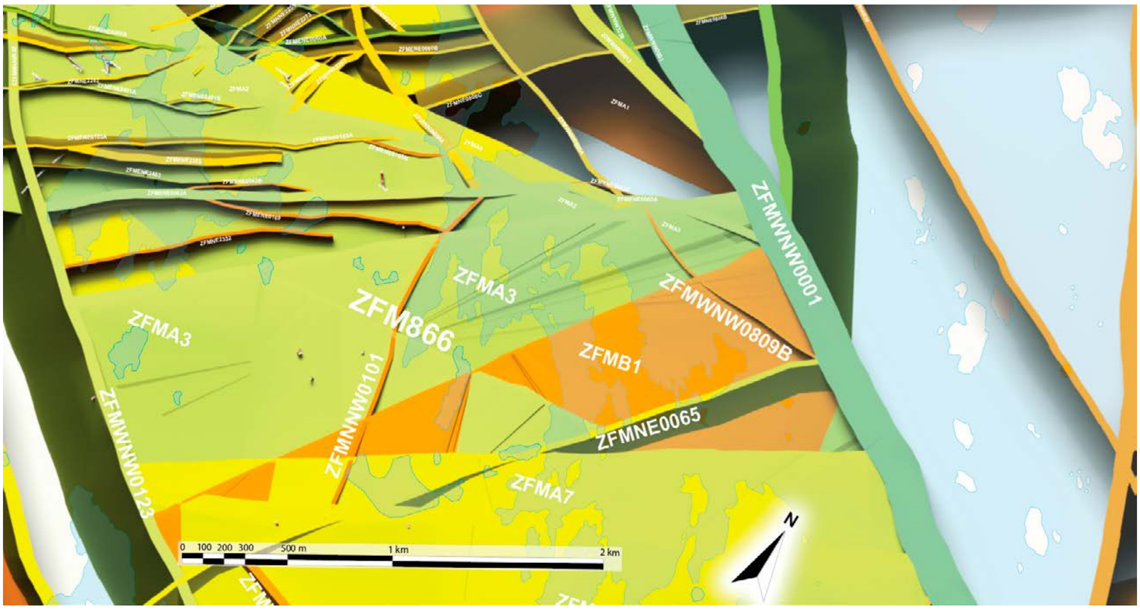
Tunnels: -

Lineament and/or seismic indications: -

MODELLING PROCEDURE

Modelled by combining borehole intervals 110- 122 m (DZ2) in KFM02A, 98-115 m (DZ1) in KFM02B, 61-64 m (DZ1) in HFM04 and 153-154 m (DZ1) in HFM05. Deformation zone plane modelled to pass through fixed points 119 m in KFM02A, 113 m in KFM02B, 62 m in HFM04 and 154 m in HFM05; gently dipping structure. Terminated against ZFMA3 and ZFMNE0065. Crush zone and clay alteration present at 119 m in KFM02A; low radar amplitude also observed at 116-121 m in KFM02A.

G	ZFM866	Version number	3	Total object CL	19



OBJECT CONFIDENCE ESTIMATE

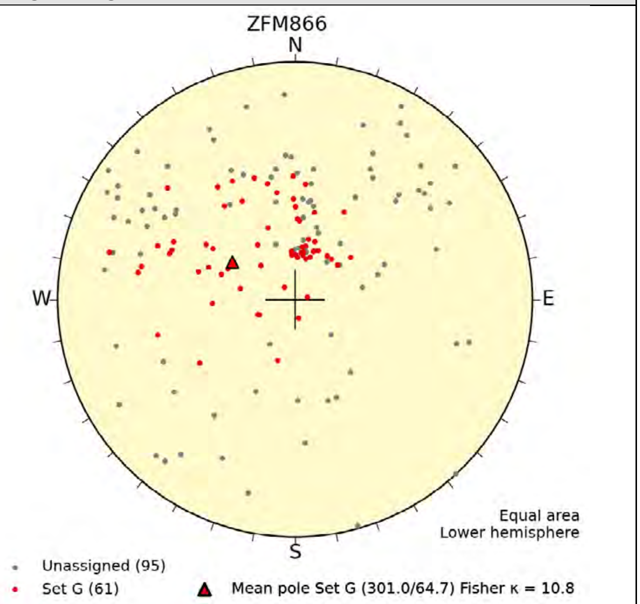
Category	Object CL	Comment
INTERPRETATION		
Data source	2	HFM04, HFM05, KFM02A, KFM02B.
Results of interpretation	3	High confidence observation in KFM2A, HFM04, HFM05.
INFORMATION DENSITY		
Number of observation points	3	4
Distribution of observation points	2	Three-four observation points in the western part of the modelled zone contributing to relative high conf. of interpolated geometry between the obs. points. Mainly a cluster and no outlier.
INTERPOLATION		
Geometry	3	One strong alternative based on multiples sub-surface obs. points.
Geological indicators	2	Some discrepancies in the geological data or geological character.
EXTRAPOLATION		
Dip direction	2	Conceptual constraints. Constrained down dip by ZFMA3.
Strike direction	2	Conceptual constraints. Inferred truncation against ZFMA3 and ZFMNE0065.

FRACTURE CHARACTER

Orientation: (strike/dip right-hand-rule): Set G: 31.0°/25.3°

Frequency: Boreholes: KFM02B, KFM02A

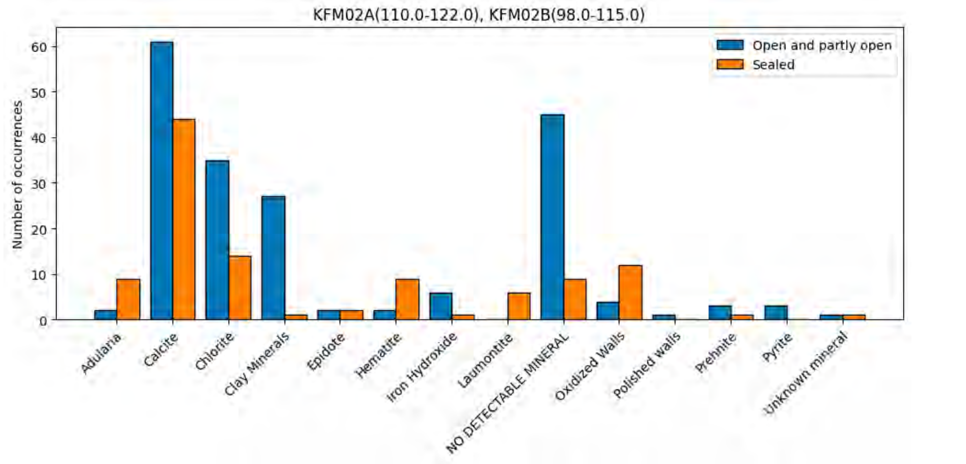
FRACTURE TYPE	TERZAGHI-WEIGHED P10
Open and partly open	7.2 m-1
Sealed	4.8 m-1
Sealed network	0.0 % of DZ intercept
Crush	2.9 % of DZ intercept



RQD: min:71, max:100, mean:91

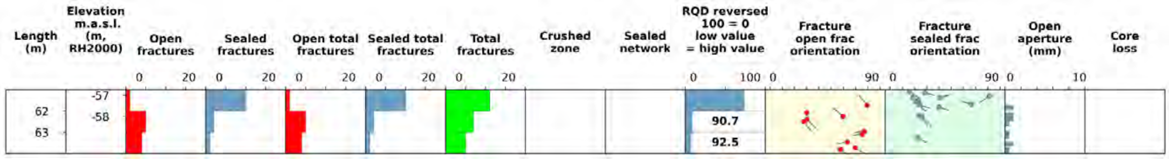
G	ZFM866	Version number	3	Total object CL	19

Fracture fill mineralogy:

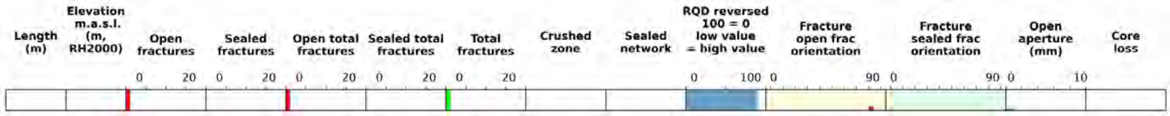


INDIVIDUAL INTERCEPTS

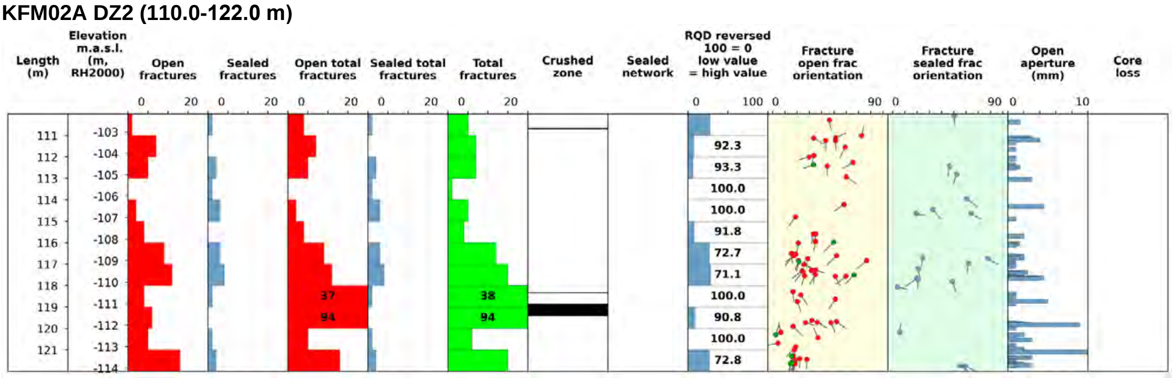
HFM04 DZ1 (61.0-64.0 m)

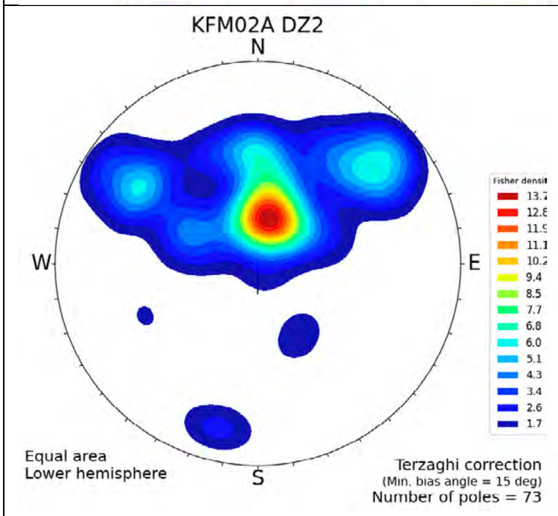


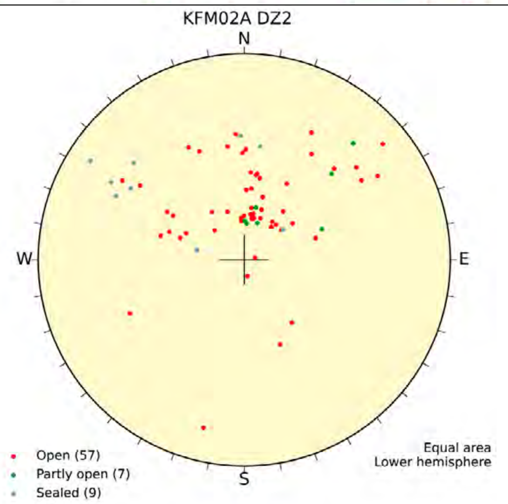
HFM05 DZ1 (153.0-154.0 m)



KFM02A DZ2 (110.0-122.0 m)

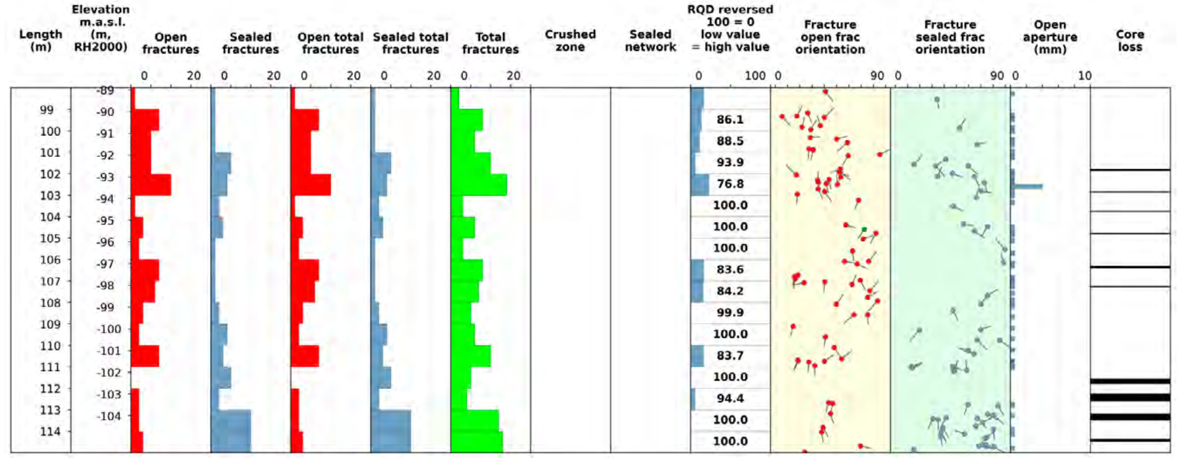


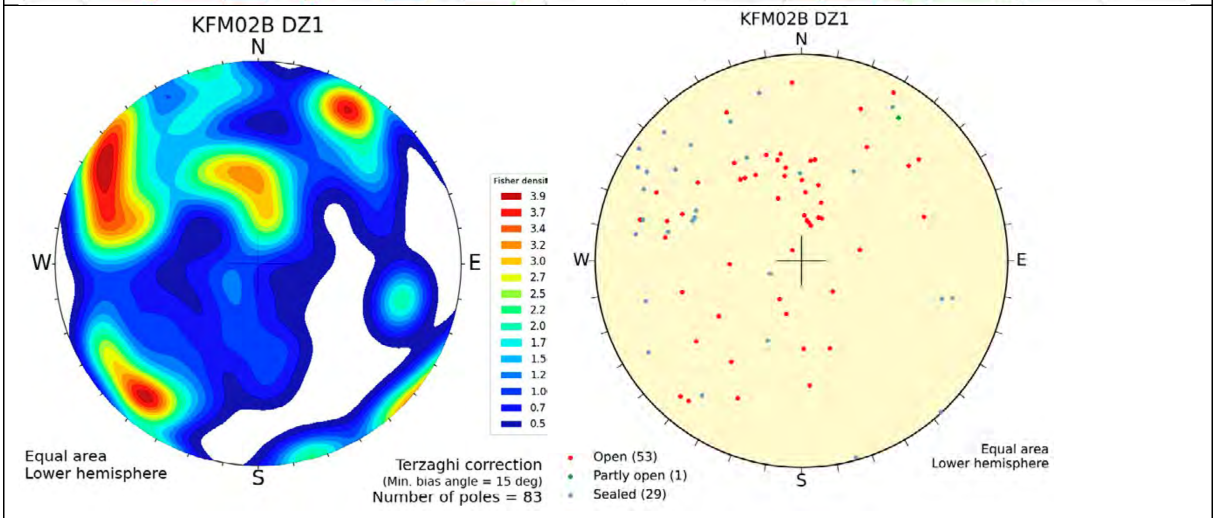




G	ZFM866	Version number	3	Total object CL	19

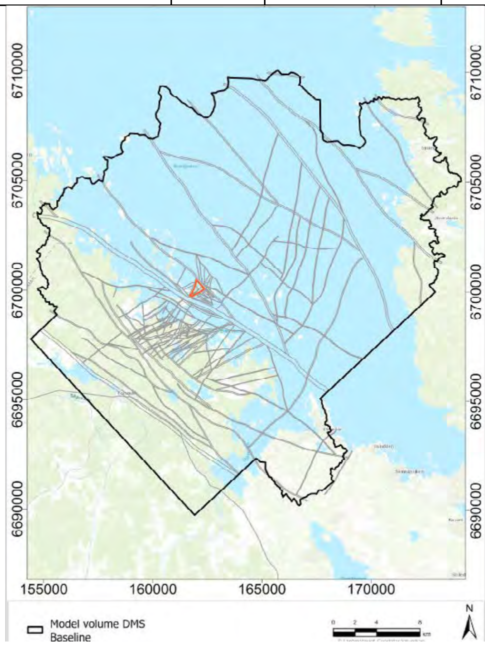
KFM02B DZ1 (98.0-115.0 m)





G	ZFM871		Version number	3	Total object CL	22

GEOLOGICAL CHARACTER		Property CL
Deformation style:	Brittle	3
Deformation description:	No data available.	
Alteration:		
- First order:	Oxidation	3
- Second order:	Argillization	
- Third order:	Chloritization	
Fracture orientation and type:	No oriented fracture data are available. Construction reports generally include the description of two dominantly gently dipping fracture sets as well as an increase in frequency of steeply dipping fractures.	2
Fracture comment:	No data available.	
Fracture fill mineralogy:	Clay minerals, chlorite and calcite dominate. Hematite/adularia, laumontite, epidote, pyrite and quartz are also present. Note also high frequency of fractures with no mineral coating/filling.	



OBJECT GEOMETRY	
Strike/dip:	76°/19°
Length:	-
Mean thickness:	20 m (1 - 22 m)
Max depth:	-278 m
Geometrical constraints:	ZFMWNW1035, ZFMNW0805A, ZFMNW0805B, ZFMNNE0869, ZFMENE3115, Topo 40m grid Max error 20m.

BASIS FOR MODELLING

Zone based on SFR tunnel intersections and boreholes. There is no corresponding magnetic lineament at the ground surface. No intersection with the ground surface.

Outcrops:	-

Boreholes:

Borehole	PDZ	Target intercept		Geometric intercept		Comment
		Sec_up [m]	Sec_low [m]	Sec_up [m]	Sec_low [m]	
KFR02	DZ3	114.80	124.45	109.18	130.15	
KFR03	DZ4	81.86	95.95	78.32	99.72	
KFR04		91.00	100.00	84.50	100.49	Neither of the SHI interpreted possible DZs in KFR04 correlate with ZFM871. However, there are planar chlorite filled fractures from 86 m onwards and some clay filled fractures towards the base of the hole that could be associated with the zone (100.5 m). A target intercept is defined at 91–100 m.
KFR05	DZ1	85.00	87.90	76.53	96.27	
KFR12	DZ1	21.25	31.50	14.74	36.79	
KFR13	DZ4	61.00	68.00	53.36	74.99	
KFR21		-	-	108.57	129.26	No SHI available.
KFR22		-	-	139.98	160.10	No SHI available.
KFR23		-	-	82.68	105.95	No SHI available.
KFR31	DZ2	228.76	232.00	217.28	242.10	
KFR32	DZ2	163.10	186.10	161.72	186.25	
KFR33		-	-	158.02	167.00	No SHI available.
KFR37	DZ2	183.43	193.60	171.82	200.89	
KFR57	DZ1	15.85	25.38	6.04	25.38	

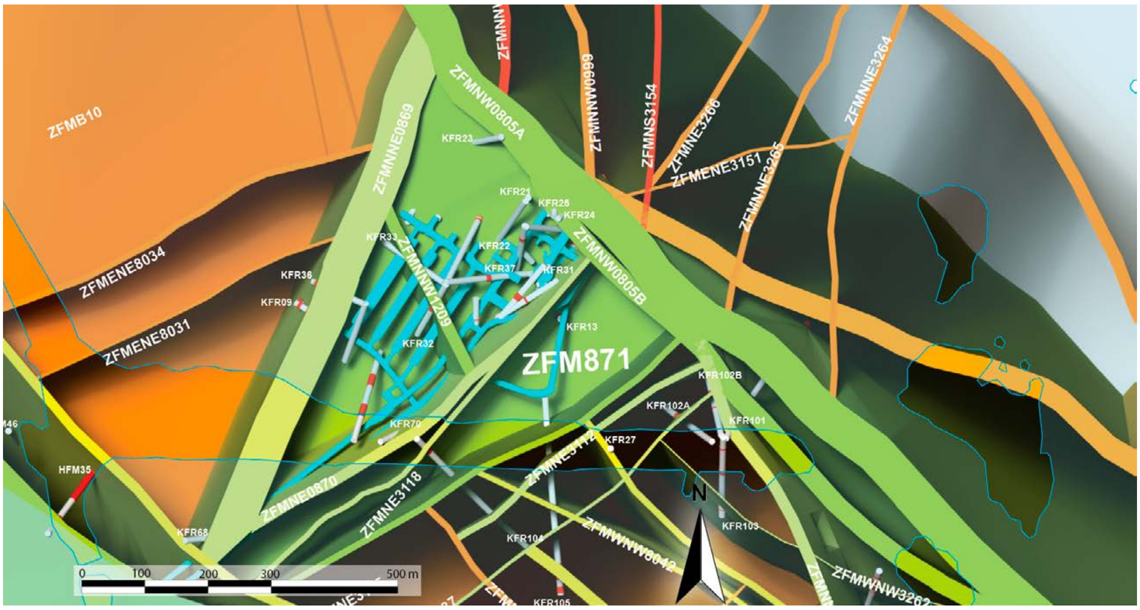
G	ZFM871	Version number	3	Total object CL	22

KFR7A	DZ1	-	-	0.00	11.25	No geometrical Sec_low as the borehole not penetrates the modelled surfaces. DZ1 is interpreted as being dominated by ZFMNW0805A and ZFMNW0805B due to the brittle ductile style of deformation seen in the core. No target intercept for ZFM871 is defined.
KFR7B	DZ1	0.00	17.00	0.00	20.39	
KFR7C	DZ1	6.00	32.00	5.91	32.74	
KFR80		-	-	0.00	12.92	No SHI available.
KFR83		-	-	5.50	20.00	No SHI available.
KFR87		-	-	0.00	15.10	No SHI available.
KFR88		-	-	0.00	29.99	No SHI available.

Tunnels:	NBT target intercept 0+405 - 0+432 m, geometric intercept 0+380 - 0+432 m.
Lineament and/or seismic indications:	-

MODELLING PROCEDURE

Modelling procedure and properties inherited from updated geological model for SFR as presented in Appendix 11 in Curtis et al. (2011). Modification made so as to terminate against ZFMNW0002, ZFMWNW1035, ZFMNW0805A, ZFMNW0805B and ZFMENE3115 (only in SFR model), i.e. not terminated against ZFMNNE0869 as in Curtis et al. (2011) but continued up to ground surface. Proposed here as an alternative model for ZFM871.



G	ZFM871	Version number	3	Total object CL	22

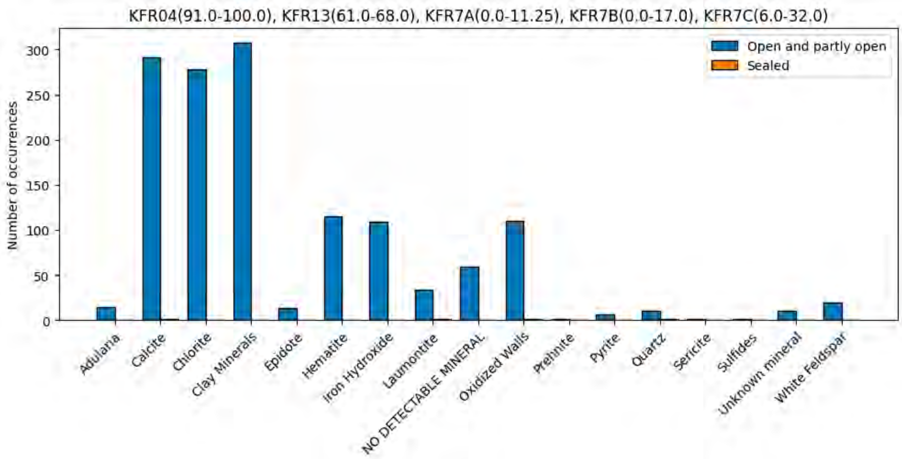
OBJECT CONFIDENCE ESTIMATE

Category	Object CL	Comment
INTERPRETATION		
Data source	3	KFR22, KFR23, KFR02, KFR03, KFR31, KFR04, KFR32, KFR05, KFR12, KFR33, KFR13, KFR83, KFR21, KFR37, KFR57, KFR7B, KFR7C, KFR80, KFR7A, KFR87, KFR88, tDZ101, tDZ102, tDZ103 and tDZ104, Outcrops 400 m NNE of the silo.
Results of interpretation	3	High confidence observations in multiple boreholes and SFR tunnels.
INFORMATION DENSITY		
Number of observation points	3	>4
Distribution of observation points	3	Even distribution of obs. points.
INTERPOLATION		
Geometry	3	One strong alternative based on tunnel and borehole data.
Geological indicators	3	Interpolation supported by data from boreholes and tunnels.
EXTRAPOLATION		
Dip direction	2	Conceptual constraints. Truncated against ZFMWNW1035, ZFMNW0805A, ZFMNW0805B, ZFMNNE0869, ZFMENE3115.
Strike direction	2	Conceptual constraints. Truncated against ZFMWNW1035, ZFMNW0805A, ZFMNW0805B, ZFMNNE0869, ZFMENE3115.

FRACTURE CHARACTER

Orientation: (strike/dip right-hand-rule)	--
Frequency:	Boreholes: KFR13, KFR7B, KFR03, KFR83, KFR23, KFR12, KFR7A, KFR05, KFR87, KFR02, KFR57, KFR31, KFR88, KFR37, KFR33, KFR04, KFR80, KFR32, KFR22, KFR7C, KFR21

FRACTURE TYPE	TERZAGHI-WEIGHED P10
Open and partly open	2.7 m-1
Sealed	0.0 m-1
Sealed network	0.0 % of DZ intercept
Crush	1.4 % of DZ intercept

RQD:	min:13, max:100, mean:67
Fracture fill mineralogy:	

G	ZFM871	Version number	3	Total object CL	22

INDIVIDUAL INTERCEPTS

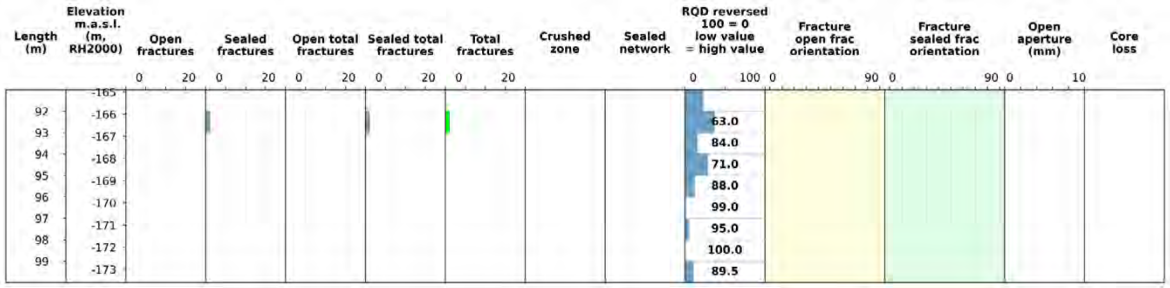
KFR02 DZ3 (114.8-124.45 m)

No data available

KFR03 DZ4 (81.86-95.95 m)

No data available

KFR04 (91.0-100.0 m)



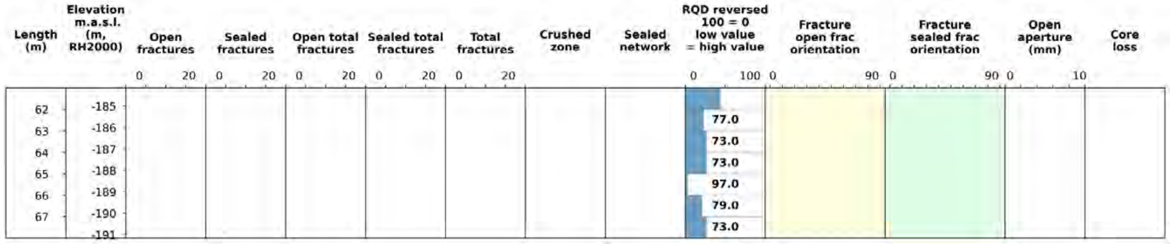
KFR05 DZ1 (85.0-87.9 m)

No data available

KFR12 DZ1 (21.25-31.5 m)

No data available

KFR13 DZ4 (61.0-68.0 m)



KFR21 (108.57-129.26 m)

No data available

KFR22 (139.98-160.1 m)

No data available

KFR23 (82.68-105.95 m)

No data available

KFR31 DZ2 (228.76-232.0 m)

No data available

KFR32 DZ2 (163.1-186.1 m)

No data available

KFR33 (158.02-167.0 m)

No data available

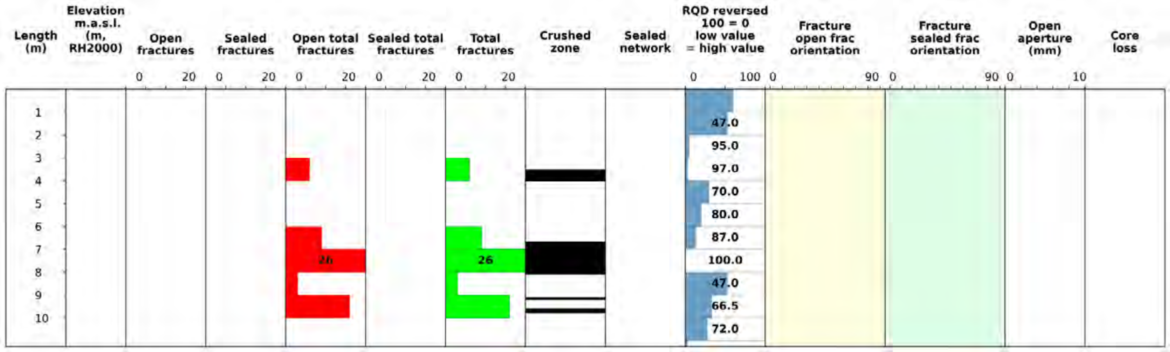
KFR37 DZ2 (183.43-193.6 m)

No data available

KFR57 DZ1 (15.85-25.38 m)

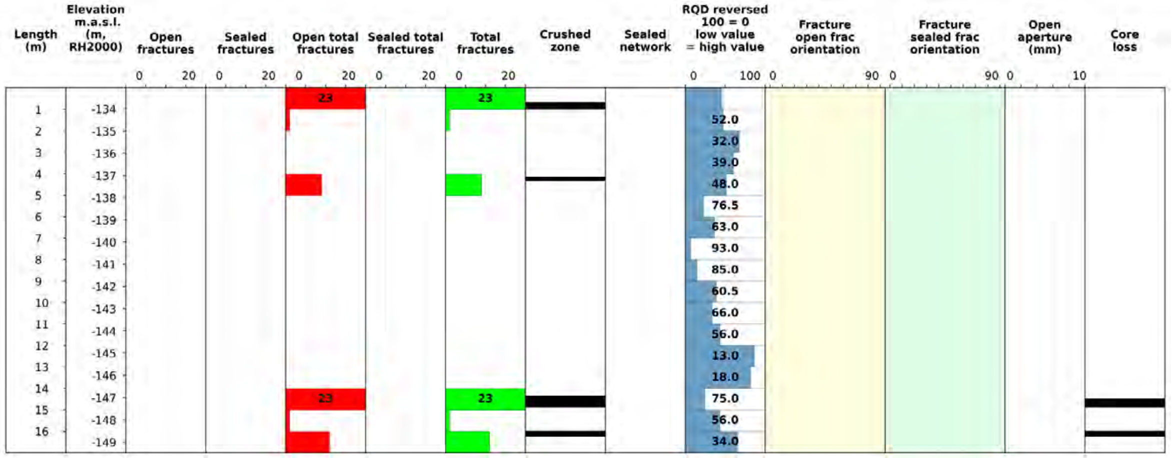
No data available

KFR7A DZ1 (0.0-11.25 m)

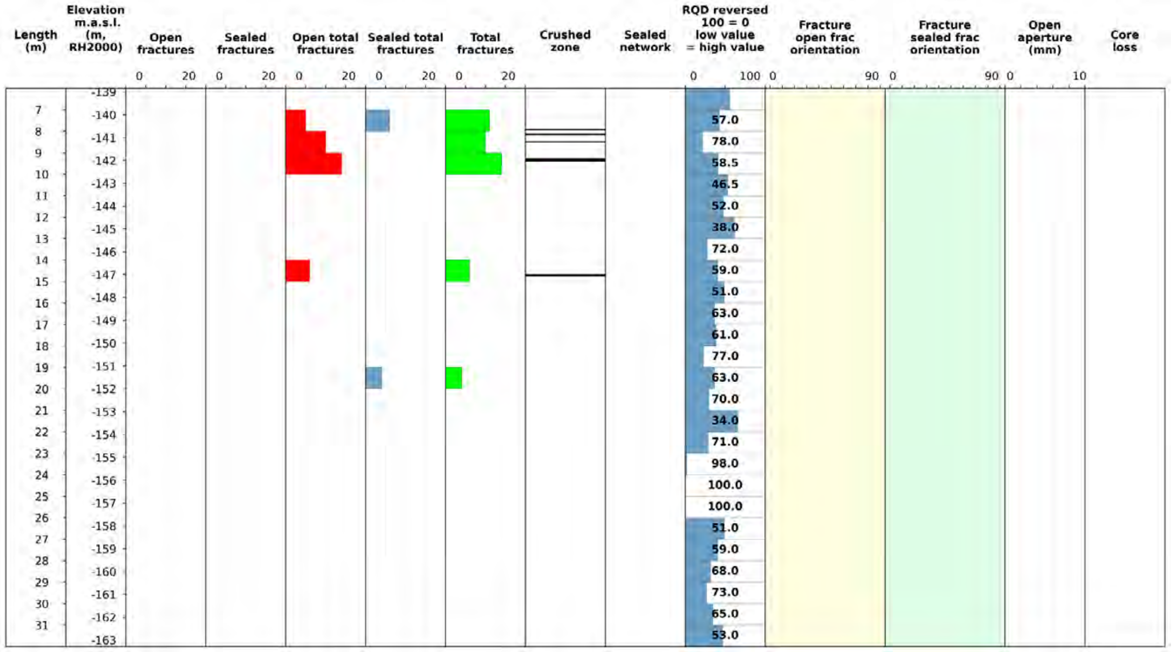


G	ZFM871	Version number	3	Total object CL	22

KFR7B DZ1 (0.0-17.0 m)



KFR7C DZ1 (6.0-32.0 m)



KFR80 (0.0-12.92 m)

No data available

KFR83 (5.5-20.0 m)

No data available

KFR87 (0.0-15.1 m)

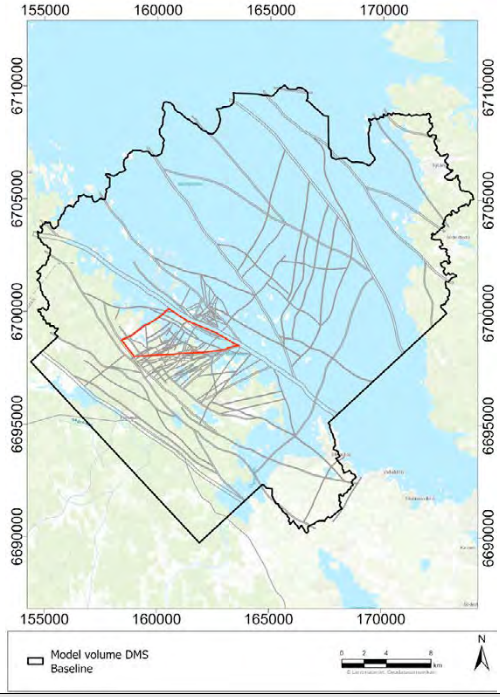
No data available

KFR88 (0.0-29.99 m)

No data available

G	ZFMA1	Version number	3	Total object CL	10

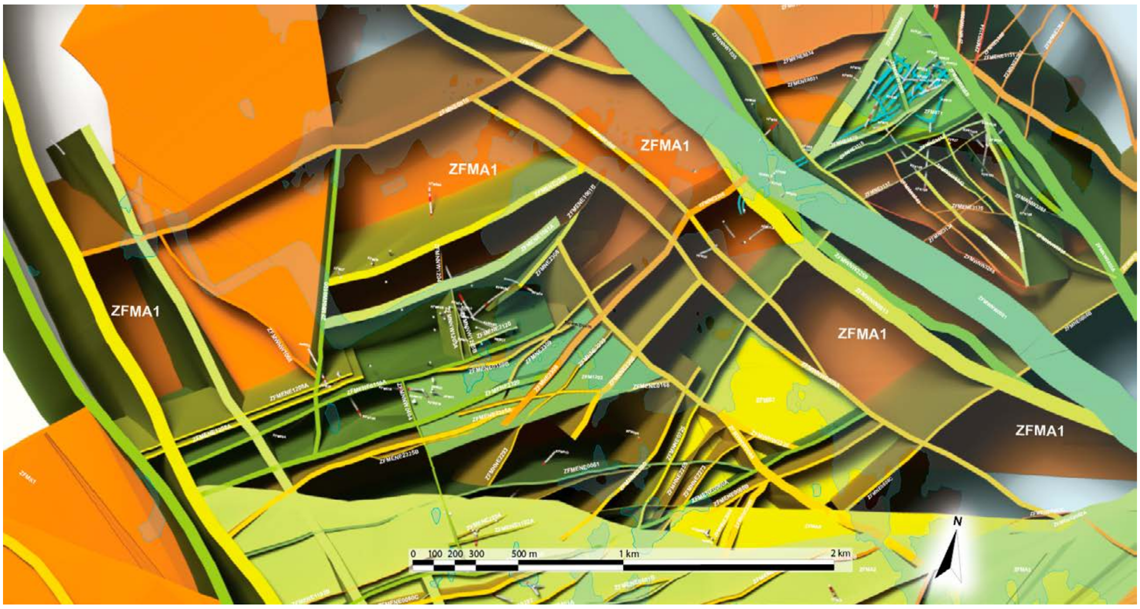
GEOLOGICAL CHARACTER		Property CL
Deformation style:	Brittle	2
Deformation description:	No data available.	
Alteration:		
- First order:	Not observed	
- Second order:	Not observed	
- Third order:	Not observed	
Fracture orientation and type:	No data available.	
Fracture comment:	No data available.	
Fracture fill mineralogy:	No data available.	
OBJECT GEOMETRY		
Strike/dip:	84°/45°	
Length:	-	
Mean thickness:	40 m (9 - 45 m)	
Max depth:	-2100 m	
Geometrical constraints:	ZFMWNW0001, ZFMNW0017, ZFMNE0810.	



BASIS FOR MODELLING		
Corresponds to seismic reflector A1/A0 Juhlin et al. (2002), the position of which in 3D space has been attained from Cosma et al. (2003).		
Outcrops:	-	
Boreholes: -		
Tunnels:	-	
Lineament and/or seismic indications:	A1/A0.	2

MODELLING PROCEDURE

Corresponds to seismic reflector A1/A0, the position of which in 3D space has been attained from Cosma et al. (2003). Modelled to the base of the model volume with termination against ZFMWNW0001, ZFMNW0017 and ZFMENE0810. An alternative interpretation of the seismic reflector A1/A0 is that it is related, wholly or partly, to compositional variations in the bedrock inside rock domain RFM032.



G	ZFMA1	Version number	3	Total object CL	10

OBJECT CONFIDENCE ESTIMATE

Category	Object CL	Comment
INTERPRETATION		
Data source	1	A1
Results of interpretation	2	Medium confidence in seismic reflector A1.
INFORMATION DENSITY		
Number of observation points	1	1
Distribution of observation points	1	Single observation point in the form of a seismic reflector.
INTERPOLATION		
Geometry	1	Geometry supported by surface geophysical data.
Geological indicators	1	Indirect support by geophysical data.
EXTRAPOLATION		
Dip direction	1	Modelled and extrapolated based on information from seismic reflector A1.
Strike direction	2	Conceptual constraints. Truncated against ZFMWNW0001, ZFMNW0017, ZFMNE0810.

FRACTURE CHARACTER

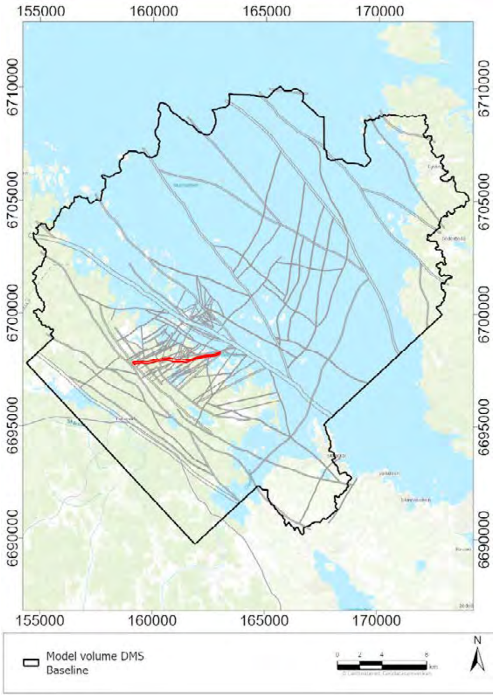
No data available

INDIVIDUAL INTERCEPTS

No data available

G	ZFMA2	Version number	4	Total object CL	21

GEOLOGICAL CHARACTER		Property CL
Deformation style:	Brittle	3
Deformation description:	Evidence show strike slip and dip-slip components with sinistral, dextral and normal and reverse movements respectively. Fault core intervals with elevated fracture frequency, cohesive breccia/cataclasite and crush zones.	
Alteration:		3
- First order:	Oxidation	
- Second order:	Quartz dissolution	
- Third order:	Carbonatization	
Fracture orientation and type:	Three fracture sets are conspicuous, a gently-dipping fracture set and steeply-dipping NE and NW sets. Open and sealed fractures. Quantitative estimate and span include a crush zone and sealed fracture networks.	3
Fracture comment:	No data available.	
Fracture fill mineralogy:	Chlorite, calcite, hematite/adularia, prehnite, clay minerals, laumontite, quartz. Note high frequency of fractures with no mineral coating/filling in KFM02A.	



OBJECT GEOMETRY	
Strike/dip:	82°/24°
Length:	4031 m
Mean thickness:	34 m (20 - 50 m)
Max depth:	-576 m
Geometrical constraints:	Topo 40m grid Max error 20m, ZFMNW0017, ZFMA3, ZFMF1, Trunc_A2.

BASIS FOR MODELLING

Based on intersections along the boreholes and ground and borehole reflection seismic data (seismic reflector A2).

Outcrops:	-

Boreholes:

Borehole	PDZ	Target intercept		Geometric intercept		Comment
		Sec_up [m]	Sec_low [m]	Sec_up [m]	Sec_low [m]	
HFM01	DZ1	35.00	44.00	21.00	55.11	
HFM02	DZ1	42.00	47.00	6.41	44.60	
HFM03		-	-	6.85	26.00	According to the geological mapping two gently dipping crush/fracture zones at 15.5-15.8 and 21.1-21.2 (cf. Nordman 2003), but the image quality is too low to allow interpretation.
HFM14	DZ1	68.00	76.00	97.06	134.57	
HFM14	DZ2	92.00	104.00	97.06	134.57	
HFM15	DZ1	86.00	96.00	-	-	HFM15 ends 20 m above ZFMA2. The target intercept is inferred to be a splay to ZFMA2.
HFM19	DZ1	121.00	148.00	160.05	185.19	
HFM19	DZ2	168.00	185.00	160.05	185.19	
HFM27	DZ1	26.00	30.00	4.40	40.53	
KFM01A	DZ1	29.00	51.00	36.89	71.74	29-36 m and 48-51 m added (cf. Table 3-2 in Stephens et al. 2007).
KFM01B	DZ1	16.00	64.00	33.50	70.22	53-64 m added (cf. Table 3-2 in Stephens et al. 2007).
KFM01C	DZ1	23.00	48.00	73.21	138.55	

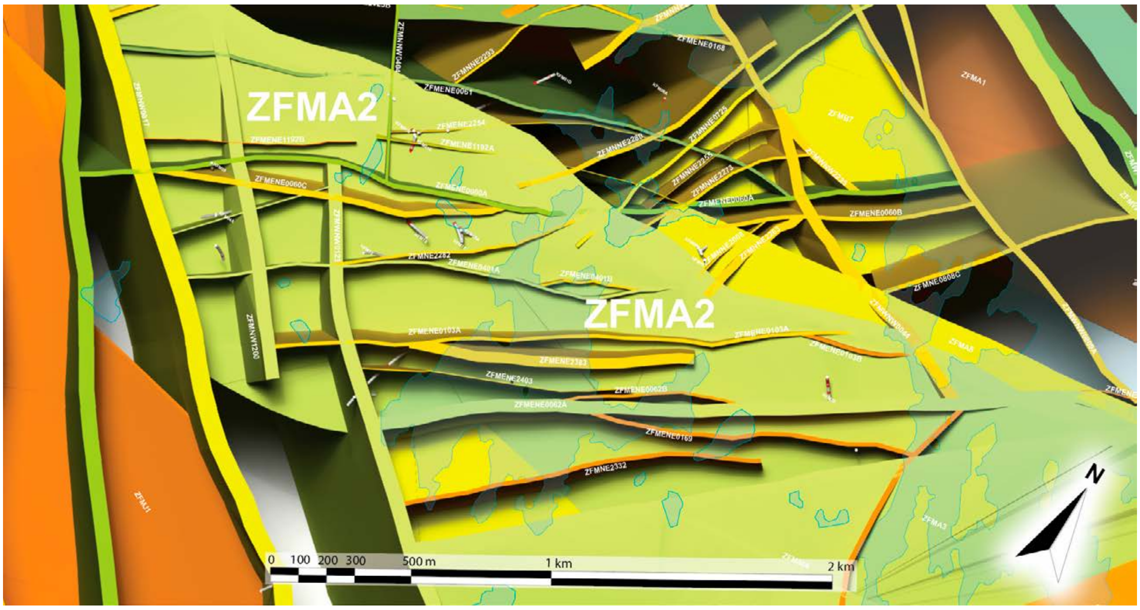
G	ZFMA2	Version number	4	Total object CL	21

KFM01C	DZ2	62.00	99.00	73.21	138.55	ZFMENE1192A also intersects DZ1.
KFM01D		68.00	68.00	37.04	75.23	No mapping or borehole image available for the interval. According to the drilling report (Claesson et al. 2007) an unstable, fractured section at 68 m borehole length, interpreted as the same gently dipping fracture zone as was encountered in KFM01A, 1B and 1C.
KFM02A	DZ6	417.00	442.00	416.70	455.79	
KFM02B	DZ3	411.00	431.00	407.07	441.69	
KFM04A	DZ2	202.00	242.00	227.89	265.29	213-232 m added (cf. Table 3-2 in Stephens et al. 2007). DZ2 and DZ3 merged.
KFM04A	DZ3	202.00	242.00	227.89	265.29	213-232 m added (cf. Table 3-2 in Stephens et al. 2007). DZ2 and DZ3 merged.
KFM05A	DZ1	102.00	114.00	95.23	138.41	
KFM10A	DZ2	430.00	449.00	475.01	500.11	
KFM10A	DZ3	478.00	490.00	475.01	500.11	

Tunnels:	-	
Lineament and/or seismic indications:	A2.	2

MODELLING PROCEDURE

Corresponds to seismic reflector A2, the position of which in 3D space has been attained from Cosma et al. (2003). Modelling takes account of: 1) Ground and borehole reflection seismic data. 2) Intersections along the borehole intervals 16-64 m in KFM01B with fixed point at 40 m (DZ1 and extension at 53-64 m), 23-48 m and 62-99 m in KFM01C with fixed point at 85 m (DZ1, and DZ2), 417-442 m in KFM02A with fixed point at 423 m (part of DZ6), 411-431 m in KFM02B with fixed point at 413 m (DZ3), 202-242 m in KFM04A with fixed point at 234 m (DZ2 and extension 213-232 m, DZ3), 102-114 m with fixed point at 102 m in KFM05A (DZ1), and 430-449 m and 478-490 m in KFM10A with fixed point at 485 m (DZ2 and DZ3). Zone ZFMA2 also intersects percussion boreholes HFM01 (DZ1), HFM14 (DZ1 and DZ2), HFM15 (DZ1), HFM19 (DZ1 and DZ2), HFM27 (DZ1) and KFM01A percussion (DZ1). Probable interference in KFM04A with ZFMNE1188, which is situated close to and strikes subparallel to the borehole, and with fracturing related to stress-release processes along the borehole intersections close to the surface. Low radar amplitudes also observed, for example, at 38-42 m in KFM01B, 232-242 m in KFM04A and 483-488 m in KFM10A. Modelled so as to splay from ZFMF1 at depth up to the surface, and to terminate along strike against ZFMNW0017 and ZFMA3.



G	ZFMA2	Version number	4	Total object CL	21

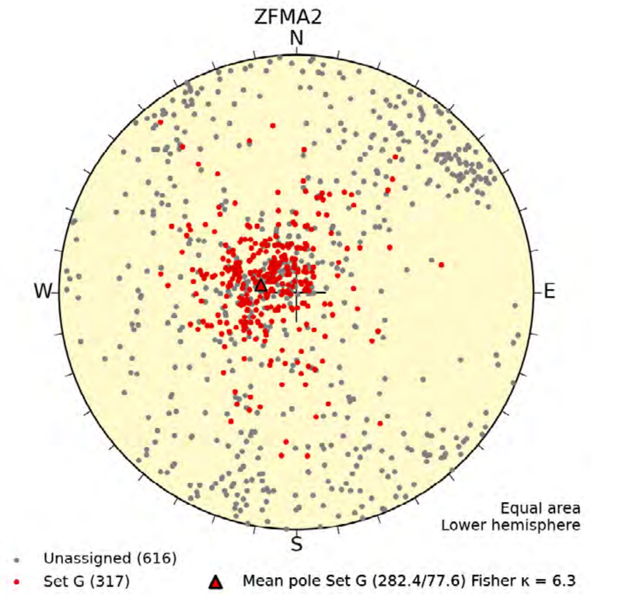
OBJECT CONFIDENCE ESTIMATE

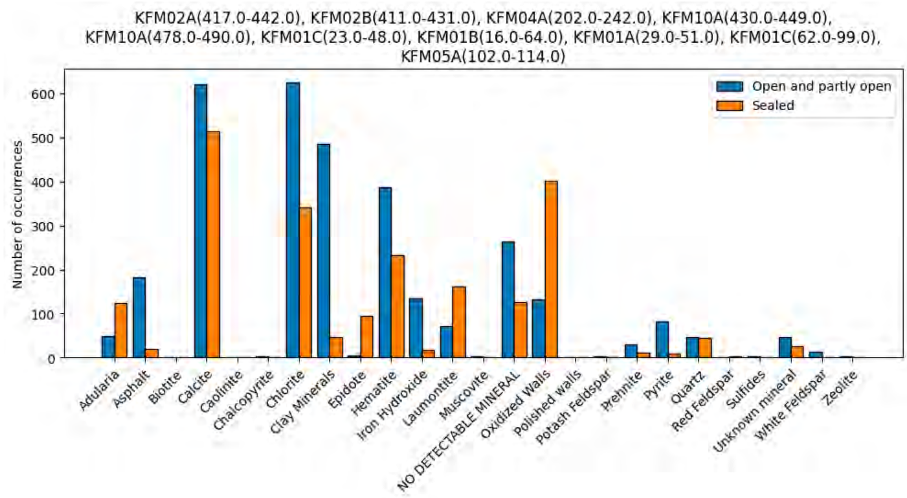
Category	Object CL	Comment
INTERPRETATION		
Data source	2	A2, HFM01, HFM02, HFM03, HFM04, HFM14, HFM19, HFM27, KFM01A, KFM01B, KFM01C, KFM01D, KFM02A, KFM02B, KFM04A, KFM05A, KFM10A
Results of interpretation	3	High confidence observations in multiple boreholes.
INFORMATION DENSITY		
Number of observation points	3	>4
Distribution of observation points	3	Majority of the drill holes are placed in the westernmost part and two drill holes (KFM02A and KFM02B) in the central area of the modelled zone. The sub-surface information density from most western part is higher from the central part of the modelled zone however the distance is > 1400m. The zone is extrapolated c. 1500 m towards the east. This constellation can be considered as two group of clustered obs. points and the lineament as an outlier.
INTERPOLATION		
Geometry	3	One strong alternative based on available sub-surface observation points.
Geological indicators	3	Interpolation supported by key geological parameters, foremost fracture orientation pattern.
EXTRAPOLATION		
Dip direction	2	Conceptual constraints. Inferred truncation against surrounding steeply dipping and gently dipping zones ZFMNW0017, ZFMA3, ZFMF1.
Strike direction	2	Conceptual constraints. Inferred truncation against surrounding steeply dipping and gently dipping zones ZFMNW0017, ZFMA3, ZFMF1.

FRACTURE CHARACTER

Orientation: (strike/dip right-hand-rule)	Set G: 12.4°/12.4°
Frequency:	Boreholes: KFM02A, KFM01A, KFM01C, KFM04A, KFM01B, KFM10A, KFM01D, KFM02B, KFM05A
RQD:	min:14, max:100, mean:85

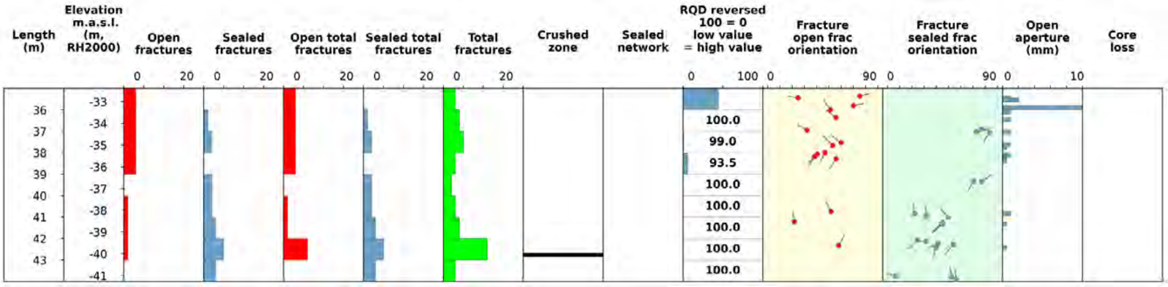
FRACTURE TYPE	TERZAGHI-WEIGHED P10
Open and partly open	8.5 m-1
Sealed	8.8 m-1
Sealed network	7.5 % of DZ intercept
Crush	1.4 % of DZ intercept



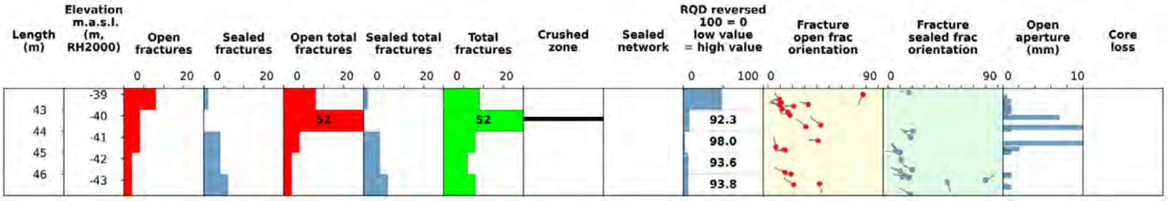
G	ZFMA2	Version number	4	Total object CL	21
Fracture fill mineralogy:					

G	ZFMA2	Version number	4	Total object CL	21
INDIVIDUAL INTERCEPTS					

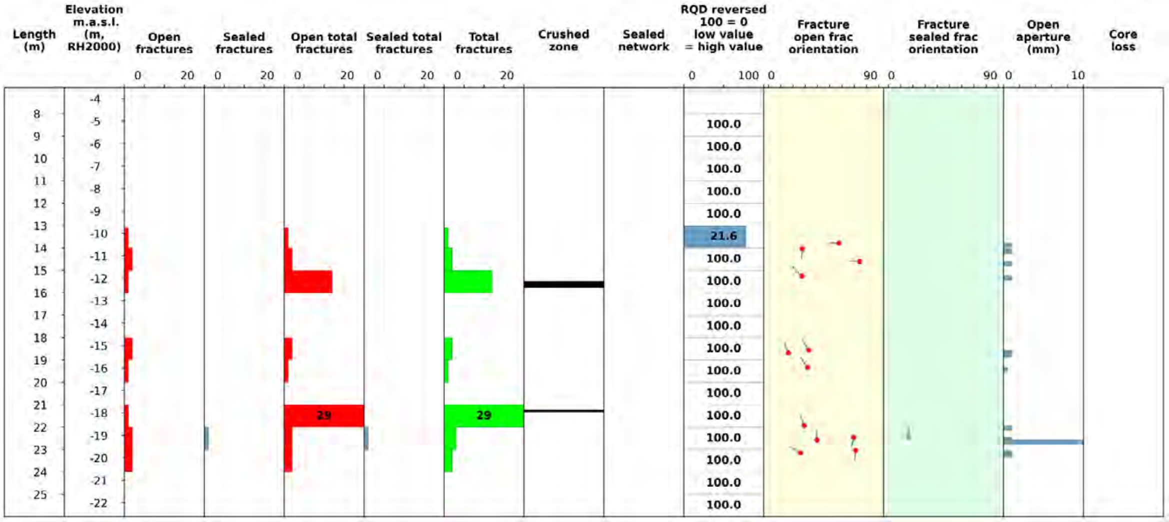
HFM01 DZ1 (35.0-44.0 m)



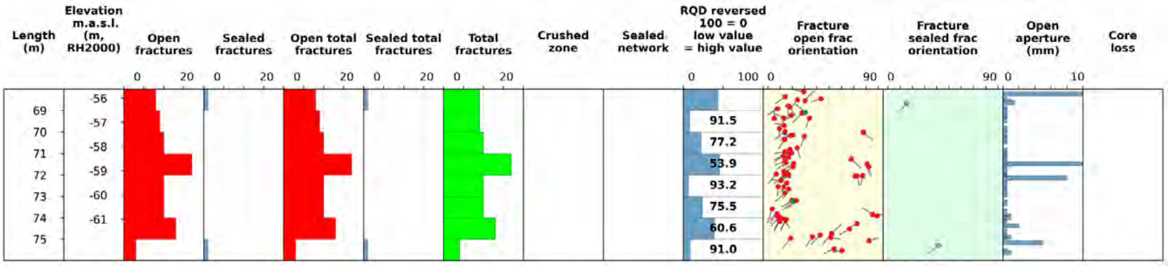
HFM02 DZ1 (42.0-47.0 m)



HFM03 (6.85-26.0 m)

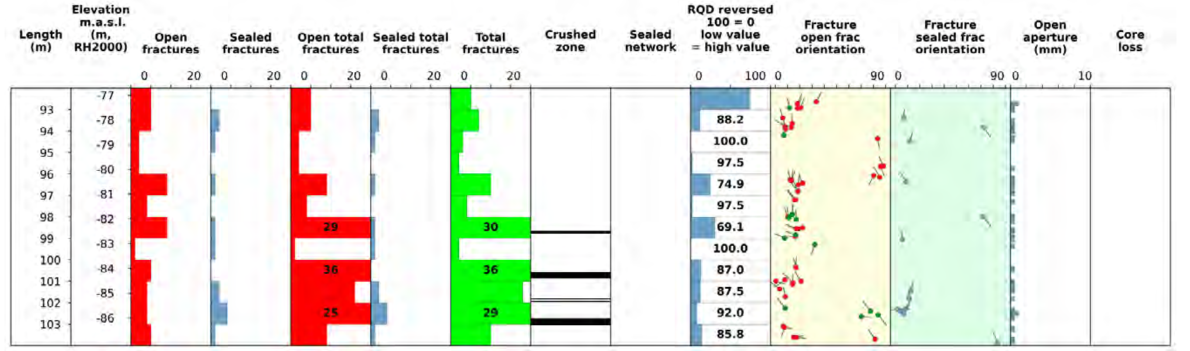


HFM14 DZ1 (68.0-76.0 m)

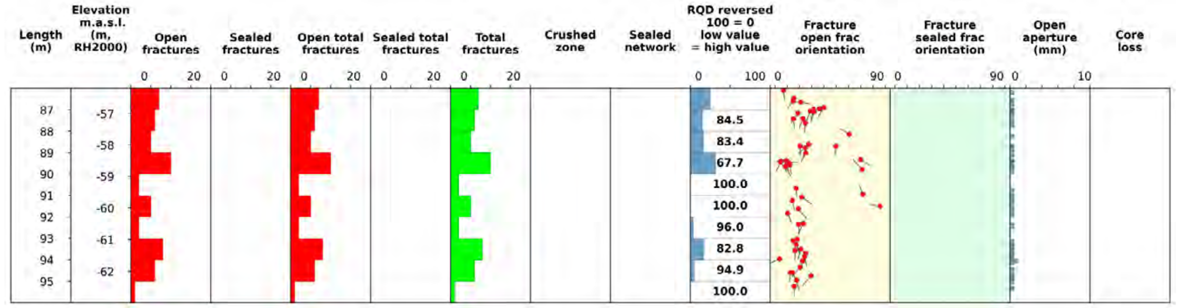


G	ZFMA2	Version number	4	Total object CL	21

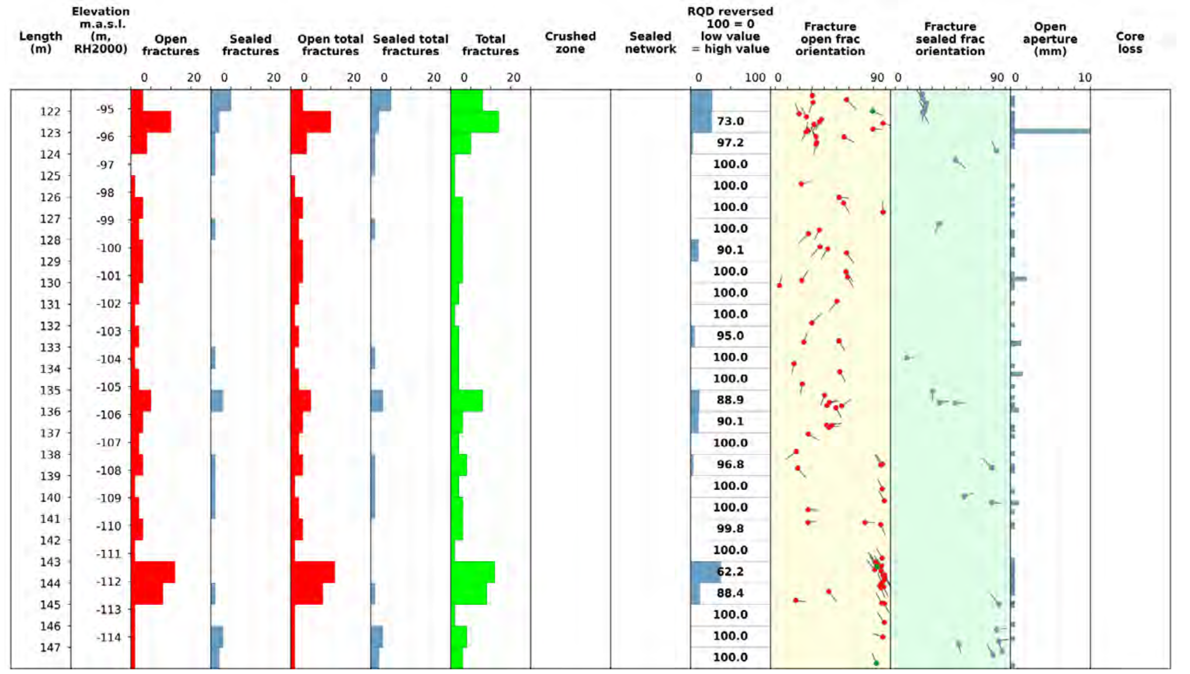
HFM14 DZ2 (92.0-104.0 m)



HFM15 DZ1 (86.0-96.0 m)

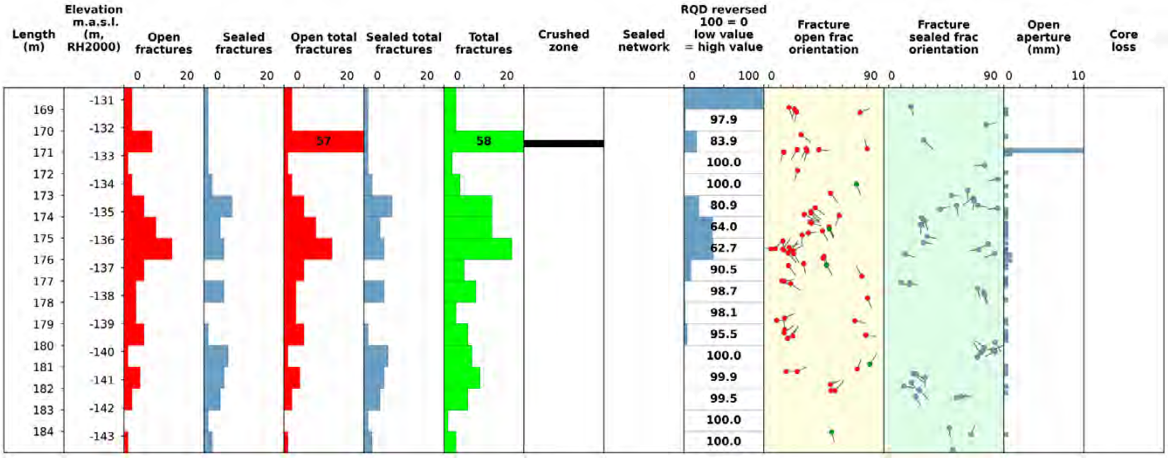


HFM19 DZ1 (121.0-148.0 m)

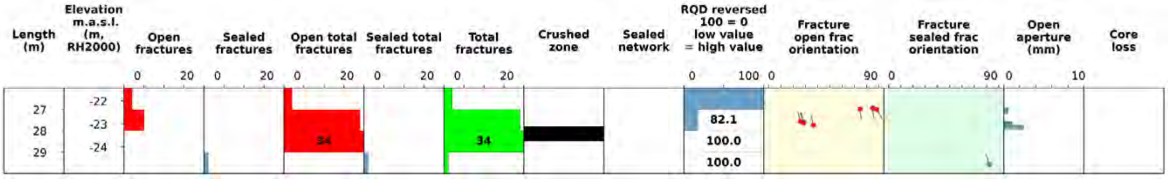


G	ZFMA2	Version number	4	Total object CL	21

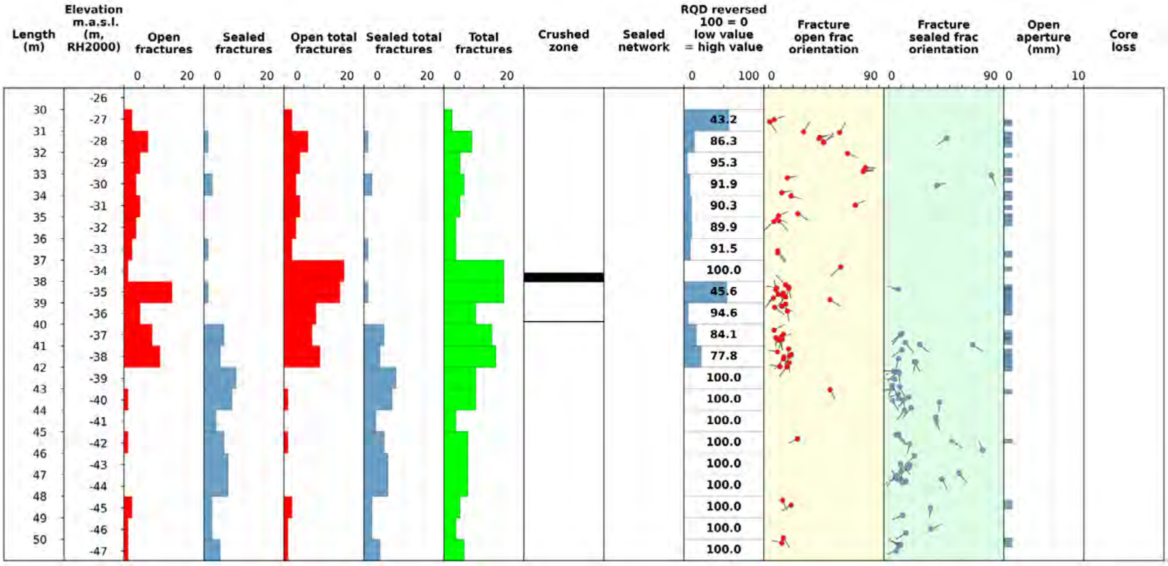
HFM19 DZ2 (168.0-185.0 m)



HFM27 DZ1 (26.0-30.0 m)

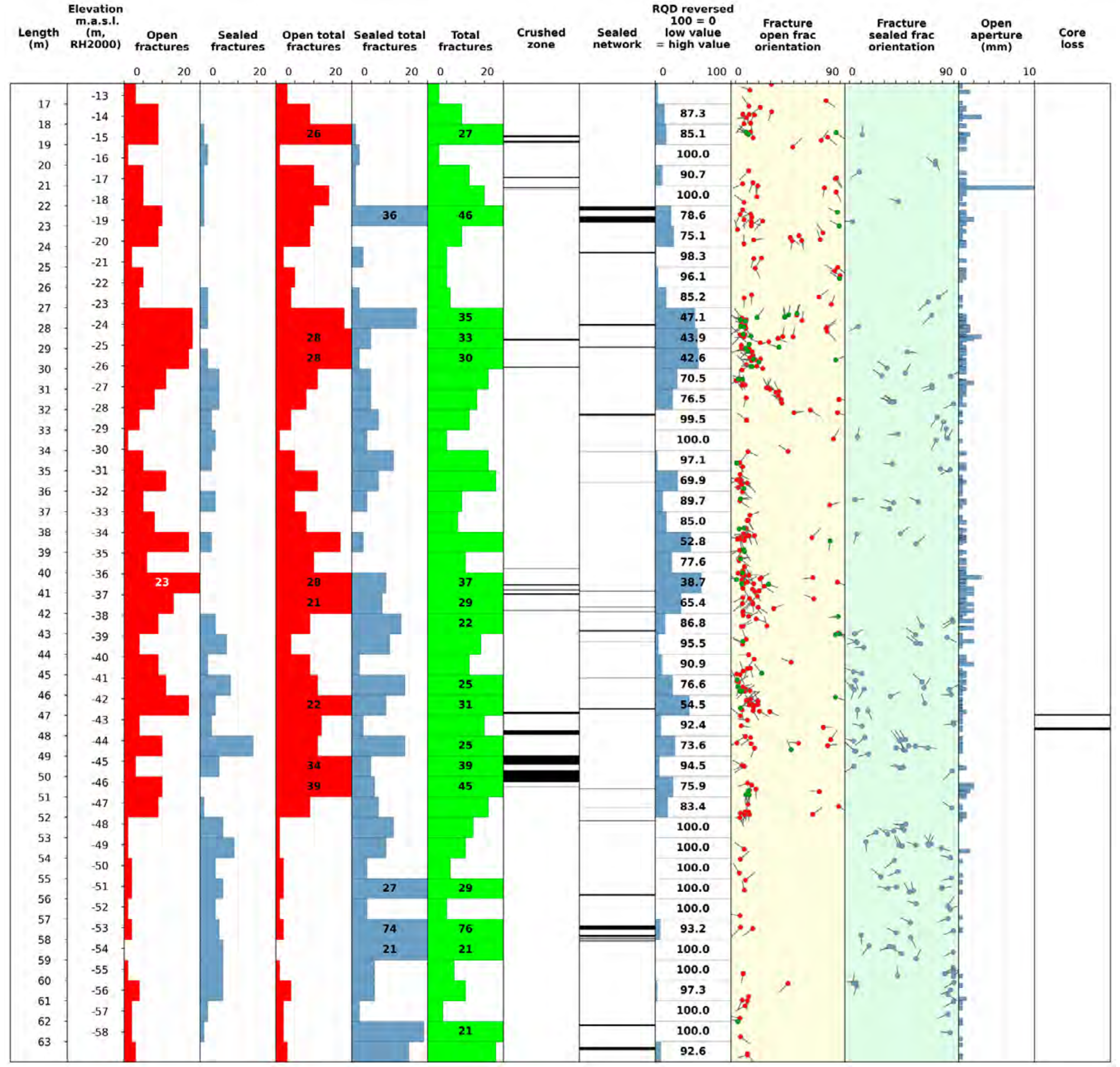


KFM01A DZ1 (29.0-51.0 m)



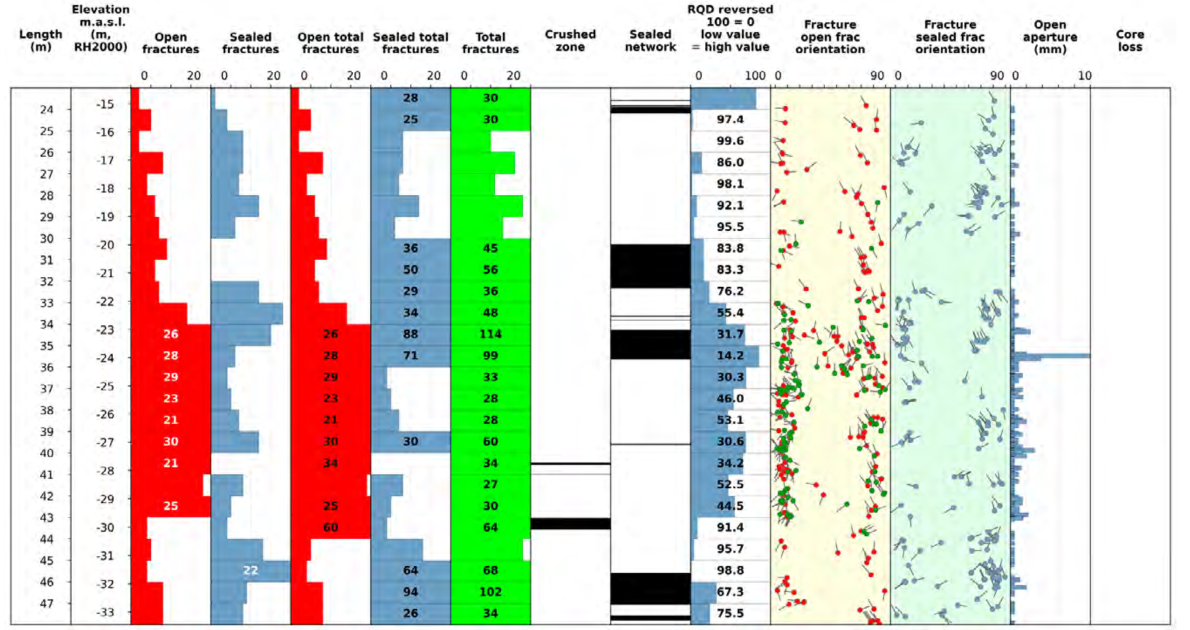
G	ZFMA2	Version number	4	Total object CL	21

KFM01B DZ1 (16.0-64.0 m)

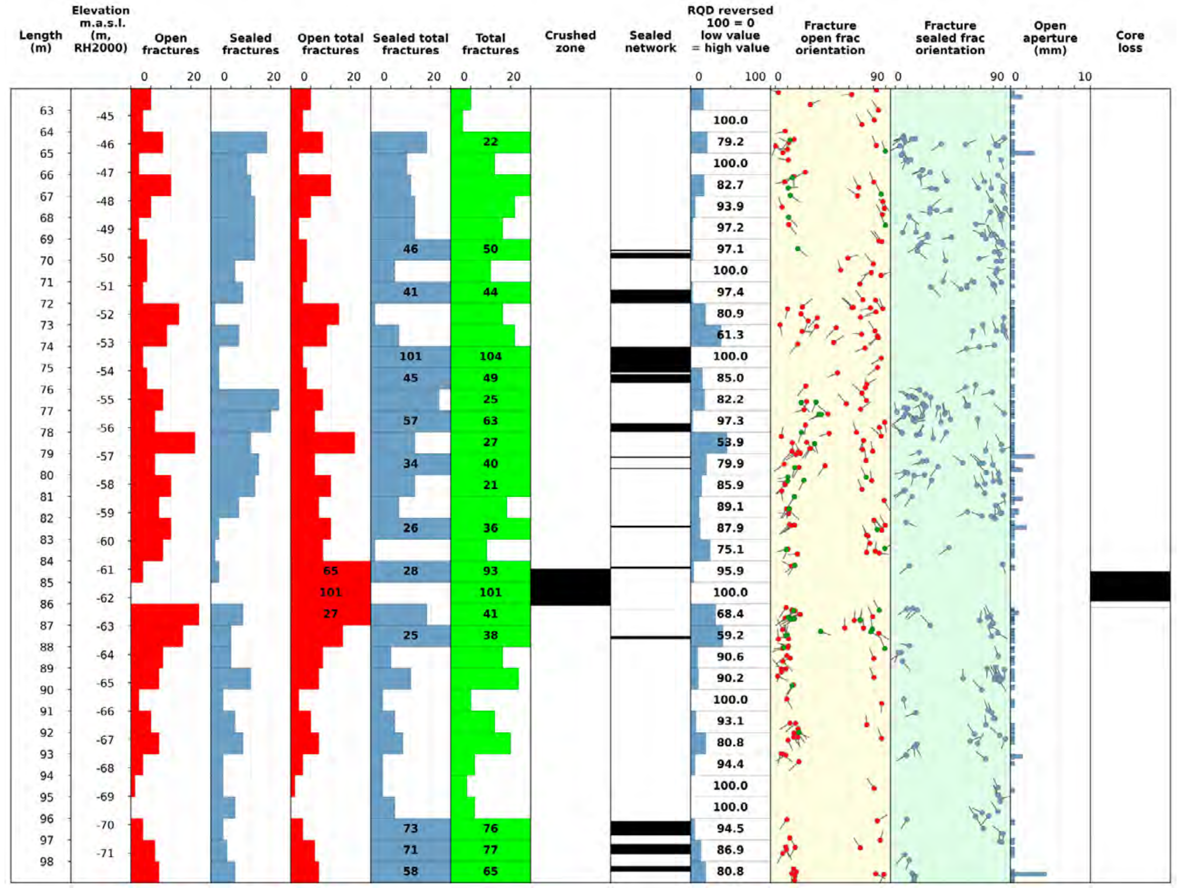


G	ZFMA2	Version number	4	Total object CL	21

KFM01C DZ1 (23.0-48.0 m)



KFM01C DZ2 (62.0-99.0 m)

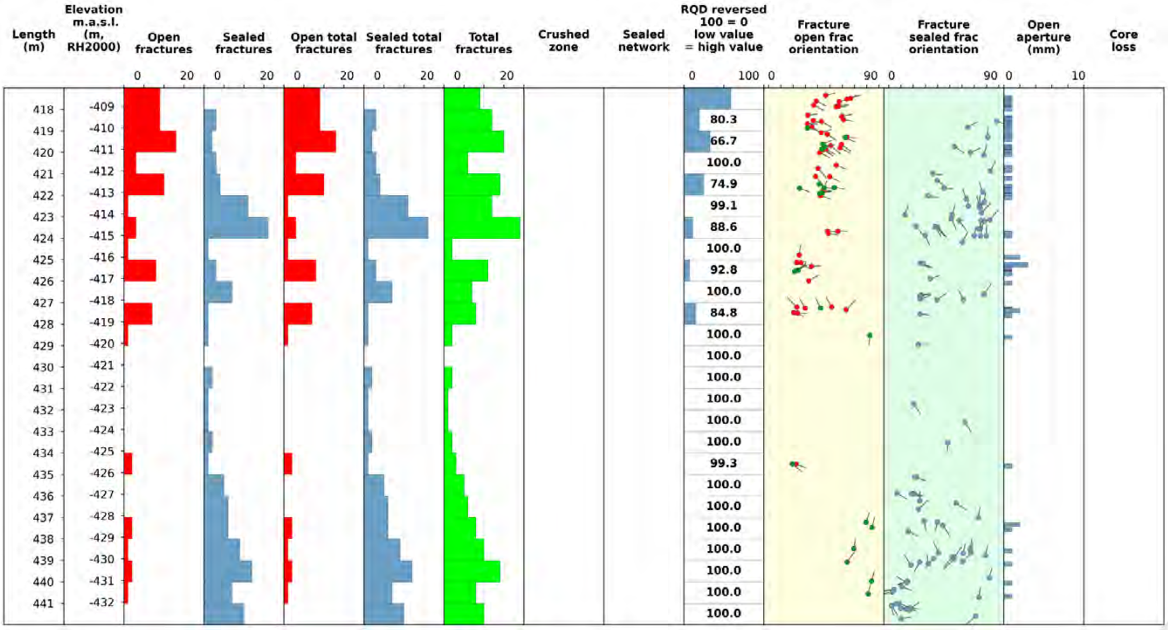


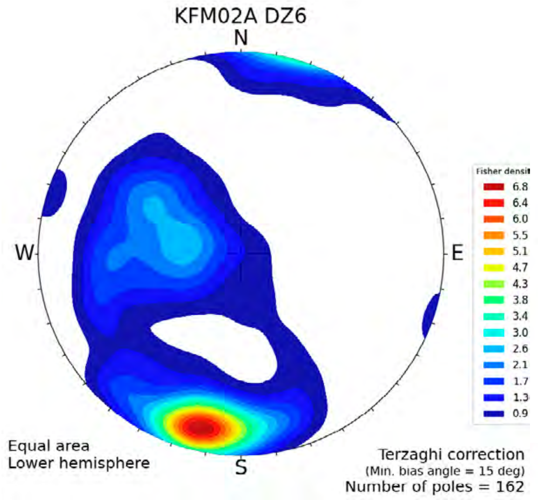
G	ZFMA2	Version number	4	Total object CL	21

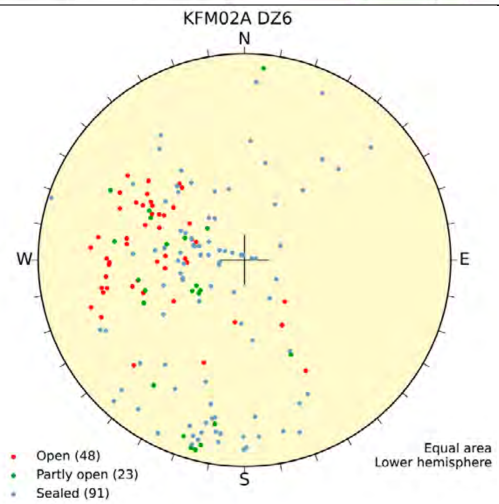
KFM01D (68.0-68.0 m)

No data available

KFM02A DZ6 (417.0-442.0 m)

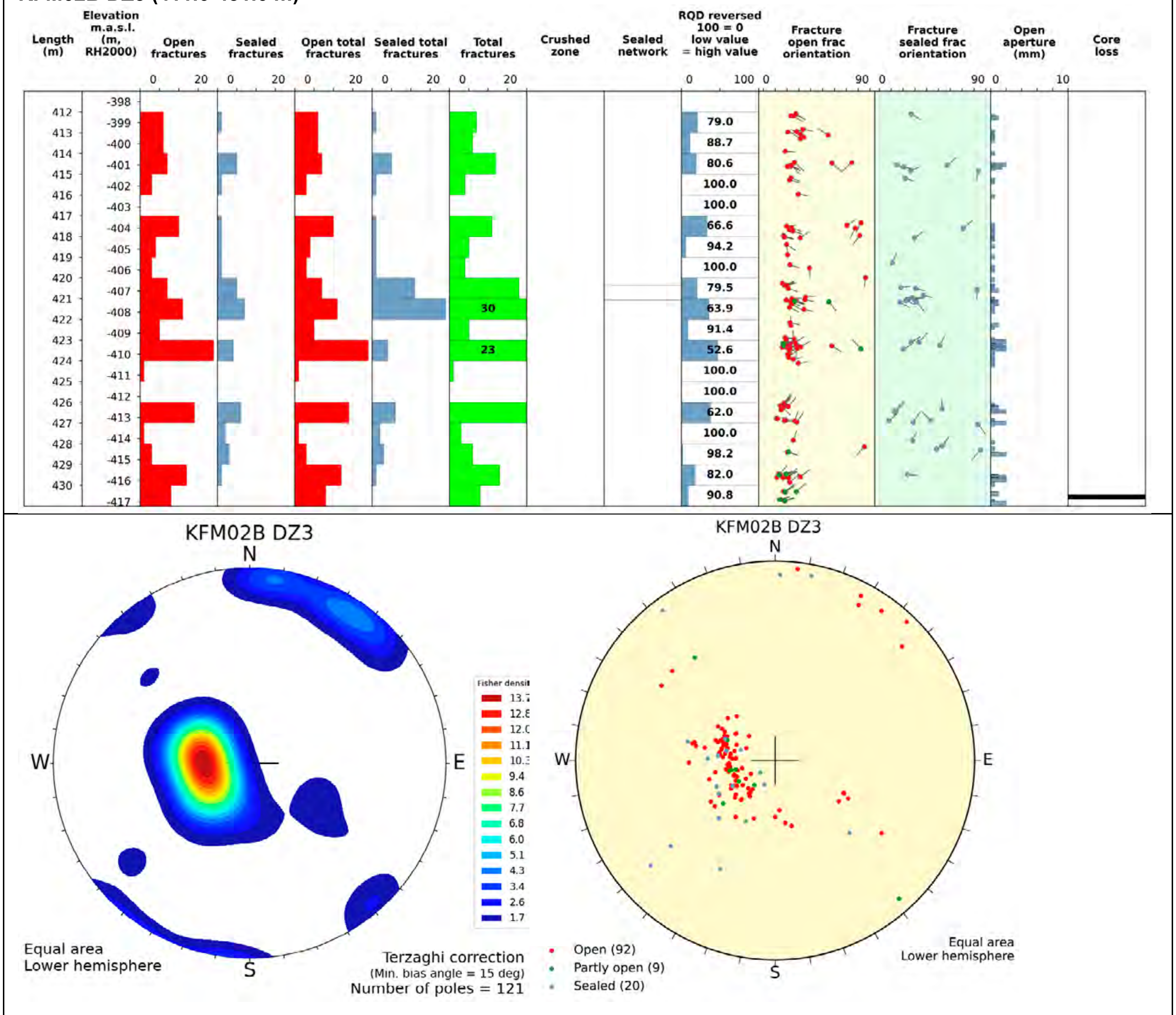






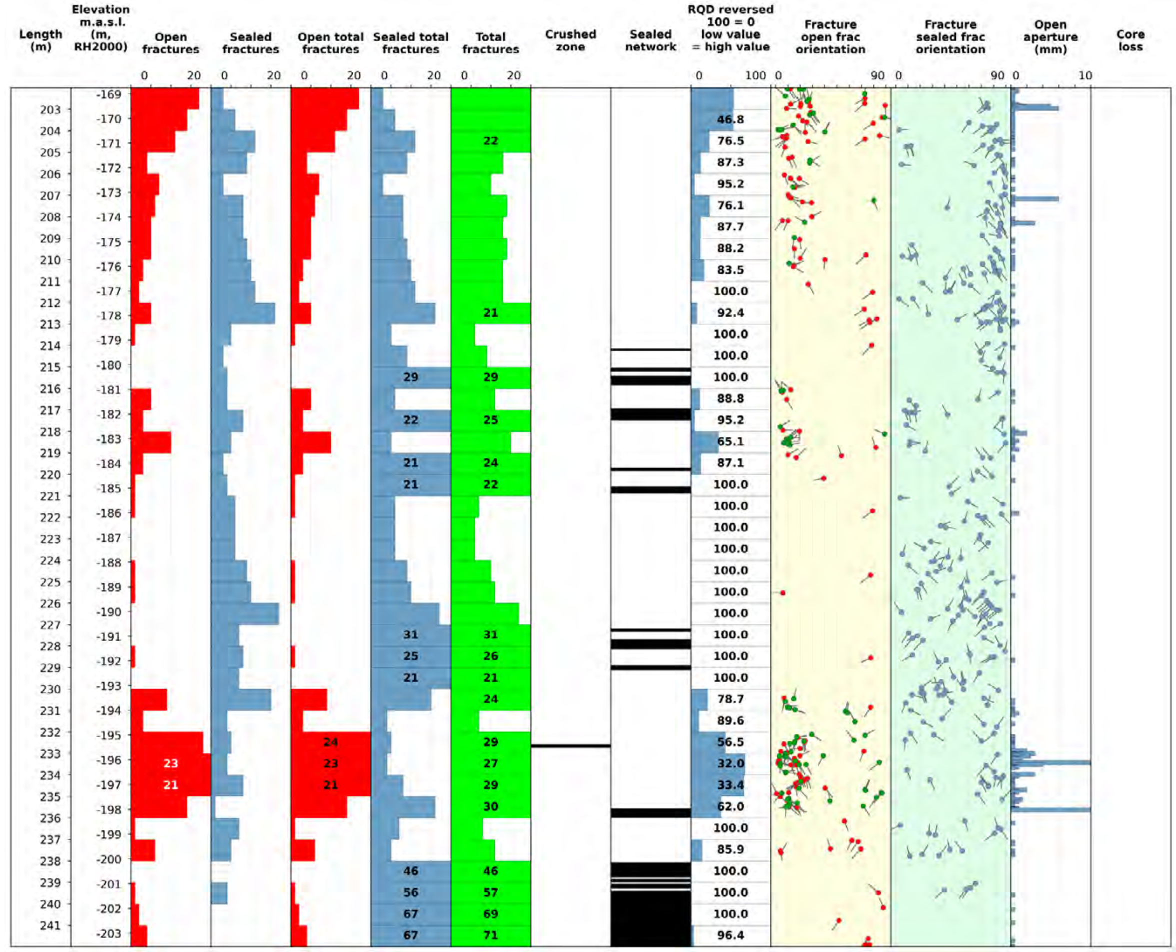
G	ZFMA2	Version number	4	Total object CL	21

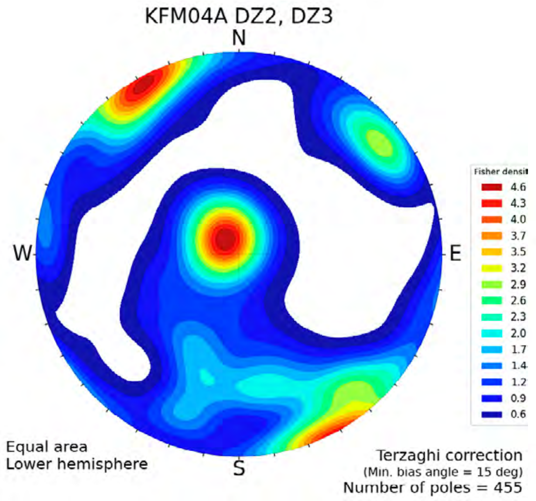
KFM02B DZ3 (411.0-431.0 m)

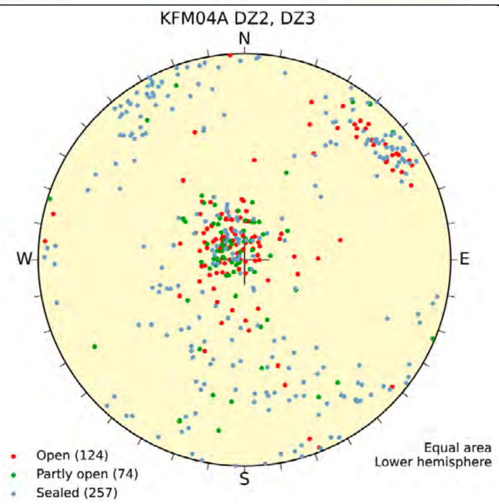


G	ZFMA2	Version number	4	Total object CL	21

KFM04A DZ2, DZ3 (202.0-242.0 m)

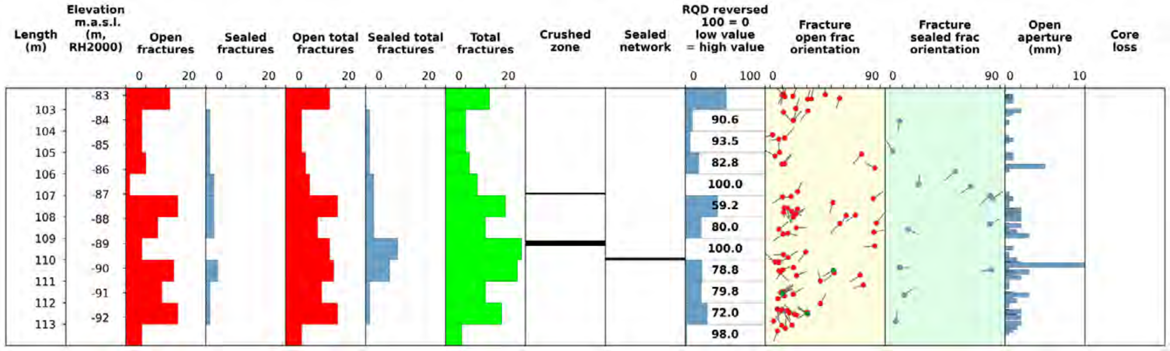






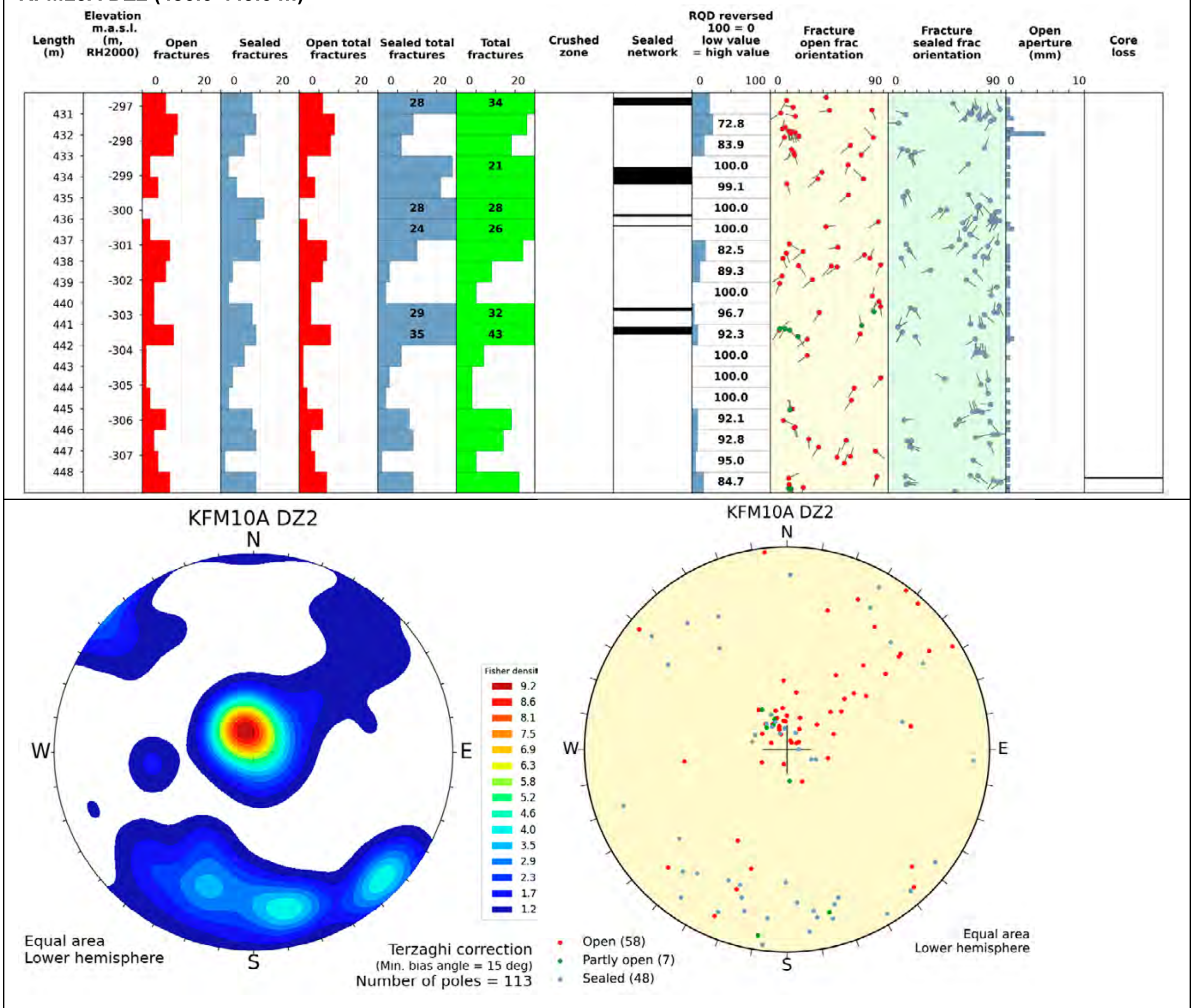
G	ZFMA2	Version number	4	Total object CL	21

KFM05A DZ1 (102.0-114.0 m)



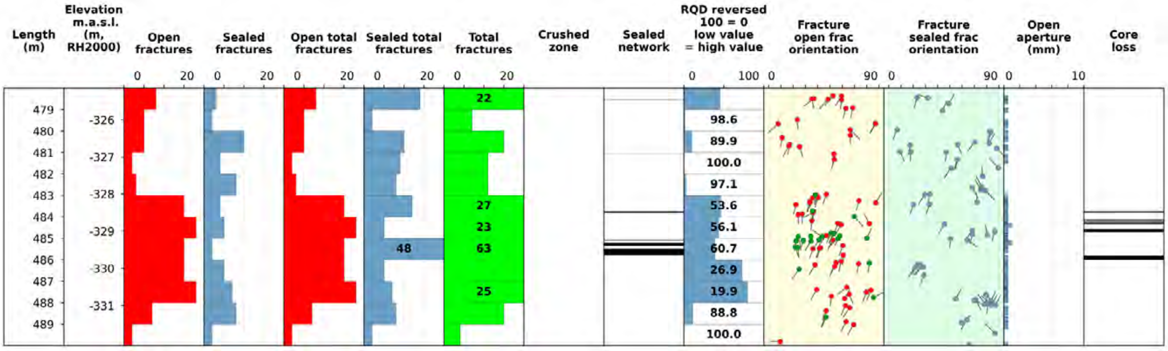
G	ZFMA2	Version number	4	Total object CL	21

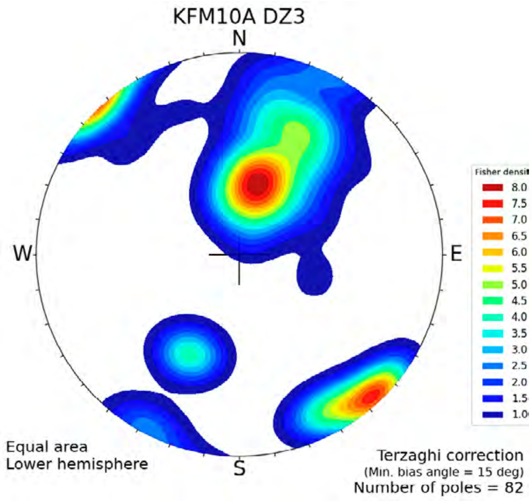
KFM10A DZ2 (430.0-449.0 m)

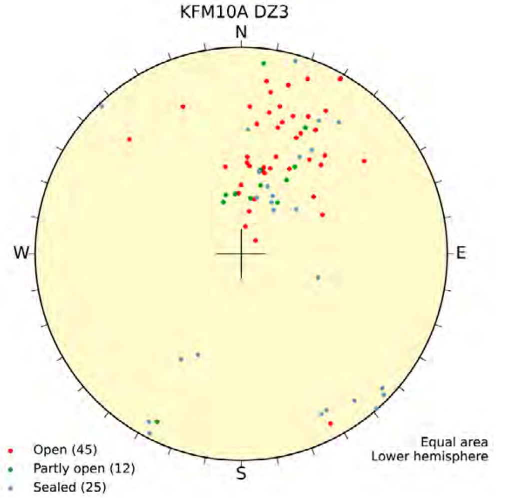


G	ZFMA2	Version number	4	Total object CL	21

KFM10A DZ3 (478.0-490.0 m)

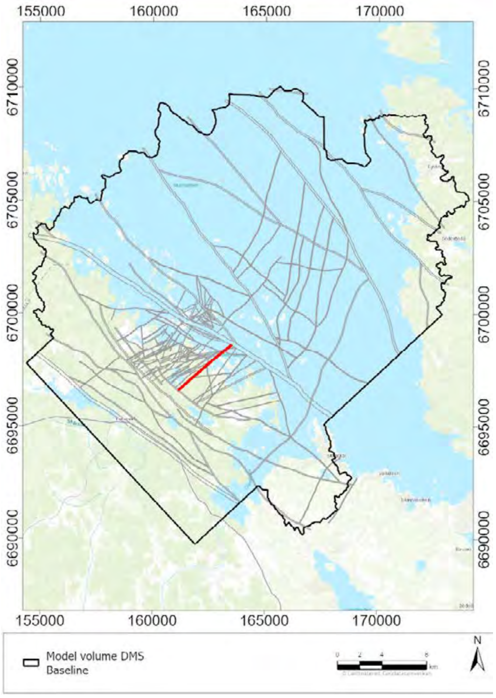






G	ZFMA3		Version number	3	Total object CL	20

GEOLOGICAL CHARACTER		Property CL
Deformation style:	Brittle	3
Deformation description:	Dip-slip reverse faults in possible conjugate system. Oblique to strike-slip striae present on faults with the same strike.	
Alteration:		
- First order:	Oxidation	2
- Second order:	Quartz dissolution	
- Third order:	Not observed	
Fracture orientation and type:	Gently dipping fractures with variable orientation dominates. Sealed and open fractures. Quantitative estimate and span include crush zone and fracture networks.	2
Fracture comment:	No data available.	
Fracture fill mineralogy:	Calcite, chlorite, quartz, hematite/adularia, pyrite, clay minerals, prehnite. Note high frequency of fractures with no mineral coating/filling.	



OBJECT GEOMETRY	
Strike/dip:	49°/22°
Length:	3196 m
Mean thickness:	23 m (11 - 58 m)
Max depth:	-1858 m
Geometrical constraints:	ZFMWNW0123, ZFMWNW0023, ZFMWNW0001, ZFMNNE0828, ZFMNNW0823, Topo 40m grid Max error 20m.

BASIS FOR MODELLING

Corresponds to seismic reflector A3, the position of which in 3D space has been attained from Cosma et al. (2003). Supported by borehole observations.

Outcrops: -

Boreholes:

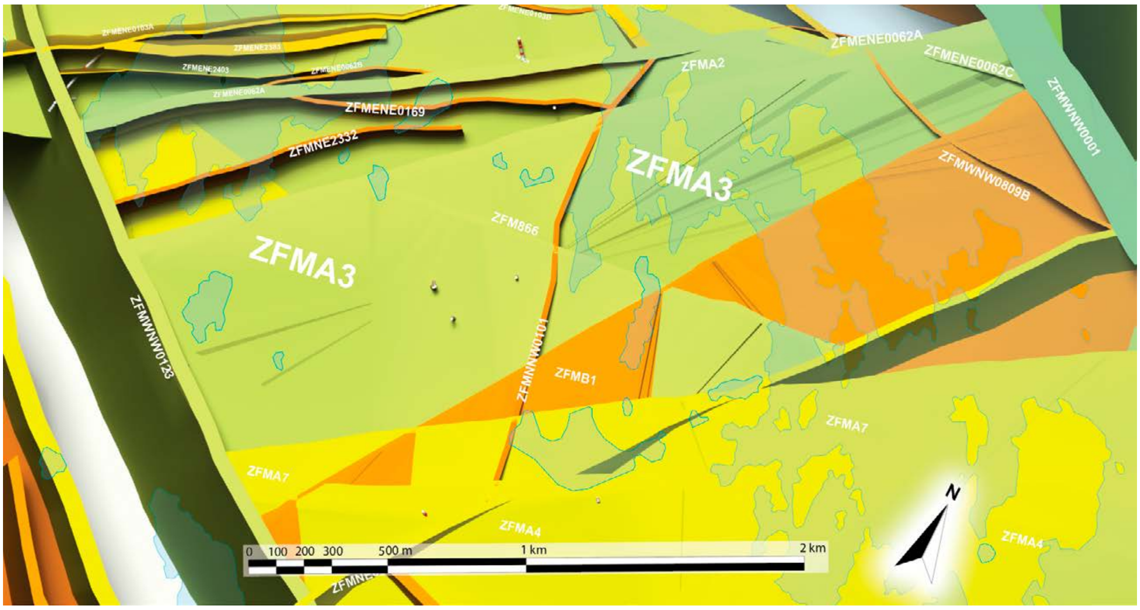
Borehole	PDZ	Target intercept		Geometric intercept		Comment
		Sec_up [m]	Sec_low [m]	Sec_up [m]	Sec_low [m]	
HFM04	DZ2	183.00	187.00	181.35	209.91	
HFM29		-	-	191.65	199.70	
KFM02A	DZ3	160.00	184.00	159.87	184.10	
KFM02B	DZ2	145.00	204.00	154.92	178.38	
KFM03A	DZ4	803.00	816.00	810.87	834.84	

Tunnels:	-	
Lineament and/or seismic indications:	A3.	3

MODELLING PROCEDURE

Corresponds to seismic reflector A3, the position of which in 3D space has been attained from Cosma et al. (2003). Terminated against ZFMWNW0001, ZFMWNW0023, ZFMWNW0123, ZFMNNW0823 and ZFMNNE0828. Fixed point intersections at 163 m along DZ3 (160-184 m) in KFM02A, at 158 m along DZ2 (145-204 m) in KFM02B, at 814 m along DZ4 (803-816 m) in KFM03A and at 185 m along DZ2 (183-187 m) in HFM04. Modelled zone also fringes on the lower part of HFM29. Low radar amplitude also observed at 160-184 m in KFM02A and at 813-817 m in KFM03A.

G	ZFMA3	Version number	3	Total object CL	20



OBJECT CONFIDENCE ESTIMATE

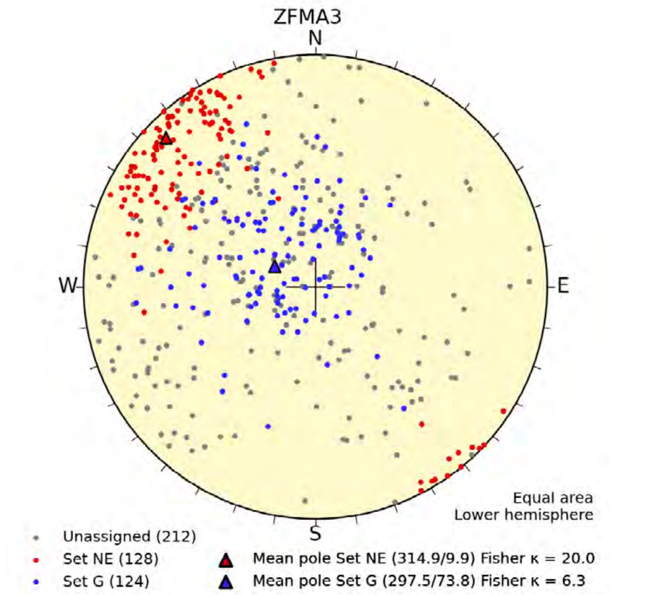
Category	Object CL	Comment
INTERPRETATION		
Data source	2	A3, HFM04, HFM29, KFM02A, KFM02B, KFM03A
Results of interpretation	3	High confidence observations in multiple boreholes.
INFORMATION DENSITY		
Number of observation points	3	>4
Distribution of observation points	2	Two clusters and the lineament considered as an outlier.
INTERPOLATION		
Geometry	3	Multiple sub-surface obs. points where measurable apertures, occurrence of episynites are noted in SHI. In combination with the interpreted seismic reflector, indicative of one strong alternative.
Geological indicators	3	Supported by key geological parameters.
EXTRAPOLATION		
Dip direction	2	Conceptual constraints. Inferred truncation against surrounding steeply dipping zones ZFMWNW0001, ZFMWNW0123, ZFMWNW0023, ZFMNNW0823, ZFMNNE0828.
Strike direction	2	Conceptual constraints. Inferred truncation against surrounding steeply dipping zones ZFMWNW0001, ZFMWNW0123, ZFMWNW0023, ZFMNNW0823, ZFMNNE0828.

G	ZFMA3	Version number	3	Total object CL	20

FRACTURE CHARACTER

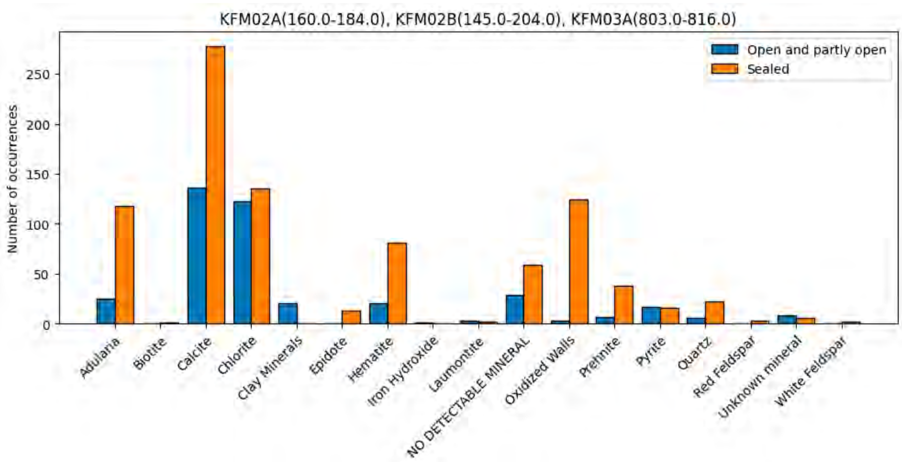
Orientation: (strike/dip right-hand-rule)	Set NE: 44.9°/80.1° Set G: 27.5°/16.2°
Frequency:	Boreholes: KFM03A, KFM02B, KFM02A

FRACTURE TYPE	TERZAGHI-WEIGHED P10
Open and partly open	3.5 m-1
Sealed	9.0 m-1
Sealed network	0.9 % of DZ intercept
Crush	0.0 % of DZ intercept



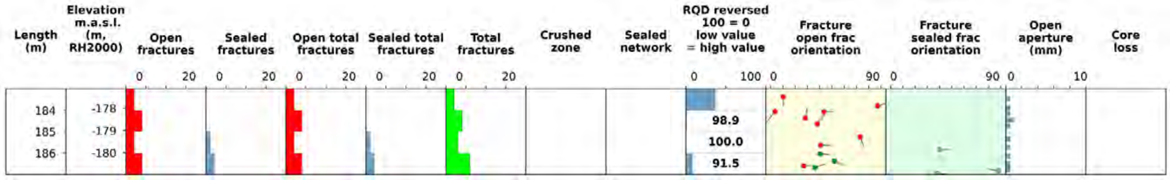
RQD:	min:21, max:100, mean:95

Fracture fill mineralogy:

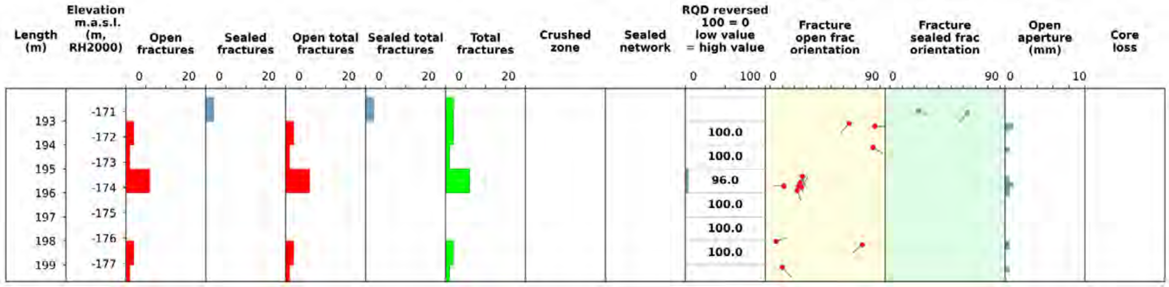


G	ZFMA3	Version number	3	Total object CL	20
INDIVIDUAL INTERCEPTS					

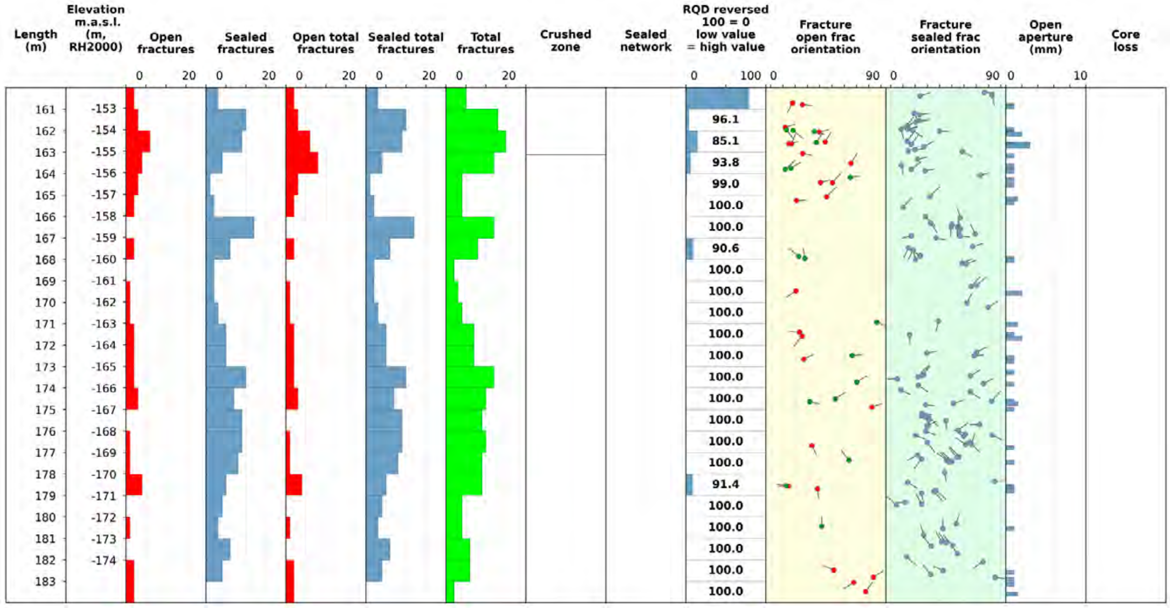
HFM04 DZ2 (183.0-187.0 m)

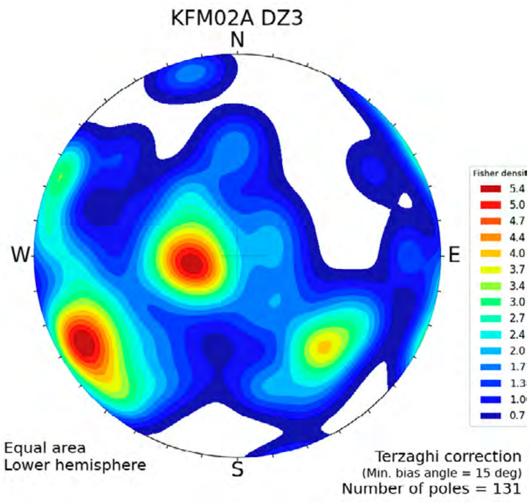


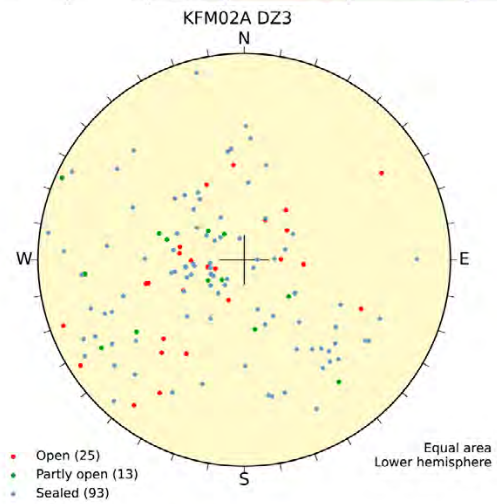
HFM29 (191.65-199.7 m)



KFM02A DZ3 (160.0-184.0 m)

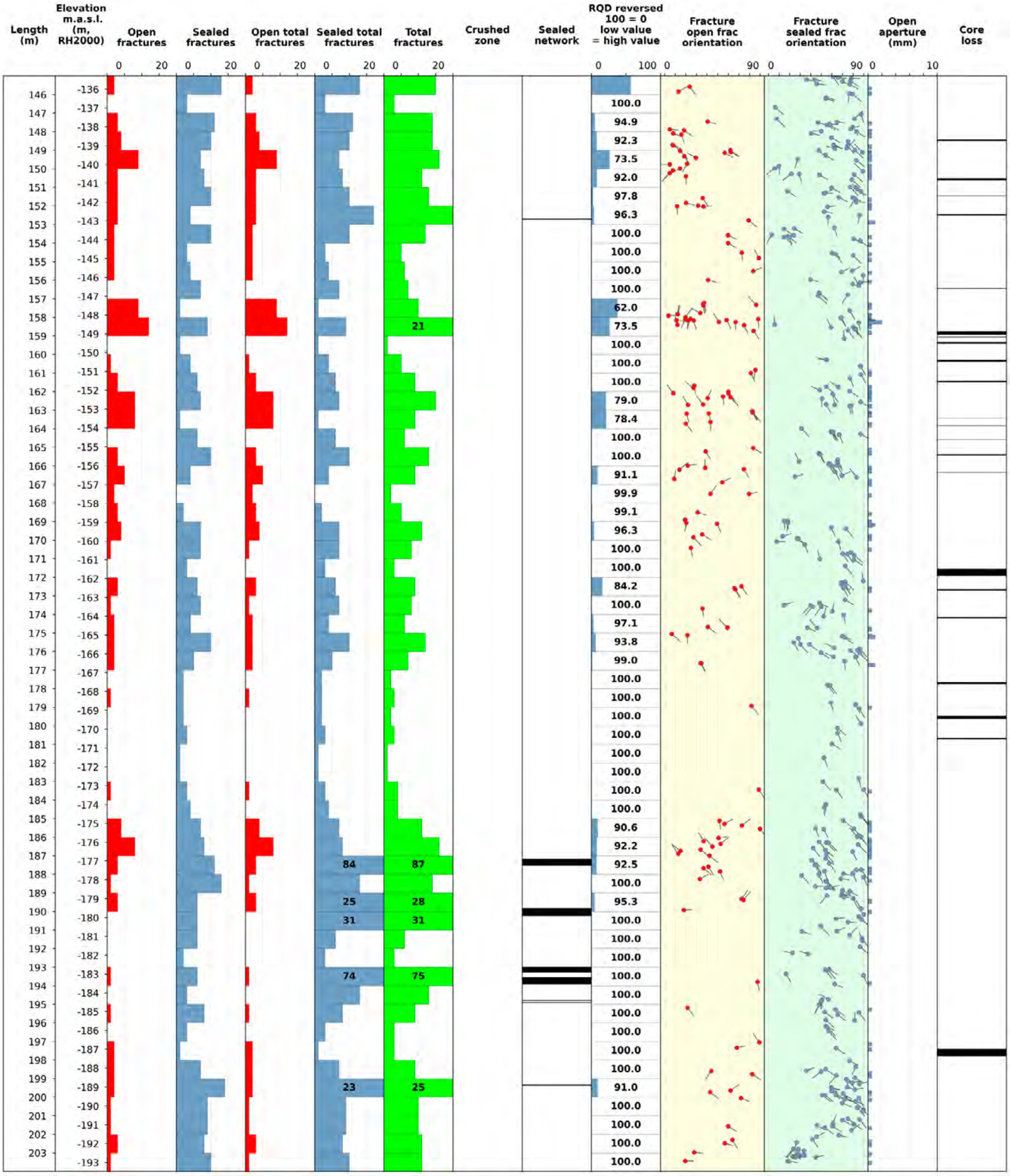




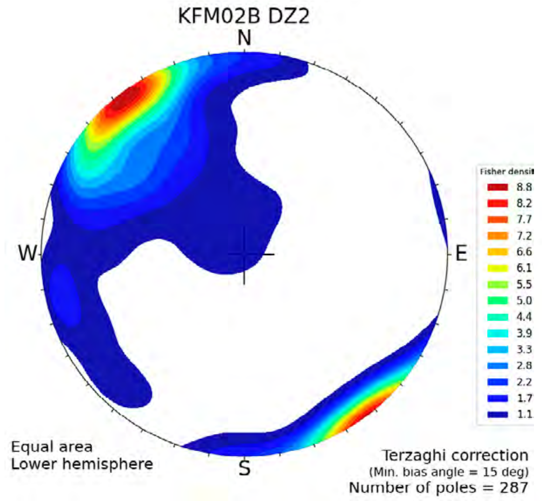


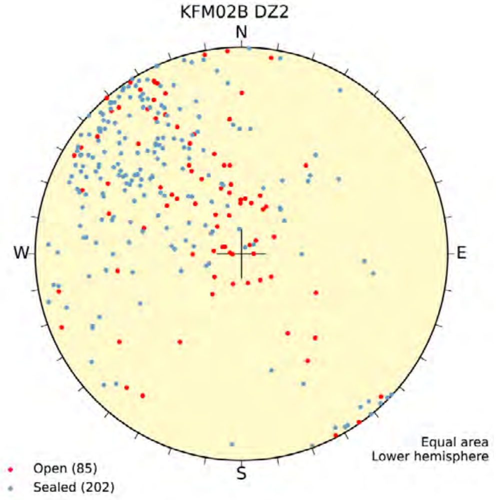
G	ZFMA3	Version number	3	Total object CL	20

KFM02B DZ2 (145.0-204.0 m)

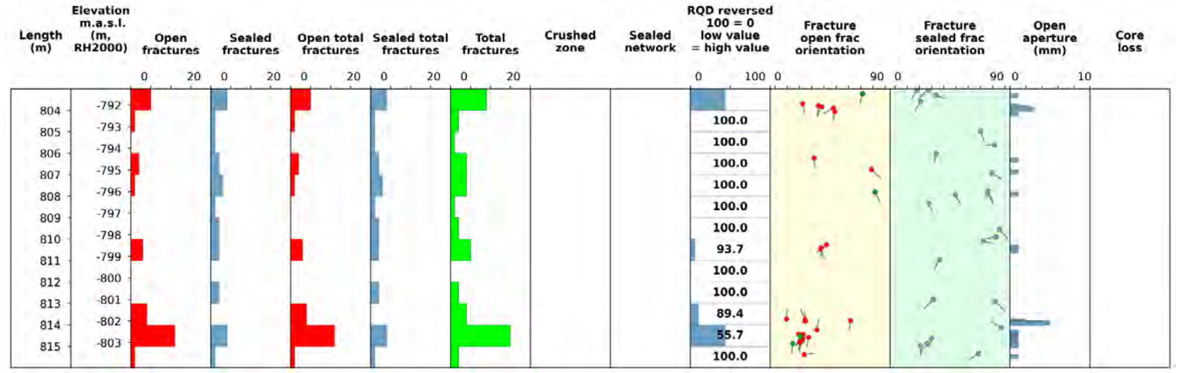


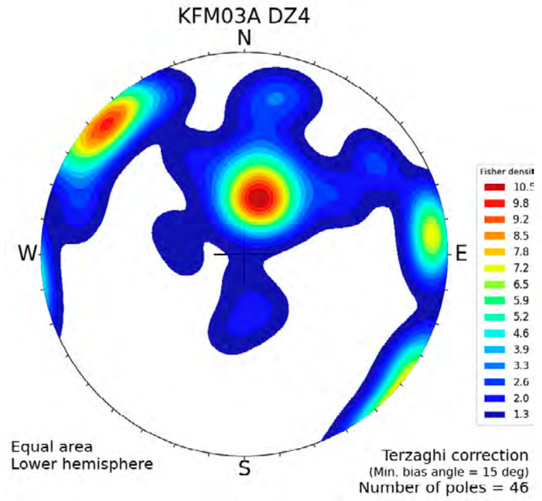
G	ZFMA3	Version number	3	Total object CL	20

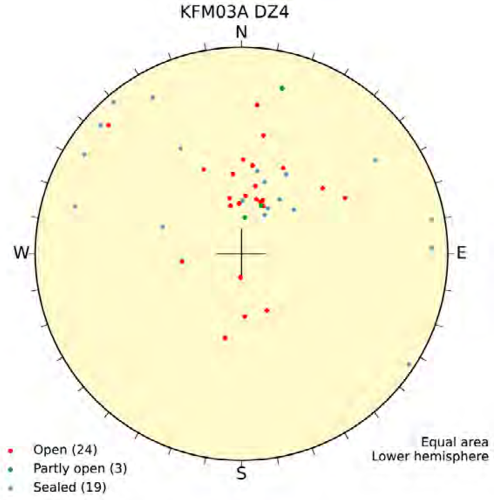




KFM03A DZ4 (803.0-816.0 m)

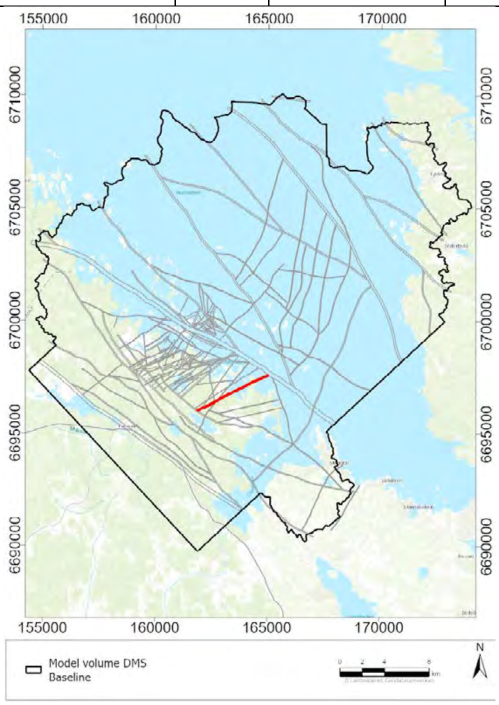






G	ZFMA4	Version number	3	Total object CL	17

GEOLOGICAL CHARACTER		Property CL
Deformation style:	Brittle	2
Deformation description:	Dip-slip movement along minor fault that dips gently to the SSE. Strike-slip movement along minor fault that is steeply dipping and strikes NS.	
Alteration:		2
- First order:	Oxidation	
- Second order:	Not observed	
- Third order:	Not observed	
Fracture orientation and type:	Gently dipping fractures dominates. Variable orientation. Open and sealed fractures. Quantitative estimate and span include crush zones and sealed fracture networks.	2
Fracture comment:	No data available.	
Fracture fill mineralogy:	Chlorite, calcite. Laumontite present along steeply dipping fractures (strike ENE) and along a gently dipping fracture. Note high frequency of fractures with no mineral coating/filling.	



OBJECT GEOMETRY	
Strike/dip:	63°/25°
Length:	3659 m
Mean thickness:	26 m (13 - 39 m)
Max depth:	-1469 m
Geometrical constraints:	ZFMWNW0123, ZFMWNW0023, ZFMWNW0001, ZFMNNE0828, ZFMNNW0823, Topo 40m grid Max error 20m.

BASIS FOR MODELLING

Corresponds to seismic reflector A4, the position of which in 3D space has been attained from Cosma et al. (2003). Supported by borehole observations.

Outcrops:	-
Boreholes:	

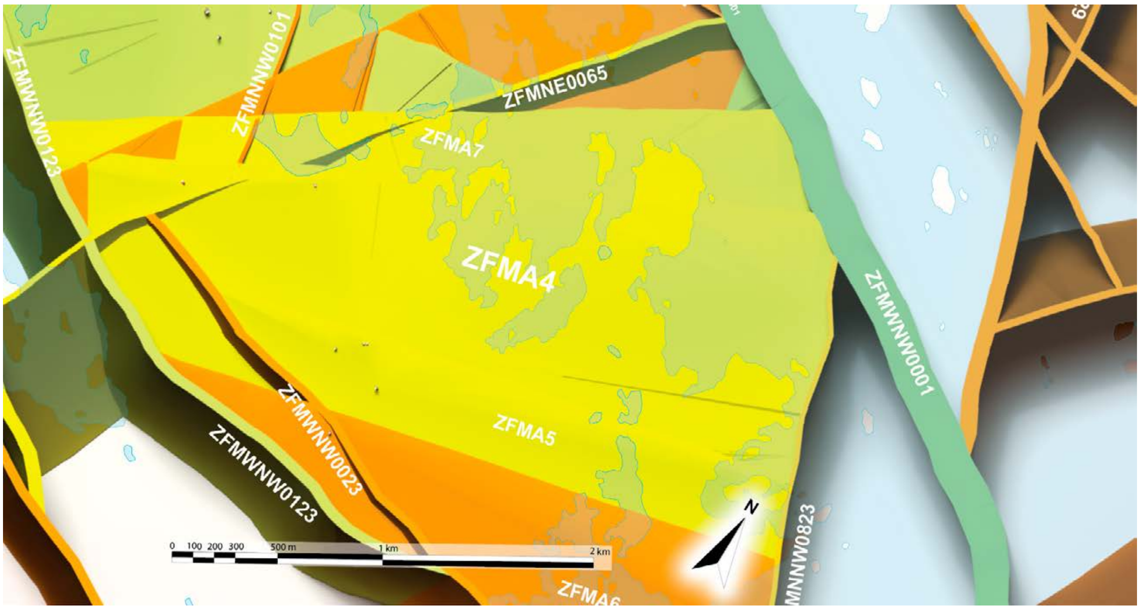
Borehole	PDZ	Target intercept		Geometric intercept		Comment
		Sec_up [m]	Sec_low [m]	Sec_up [m]	Sec_low [m]	
HFM18	DZ2	36.00	49.00	20.49	47.02	
HFM26	DZ1	-	-	20.77	72.37	
HFM26	DZ2	60.00	95.00	20.77	72.37	
KFM03A	DZ1	356.00	399.00	361.81	390.07	

Tunnels:	-	
Lineament and/or seismic indications:	A4.	3

MODELLING PROCEDURE

Corresponds to seismic reflector A4, the position of which in 3D space has been attained from Cosma et al. (2003). Terminated against ZFMWNW0001, ZFMWNW0023, ZFMWNW0123, ZFMNNW0823 and ZFMNNE0828. Fixed point intersections at 389 m along DZ1 (356-399 m) in KFM03A, at 46 m along DZ2 (36-49 m) in HFM18 and at 70 m along DZ2 (60-95 m) in HFM26. Low radar amplitude also observed at 386-390 m along DZ1 in KFM03A. Zone also intersects DZ1 (12-46 m) in HFM26.

G	ZFMA4	Version number	3	Total object CL	17



OBJECT CONFIDENCE ESTIMATE

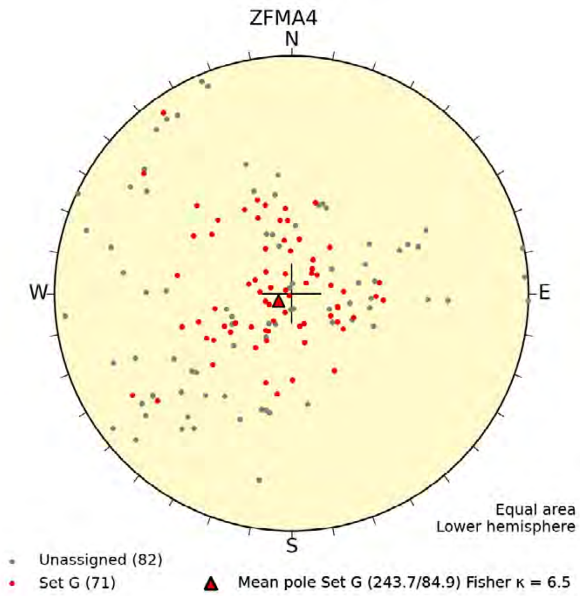
Category	Object CL	Comment
INTERPRETATION		
Data source	2	A4,HFM18, HFM26, KFM03A
Results of interpretation	3	High confidence observations in KFM03A.
INFORMATION DENSITY		
Number of observation points	2	3
Distribution of observation points	2	Two clusters and the lineament considered as an outlier.
INTERPOLATION		
Geometry	2	Low data quality from percussion drill holes do not allow strong correlation with cored boreholes.
Geological indicators	2	Some discrepancies in the geological data.
EXTRAPOLATION		
Dip direction	2	Conceptual constraints. Inferred truncation against surrounding steeply dipping zones ZFMWNW0001, ZFMWNW0123, ZFMWNW0023, ZFMNNW0823, ZFMNNE0828.
Strike direction	2	Conceptual constraints. Inferred truncation against surrounding steeply dipping zones ZFMWNW0001, ZFMWNW0123, ZFMWNW0023, ZFMNNW0823, ZFMNNE0828.

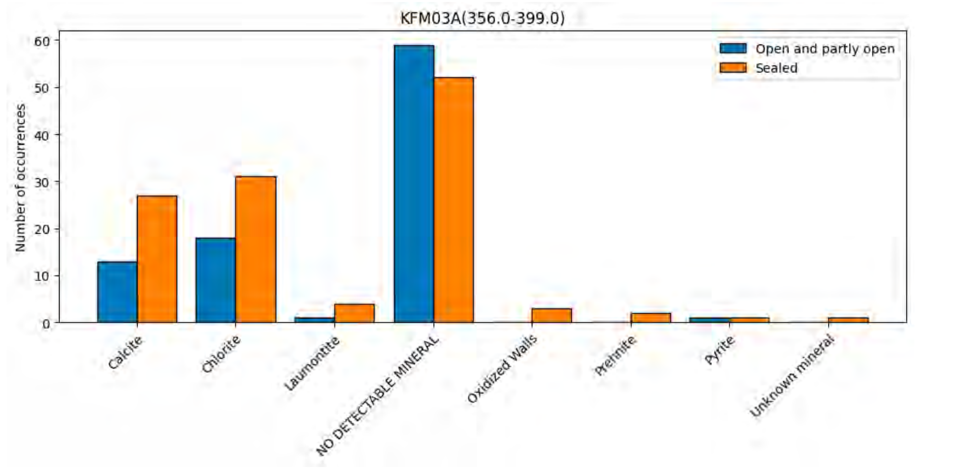
FRACTURE CHARACTER

Orientation: (strike/dip right-hand-rule): Set G: 333.7°/5.1°

Frequency: Boreholes: KFM03A

FRACTURE TYPE	TERZAGHI-WEIGHED P10
Open and partly open	2.7 m-1
Sealed	3.7 m-1
Sealed network	0.0 % of DZ intercept
Crush	0.4 % of DZ intercept

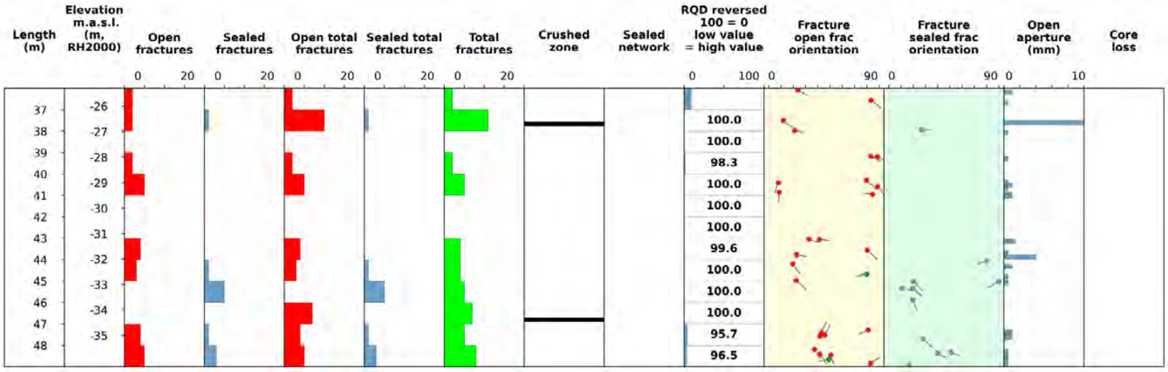


G	ZFMA4	Version number	3	Total object CL	17
RQD:	min:3, max:100, mean:94				
Fracture fill mineralogy:					

G	ZFMA4	Version number	3	Total object CL	17

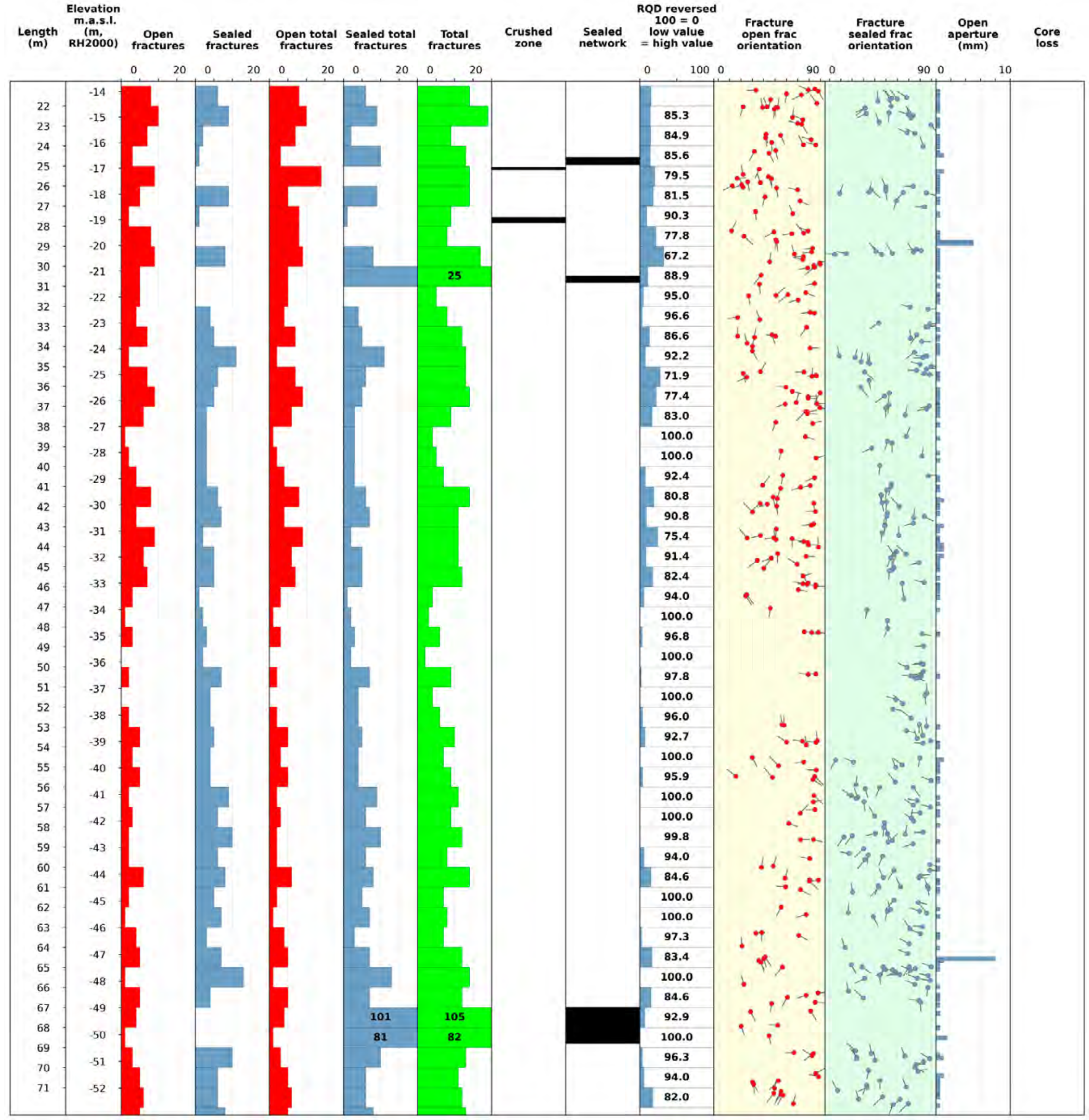
INDIVIDUAL INTERCEPTS

HFM18 DZ2 (36.0-49.0 m)



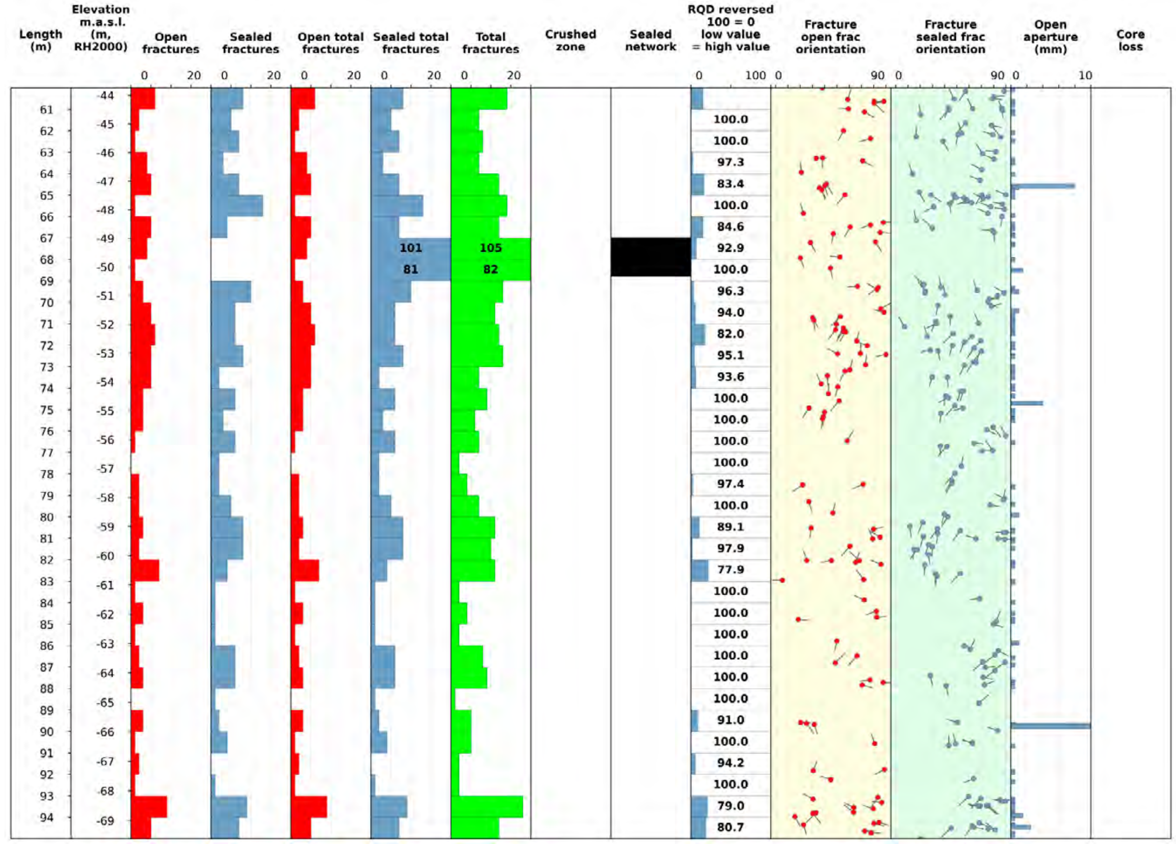
G	ZFMA4	Version number	3	Total object CL	17

HFM26 DZ1 (20.77-72.37 m)



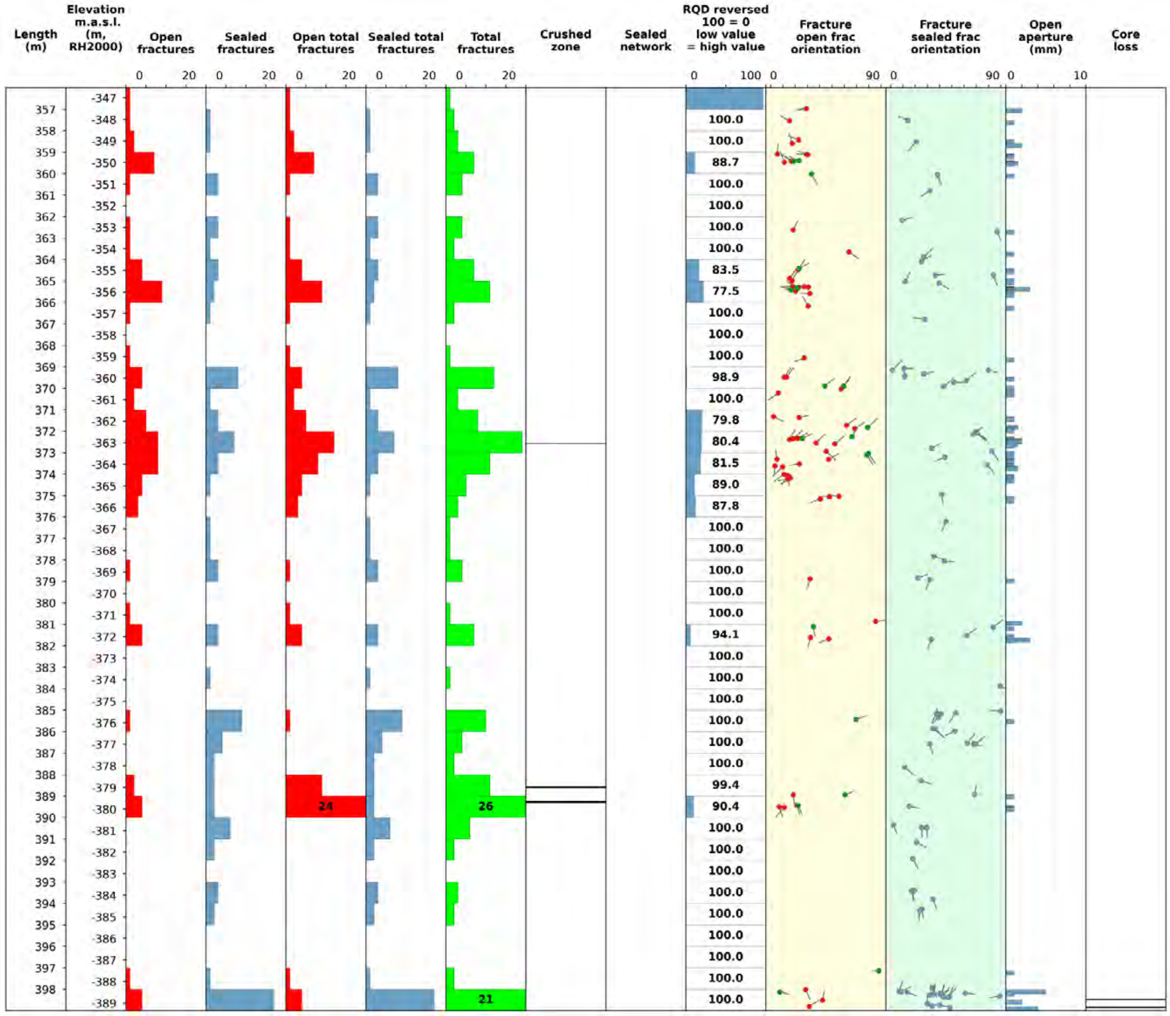
G	ZFMA4	Version number	3	Total object CL	17

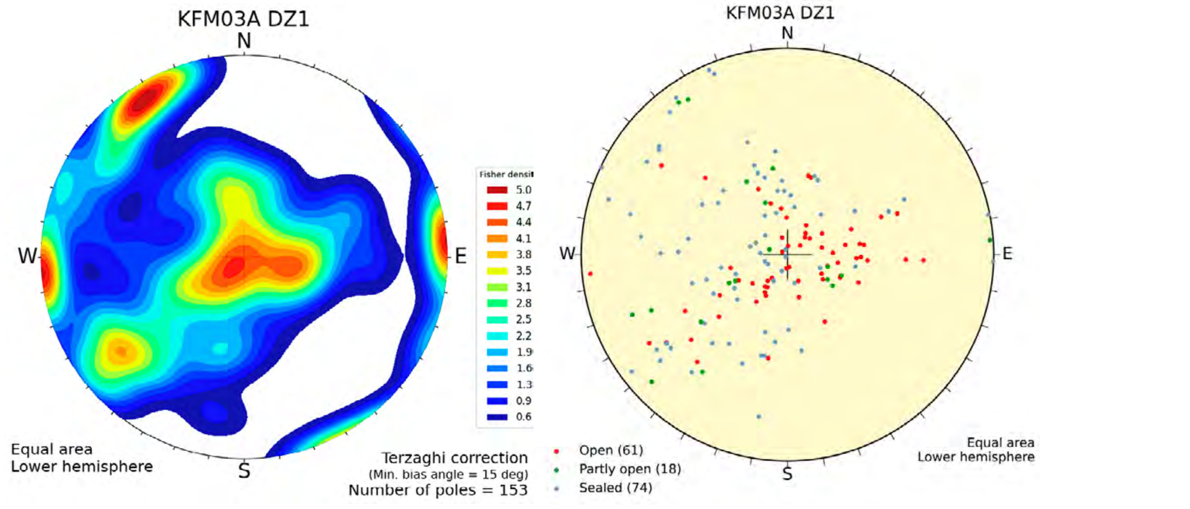
HFM26 DZ2 (60.0-95.0 m)



G	ZFMA4	Version number	3	Total object CL	17

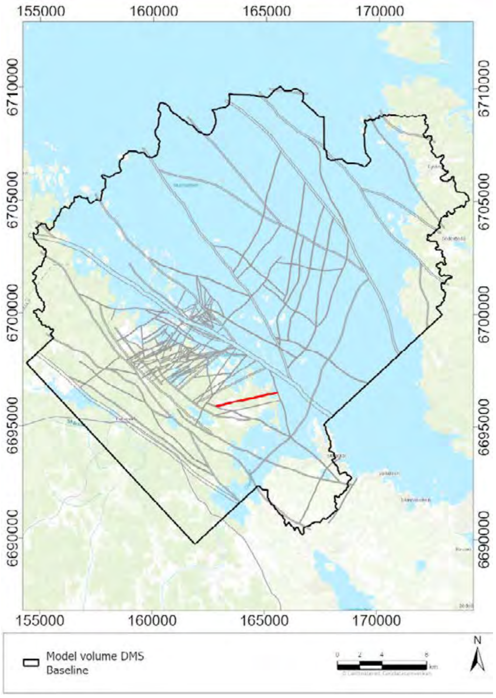
KFM03A DZ1 (356.0-399.0 m)





G	ZFMA5		Version number	3	Total object CL	18

GEOLOGICAL CHARACTER		Property CL
Deformation style:	Brittle	2
Deformation description:	No complementary data available.	
Alteration:		2
- First order:	Oxidation	
- Second order:	Not observed	
- Third order:	Not observed	
Fracture orientation and type:	Gently dipping fractures dominates. Variable orientation. No mean value estimated. Dominated by sealed followed by open and partly open fractures.	2
Fracture comment:	No data available.	
Fracture fill mineralogy:	Chlorite, calcite, clay minerals. Quartz and prehnite along more steeply dipping fractures.	



OBJECT GEOMETRY	
Strike/dip:	77°/31°
Length:	2842 m
Mean thickness:	16 m (5 - 16 m)
Max depth:	-1219 m
Geometrical constraints:	ZFMWNW0023, ZFMNNE0828, ZFMNNW0823, Topo 40m grid Max error 20m.

BASIS FOR MODELLING

Corresponds to seismic reflector A5, the position of which in 3D space has been attained from Cosma et al. (2003). Supported by borehole observations.

Outcrops:	-

Boreholes:

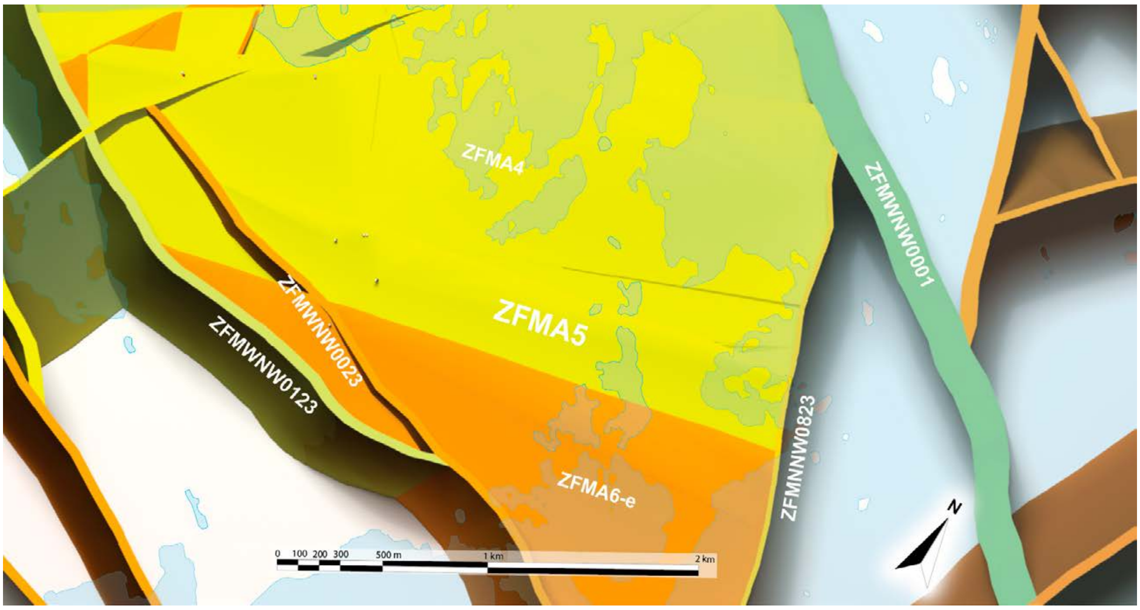
Borehole	PDZ	Target intercept		Geometric intercept		Comment
		Sec_up [m]	Sec_low [m]	Sec_up [m]	Sec_low [m]	
HFM06	DZ1	61.00	71.00	54.33	72.27	
HFM08	DZ1	136.00	141.00	120.28	139.45	
KFM03A		60.00	62.00	20.80	39.22	No mapping or borehole image available for the interval. According to the drilling report (Claesson and Nilsson 2004) a flat-dipping fracture zone at about 60-62 m.
KFM03B	DZ1	24.00	42.00	23.76	42.26	

Tunnels:	-	
Lineament and/or seismic indications:	A5.	3

MODELLING PROCEDURE

Corresponds to seismic reflector A5, the position of which in 3D space has been attained from Cosma et al. (2003). Termination against ZFMWNW0023, ZFMNNW823 and ZFMNNE0828. Fixed point intersections at 40 m along DZ1 (24-42 m) in KFM03B, at 70 m along DZ1 (61-71 m) in HFM06 and at 137 m along DZ1 (136-141 m) in HFM08.

G	ZFMA5	Version number	3	Total object CL	18



OBJECT CONFIDENCE ESTIMATE

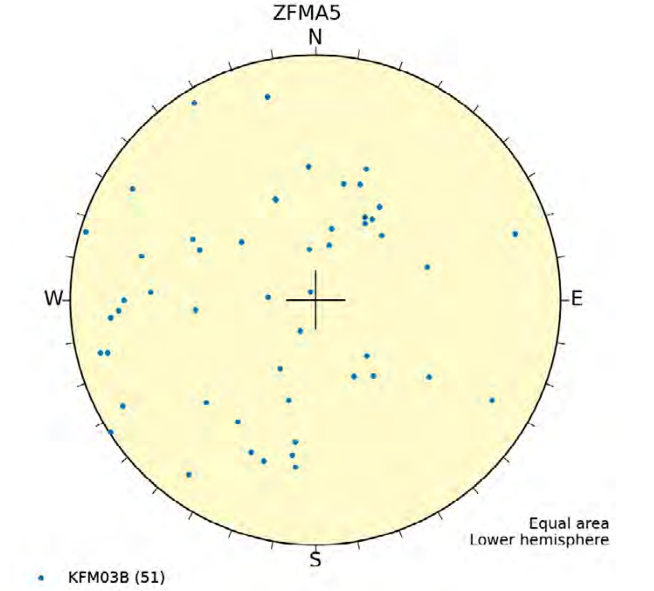
Category	Object CL	Comment
INTERPRETATION		
Data source	2	A5, HFM06, HFM08, KFM03A, KFM03B
Results of interpretation	3	High confidence observation in HFM06, HFM08.
INFORMATION DENSITY		
Number of observation points	3	4
Distribution of observation points	1	If there is a geometric coincidence between the seismic reflector and the borehole observation points, the reflector shall not be regarded as an observation point. Henceforth, reflector not considered as an outlier. Looking at the entire modelled zone, the observation points are restricted to most western part of the zone and perhaps can be considered as a cluster. Since the reflector is not considered an observation point in this case, all obs.points are restricted to a small area considering t
INTERPOLATION		
Geometry	3	One strong interpolation alt. Based on sub-surface obs. points in combination with high-confidence seismic reflector.
Geological indicators	2	Some discrepancies in the geological data.
EXTRAPOLATION		
Dip direction	2	Conceptual constraints. Inferred truncation against surrounding steeply dipping zones ZFMWNW0023, ZFMNNW0823, ZFMNNE0828.
Strike direction	2	Conceptual constraints. Inferred truncation against surrounding steeply dipping zones ZFMWNW0023, ZFMNNW0823, ZFMNNE0828.

G	ZFMA5	Version number	3	Total object CL	18

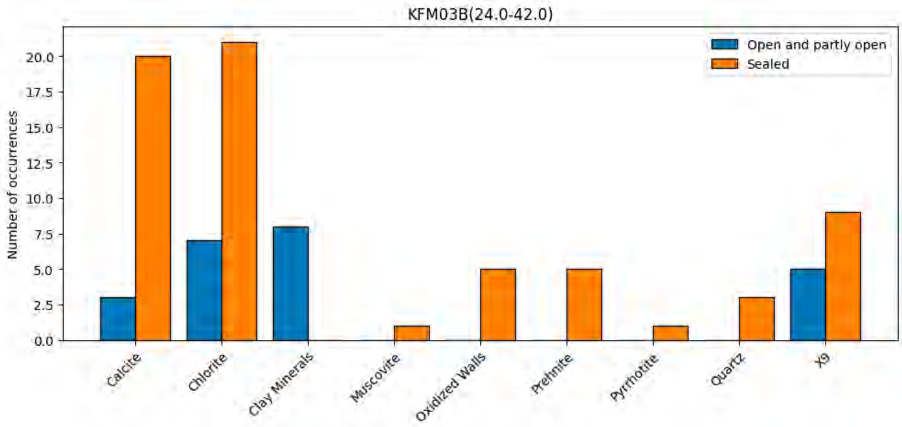
FRACTURE CHARACTER

Orientation: (strike/dip right-hand-rule)	--
Frequency:	Boreholes: KFM03A, KFM03B

FRACTURE TYPE	TERZAGHI-WEIGHED P10
Open and partly open	1.0 m-1
Sealed	2.0 m-1
Sealed network	0.0 % of DZ intercept
Crush	0.0 % of DZ intercept



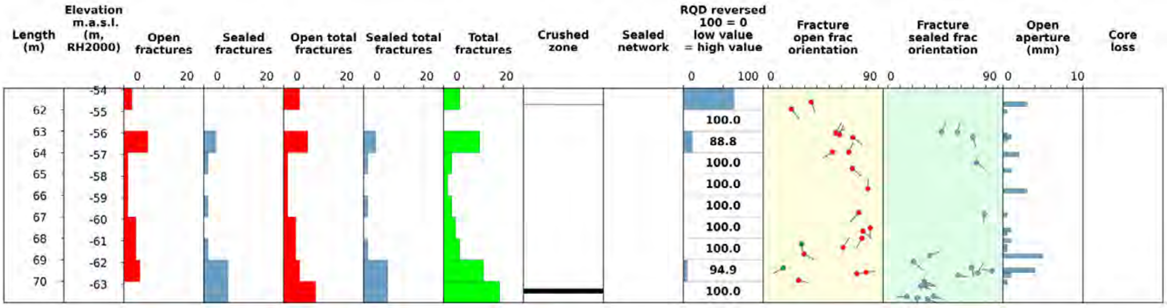
RQD:	min:33, max:100, mean:95
Fracture fill mineralogy:	



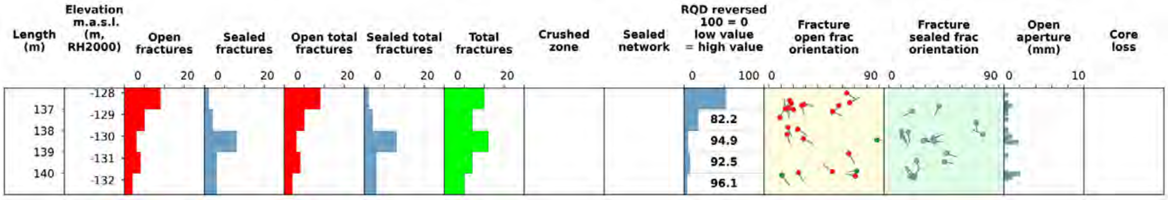
G	ZFMA5	Version number	3	Total object CL	18

INDIVIDUAL INTERCEPTS

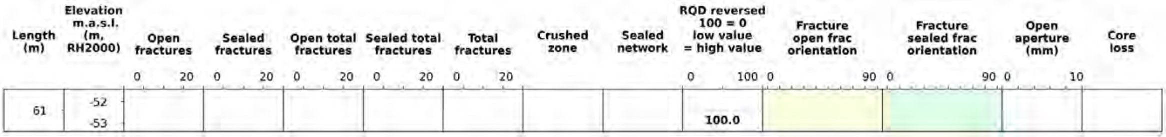
HFM06 DZ1 (61.0-71.0 m)



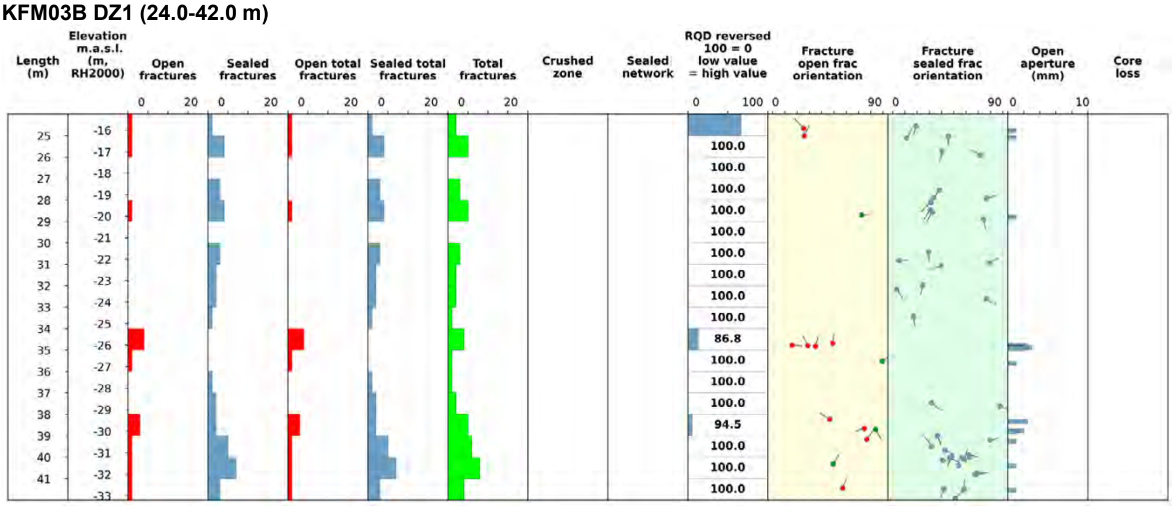
HFM08 DZ1 (136.0-141.0 m)

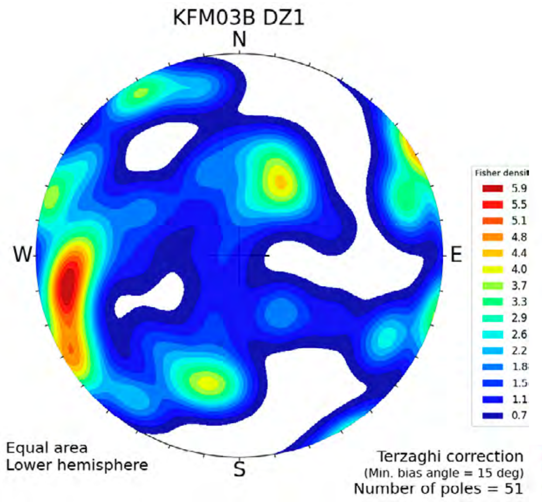


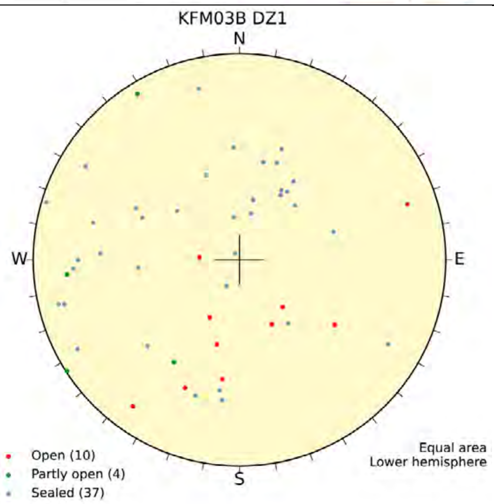
KFM03A (60.0-62.0 m)



KFM03B DZ1 (24.0-42.0 m)

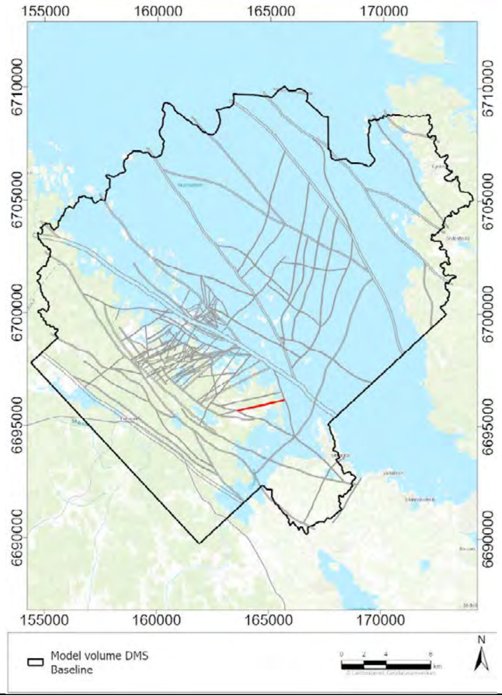






G	ZFMA6-e	Version number	3	Total object CL	13

GEOLOGICAL CHARACTER		Property CL
Deformation style:	Brittle	3
Deformation description:	No data available.	
Alteration:		2
- First order:	Oxidation	
- Second order:	Chloritization	
- Third order:	Not observed	
Fracture orientation and type:	Fractures that dip to the south and east dominates. Variable orientation. No mean value estimated. Dominated by open followed by sealed and partly open fractures.	1
Fracture comment:	No data available.	
Fracture fill mineralogy:	Chlorite and calcite.	



OBJECT GEOMETRY	
Strike/dip:	77°/31°
Length:	2206 m
Mean thickness:	10 m (6 - 32 m)
Max depth:	-997 m
Geometrical constraints:	ZFMNNE0828, ZFMNNW0823, ZFMWNW0023, Topo 40m grid Max error 20m.

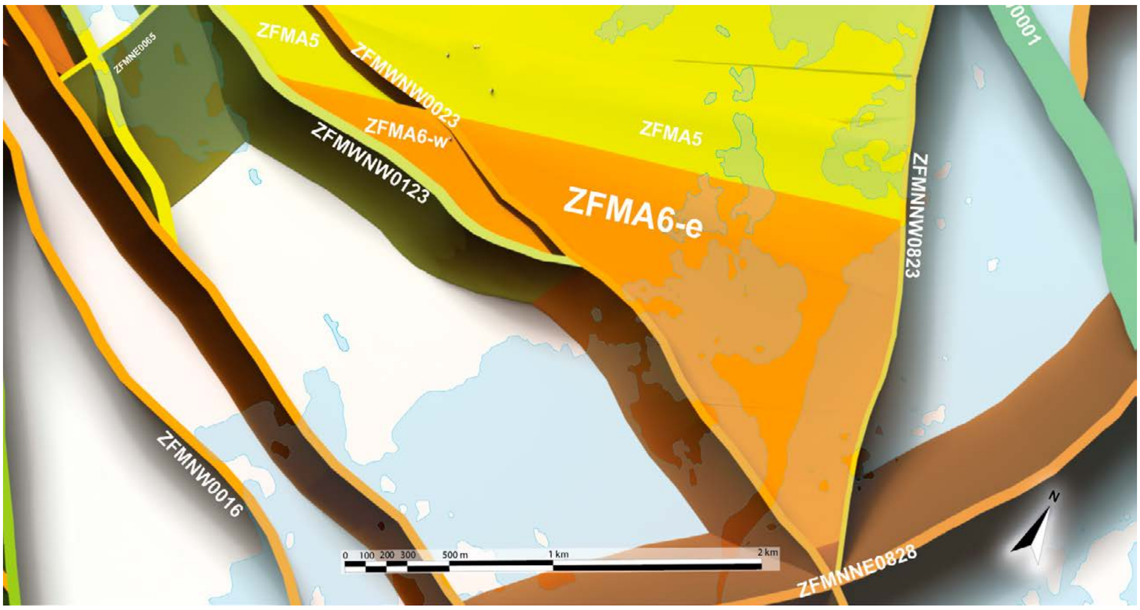
BASIS FOR MODELLING

Corresponds to seismic reflector A6, the position of which in 3D space has been attained from Cosma et al. (2003). Supported by a borehole observation.

Outcrops:	-	
Boreholes: -		
Tunnels:	-	
Lineament and/or seismic indications:	A6.	3

MODELLING PROCEDURE

Corresponds to seismic reflector A6, the position of which in 3D space has been attained from Cosma et al. (2003). The zone has been divided into two separate segments with different terminations. The eastern part is terminated against ZFMWNW0023, ZFMNNW0823 and ZFMNNE0828, while the western part is terminated against ZFMWNW0023 and ZFMWNW0123. Fixed point intersection at 59 m along DZ1 (54-66 m) in HFM07.



G	ZFMA6-e	Version number	3	Total object CL	13

OBJECT CONFIDENCE ESTIMATE

Category	Object CL	Comment
INTERPRETATION		
Data source	2	A6, HFM07
Results of interpretation	3	High confidence observation in HFM07.
INFORMATION DENSITY		
Number of observation points	1	1
Distribution of observation points	1	Single observation point at depth and a seismic reflector.
INTERPOLATION		
Geometry	1	Geometry supported by surface geophysical data.
Geological indicators	1	Indirect support by geophysical data.
EXTRAPOLATION		
Dip direction	2	Conceptual constraints. Inferred truncation against surrounding steeply dipping zones ZFMWNW0023, ZFMNNW0823, ZFMNNE0828.
Strike direction	2	Conceptual constraints. Inferred truncation against surrounding steeply dipping zones ZFMWNW0023, ZFMNNW0823, ZFMNNE0828.

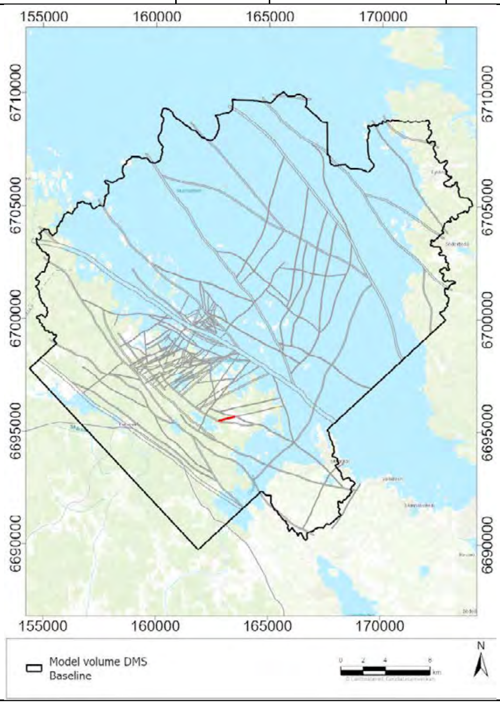
FRACTURE CHARACTER

No data available

INDIVIDUAL INTERCEPTS

No data available

G	ZFMA6-w	Version number	3	Total object CL	13



GEOLOGICAL CHARACTER		Property CL
Deformation style:	Brittle	3
Deformation description:	No data available.	
Alteration:		
- First order:	Oxidation	2
- Second order:	Chloritization	
- Third order:	Not observed	
Fracture orientation and type:	Fractures that dip to the south and east dominates. Variable orientation. No mean value estimated. Dominated by open followed by sealed and partly open fractures.	1
Fracture comment:	No data available.	
Fracture fill mineralogy:	Chlorite and calcite.	

OBJECT GEOMETRY	
Strike/dip:	77°/31°
Length:	812 m
Mean thickness:	10 m (6 - 32 m)
Max depth:	-330 m
Geometrical constraints:	ZFMWNW0023, Topo 40m grid Max error 20m, ZFMWNW0123.

BASIS FOR MODELLING

Corresponds to seismic reflector A6, the position of which in 3D space has been attained from Cosma et al. (2003). Supported by a borehole observation.

Outcrops: -

Boreholes:

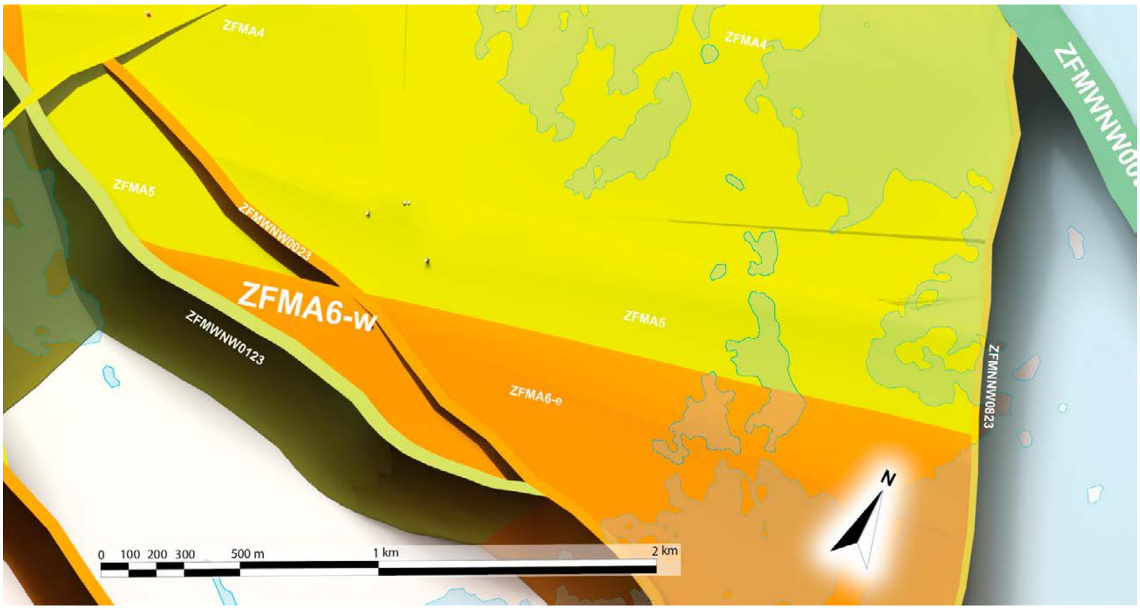
Borehole	PDZ	Target intercept		Geometric intercept		Comment
		Sec_up [m]	Sec_low [m]	Sec_up [m]	Sec_low [m]	
HFM07	DZ1	54.00	66.00	53.27	64.84	

Tunnels:	-	
Lineament and/or seismic indications:	A6.	3

MODELLING PROCEDURE

Corresponds to seismic reflector A6, the position of which in 3D space has been attained from Cosma et al. (2003). The zone has been divided into two separate segments with different terminations. The eastern part is terminated against ZFMWNW0023, ZFMNNW0823 and ZFMNNE0828, while the western part is terminated against ZFMWNW0023 and ZFMWNW0123. Fixed point intersection at 59 m along DZ1 (54-66 m) in HFM07.

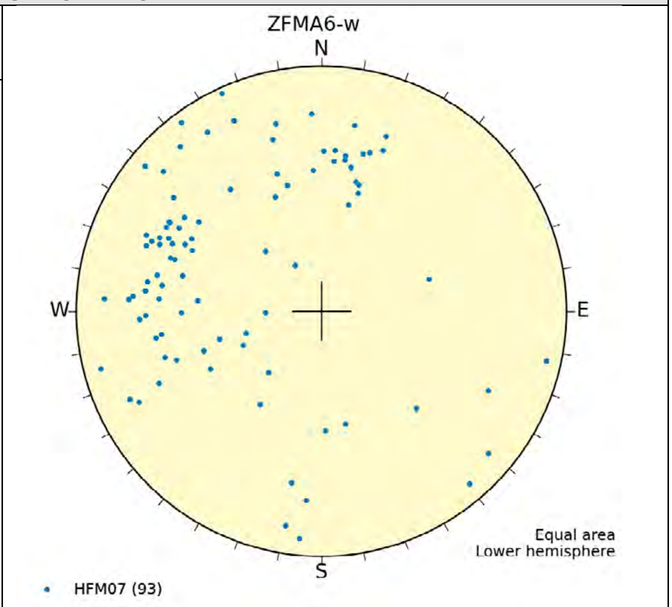
G	ZFMA6-w	Version number	3	Total object CL	13



OBJECT CONFIDENCE ESTIMATE

Category	Object CL	Comment
INTERPRETATION		
Data source	2	A6, HFM07
Results of interpretation	3	High confidence observation in HFM07.
INFORMATION DENSITY		
Number of observation points	1	1
Distribution of observation points	1	Single observation point at depth and a seismic reflector.
INTERPOLATION		
Geometry	1	Geometry supported by surface geophysical data.
Geological indicators	1	Indirect support by geophysical data.
EXTRAPOLATION		
Dip direction	2	Conceptual constraints. Inferred truncation against surrounding steeply dipping zones ZFMWNW0023, ZFMWNW0123.
Strike direction	2	Conceptual constraints. Inferred truncation against surrounding steeply dipping zones ZFMWNW0023, ZFMWNW0123.

FRACTURE CHARACTER

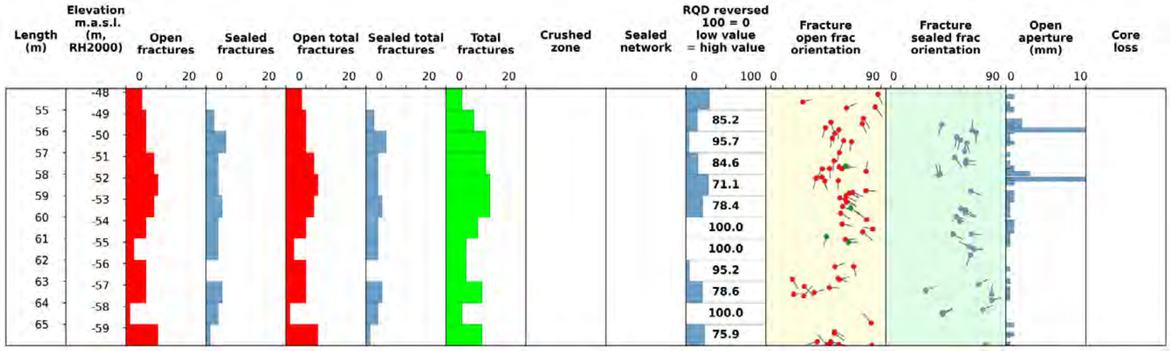
Orientation: (strike/dip right-hand-rule)	--	
Frequency:	Boreholes: -	
RQD:	--	
Fracture fill mineralogy:	No data available	

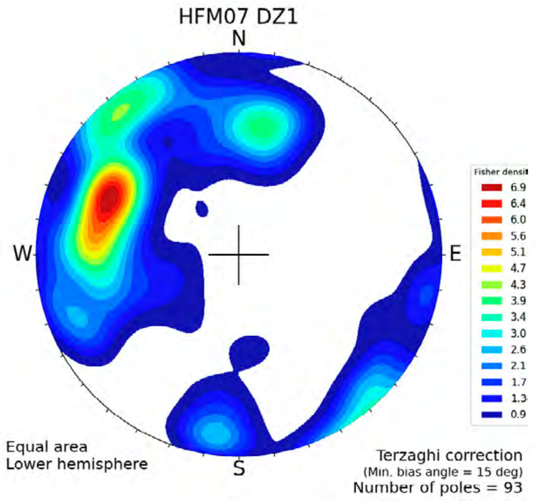
FRACTURE TYPE	TERZAGHI-WEIGHED P10
Open and partly open	0.0 m-1
Sealed	0.0 m-1
Sealed network	0.0 % of DZ intercept
Crush	0.0 % of DZ intercept

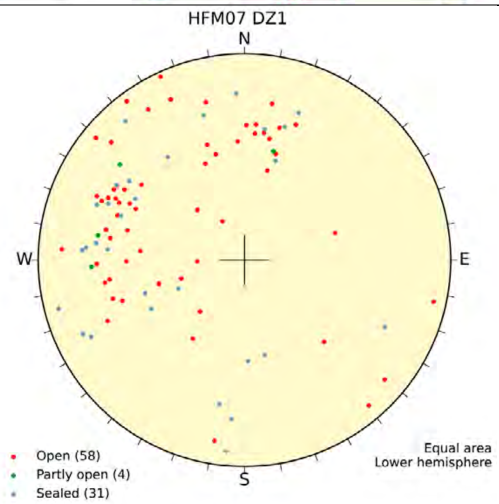
G	ZFMA6-w	Version number	3	Total object CL	13

INDIVIDUAL INTERCEPTS

HFM07 DZ1 (54.0-66.0 m)

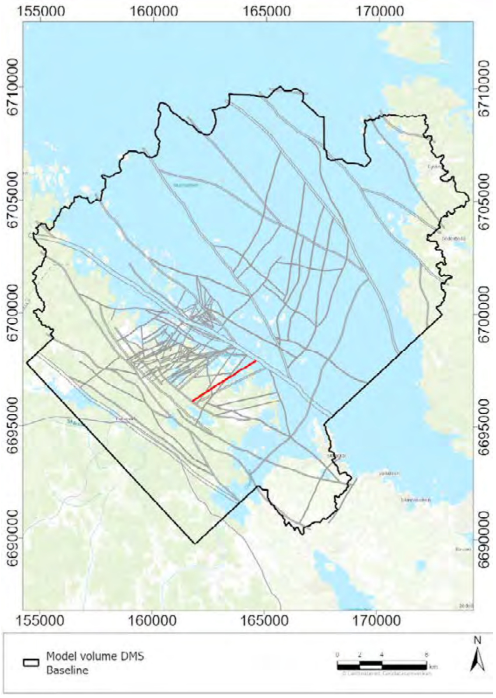






G	ZFMA7		Version number	4	Total object CL	17

GEOLOGICAL CHARACTER		Property CL
Deformation style:	Brittle	3
Deformation description:	Strike-slip movement along steeply dipping fault that strikes ENE. No fault-slip data observed on the gently dipping fractures.	
Alteration:		
- First order:	Oxidation	2
- Second order:	Not observed	
- Third order:	Not observed	
Fracture orientation and type:	Gently dipping fractures are conspicuous. Variable orientation. Sealed fractures dominates.	2
Fracture comment:	No data available.	
Fracture fill mineralogy:	Calcite, chlorite hematite/adularia, prehnite, clay minerals.	



OBJECT GEOMETRY	
Strike/dip:	57°/23°
Length:	3496 m
Mean thickness:	7 m (6 - 32 m)
Max depth:	-1495 m
Geometrical constraints:	ZFMWNW0123, ZFMWNW0023, ZFMWNW0001, ZFMNNE0828, ZFMNNW0823, Topo 40m grid Max error 20m.

BASIS FOR MODELLING

Corresponds to seismic reflector A7, the position of which in 3D space has been attained from Balu and Cosma (2005). Supported by borehole observations.

Outcrops: -

Boreholes:

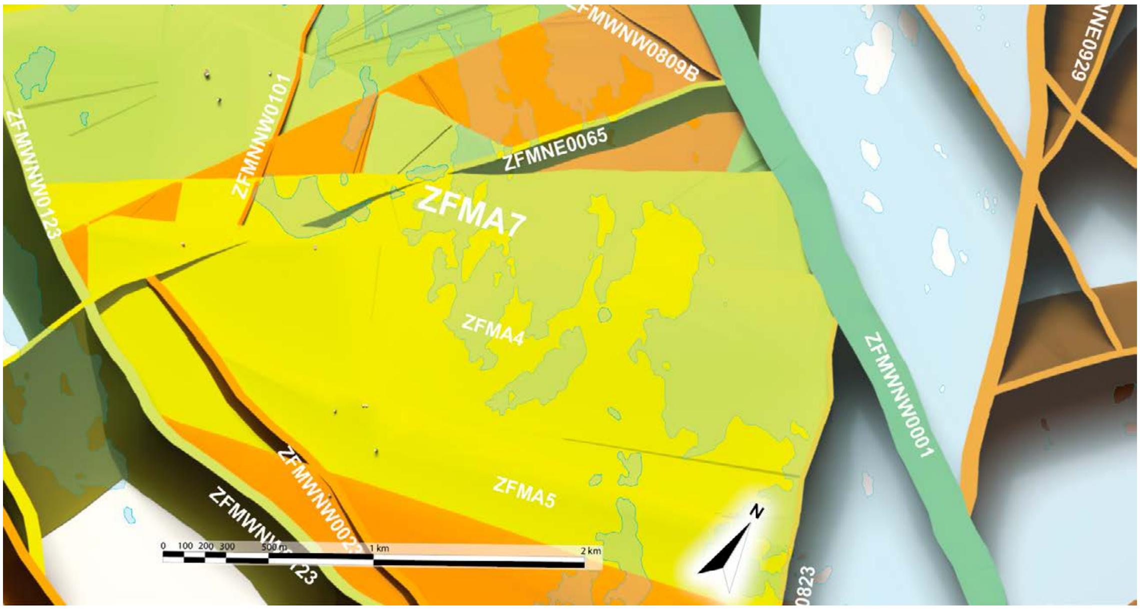
Borehole	PDZ	Target intercept		Geometric intercept		Comment
		Sec_up [m]	Sec_low [m]	Sec_up [m]	Sec_low [m]	
HFM18	DZ3	119.00	148.00	138.76	146.08	ZFMNE0065 also intersects DZ3.
KFM03A	DZ2	448.00	455.00	444.71	452.12	

Tunnels:	-	
Lineament and/or seismic indications:	A7.	3

MODELLING PROCEDURE

Corresponds to seismic reflector A7, the position of which in 3D space has been attained from Balu and Cosma (2005). Terminated against ZFMWNW0001, ZFMWNW0023, ZFMWNW0123, ZFMNNW0823 and ZFMNNE0828. Fixed point intersections at 450 m along DZ2 (448-455 m) in KFM03A and at 144 m along DZ3 (119-148 m) in HFM18. Low radar amplitude also observed at 450-505 m along DZ2 in KFM03A. The steeply dipping zone ZFMNE0065 is also modelled to intersect DZ3 in HFM18. For character and kinematics of DZ2 in KFM03A, see Nordgulen and Saintot (2006). DZ2 in KFM03A occurs in close spatial association with a thicker amphibolite body. Fine fracture network with quartz and epidote cut by open fracture with chlorite and corrensite occurs at 450-501 m. Apart from this narrow interval, which defines the fault core, the zone shows a “damage zone” character. Fault-slip data only observed on one steeply dipping fracture. The gently dipping fractures do not show evidence for shear deformation.".

G	ZFMA7	Version number	4	Total object CL	17



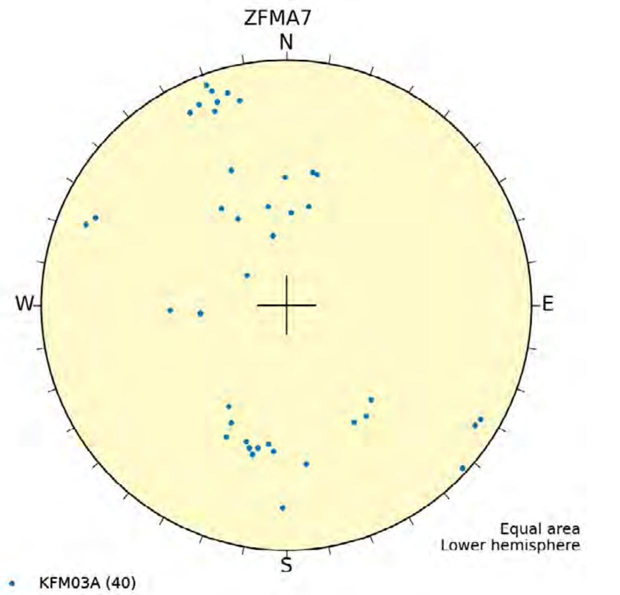
OBJECT CONFIDENCE ESTIMATE

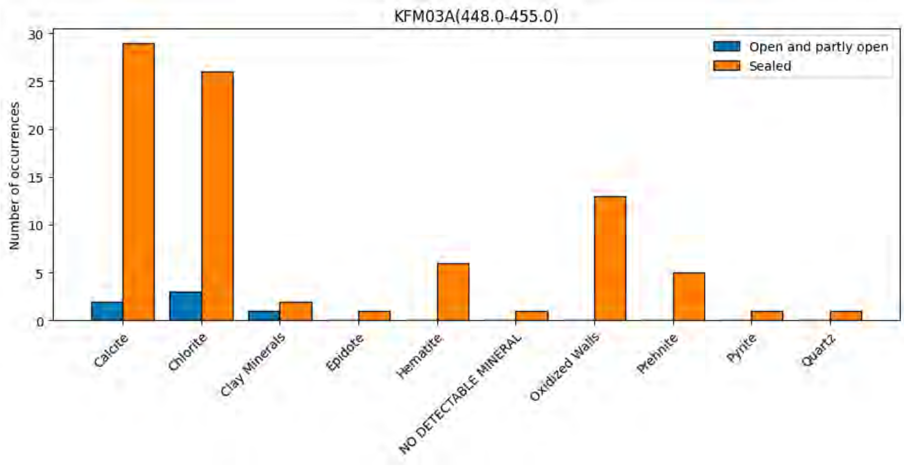
Category	Object CL	Comment
INTERPRETATION		
Data source	2	A7, HFM18, KFM03A
Results of interpretation	3	High confidence observation in KFM03A and HFM18.
INFORMATION DENSITY		
Number of observation points	2	2
Distribution of observation points	1	Two sub-surface obs. points c. 800m apart.
INTERPOLATION		
Geometry	3	One strong interpolation alternative due to two sub-surface obs. points supported by reflector.
Geological indicators	2	Some discrepancies in the geological data.
EXTRAPOLATION		
Dip direction	2	Conceptual constraints. Inferred truncation against surrounding steeply dipping zones ZFMWNW0023, ZFMWNW0123 ZFMWNW0001 ZFMNNW0823, ZFMNNE0828.
Strike direction	2	Conceptual constraints. Inferred truncation against surrounding steeply dipping zones ZFMWNW0023, ZFMWNW0123 ZFMWNW0001 ZFMNNW0823, ZFMNNE0828.

FRACTURE CHARACTER

Orientation: (strike/dip right-hand-rule)	--
Frequency:	Boreholes: KFM03A

FRACTURE TYPE	TERZAGHI-WEIGHED P10
Open and partly open	0.5 m-1
Sealed	16.1 m-1
Sealed network	0.0 % of DZ intercept
Crush	0.0 % of DZ intercept

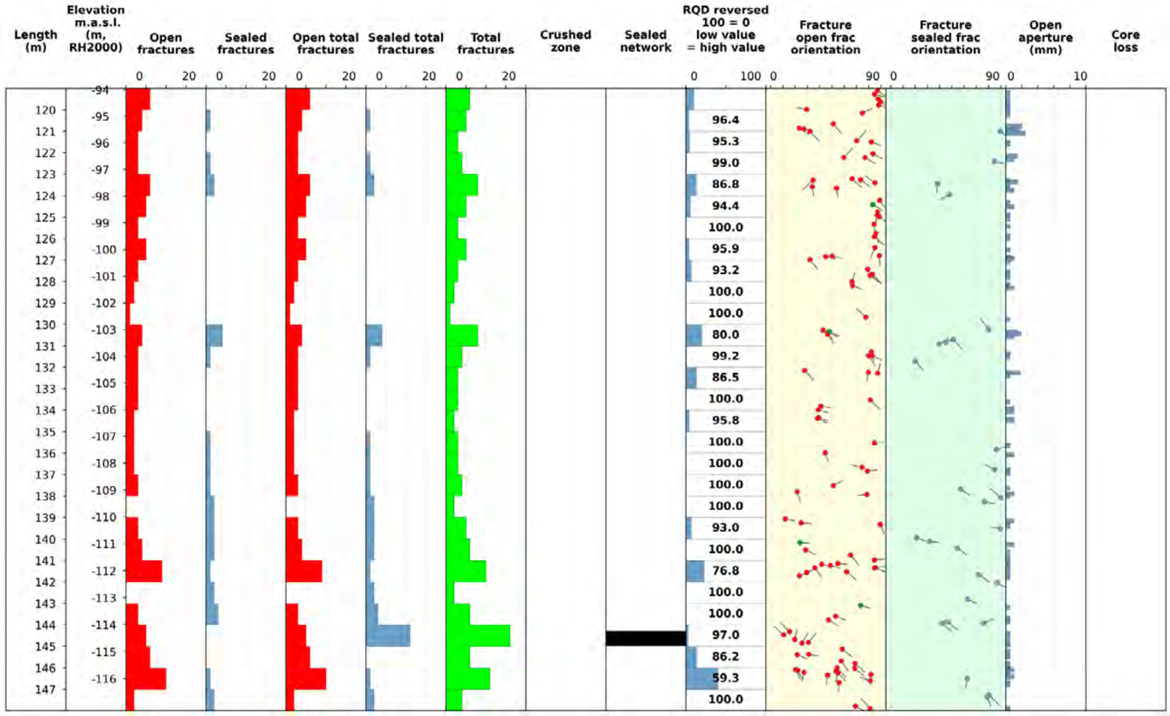


G	ZFMA7	Version number	4	Total object CL	17
RQD:	min:70, max:100, mean:96				
Fracture fill mineralogy:					

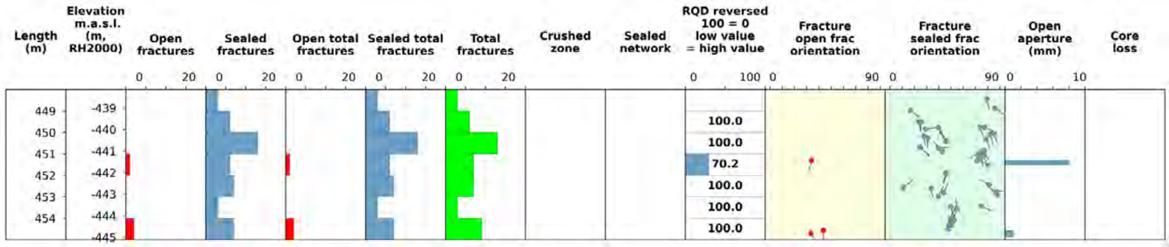
G	ZFMA7	Version number	4	Total object CL	17

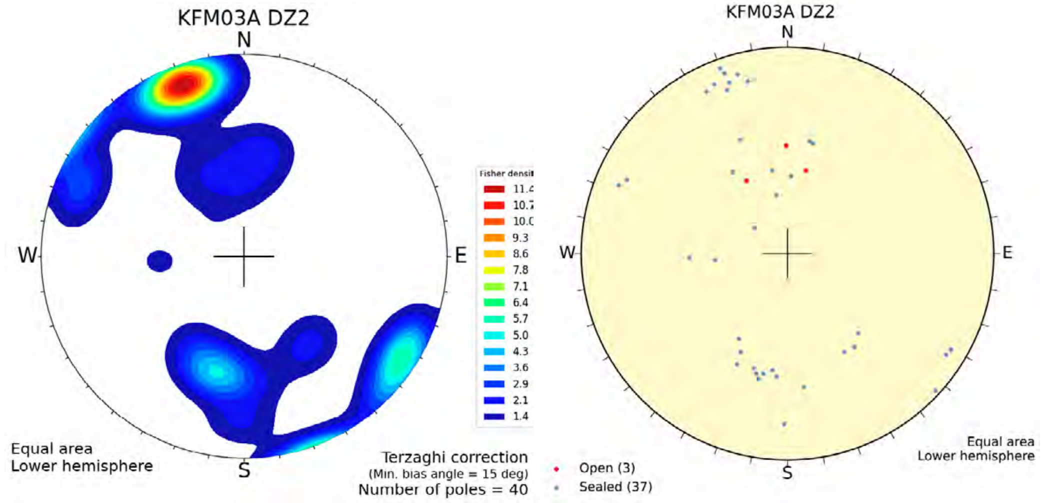
INDIVIDUAL INTERCEPTS

HFM18 DZ3 (119.0-148.0 m)



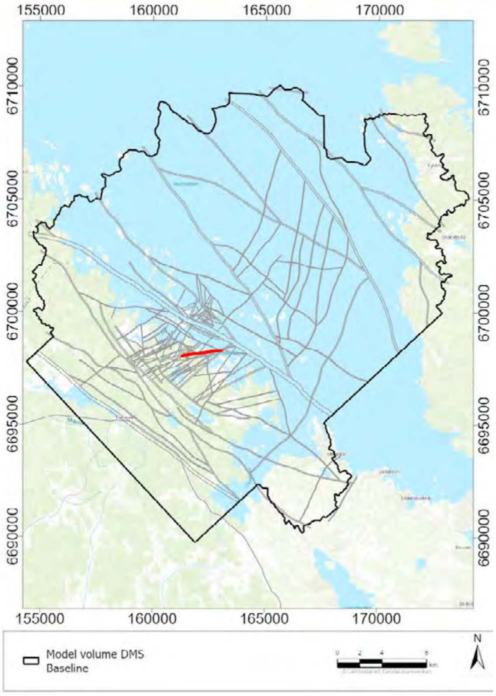
KFM03A DZ2 (448.0-455.0 m)





G	ZFMA8	Version number	5	Total object CL	16

GEOLOGICAL CHARACTER		Property CL
Deformation style:	Brittle	3
Deformation description:	Fault with moderate dip to the west shows a strong, reverse dip-slip component of movement. Strike-slip movement along steeply dipping fault that strikes SSE.	
Alteration:		3
- First order:	Oxidation	
- Second order:	Quartz dissolution	
- Third order:	Not observed	
Fracture orientation and type:	Gently dipping fractures and steeply dipping fractures that strike NNE dominates. Dominated by sealed followed by open and partly open fractures.	2
Fracture comment:	No data available.	
Fracture fill mineralogy:	Calcite, chlorite clay minerals pyrite asphaltite hematite/adularia clay minerals. Quartz is common along fractures that dip steeply to the ESE and epidote is present along fractures with gentle dips to the NW. Note also high frequency of fractures with no mineral coating/filling.	



OBJECT GEOMETRY	
Strike/dip:	82°/35°
Length:	1893 m
Mean thickness:	32 m (6 - 32 m)
Max depth:	-494 m
Geometrical constraints:	ZFMA3, ZFMENE0060A, Topo 40m grid Max error 20m, 1 UNIVERSE Planar Cut(s).

BASIS FOR MODELLING

Corresponds to seismic reflector A8 identified by Juhlin in Stephens and Skagius (2007). Supported by borehole observations.

Outcrops: -

Boreholes:

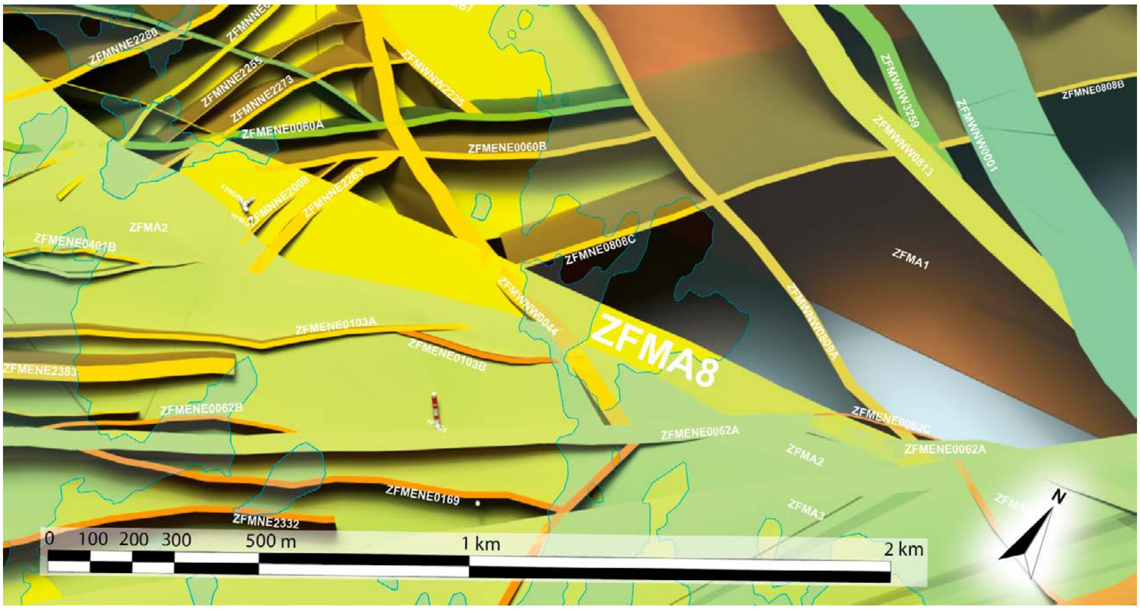
Borehole	PDZ	Target intercept		Geometric intercept		Comment
		Sec_up [m]	Sec_low [m]	Sec_up [m]	Sec_low [m]	
HFM16	DZ1	12.00	71.00	66.46	108.16	
KFM06A		51.00	51.00	52.37	88.33	No mapping or borehole image available for the interval. According to the drilling report (Claesson and Nilsson 2005) a flat-lying fracture zone at about 51 m.
KFM06B	DZ1	55.00	93.00	55.83	93.28	
KFM06C		57.00	57.00	44.36	78.37	No mapping or borehole image available for the interval. According to the drilling report (Claesson and Nilsson 2006) a gently dipping fracture zone at about 57 m.

Tunnels:	-	
Lineament and/or seismic indications:	A8.	2

G	ZFMA8	Version number	5	Total object CL	16

MODELLING PROCEDURE

Corresponds to seismic reflector A8 identified by Juhlin in Stephens and Skagius (2007). Termination against ZFMA3 and ZFMENE0060A. Reflector is not observed along profiles 1 and 4 (Juhlin in Stephens and Skagius 2007) and is, therefore, restricted in extent to the west. Inferred to intersect borehole intervals 55-93 m in KFM06B (DZ1) and 12-71 m in HFM16 (DZ1). Fixed point intersection placed at 57 m along KFM06B, where there is both a sealed fracture network and a crush zone.



OBJECT CONFIDENCE ESTIMATE

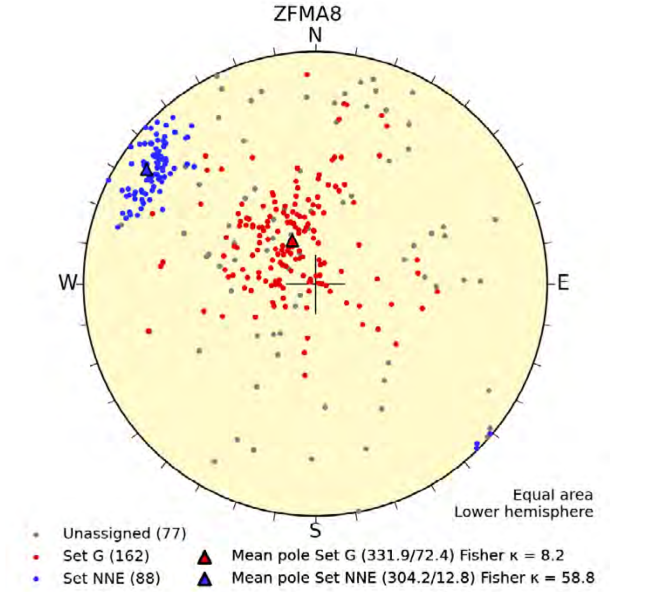
Category	Object CL	Comment
INTERPRETATION		
Data source	2	A8, HFM16, KFM06A, KFM06B, KFM06C
Results of interpretation	3	High confidence observation in HFM16 and KFM06B
INFORMATION DENSITY		
Number of observation points	3	4
Distribution of observation points	1	If there is a geometric coincidence between the seismic reflector and the borehole observation points, the reflector shall not be regarded as an observation point. Henceforth, reflector not considered as an outlier. Looking at the entire modelled zone, the observation points are restricted to most western part of the zone and perhaps can be considered as a cluster. Since the reflector is not considered an observation point in this case, all obs.points are restricted to a small area considering t
INTERPOLATION		
Geometry	1	None or more than two alternative observation points exist.
Geological indicators	2	Some discrepancies in the geological data.
EXTRAPOLATION		
Dip direction	2	Conceptual constraints. Inferred truncation against surrounding steeply and gently dipping zones.
Strike direction	2	Conceptual constraints. Inferred truncation against surrounding steeply and gently dipping zones ZFMENE0060A, ZFMA3.

G	ZFMA8	Version number	5	Total object CL	16

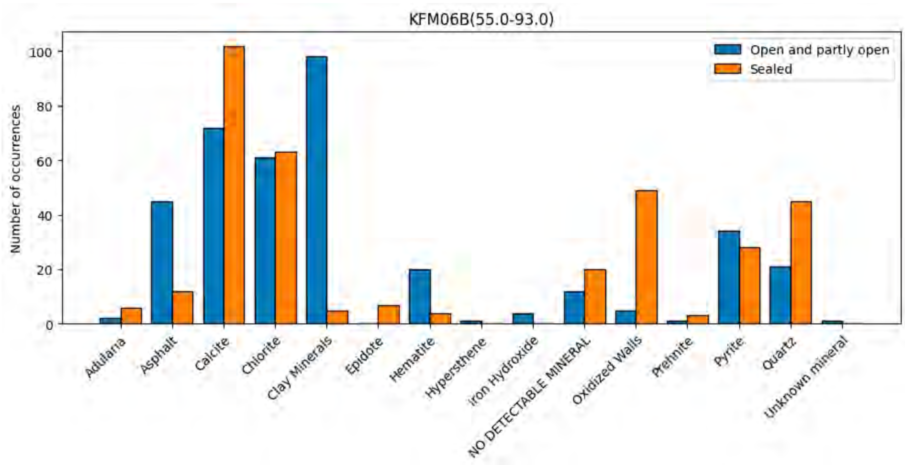
FRACTURE CHARACTER

Orientation: (strike/dip right-hand-rule)	Set G: 61.9°/17.6° Set NNE: 34.2°/77.2°
Frequency:	Boreholes: KFM06A, KFM06C, KFM06B

FRACTURE TYPE	TERZAGHI-WEIGHED P10
Open and partly open	2.3 m-1
Sealed	3.4 m-1
Sealed network	1.1 % of DZ intercept
Crush	0.6 % of DZ intercept

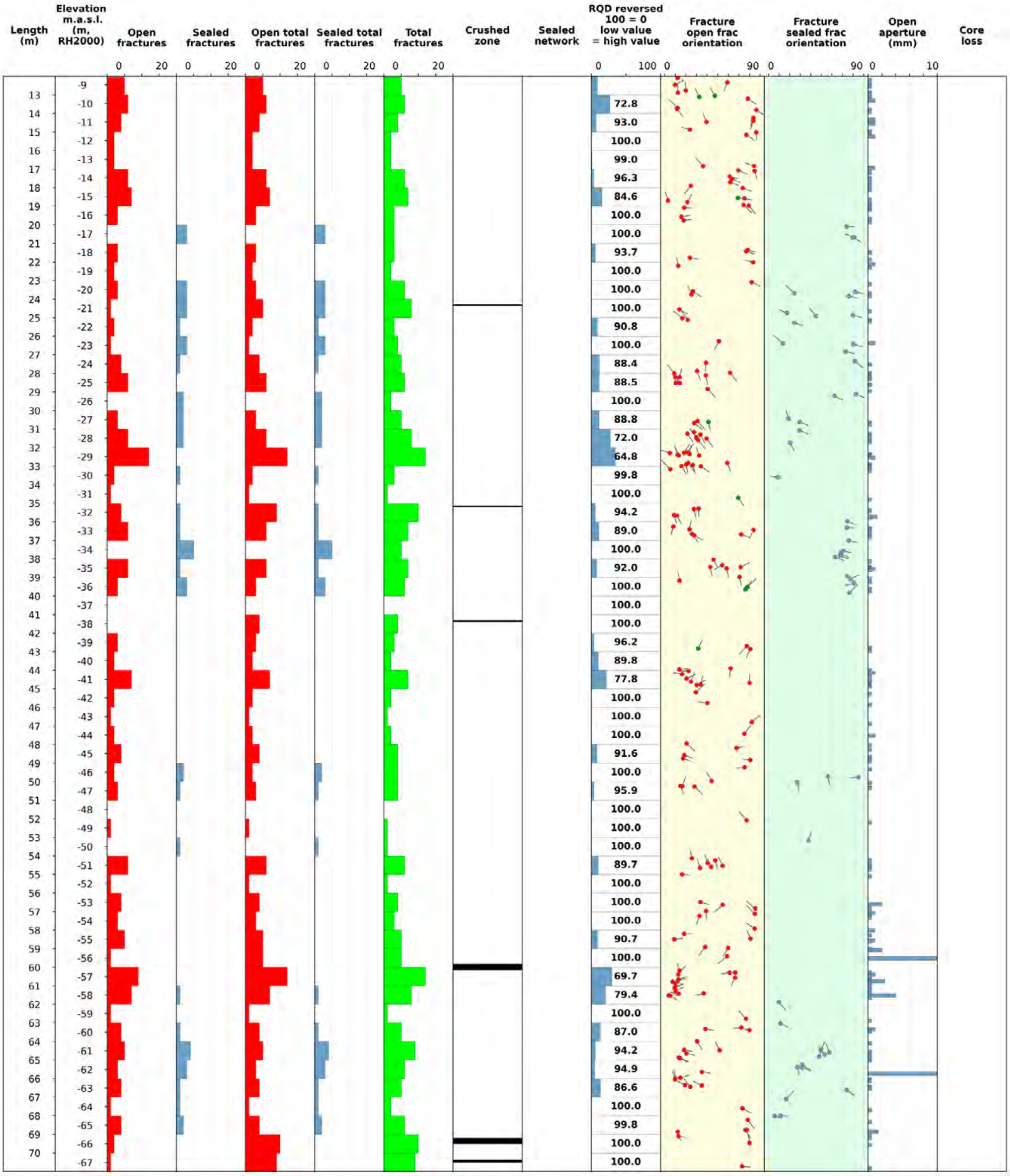


RQD:	min:45, max:100, mean:92
Fracture fill mineralogy:	



G	ZFMA8	Version number	5	Total object CL	16
INDIVIDUAL INTERCEPTS					

HFM16 DZ1 (12.0-71.0 m)

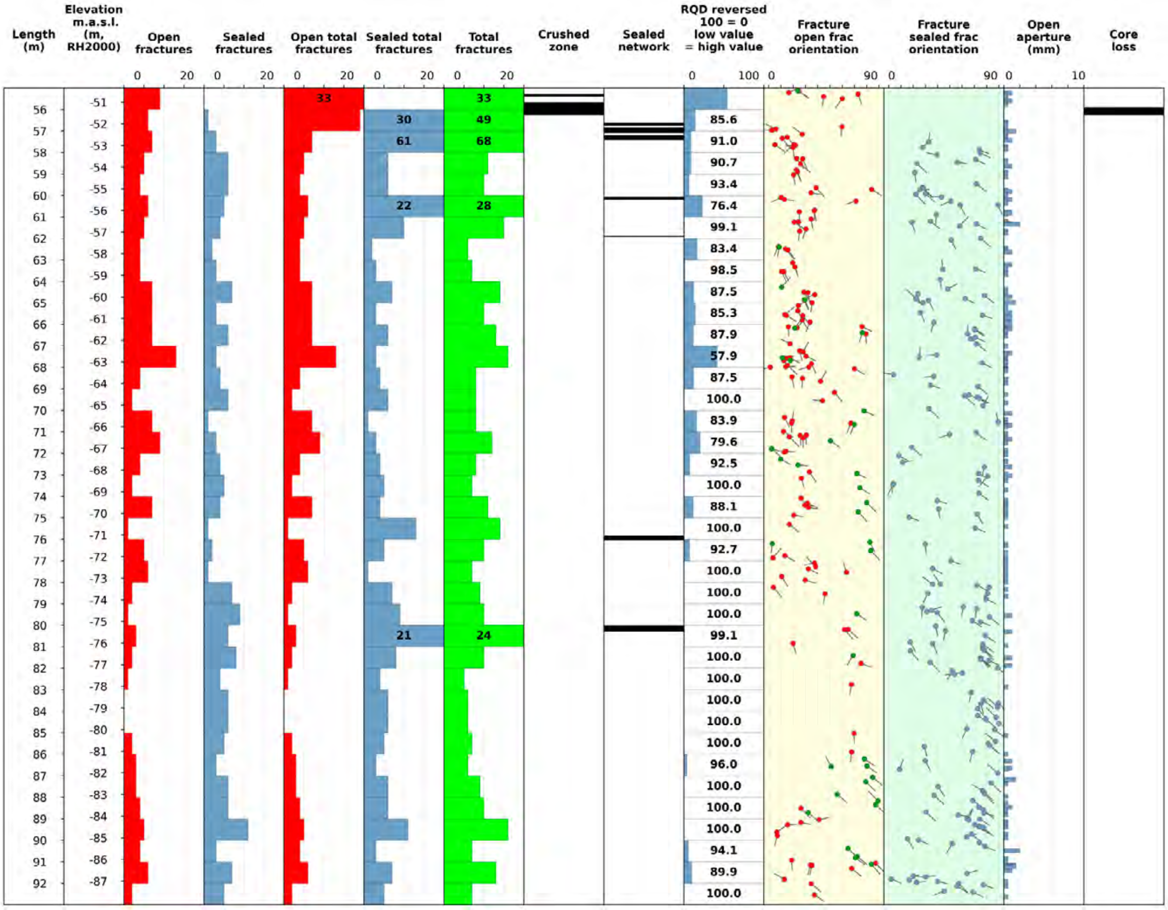


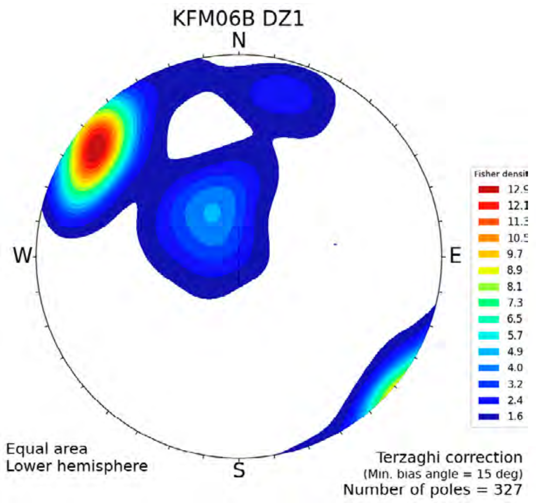
G	ZFMA8	Version number	5	Total object CL	16

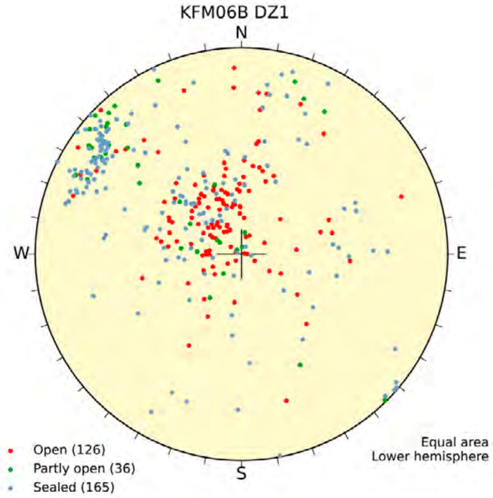
KFM06A (51.0-51.0 m)

No data available

KFM06B DZ1 (55.0-93.0 m)





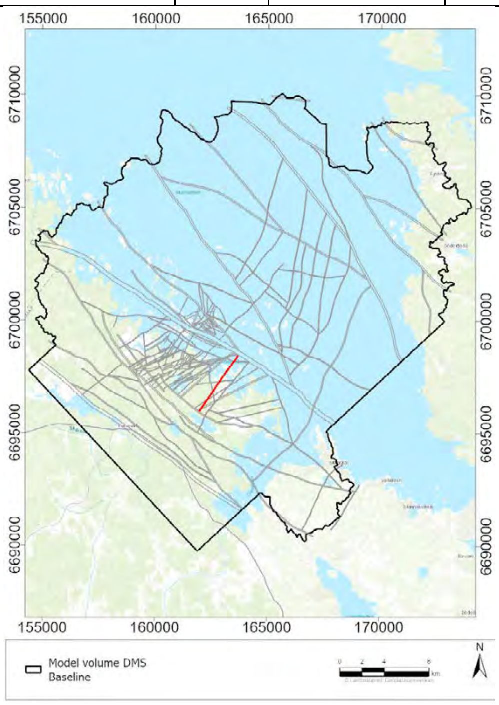


KFM06C (57.0-57.0 m)

No data available

G	ZFMB1	Version number	3	Total object CL	13

GEOLOGICAL CHARACTER		Property CL
Deformation style:	Brittle	3
Deformation description:	No data available.	
Alteration:		
- First order:	Oxidation	2
- Second order:	Not observed	
- Third order:	Not observed	
Fracture orientation and type:	Gently dipping fractures dominates. Variable orientation. Dominated by sealed followed by open fractures.	2
Fracture comment:	No data available.	
Fracture fill mineralogy:	Chlorite, calcite, prehnite, hematite/adularia, quartz, clay minerals. Epidote also present along one gently dipping fracture.	



OBJECT GEOMETRY	
Strike/dip:	34°/27°
Length:	3159 m
Mean thickness:	7 m (6 - 32 m)
Max depth:	-1491 m
Geometrical constraints:	ZFMWNW0123, ZFMWNW0023, ZFMWNW0001, ZFMA3, Topo 40m grid Max error 20m.

BASIS FOR MODELLING

Corresponds to seismic reflector B1, the position of which in 3D space has been attained from Cosma et al. (2003). Supported by a borehole observation.

Outcrops: -

Boreholes:

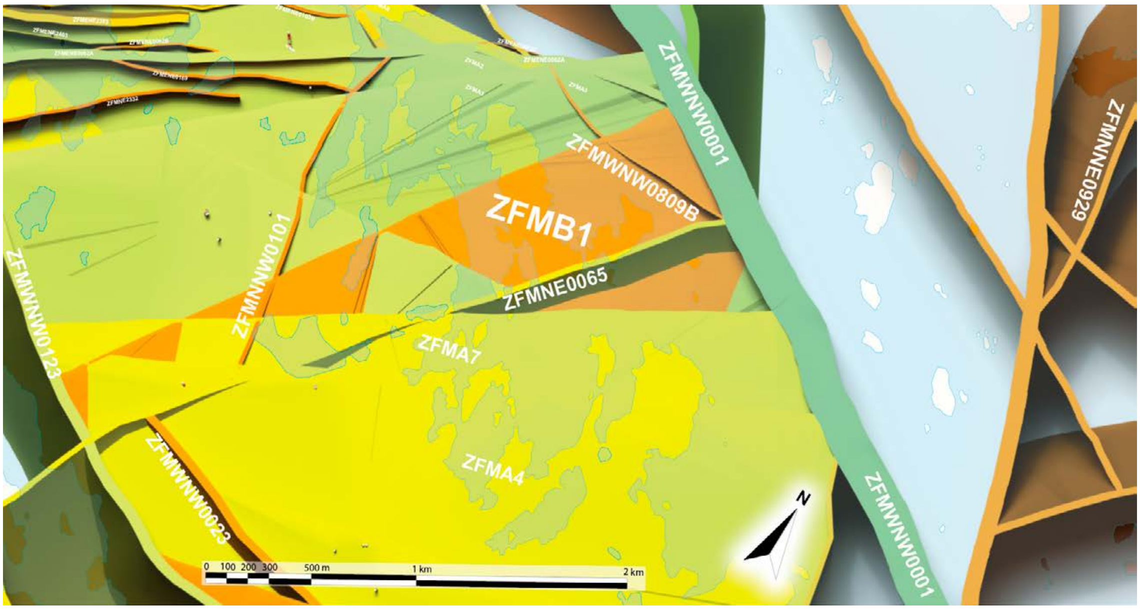
Borehole	PDZ	Target intercept		Geometric intercept		Comment
		Sec_up [m]	Sec_low [m]	Sec_up [m]	Sec_low [m]	
KFM03A	DZ3	638.00	646.00	639.24	646.75	

Tunnels:	-	
Lineament and/or seismic indications:	B1.	3

MODELLING PROCEDURE

Corresponds to seismic reflector B1, the position of which in 3D space has been attained from Cosma et al. (2003). Terminated against ZFMWNW0001, ZFMWNW0023, ZFMWNW0123 and ZFMA3. Fixed point intersection at 643 m along DZ3 (638-646 m) in KFM03A. Low radar amplitude also observed at 645-650 m along DZ3 in KFM03A.

G	ZFMB1	Version number	3	Total object CL	13



OBJECT CONFIDENCE ESTIMATE

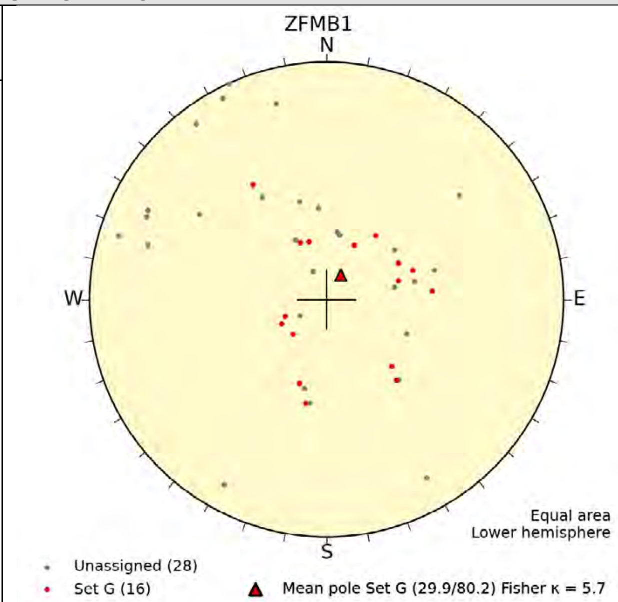
Category	Object CL	Comment
INTERPRETATION		
Data source	2	B1, KFM03A
Results of interpretation	3	High confidence observation in KFM03A.
INFORMATION DENSITY		
Number of observation points	1	1
Distribution of observation points	1	Single observation point at depth and a seismic reflector.
INTERPOLATION		
Geometry	1	Geometry supported by a lineament and a single intercept.
Geological indicators	1	Single observation point at depth. Zone modelled mainly based on surface geophysical data.
EXTRAPOLATION		
Dip direction	2	Conceptual constraints. Inferred truncation against surrounding steeply and dipping zones ZFMWNW0001 ZFMWNW0023, ZFMWNW0123.
Strike direction	2	Conceptual constraints. Inferred truncation against surrounding steeply and dipping zones ZFMWNW0001 ZFMWNW0023, ZFMWNW0123.

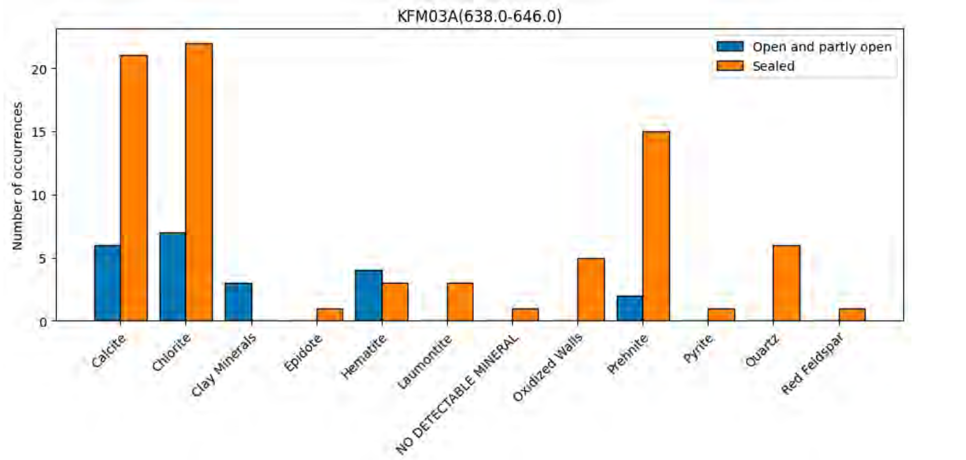
FRACTURE CHARACTER

Orientation: (strike/dip right-hand-rule): Set G: 119.9°/9.8°

Frequency: Boreholes: KFM03A

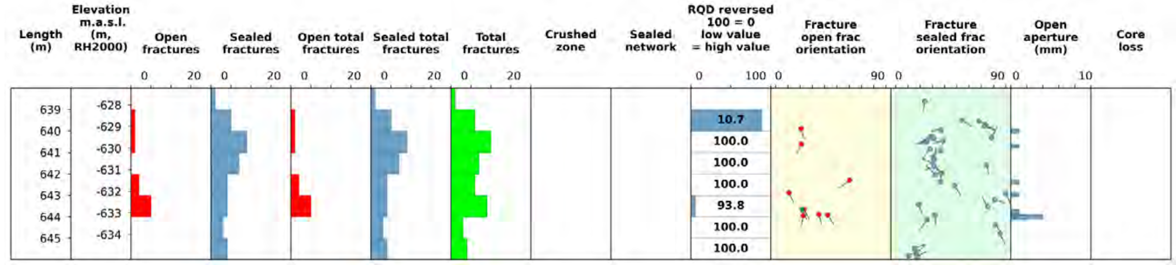
FRACTURE TYPE	TERZAGHI-WEIGHED P10
Open and partly open	1.4 m-1
Sealed	9.1 m-1
Sealed network	0.0 % of DZ intercept
Crush	0.0 % of DZ intercept

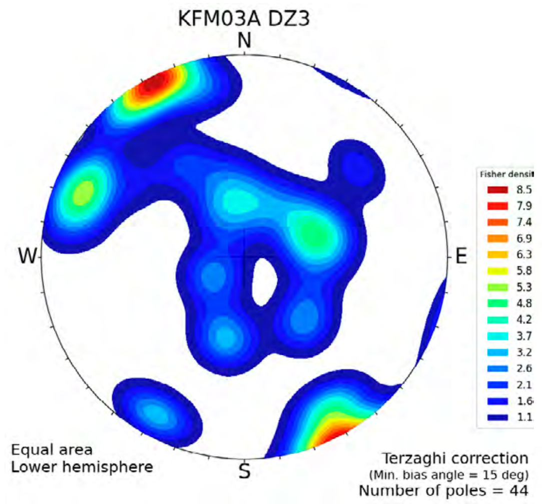


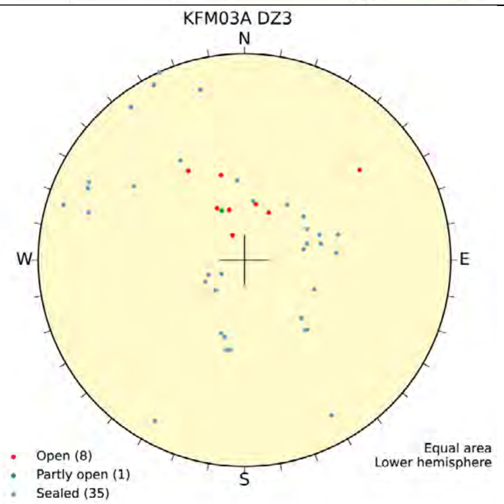
G	ZFMB1	Version number	3	Total object CL	13
RQD:	min:11, max:100, mean:88				
Fracture fill mineralogy:					

INDIVIDUAL INTERCEPTS

KFM03A DZ3 (638.0-646.0 m)

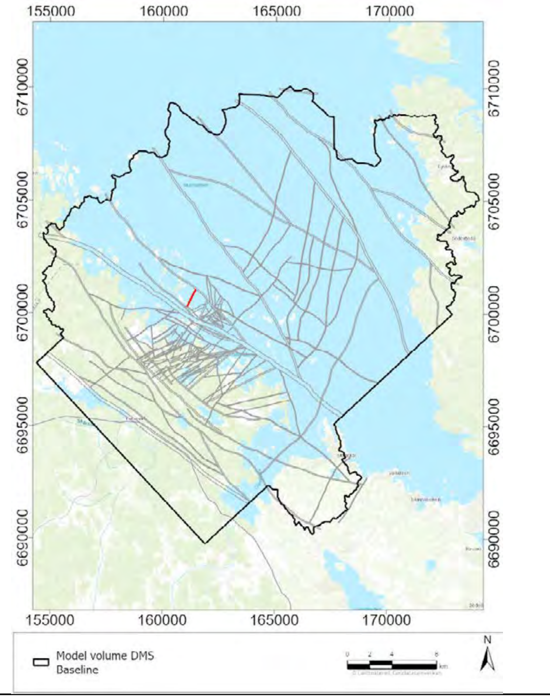






G	ZFMB10	Version number	5	Total object CL	10

GEOLOGICAL CHARACTER		Property CL
Deformation style:	Brittle	1
Deformation description:	No data available.	
Alteration:		
- First order:	Not observed	
- Second order:	Not observed	
- Third order:	Not observed	
Fracture orientation and type:	No data available.	
Fracture comment:	No data available.	
Fracture fill mineralogy:	No data available.	
OBJECT GEOMETRY		
Strike/dip:	27°/35°	
Length:	892 m	
Mean thickness:	10 m (6 - 32 m)	
Max depth:	-1479 m	
Geometrical constraints:	ZFMWNW0001, ZFMWNW1035, ZFMNW0805A, ZFMNW0805B, Topo 40m grid Max error 20m, ZFMNE0808B.	

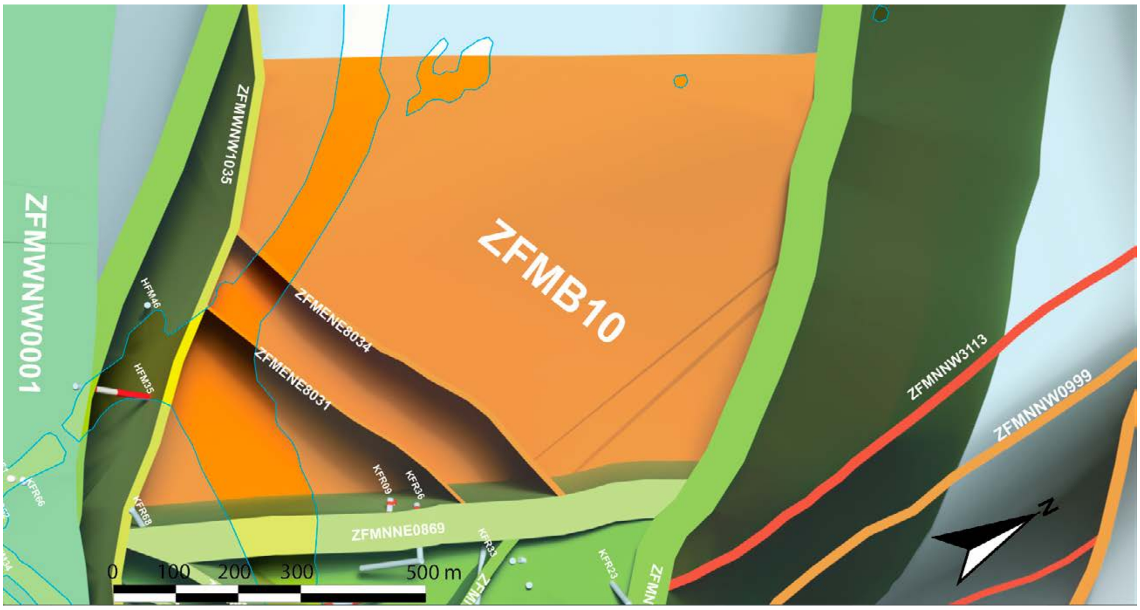


BASIS FOR MODELLING		
The modelled zone is based on the reprocessed seismic data and resulting reflector geometry as reported by Juhlin and Zhang (2010).		
Outcrops:	-	
Boreholes: -		
Tunnels:	-	
Lineament and/or seismic indications:	B10.	2

MODELLING PROCEDURE

The modelled zone is based on the reprocessed seismic data and resulting reflector geometry as reported by Juhlin and Zhang (2010). The main conclusion from the report is that a new reflection (B10) has been identified that may extend below the SFR site. This reflection was not clearly observed in the previous processing Juhlin and Palm (2005). The reflection is oriented approximately 025°/35°. This orientation is similar to the set B group identified earlier Juhlin and Palm (2005). Note that the dip of the reflection is uncertain. On shot gathers it appears to dip at a slightly shallower angle while on the stacked sections it appears to dip at a greater angle. This discrepancy is probably due to the crooked nature of the profiles. However, reflections are clearly observed in shot gathers and its presence below SFR is highly probable. See Juhlin and Zhang (2010) for further details. In accordance with earlier modelling work at Forsmark, ZFMB10 has been terminated against the major WNW-ESE and NW-SE, composite ductile and brittle deformation zones (ZFMWNW0001, ZFMWNW1035, ZFMNW0805A and ZFMNW0805B).

G	ZFMB10	Version number	5	Total object CL	10



OBJECT CONFIDENCE ESTIMATE

Category	Object CL	Comment
INTERPRETATION		
Data source	1	B10
Results of interpretation	2	Medium confidence in the seismic reflector B10.
INFORMATION DENSITY		
Number of observation points	1	1
Distribution of observation points	1	Single observation point in the form of a seismic reflector.
INTERPOLATION		
Geometry	1	Geometry supported by seismic data. No sub-surface obs. point available.
Geological indicators	1	Indirect support by geophysical data.
EXTRAPOLATION		
Dip direction	1	Extrapolated based on information from seismic reflector B10. Truncated by steeply dipping zones ZFMWNW0001, ZFMWNW1035, ZFMNW0805A, ZFMNW0805B and ZFMNE0808B.
Strike direction	2	Conceptual constraints. Truncated by steeply dipping zones ZFMWNW0001, ZFMWNW1035, ZFMNW0805A, ZFMNW0805B and ZFMNE0808B.

FRACTURE CHARACTER

No data available

INDIVIDUAL INTERCEPTS

No data available

G	ZFMB23-e	Version number	3	Total object CL	11

GEOLOGICAL CHARACTER		Property CL
Deformation style:	Brittle-Ductile	1
Deformation description:	No data available.	
Alteration:		
- First order:	Not observed	
- Second order:	Not observed	
- Third order:	Not observed	
Fracture orientation and type:	No data available.	
Fracture comment:	No data available.	
Fracture fill mineralogy:	No data available.	
OBJECT GEOMETRY		
Strike/dip:	30°/25°	
Length:	-	
Mean thickness:	15 m (6 - 32 m)	
Max depth:	-2100 m	
Geometrical constraints:	ZFMWNW0001, ZFMNE0065, ZFMNNW0823, ZFMWNW0023, Topo 40m grid Max error 20m.	

No figure available

BASIS FOR MODELLING

Corresponds to seismic reflectors B2 and B3, which have been combined into a single zone with two separate segments east and west of zone ZFMNE0065. The positions of these reflectors in 3D space have been attained from Cosma et al. (2003).

Outcrops:	-	
Boreholes: -		
Tunnels:	-	
Lineament and/or seismic indications:	B2, B3.	3

MODELLING PROCEDURE

Corresponds to seismic reflectors B2 and B3, which have been combined into a single zone with two separate segments east and west of zone ZFMNE0065. The positions of these reflectors in 3D space have been attained from Cosma et al.(2003). Modelled to the base of the model volume with termination against ZFMWNW0001, ZFMWNW0023, ZFMNE0065 and ZFMNNW0823 in the eastern segment; and ZFMWNW0001, ZFMNNW0101 and ZFMNE0065 in the western segment.

No figure available.

OBJECT CONFIDENCE ESTIMATE

Category	Object CL	Comment
INTERPRETATION		
Data source	1	B2, B3
Results of interpretation	3	High confidence in the seismic reflector B2,B3.
INFORMATION DENSITY		
Number of observation points	1	1
Distribution of observation points	1	Single observation point in the form of a seismic reflector.
INTERPOLATION		
Geometry	1	Geometry supported by seismic data. No sub-surface obs. point available.
Geological indicators	1	Indirect support by geophysical data.
EXTRAPOLATION		
Dip direction	1	Extrapolated based on information from seismic reflector B2 and B3. Truncated by steeply dipping zones ZFMWNW0001, ZFMNE0065, ZFMNNW0101.
Strike direction	2	Conceptual constraints. Truncated by steeply dipping zones ZFMWNW0001, ZFMNE0065, ZFMNNW0101.

FRACTURE CHARACTER

No data available

INDIVIDUAL INTERCEPTS

No data available

G	ZFMB23-w	Version number	4	Total object CL	11

GEOLOGICAL CHARACTER		Property CL
Deformation style:	Brittle	1
Deformation description:	No data available.	
Alteration:		
- First order:	Not observed	
- Second order:	Not observed	
- Third order:	Not observed	
Fracture orientation and type:	No data available.	
Fracture comment:	No data available.	
Fracture fill mineralogy:	No data available.	

No figure available

OBJECT GEOMETRY

Strike/dip:	30°/25°
Length:	-
Mean thickness:	15 m (6 - 32 m)
Max depth:	-1185 m
Geometrical constraints:	ZFMWNW0001, ZFMNE0065, ZFMNNW0101, Topo 40m grid Max error 20m, 1 UNIVERSE Planar Cut(s).

BASIS FOR MODELLING

Corresponds to seismic reflectors B2 and B3, which have been combined into a single zone with two separate segments east and west of zone ZFMNE0065. The positions of these reflectors in 3D space have been attained from Cosma et al. (2003).

Outcrops:	-	
Boreholes: -		
Tunnels:	-	
Lineament and/or seismic indications:	B2, B3.	3

MODELLING PROCEDURE

Corresponds to seismic reflectors B2 and B3, which have been combined into a single zone with two separate segments east and west of zone ZFMNE0065. The positions of these reflectors in 3D space have been attained from Cosma et al.(2003). Modelled to the base of the model volume with termination against ZFMWNW0001, ZFMWNW0023, ZFMNE0065 and ZFMNNW0823 in the eastern segment; and ZFMWNW0001, ZFMNNW0101 and ZFMNE0065 in the western segment.

No figure available.

OBJECT CONFIDENCE ESTIMATE

Category	Object CL	Comment
INTERPRETATION		
Data source	1	B2, B3
Results of interpretation	3	High confidence in the seismic reflector B2,B3.
INFORMATION DENSITY		
Number of observation points	1	1
Distribution of observation points	1	Single observation point in the form of a seismic reflector.
INTERPOLATION		
Geometry	1	Geometry supported by surface geophysical data.
Geological indicators	1	Indirect support by geophysical data.
EXTRAPOLATION		
Dip direction	1	Extrapolated based on information from seismic reflector B2 and B3. Truncated by steeply dipping zones ZFMWNW0001, ZFMNE0065, ZFMNNW0101.
Strike direction	2	Conceptual constraints. Truncated by steeply dipping zones ZFMWNW0001, ZFMNE0065, ZFMNNW0101.

FRACTURE CHARACTER

No data available

INDIVIDUAL INTERCEPTS

No data available

G	ZFMB4	Version number	3	Total object CL	13

GEOLOGICAL CHARACTER		Property CL
Deformation style:	Brittle	3
Deformation description:	Gently south-east and south dipping faults show dip-slip sense of movement. Reverse dip-slip movement along two of these faults.	
Alteration:		
- First order:	Not observed	
- Second order:	Not observed	
- Third order:	Not observed	
Fracture orientation and type:	Fractures show variable orientation. No mean value calculated. Dominated by sealed followed by open and partly open fractures.	2
Fracture comment:	No data available.	
Fracture fill mineralogy:	Chlorite, calcite, clay minerals. Quartz and prehnite along more steeply dipping fractures.	

No figure available

OBJECT GEOMETRY	
Strike/dip:	52°/29°
Length:	-
Mean thickness:	12 m (6 - 32 m)
Max depth:	-1874 m
Geometrical constraints:	ZFMWNW0001, ZFMWNW0123, ZFMENE0062A, ZFMNE0065.

BASIS FOR MODELLING

Corresponds to seismic reflector B4, the position of which in 3D space has been attained from Cosma et al. (2003). Supported by a borehole observation.

Outcrops: -

Boreholes:

Borehole	PDZ	Target intercept		Geometric intercept		Comment
		Sec_up [m]	Sec_low [m]	Sec_up [m]	Sec_low [m]	
KFM02A	DZ8	893.00	905.00	892.69	904.99	

Tunnels:	-	
Lineament and/or seismic indications:	B4.	3

MODELLING PROCEDURE

Corresponds to seismic reflector B4, the position of which in 3D space has been attained from Cosma et al. (2003). Terminated against ZFMWNW0001, ZFMENE0062A, ZFMNE0065 and ZFMWNW0123. Deformation zone plane placed at fixed point 903 m along DZ8 (893-905 m) in KFM02A.

No figure available.

OBJECT CONFIDENCE ESTIMATE

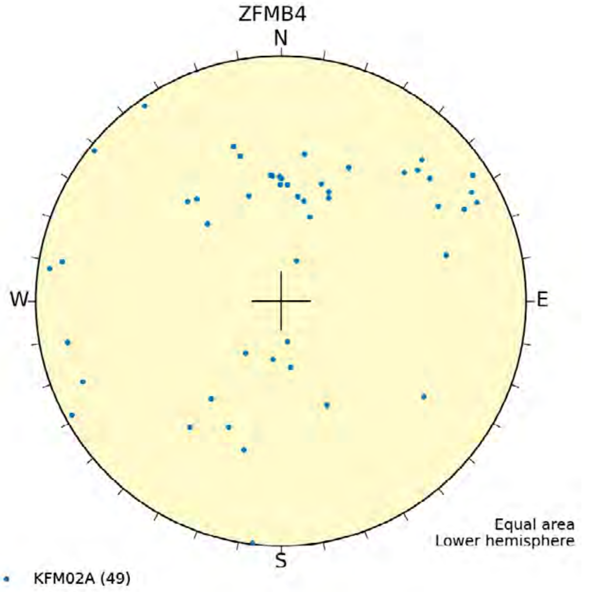
Category	Object CL	Comment
INTERPRETATION		
Data source	2	B4, KFM02A
Results of interpretation	3	High confidence observation in KFM02A.
INFORMATION DENSITY		
Number of observation points	1	1
Distribution of observation points	1	Single observation point at depth and a seismic reflector.
INTERPOLATION		
Geometry	1	Geometry supported by surface geophysical data.
Geological indicators	1	Indirect support by geophysical data.
EXTRAPOLATION		
Dip direction	2	Conceptual constraints. Inferred truncation against surrounding steeply dipping zones ZFMWNW0001, ZFMWNW0123, ZFMENE0062A, ZFMNE0065.
Strike direction	2	Conceptual constraints. Inferred truncation against surrounding steeply dipping zones ZFMWNW0001, ZFMWNW0123, ZFMENE0062A, ZFMNE0065.

G	ZFMB4	Version number	3	Total object CL	13

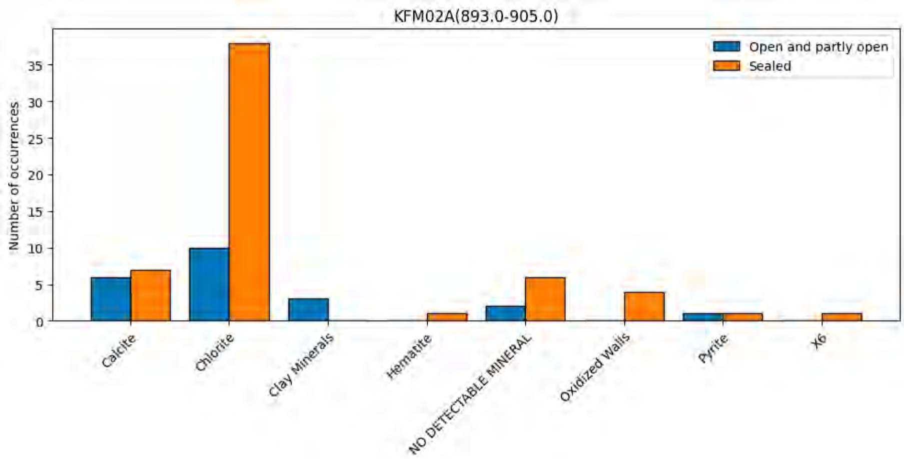
FRACTURE CHARACTER

Orientation: (strike/dip right-hand-rule)	--	
Frequency:	Boreholes: KFM02A	
RQD:	min:69, max:100, mean:97	

FRACTURE TYPE	TERZAGHI-WEIGHED P10
Open and partly open	1.8 m-1
Sealed	8.6 m-1
Sealed network	0.0 % of DZ intercept
Crush	0.0 % of DZ intercept



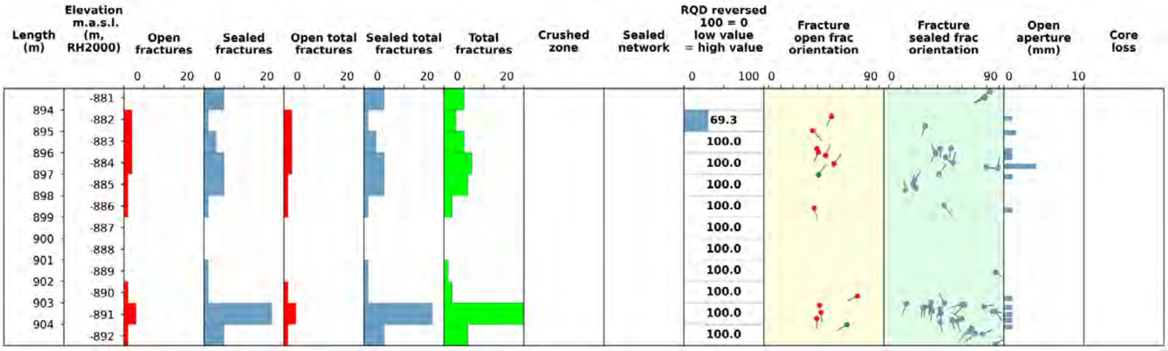
Fracture fill mineralogy:

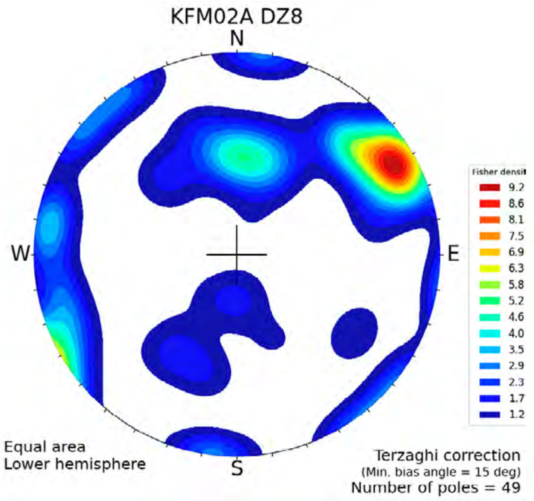


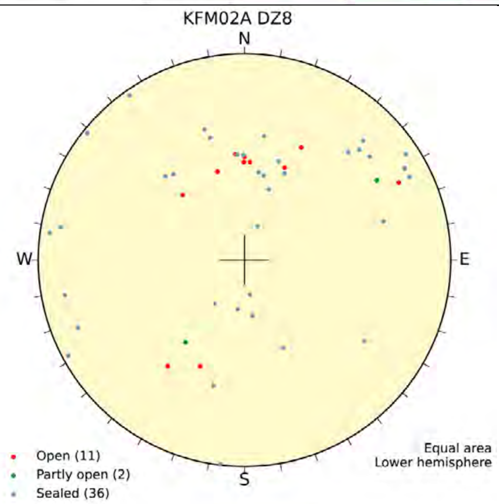
G	ZFMB4	Version number	3	Total object CL	13

INDIVIDUAL INTERCEPTS

KFM02A DZ8 (893.0-905.0 m)







G	ZFMB5-e	Version number	3	Total object CL	11

GEOLOGICAL CHARACTER		Property CL
Deformation style:	Brittle	1
Deformation description:	No data available.	
Alteration:		
- First order:	Not observed	
- Second order:	Not observed	
- Third order:	Not observed	
Fracture orientation and type:	No data available.	
Fracture comment:	No data available.	
Fracture fill mineralogy:	No data available.	

No figure available

OBJECT GEOMETRY

Strike/dip:	58°/18°
Length:	-
Mean thickness:	15 m (6 - 32 m)
Max depth:	-2100 m
Geometrical constraints:	ZFMWNW0001, ZFMNE0065, ZFMNNW0823, ZFMWNW0023, Topo 40m grid Max error 20m.

BASIS FOR MODELLING

Corresponds to seismic reflector B5, which has been divided into two separate segments east and west of zone ZFMNE0065.

Outcrops:	-	
Boreholes: -		
Tunnels:	-	
Lineament and/or seismic indications:	B5.	3

MODELLING PROCEDURE

Corresponds to seismic reflector B5, which has been divided into two separate segments east and west of zone ZFMNE0065. The position of the reflector in 3D space has been attained from Cosma et al. (2003). Modelled to the base of the model volume with termination against ZFMWNW0001, ZFMWNW0023, ZFMNE0065, ZFMNNW0823 and ZFMNNW0101 in the eastern segment; and ZFMNNW0101 and ZFMNE0065 in the western segment.

No figure available.

OBJECT CONFIDENCE ESTIMATE

Category	Object CL	Comment
INTERPRETATION		
Data source	1	B5
Results of interpretation	3	High confidence in seismic reflector B5.
INFORMATION DENSITY		
Number of observation points	1	1
Distribution of observation points	1	Single observation point in the form of a seismic reflector.
INTERPOLATION		
Geometry	1	Geometry supported by surface geophysical data.
Geological indicators	1	Indirect support by geophysical data.
EXTRAPOLATION		
Dip direction	1	Extrapolated based on information from seismic reflector B5. Truncated by steeply dipping zones ZFMWNW0001, ZFMNE0065, ZFMNNW0823, ZFMWNW0023.
Strike direction	2	Conceptual constraints. Truncated by steeply dipping zones ZFMWNW0001, ZFMNE0065, ZFMNNW0823, ZFMWNW0023.

FRACTURE CHARACTER

No data available

INDIVIDUAL INTERCEPTS

No data available

G	ZFMB5-w	Version number	4	Total object CL	11

GEOLOGICAL CHARACTER		Property CL
Deformation style:	Brittle	1
Deformation description:	No data available.	
Alteration:		
- First order:	Not observed	
- Second order:	Not observed	
- Third order:	Not observed	
Fracture orientation and type:	No data available.	
Fracture comment:	No data available.	
Fracture fill mineralogy:	No data available.	
OBJECT GEOMETRY		
Strike/dip:	58°/18°	
Length:	-	
Mean thickness:	15 m (6 - 32 m)	
Max depth:	-1992 m	
Geometrical constraints:	ZFMWNW0001, ZFMNE0065, ZFMNNW0101, Topo 40m grid Max error 20m, 1 UNIVERSE Planar Cut(s).	

No figure available

BASIS FOR MODELLING

Corresponds to seismic reflector B5, which has been divided into two separate segments east and west of zone ZFMNE0065.

Outcrops:	-	
Boreholes: -		
Tunnels:	-	
Lineament and/or seismic indications:	B5.	3

MODELLING PROCEDURE

Corresponds to seismic reflector B5, which has been divided into two separate segments east and west of zone ZFMNE0065. The position of the reflector in 3D space has been attained from Cosma et al. (2003). Modelled to the base of the model volume with termination against ZFMWNW0001, ZFMWNW0023, ZFMNE0065, ZFMNNW0823 and ZFMNNW0101 in the eastern segment; and ZFMNNW0101 and ZFMNE0065 in the western segment.

No figure available.

OBJECT CONFIDENCE ESTIMATE

Category	Object CL	Comment
INTERPRETATION		
Data source	1	B5
Results of interpretation	3	High confidence in seismic reflector B5.
INFORMATION DENSITY		
Number of observation points	1	1
Distribution of observation points	1	Single observation point in the form of a seismic reflector.
INTERPOLATION		
Geometry	1	Geometry supported by surface geophysical data.
Geological indicators	1	Indirect support by geophysical data.
EXTRAPOLATION		
Dip direction	1	Extrapolated based on information from seismic reflector B5. Terminated against ZFMWNW0001, ZFMNE0065, ZFMNNW0101.
Strike direction	2	Conceptual constraints. Terminated against ZFMWNW0001, ZFMNE0065, ZFMNNW0101.

FRACTURE CHARACTER

No data available

INDIVIDUAL INTERCEPTS

No data available

G	ZFMB6	Version number	3	Total object CL	11

GEOLOGICAL CHARACTER		Property CL
Deformation style:	Brittle	1
Deformation description:	No data available.	
Alteration:		
- First order:	Not observed	
- Second order:	Not observed	
- Third order:	Not observed	
Fracture orientation and type:	No data available.	
Fracture comment:	No data available.	
Fracture fill mineralogy:	No data available.	

No figure available

OBJECT GEOMETRY	
Strike/dip:	32°/32°
Length:	-
Mean thickness:	15 m (6 - 32 m)
Max depth:	-2100 m
Geometrical constraints:	ZFMWNW0001, ZFMNNW0823, ZFMNE0065, ZFMWNW0023.

BASIS FOR MODELLING

Corresponds to seismic reflector B6, the position of which in 3D space has been attained from Balu and Cosma (2005).

Outcrops:	-	
Boreholes: -		
Tunnels:	-	
Lineament and/or seismic indications:	B6.	3

MODELLING PROCEDURE

Corresponds to seismic reflector B6, the position of which in 3D space has been attained from Balu and Cosma (2005). Modelled to the base of the model volume with termination against ZFMWNW0001, ZFMWNW0023, ZFMNE0065 and ZFMNNW0823.

No figure available.

OBJECT CONFIDENCE ESTIMATE

Category	Object CL	Comment
INTERPRETATION		
Data source	1	B6
Results of interpretation	3	High confidence in seismic reflector B6.
INFORMATION DENSITY		
Number of observation points	1	1
Distribution of observation points	1	Single observation point in the form of a seismic reflector.
INTERPOLATION		
Geometry	1	Geometry supported by surface geophysical data.
Geological indicators	1	Indirect support by geophysical data.
EXTRAPOLATION		
Dip direction	1	Extrapolated based on information from seismic reflector B6. Truncated by steeply dipping zones ZFMWNW0001, ZFMNE0065, ZFMNNW0823, ZFMWNW0023.
Strike direction	2	Conceptual constraints. Truncated by steeply dipping zones ZFMWNW0001, ZFMNE0065, ZFMNNW0823, ZFMWNW0023.

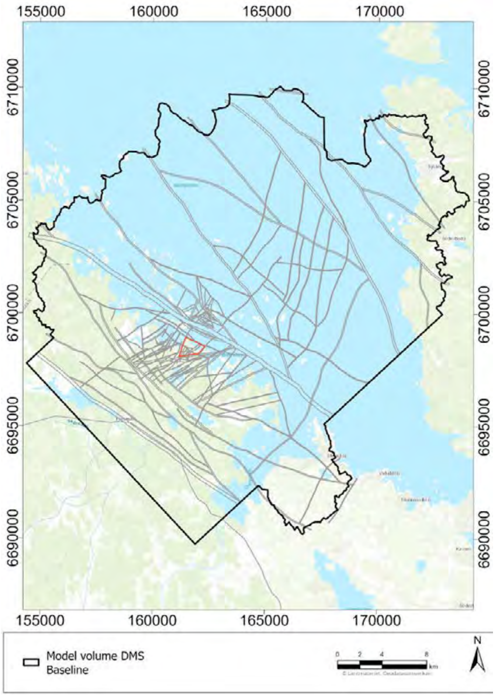
FRACTURE CHARACTER

No data available

INDIVIDUAL INTERCEPTS

No data available

G	ZFMB7	Version number	5	Total object CL	16



GEOLOGICAL CHARACTER		Property CL
Deformation style:	Brittle	3
Deformation description:	Gently dipping fault shows dip-slip and oblique-slip with a reverse component. Steeply dipping faults with SW strike shows a dominant dextral strike-slip with a oblique component.	
Alteration:		3
- First order:	Oxidation	
- Second order:	Quartz dissolution	
- Third order:	Not observed	
Fracture orientation and type:	Two sets of fractures are conspicuous. One of these sets strikes SSW and dips steeply to the WNW, the other is gently dipping. Dominated by sealed followed by open and partly open fractures.	2
Fracture comment:	No data available.	
Fracture fill mineralogy:	Calcite and chlorite. Clay minerals, pyrite, prehnite, hematite/adularia, epidote and laumontite are also locally present. Note also fractures with no mineral coating/filling.	

OBJECT GEOMETRY	
Strike/dip:	1°/20°
Length:	-
Mean thickness:	28 m (6 - 32 m)
Max depth:	-543 m
Geometrical constraints:	ZFMWNW0809A, Trunc_B7_1, ZFMENE0401A, ZFMNNE0725, Trunc_B7_2.

BASIS FOR MODELLING

Corresponds to seismic reflector B7, the position of which in 3D space has been attained from Balu and Cosma (2005). Supported by borehole observations.

Outcrops:	-

Boreholes:

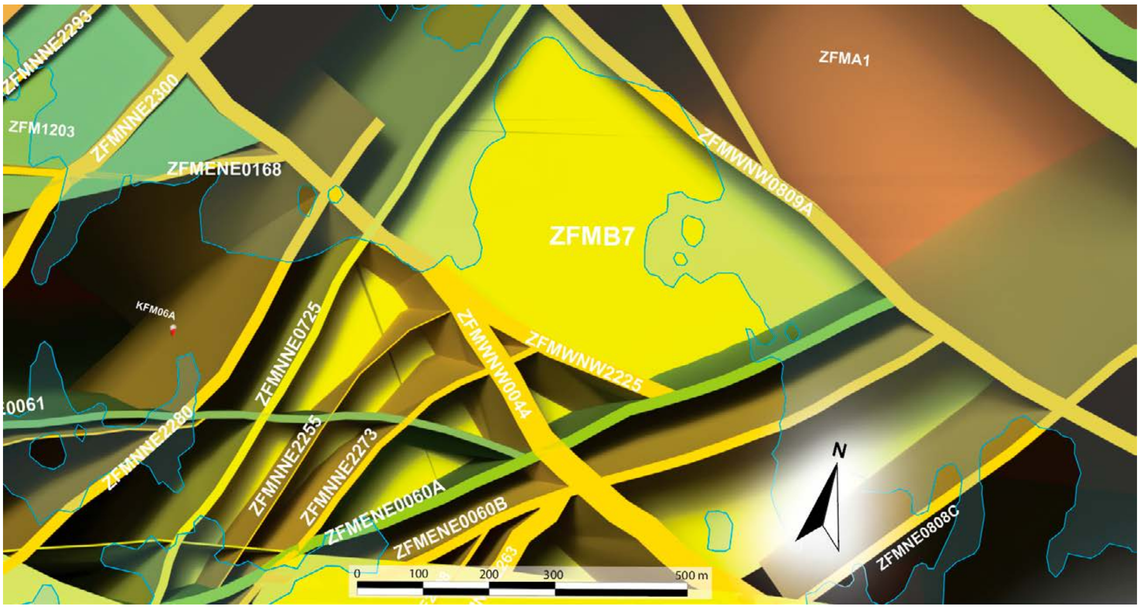
Borehole	PDZ	Target intercept		Geometric intercept		Comment
		Sec_up [m]	Sec_low [m]	Sec_up [m]	Sec_low [m]	
KFM06A	DZ4	318.00	358.00	321.08	346.20	ZFMENE0060A also intersects DZ4.
KFM06C	DZ2	359.00	400.00	359.17	401.62	

Tunnels:	-	
Lineament and/or seismic indications:	B7.	2

MODELLING PROCEDURE

Corresponds to seismic reflector B7, the position of which in 3D space has been attained from Balu and Cosma (2005). Terminated against ZFMWNW0809A, ZFMNNE0725 and ZFMENE0401A. Deformation zone plane placed at fixed point 323 m along DZ4 (318-358 m) in KFM06A and at 361 m along DZ2 (359-400 m) in KFM06C. The steeply dipping zone ZFMENE0060A is also modelled to intersect DZ4 in KFM06A. Zone ZFMB7.

G	ZFMB7	Version number	5	Total object CL	16



OBJECT CONFIDENCE ESTIMATE

Category	Object CL	Comment
INTERPRETATION		
Data source	2	B7, KFM06A, KFM06C
Results of interpretation	3	High confidence observation in KFM06A and KFM06C.
INFORMATION DENSITY		
Number of observation points	2	2
Distribution of observation points	1	C. 250 meter between obs. points.
INTERPOLATION		
Geometry	3	One strong interpolation alternative.
Geological indicators	2	Some discrepancies in the geological data.
EXTRAPOLATION		
Dip direction	1	Extrapolated based on information from seismic reflector B7. Terminated against ZFMWNW0809A, ZFMENE0401A and ZFMNNE0725. Open ended in down-dip direction.
Strike direction	2	Extrapolated and modelled based on information from seismic reflector B7. Terminated against ZFMWNW0809A, ZFMENE0401A and ZFMNNE0725.

FRACTURE CHARACTER

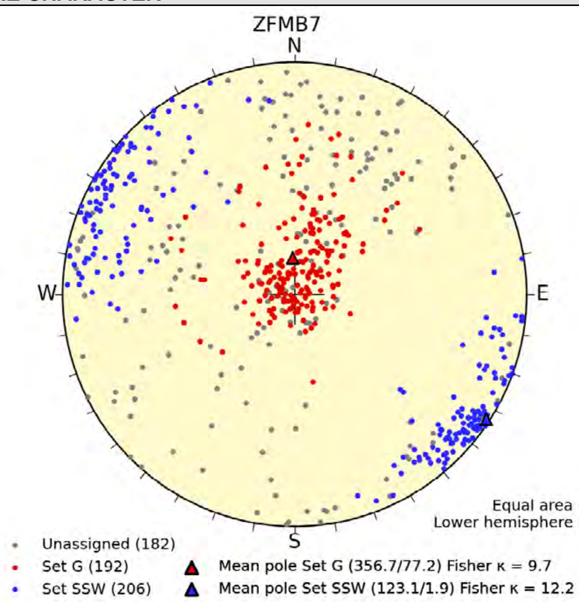
Orientation: (strike/dip right-hand-rule)

Set G: 86.7°/12.8°
Set SSW: 213.1°/88.1°

Frequency:

Boreholes: KFM06A, KFM06C

FRACTURE TYPE	TERZAGHI-WEIGHED P10
Open and partly open	2.8 m-1
Sealed	12.0 m-1
Sealed network	8.9 % of DZ intercept
Crush	0.1 % of DZ intercept



RQD: min:9, max:100, mean:97

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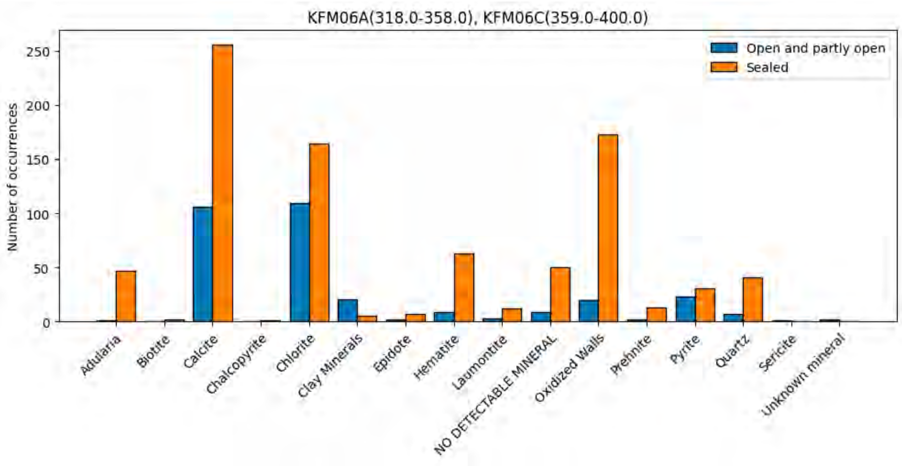
<tr><td>Fracture fill mineralogy:</td><td colspan="5">
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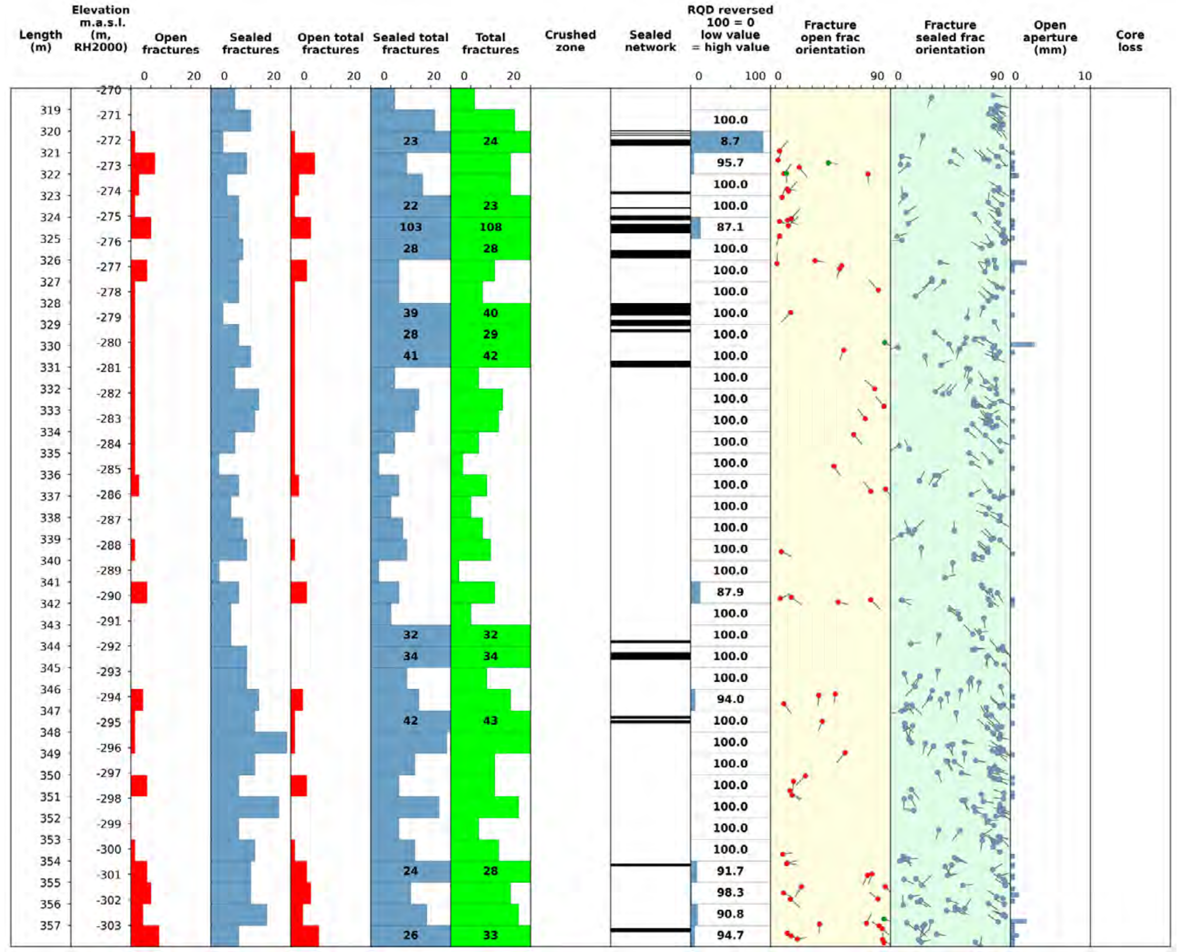
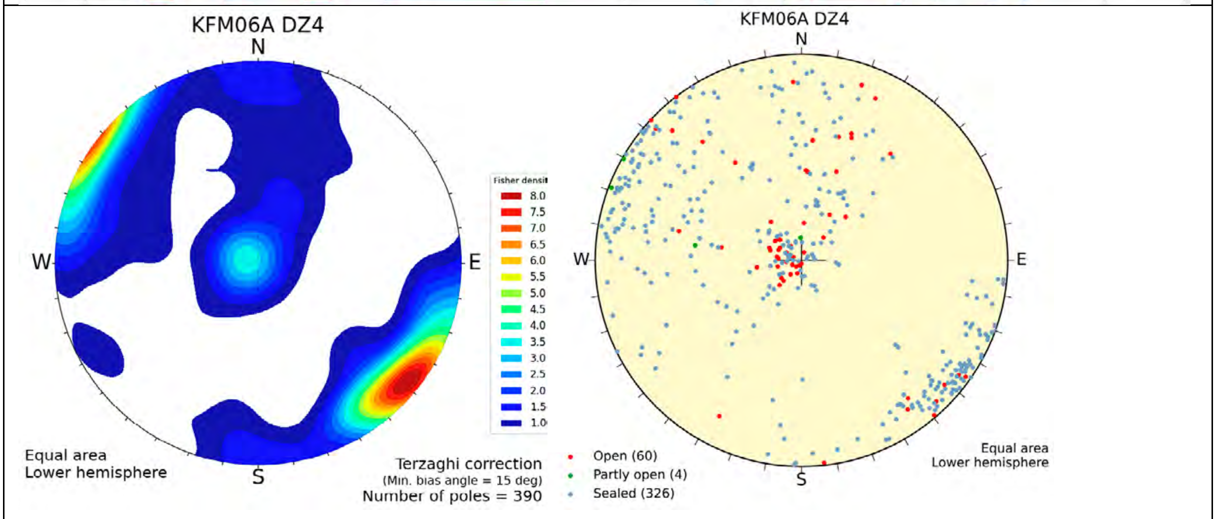
G	ZFMB7	Version number	5	Total object CL	16

INDIVIDUAL INTERCEPTS

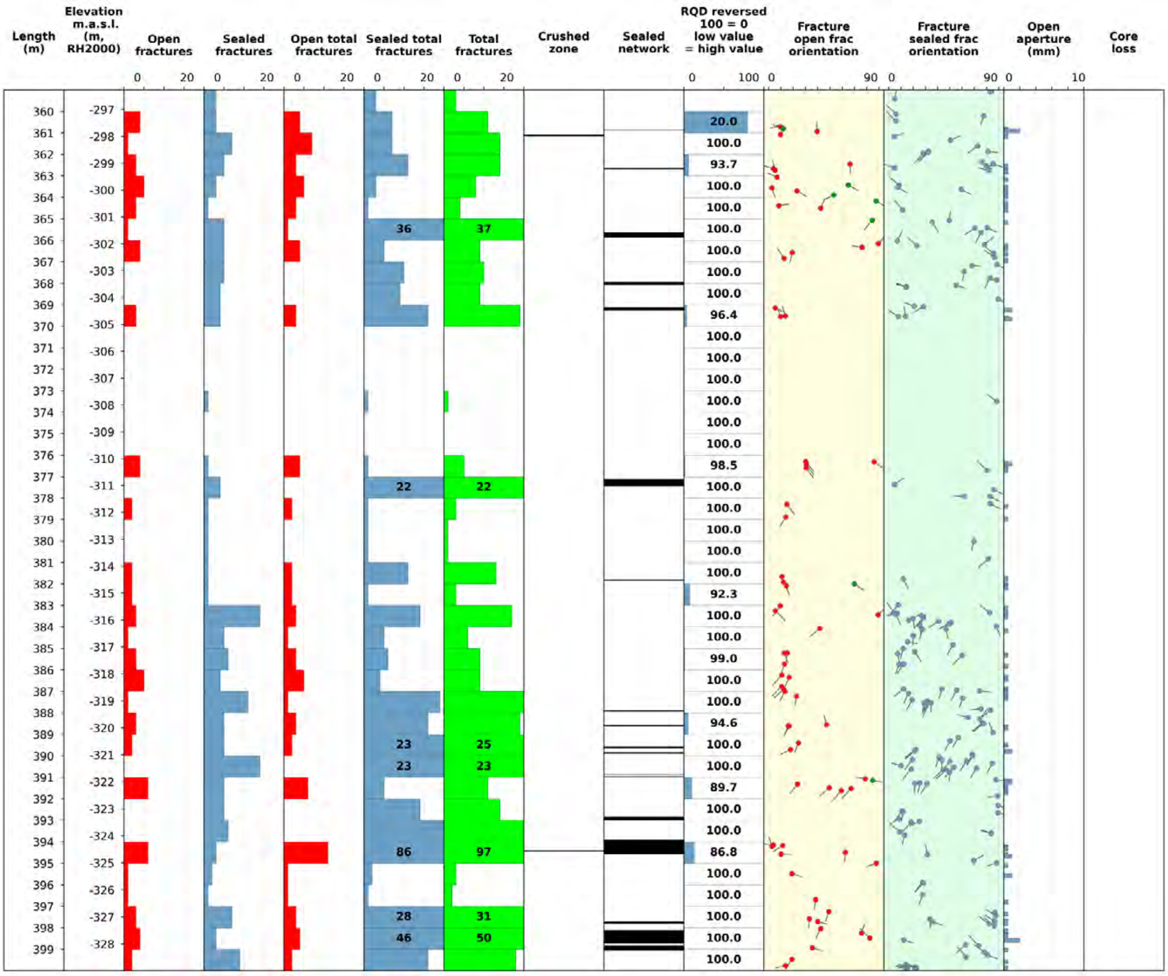
KFM06A DZ4 (318.0-358.0 m)

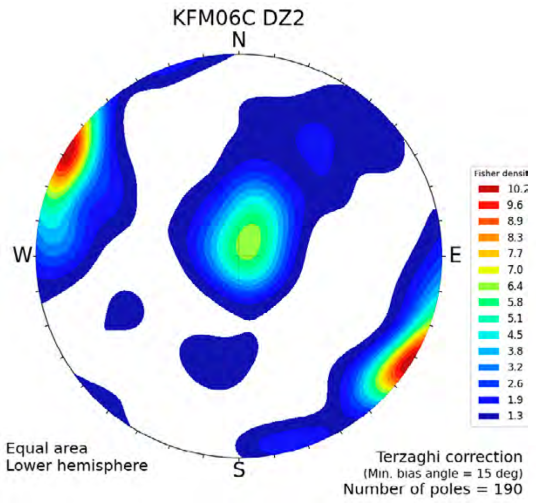


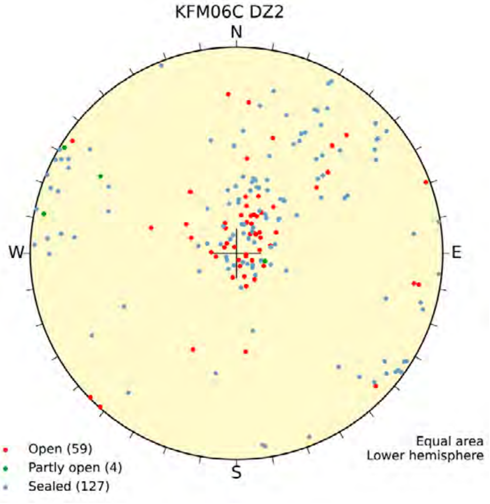


G	ZFMB7	Version number	5	Total object CL	16

KFM06C DZ2 (359.0-400.0 m)

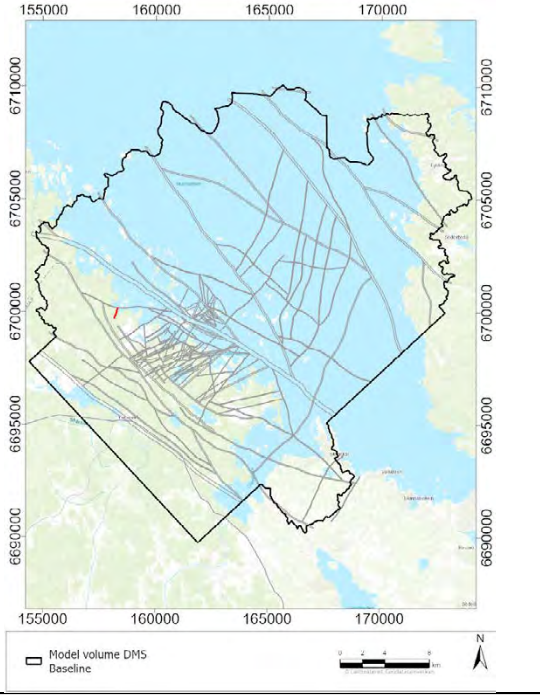






G	ZFMB8	Version number	6	Total object CL	10

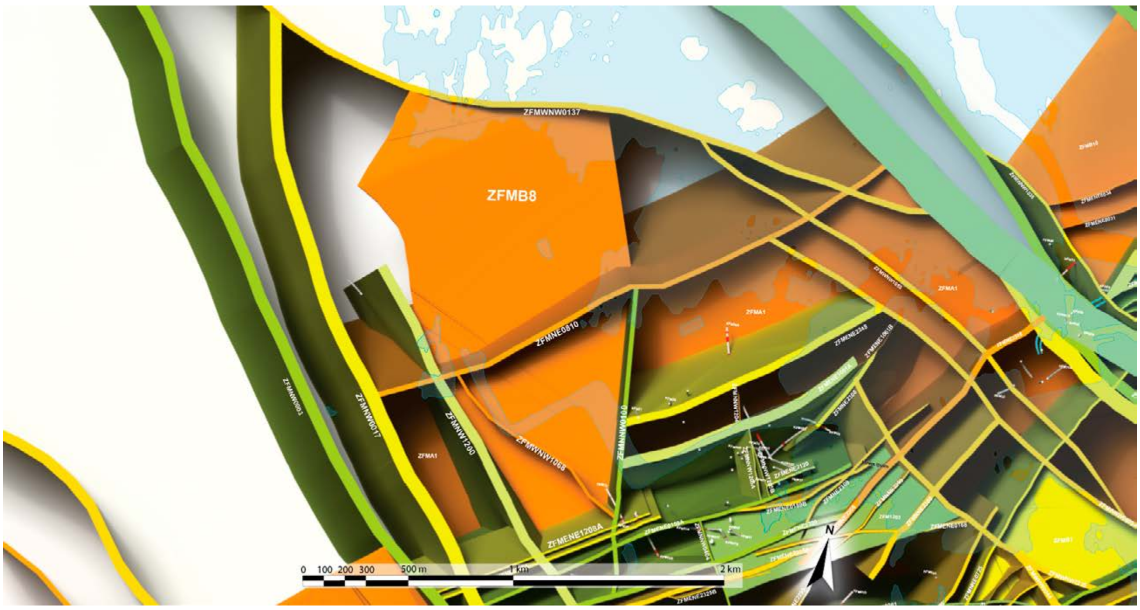
GEOLOGICAL CHARACTER		Property CL
Deformation style:	Brittle	3
Deformation description:	No data available.	
Alteration:		1
- First order:	Not observed	
- Second order:	Not observed	
- Third order:	Not observed	
Fracture orientation and type:	No data available.	
Fracture comment:	No data available.	
Fracture fill mineralogy:	No data available.	
OBJECT GEOMETRY		
Strike/dip:	17°/25°	
Length:	519 m	
Mean thickness:	6 m (6 - 32 m)	
Max depth:	-826 m	
Geometrical constraints:	ZFMWNW0137, ZFMENE2320, ZFMNNW0100, Topo 40m grid Max error 20m, ZFMNW1200, Trunc_B8_RUB25, 1 UNIVERSE Planar Cut(s).	



BASIS FOR MODELLING		
Corresponds to seismic reflector B8, the position of which in 3D space has been attained from Cosma et al. (2006). Supported by a borehole observation.		
Outcrops:	-	
Boreholes: -		
Tunnels:	-	
Lineament and/or seismic indications:	B8.	3

MODELLING PROCEDURE

Corresponds to seismic reflector B8, the position of which in 3D space has been attained from Cosma et al. (2006). Termination against ZFMNW1200, ZFMNNW0100, ZFMEW0137, ZFMENE2320 and boundary to rock domain RFM025. Modelling takes account of a fixed point intersection at 317 m along borehole interval 316-322 m in DBT1/KFK001 and the results from the drilling of HFM31, where the zone was not intersected. Zone is modelled to lie close to the base of borehole KFM07A. The position of borehole DBT1/KFK001 is uncertain. Zone ZFMB8 is.



G	ZFMB8	Version number	6	Total object CL	10

OBJECT CONFIDENCE ESTIMATE

Category	Object CL	Comment
INTERPRETATION		
Data source	1	B8
Results of interpretation	3	High confidence in seismic reflector B8.
INFORMATION DENSITY		
Number of observation points	1	1
Distribution of observation points	1	Single observation point in the form of a seismic reflector.
INTERPOLATION		
Geometry	1	Geometry supported by surface geophysical data.
Geological indicators	1	Indirect support by geophysical data.
EXTRAPOLATION		
Dip direction	1	Extrapolated based on information from seismic reflector B8. Truncated by steeply dipping zones ZFMNW1200, ZFMNNW0100, ZFMENE2320. Constrained by KFM07A in ENE and HFM31 in NW. ZFMWNW0137 ZFMEW0137, ZFMENE2320.
Strike direction	1	Extrapolated and modelled based on information from seismic reflector B8. Truncated by steeply dipping zones ZFMNW1200, ZFMNNW0100, ZFMENE2320. Constrained by KFM07A in ENE and HFM31 in NW. ZFMWNW0137 ZFMEW0137, ZFMENE2320.

FRACTURE CHARACTER

No data available

INDIVIDUAL INTERCEPTS

No data available

G	ZFME1	Version number	3	Total object CL	10

GEOLOGICAL CHARACTER		Property CL
Deformation style:	Brittle	1
Deformation description:	No data available.	
Alteration:		
- First order:	Not observed	
- Second order:	Not observed	
- Third order:	Not observed	
Fracture orientation and type:	No data available.	
Fracture comment:	No data available.	
Fracture fill mineralogy:	No data available.	
OBJECT GEOMETRY		
Strike/dip:	299°/12°	
Length:	-	
Mean thickness:	15 m (6 - 32 m)	
Max depth:	-2100 m	
Geometrical constraints:	ZFMWNW0123, ZFMNE0065, ZFMENE0062A.	

No figure available

BASIS FOR MODELLING

Corresponds to seismic reflector E1, the position of which in 3D space has been attained from Cosma et al. (2003).

Outcrops:	-	
Boreholes: -		
Tunnels:	-	
Lineament and/or seismic indications:	E1.	2

MODELLING PROCEDURE

Corresponds to seismic reflector E1, the position of which in 3D space has been attained from Cosma et al. (2003). Modelled to the base of the model volume with termination against ZFMWNW0123, ZFMNE0065 and ZFMENE0062A.

No figure available.

OBJECT CONFIDENCE ESTIMATE

Category	Object CL	Comment
INTERPRETATION		
Data source	1	E1
Results of interpretation	2	Medium confidence in seismic reflector E1.
INFORMATION DENSITY		
Number of observation points	1	1
Distribution of observation points	1	Single observation point in the form of a seismic reflector.
INTERPOLATION		
Geometry	1	Geometry supported by surface geophysical data.
Geological indicators	1	Indirect support by geophysical data.
EXTRAPOLATION		
Dip direction	1	Extrapolated based on information from seismic reflector E1. Truncated by steeply dipping zones ZFMWNW0123, ZFMNE0065. Open ended in downdip direction. ZFMENE0062A. Constrained by KFM07A in ENE and HFM31 in NW. ZFMWNW0137 ZFMEW0137, ZFMENE2320. Constrained by KFM07A in ENE and HFM31 in NW.
Strike direction	2	Conceptual constraints. Truncated by steeply dipping zones ZFMWNW0123, ZFMNE0065. ZFMENE0062A.

FRACTURE CHARACTER

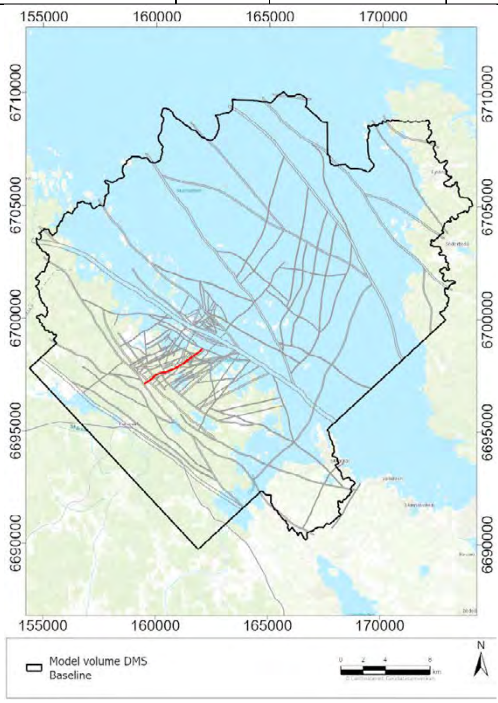
No data available

INDIVIDUAL INTERCEPTS

No data available

ENE	ZFMENE0060A	Version number	3	Total object CL	22

GEOLOGICAL CHARACTER		Property CL
Deformation style:	Brittle	3
Deformation description:	Two steeply dipping faults with SW strike show oblique movement with dominant strike-slip component Sub-horizontal fault shows dip-slip movement. Steep NE-SW faults show strike-slip, dip-slip or oblique- slip. One fault shows dextral strike-slip. Fault with moderate dip to north show reverse dip-slip. Faults with steep dip to south show dip-slip or dextral strike-slip. Steep NNW faults show reverse dip slip or oblique-slip.	
Alteration:		3
- First order:	Oxidation	
- Second order:	Quartz dissolution	
- Third order:	Not observed	
Fracture orientation and type:	Two sets of fractures are conspicuous. Steeply dipping WSW to SSW and gently dipping. Dominated by sealed followed by open and partly open fractures.	2
Fracture comment:	No data available.	
Fracture fill mineralogy:	Calcite and chlorite, laumontite, prehnite, hematite/adularia, quartz, epidote and clay minerals common in both steeply and gently dipping fractures.	



OBJECT GEOMETRY	
Strike/dip:	241°/85°
Length:	3122 m
Mean thickness:	17 m (15 - 64 m)
Max depth:	-2100 m
Geometrical constraints:	ZFMWNW0809A, ZFMNW0003, Topo 40m grid Max error 20m.

BASIS FOR MODELLING

Zone ZFMENE0060 consists of different branches. Zone based on surface lineaments supported by borehole observations.

Outcrops: -

Boreholes:

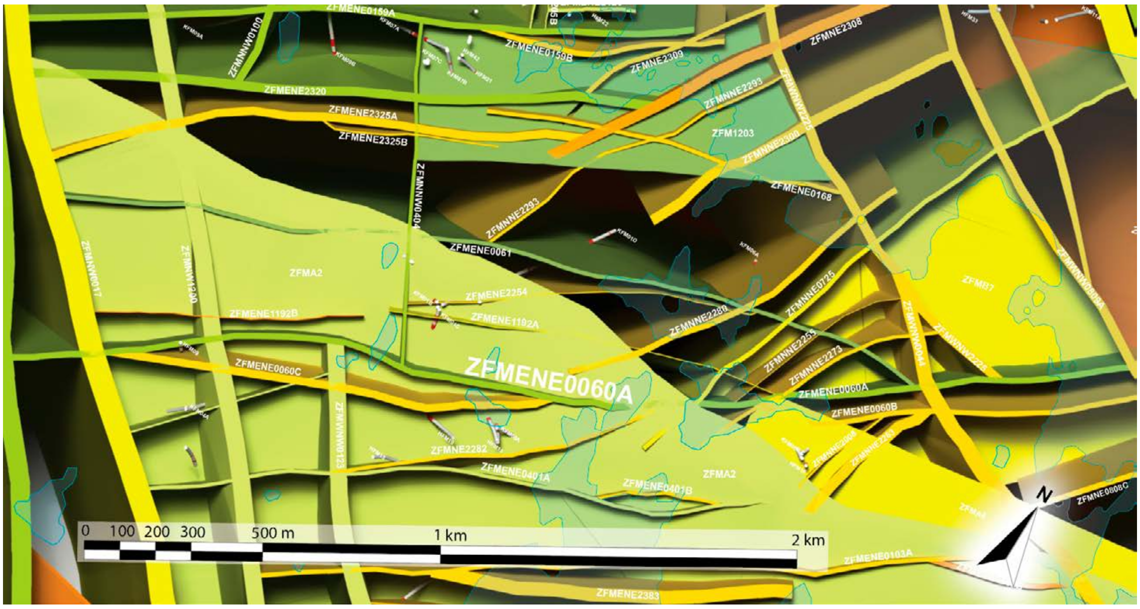
Borehole	PDZ	Target intercept		Geometric intercept		Comment
		Sec_up [m]	Sec_low [m]	Sec_up [m]	Sec_low [m]	
HFM09	DZ1	18.00	28.00	5.52	22.96	
KFM01C	DZ3	235.00	252.00	228.16	250.60	Only borehole intervals 235-252 m and 305-330 m included in the DZ deterministic modelling. Fractured rock between 252 and 305 m, and 330 and 450 m inferred to be affected by DZ (cf. Table 3-2 in Stephens et al. 2007).
KFM06A	DZ4	318.00	358.00	318.49	358.68	ZFMB7 also intersects DZ4.

Tunnels:	-	
Lineament and/or seismic indications:	MFM0060, MFM0060G0.	2

ENE	ZFMENE0060A	Version number	3	Total object CL	22

MODELLING PROCEDURE

Zone ZFMENE0060 consists of different branches, the most prominent of which is denoted ZFMENE0060A. Though the branches are described separately in subsequent property sheets, it should be recalled that these probably constitute elements of one and the same structure. At the surface, zone ZFMENE0060A corresponds to the low magnetic lineaments MFM0060 and MFM0060G0. Modelled to the base of the model volume using the dip estimated by connecting these lineament segments with the borehole intersections 235-252 m in KFM01C (part of DZ3) and 318-358 m in KFM06A (DZ4). Deformation zone plane placed at fixed points 247 m and 324 m in KFM01C and KFM06A, respectively. Model implies that this zone also intersects DZ1 in HFM09. The gently dipping zone ZFMB7 is also modelled to intersect borehole KFM06A along DZ4. For this reason, there are some difficulties to separate the influence of zones ZFMENE0060A and ZFMB7 along this borehole interval.



OBJECT CONFIDENCE ESTIMATE

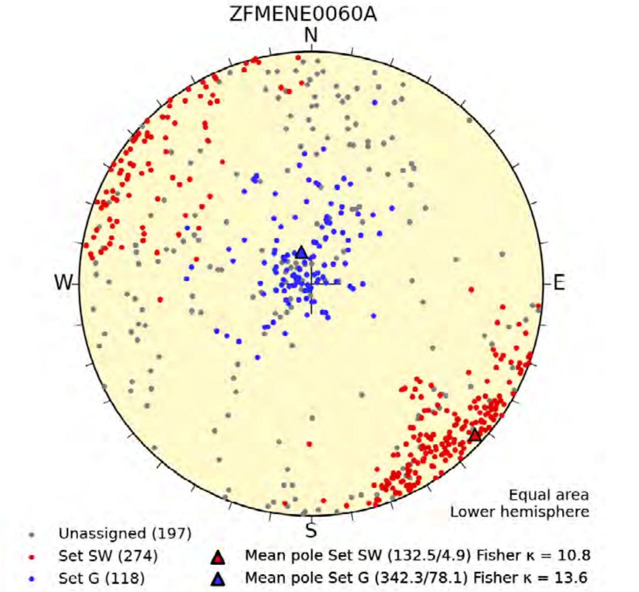
Category	Object CL	Comment
INTERPRETATION		
Data source	2	MFM0060G0, HFM09, KFM01C, KFM06A
Results of interpretation	3	High confidence observation in KFM06A, KFM01C.
INFORMATION DENSITY		
Number of observation points	3	4
Distribution of observation points	3	Even distribution of obs. points.
INTERPOLATION		
Geometry	3	One strong interpolation alternative.
Geological indicators	2	Some discrepancies in the geological data.
EXTRAPOLATION		
Dip direction	3	Extrapolated to the base of the model volume. Strike length of the modelled zone > 2000 m.
Strike direction	3	Conceptual understanding of the site and that the entire modelled zone is supported by lineament.

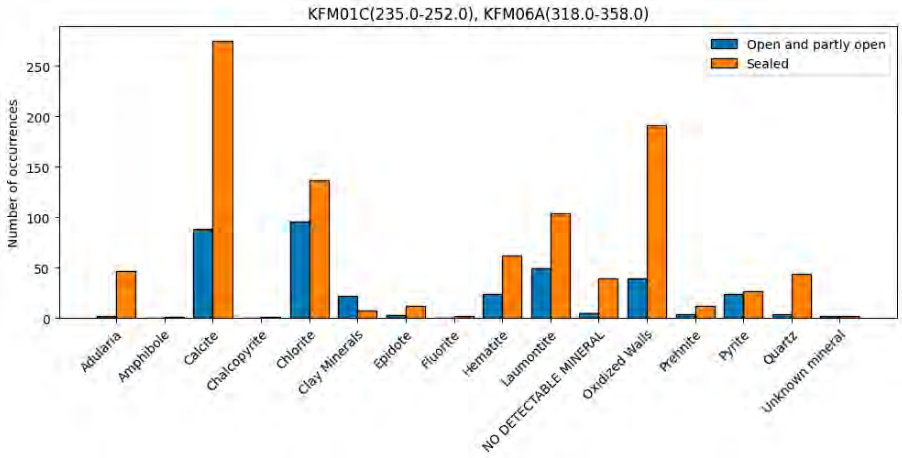
ENE	ZFMENE0060A	Version number	3	Total object CL	22

FRACTURE CHARACTER

Orientation: (strike/dip right-hand-rule)	Set SW: 222.5°/85.1° Set G: 72.3°/11.9°	
Frequency:	Boreholes: KFM06A, KFM01C	
RQD:	min:9, max:100, mean:95	
Fracture fill mineralogy:		

FRACTURE TYPE	TERZAGHI-WEIGHED P10
Open and partly open	5.0 m-1
Sealed	17.3 m-1
Sealed network	24.0 % of DZ intercept
Crush	0.0 % of DZ intercept

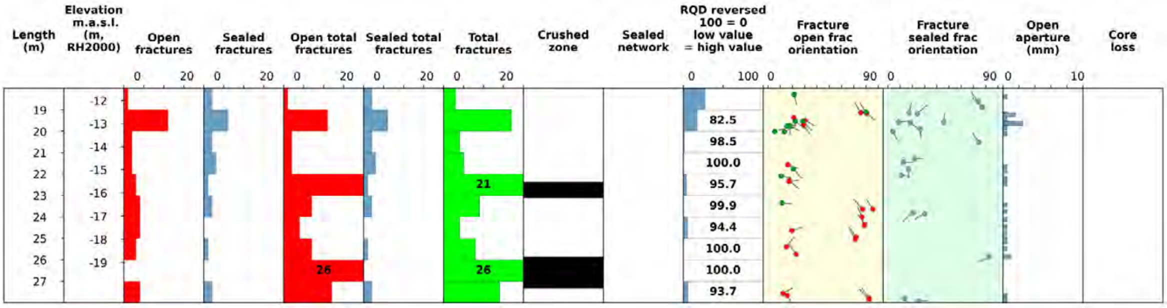




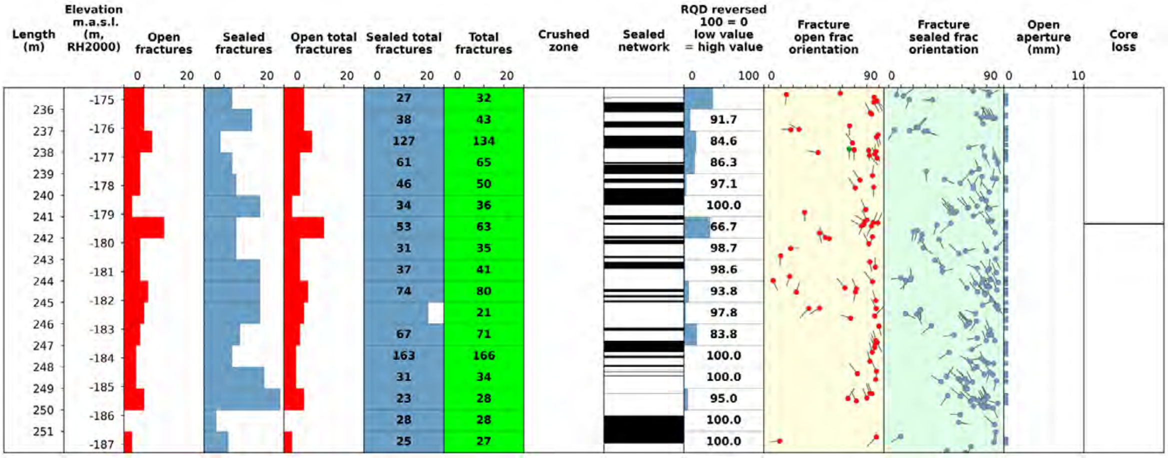
ENE	ZFMENE0060A	Version number	3	Total object CL	22

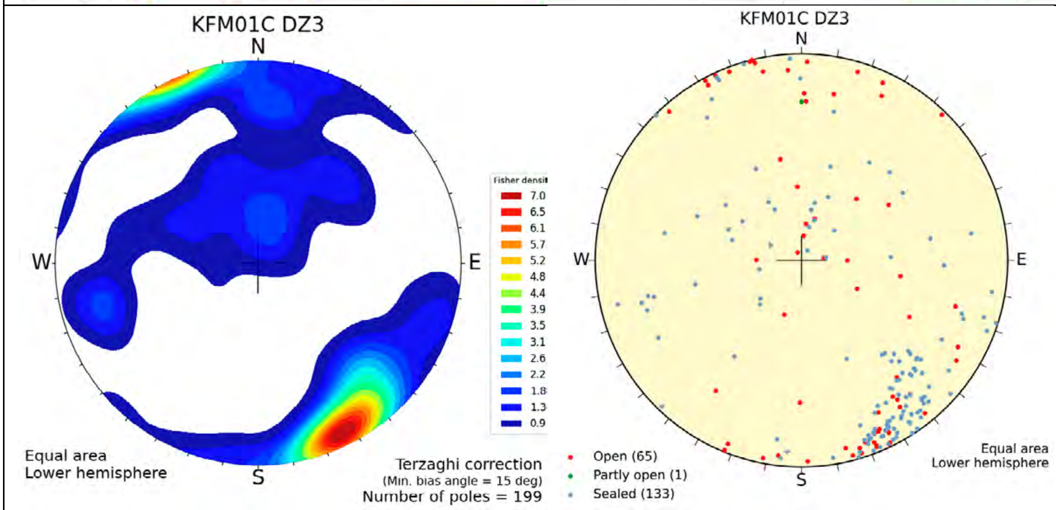
INDIVIDUAL INTERCEPTS

HFM09 DZ1 (18.0-28.0 m)



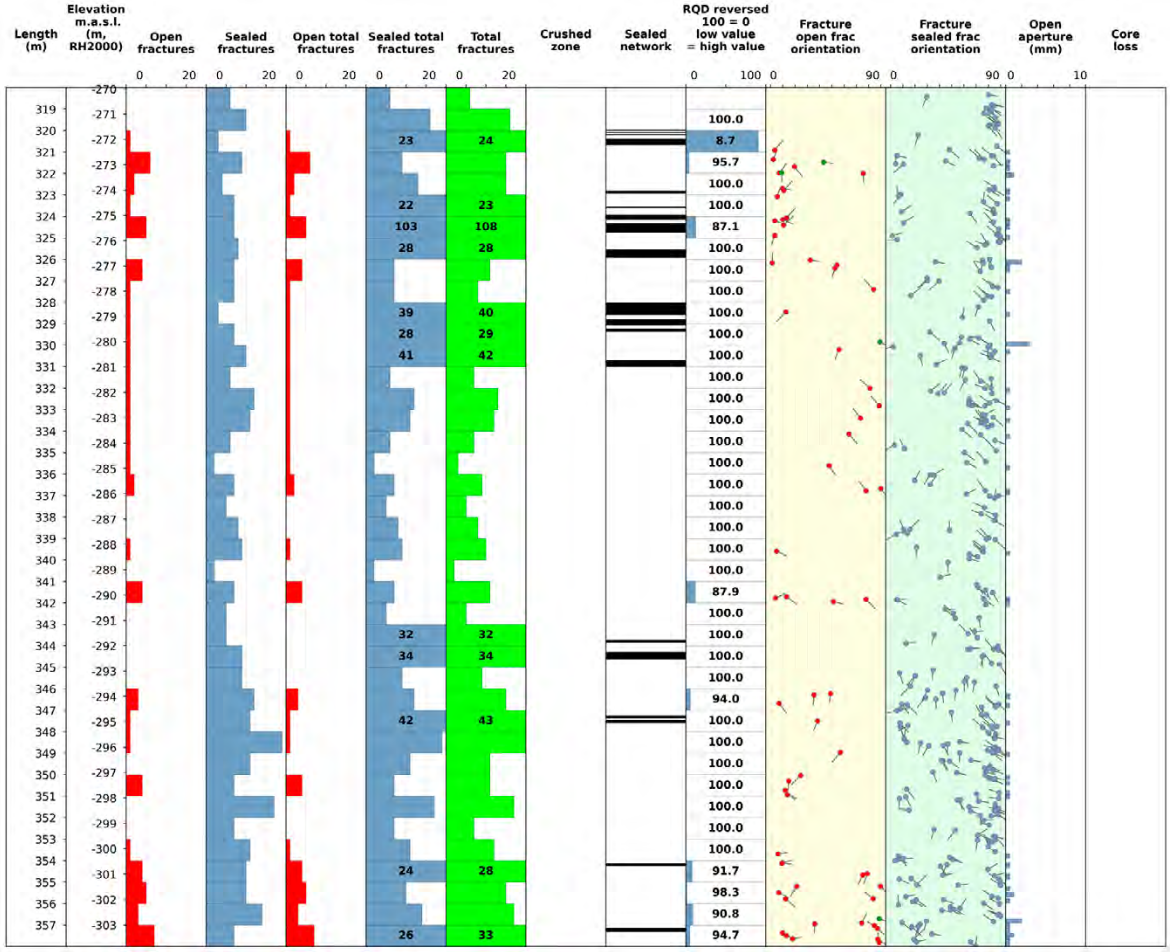
KFM01C DZ3 (235.0-252.0 m)

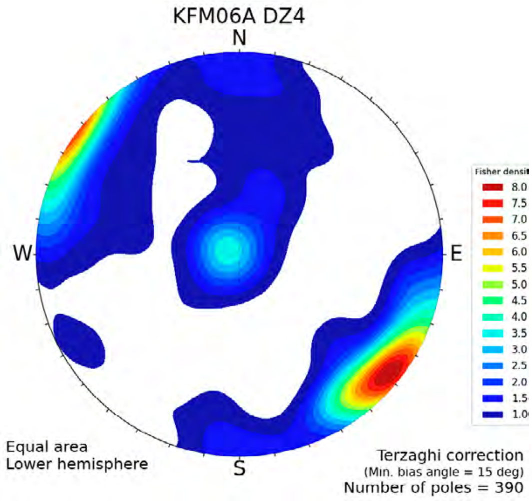


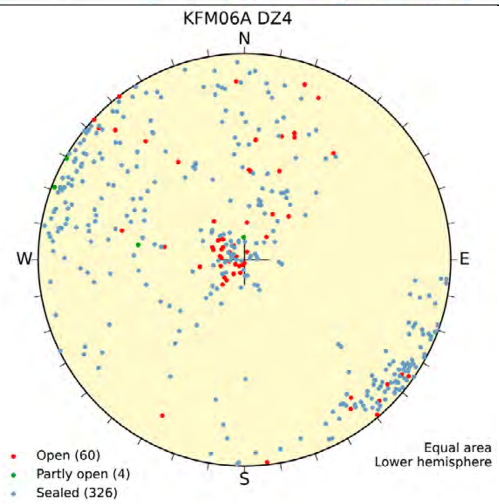


ENE	ZFMENE0060A	Version number	3	Total object CL	22

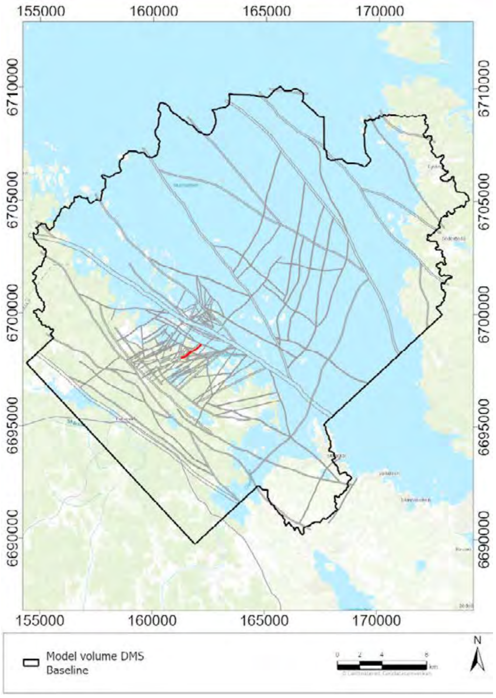
KFM06A DZ4 (318.0-358.0 m)







ENE	ZFMENE0060B	Version number	3	Total object CL	15



GEOLOGICAL CHARACTER		Property CL
Deformation style:	Brittle	3
Deformation description:	Two steeply dipping faults with SW strike show oblique movement with dominant strike-slip component Sub-horizontal fault shows dip-slip movement. Steep NE-SW faults show strike-slip, dip-slip or oblique- slip. One fault shows dextral strike-slip. Fault with moderate dip to north show reverse dip-slip. Faults with steep dip to south show dip-slip or dextral strike-slip. Steep NNW faults show reverse dip slip or oblique-slip.	
Alteration:		3
- First order:	Oxidation	
- Second order:	Not observed	
- Third order:	Not observed	
Fracture orientation and type:	Two sets of fractures are conspicuous. One of these sets strikes SSW and dips steeply to the WNW, the other is sub-horizontal. Fractures that strike NS and dip steeply to the east are also present.	2
Fracture comment:	No data available.	
Fracture fill mineralogy:	No data available.	

OBJECT GEOMETRY	
Strike/dip:	236°/78°
Length:	1069 m
Mean thickness:	15 m (3 - 50 m)
Max depth:	-644 m
Geometrical constraints:	ZFMENE0060A, ZFMWNW0809A, Topo 40m grid Max error 20m.

BASIS FOR MODELLING

Zone based on surface lineaments supported by borehole observations. Modelled to the base of the model volume as a splay to ZFMENE0060A.

Outcrops: -

Boreholes:

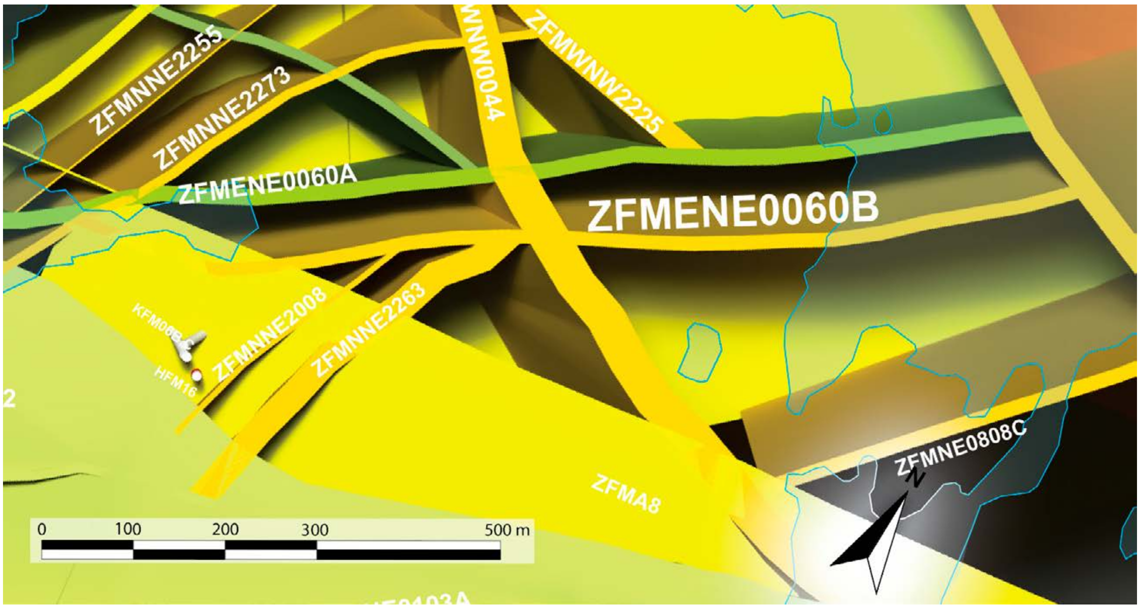
Borehole	PDZ	Target intercept		Geometric intercept		Comment
		Sec_up [m]	Sec_low [m]	Sec_up [m]	Sec_low [m]	
KFM06A	DZ2	195.00	278.00	195.00	236.30	245-260 m added (cf. Table 3-2 in Stephens et al. 2007). DZ2 and DZ3 merged.
KFM06A	DZ3	195.00	278.00	195.00	236.30	245-260 m added (cf. Table 3-2 in Stephens et al. 2007). DZ2 and DZ3 merged.

Tunnels:	-	
Lineament and/or seismic indications:	MFM0060G1.	1

MODELLING PROCEDURE

At the surface, corresponds to the low magnetic lineament MFM0060G1 and its inferred continuation to the ENE close to MFM0060. Modelled to the base of the model volume as a splay from ZFMENE0060A. Dip estimated by connecting these lineament segments with the borehole intersection 195-278 m in KFM06A (DZ2, DZ3 and less fractured rock between these two zones along borehole interval 245-260 m). Deformation zone plane placed at fixed point 221 m in KFM06A. Decreased radar penetration also along the borehole interval 267-270 m.

ENE	ZFMENE0060B	Version number	3	Total object CL	15



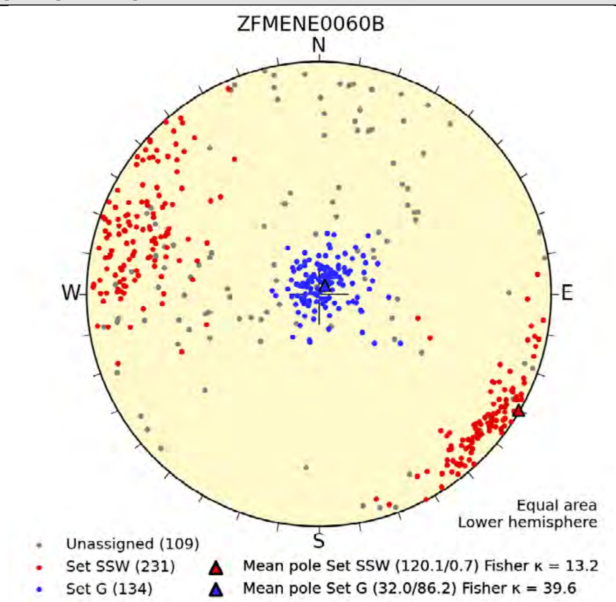
OBJECT CONFIDENCE ESTIMATE

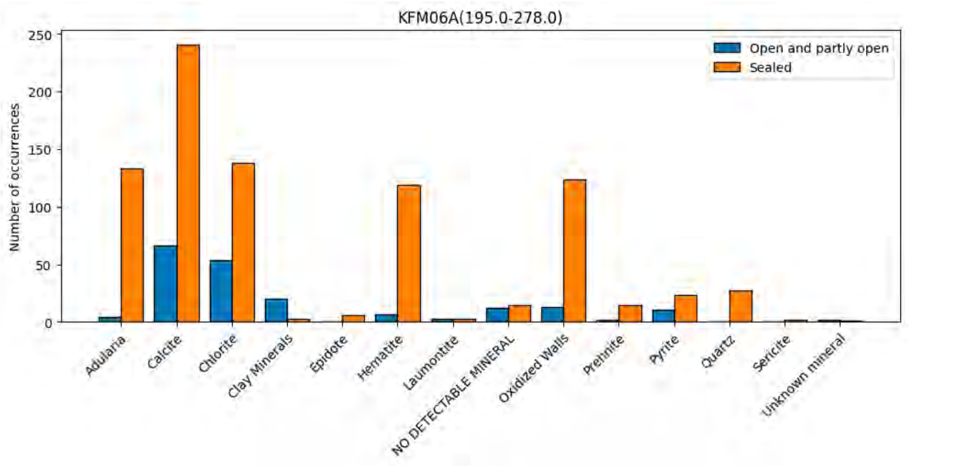
Category	Object CL	Comment
INTERPRETATION		
Data source	2	MFM0060G0, HFM09, KFM01C, KFM06A
Results of interpretation	3	High confidence observation in KFM06A, KFM01C.
INFORMATION DENSITY		
Number of observation points	2	4
Distribution of observation points	1	Less than two subsurface obs. points.
INTERPOLATION		
Geometry	1	Geometry supported by a lineament and a single intercept.
Geological indicators	1	Single observation point at depth. Zone modelled mainly based on surface geophysical data.
EXTRAPOLATION		
Dip direction	2	Extrapolated to the base of the model volume. Strike length of the modelled zone < 2000 m.
Strike direction	3	Conceptual understanding of the site and that the entire modelled zone is supported by lineament.

FRACTURE CHARACTER

Orientation: (strike/dip right-hand-rule)	Set SSW: 210.1°/89.3° Set G: 122.0°/3.8°	
Frequency:	Boreholes: KFM06A	
RQD:	min:80, max:100, mean:99	

FRACTURE TYPE	TERZAGHI-WEIGHED P10
Open and partly open	1.6 m-1
Sealed	9.1 m-1
Sealed network	2.9 % of DZ intercept
Crush	0.1 % of DZ intercept

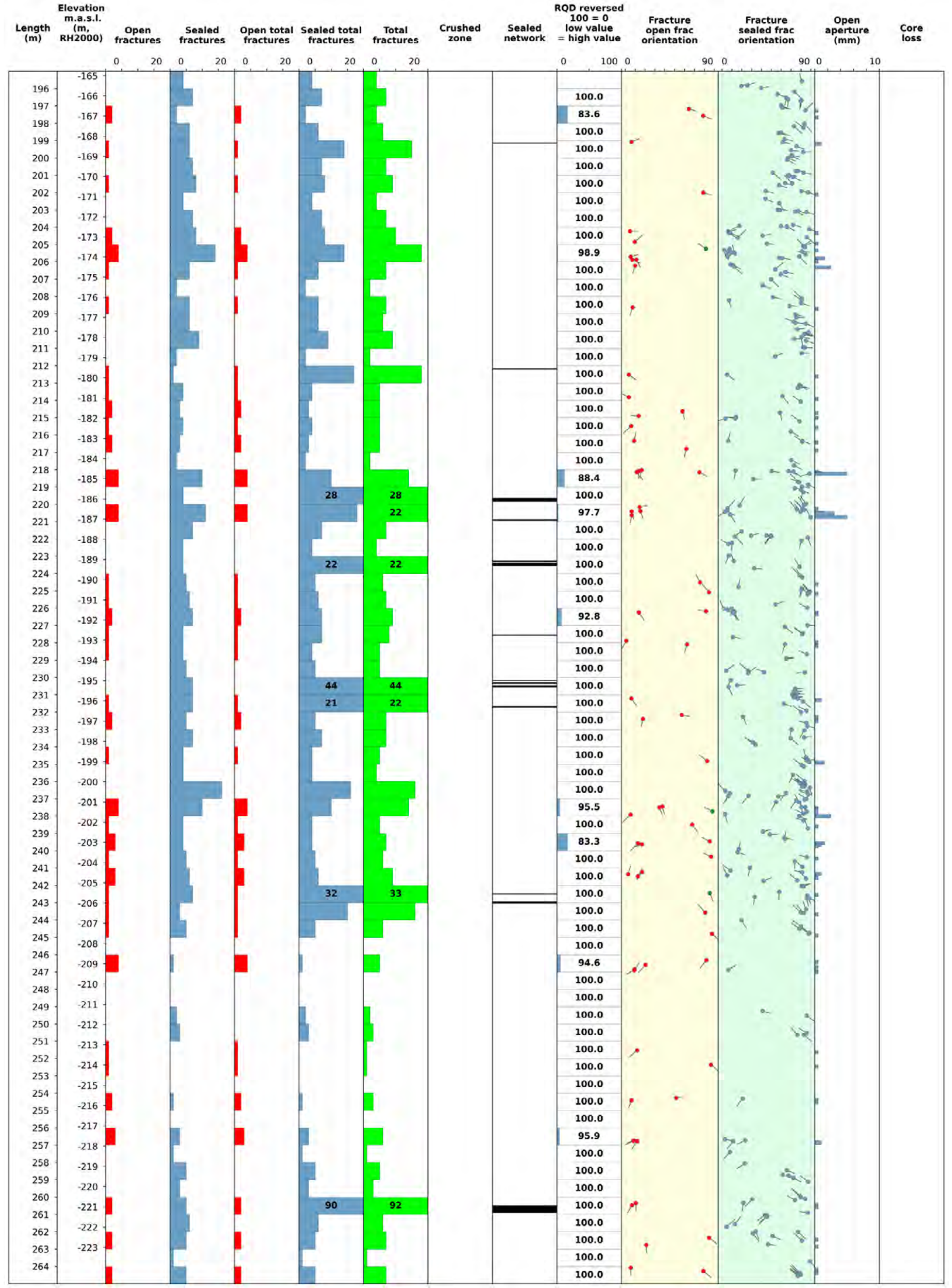


ENE	ZFMENE0060B	Version number	3	Total object CL	15
Fracture fill mineralogy:					

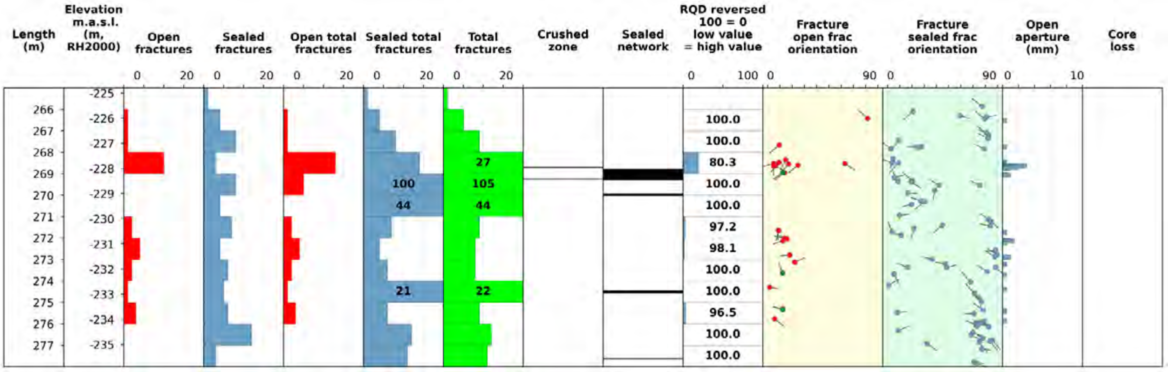
ENE	ZFMENE0060B	Version number	3	Total object CL	15

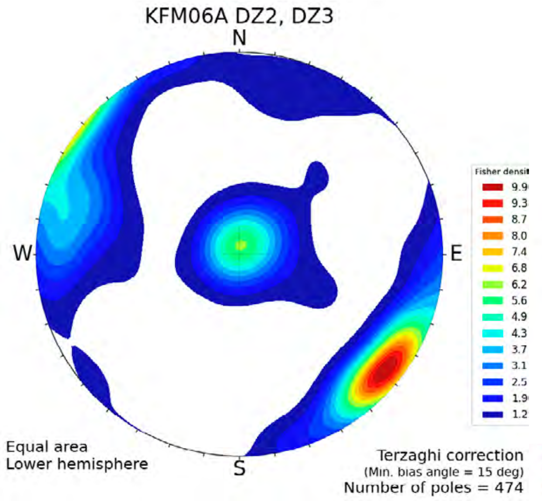
INDIVIDUAL INTERCEPTS

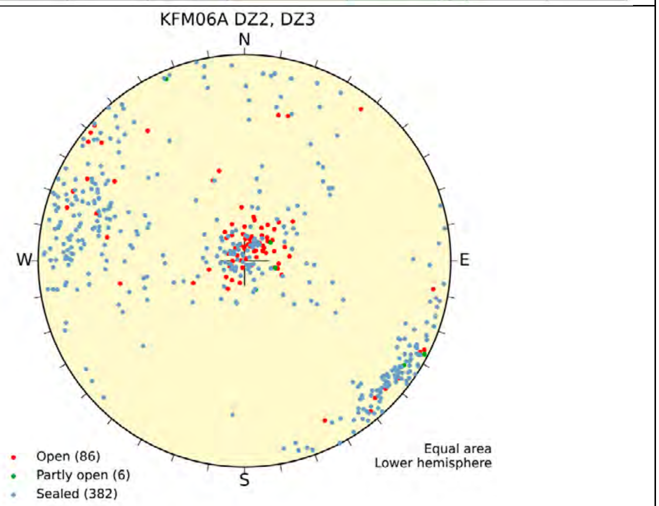
KFM06A DZ2, DZ3 (195.0-278.0 m)



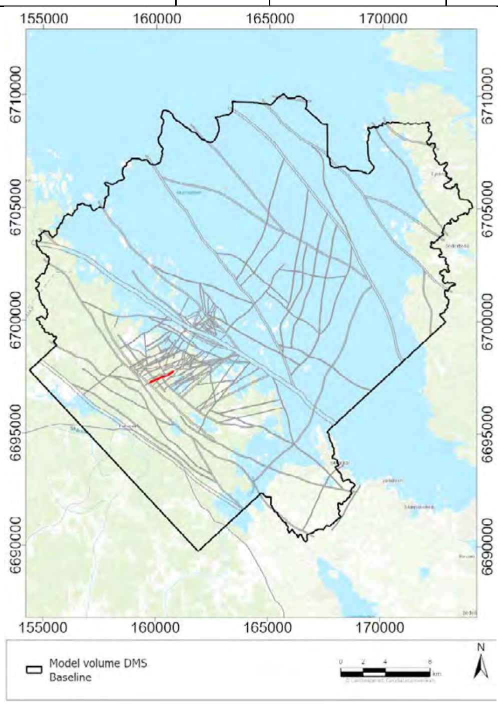
ENE	ZFMENE0060B	Version number	3	Total object CL	15







ENE	ZFMENE0060C	Version number: 3	Total object CL: 15
GEOLOGICAL CHARACTER		**Property CL**	
Deformation style:	Brittle	3	
Deformation description:	Two steeply dipping faults with SW strike show oblique movement with dominant strike-slip component Sub-horizontal fault shows dip-slip movement. Steep NE-SW faults show strike-slip, dip-slip or oblique- slip. One fault shows dextral strike-slip. Fault with moderate dip to north show reverse dip-slip. Faults with steep dip to south show dip-slip or dextral strike-slip. Steep NNW faults show reverse dip slip or oblique-slip.		
Alteration:		3	
- First order:	Oxidation		
- Second order:	Not observed		
- Third order:	Not observed		
Fracture orientation and type:	Two sets of fractures are conspicuous. One of these sets strikes SSW and dips steeply to the WNW, the other is sub-horizontal. Fractures that strike NS and dip steeply to the east are also present. Dominance of sealed fractures. Open fractures significant in the sub horizontal set. Mean value and span include sealed fracture networks and crushed rock.	2	
Fracture comment:	No data available.		
Fracture fill mineralogy:	Calcite and chlorite in both steeply and gently dipping fractures. Hematite/adularia, quartz and prehnite predominantly in steeply dipping fractures but also in gently dipping fractures. Clay minerals predominantly in gently dipping fractures but also in steeply dipping fractures.		
OBJECT GEOMETRY			
Strike/dip:	243°/75°		
Length:	1156 m		
Mean thickness:	21 m (3 - 50 m)		
Max depth:	-594 m		
Geometrical constraints:	ZFMENE0060A, Topo 40m grid Max error 20m.		



ENE	ZFMENE0060C	Version number	3	Total object CL	15

BASIS FOR MODELLING

Zone based on surface lineaments and a borehole observation. Modelled to the base of the model volume as a splay to ZFMENE0060A.

Outcrops: -

Boreholes:

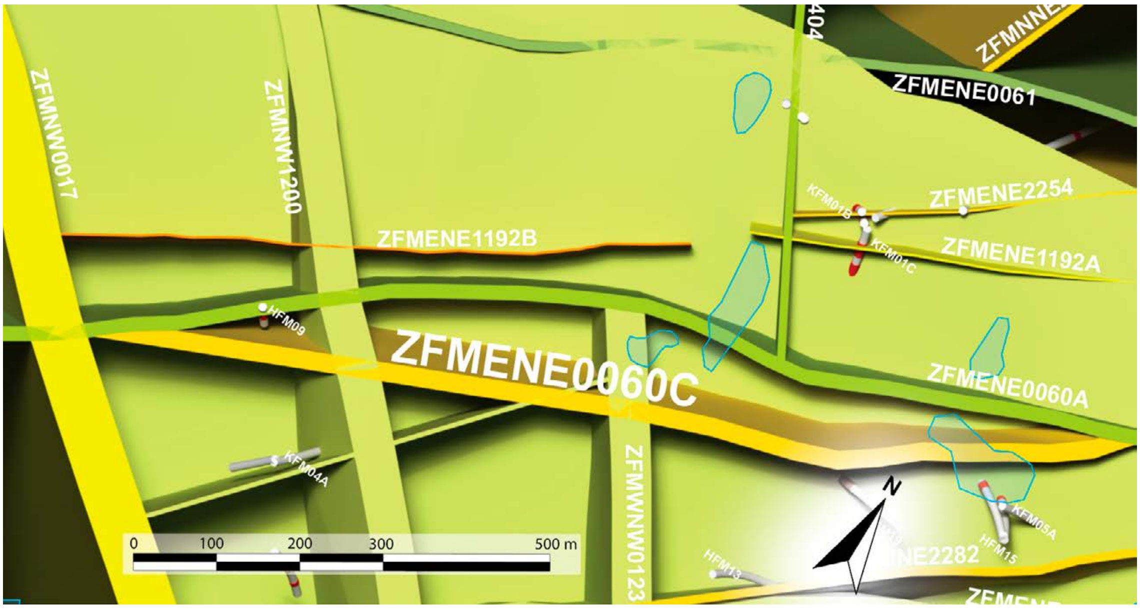
Borehole	PDZ	Target intercept		Geometric intercept		Comment
		Sec_up [m]	Sec_low [m]	Sec_up [m]	Sec_low [m]	
KFM01C	DZ3	305.00	330.00	304.27	329.14	Only borehole intervals 235-252 m and 305-330 m included in the DZ deterministic modelling. Fractured rock between 252 and 305 m, and 330 and 450 m inferred to be affected by DZ (cf. Table 3-2 in Stephens et al. 2007).

Tunnels: -

Lineament and/or seismic indications:	MFM2281G.	2

MODELLING PROCEDURE

At the surface, corresponds to the low magnetic lineament MFM2281G and its inferred continuation to the WSW. Modelled to the base of the model volume as a splay from ZFMENE0060A. Dip estimated by connecting lineament segment MFM2281G and its extension with the borehole intersection 305-330 m in KFM01C (part of DZ3). Deformation zone plane placed at fixed point 312 m in KFM01C.



ENE	ZFMENE0060C	Version number	3	Total object CL	15

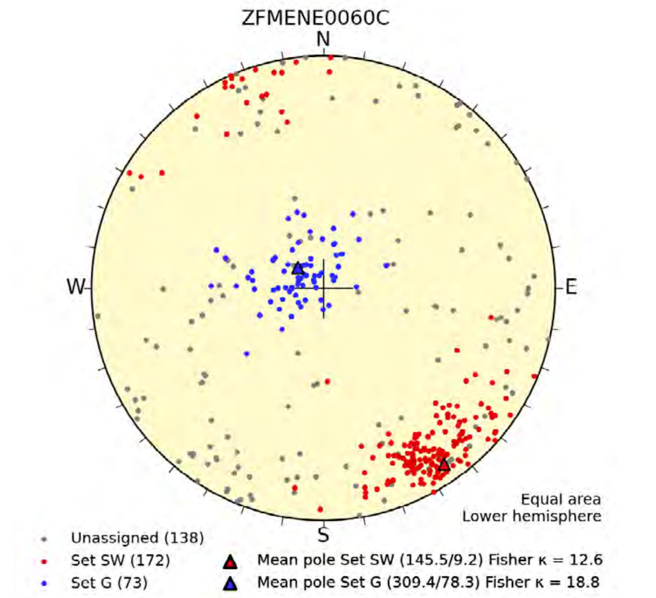
OBJECT CONFIDENCE ESTIMATE

Category	Object CL	Comment
INTERPRETATION		
Data source	2	MFM0060G1, KFM06A
Results of interpretation	3	High confidence observation in KFM06A.
INFORMATION DENSITY		
Number of observation points	2	2
Distribution of observation points	1	Less than two subsurface obs. points.
INTERPOLATION		
Geometry	1	Geometry supported by a lineament and a single intercept.
Geological indicators	1	Single observation point at depth. Zone modelled mainly based on surface geophysical data.
EXTRAPOLATION		
Dip direction	2	Extrapolation in dip direction supported by subsurface obs. point. Strike length of the modelled zone < 2000 m.
Strike direction	3	Conceptual understanding of the site and that the entire modelled zone is supported by lineament.

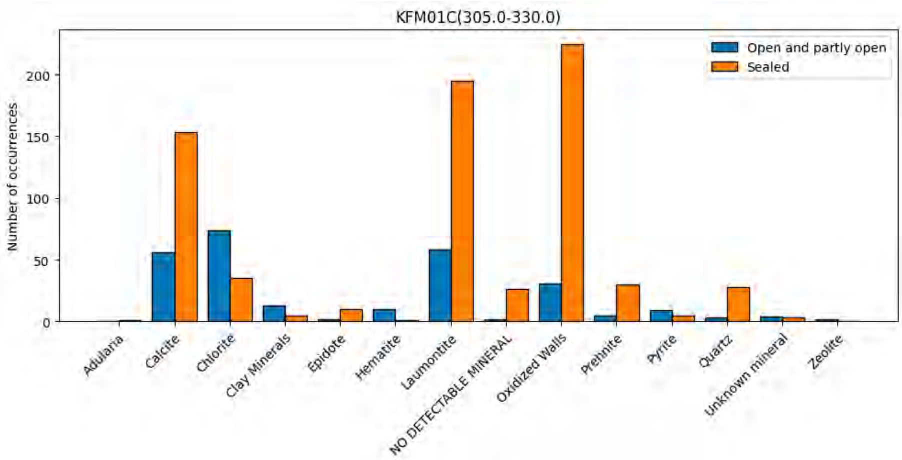
FRACTURE CHARACTER

Orientation: (strike/dip right-hand-rule)	Set SW: 235.5°/80.8° Set G: 39.4°/11.7°
Frequency:	Boreholes: KFM01C

FRACTURE TYPE	TERZAGHI-WEIGHED P10
Open and partly open	7.1 m-1
Sealed	29.5 m-1
Sealed network	11.0 % of DZ intercept
Crush	0.0 % of DZ intercept



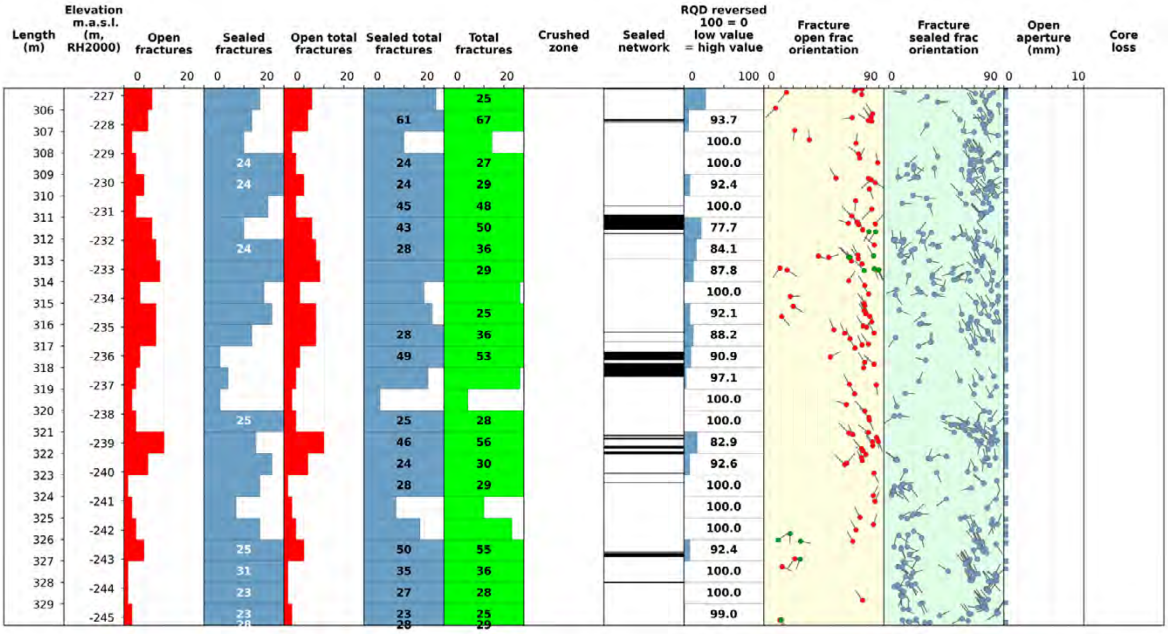
RQD:	min:72, max:100, mean:94
Fracture fill mineralogy:	

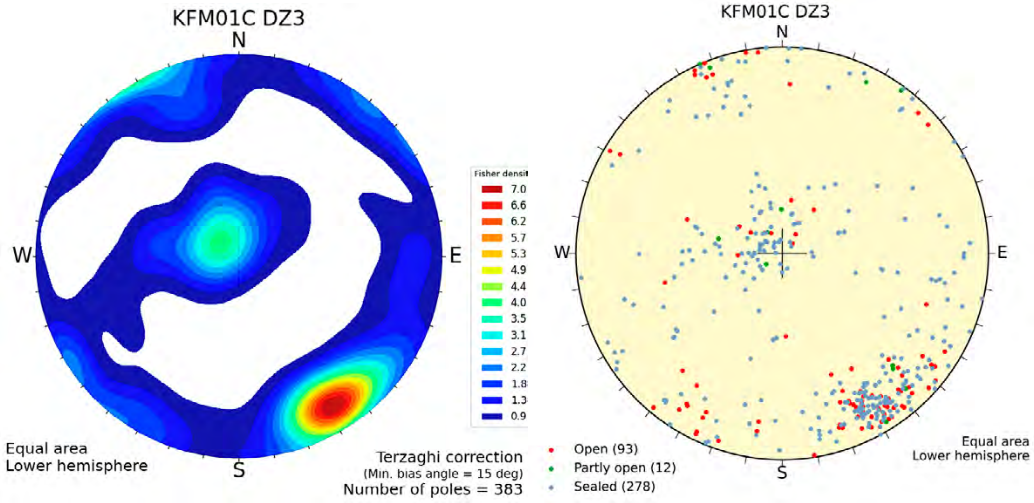


ENE	ZFMENE0060C	Version number	3	Total object CL	15

INDIVIDUAL INTERCEPTS

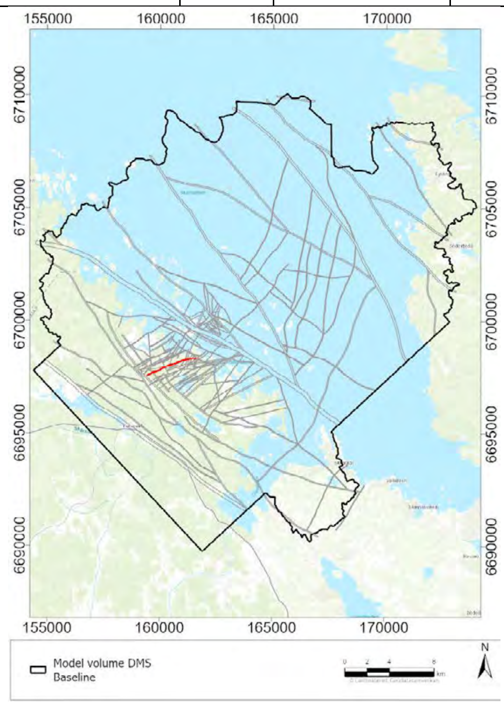
KFM01C DZ3 (305.0-330.0 m)





ENE	ZFMENE0061	Version number	3	Total object CL	20

GEOLOGICAL CHARACTER		Property CL
Deformation style:	Brittle	3
Deformation description:	Steeply dipping faults with WSW, ESE and SW strike all show strike-slip displacement. Steeply dipping fault with NNW strike shows dip-slip displacement.	
Alteration:		3
- First order:	Oxidation	
- Second order:	Not observed	
- Third order:	Not observed	
Fracture orientation and type:	Steeply dipping fractures with WSW and SSW strike dominates. Dominance of sealed fractures. Mean value and span include sealed fracture networks.	2
Fracture comment:	No data available.	
Fracture fill mineralogy:	Calcite, chlorite, laumontite, quartz, hematite/adularia.	



OBJECT GEOMETRY

Strike/dip:	250°/85°
Length:	2431 m
Mean thickness:	11 m (3 - 50 m)
Max depth:	-2100 m
Geometrical constraints:	ZFMNW0017, ZFMENE0060A, Topo 40m grid Max error 20m.

BASIS FOR MODELLING

Zone based on surface lineaments supported by borehole observations.

Outcrops:	-

Boreholes:

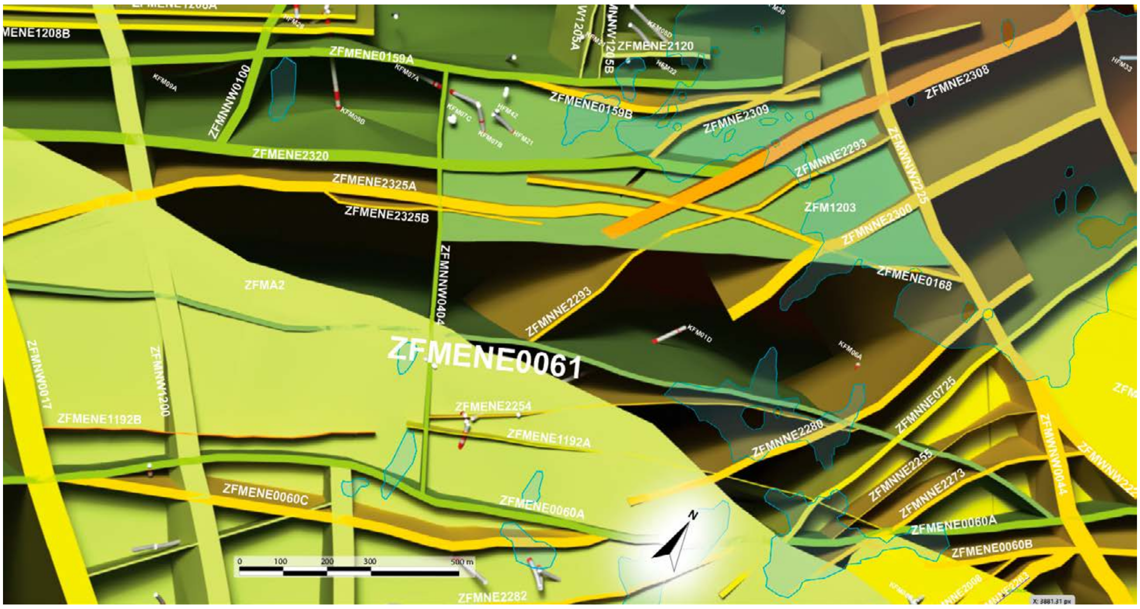
Borehole	PDZ	Target intercept		Geometric intercept		Comment
		Sec_up [m]	Sec_low [m]	Sec_up [m]	Sec_low [m]	
KFM01D	DZ4	670.00	700.00	661.78	691.36	
KFM06A	DZ8	788.00	810.00	785.82	806.36	

Tunnels:	-	
Lineament and/or seismic indications:	MFM0061, MFM0061G.	2

MODELLING PROCEDURE

At the surface, corresponds to the low magnetic lineaments MFM0061 and MFM0061G0. Modelled to the base of the model volume using dip estimated by connecting lineaments MFM0061 and MFM0061G0 with the borehole intersections 670-700 m in KFM01D (DZ4) and 788-810 m in KFM06A (DZ8). Deformation zone plane placed at fixed points 683 m and 797 m in KFM01D and KFM06A, respectively.

ENE	**ZFMENE0061**	Version number	**3**	Total object CL	**20**

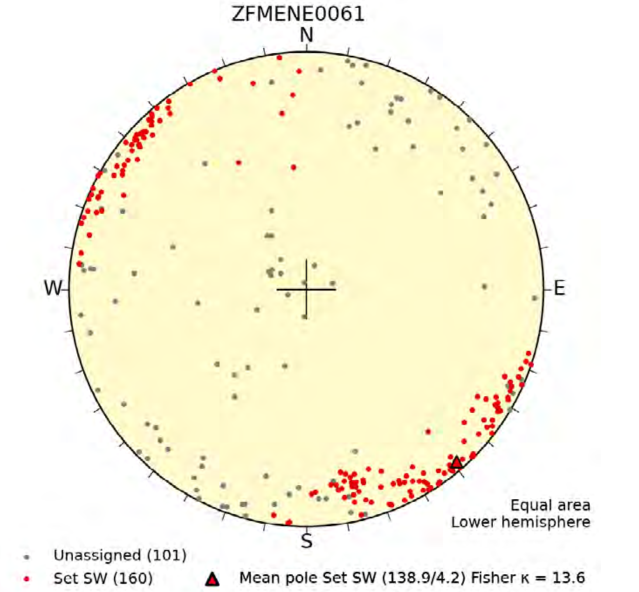
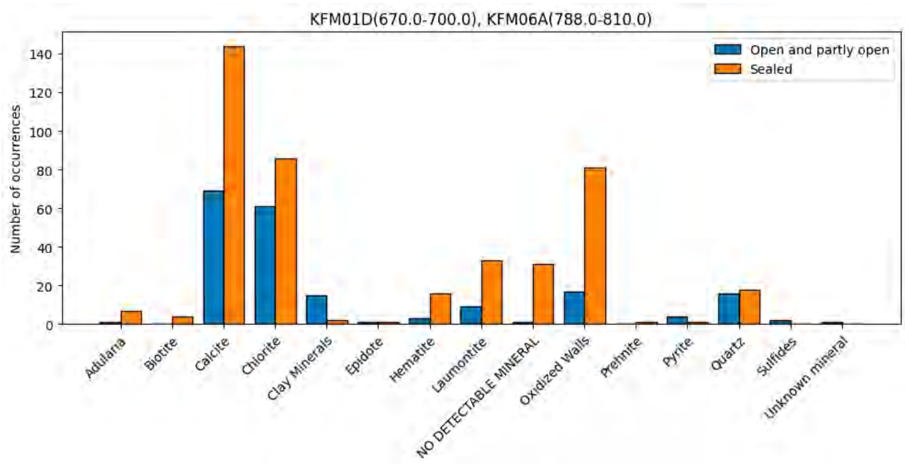


OBJECT CONFIDENCE ESTIMATE

Category	**Object CL**	**Comment**
INTERPRETATION		
Data source	2	MFM2281G, KFM01D, KFM06A
Results of interpretation	3	High confidence observation in KFM01C.
INFORMATION DENSITY		
Number of observation points	2	2
Distribution of observation points	2	Two intercepts and the reflector considered as an outlier. Three scattered observation points.
INTERPOLATION		
Geometry	2	Interpreted NE-striking fractures and laumontite perhaps strengthens interpretation of one strong interpolation geometry, however west of the last obs. point there is room for the zone to follow MFM2074G, MFM0061 or MFM0061G0.
Geological indicators	3	Supported by key geological parameters.
EXTRAPOLATION		
Dip direction	3	Extrapolated to the base of the model volume. Strike length of the modelled zone > 2000 m.
Strike direction	3	Conceptual understanding of the site and that the entire modelled zone is supported by lineament.

ENE	ZFMENE0061	Version number	3	Total object CL	20

FRACTURE CHARACTER

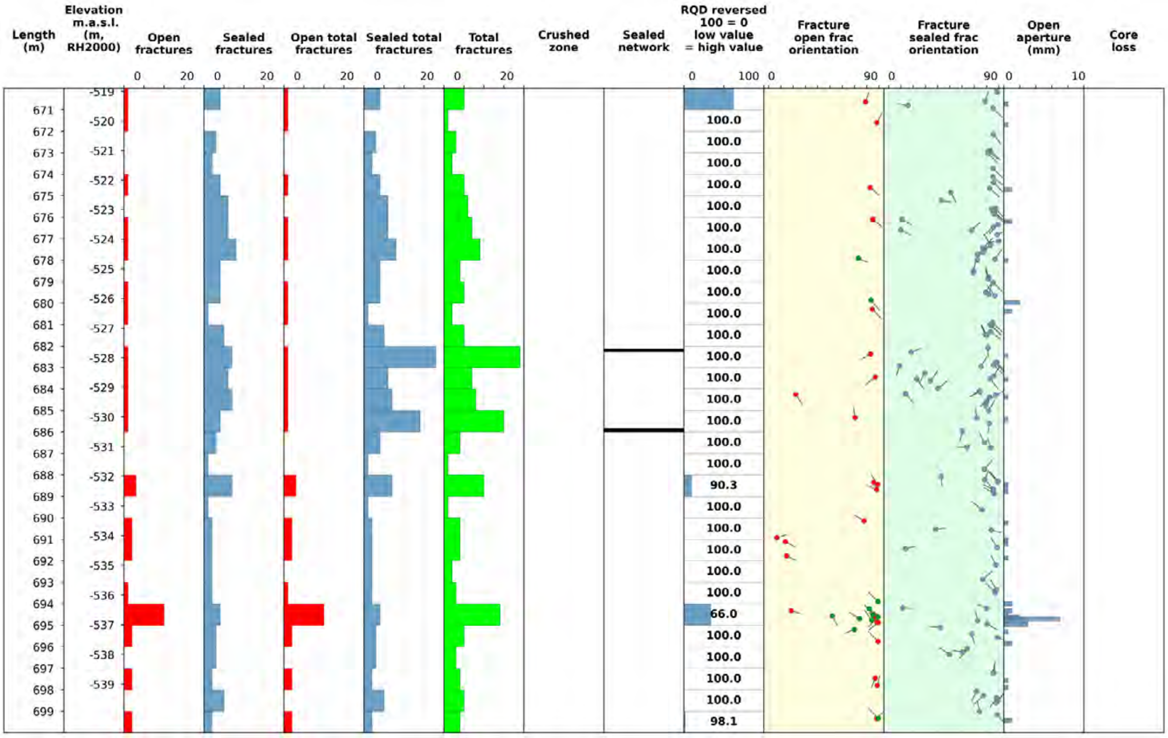
Orientation: (strike/dip right-hand-rule)	Set SW: 228.9°/85.8°	
Frequency:	Boreholes: KFM06A, KFM01D	
RQD:	min:38, max:100, mean:97	
Fracture fill mineralogy:		

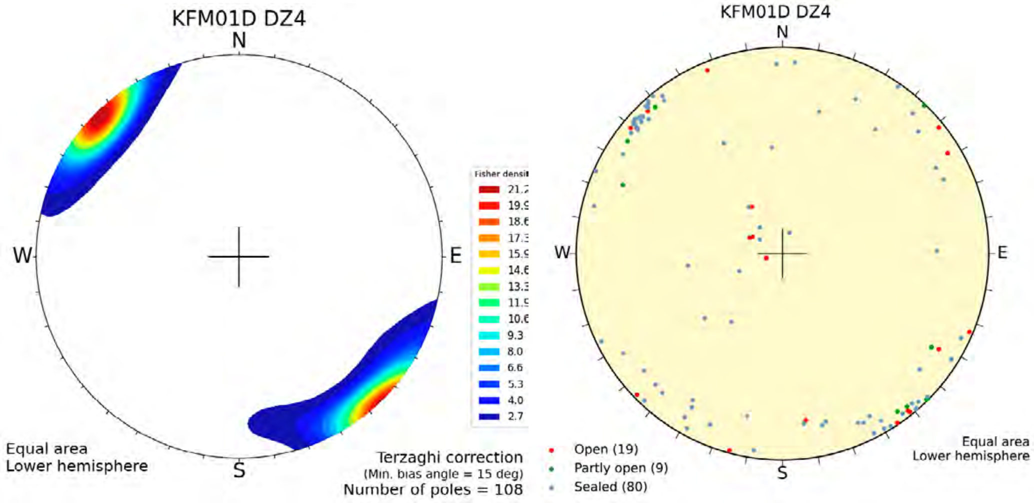
FRACTURE TYPE	TERZAGHI-WEIGHED P10
Open and partly open	4.3 m-1
Sealed	12.6 m-1
Sealed network	4.3 % of DZ intercept
Crush	0.0 % of DZ intercept

ENE	ZFMENE0061	Version number	3	Total object CL	20

INDIVIDUAL INTERCEPTS

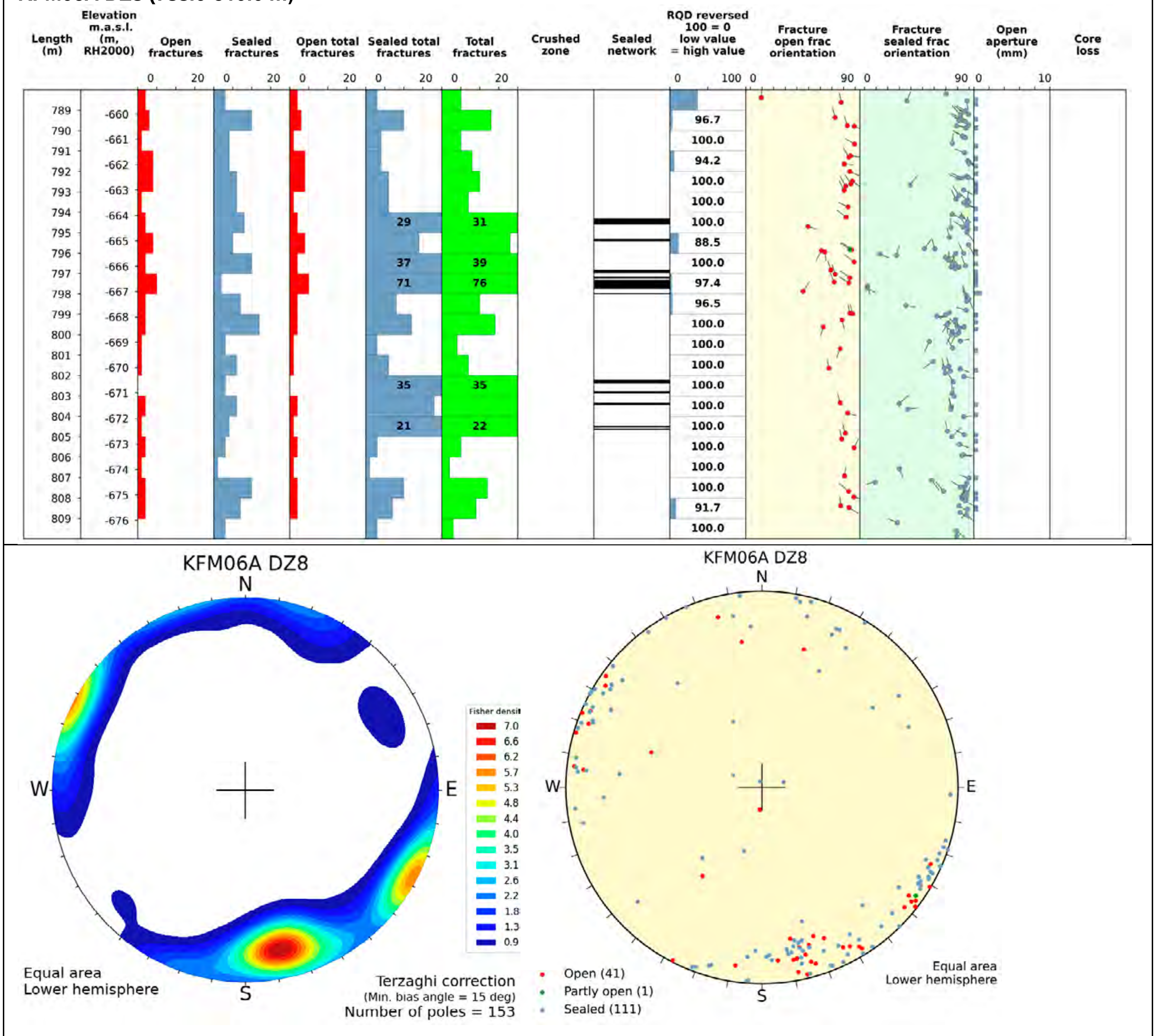
KFM01D DZ4 (670.0-700.0 m)



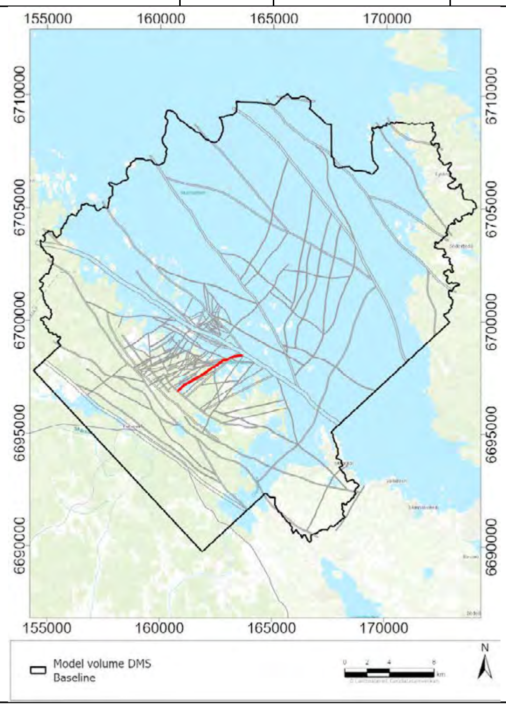


ENE	**ZFMENE0061**	Version number	**3**	Total object CL	**20**

KFM06A DZ8 (788.0-810.0 m)



ENE	ZFMENE0062A	Version number	3	Total object CL	20



GEOLOGICAL CHARACTER		Property CL
Deformation style:	Brittle	3
Deformation description:	No data available.	
Alteration:		1
- First order:	Oxidation	
- Second order:	Not observed	
- Third order:	Not observed	
Fracture orientation and type:	Steeply dipping fractures dominating in NE orientation . Gently dipping fractures are also present. Dominated by sealed followed by open and partly open fractures.	2
Fracture comment:	No data available.	
Fracture fill mineralogy:	Chlorite, calcite, adularia, laumontite.	

OBJECT GEOMETRY	
Strike/dip:	60°/85°
Length:	3439 m
Mean thickness:	44 m (15 - 64 m)
Max depth:	-2100 m
Geometrical constraints:	ZFMWNW0123, ZFMWNW0001, Topo 40m grid Max error 20m.

BASIS FOR MODELLING

Zone based on surface excavation, borehole observations and surface lineaments.

Outcrops: AFM001243

Boreholes:

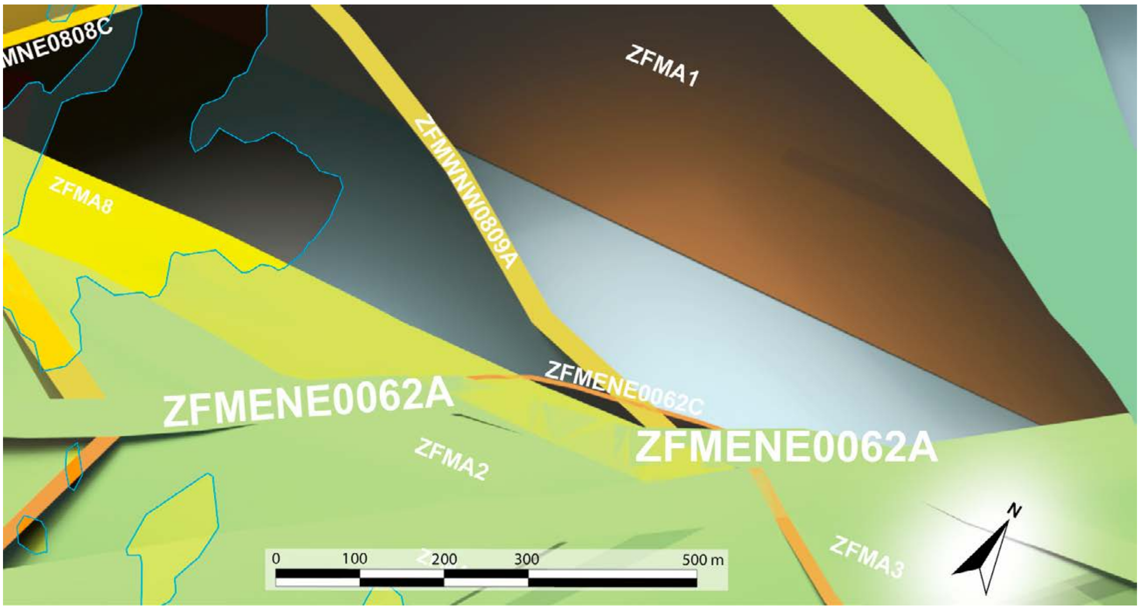
Borehole	PDZ	Target intercept		Geometric intercept		Comment
		Sec_up [m]	Sec_low [m]	Sec_up [m]	Sec_low [m]	
HFM25	DZ4	143.00	155.00	142.98	187.48	
HFM25	DZ5	169.00	187.00	142.98	187.48	

Tunnels:	-	
Lineament and/or seismic indications:	MFM0062, MFM0062G0.	2

MODELLING PROCEDURE

Zone ZFMENE0062 consists of different branches, the most prominent of which is denoted ZFMENE0062A. Though the branches are described separately in subsequent property sheets, it should be recalled that these probably constitute elements of one and the same structure. At the surface, corresponds to the low magnetic lineaments MFM0062 and MFM0062G0, and excavation AFM001243. Modelled to the base of the model volume using dip estimated by connecting lineaments MFM0062 and MFM0062G0 with the borehole intersections 143-155 m and 169-187 m in HFM25 (DZ4 and DZ5, respectively).

ENE	ZFMENE0062A	Version number	3	Total object CL	20

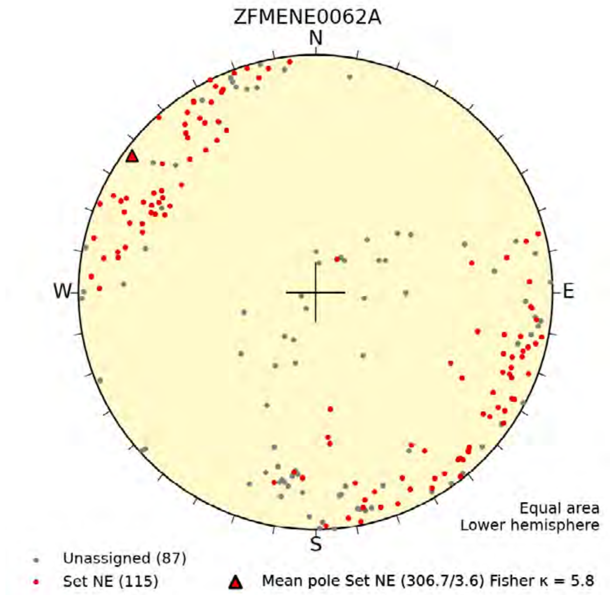


OBJECT CONFIDENCE ESTIMATE

Category	Object CL	Comment
INTERPRETATION		
Data source	3	MFM0062G0, HFM25, AFM001243
Results of interpretation	3	High confidence observations in AFM001243.
INFORMATION DENSITY		
Number of observation points	2	3
Distribution of observation points	1	Less than two subsurface obs. points.
INTERPOLATION		
Geometry	2	Interpreted NE-striking fractures and laumontite perhaps strengthens interpretation of one strong interpolation geometry, however west of the last obs. point there is room for the zone to follow MFM2074G, MFM0061 or MFM0061G0.
Geological indicators	3	Supported by key geological parameters.
EXTRAPOLATION		
Dip direction	3	Extrapolated to the base of the model volume. Strike length of the modelled zone > 2000 m.
Strike direction	3	Conceptual understanding of the site and that the entire modelled zone is supported by the lineament.

ENE	ZFMENE0062A	Version number	3	Total object CL	20

FRACTURE CHARACTER

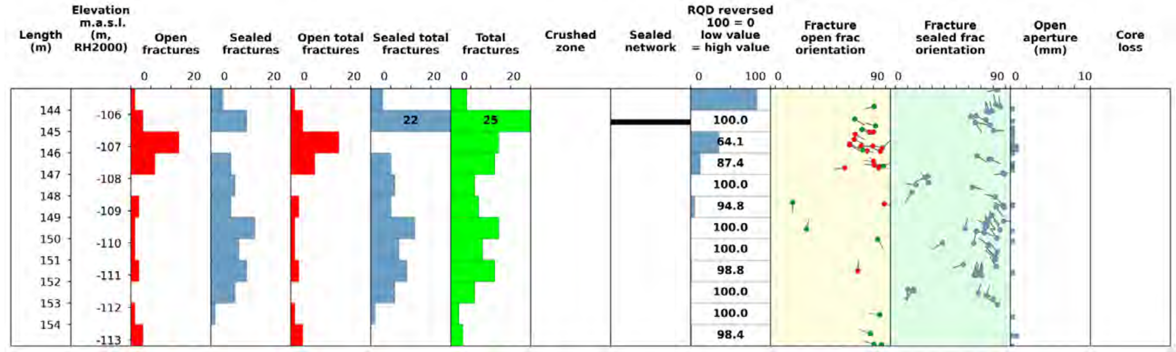
Orientation: (strike/dip right-hand-rule)	Set NE: 36.7°/86.4°	
Frequency:	Boreholes: -	
RQD:	--	
Fracture fill mineralogy:	No data available	

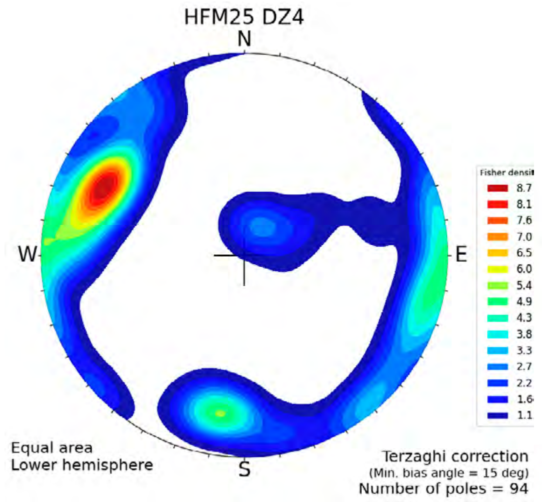
FRACTURE TYPE	TERZAGHI-WEIGHED P10
Open and partly open	0.0 m-1
Sealed	0.0 m-1
Sealed network	0.0 % of DZ intercept
Crush	0.0 % of DZ intercept

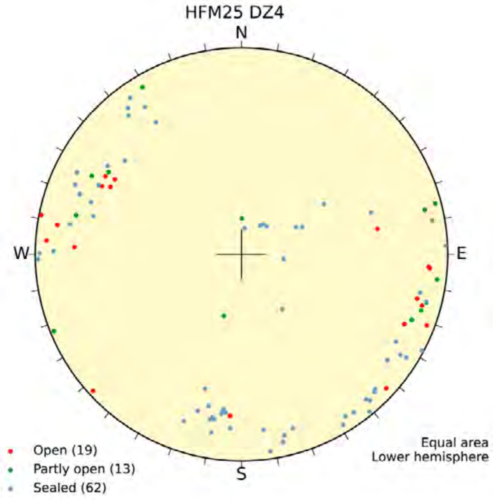
ENE	ZFMENE0062A	Version number	3	Total object CL	20

INDIVIDUAL INTERCEPTS

HFM25 DZ4 (143.0-155.0 m)

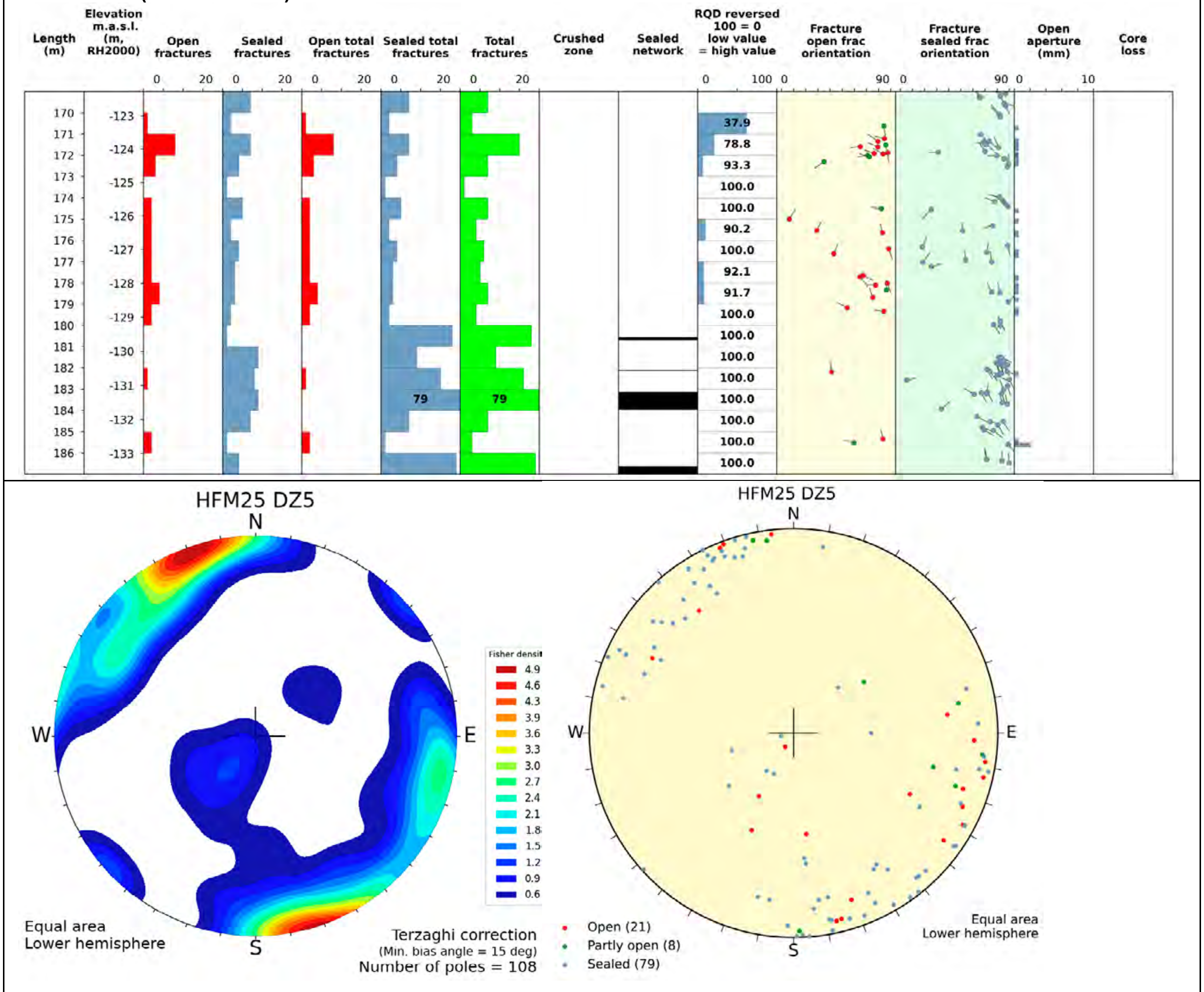






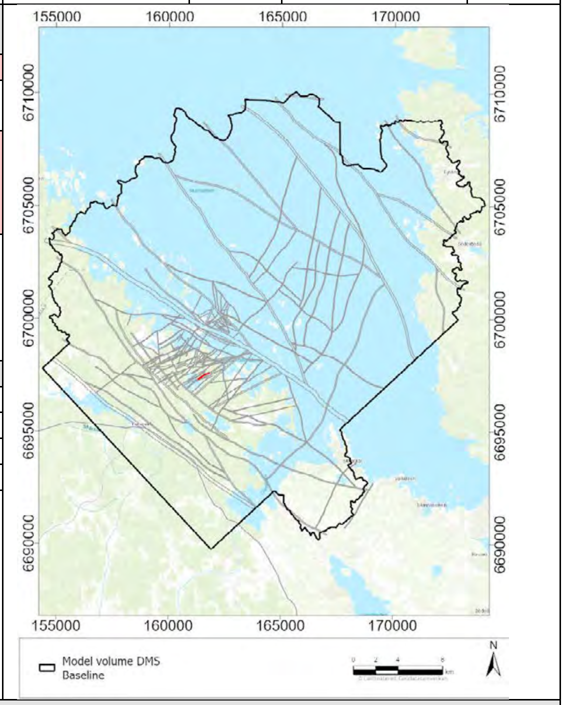
ENE	ZFMENE0062A	Version number	3	Total object CL	20

HFM25 DZ5 (169.0-187.0 m)



ENE	ZFMENE0062B	Version number	3	Total object CL	18

GEOLOGICAL CHARACTER		Property CL
Deformation style:	Brittle	1
Deformation description:	No data available.	
Alteration:		1
- First order:	Oxidation	
- Second order:	Not observed	
- Third order:	Not observed	
Fracture orientation and type:	No data available.	
Fracture comment:	No data available.	
Fracture fill mineralogy:	No data available.	



OBJECT GEOMETRY	
Strike/dip:	58°/82°
Length:	613 m
Mean thickness:	10 m (2 - 36 m)
Max depth:	-892 m
Geometrical constraints:	ZFMENE0062A, Topo 40m grid Max error 20m.

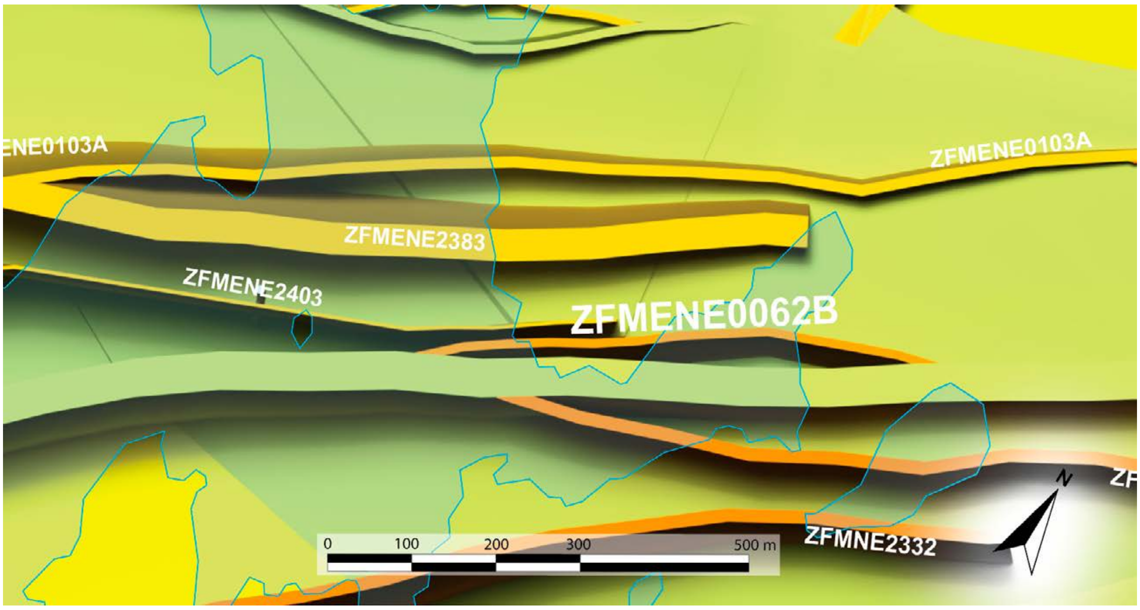
BASIS FOR MODELLING

Zone based on surface lineaments. Modelled to as a splay from zone ZFMENE0062A.

Outcrops:	-	
Boreholes: -		
Tunnels:	-	
Lineament and/or seismic indications:	MFM0062G1.	3

MODELLING PROCEDURE

At the surface, corresponds to the low magnetic lineament MFM0062G1. Modelled to a maximum depth of 780 m as a splay from zone ZFMENE0062A with a dip of 82 degrees to the NNW.



ENE	ZFMENE0062B	Version number	3	Total object CL	18

OBJECT CONFIDENCE ESTIMATE

Category	Object CL	Comment
INTERPRETATION		
Data source	1	MFM0062G1
Results of interpretation	3	High confidence observation in AFM001243.
INFORMATION DENSITY		
Number of observation points	1	1
Distribution of observation points	1	The zone is vertically extrapolated based on a single intercept to the base of the modelled volume. Large dist. between obs. points.
INTERPOLATION		
Geometry	1	Geometry supported by surface geophysical data. Modelled as a splay.
Geological indicators	1	Indirect support by geophysical data.
EXTRAPOLATION		
Dip direction	1	No subsurface obs. point. High uncertainty in dip-direction.
Strike direction	3	Conceptual understanding of the site and that the entire modelled zone is supported by lineament.

FRACTURE CHARACTER

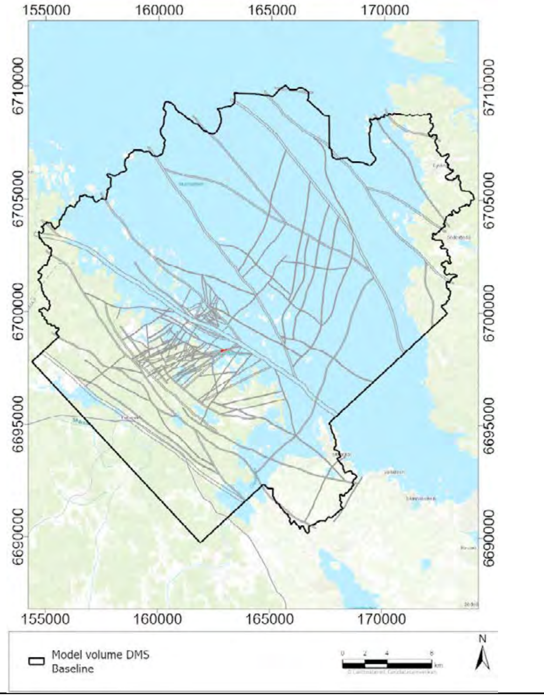
No data available

INDIVIDUAL INTERCEPTS

No data available

ENE	ZFMENE0062C	Version number	4	Total object CL	10

GEOLOGICAL CHARACTER		Property CL
Deformation style:	Brittle	1
Deformation description:	No data available.	
Alteration:		2
- First order:	Oxidation	
- Second order:	Not observed	
- Third order:	Not observed	
Fracture orientation and type:	No data available.	
Fracture comment:	No data available.	
Fracture fill mineralogy:	No data available.	



OBJECT GEOMETRY	
Strike/dip:	66°/80°
Length:	342 m
Mean thickness:	5 m (1 - 13 m)
Max depth:	-384 m
Geometrical constraints:	ZFMENE0062A, Topo 40m grid Max error 20m.

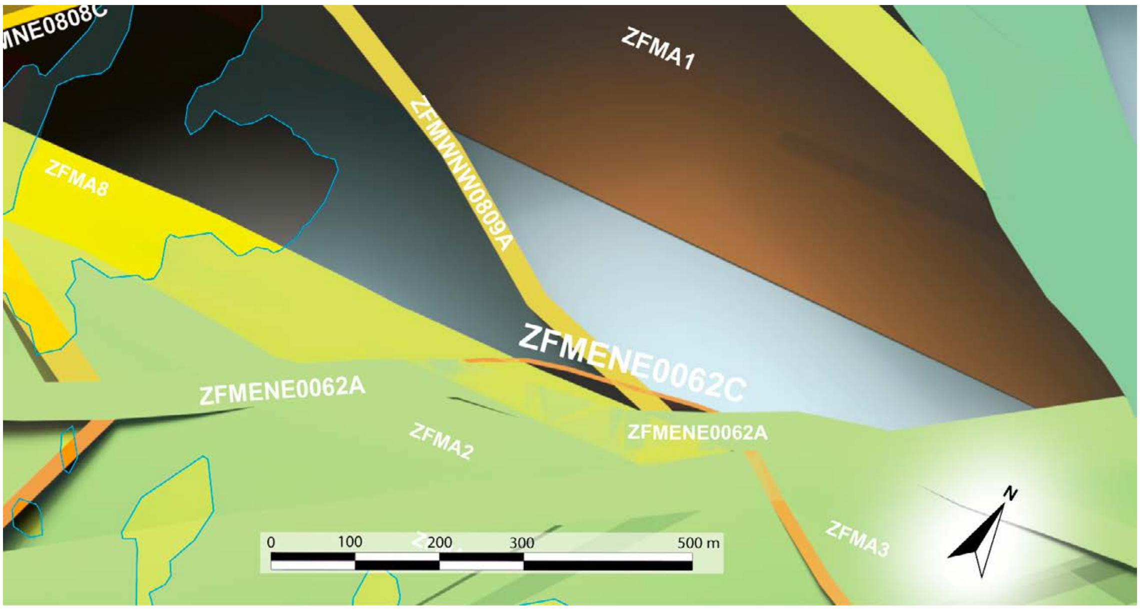
BASIS FOR MODELLING

Zone based on surface lineaments. Modelled to as a splay to zone ZFMENE0062A.

Outcrops:	-	
Boreholes: -		
Tunnels:	-	
Lineament and/or seismic indications:	MFM0062G2.	1

MODELLING PROCEDURE

At the surface, corresponds to the low magnetic lineament MFM0062G2. Modelled to a maximum depth of 320 m as a splay from zone ZFMENE0062A with a dip of 80 degrees to the NNW.



ENE	ZFMENE0062C	Version number	4	Total object CL	10

OBJECT CONFIDENCE ESTIMATE

Category	Object CL	Comment
INTERPRETATION		
Data source	1	MFM0062G2
Results of interpretation	1	Low confidence in lineament MFM0062G2.
INFORMATION DENSITY		
Number of observation points	1	1
Distribution of observation points	1	Single observation point in the form of a lineament.
INTERPOLATION		
Geometry	1	Geometry supported by surface geophysical data. Modelled as a splay.
Geological indicators	1	Indirect support by geophysical data.
EXTRAPOLATION		
Dip direction	1	No subsurface obs. point. High uncertainty in dip-direction.
Strike direction	3	Conceptual understanding of the site and that the entire modelled zone is supported by lineament.

FRACTURE CHARACTER

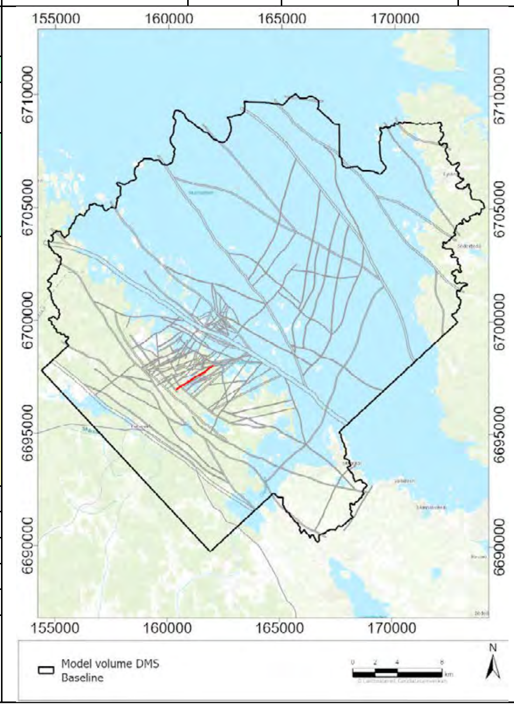
No data available

INDIVIDUAL INTERCEPTS

No data available

ENE	ZFMENE0103A	Version number	4	Total object CL	15

GEOLOGICAL CHARACTER		Property CL
Deformation style:	Brittle	3
Deformation description:	No data available.	
Alteration:		3
- First order:	Oxidation	
- Second order:	Not observed	
- Third order:	Not observed	
Fracture orientation and type:	Steeply dipping fractures with ENE strike dominates. Dominance of sealed fractures. Quantitative estimate and span include sealed fracture networks.	2
Fracture comment:	No data available.	
Fracture fill mineralogy:	Calcite, chlorite, hematite/adularia, laumontite, quartz.	



OBJECT GEOMETRY	
Strike/dip:	238°/84°
Length:	2004 m
Mean thickness:	12 m (3 - 50 m)
Max depth:	-2100 m
Geometrical constraints:	ZFMNW1200, Topo 40m grid Max error 20m, 1 UNIVERSE Planar Cut(s).

BASIS FOR MODELLING

Based on surface lineament and a borehole observation. Zone ZFMENE0103 consists of two segments, ZFMENE0103A and ZFMENE0103B, judged to constitute elements of one and the same structure.

Outcrops: -

Boreholes:

Borehole	PDZ	Target intercept		Geometric intercept		Comment
		Sec_up [m]	Sec_low [m]	Sec_up [m]	Sec_low [m]	
KFM05A	DZ4	892.00	916.00	891.84	915.83	

Tunnels:	-	
Lineament and/or seismic indications:	MFM0103, MFM0103G0.	2

MODELLING PROCEDURE

Zone ZFMENE0103 consists of two segments, the most prominent of which is denoted ZFMENE0103A. The subordinate component is an extension to the north-east with slightly different strike and is denoted ZFMENE0103B. These two segments are judged to constitute elements of one and the same structure. Zone ZFMENE01013A corresponds at the surface to the low magnetic lineaments MFM0103 and MFM0103G0. Modelled down to c.1400 m depth, using the dip estimated by connecting these lineaments with the borehole intersection 892-916 m in KFM05A (DZ4). Deformation zone plane placed at fixed point 906 m in KFM05A. Decreased radar penetration also along the borehole interval 905-912 m.

ENE	ZFMENE0103A	Version number	4	Total object CL	15

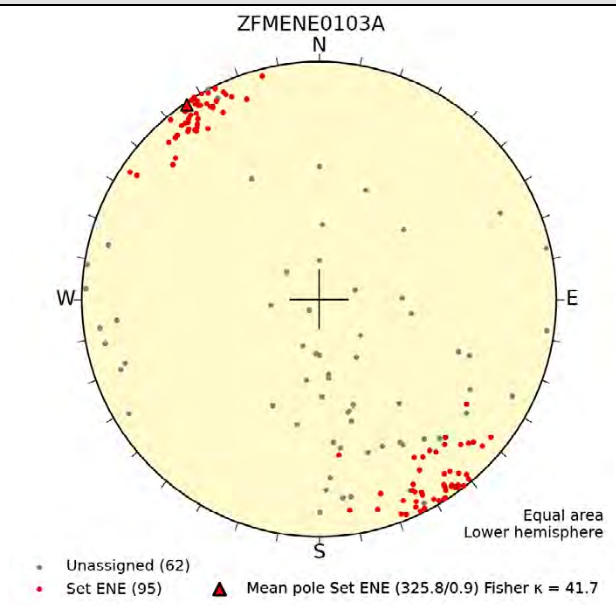
OBJECT CONFIDENCE ESTIMATE

Category	Object CL	Comment
INTERPRETATION		
Data source	2	MFM0103G0, KFM05A
Results of interpretation	2	Medium confidence observation in KFM05A.
INFORMATION DENSITY		
Number of observation points	2	2
Distribution of observation points	1	More than 700 m between the surface lineament and borehole intercept at depth.
INTERPOLATION		
Geometry	1	Geometry supported by a lineament and a single intercept.
Geological indicators	1	Single observation point at depth. Zone modelled mainly based on surface geophysical data.
EXTRAPOLATION		
Dip direction	3	Extrapolated to the base of the model volume. Strike length of the modelled zone > 2000 m.
Strike direction	3	Conceptual understanding of the site and that the entire modelled zone is supported by lineament.

FRACTURE CHARACTER

Orientation: (strike/dip right-hand-rule)	Set ENE: 55.8°/89.1°
Frequency:	Boreholes: KFM05A
RQD:	min:7, max:100, mean:96

FRACTURE TYPE	TERZAGHI-WEIGHED P10
Open and partly open	1.0 m-1
Sealed	13.2 m-1
Sealed network	7.9 % of DZ intercept
Crush	0.0 % of DZ intercept



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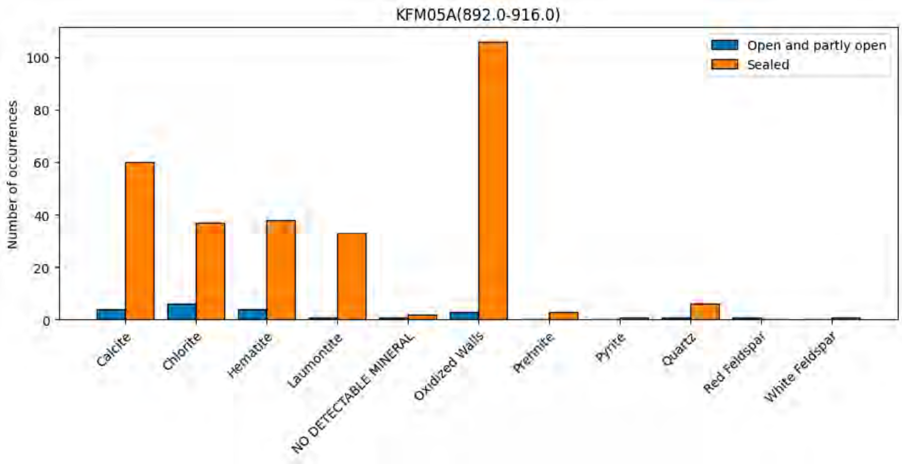
<tr><td>Fracture fill mineralogy:</td><td colspan="5">
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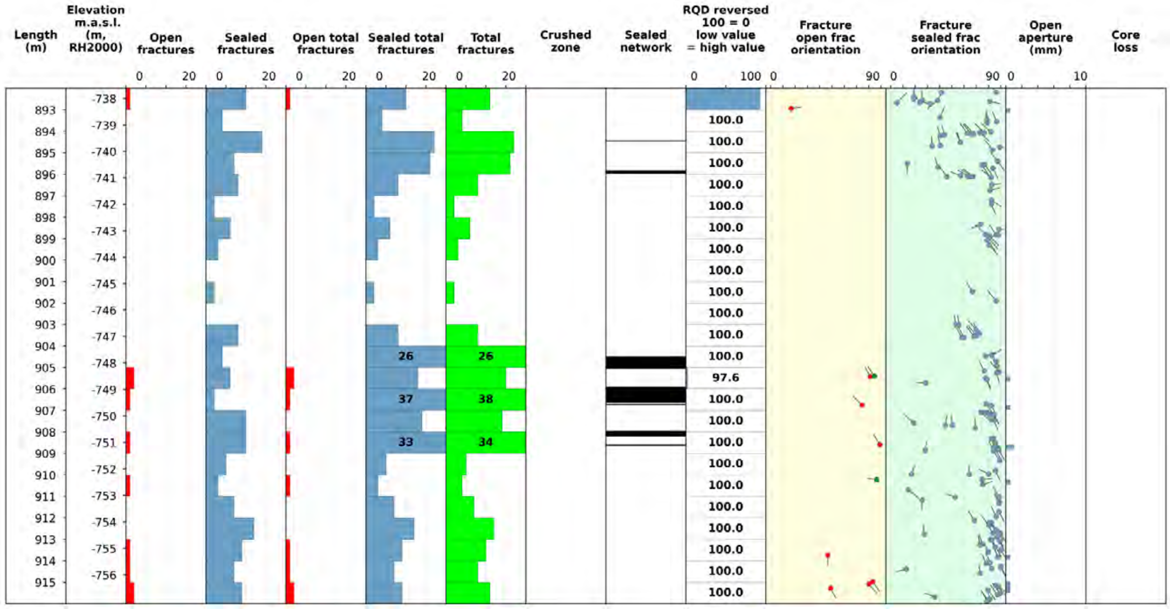
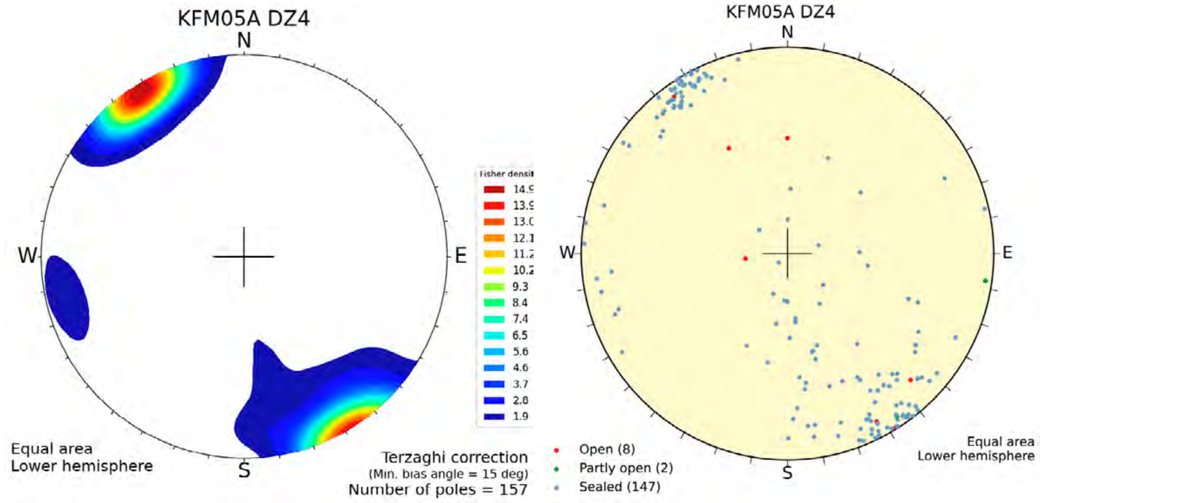
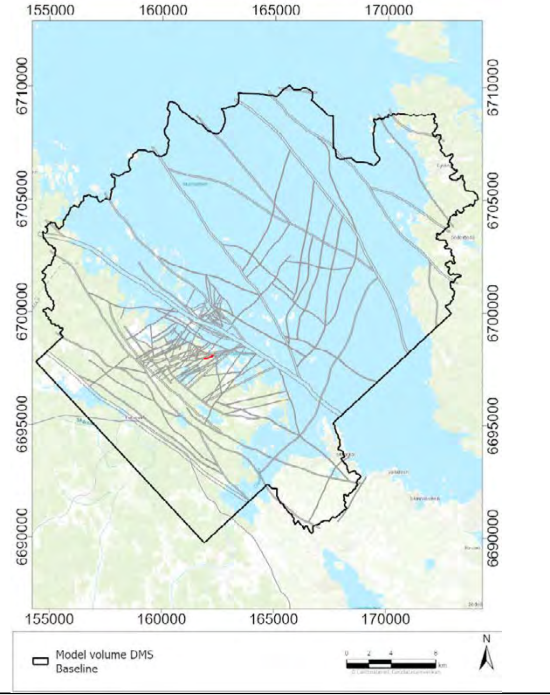
ENE	ZFMENE0103A	Version number	4	Total object CL	15

INDIVIDUAL INTERCEPTS

KFM05A DZ4 (892.0-916.0 m)





ENE	ZFMENE0103B		Version number	4	Total object CL	11
GEOLOGICAL CHARACTER		**Property CL**				
Deformation style:	Brittle	1				
Deformation description:	No data available.					
Alteration:		2				
- First order:	Oxidation					
- Second order:	Not observed					
- Third order:	Not observed					
Fracture orientation and type:	No data available.					
Fracture comment:	No data available.					
Fracture fill mineralogy:	No data available.					
OBJECT GEOMETRY						
Strike/dip:	248°/84°					
Length:	432 m					
Mean thickness:	12 m (1 - 13 m)					
Max depth:	-2100 m					
Geometrical constraints:	ZFMENE0103A, Topo 40m grid Max error 20m, 1 UNIVERSE Planar Cut(s).					

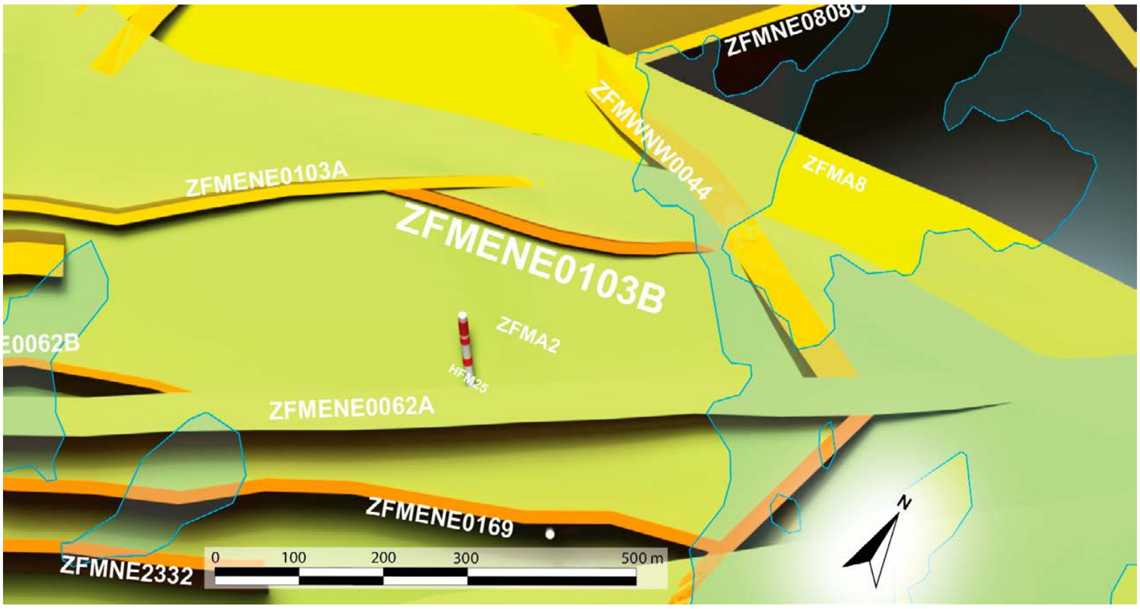
BASIS FOR MODELLING

Zone based on surface lineaments. Modelled as a splay to ZFMENE0103A.

Outcrops:	-	
Boreholes: -		
Tunnels:	-	
Lineament and/or seismic indications:	MFM0103G1.	2

MODELLING PROCEDURE

Zone ZFMENE0103 consists of two segments, the most prominent of which is denoted ZFMENE0103A. The subordinate component is an extension to the north-east with slightly different strike and is denoted ZFMENE0103B. These two segments are judged to constitute elements of one and the same structure. At the surface, corresponds to the low magnetic lineament MFM0103G1. Modelled with the same dip, the same thickness and to the same depth (c.1400 m) as ZFMENE0103A.



ENE	ZFMENE0103B	Version number	4	Total object CL	11

OBJECT CONFIDENCE ESTIMATE

Category	Object CL	Comment
INTERPRETATION		
Data source	1	MFM0103G1
Results of interpretation	2	Medium confidence in lineament MFM0103G1.
INFORMATION DENSITY		
Number of observation points	1	1
Distribution of observation points	1	Single observation point in the form of a lineament.
INTERPOLATION		
Geometry	1	Geometry supported by surface geophysical data.
Geological indicators	1	Indirect support by geophysical data.
EXTRAPOLATION		
Dip direction	1	No subsurface obs. point. High uncertainty in dip-direction.
Strike direction	3	Conceptual understanding of the site and that the entire modelled zone is supported by lineament.

FRACTURE CHARACTER

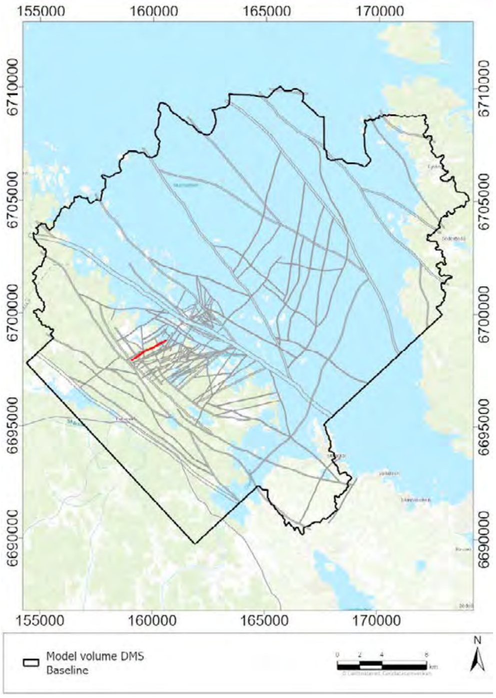
No data available

INDIVIDUAL INTERCEPTS

No data available

ENE	ZFMENE0159A	Version number	4	Total object CL	22

GEOLOGICAL CHARACTER		Property CL
Deformation style:	Brittle	3
Deformation description:	Faults dipping gently to the north show reverse dip-slip or reverse sinistral strike-slip components of movement. Steep WSW faults show strike-slip movement, both dextral and sinistral. A steep NNW fault shows a predominantly dextral sense of shear.	
Alteration:		3
- First order:	Oxidation	
- Second order:	Not observed	
- Third order:	Not observed	
Fracture orientation and type:	Gently dipping fractures dominates. Steeply dipping fractures are also present. Dominated by sealed followed by open and partly open fractures.	2
Fracture comment:	No data available.	
Fracture fill mineralogy:	Calcite, chlorite, clay minerals, hematite/adularia, laumontite, prehnite and epidote in sub-horizontal and gently dipping fractures. Note also some gently dipping fractures with no mineral coating/filling.	
OBJECT GEOMETRY		
Strike/dip:	241°/80°	
Length:	1834 m	
Mean thickness:	18 m (4 - 22 m)	
Max depth:	-1850 m	
Geometrical constraints:	ZFMNW0017, Topo 40m grid Max error 20m, 1 UNIVERSE Planar Cut(s).	



ENE	ZFMENE0159A	Version number	4	Total object CL	22

BASIS FOR MODELLING

Based on surface lineament, excavations and borehole observations. Zone ZFMENE0159A consists of two segments, ZFMENE0159A and ZFMENE0159B, judged to constitute elements of one and the same structure.

Outcrops: AFM001265, PFM007097

Boreholes:

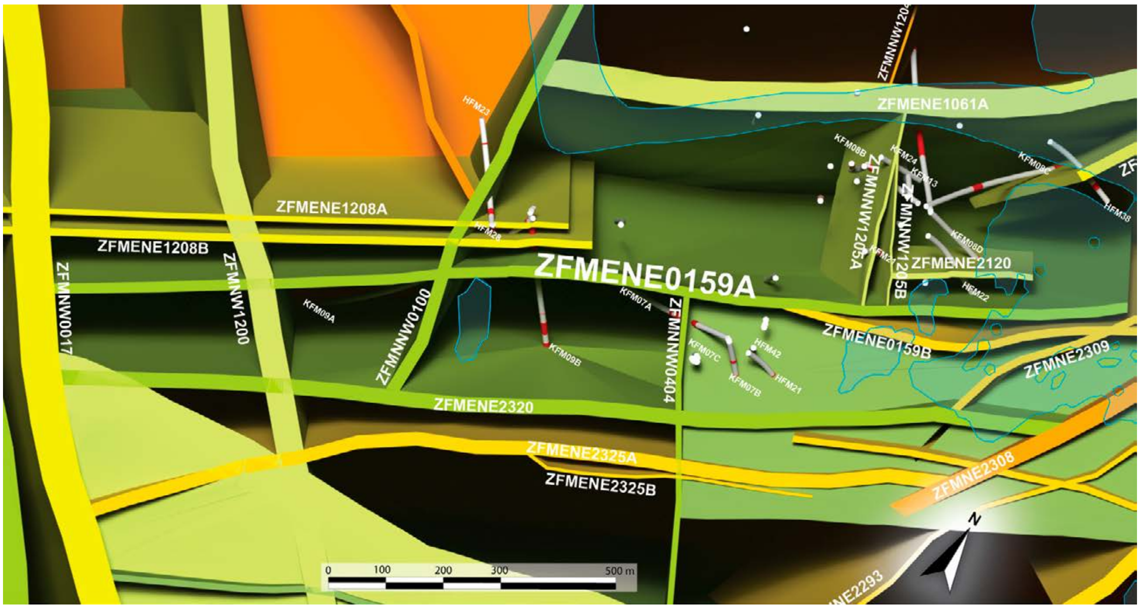
Borehole	PDZ	Target intercept		Geometric intercept		Comment
		Sec_up [m]	Sec_low [m]	Sec_up [m]	Sec_low [m]	
HFM22		-	-	185.82	208.73	No indication of possible zone according to the borehole image or mapping. Located close to (c. 120 m) KFM08D DZ1 (confidence level = 1). Highly uncertain branch of ZFMENE0159A. Lineament MFM0159G (confidence level = 1.916).
KFM07A	DZ3	417.00	422.00	395.32	601.56	Fractured rock beneath DZ3, between 422 and 507 m, inferred to be affected by DZ (cf. Table 3-2 in Stephens et al. 2007).
KFM08D	DZ2	318.00	324.00	298.14	331.90	
KFM09A	DZ3	217.00	280.00	205.17	258.04	ZFMNNW0100 also intersects DZ3.
KFM09B	DZ1	106.00	132.00	106.46	132.15	Only borehole intervals 9-43 m, 59-78 m and 106-132 m included in the DZ deterministic modelling (cf. Table 3-2 in Stephens et al. 2007). Fractured rock between these modelled zones and between 132 and 308 m inferred to be affected by DZ.

Tunnels:	-	
Lineament and/or seismic indications:	MFM0159, MFM0159G.	2

MODELLING PROCEDURE

Zone ZFMENE0159 consists of two branches. The most prominent branch is denoted ZFMENE0159A and an inferred splay from this branch is denoted ZFMENE0159B. Though the branches are described separately in subsequent property sheets, it should be recalled that these probably constitute elements of one and the same structure. At the surface, corresponds to the low magnetic lineaments MFM0159 and MFM0159G, and excavation AFM001265. Modelled down to 1900 m depth, using the dip estimated by connecting these lineaments with the borehole intersections 417-422 m in KFM07A (DZ3), 318-324 m in KFM08D (DZ2), 217-280 m in KFM09A (DZ3) and 106-132 m in KFM09B (part of DZ1). Deformation zone plane placed at fixed points 419 m in KFM07A, 322 m in KFM08D, 244 m in KFM09A and 121 m in KFM09B. Decreased radar penetration also along the borehole intervals 418-422 m in KFM07A and 119-122 m in KFM09B.

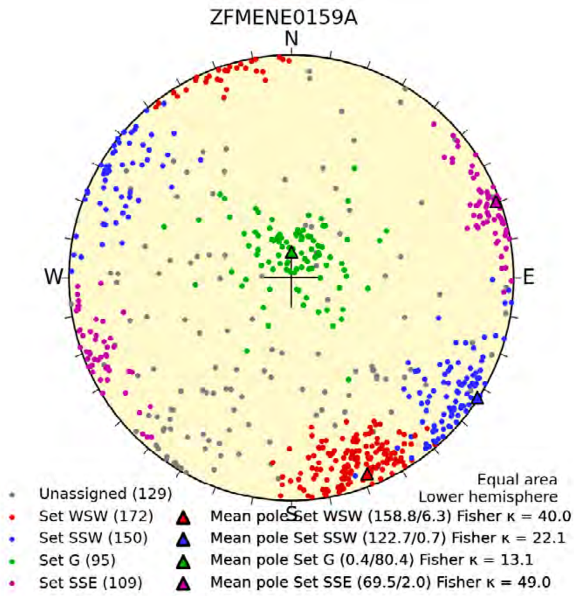
ENE	ZFMENE0159A	Version number	4	Total object CL	22



OBJECT CONFIDENCE ESTIMATE

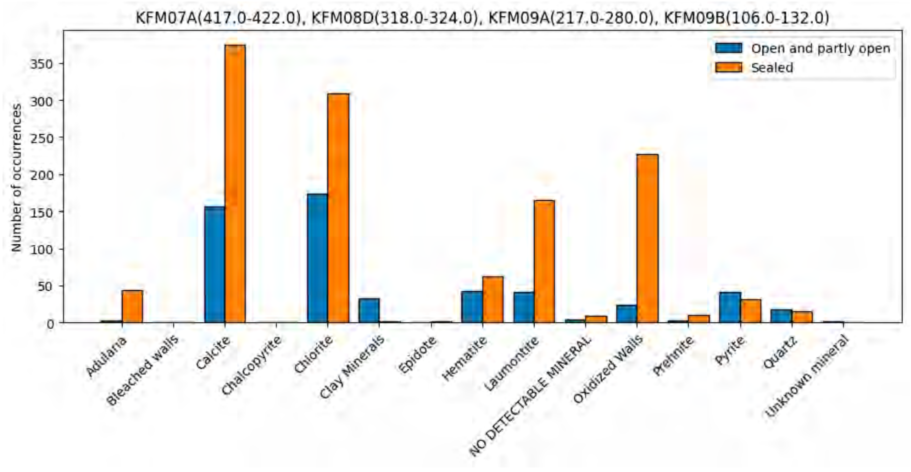
Category	Object CL	Comment
INTERPRETATION		
Data source	3	MFM0159G, KFM07A, KFM08D, KFM09B, HFM22, AFM001265, PFM007097
Results of interpretation	3	High confidence observation in multiple boreholes and outcrops.
INFORMATION DENSITY		
Number of observation points	3	>4
Distribution of observation points	3	Even distribution of obs. points.
INTERPOLATION		
Geometry	3	Geometry supported by minerals fillings within fractures interpreted by GSHI, a strong correlation exists to connect obs. points.
Geological indicators	2	Interpolation supported by mineral fillings within fractures from boreholes and outcrops.
EXTRAPOLATION		
Dip direction	2	Extrapolation supported by multiple subsurface obs. points.
Strike direction	3	Conceptual understanding of the site and that the entire modelled zone is supported by lineament.

FRACTURE CHARACTER

Orientation: (strike/dip right-hand-rule)	Set WSW: 248.8°/83.7° Set SSW: 212.7°/89.3° Set G: 90.4°/9.6° Set SSE: 159.5°/88.0°	
Frequency:	Boreholes: KFM09B, KFM07A, KFM09A, KFM08D	
RQD:	min:20, max:100, mean:96	

FRACTURE TYPE	TERZAGHI-WEIGHED P10
Open and partly open	3.7 m-1
Sealed	13.5 m-1
Sealed network	12.1 % of DZ intercept
Crush	0.4 % of DZ intercept

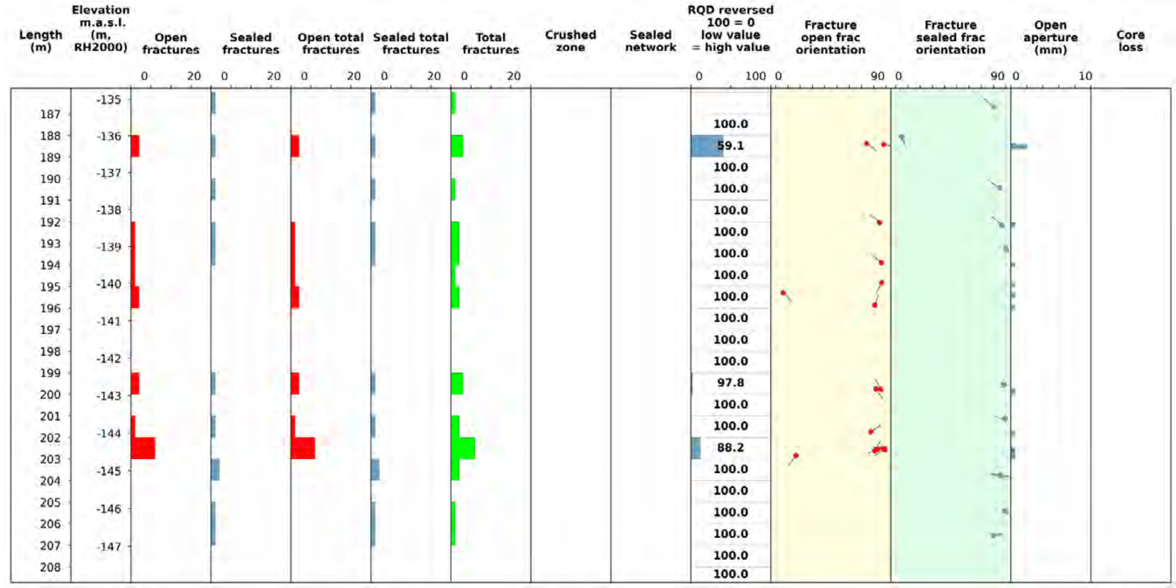
ENE	ZFMENE0159A	Version number	4	Total object CL	22
Fracture fill mineralogy:					



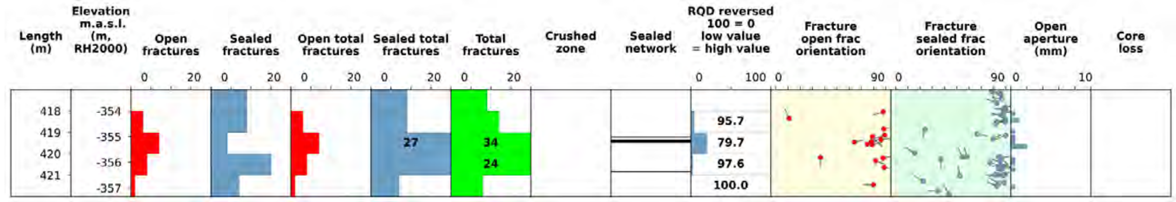
ENE	ZFMENE0159A	Version number	4	Total object CL	22

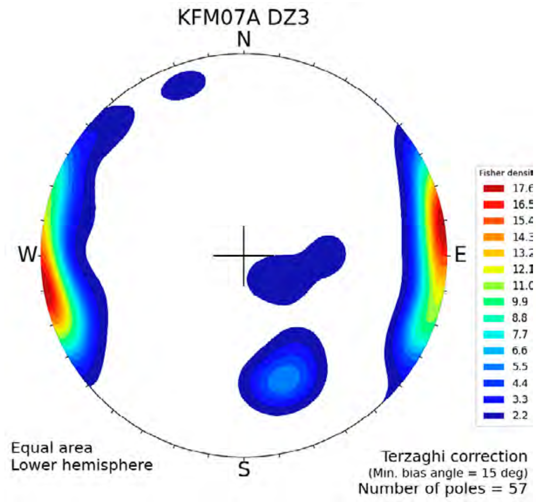
INDIVIDUAL INTERCEPTS

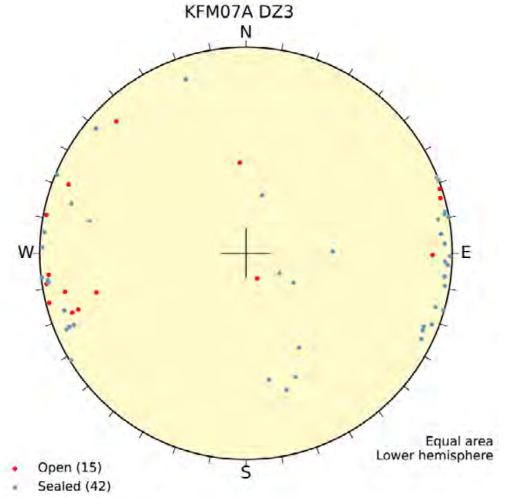
HFM22 (185.82-208.73 m)



KFM07A DZ3 (417.0-422.0 m)

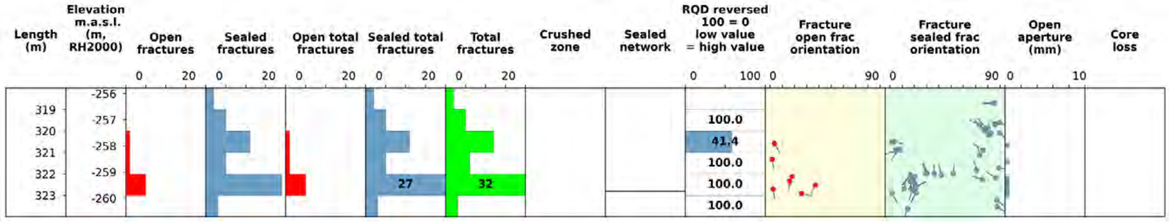


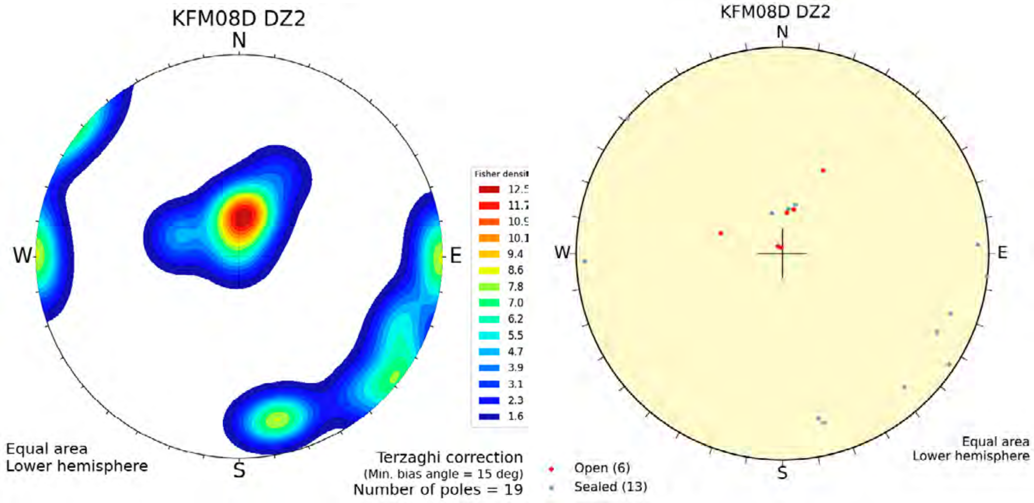




ENE	ZFMENE0159A	Version number	4	Total object CL	22

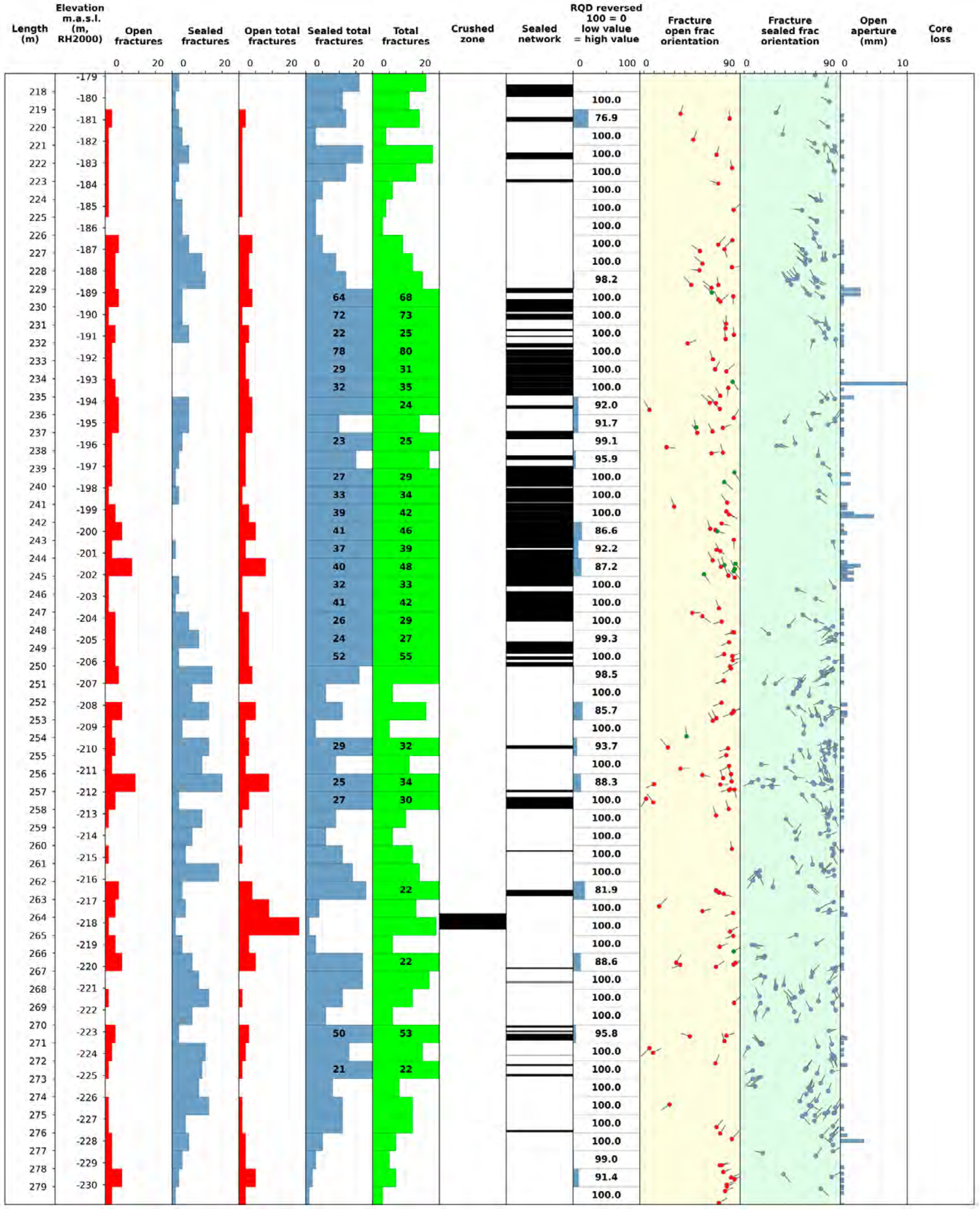
KFM08D DZ2 (318.0-324.0 m)



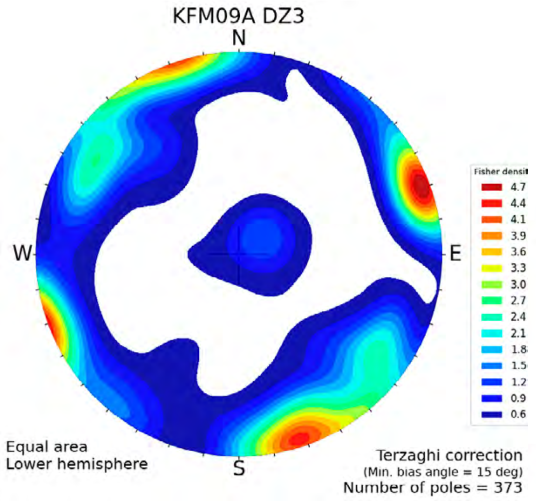


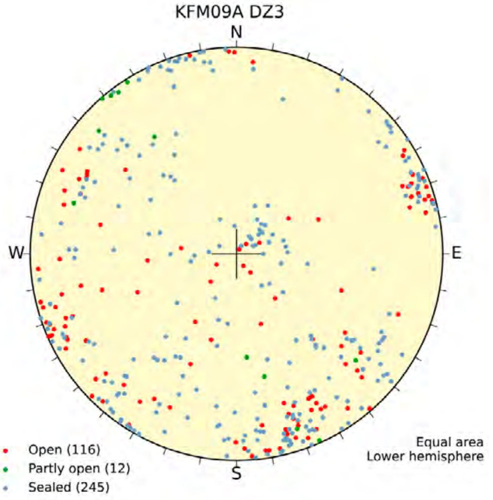
ENE	ZFMENE0159A	Version number	4	Total object CL	22

KFM09A DZ3 (217.0-280.0 m)

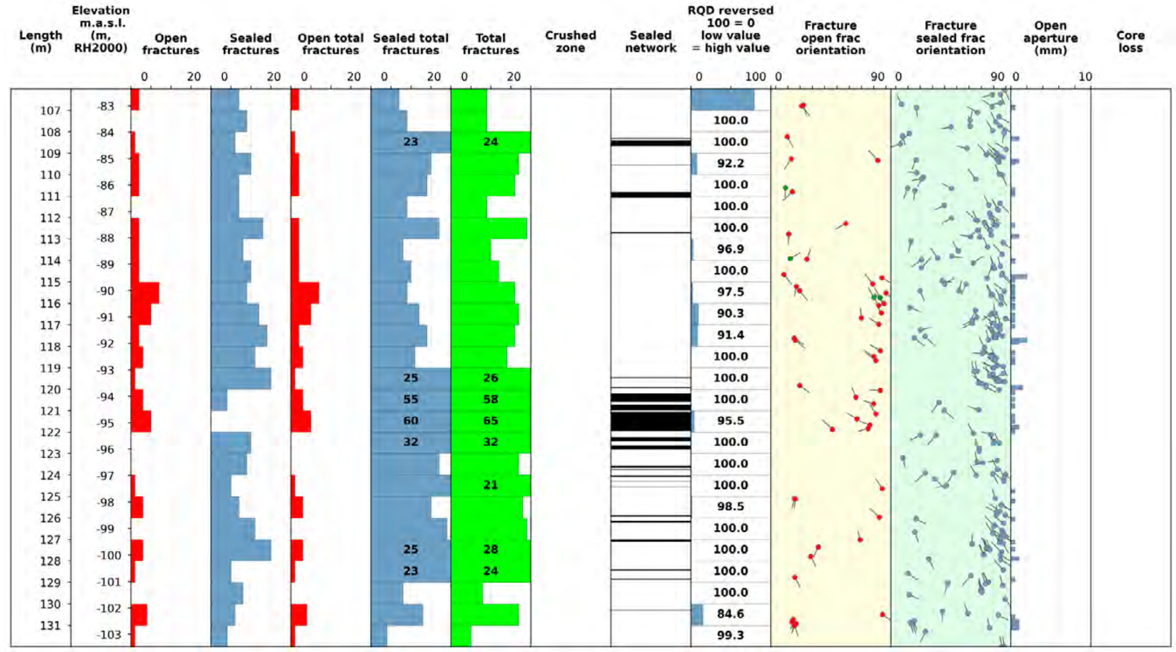


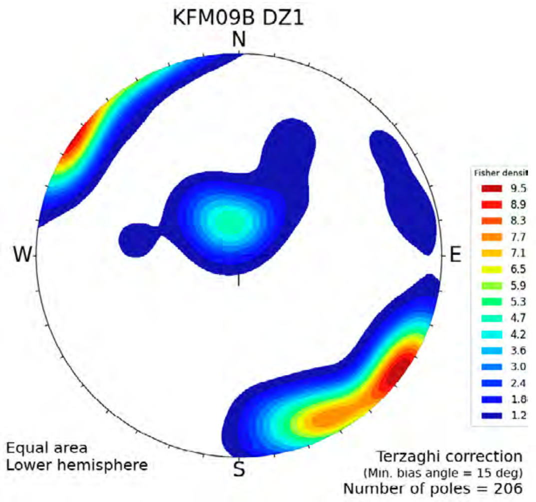
ENE	ZFMENE0159A	Version number	4	Total object CL	22

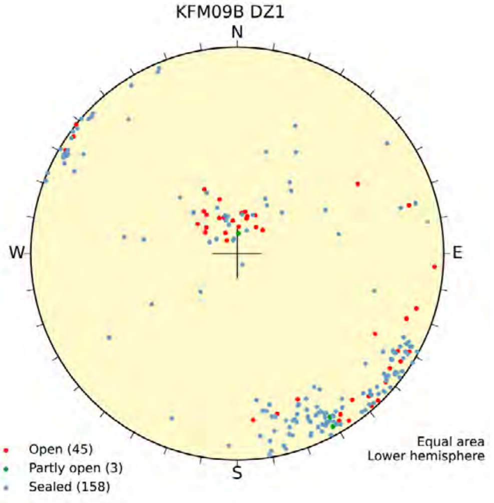




KFM09B DZ1 (106.0-132.0 m)

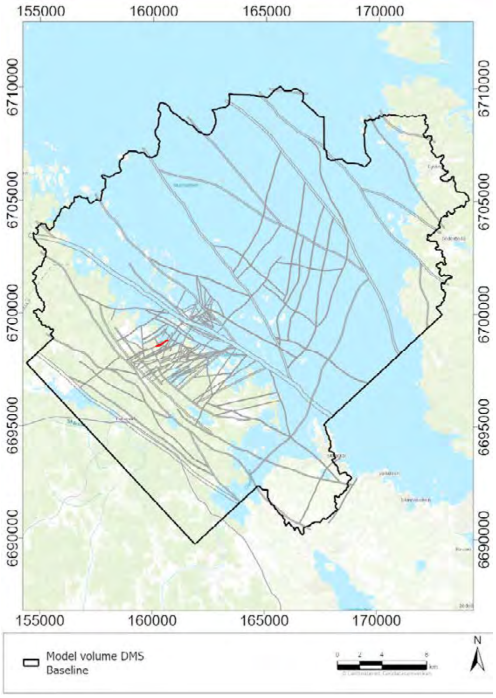






ENE	ZFMENE0159B	Version number	4	Total object CL	15

GEOLOGICAL CHARACTER		Property CL
Deformation style:	Brittle	3
Deformation description:	Steep fault with ENE strike shows dextral strike-slip displacement.	
Alteration:		3
- First order:	Oxidation	
- Second order:	Not observed	
- Third order:	Not observed	
Fracture orientation and type:	Steeply dipping fractures with ENE-WSW and SSW strike are prominent. Steeply dipping fractures with NNW-SSE and ESE strike and gently dipping fractures are also present. Dominance of sealed fractures. Quantitative estimate and span include sealed fracture networks.	2
Fracture comment:	No data available.	
Fracture fill mineralogy:	Calcite, chlorite, hematite/adularia, prehnite and other minerals.	



OBJECT GEOMETRY	
Strike/dip:	240°/80°
Length:	671 m
Mean thickness:	14 m (2 - 36 m)
Max depth:	-1850 m
Geometrical constraints:	ZFMENE0159A, Topo 40m grid Max error 20m, 1 UNIVERSE Planar Cut(s).

BASIS FOR MODELLING

Based on surface lineaments and a borehole observation. Zone ZFMENE0159 consists of two segments, ZFMENE0159A and ZFMENE0159B, judged to constitute elements of one and the same structure.

Outcrops: -

Boreholes:

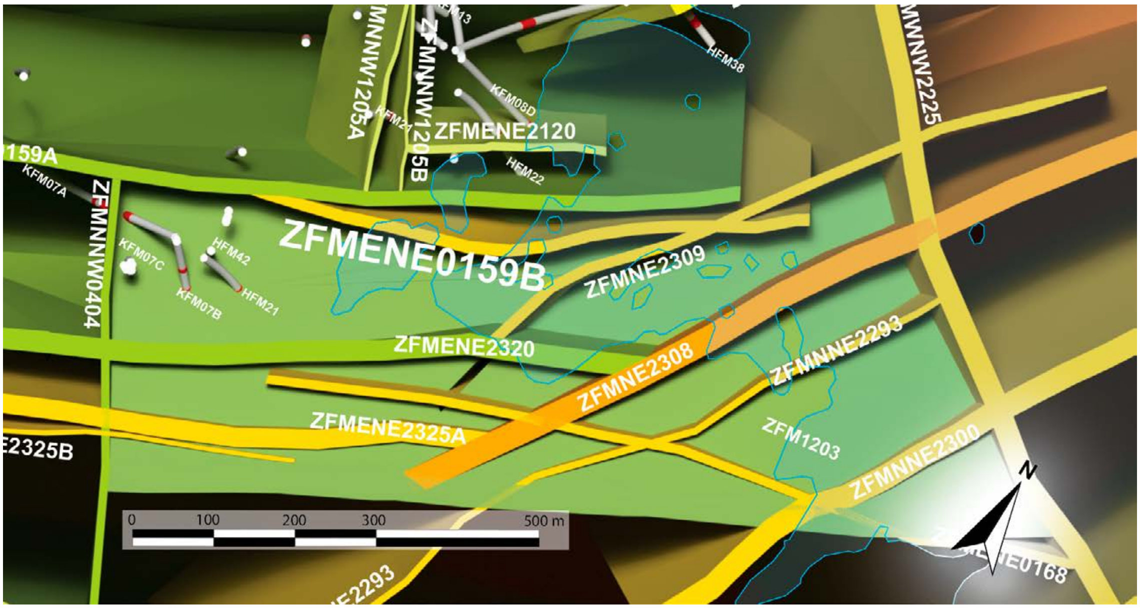
Borehole	PDZ	Target intercept		Geometric intercept		Comment
		Sec_up [m]	Sec_low [m]	Sec_up [m]	Sec_low [m]	
KFM08D	DZ3	371.00	396.00	371.15	396.48	

Tunnels:	-	
Lineament and/or seismic indications:	MFM2326G0.	2

MODELLING PROCEDURE

Zone ZFMENE0159 consists of two branches. The most prominent branch is denoted ZFMENE0159A and an inferred splay from this branch is denoted ZFMENE0159B. Though the branches are described separately in subsequent property sheets, these branches are inferred to constitute elements of one and the same structure. At the surface, corresponds to the low magnetic lineament MFM2326G0. Modelled as a splay from zone ZFMENE0159A by connecting this lineament to the borehole intersection 371-396 m along KFM08D (DZ3). Deformation zone plane placed at fixed point 384 m (sealed fracture network).

ENE	ZFMENE0159B	Version number	4	Total object CL	15



OBJECT CONFIDENCE ESTIMATE

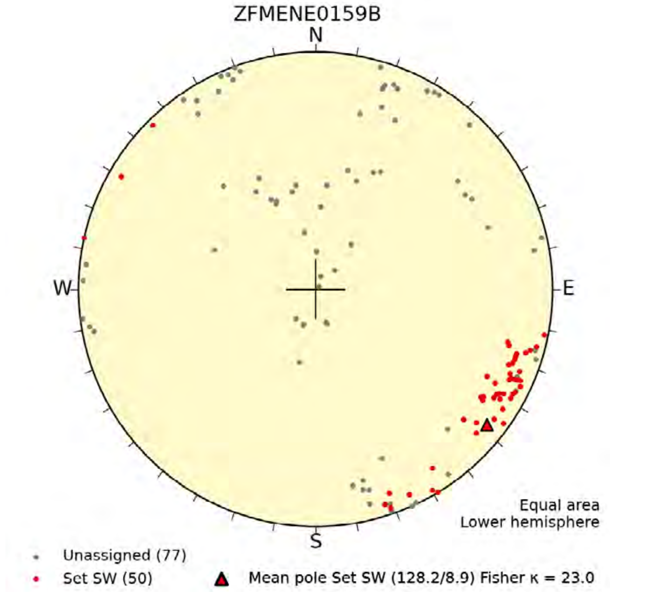
Category	Object CL	Comment
INTERPRETATION		
Data source	2	MFM2326G0, KFM08D
Results of interpretation	3	High confidence observation in KFM08D.
INFORMATION DENSITY		
Number of observation points	2	2
Distribution of observation points	1	Less than two subsurface obs. points.
INTERPOLATION		
Geometry	1	Not sure if the ZFMENE0159A widens or if it is split into a splay? Perhaps two alternatives for the geometry. Could the zone propagate in other direction. Difficult to say from a single sub-surface obs. point.
Geological indicators	1	Single observation point at depth. Zone modelled mainly based on surface geophysical data.
EXTRAPOLATION		
Dip direction	2	Extrapolation in dip direction supported by subsurface obs. point. Strike length of the modelled zone < 2000 m.
Strike direction	3	Conceptual understanding of the site and that the entire modelled zone is supported by lineament.

ENE	ZFMENE0159B	Version number	4	Total object CL	15

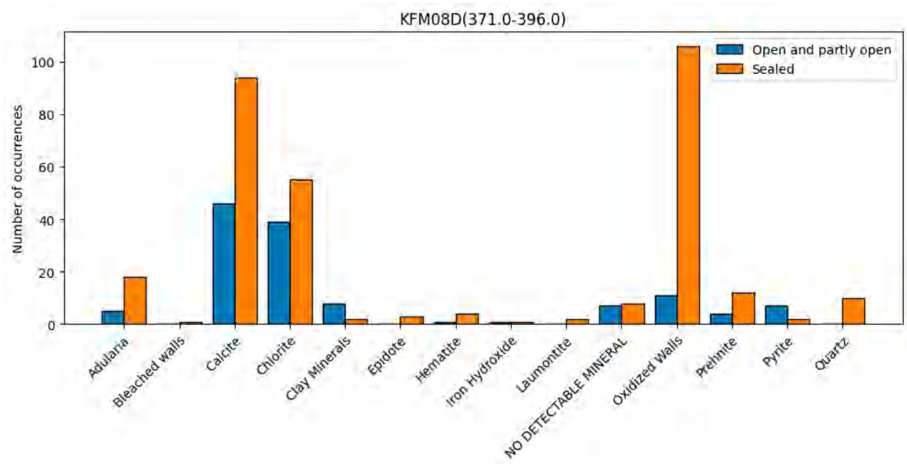
FRACTURE CHARACTER

Orientation: (strike/dip right-hand-rule)	Set SW: 218.2°/81.1°
Frequency:	Boreholes: KFM08D

FRACTURE TYPE	TERZAGHI-WEIGHED P10
Open and partly open	4.7 m-1
Sealed	14.2 m-1
Sealed network	1.1 % of DZ intercept
Crush	0.0 % of DZ intercept



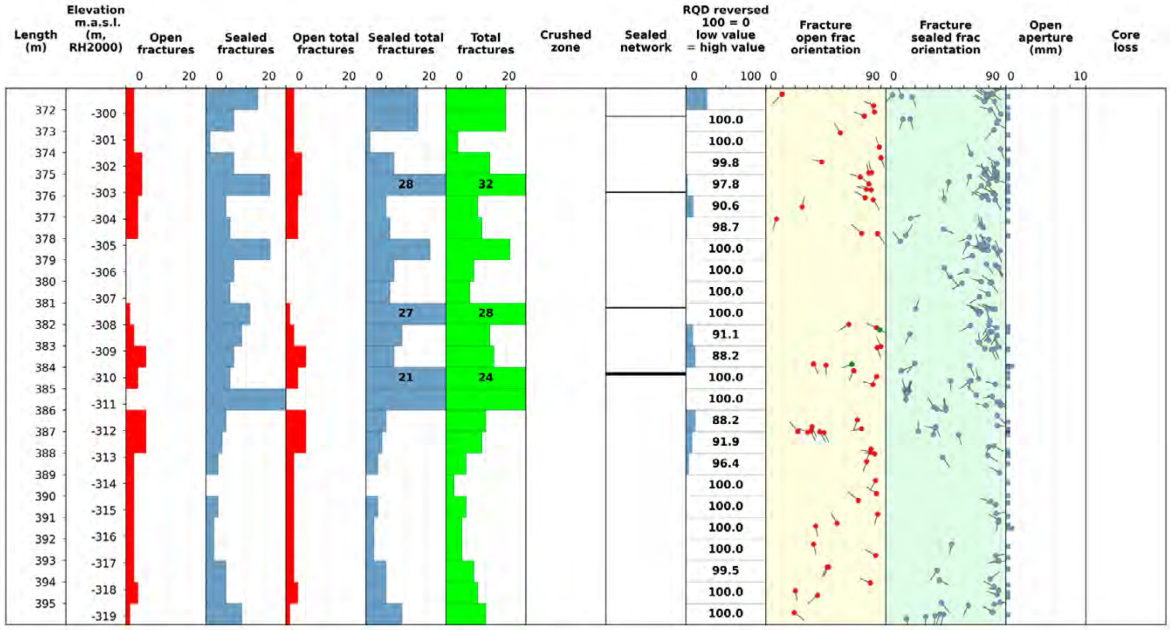
RQD:	min:73, max:100, mean:97
Fracture fill mineralogy:	

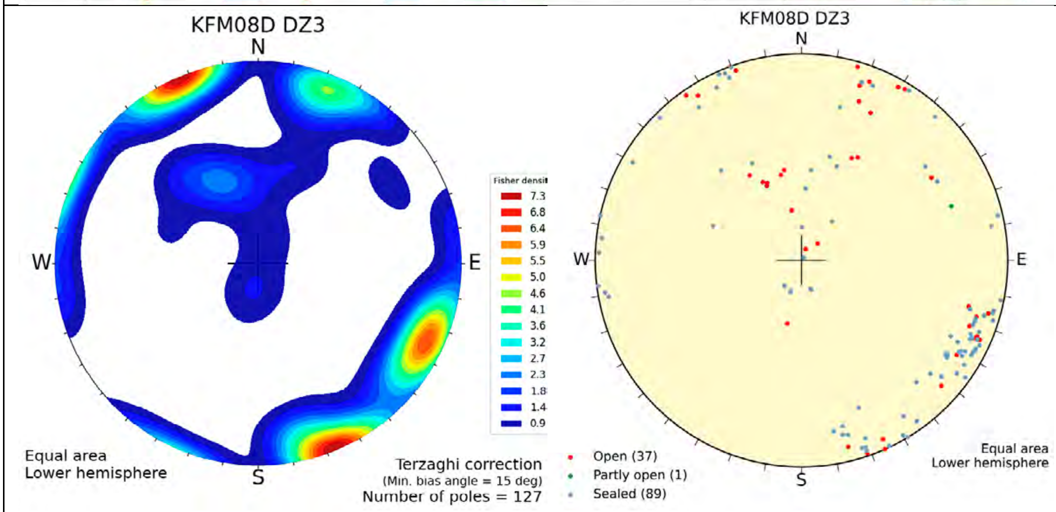


ENE	ZFMENE0159B	Version number	4	Total object CL	15

INDIVIDUAL INTERCEPTS

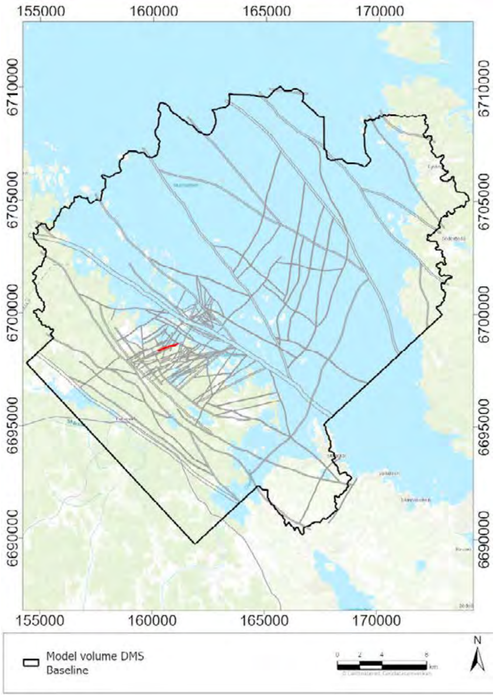
KFM08D DZ3 (371.0-396.0 m)





ENE	ZFMENE0168	Version number	4	Total object CL	14

GEOLOGICAL CHARACTER		Property CL
Deformation style:	Brittle	3
Deformation description:	No data available.	
Alteration:		3
- First order:	Oxidation	
- Second order:	Not observed	
- Third order:	Not observed	
Fracture orientation and type:	Steeply dipping fractures with NE-SW to NNE-SSW strike and NNW-SSE strike dominates. Gently dipping fractures are also present. Dominance of sealed fractures. Quantitative estimate and span include sealed fracture networks.	2
Fracture comment:	No data available.	
Fracture fill mineralogy:	Chlorite, hematite/adularia, quartz, calcite and clay minerals.	



OBJECT GEOMETRY	
Strike/dip:	255°/77°
Length:	991 m
Mean thickness:	10 m (2 - 36 m)
Max depth:	-1000 m
Geometrical constraints:	ZFMWNW2225, Topo 40m grid Max error 20m, 1 UNIVERSE Planar Cut(s).

BASIS FOR MODELLING

Zone based on surface lineaments and borehole observations.

Outcrops:	-

Boreholes:

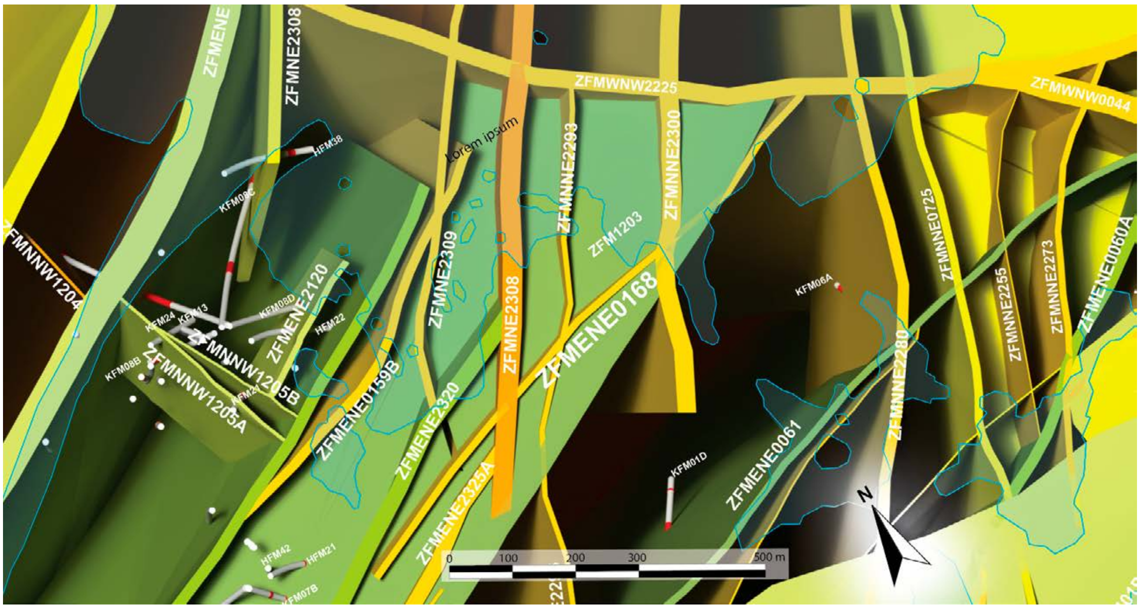
Borehole	PDZ	Target intercept		Geometric intercept		Comment
		Sec_up [m]	Sec_low [m]	Sec_up [m]	Sec_low [m]	
KFM08D	DZ11	819.00	842.00	818.79	841.72	

Tunnels:	-	
Lineament and/or seismic indications:	MFM0168G.	2

MODELLING PROCEDURE

At the surface, corresponds to the low magnetic lineament MFM0168G and its probable continuation along MFM2324G. Modelled at depth using the dip estimated by connecting these lineaments with the borehole intersection 819-842 m along KFM08D (DZ11). Deformation zone plane placed at fixed point 838 m (sealed fracture network).

ENE	ZFMENE0168	Version number	4	Total object CL	14



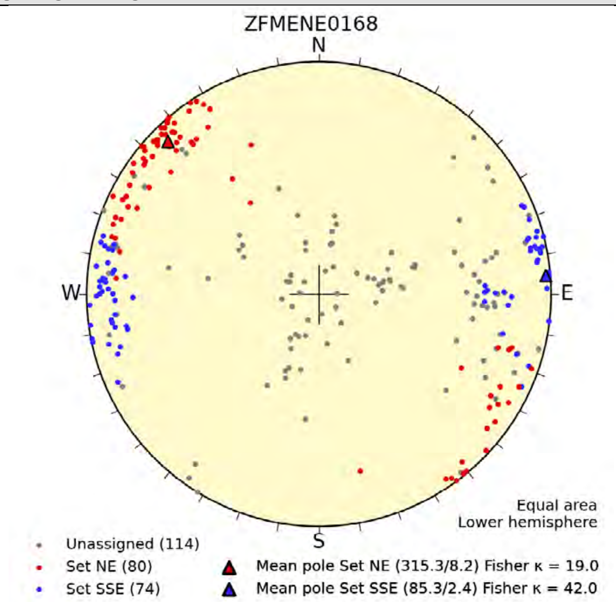
OBJECT CONFIDENCE ESTIMATE

Category	Object CL	Comment
INTERPRETATION		
Data source	2	MFM0168G, MFM2324G, KFM08D
Results of interpretation	2	Medium confidence observation in KFM08D.
INFORMATION DENSITY		
Number of observation points	2	2
Distribution of observation points	1	Less than two subsurface obs. points.
INTERPOLATION		
Geometry	1	Geometry supported by a lineament and a single intercept.
Geological indicators	1	Single observation point at depth. Zone modelled mainly based on surface geophysical data.
EXTRAPOLATION		
Dip direction	2	Extrapolation in dip direction supported by subsurface obs. point. Strike length of the modelled zone < 2000 m.
Strike direction	3	Conceptual understanding of the site and that the entire modelled zone is supported by lineament.

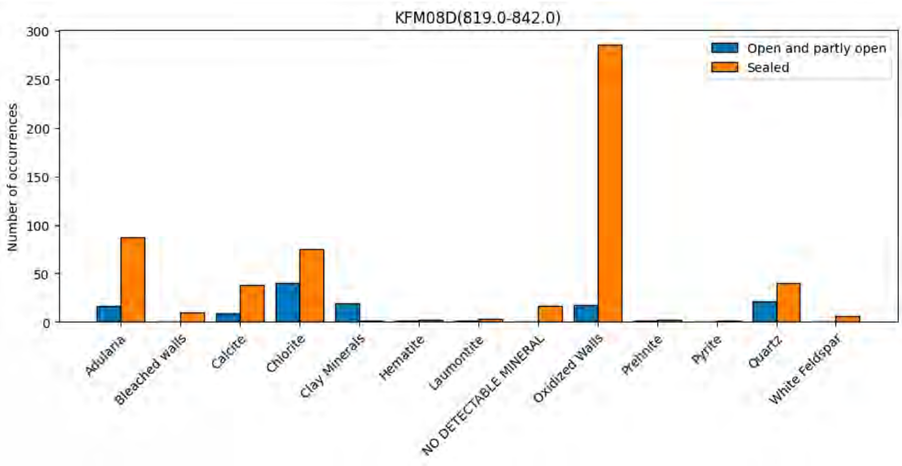
FRACTURE CHARACTER

Orientation: (strike/dip right-hand-rule)	Set NE: 45.3°/81.8° Set SSE: 175.3°/87.6°
Frequency:	Boreholes: KFM08D

FRACTURE TYPE	TERZAGHI-WEIGHED P10
Open and partly open	4.0 m-1
Sealed	27.9 m-1
Sealed network	1.2 % of DZ intercept
Crush	0.0 % of DZ intercept



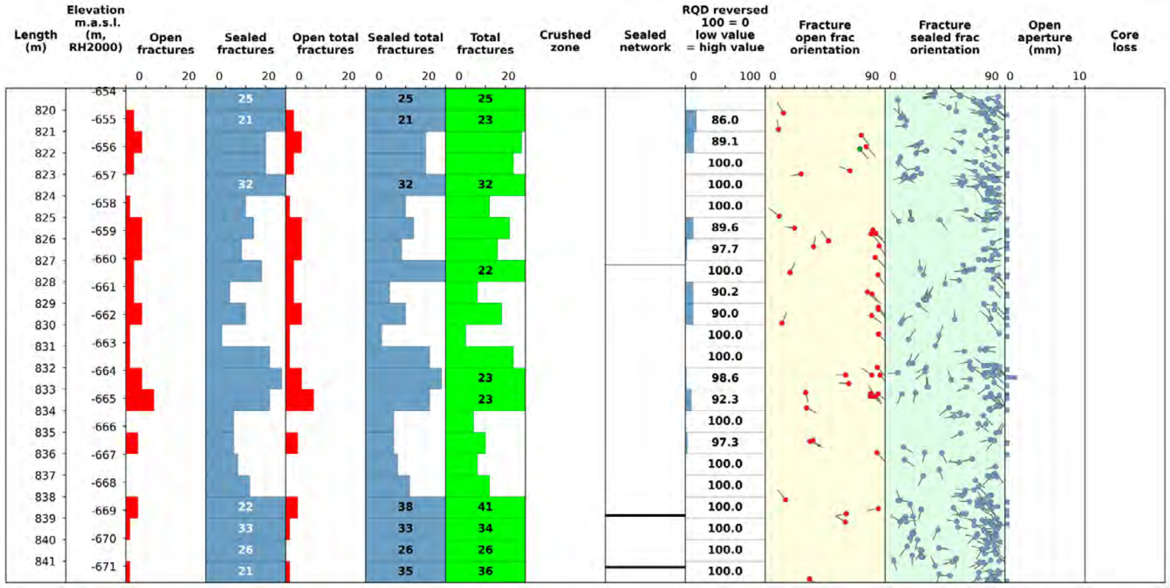
RQD:	min:86, max:100, mean:97

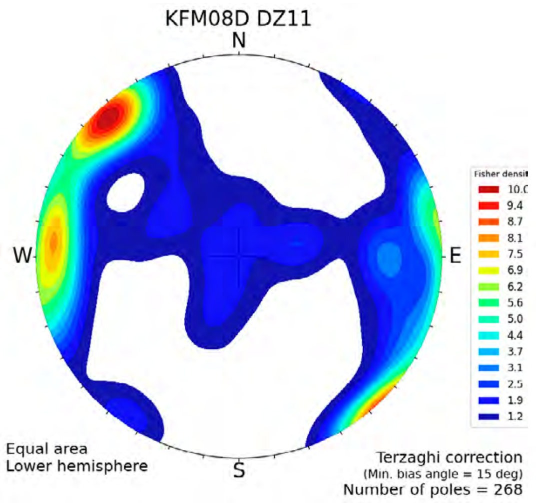
ENE	ZFMENE0168	Version number	4	Total object CL	14
Fracture fill mineralogy:					

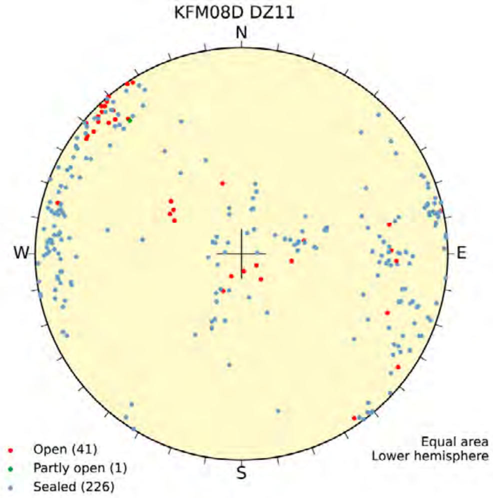
ENE	ZFMENE0168	Version number	4	Total object CL	14

INDIVIDUAL INTERCEPTS

KFM08D DZ11 (819.0-842.0 m)

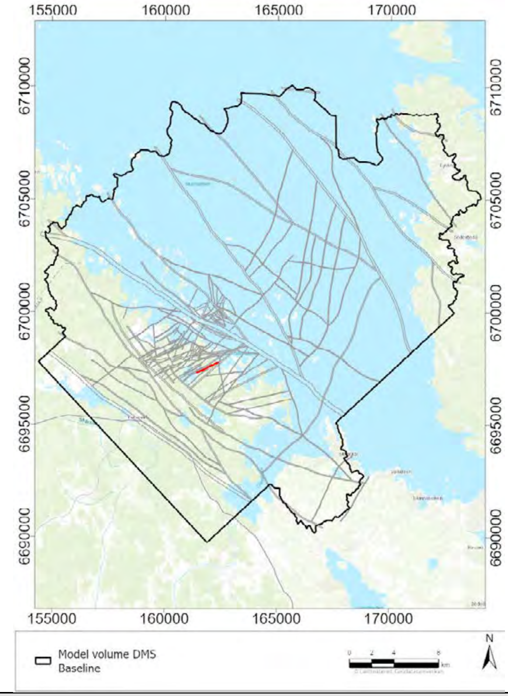






ENE	ZFMENE0169	Version number	3	Total object CL	11

GEOLOGICAL CHARACTER		Property CL
Deformation style:	Brittle	1
Deformation description:	No data available.	
Alteration:		2
- First order:	Oxidation	
- Second order:	Not observed	
- Third order:	Not observed	
Fracture orientation and type:	No data available.	
Fracture comment:	No data available.	
Fracture fill mineralogy:	No data available.	



OBJECT GEOMETRY	
Strike/dip:	65°/90°
Length:	1598 m
Mean thickness:	15 m (3 - 50 m)
Max depth:	-1100 m
Geometrical constraints:	ZFMENE0062A, ZFMNNW0101, Topo 40m grid Max error 20m, 1 UNIVERSE Planar Cut(s).

BASIS FOR MODELLING

Zone based on surface lineament.

Outcrops:	-	
Boreholes: -		
Tunnels:	-	
Lineament and/or seismic indications:	MFM0169, MFM0169G.	2

MODELLING PROCEDURE

At the surface, corresponds to the lowmagnetic lineaments MFM0169 and MFM0169G. Modelled to a depth of 1100 m, using an assumed dip of 90 degrees based on a comparison with high confidence, vertical and steeply dipping zones with ENE strike.

OBJECT CONFIDENCE ESTIMATE

Category	Object CL	Comment
INTERPRETATION		
Data source	1	MFM0169G

ENE	ZFMENE0169	Version number	3	Total object CL	11

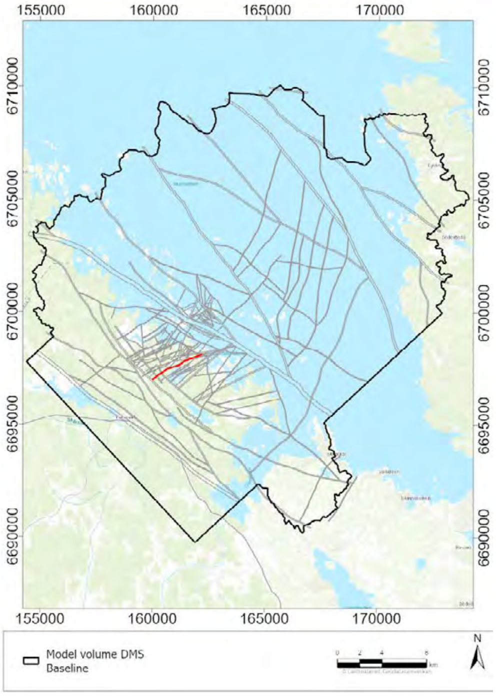
Results of interpretation	2	Medium confidence in lineament MFM0169G.
INFORMATION DENSITY		
Number of observation points	1	1
Distribution of observation points	1	Single observation point in the form of a lineament.
INTERPOLATION		
Geometry	1	Geometry supported by surface geophysical data.
Geological indicators	1	Indirect support by geophysical data.
EXTRAPOLATION		
Dip direction	1	No subsurface obs. point, supported only by surface data. High uncertainty in dip-direction. Strike length of the modelled zone < 2000 m.
Strike direction	3	Conceptual understanding of the site and that the entire modelled zone is supported by lineament.

FRACTURE CHARACTER
No data available

INDIVIDUAL INTERCEPTS
No data available

ENE	ZFMENE0401A		Version number	4	Total object CL	21

GEOLOGICAL CHARACTER		Property CL
Deformation style:	Brittle	3
Deformation description:	Steeply dipping fault with SW strike shows oblique-slip displacement with a strong strike-slip component.	
Alteration:		3
- First order:	Oxidation	
- Second order:	Not observed	
- Third order:	Not observed	
Fracture orientation and type:	Steeply dipping fractures with NNE strike dominates. Fractures with more gentle dips as well as steeply dipping fractures that strike NW are also present. Dominance of sealed fractures followed by open and partly open fractures. Quantitative estimate and span include sealed fracture networks.	2
Fracture comment:	No data available.	
Fracture fill mineralogy:	Calcite, chlorite, quartz, laumontite, hematite/adularia. Only calcite, chlorite and some prehnite observed in percussion borehole HFM13 (DZ1).	



OBJECT GEOMETRY	
Strike/dip:	243°/89°
Length:	2565 m
Mean thickness:	10 m (3 - 50 m)
Max depth:	-2100 m
Geometrical constraints:	ZFMNW0017, Topo 40m grid Max error 20m, 1 UNIVERSE Planar Cut(s).

BASIS FOR MODELLING

Zone based on surface lineaments and borehole observations. Zone ZFMENE0401A consists of two segments, ZFMENE0401A and ZFMENE0401B, judged to constitute elements of one and the same structure.

Outcrops:	-

Boreholes:

Borehole	PDZ	Target intercept		Geometric intercept		Comment
		Sec_up [m]	Sec_low [m]	Sec_up [m]	Sec_low [m]	
HFM13	DZ1	162.00	175.30	145.65	172.53	
KFM05A	DZ3	685.00	720.00	682.67	718.77	Only borehole intervals 590-616 m and 685-720 m included in the DZ deterministic modelling (cf. Table 3-2 in Stephens et al. 2007). Fractured rock between 616 and 685 m, and 720 and 796 m inferred to be affected by DZ.

Tunnels:	-	
Lineament and/or seismic indications:	MFM0401, MFM0401G0.	2

MODELLING PROCEDURE

Zone ZFMENE0401 consists of two branches, the most prominent of which is denoted ZFMENE0401A. Though the branches are described separately in subsequent property sheets, it should be recalled that these probably constitute elements of one and the same structure. At the surface, corresponds to the low magnetic lineaments MFM0401 and MFM0401G0, and their inferred continuation towards the north-east. Modelled down to 1950 m depth, using the dip estimated by connecting these lineaments with the borehole intersections 685-720 m in KFM05A (part of DZ3) and 162-176 m in HFM13 (DZ1). Deformation zone plane placed at fixed points 717 m in KFM05A and 170 m in HFM13. Decreased radar penetration also along the borehole interval 714-723 m in KFM05A.

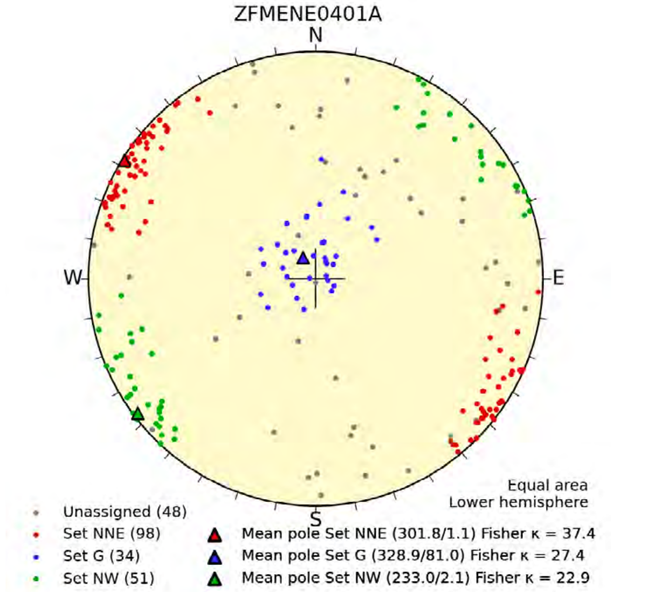
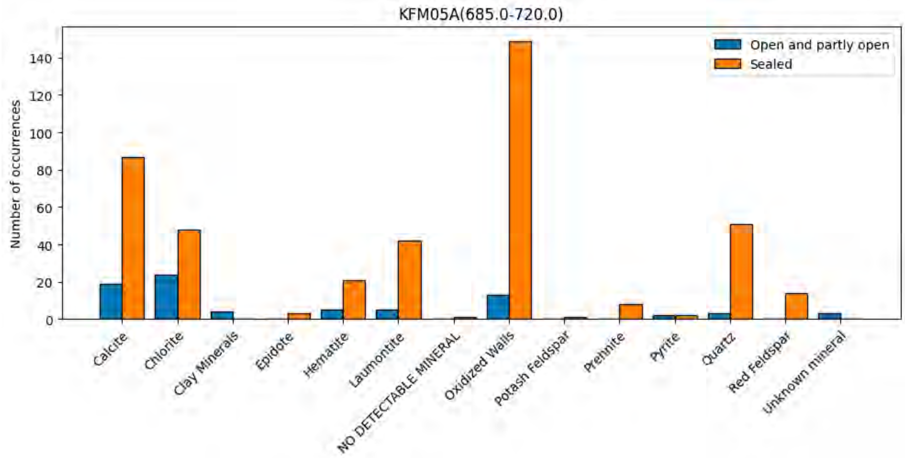
ENE	ZFMENE0401A	Version number	4	Total object CL	21

OBJECT CONFIDENCE ESTIMATE

Category	**Object CL**	**Comment**
INTERPRETATION		
Data source	2	MFM0401G0, KFM05A, HFM13
Results of interpretation	3	High confidence observation in KFM05A for the densely fractured interval and low confidence for the whole interval. Medium confidence observation in HFM13.
INFORMATION DENSITY		
Number of observation points	2	3
Distribution of observation points	2	Two intercepts c. 1000 in between and lineament considered as an outlier. Three scattered observation points.
INTERPOLATION		
Geometry	3	Two intercepts c. 600 m apart. Fracture filling minerals support one strong alternative along the lineament.
Geological indicators	3	Supported by key geological parameters.
EXTRAPOLATION		
Dip direction	3	Extrapolated to the base of the model volume. Strike length of the modelled zone > 2000 m.
Strike direction	3	Conceptual understanding of the site and that the entire modelled zone is supported by lineament.

ENE	ZFMENE0401A	Version number	4	Total object CL	21

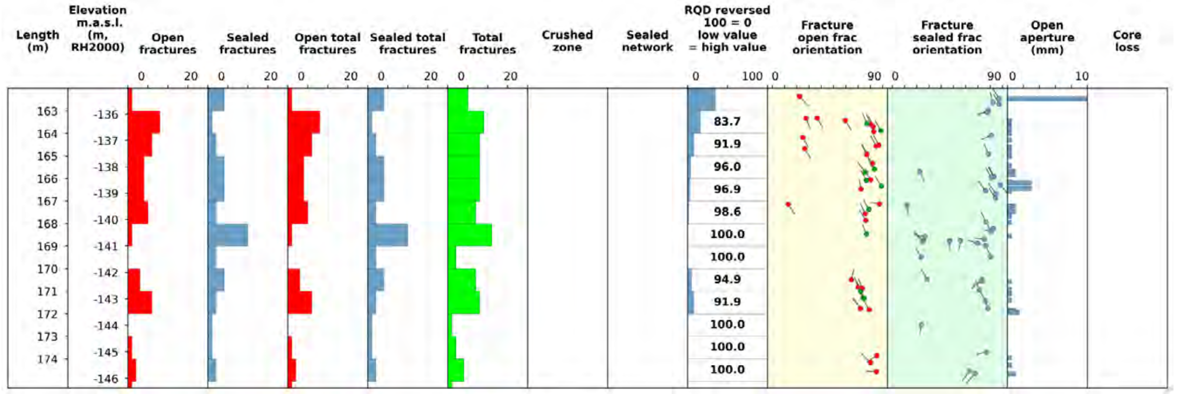
FRACTURE CHARACTER

Orientation: (strike/dip right-hand-rule)	Set NNE: 31.8°/88.9° Set G: 58.9°/9.0° Set NW: 323.0°/87.9°	
Frequency:	Boreholes: KFM05A	
RQD:	min:58, max:100, mean:98	
Fracture fill mineralogy:		

FRACTURE TYPE	TERZAGHI-WEIGHED P10
Open and partly open	1.5 m-1
Sealed	13.7 m-1
Sealed network	10.7 % of DZ intercept
Crush	0.0 % of DZ intercept

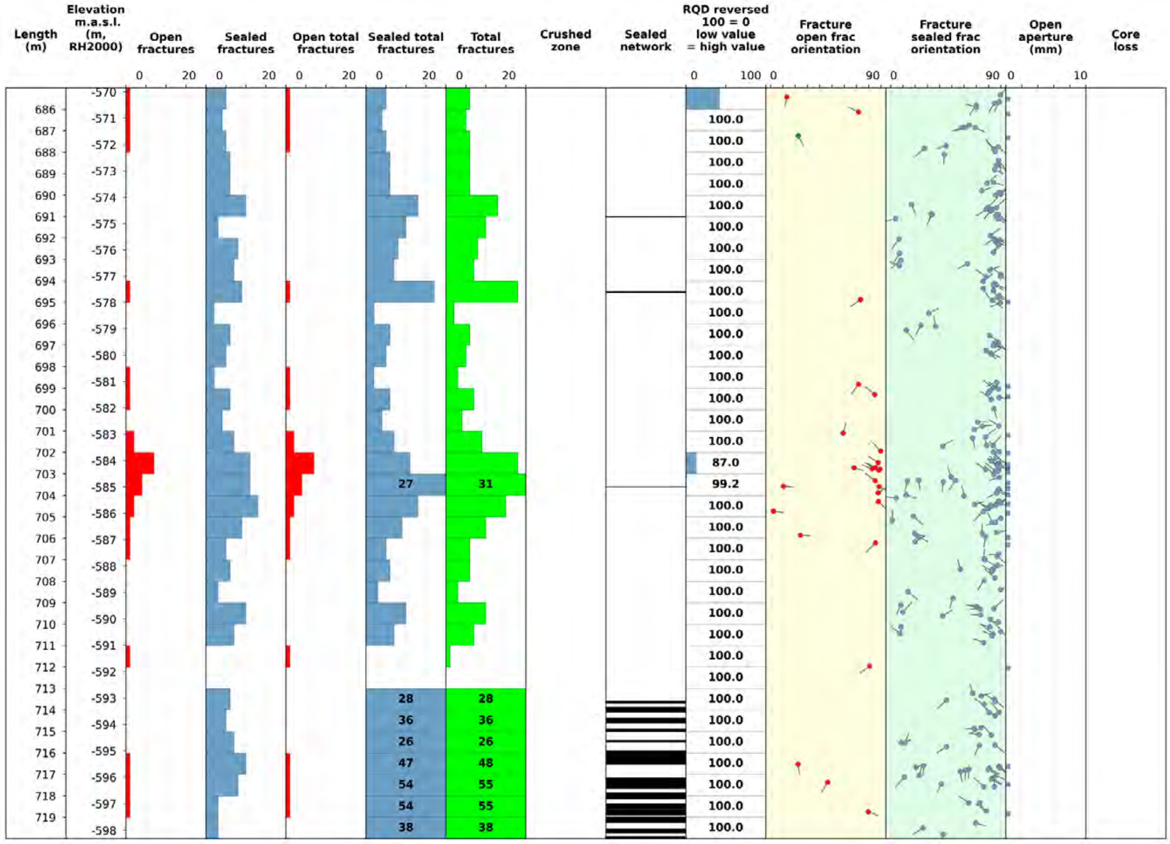
ENE	ZFMENE0401A	Version number	4	Total object CL	21
INDIVIDUAL INTERCEPTS					

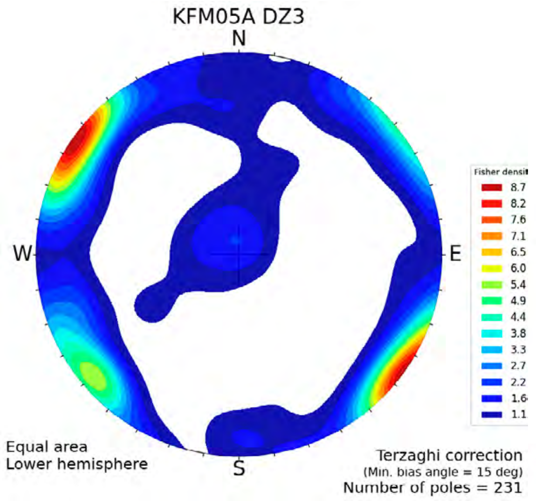
HFM13 DZ1 (162.0-175.3 m)

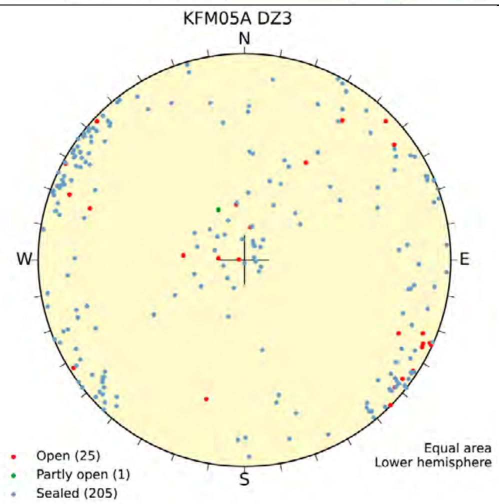


ENE	ZFMENE0401A	Version number	4	Total object CL	21

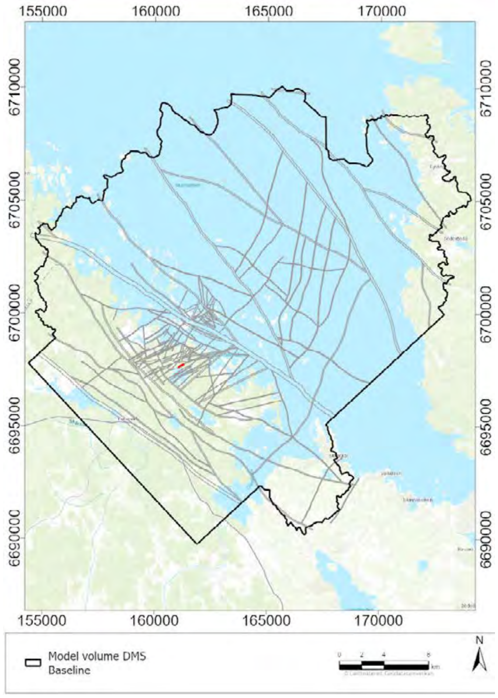
KFM05A DZ3 (685.0-720.0 m)







ENE	ZFMENE0401B	Version number	4	Total object CL	15



GEOLOGICAL CHARACTER		Property CL
Deformation style:	Brittle	3
Deformation description:	Steeply dipping fault with SSE strike shows strike-slip displacement.	
Alteration:		3
- First order:	Oxidation	
- Second order:	Not observed	
- Third order:	Not observed	
Fracture orientation and type:	Steeply dipping fractures with SW strike dominates. Fractures with more gentle dips as well as steeply dipping fractures that strike NNW are also present. Dominance of sealed fractures. Quantitative estimate and span include sealed fracture networks.	2
Fracture comment:	No data available.	
Fracture fill mineralogy:	Calcite, chlorite, laumontite, hematite/adularia.	

OBJECT GEOMETRY	
Strike/dip:	63°/88°
Length:	359 m
Mean thickness:	8 m (1 - 13 m)
Max depth:	-915 m
Geometrical constraints:	ZFMENE0401A, Topo 40m grid Max error 20m.

BASIS FOR MODELLING

Zone ZFMENE0401B consists of two segments, ZFMENE0401A and ZFMENE0401B, judged to constitute elements of one and the same structure.

Outcrops: -

Boreholes:

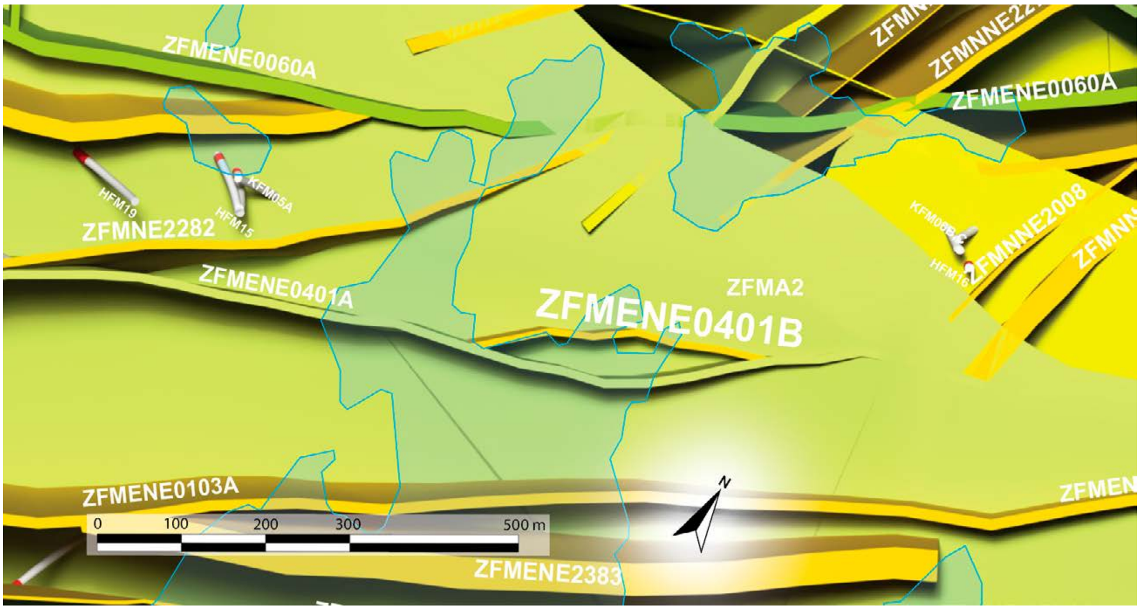
Borehole	PDZ	Target intercept		Geometric intercept		Comment
		Sec_up [m]	Sec_low [m]	Sec_up [m]	Sec_low [m]	
KFM05A	DZ3	590.00	616.00	610.96	615.85	Only borehole intervals 590-616 m and 685-720 m included in the DZ deterministic modelling (cf. Table 3-2 in Stephens et al. 2007). Fractured rock between 616 and 685 m, and 720 and 796 m inferred to be affected by DZ.

Tunnels:	-	
Lineament and/or seismic indications:	MFM0401G1.	1

MODELLING PROCEDURE

At the surface, corresponds to the low magnetic lineament MFM0401G1. Modelled as a splay from zone ZFMENE0401A, using the dip estimated by connecting lineament MFM0401G1 with the borehole intersection 590- 616 m in KFM05A (part of DZ3). Deformation zone plane placed at fixed point 611 m in KFM05A.

ENE	ZFMENE0401B	Version number	4	Total object CL	15



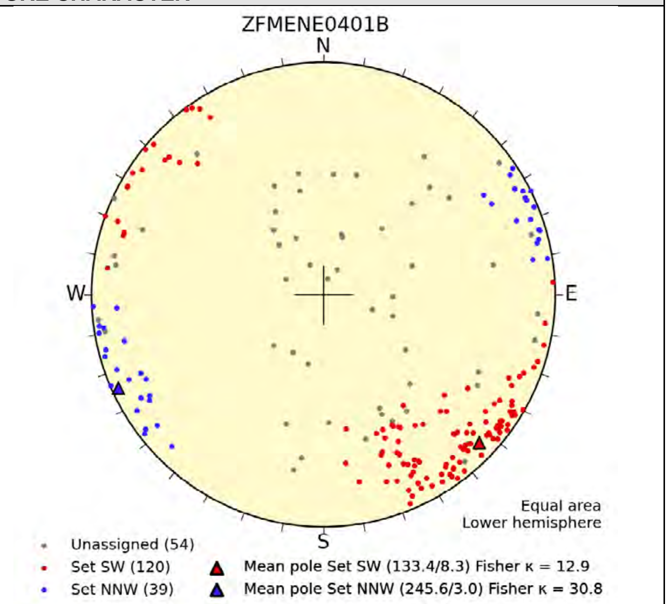
OBJECT CONFIDENCE ESTIMATE

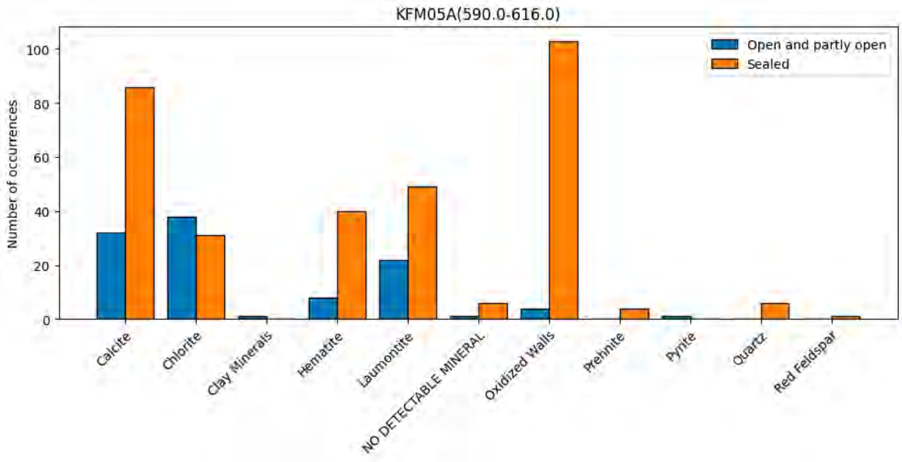
Category	Object CL	Comment
INTERPRETATION		
Data source	2	MFM0401G1, KFM05A
Results of interpretation	3	High confidence observation in KFM05A for the densely fractured interval and low confidence for the whole interval.
INFORMATION DENSITY		
Number of observation points	2	2
Distribution of observation points	1	Less than two subsurface obs. points.
INTERPOLATION		
Geometry	1	Zone intercepted by a single borehole. Modelled as a splay. Difficult to justify multiple options for geometry due to lack of data.
Geological indicators	1	Single observation point at depth. Zone modelled mainly based on surface geophysical data.
EXTRAPOLATION		
Dip direction	2	Extrapolation in dip direction supported by subsurface obs. point. Strike length of the modelled zone < 2000 m.
Strike direction	3	Conceptual understanding of the site and that the entire modelled zone is supported by the lineament.

FRACTURE CHARACTER

Orientation: (strike/dip right-hand-rule)	Set SW: 223.4°/81.7° Set NNW: 335.6°/87.0°
Frequency:	Boreholes: KFM05A

FRACTURE TYPE	TERZAGHI-WEIGHED P10
Open and partly open	3.0 m-1
Sealed	13.4 m-1
Sealed network	10.6 % of DZ intercept
Crush	0.0 % of DZ intercept

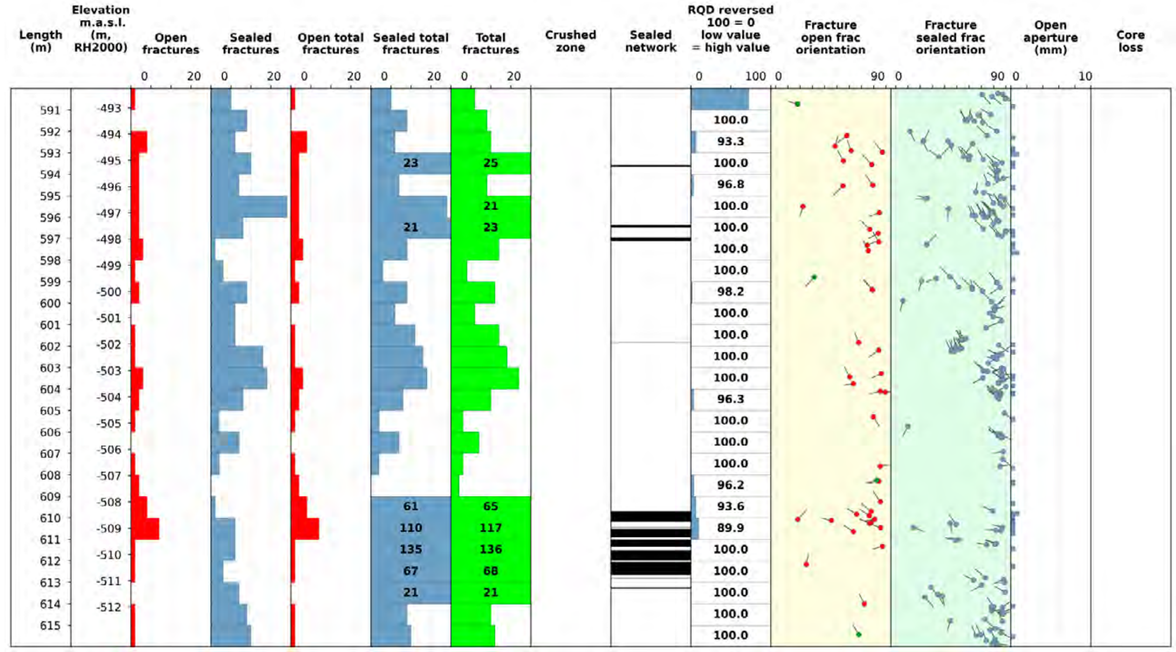


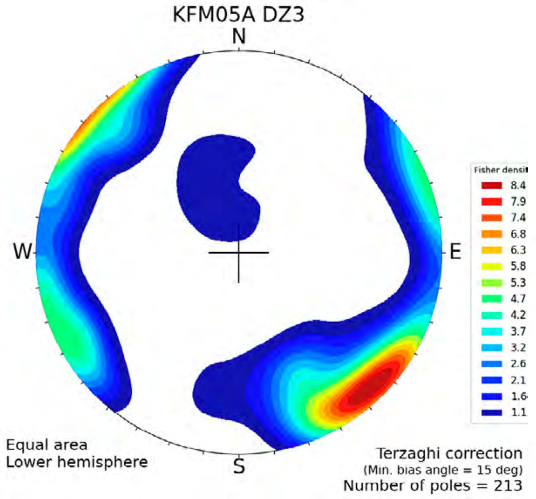
ENE	ZFMENE0401B	Version number	4	Total object CL	15
RQD:	min:27, max:100, mean:96				
Fracture fill mineralogy:					

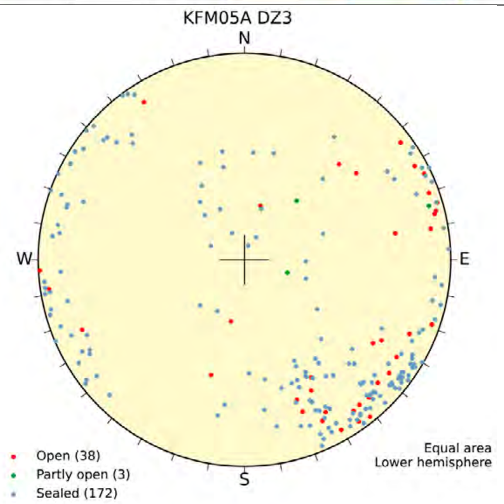
ENE	ZFMENE0401B	Version number	4	Total object CL	15

INDIVIDUAL INTERCEPTS

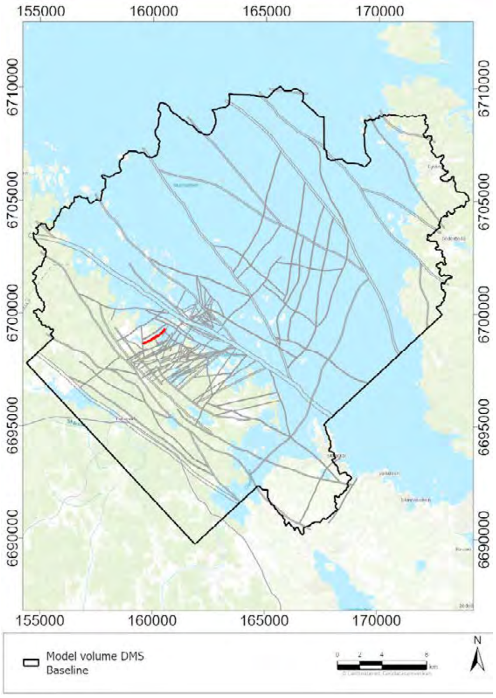
KFM05A DZ3 (590.0-616.0 m)







ENE	ZFMENE1061A	Version number	4	Total object CL	20



GEOLOGICAL CHARACTER		Property CL
Deformation style:	Brittle	3
Deformation description:	Steeply dipping faults with NNW strike show strike-slip displacement, some of which can be determined to be sinistral. Steeply dipping fault with SSW strike shows sinistral strike-slip displacement. Gently dipping fault with NNE strike shows reverse dip-slip displacement and a sub-horizontal fault shows dextral displacement.	
Alteration:		3
- First order:	Oxidation	
- Second order:	Not observed	
- Third order:	Not observed	
Fracture orientation and type:	Variable fracture orientation. Steeply dipping NNE as well as gently dipping fractures are prominent. Dominated by sealed followed by open and partly open fractures. Quantitative estimate and span include sealed fracture networks.	2
Fracture comment:	No data available.	
Fracture fill mineralogy:	Calcite, chlorite, laumontite, hematite/adularia, pyrite, quartz, clay minerals.	

OBJECT GEOMETRY	
Strike/dip:	58°/82°
Length:	1200 m
Mean thickness:	48 m (3 - 50 m)
Max depth:	-1200 m
Geometrical constraints:	ZFMNNW0100, Topo 40m grid Max error 20m, 1 UNIVERSE Planar Cut(s).

BASIS FOR MODELLING

Zone based on surface lineaments and borehole observations. Zone ZFMENE1061 consists of two segments, ZFMENE1061A and ZFMENE1061B, judged to constitute elements of one and the same structure.

Outcrops: -

Boreholes:

Borehole	PDZ	Target intercept		Geometric intercept		Comment
		Sec_up [m]	Sec_low [m]	Sec_up [m]	Sec_low [m]	
KFM08A	DZ1	244.00	315.00	249.46	321.90	Only borehole interval 244-315 m included in the DZ deterministic modelling (cf. Table 3-2 in Stephens et al. 2007). Fractured rock between 172 and 244 m, and 315 and 342 m inferred to be affected by DZ.
KFM08C	DZ4	829.00	832.00	826.09	951.02	ZFMENE1061B also intersects DZ4.
KFM08C	DZ5	946.00	949.00	826.09	951.02	
KFM19	DZ1	7.28	102.37	4.99	102.37	

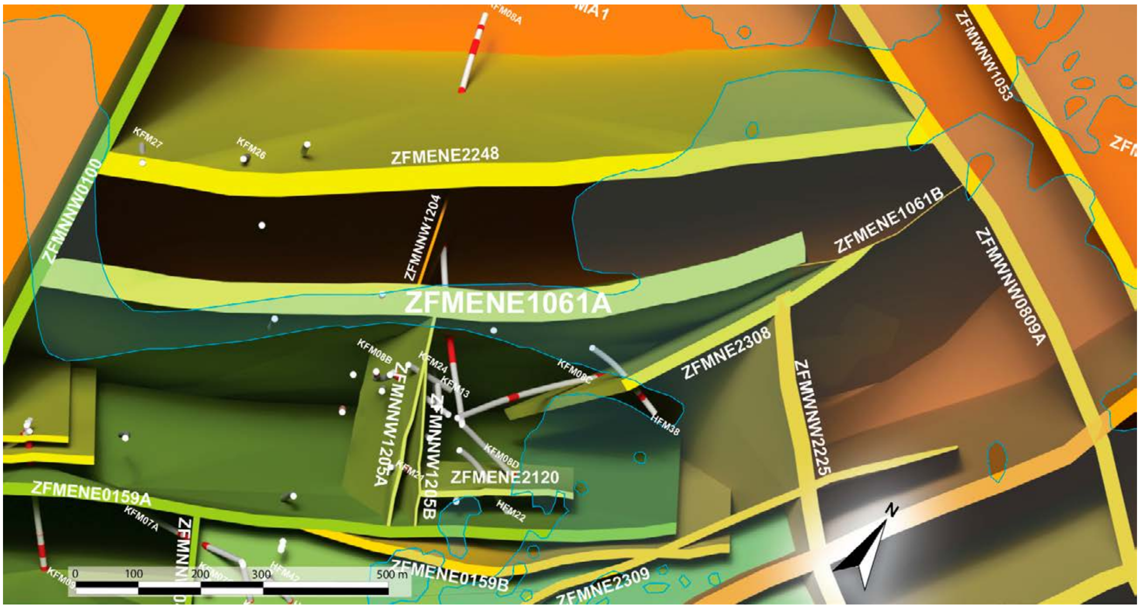
Tunnels:	-	
Lineament and/or seismic indications:	MFM2054G0.	1

MODELLING PROCEDURE

Zone ZFMENE1061 consists of two segments with slightly different orientations, the most prominent of which is denoted ZFMENE1061A. These segments are judged to constitute elements of one and the same structure. At the surface, corresponds to the low magnetic lineament MFM2054G0 and its inferred continuation to the south-west. This lineament lies in the vicinity of a topographic lineament defined by a depression in the bedrock surface, the form of which has been recognised on the basis of an analysis of old refraction seismic data Isaksson and Keisu (2005). Possible correlation also

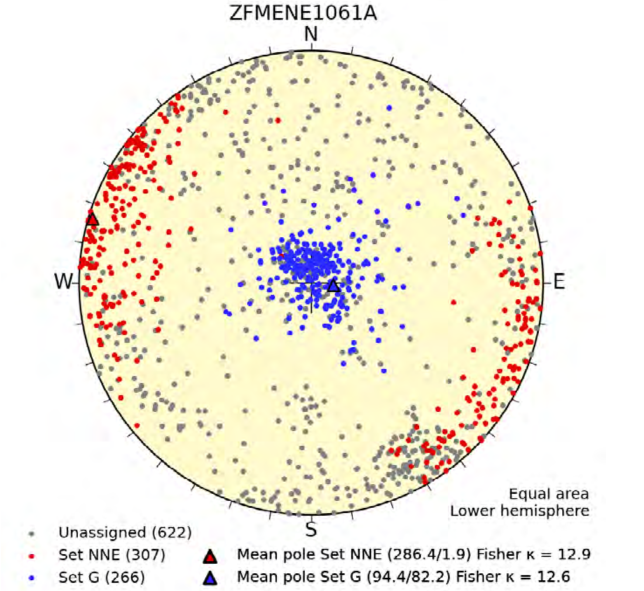
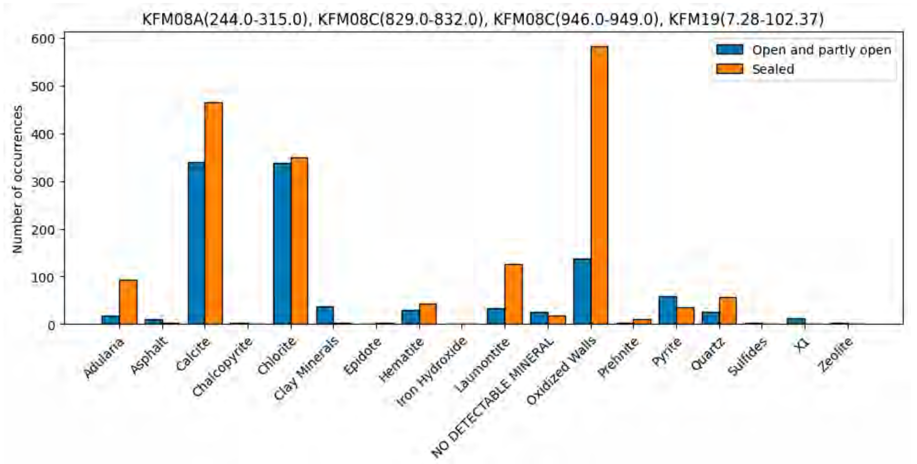
ENE	ZFMENE1061A	Version number	4	Total object CL	20

with a low velocity seismic refraction anomaly (see Isaksson and Keisu (2005) and Figure 5-33 in SKB (2005). Modelled using the dip estimated by connecting lineament MFM2054G0 and its extension to the south-west with the borehole intersection 244-315 m in KFM08A (part of DZ1). Deformation zone plane placed at fixed point 277 m in KFM08A. Decreased radar penetration also along the borehole interval 272-276 m in KFM08A. Zone also intersects borehole intervals 829-832 m and 946-949 m in KFM08C (DZ4 and DZ5, respectively), close to its north-eastern termination.



OBJECT CONFIDENCE ESTIMATE

Category	Object CL	Comment
INTERPRETATION		
Data source	2	MFM2054G0, KFM8A, KFM8C, KFM19
Results of interpretation	3	High confidence observation in KFM08A and KFM08C.
INFORMATION DENSITY		
Number of observation points	3	4
Distribution of observation points	2	Zone intercepted by three boreholes. More than 700m between obs. points KFM08A and KFM08C and > 150 m between intercept of KFM08A and KFM19.
INTERPOLATION		
Geometry	3	One strong interpolation alternative.
Geological indicators	2	Some discrepancies in the geological data.
EXTRAPOLATION		
Dip direction	2	Extrapolation in dip direction supported by subsurface obs. point. Strike length of the modelled zone < 2000 m.
Strike direction	3	Zone modelled length < 2000 m. Intersected in multiple boreholes. High confidence in this category based on conceptual understanding of the site.

<table>
<tr><td>ENE</td><td>ZFMENE1061A</td><td>Version number</td><td>4</td><td>Total object CL</td><td>20</td></tr>
<tr><td colspan="6">FRACTURE CHARACTER</td></tr>
<tr><td>Orientation:
(strike/dip right-hand-rule)</td><td>Set NNE: 16.4°/88.1°
Set G: 184.4°/7.8°</td><td colspan="4" rowspan="2">
</td></tr>
<tr><td>Frequency:</td><td>Boreholes: KFM19, KFM08A, KFM08C
<table>
<tr><td>FRACTURE TYPE</td><td>TERZAGHI-WEIGHED P10</td></tr>
<tr><td>Open and partly open</td><td>5.1 m-1</td></tr>
<tr><td>Sealed</td><td>14.8 m-1</td></tr>
<tr><td>Sealed network</td><td>6.9 % of DZ intercept</td></tr>
<tr><td>Crush</td><td>0.7 % of DZ intercept</td></tr>
</table></td></tr>
<tr><td>RQD:</td><td>min:67, max:100, mean:97</td><td colspan="4"></td></tr>
<tr><td>Fracture fill mineralogy:</td><td colspan="5">
</td></tr>
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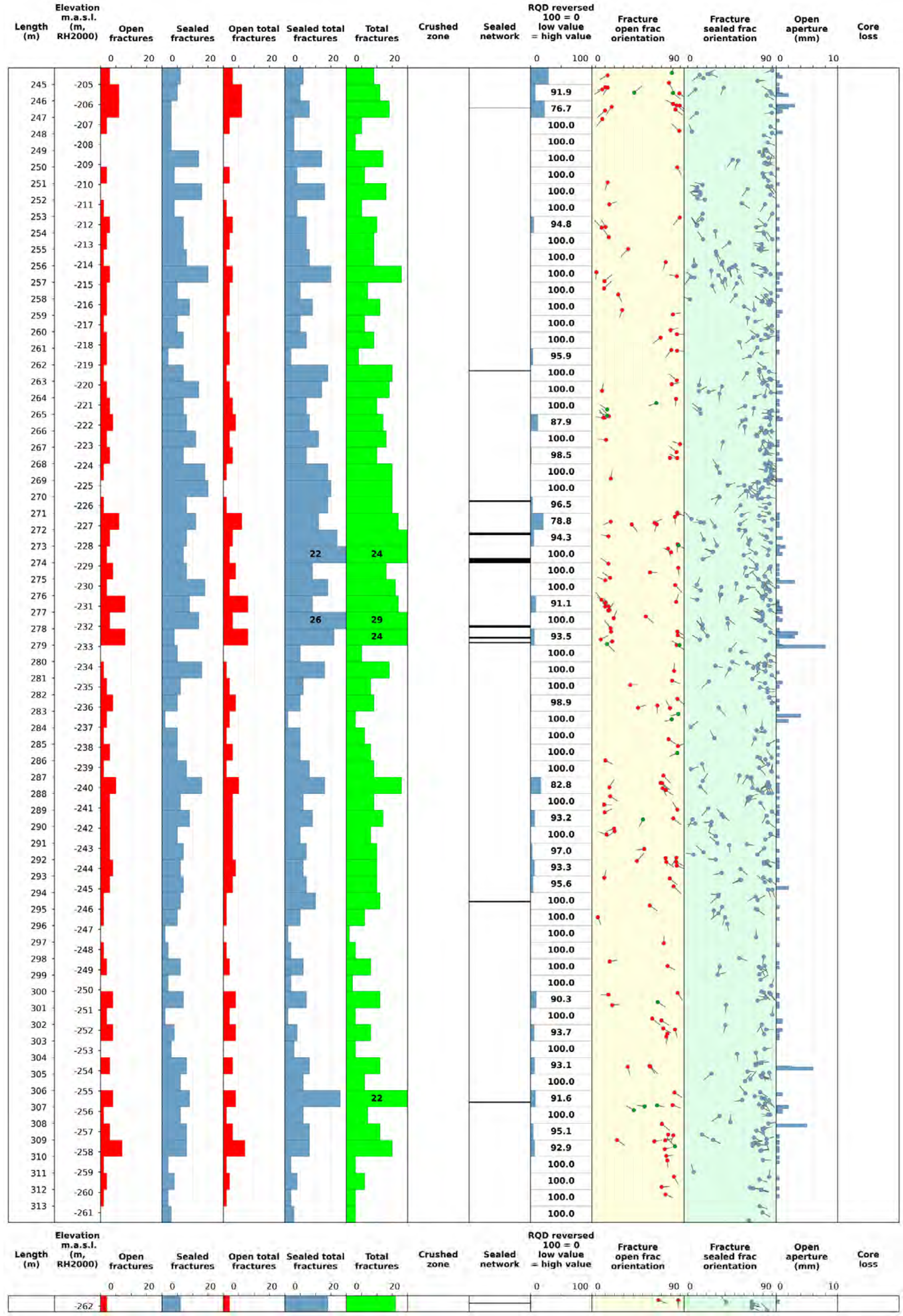
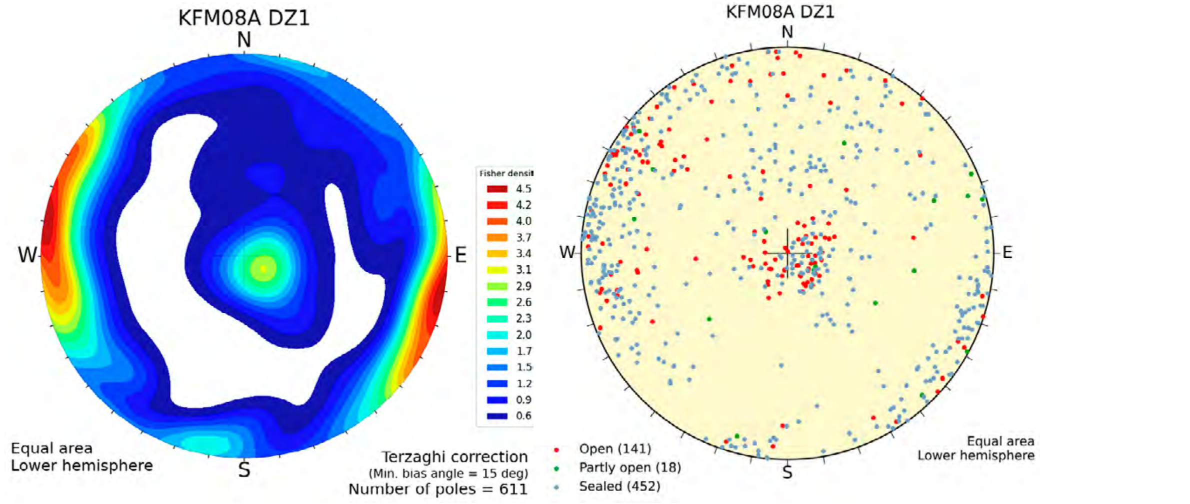
ENE	ZFMENE1061A	Version number	4	Total object CL	20
INDIVIDUAL INTERCEPTS					

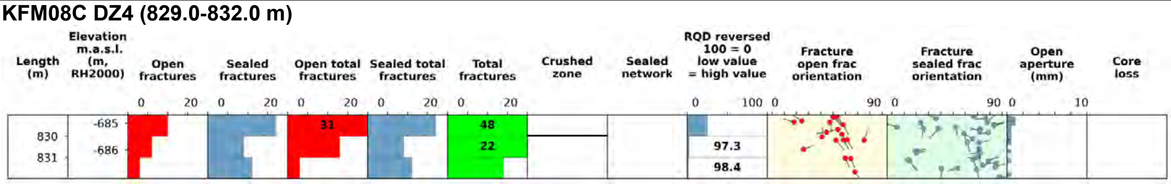
KFM08A DZ1 (244.0-315.0 m)

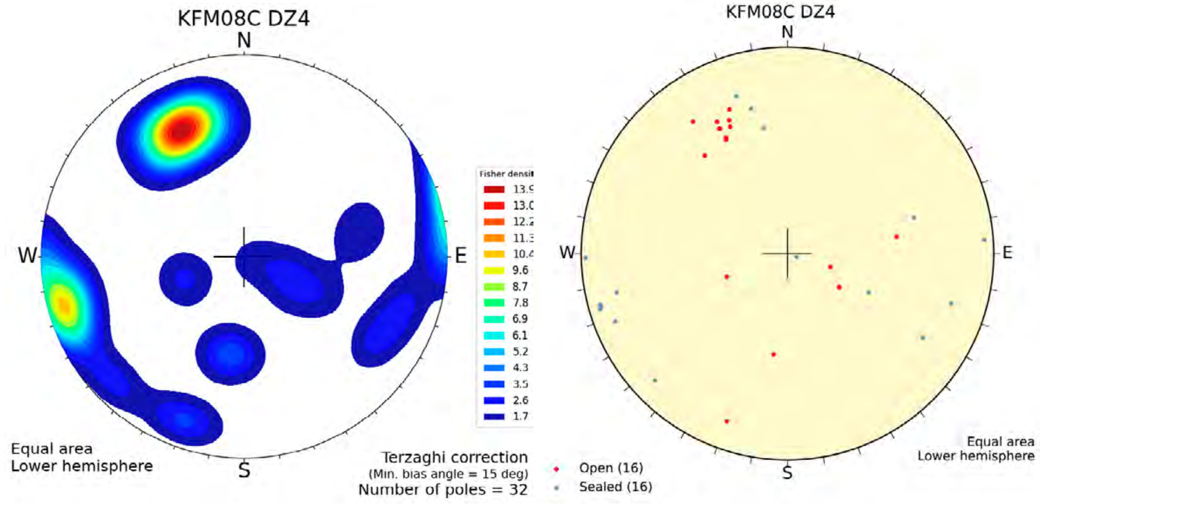


ENE	ZFMENE1061A	Version number	4	Total object CL	20



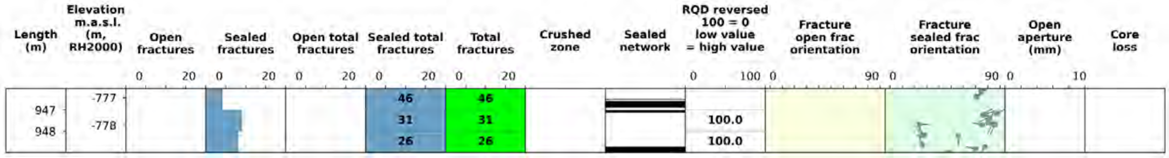
KFM08C DZ4 (829.0-832.0 m)

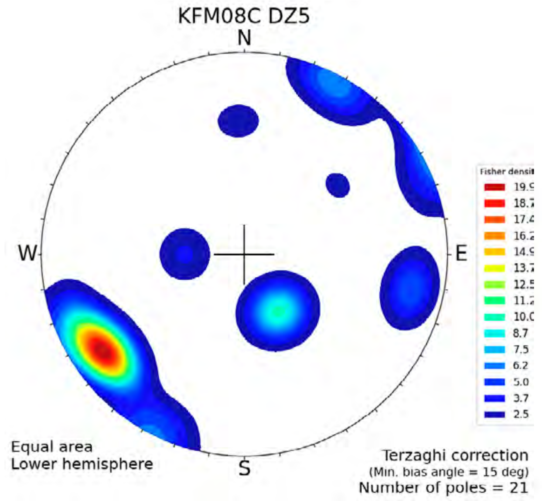


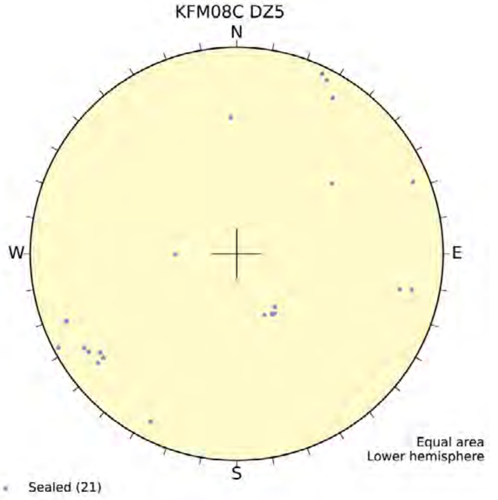


ENE	ZFMENE1061A	Version number	4	Total object CL	20

KFM08C DZ5 (946.0-949.0 m)

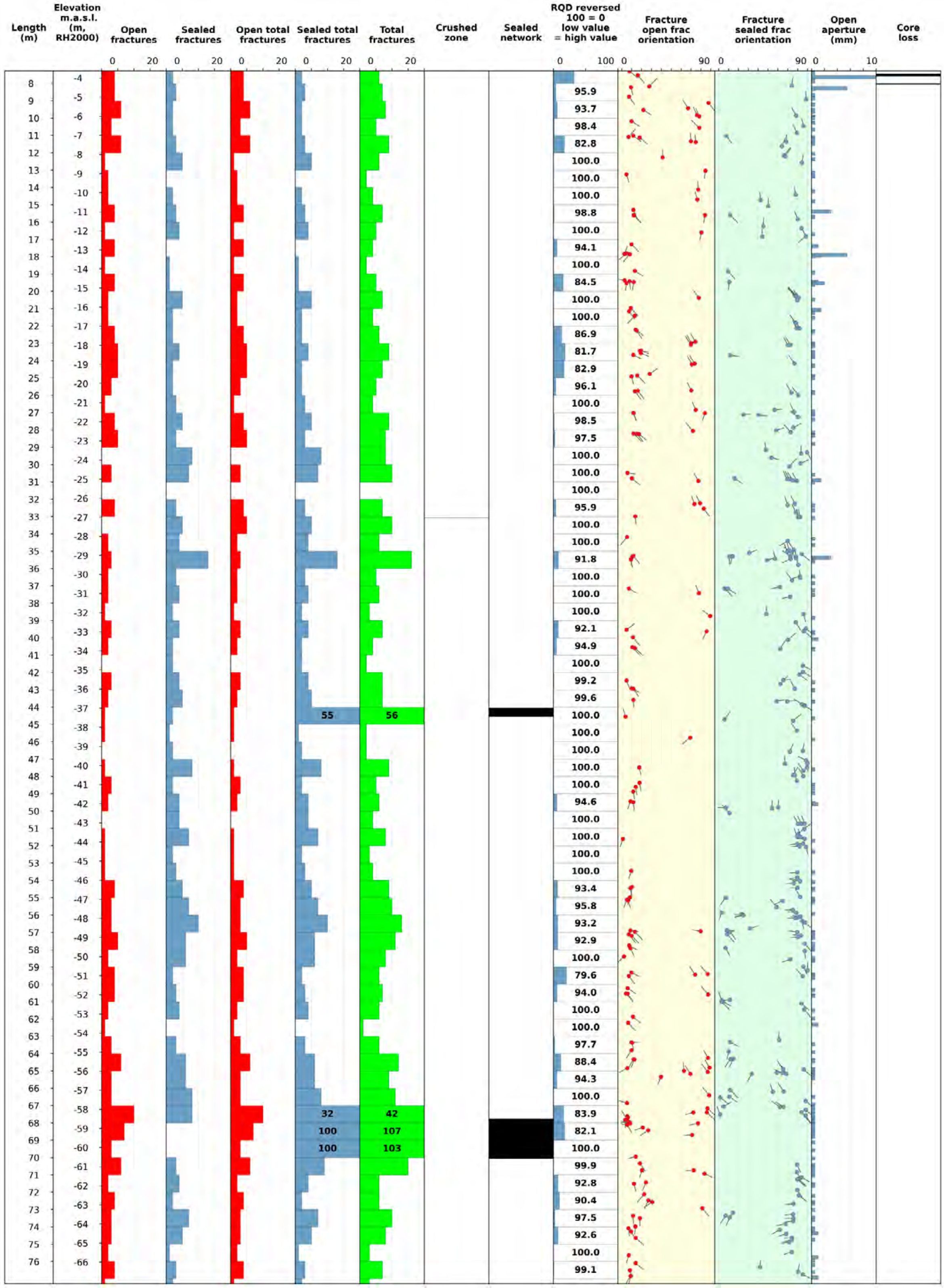




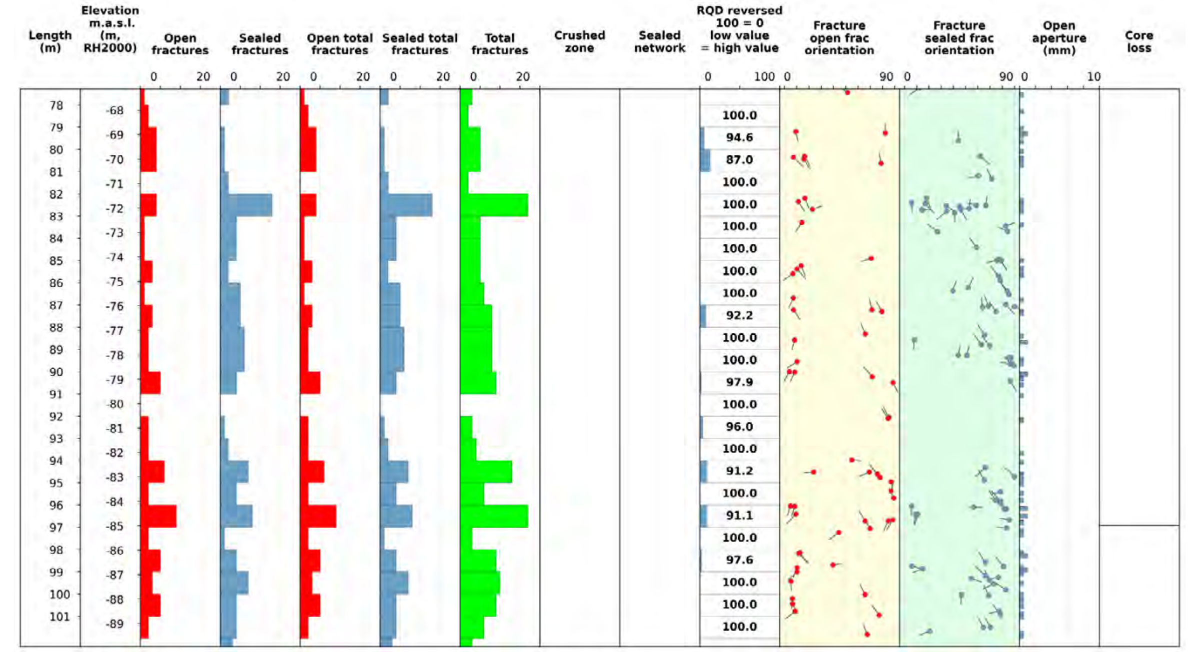


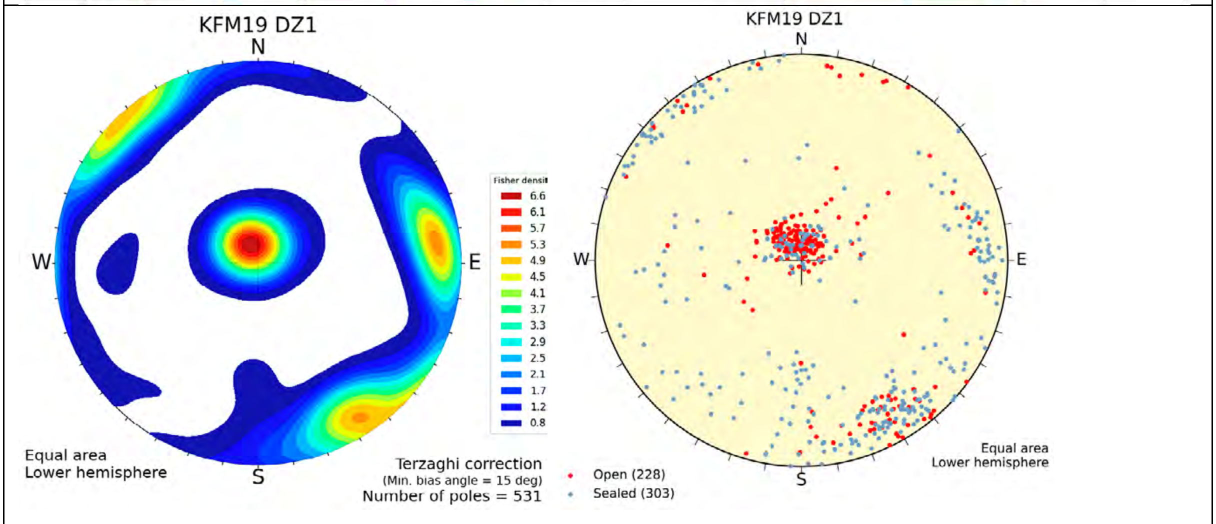
ENE	ZFMENE1061A	Version number	4	Total object CL	20

KFM19 DZ1 (7.28-102.37 m)



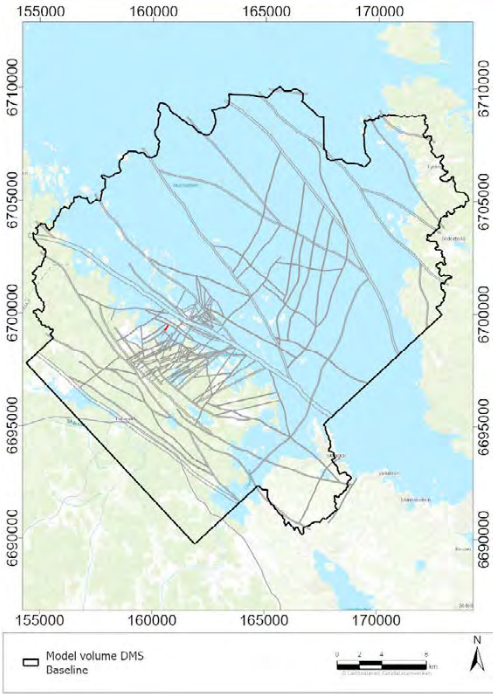
ENE	ZFMENE1061A	Version number	4	Total object CL	20





ENE	ZFMENE1061B	Version number	3	Total object CL	15

GEOLOGICAL CHARACTER		Property CL
Deformation style:	Brittle	3
Deformation description:	Steeply dipping fault with ENE strike shows oblique slip. Fault core with elevated fracture frequency and a 10 cm wide crush zone identified along DZ4 in KFM08C.	
Alteration:		3
- First order:	Oxidation	
- Second order:	Not observed	
- Third order:	Not observed	
Fracture orientation and type:	Few fractures. Fractures with ENE strike that dip moderately to steeply to the SSE are conspicuous. Open and sealed fractures where the later dominates. Quantitative estimate and span include crush zones along a single, short borehole interval.	1
Fracture comment:	No data available.	
Fracture fill mineralogy:	Calcite, chlorite, hematite/adularia, clay minerals.	



OBJECT GEOMETRY	
Strike/dip:	35°/81°
Length:	432 m
Mean thickness:	1 m (1 - 13 m)
Max depth:	-1200 m
Geometrical constraints:	ZFMWNW0809A, Topo 40m grid Max error 20m, ZFMENE1061A, 1 UNIVERSE Planar Cut(s).

BASIS FOR MODELLING

Zone based on surface lineaments and a borehole observation. Zone ZFMENE1061 consists of two segments, ZFMENE1061A and ZFMENE1061B, judged to constitute elements of one and the same structure.

Outcrops:	-

Boreholes:

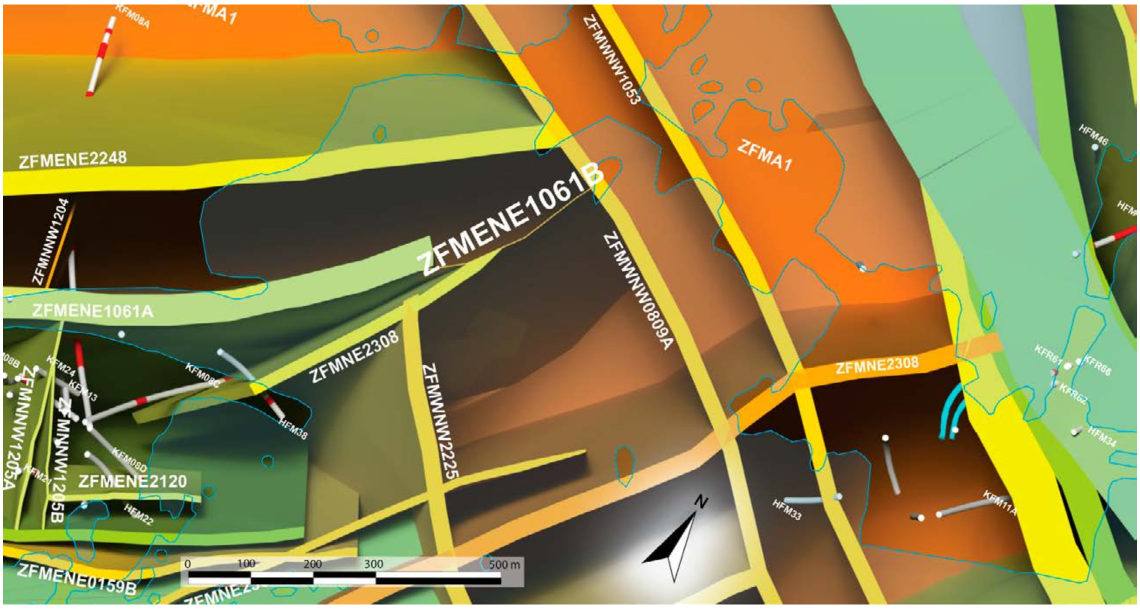
Borehole	PDZ	Target intercept		Geometric intercept		Comment
		Sec_up [m]	Sec_low [m]	Sec_up [m]	Sec_low [m]	
KFM08C	DZ4	829.00	832.00	-	-	Only geometrical intercept with the central zone surface due to truncation against ZFMENE1061A. ZFMENE1061A also intersects DZ4.

Tunnels:	-	
Lineament and/or seismic indications:	MFM2054G1.	2

MODELLING PROCEDURE

At the surface, corresponds to the low magnetic lineament MFM2054G1. Modelled using the dip estimated by connecting lineament MFM2054G1 with the borehole intersection 829-832 m (DZ4) in KFM08C. Deformation zone plane placed at fixed point 829 m in KFM08C. Decreased radar penetration also along the borehole interval 827-832 m.

ENE	ZFMENE1061B	Version number	3	Total object CL	15



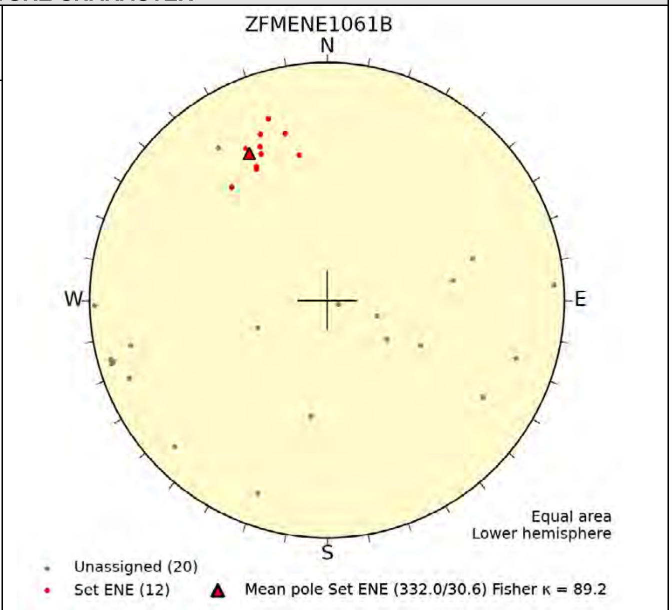
OBJECT CONFIDENCE ESTIMATE

Category	Object CL	Comment
INTERPRETATION		
Data source	2	MFM2054G1, KFM108C
Results of interpretation	3	High confidence observation in KFM08C.
INFORMATION DENSITY		
Number of observation points	2	2
Distribution of observation points	1	Single observation point at depth and surface lineaments.
INTERPOLATION		
Geometry	1	One sub-subsurface observation point and lineament.
Geological indicators	1	Single observation point at depth. Zone modelled mainly based on surface geophysical data.
EXTRAPOLATION		
Dip direction	2	Extrapolation in dip direction supported by subsurface obs. point. Strike length of the modelled zone < 2000 m.
Strike direction	3	Zone modelled length < 2000 m. Intersected in multiple boreholes. High confidence in this category based on conceptual understanding of the site.

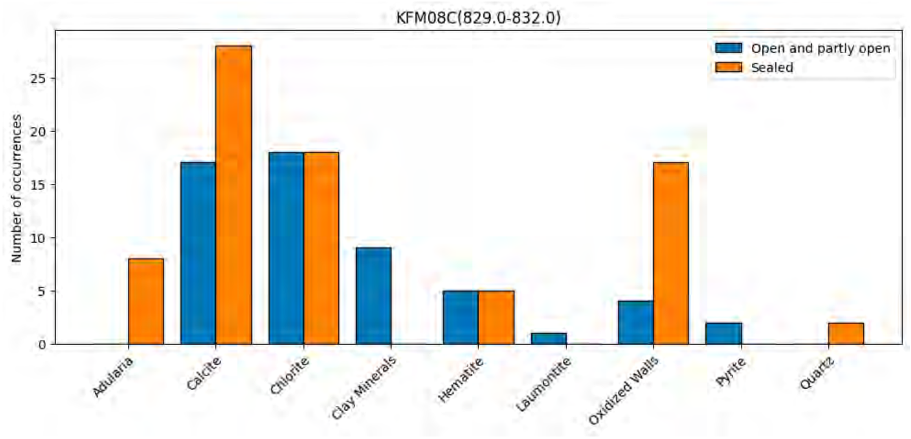
FRACTURE CHARACTER

Orientation: (strike/dip right-hand-rule)	Set ENE: 62.0°/59.4°
Frequency:	Boreholes: KFM08C

FRACTURE TYPE	TERZAGHI-WEIGHED P10
Open and partly open	11.7 m-1
Sealed	22.4 m-1
Sealed network	0.0 % of DZ intercept
Crush	2.7 % of DZ intercept



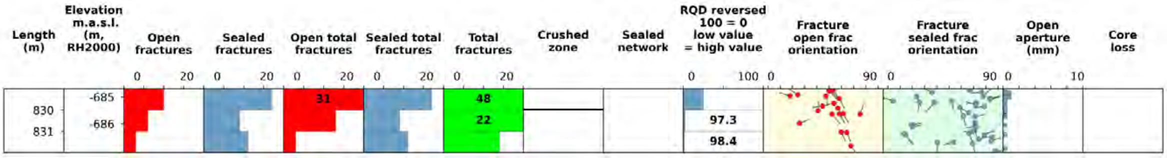
RQD:	min:75, max:98, mean:90

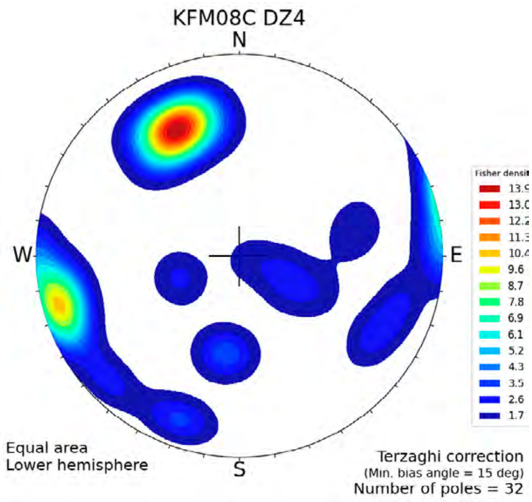
ENE	ZFMENE1061B	Version number	3	Total object CL	15
Fracture fill mineralogy:					

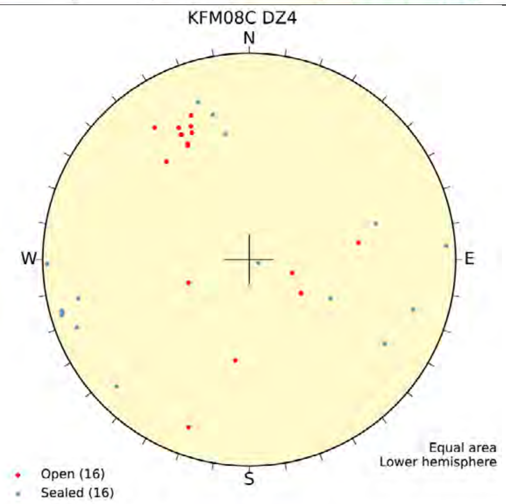
ENE	ZFMENE1061B	Version number	3	Total object CL	15

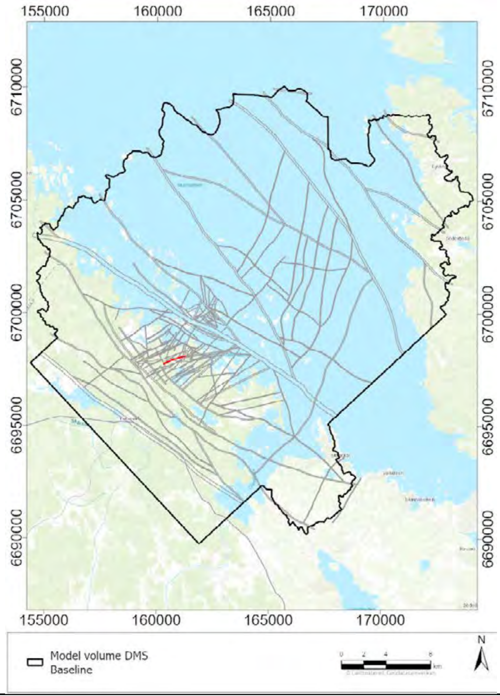
INDIVIDUAL INTERCEPTS

KFM08C DZ4 (829.0-832.0 m)







ENE	ZFMENE1192A		Version number	4	Total object CL	18
GEOLOGICAL CHARACTER		**Property CL**				
Deformation style:	Brittle	3				
Deformation description:	No data available.					
Alteration:						
- First order:	Oxidation	3				
- Second order:	Not observed					
- Third order:	Not observed					
Fracture orientation and type:	Fracture set with NE strike and steep dip to the SE is prominent. Gently dipping fractures are also present. Sealed and open fractures where the former dominates.	2				
Fracture comment:	No data available.					
Fracture fill mineralogy:	Chlorite, laumontite, hematite/adularia, calcite, quartz, pyrite.					
OBJECT GEOMETRY						
Strike/dip:	66°/88°					
Length:	1099 m					
Mean thickness:	3 m (3 - 50 m)					
Max depth:	-1100 m					
Geometrical constraints:	Topo 40m grid Max error 20m, ZFMENE0060A, 1 UNIVERSE Planar Cut(s).					

BASIS FOR MODELLING

Zone based on surface lineaments and a borehole observation. Zone ZFMENE1192 consists of two segments, ZFMENE1192A and ZFMENE1192B, judged to constitute elements of one and the same structure.

Outcrops:	-
Boreholes:	

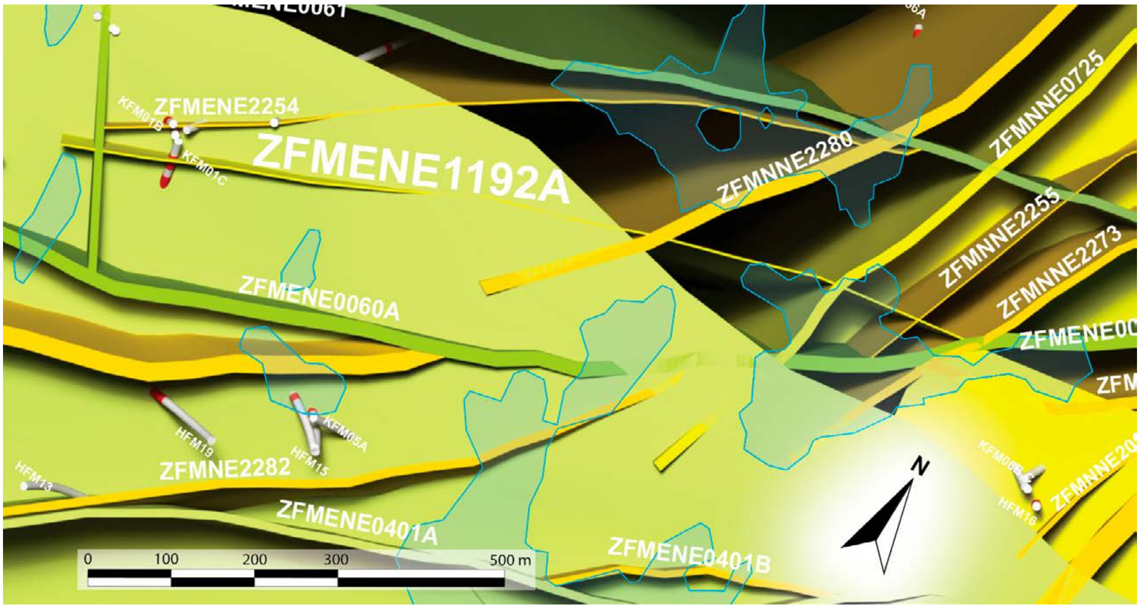
Borehole	PDZ	Target intercept		Geometric intercept		Comment
		Sec_up [m]	Sec_low [m]	Sec_up [m]	Sec_low [m]	
KFM01A	DZ2	386.00	412.00	371.60	412.40	New SHI DZ from ESHI (cf. Table 3-2 in SKB Stephens et al. 2007).
KFM01A	DZ5	267.00	285.00	253.10	309.33	
KFM01C	DZ1	23.00	48.00	30.60	34.25	ZFMA2 also intersects DZ1. Fractured rock between 48 and 62 m inferred to be affected by DZ (cf. Table 3-2 in Stephens et al. 2007).

Tunnels:	-	
Lineament and/or seismic indications:	MFM2253G0.	2

MODELLING PROCEDURE

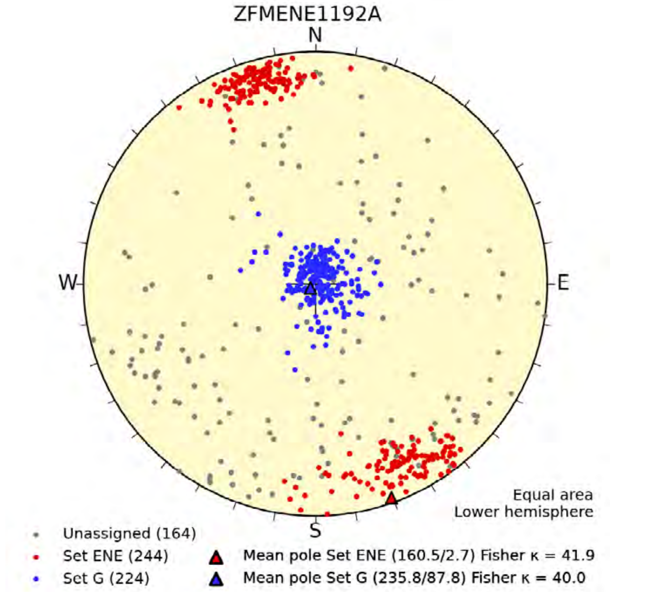
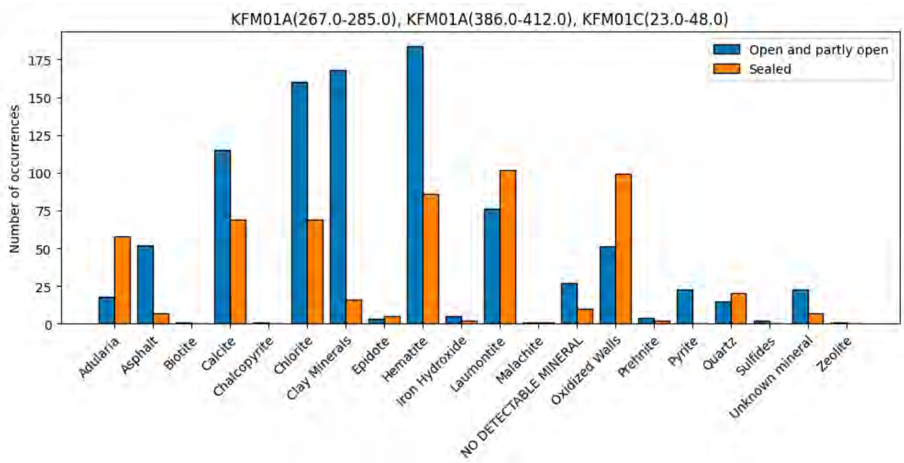
Zone ZFMENE1192 consists of two segments, labelled ZFMENE1192A and ZFMENE1192B, following lineaments with slightly different trends. These two segments are judged to constitute elements of one and the same structure. Zone ZFMENE1192A corresponds at the surface to the low magnetic lineament MFM2253G0. Modelled using the dip estimated by connecting lineament MFM2253G0 with the borehole intervals 267-285 m (DZ5) and 386-412 m (DZ2) in KFM01A. Deformation zone plane placed at fixed points 277 m and 402 m in KFM01A. Decreased radar penetration also along the borehole interval 390-400 m. Zone also intersects borehole interval 23-48 m (DZ1) in KFM01C. However, the gently dipping zone ZFMA2 is also modelled to intersect borehole KFM01C along DZ1. For this reason, there are difficulties to separate the influence of zones ZFMENE1192A and ZFMA2 along this borehole interval.

ENE	ZFMENE1192A	Version number	4	Total object CL	18



OBJECT CONFIDENCE ESTIMATE

Category	Object CL	Comment
INTERPRETATION		
Data source	2	MFM2253G0, KFM01A, KFM01C
Results of interpretation	3	High confidence observation in KFM01C.
INFORMATION DENSITY		
Number of observation points	2	3
Distribution of observation points	2	Two intercepts c. 250 in between and the lineament considered as an outlier. Three scattered observation points.
INTERPOLATION		
Geometry	2	Modelled as a splay to ZFMENE0060A. Limited information from the SHI compared to ZFMENE0060A. Due to limited information at depth, the extrapolation alternative along MFM2253G1 cannot be fully ruled out. This gives at least alternatives for the geometry.
Geological indicators	2	Interpolation supported by mineral fillings within fractures from boreholes.
EXTRAPOLATION		
Dip direction	2	Extrapolation in dip direction supported by subsurface obs. point. Strike length of the modelled zone < 2000 m.
Strike direction	3	Conceptual understanding of the site and that the entire modelled zone is supported by the lineament.

<table>
<tr><td>ENE</td><td>ZFMENE1192A</td><td>Version number</td><td>4</td><td>Total object CL</td><td>18</td></tr>
<tr><td colspan="6">FRACTURE CHARACTER</td></tr>
<tr><td>Orientation:
(strike/dip right-hand-rule)</td><td>Set ENE: 250.5°/87.3°
Set G: 325.8°/2.2°</td><td colspan="4" rowspan="2">
</td></tr>
<tr><td>Frequency:</td><td>Boreholes: KFM01A, KFM01C
<table>
<tr><th>FRACTURE TYPE</th><th>TERZAGHI-WEIGHED P10</th></tr>
<tr><td>Open and partly open</td><td>10.4 m-1</td></tr>
<tr><td>Sealed</td><td>9.4 m-1</td></tr>
<tr><td>Sealed network</td><td>7.6 % of DZ intercept</td></tr>
<tr><td>Crush</td><td>0.9 % of DZ intercept</td></tr>
</table></td></tr>
<tr><td>RQD:</td><td>min:14, max:100, mean:86</td><td colspan="4"></td></tr>
<tr><td>Fracture fill mineralogy:</td><td colspan="5">
</td></tr>
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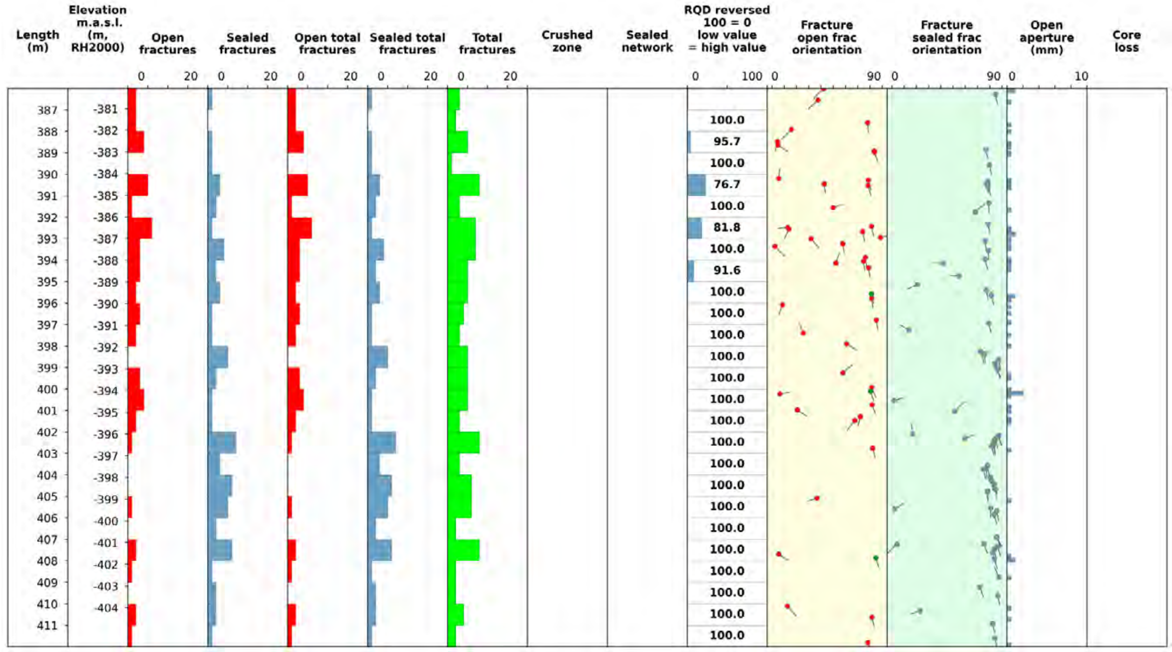
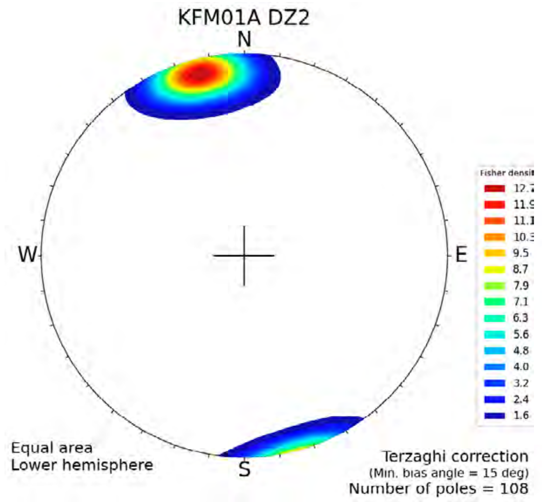
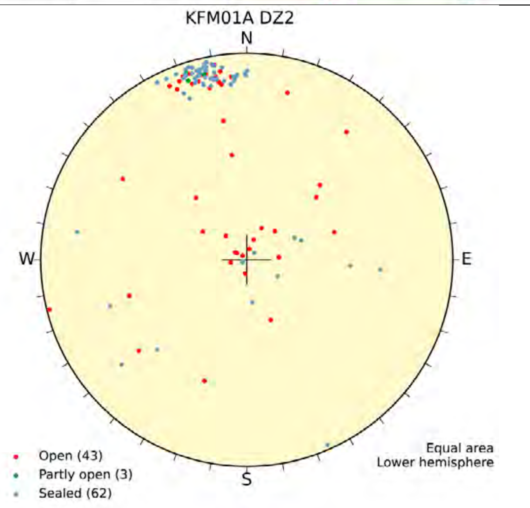
ENE	ZFMENE1192A	Version number	4	Total object CL	18

INDIVIDUAL INTERCEPTS

KFM01A DZ2 (386.0-412.0 m)

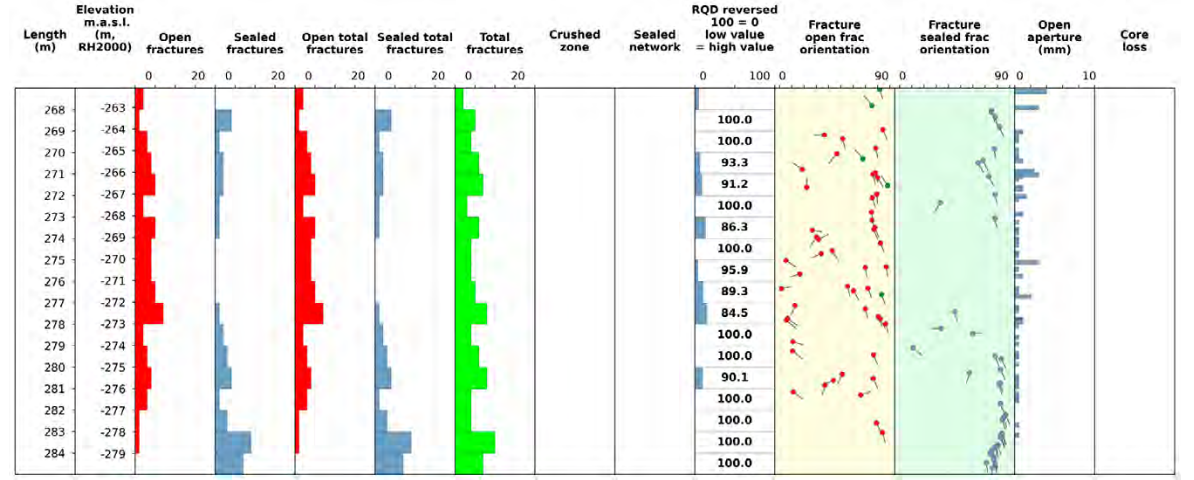


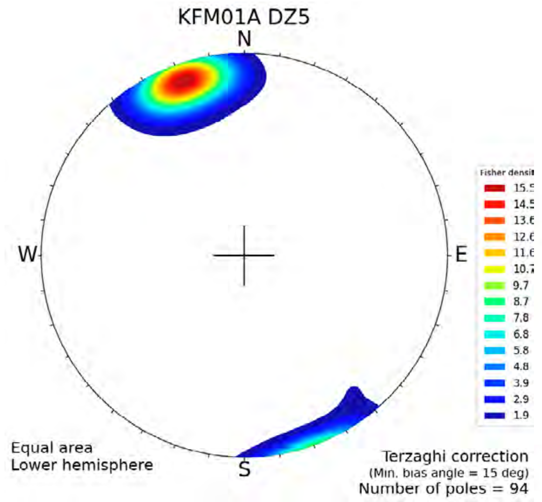


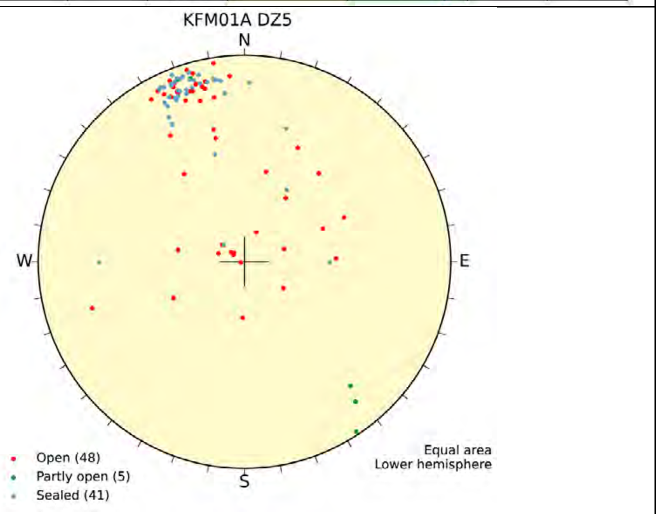


ENE	ZFMENE1192A	Version number	4	Total object CL	18

KFM01A DZ5 (267.0-285.0 m)

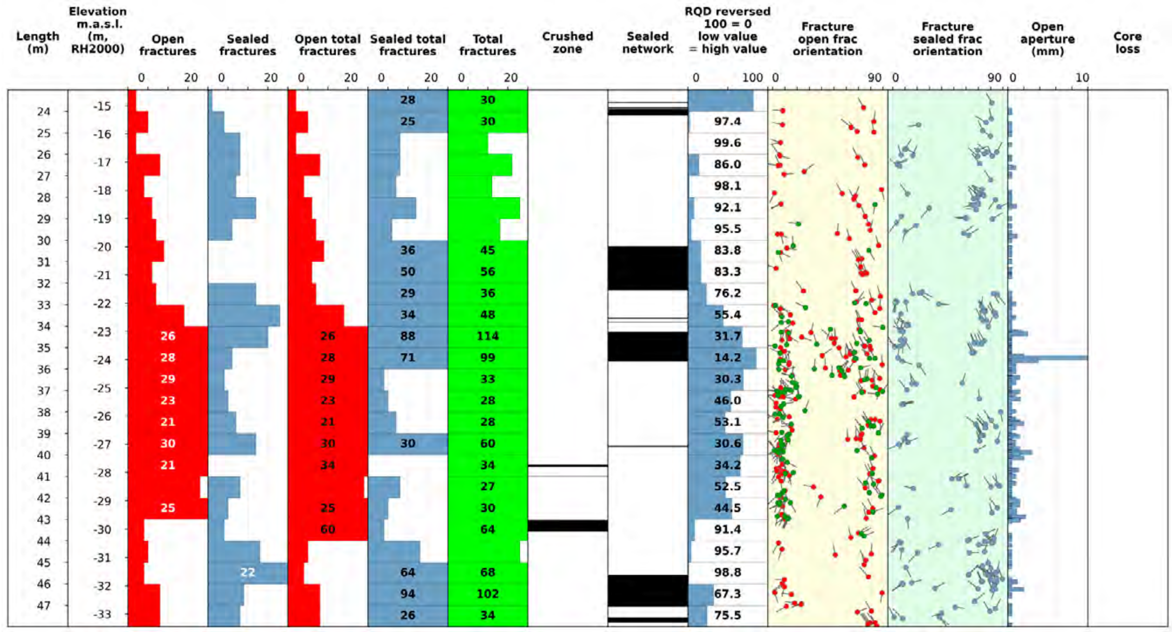


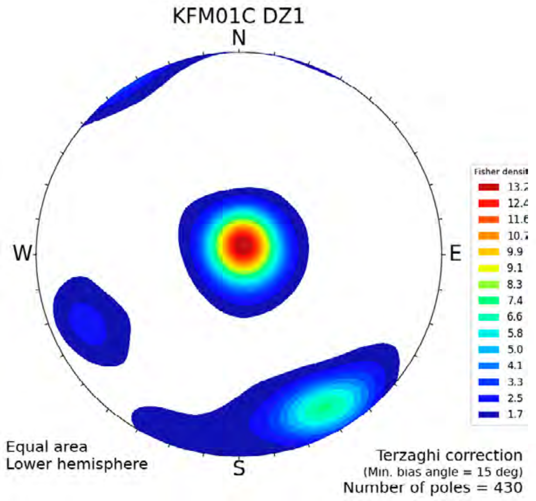


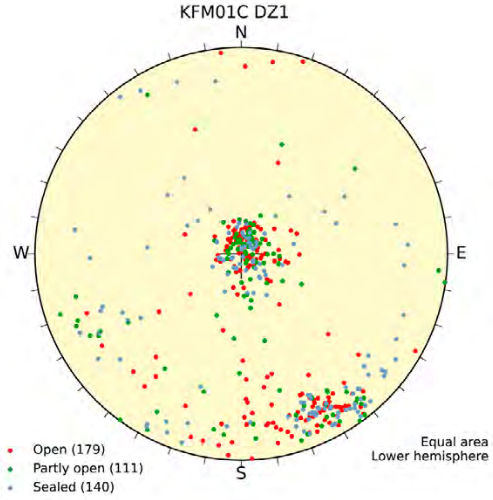


ENE	ZFMENE1192A	Version number	4	Total object CL	18

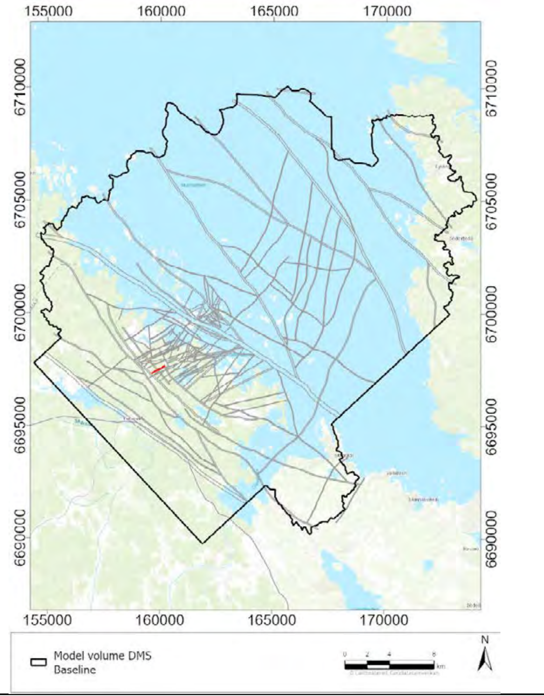
KFM01C DZ1 (23.0-48.0 m)







ENE	ZFMENE1192B	Version number	4	Total object CL	11



GEOLOGICAL CHARACTER		Property CL
Deformation style:	Brittle	1
Deformation description:	No data available.	
Alteration:		2
- First order:	Oxidation	
- Second order:	Not observed	
- Third order:	Not observed	
Fracture orientation and type:	No data available.	
Fracture comment:	No data available.	
Fracture fill mineralogy:	No data available.	

OBJECT GEOMETRY	
Strike/dip:	60°/88°
Length:	758 m
Mean thickness:	3 m (2 - 36 m)
Max depth:	-760 m
Geometrical constraints:	ZFMENE0060A, ZFMNW0017, Topo 40m grid Max error 20m, 1 UNIVERSE Planar Cut(s).

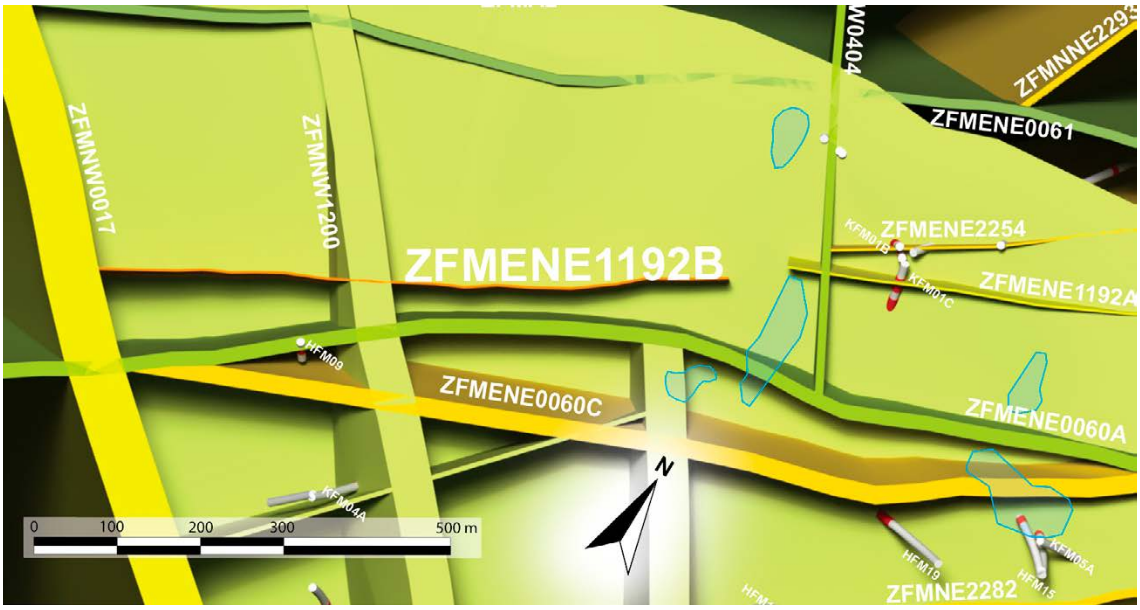
BASIS FOR MODELLING

Zone based on surface lineaments. Zone ZFMENE1192 consists of two segments, ZFMENE1192A and ZFMENE1192B, judged to constitute elements of one and the same structure.

Outcrops:	-	
Boreholes: -		
Tunnels:	-	
Lineament and/or seismic indications:	MFM2253G1.	2

MODELLING PROCEDURE

Zone ZFMENE1192 consists of two segments, labelled ZFMENE1192A and ZFMENE1192B, following lineaments with slightly different trends. These two segments are judged to constitute elements of one and the same structure. Zone ZFMENE1192B corresponds at the surface to the low magnetic lineament MFM2253G1. Modelled with the same dip, the same thickness and to the same depth as ZFMENE1192A.



ENE	ZFMENE1192B	Version number	4	Total object CL	11

OBJECT CONFIDENCE ESTIMATE

Category	Object CL	Comment
INTERPRETATION		
Data source	1	MFM2253G1
Results of interpretation	2	Medium confidence for the lineament MFM2253G1.
INFORMATION DENSITY		
Number of observation points	1	1
Distribution of observation points	1	Single observation point in the form of a lineament.
INTERPOLATION		
Geometry	1	Splay to ZFMENE0060A. Possibility to model along the MFM0060G2. No subsurface data available.
Geological indicators	1	Indirect support by geophysical data.
EXTRAPOLATION		
Dip direction	1	No subsurface obs. point, supported only by surface data. High uncertainty in dip-direction. Strike length of the modelled zone < 2000 m.
Strike direction	3	Conceptual understanding of the site and that the entire modelled zone is supported by the lineament.

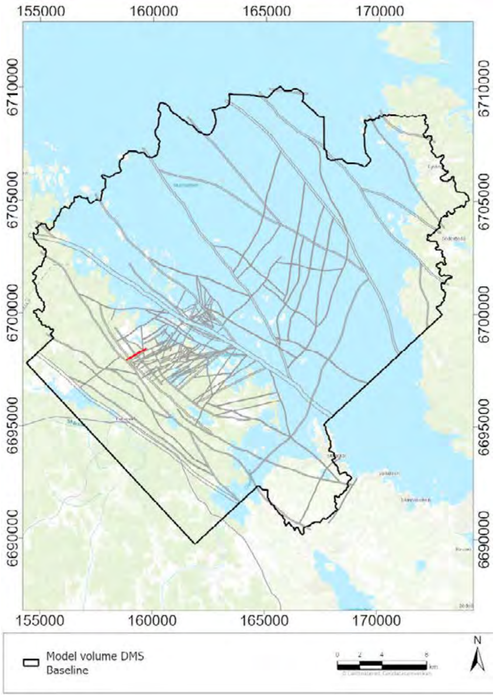
FRACTURE CHARACTER

No data available

INDIVIDUAL INTERCEPTS

No data available

ENE	ZFMENE1208A		Version number	5	Total object CL	18
GEOLOGICAL CHARACTER		**Property CL**				
Deformation style:	Brittle	3				
Deformation description:	Steeply dipping faults with NNW-SSE strike show evidence for both sinistral and dextral strike-slip. One steeply dipping fault with ENE strike also shows a strike-slip displacement.					
Alteration:		3				
- First order:	Oxidation					
- Second order:	Not observed					
- Third order:	Not observed					
Fracture orientation and type:	Steeply dipping fractures that strike WSW, SSW and SSE, and gently dipping fractures, especially in KFM09A (DZ1) and KFM09B (part of DZ1), dominates. Dominated by sealed followed by open and partly open fractures.	2				
Fracture comment:	No data available.					
Fracture fill mineralogy:	Calcite, chlorite, hematite/adularia, laumontite, quartz, clay minerals. Epidote also present in KFM07A (part of DZ4).					
OBJECT GEOMETRY						
Strike/dip:	240°/81°					
Length:	1082 m					
Mean thickness:	10 m (3 - 50 m)					
Max depth:	-1100 m					
Geometrical constraints:	ZFMNW0003, Topo 40m grid Max error 20m, 1 Surface Planar Cut(s), 1 UNIVERSE Planar Cut(s).					



ENE	ZFMENE1208A	Version number	5	Total object CL	18

BASIS FOR MODELLING

Zone based on borehole observations.

Outcrops: -

Boreholes:

Borehole	PDZ	Target intercept		Geometric intercept		Comment
		Sec_up [m]	Sec_low [m]	Sec_up [m]	Sec_low [m]	
HFM23	DZ1	26.00	42.00	8.26	10.21	Target intercept is outside geometrical intercept.
HFM28	DZ1	12.02	65.00	7.11	21.89	Target intercept is partly outside of geometrical intercept.
KFM07A	DZ4	857.00	897.00	870.66	895.24	ZFMENE1208B also intersects DZ4. Divided into three separate zones at 803-840 m, 857-897 m and 920-999 m (cf. Table 3-2 in Stephens et al. 2007). Fractured rocks between these modelled zones inferred to be affected by DZ.
KFM09A	DZ1	15.00	40.00	16.27	41.51	
KFM09B	DZ1	9.20	43.00	21.52	35.25	ZFMENE1208B also intersects DZ1. Only borehole intervals 9-43 m, 59-78 m and 106-132 m included in the DZ deterministic modelling (cf. Table 3-2 in Stephens et al. 2007). Fractured rock between these modelled zones and between 132 and 308 m inferred to be affected by DZ.

Tunnels: -

Lineament and/or seismic indications: -

MODELLING PROCEDURE

Zone ZFMENE1208 consists of two sub-parallel segments. Though these two segments with identity codes ZFMENE1208A and ZFMENE1208B are described separately in the property sheets, they are inferred to constitute elements of one and the same structure. Magnetic data are absent or of poor quality close to the residence area and magnetic lineaments are not present. Zone modelled by connecting borehole intervals 857-897 m in KFM07A (part of DZ4), 15-40 m in KFM09A (DZ1) and 9-43 m in KFM09B (part of DZ1) and, with the assistance of fracture orientation data, assuming an orientation parallel to zone ZFMENE0159A. Deformation zone plane placed at fixed points 883 m in KFM07A, 30 m in KFM09A and 28 m in KFM09B. Decreased radar penetration also along the borehole intervals 880-886 m in KFM07A, 30-32 m in KFM09A and 26-50 m in KFM09B. Zone also intersects borehole intervals 26-42 m in HFM23 (DZ1) and 12-65 m in HFM28 (DZ1). Inferred termination against ZFMNW0003 and blind, so as to avoid intersection along HFM20.

ENE	ZFMENE1208A	Version number	5	Total object CL	18

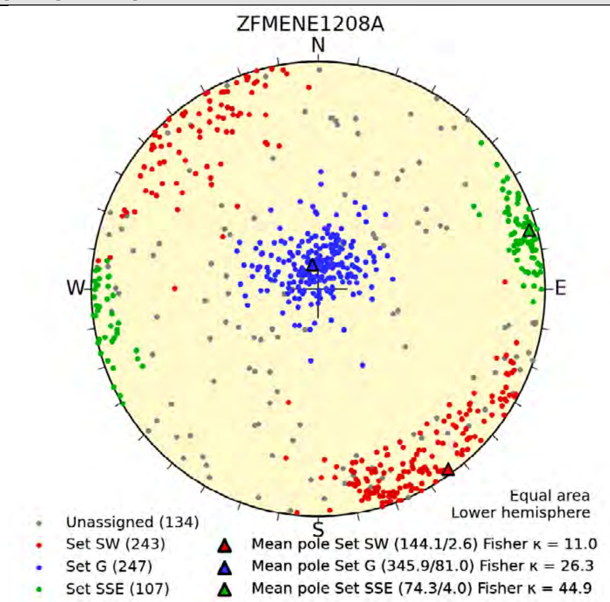
OBJECT CONFIDENCE ESTIMATE

Category	Object CL	Comment
INTERPRETATION		
Data source	2	HFM23, HFM28, KFM07A, KFM09A, KFM09B
Results of interpretation	3	High confidence observations in multiple boreholes.
INFORMATION DENSITY		
Number of observation points	3	4
Distribution of observation points	2	A group of clustered observation points and at least one outlier.
INTERPOLATION		
Geometry	2	The zone is interpolated horizontally parallel to ZFMENE1208B.
Geological indicators	2	Interpolation supported by mineral fillings within fractures from boreholes.
EXTRAPOLATION		
Dip direction	2	Extrapolation in dip direction supported by subsurface obs. point. Strike length of the modelled zone < 2000 m.
Strike direction	2	Supported by geological concept and subsurface observation points. Strike length < 2000 m.

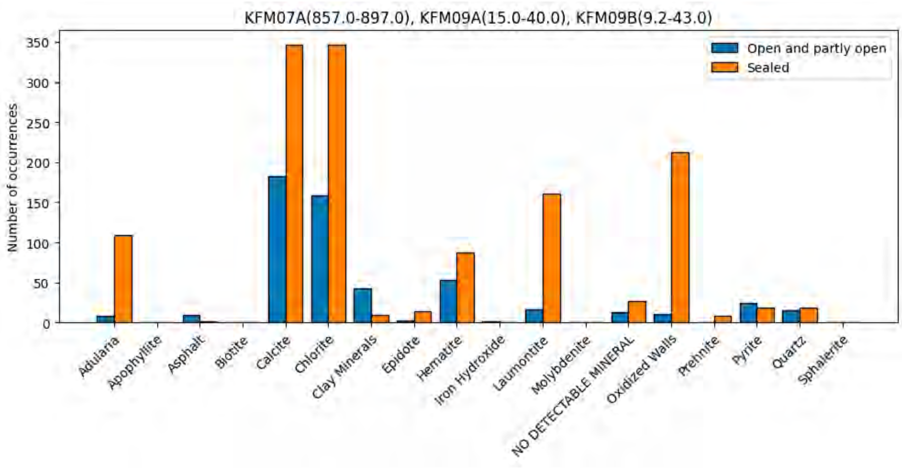
FRACTURE CHARACTER

Orientation: (strike/dip right-hand-rule)	Set SW: 234.1°/87.4° Set G: 75.9°/9.0° Set SSE: 164.3°/86.0°
Frequency:	Boreholes: KFM09B, KFM07A, KFM09A

FRACTURE TYPE	TERZAGHI-WEIGHED P10
Open and partly open	4.6 m-1
Sealed	13.4 m-1
Sealed network	18.5 % of DZ intercept
Crush	0.9 % of DZ intercept

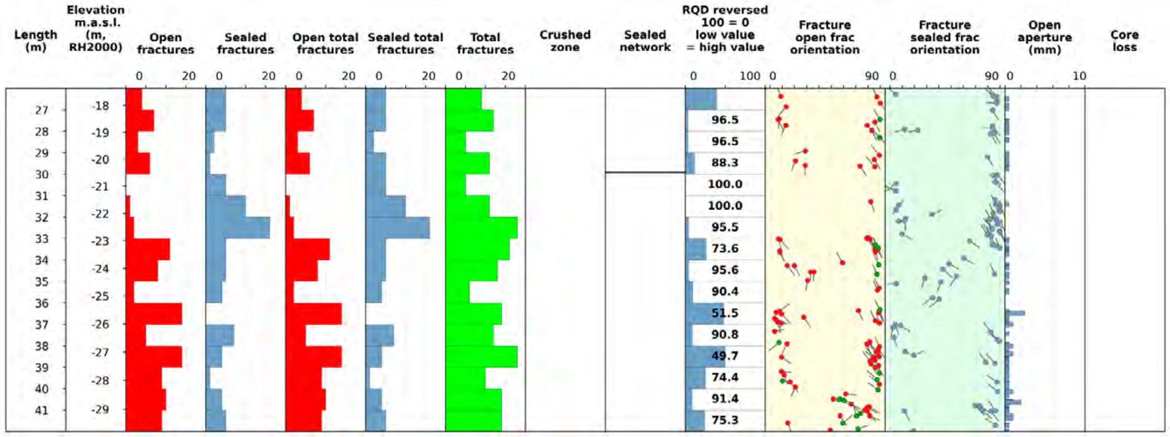


RQD:	min:3, max:100, mean:94

ENE	ZFMENE1208A	Version number	5	Total object CL	18
Fracture fill mineralogy:					

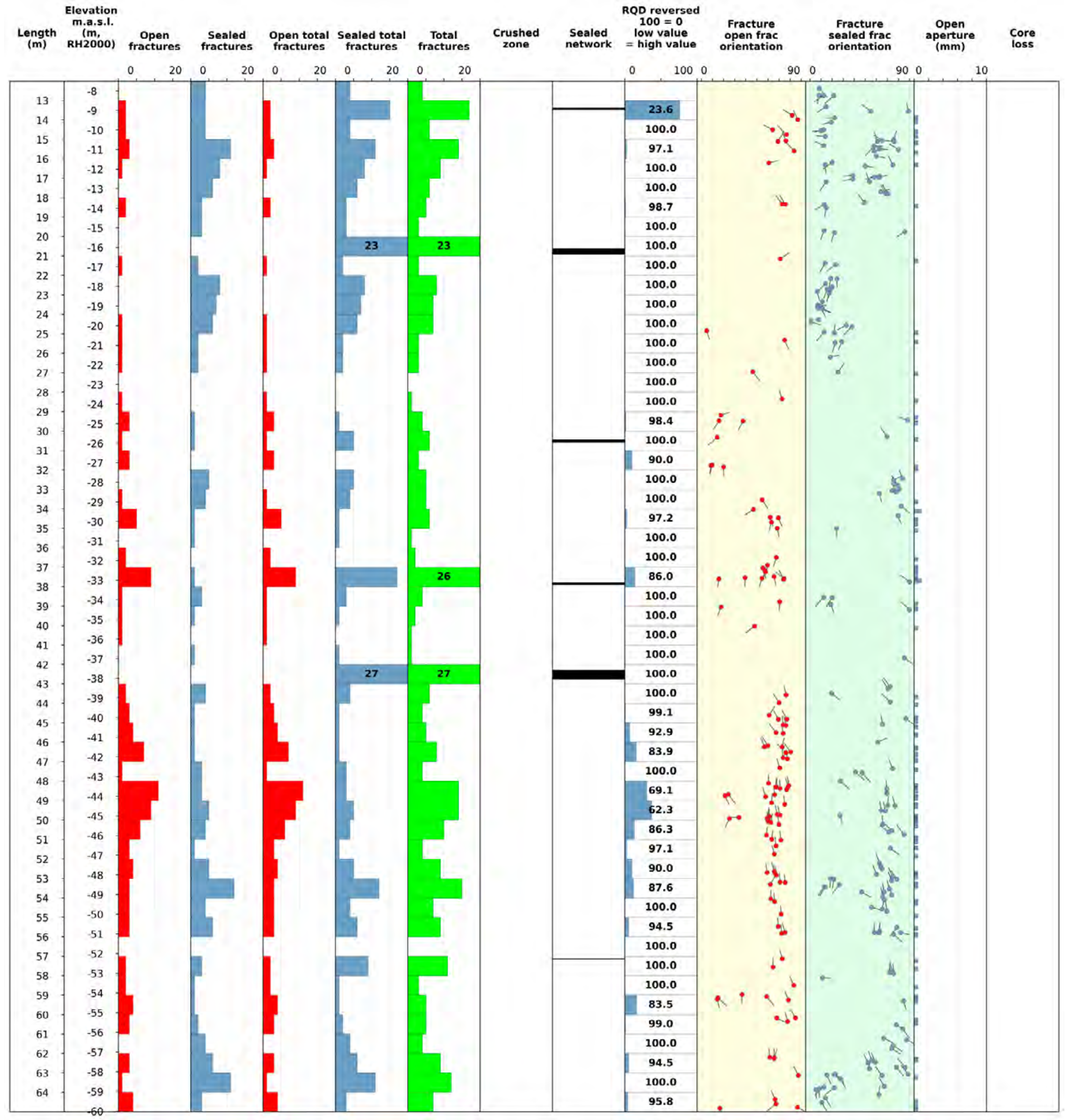
ENE	ZFMENE1208A	Version number	5	Total object CL	18
INDIVIDUAL INTERCEPTS					

HFM23 DZ1 (26.0-42.0 m)



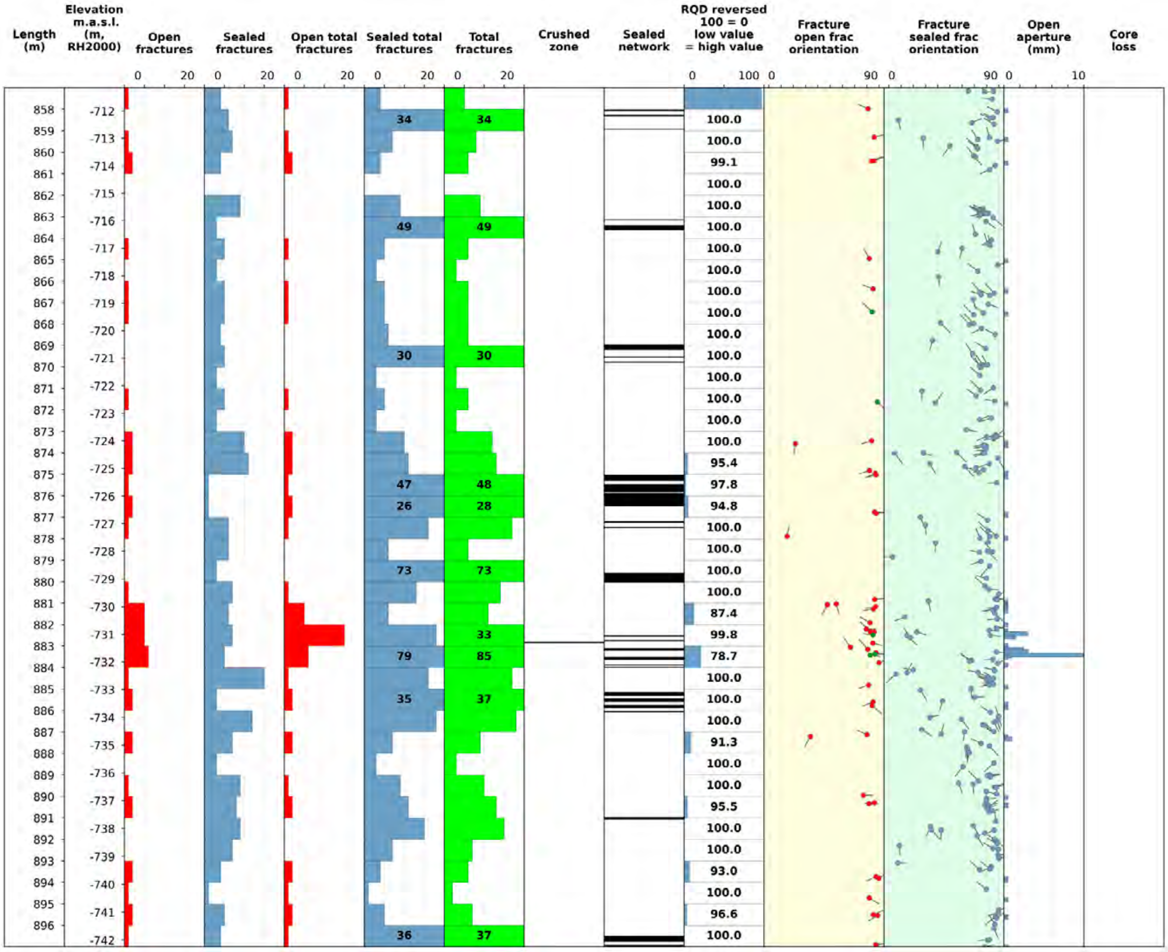
ENE	ZFMENE1208A	Version number	5	Total object CL	18

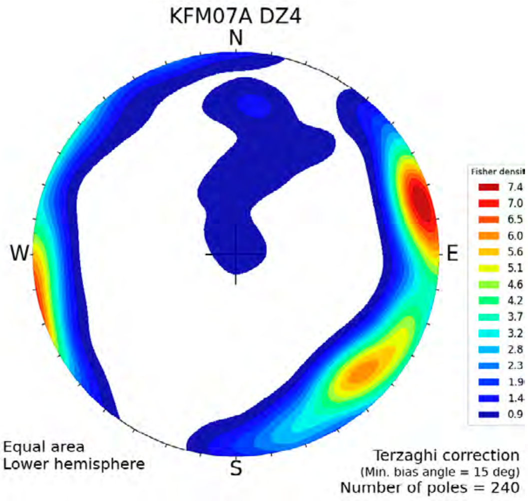
HFM28 DZ1 (12.02-65.0 m)

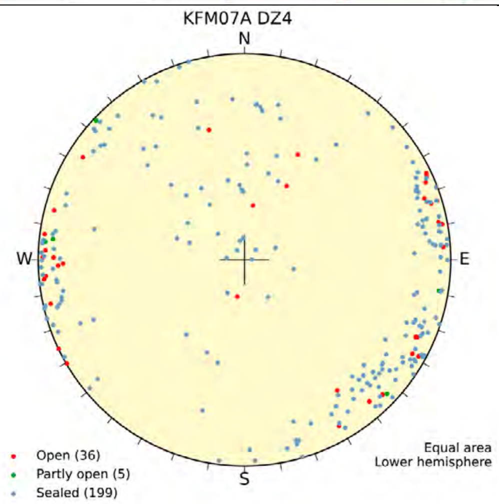


ENE	ZFMENE1208A	Version number	5	Total object CL	18

KFM07A DZ4 (857.0-897.0 m)

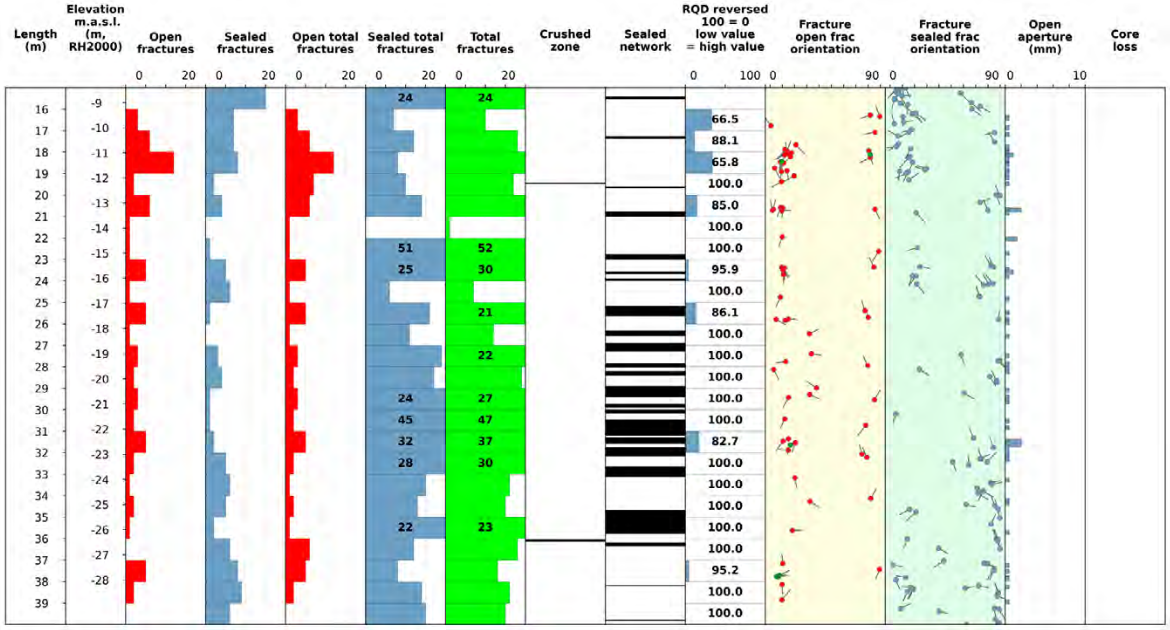


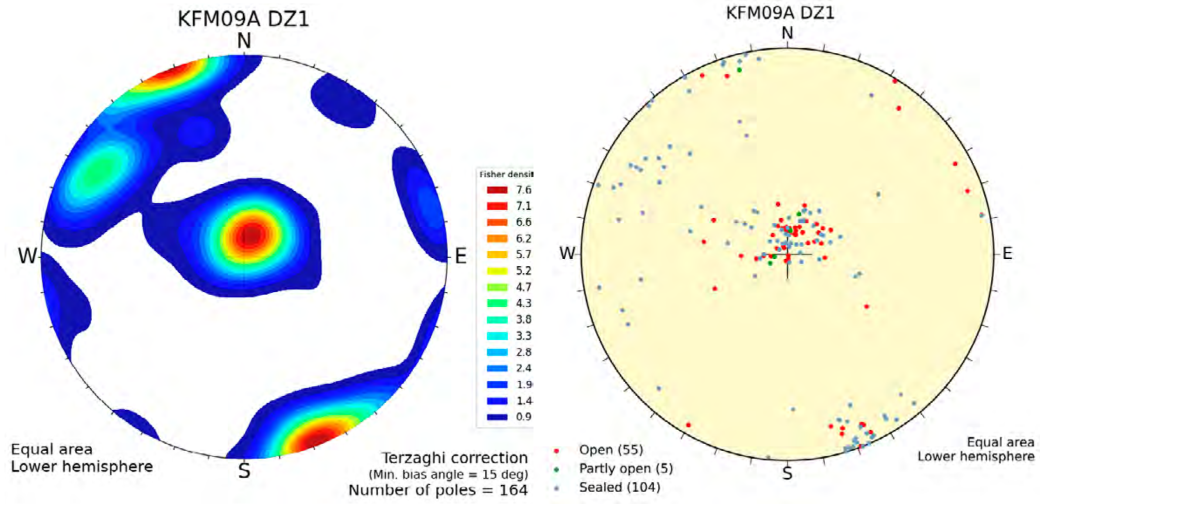




ENE	ZFMENE1208A	Version number	5	Total object CL	18

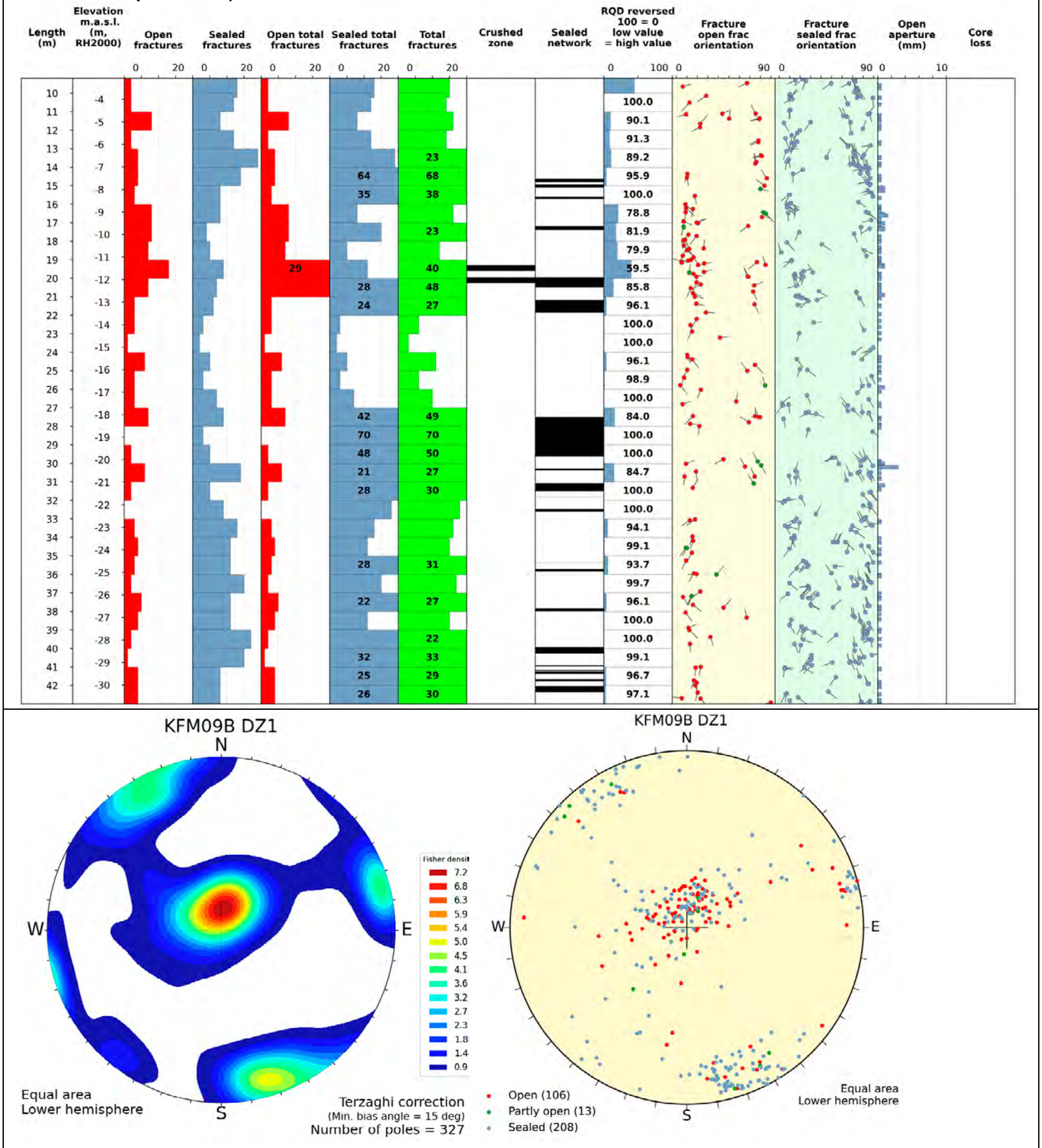
KFM09A DZ1 (15.0-40.0 m)





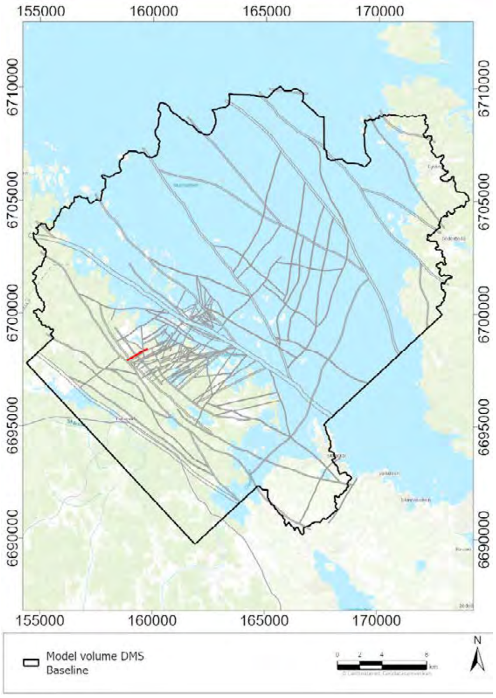
ENE	ZFMENE1208A	Version number	5	Total object CL	18

KFM09B DZ1 (9.2-43.0 m)



ENE	ZFMENE1208B		Version number	5	Total object CL	18

GEOLOGICAL CHARACTER		Property CL
Deformation style:	Brittle	3
Deformation description:	Steeply dipping faults with NNW SSE strike, sub-parallel to the tectonic foliation, show both sinistral and dextral displacement. One steeply dipping fault with W strike along DZ2 in KFM09A shows dextral strike-slip displacement, possibly conjugate to the sinistral displacement along the NNW-SSE faults.	
Alteration:		3
- First order:	Oxidation	
- Second order:	Not observed	
- Third order:	Not observed	
Fracture orientation and type:	Steeply dipping fractures that strike WSW, NE and NNW, and gently dipping fractures dominates. Sealed and open fractures, with a dominance of open fractures in the gently dipping set. Quantitative estimate and span include sealed fracture networks and crush zones.	2
Fracture comment:	No data available.	
Fracture fill mineralogy:	Calcite, chlorite, laumontite, hematite/adularia, quartz, clay minerals. Epidote also present in KFM07A (part of DZ4).	
OBJECT GEOMETRY		
Strike/dip:	240°/81°	
Length:	1111 m	
Mean thickness:	13 m (3 - 50 m)	
Max depth:	-1100 m	
Geometrical constraints:	ZFMNW0003, Topo 40m grid Max error 20m, 1 Surface Planar Cut(s), 1 UNIVERSE Planar Cut(s).	



ENE	ZFMENE1208B	Version number	5	Total object CL	18

BASIS FOR MODELLING

Zone based on borehole observations.

Outcrops: -

Boreholes:

Borehole	PDZ	Target intercept		Geometric intercept		Comment
		Sec_up [m]	Sec_low [m]	Sec_up [m]	Sec_low [m]	
HFM28		-	-	86.07	121.33	
KFM07A	DZ4	803.00	840.00	792.28	828.35	ZFMENE1208A also intersects DZ4. Divided into three separate zones at 803-840 m, 857-897 m and 920-999 m (cf. Table 3-2 in Stephens et al. 2007). Fractured rocks between these modelled zones inferred to be affected by DZ.
KFM09A	DZ2	86.00	116.00	85.16	116.30	Fractured rock between 8 and 15 m, 40 and 86 m, and 116 and 124 m inferred to be affected by DZ (cf. Table 3-2 in Stephens et al. 2007).
KFM09B	DZ1	59.00	78.00	60.81	79.88	ZFMENE1208A also intersects DZ1. Only borehole intervals 9-43 m, 59-78 m and 106-132 m included in the DZ deterministic modelling (cf. Table 3-2 in Stephens et al. 2007). Fractured rock between these modelled zones and between 132 and 308 m inferred to be affected by DZ.

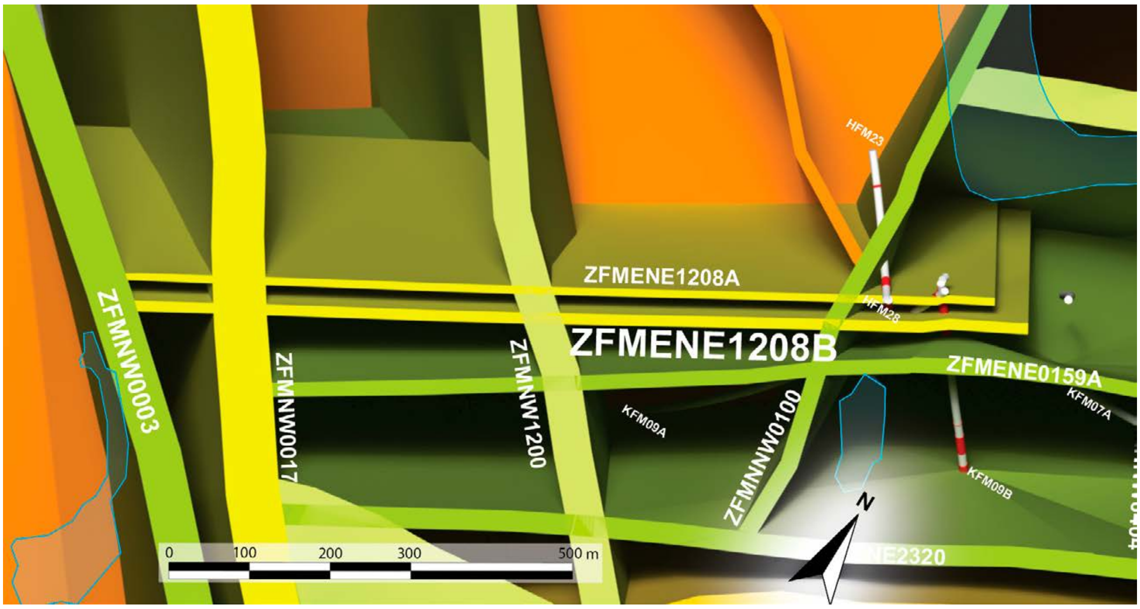
Tunnels: -

Lineament and/or seismic indications: -

MODELLING PROCEDURE

Magnetic data are absent or of poor quality close to the residence area and magnetic lineaments are not present. Zone modelled by connecting borehole intervals 803-840 m in KFM07A (part of DZ4), 86-116 m in KFM09A (DZ2) and 59-78 m in KFM09B (part of DZ1) and, with the assistance of fracture orientation data, assuming an orientation parallel to zone ZFMENE0159A. Deformation zone plane placed at fixed points 817 m in KFM07A, 94 m in KFM09A and 66 m in KFM09B. Decreased radar penetration also along the borehole interval 92-106 m in KFM09A. Zone also intersects borehole HFM28. Inferred termination against ZFMNW0003 and blind, so as to avoid intersection along HFM20.

ENE	ZFMENE1208B	Version number	5	Total object CL	18



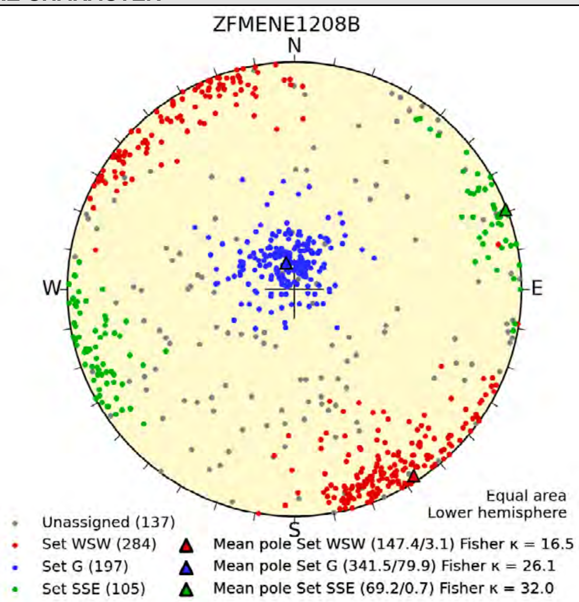
OBJECT CONFIDENCE ESTIMATE

Category	Object CL	Comment
INTERPRETATION		
Data source	2	HFM28, KFM07A, KFM09A, KFM09B
Results of interpretation	3	High confidence observations in multiple boreholes.
INFORMATION DENSITY		
Number of observation points	3	>4
Distribution of observation points	2	A group of clustered observation points and at least one outlier.
INTERPOLATION		
Geometry	2	The zone is interpolated horizontally parallel to ZFMENE1208A and ZFMENE0159A.
Geological indicators	2	Interpolation supported by mineral fillings within fractures from boreholes.
EXTRAPOLATION		
Dip direction	2	Extrapolation in dip direction supported by subsurface obs. point. Strike length of the modelled zone < 2000 m.
Strike direction	2	No surface lineament. Supported by geological concept and subsurface observation points. Strike length < 2000 m.

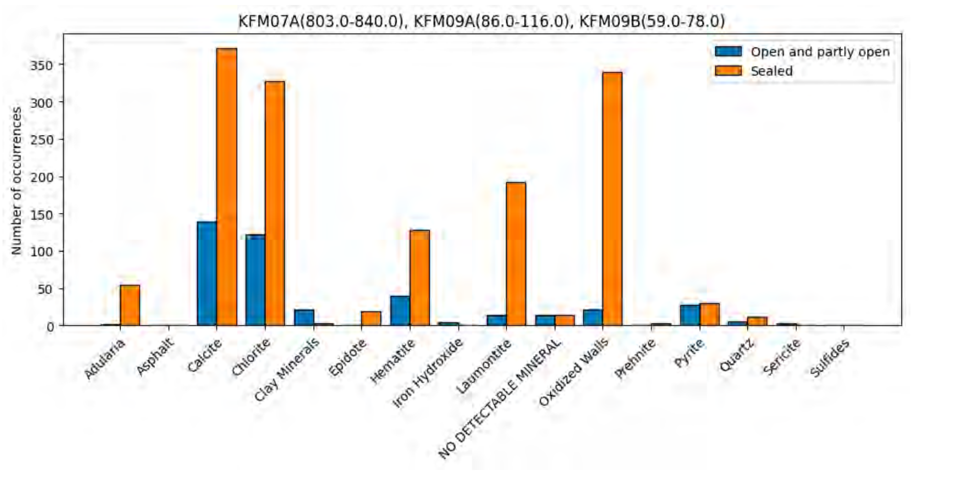
FRACTURE CHARACTER

Orientation: (strike/dip right-hand-rule)	Set WSW: 237.4°/86.9° Set G: 71.5°/10.1° Set SSE: 159.2°/89.3°
Frequency:	Boreholes: KFM09B, KFM07A, KFM09A

FRACTURE TYPE	TERZAGHI-WEIGHED P10
Open and partly open	3.9 m-1
Sealed	16.5 m-1
Sealed network	9.8 % of DZ intercept
Crush	0.0 % of DZ intercept

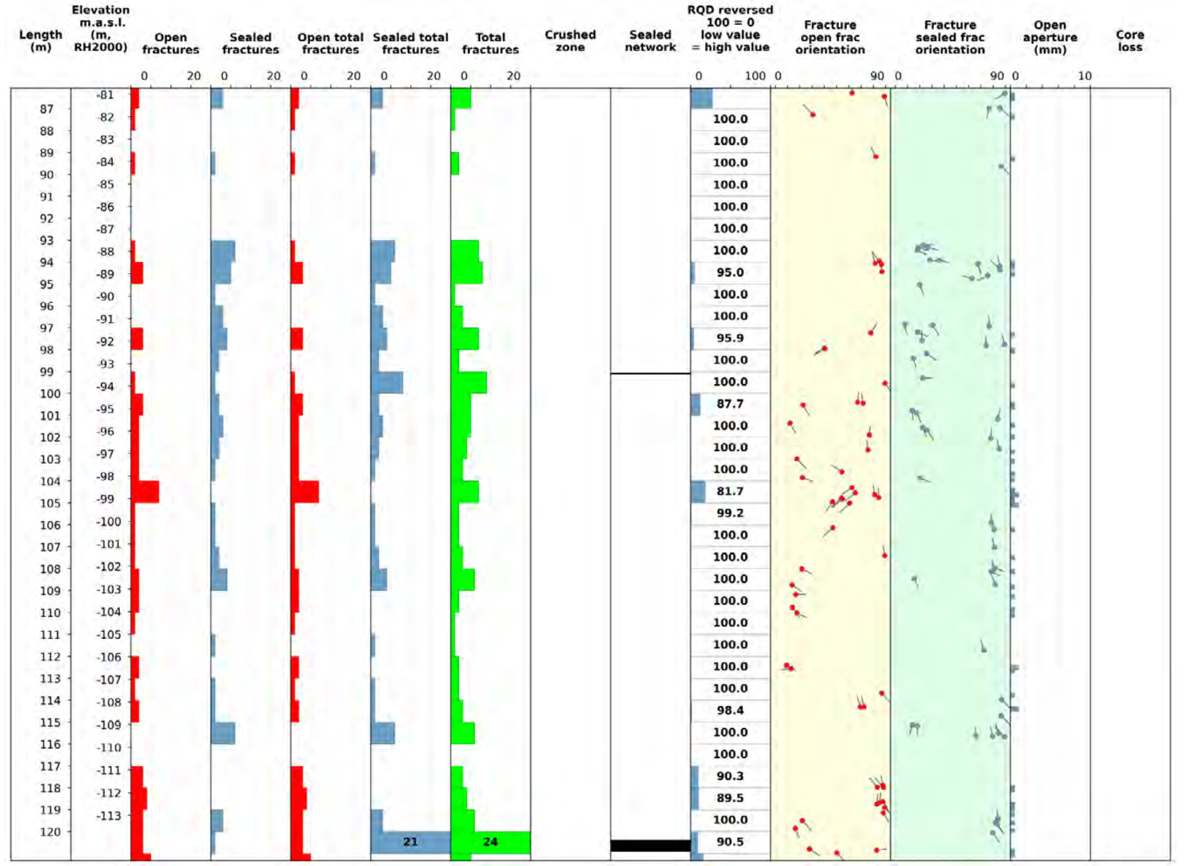


RQD:	min:64, max:100, mean:97

ENE	ZFMENE1208B	Version number	5	Total object CL	18
Fracture fill mineralogy:					

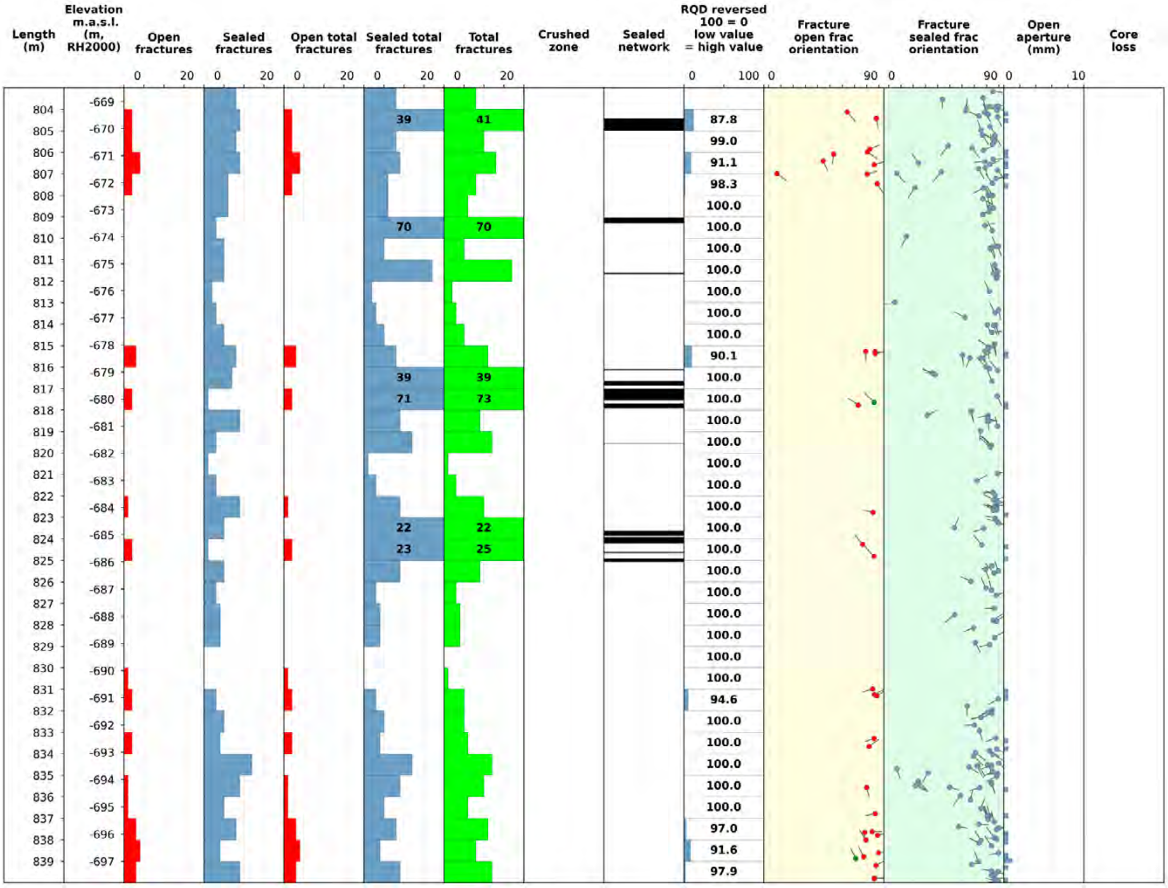
ENE	ZFMENE1208B	Version number	5	Total object CL	18
INDIVIDUAL INTERCEPTS					

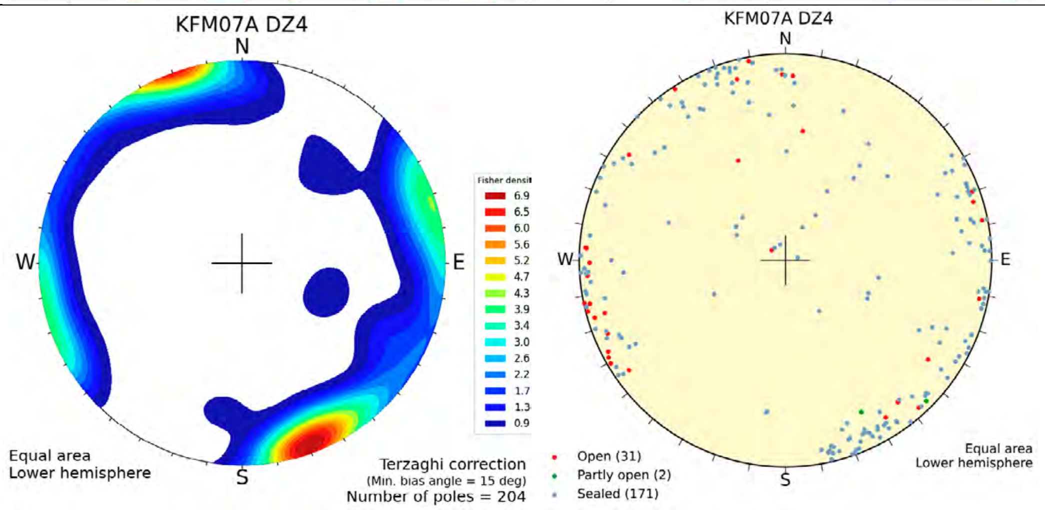
HFM28 (86.07-121.33 m)



ENE	ZFMENE1208B	Version number	5	Total object CL	18

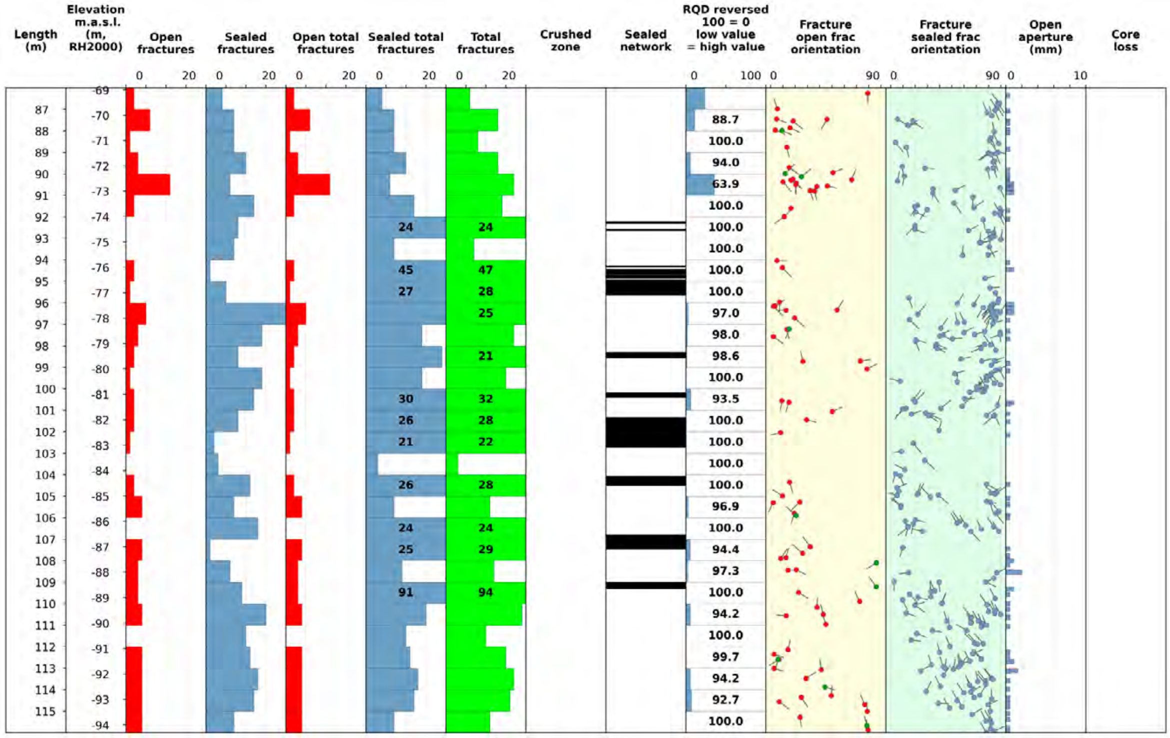
KFM07A DZ4 (803.0-840.0 m)

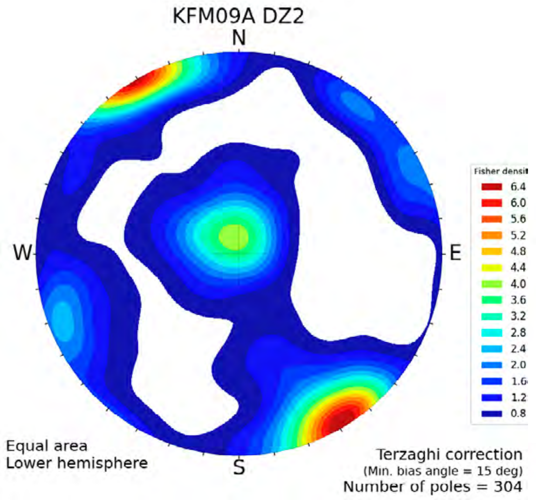


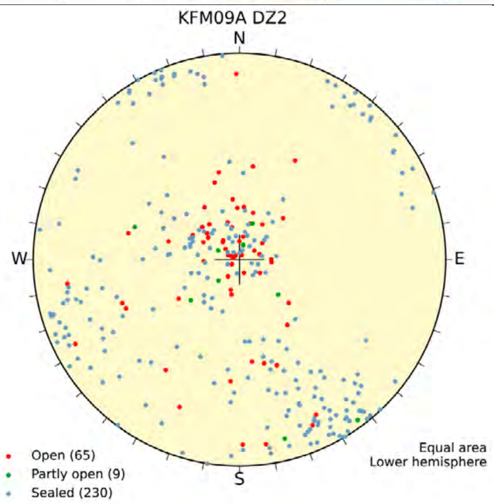


ENE	ZFMENE1208B	Version number	5	Total object CL	18

KFM09A DZ2 (86.0-116.0 m)

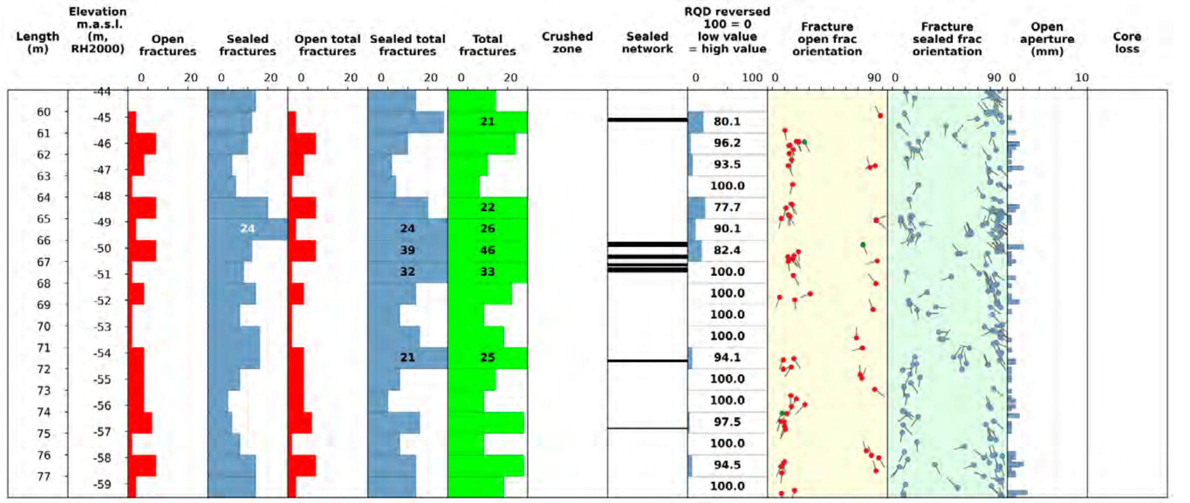


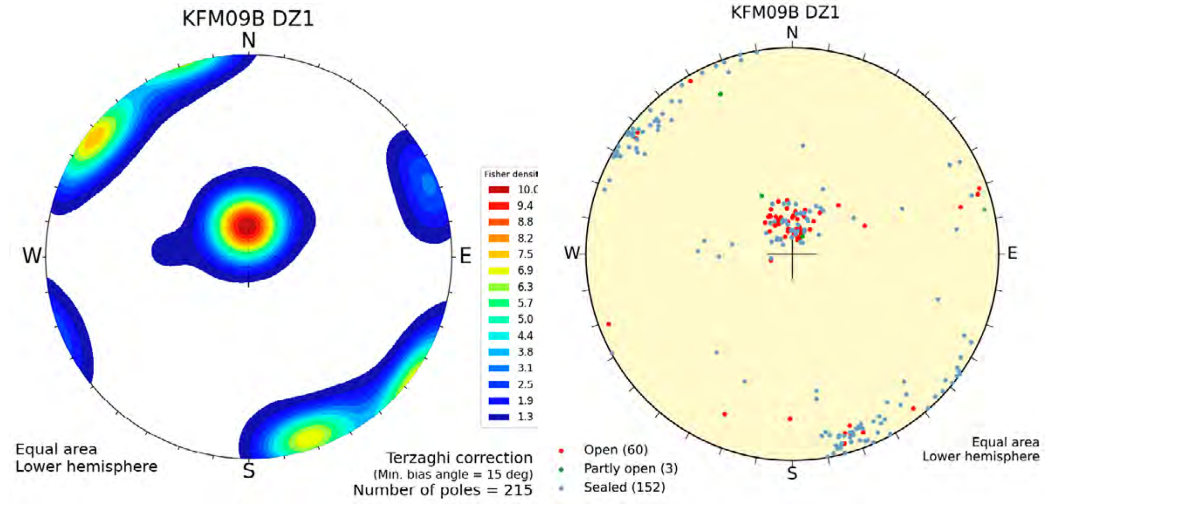




ENE	ZFMENE1208B	Version number	5	Total object CL	18

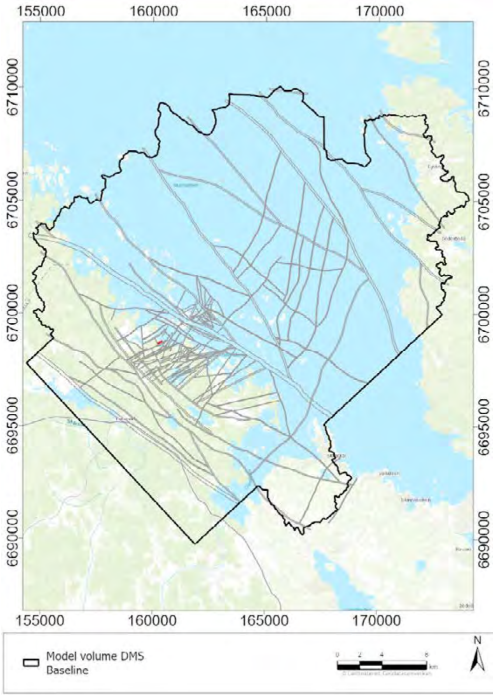
KFM09B DZ1 (59.0-78.0 m)





ENE	ZFMENE2120		Version number	5	Total object CL	21

GEOLOGICAL CHARACTER		Property CL
Deformation style:	Brittle	3
Deformation description:	No data available.	
Alteration:		3
- First order:	Oxidation	
- Second order:	Not observed	
- Third order:	Not observed	
Fracture orientation and type:	Three sets of fractures present. Two sets dip steeply and strike NE and NNW. Third set is gently dipping. Open and partly open fractures dominate in the steeply dipping NNW set. Both sealed and open/partly open fractures are present in the steeply dipping ENE set.	2
Fracture comment:	Apertures are commonly less then 1mm but few up to 3 mm are present.	
Fracture fill mineralogy:	Dominance of chlorite, calcite, quartz, adularia and clay minerals in sealed fractures. Calcite, chlorite, clay minerals, hematite dominate in open fractures.	



OBJECT GEOMETRY	
Strike/dip:	238°/79°
Length:	238 m
Mean thickness:	10 m (1 - 13 m)
Max depth:	-240 m
Geometrical constraints:	ZFMNNW1205B, Topo 40m grid Max error 20m, 1 Surface Planar Cut(s), 1 UNIVERSE Planar Cut(s).

BASIS FOR MODELLING

Zone based on surface lineaments and borehole observations.

Outcrops:	-

Boreholes:

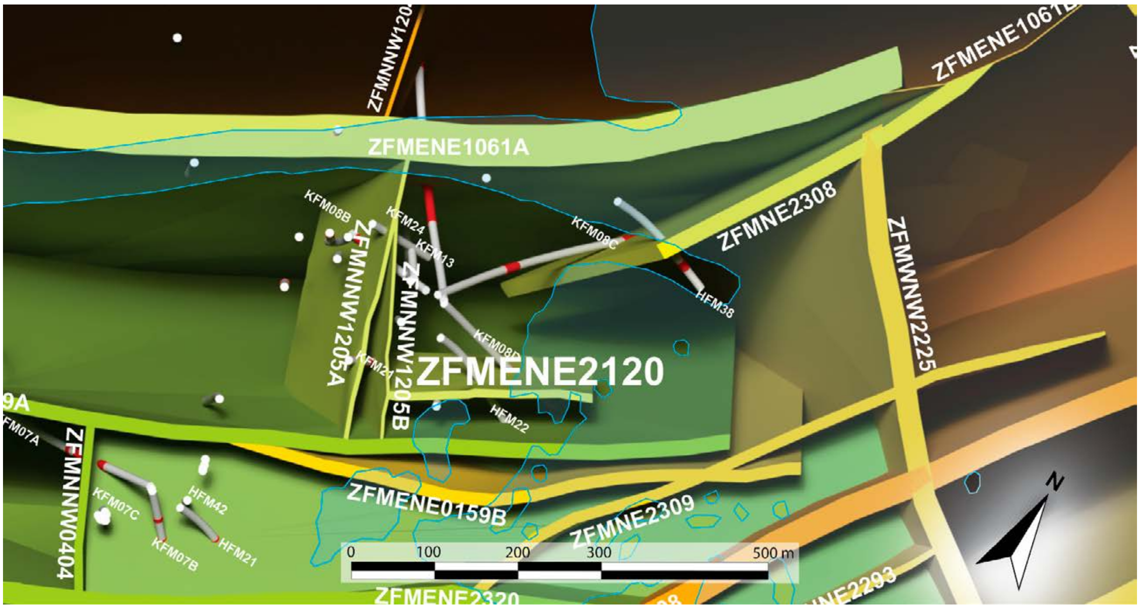
Borehole	PDZ	Target intercept		Geometric intercept		Comment
		Sec_up [m]	Sec_low [m]	Sec_up [m]	Sec_low [m]	
HFM22	DZ1	110.00	129.00	112.88	126.33	
KFM08D	DZ1	184.00	210.00	187.99	206.38	
KFM23	DZ1	21.70	35.00	17.85	100.64	

Tunnels:	-	
Lineament and/or seismic indications:	MFM2120G.	3

MODELLING PROCEDURE

At the surface, corresponds to the low magnetic lineament MFM2120G. Modelled down to 250 m depth, using the dip estimated by connecting lineament MFM2120G with the borehole intersection 110-129 m in HFM22 (DZ1), 184-210 in KFM08D (DZ1). Deformation zone plane placed at fixed point 115 m in HFM22 and 197 m in KFM08D. Inferred to be a minor zone.

ENE	ZFMENE2120	Version number	5	Total object CL	21



OBJECT CONFIDENCE ESTIMATE

Category	Object CL	Comment
INTERPRETATION		
Data source	2	MFM2120G, HFM22, KFM08D, KFM23
Results of interpretation	2	Medium confidence observations in KFM08D.
INFORMATION DENSITY		
Number of observation points	3	4
Distribution of observation points	3	Even distribution of obs. points.
INTERPOLATION		
Geometry	3	Lineament combined with borehole obs. points suggest one strong alternative.
Geological indicators	3	Interpolation supported by key geological parameters, foremost fracture orientation pattern.
EXTRAPOLATION		
Dip direction	2	Extrapolation in dip direction supported by subsurface obs. point. Strike length of the modelled zone < 2000 m.
Strike direction	3	Conceptual understanding of the site and that the entire modelled zone is supported by the lineament.

FRACTURE CHARACTER

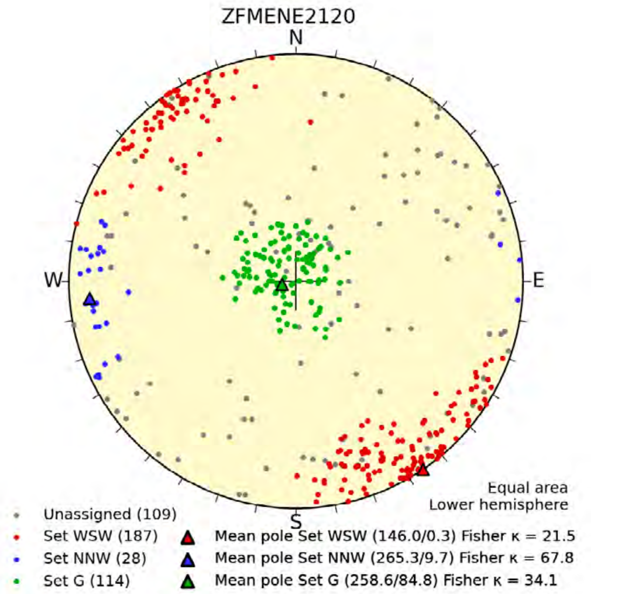
Orientation: (strike/dip right-hand-rule)

Set WSW: 236.0°/89.7°
Set NNW: 355.3°/80.3°
Set G: 348.6°/5.2°

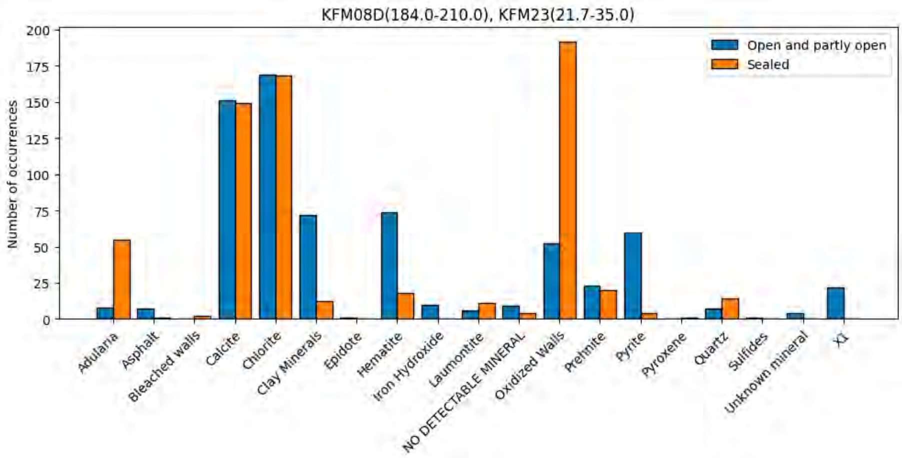
Frequency:

Boreholes: KFM23, KFM08D

FRACTURE TYPE	TERZAGHI-WEIGHED P10
Open and partly open	11.1 m-1
Sealed	15.9 m-1
Sealed network	2.0 % of DZ intercept
Crush	1.6 % of DZ intercept



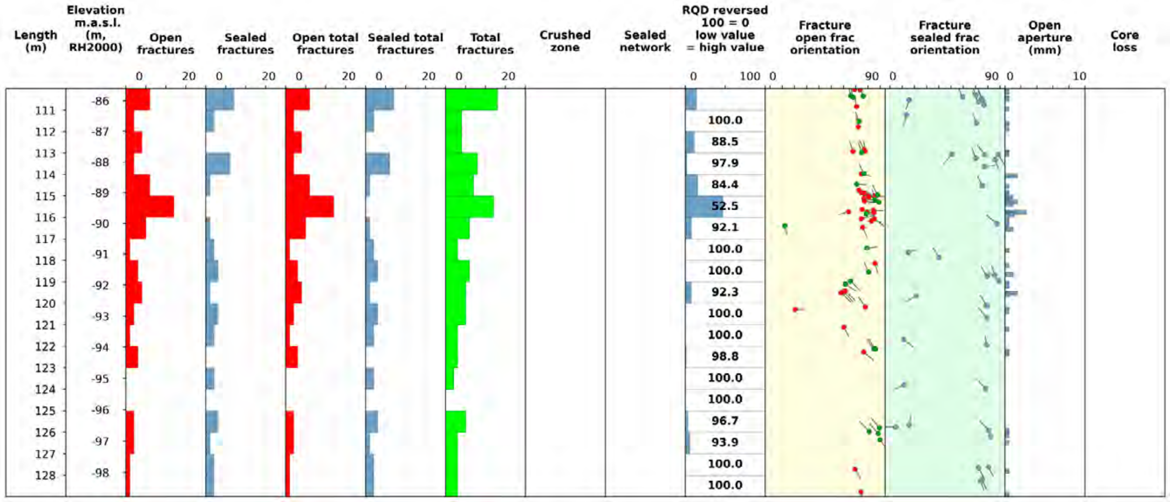
RQD: min:7, max:100, mean:84

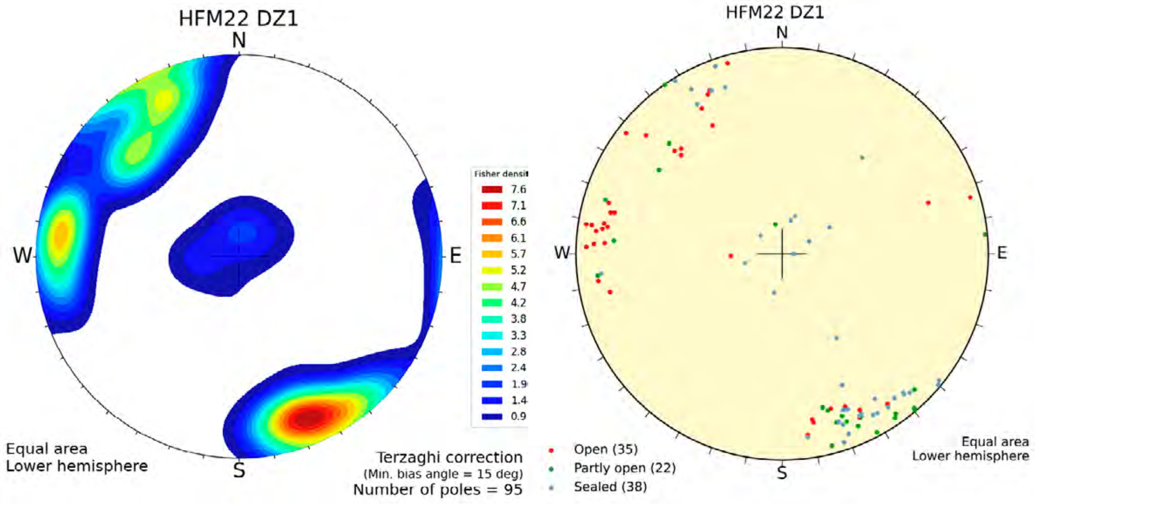
ENE	ZFMENE2120	Version number	5	Total object CL	21
Fracture fill mineralogy:					

ENE	ZFMENE2120	Version number	5	Total object CL	21

INDIVIDUAL INTERCEPTS

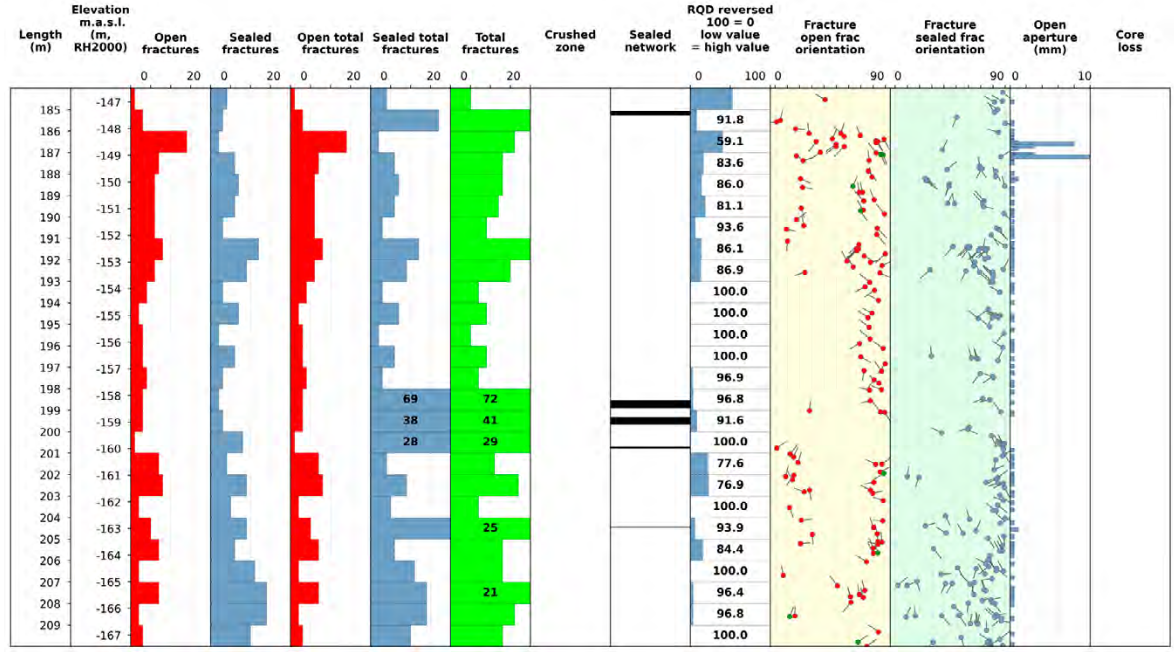
HFM22 DZ1 (110.0-129.0 m)

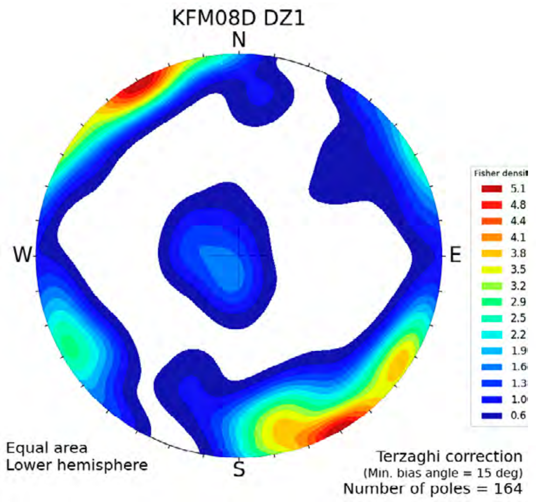


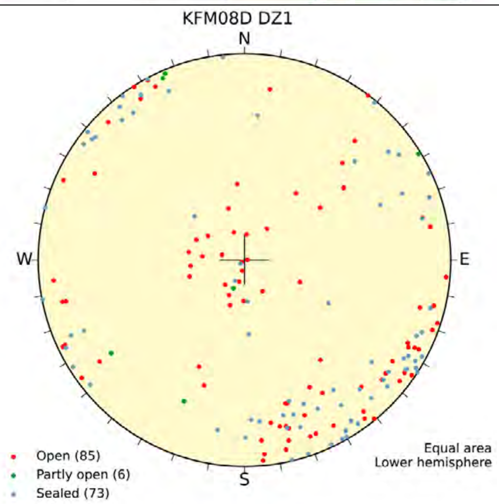


ENE	ZFMENE2120	Version number	5	Total object CL	21

KFM08D DZ1 (184.0-210.0 m)

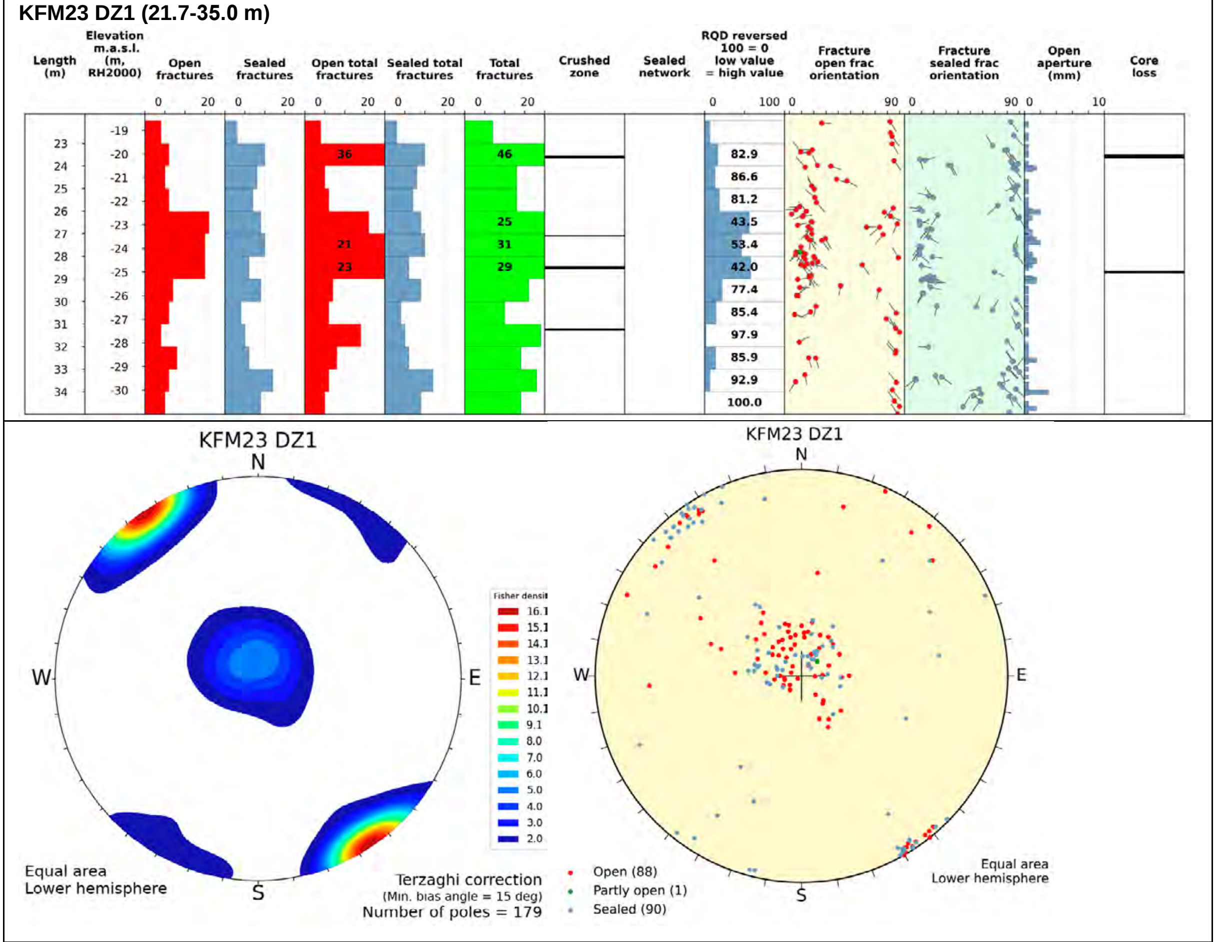






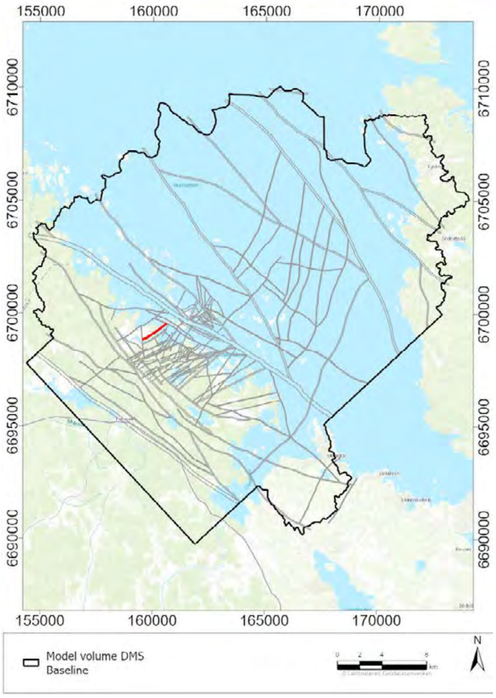
ENE	ZFMENE2120	Version number	5	Total object CL	21

KFM23 DZ1 (21.7-35.0 m)



ENE	ZFMENE2248	Version number	6	Total object CL	17

GEOLOGICAL CHARACTER		Property CL
Deformation style:	Brittle	3
Deformation description:	No data available.	
Alteration:		3
- First order:	Oxidation	
- Second order:	Not observed	
- Third order:	Not observed	
Fracture orientation and type:	Three sets of steeply dipping fractures. Dominated by sealed fractures followed by open and partly open fractures. Quantitative estimate and span include sealed fracture networks fractures as well as gently dipping fractures are present. Steeply dipping fractures strike NE, NNW and NW.	2
Fracture comment:	No data available.	
Fracture fill mineralogy:	Chlorite, calcite, hematite/adularia, laumontite, quartz. Epidote along fractures with gentle to moderate dips to the SE and steep dips with NW strike.	



OBJECT GEOMETRY	
Strike/dip:	236°/80°
Length:	1314 m
Mean thickness:	36 m (3 - 50 m)
Max depth:	-1300 m
Geometrical constraints:	ZFMNNW0100, ZFMWNW0809A, Topo 40m grid Max error 20m, 1 Surface Planar Cut(s).

BASIS FOR MODELLING

Zone based on surface lineaments and borehole observations.

Outcrops: -

Boreholes:

Borehole	PDZ	Target intercept		Geometric intercept		Comment
		Sec_up [m]	Sec_low [m]	Sec_up [m]	Sec_low [m]	
KFM08A	DZ5	775.00	843.00	774.94	837.14	840-843 m added (cf. Table 3-2 in Stephens et al. 2007).
KFM27	DZ1	30.00	92.00	5.89	84.26	

Tunnels:	-	
Lineament and/or seismic indications:	MFM2248G.	2

MODELLING PROCEDURE

At the surface, corresponds to the low magnetic lineament MFM2248G and its inferred continuation to the south-west. Modelled down to 1300 m depth, using the dip estimated by connecting lineament MFM2248G with the borehole intersection 775-843 m in KFM08A (DZ5 and extension along borehole interval 840-843 m) and 30-92 m in KFM27 (DZ1). Deformation zone plane placed at fixed point 789 m in KFM08A.

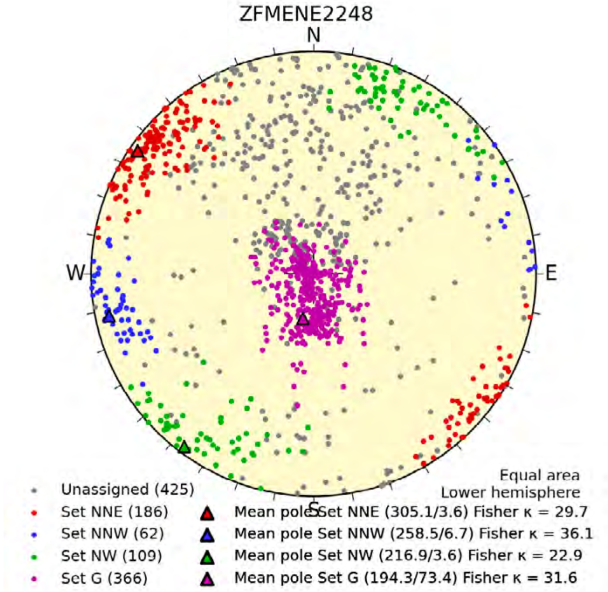
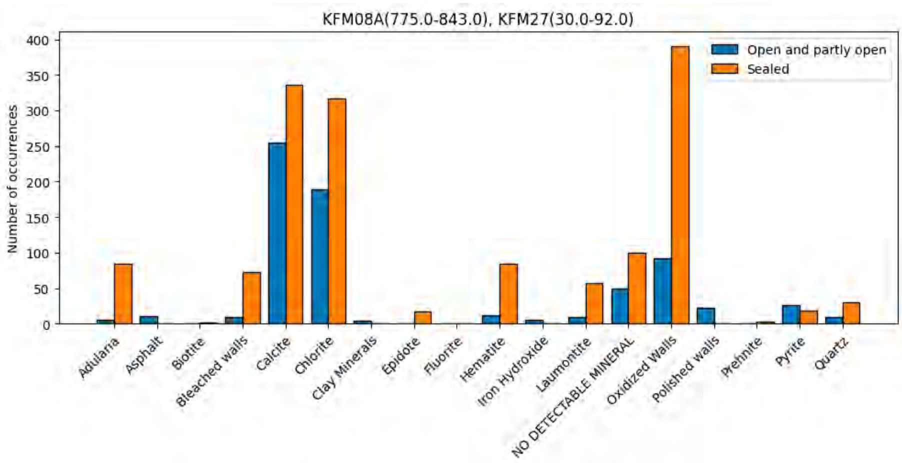
ENE	ZFMENE2248	Version number	6	Total object CL	17

OBJECT CONFIDENCE ESTIMATE

Category	Object CL	Comment
INTERPRETATION		
Data source	2	MFM2248G, KFM08A, KFM27
Results of interpretation	2	Medium confidence observations in KFM08A and KFM27.
INFORMATION DENSITY		
Number of observation points	2	3
Distribution of observation points	2	Two intercepts c. > 750m in between and the lineament considered as an outlier. Three scattered observation points.
INTERPOLATION		
Geometry	2	Due to lack of surface observations in the western part of the zone and subsurface information from eastern part , uncertainty arises regarding the zones current geometry along the strike and the dip. This lend support for more than one alternative interpolations.
Geological indicators	2	Single observation point at depth. Zone modelled mainly based on surface geophysical data.
EXTRAPOLATION		
Dip direction	2	Extrapolation in dip direction supported by subsurface obs. point. Strike length of the modelled zone < 2000 m.
Strike direction	3	Zone modelled length < 2000 m. Intersected in multiple boreholes. High confidence in this category based on conceptual understanding of the site.

ENE	ZFMENE2248	Version number	6	Total object CL	17

FRACTURE CHARACTER

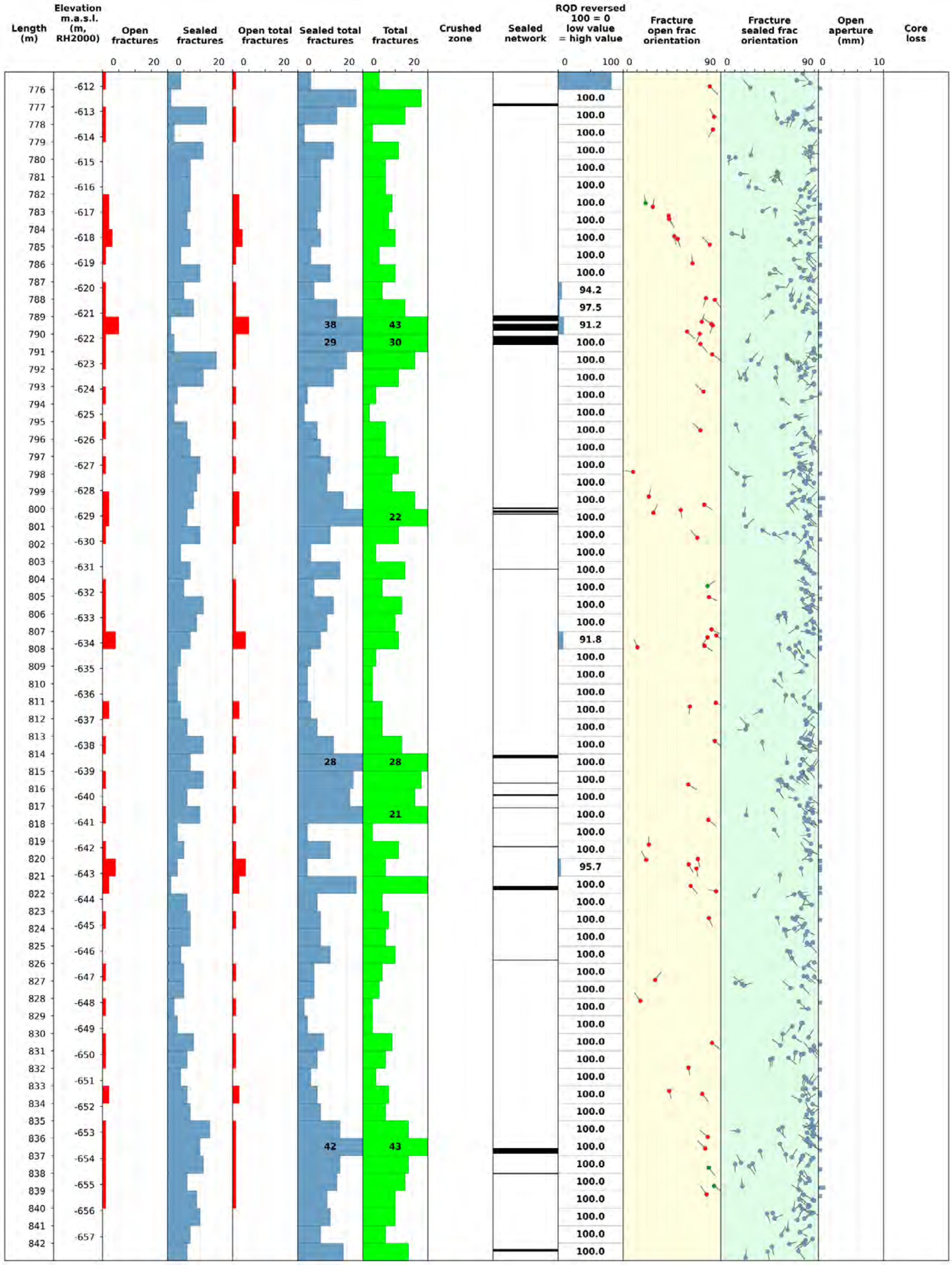
Orientation: (strike/dip right-hand-rule)	Set NNE: 35.1°/86.4° Set NNW: 348.5°/83.3° Set NW: 306.9°/86.4° Set G: 284.3°/16.6°	
Frequency:	Boreholes: KFM27, KFM08A	
RQD:	min:17, max:100, mean:95	
Fracture fill mineralogy:		

FRACTURE TYPE	TERZAGHI-WEIGHED P10
Open and partly open	4.0 m-1
Sealed	13.8 m-1
Sealed network	5.2 % of DZ intercept
Crush	0.6 % of DZ intercept

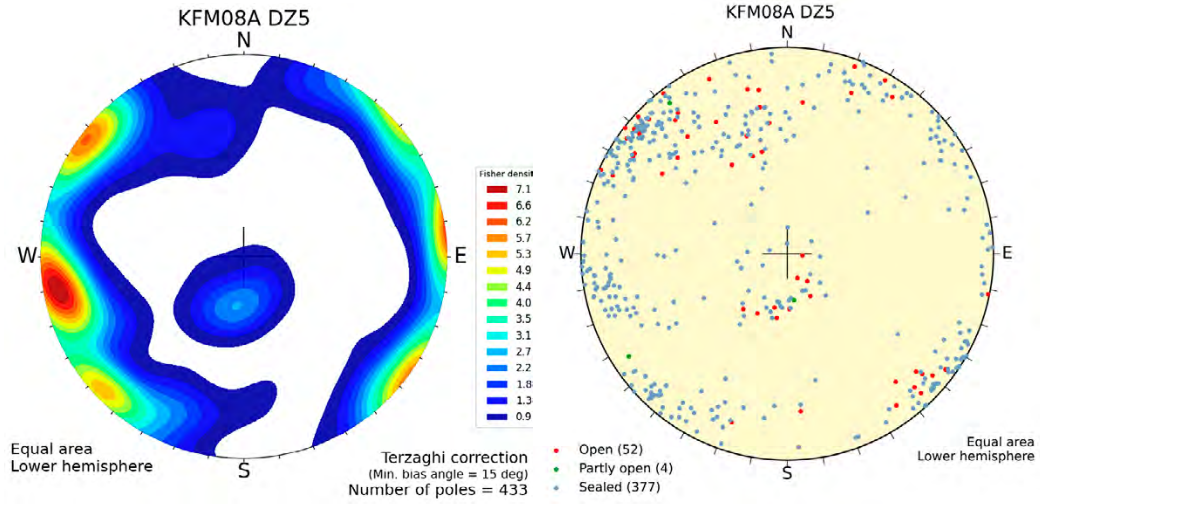
ENE	ZFMENE2248	Version number	6	Total object CL	17

INDIVIDUAL INTERCEPTS

KFM08A DZ5 (775.0-843.0 m)

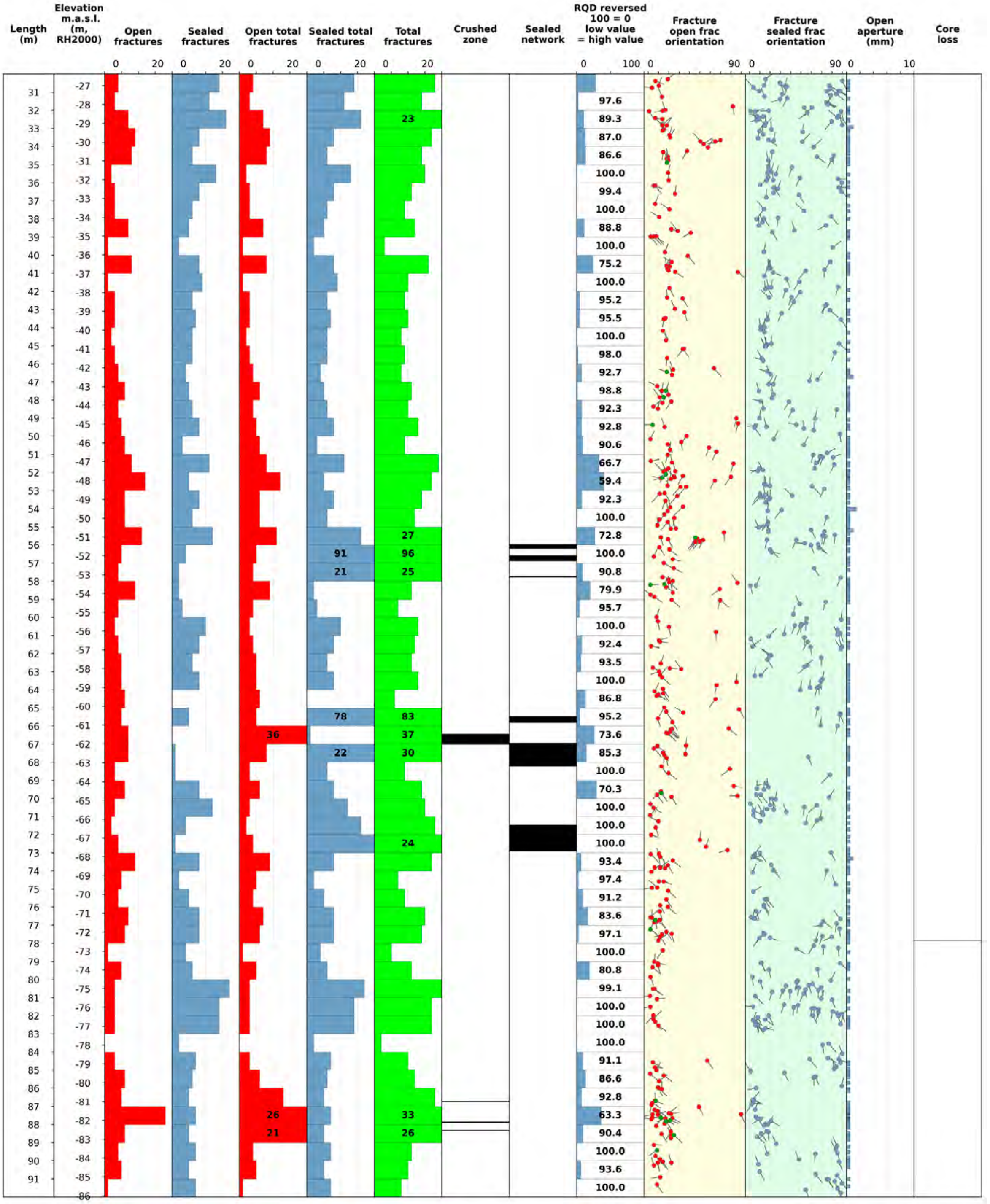


ENE	ZFMENE2248	Version number	6	Total object CL	17

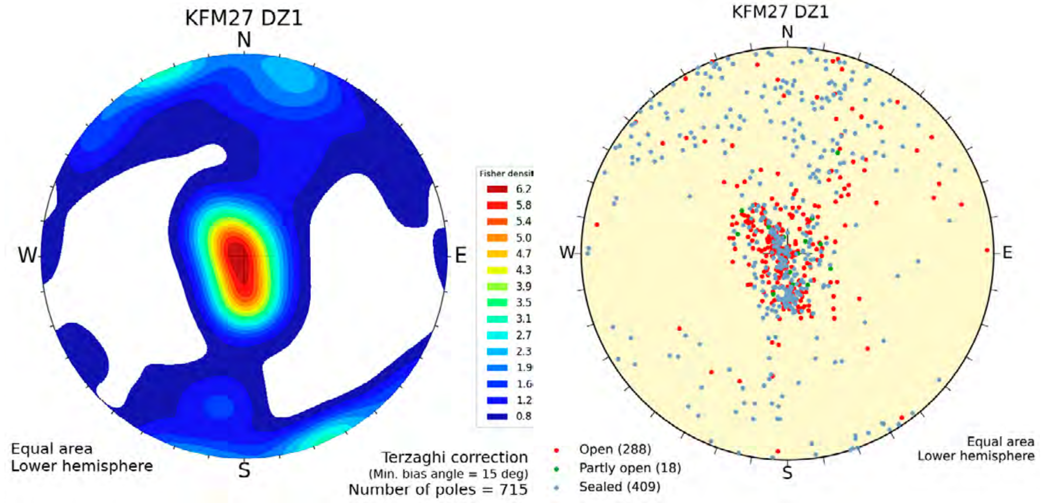


ENE	ZFMENE2248	Version number	6	Total object CL	17

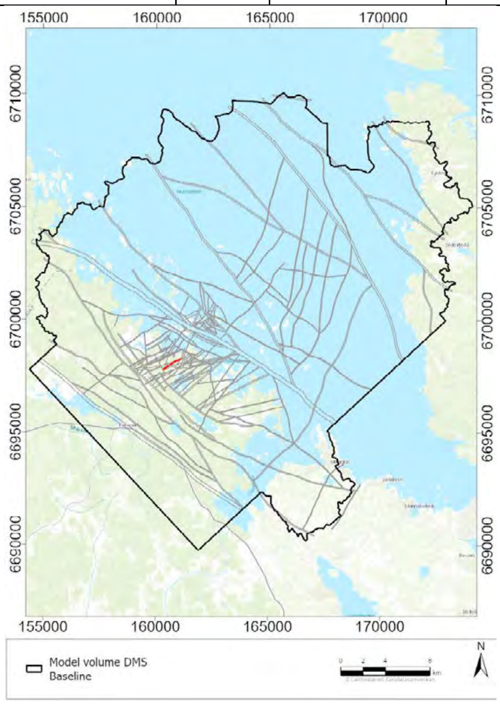
KFM27 DZ1 (30.0-92.0 m)



ENE	ZFMENE2248	Version number	6	Total object CL	17



ENE	ZFMENE2254	Version number	4	Total object CL	14



GEOLOGICAL CHARACTER		Property CL
Deformation style:	Brittle	3
Deformation description:	Steeply dipping faults with NE strike show oblique-slip displacement. One fault shows both normal and dextral strike-slip components of movement.	
Alteration:		3
- First order:	Oxidation	
- Second order:	Not observed	
- Third order:	Not observed	
Fracture orientation and type:	Fractures with steep dip to the ESE dominates. Dominated by sealed followed by open and partly open fractures.	2
Fracture comment:	No data available.	
Fracture fill mineralogy:	Laumontite, chlorite, hematite/adularia, calcite.	

OBJECT GEOMETRY	
Strike/dip:	240°/83°
Length:	971 m
Mean thickness:	3 m (2 - 36 m)
Max depth:	-970 m
Geometrical constraints:	ZFMENE0061, ZFMNNW0404, Topo 40m grid Max error 20m, 1 Surface Planar Cut(s).

BASIS FOR MODELLING

Zone based on surface lineaments and borehole observations.

Outcrops:	-

Boreholes:

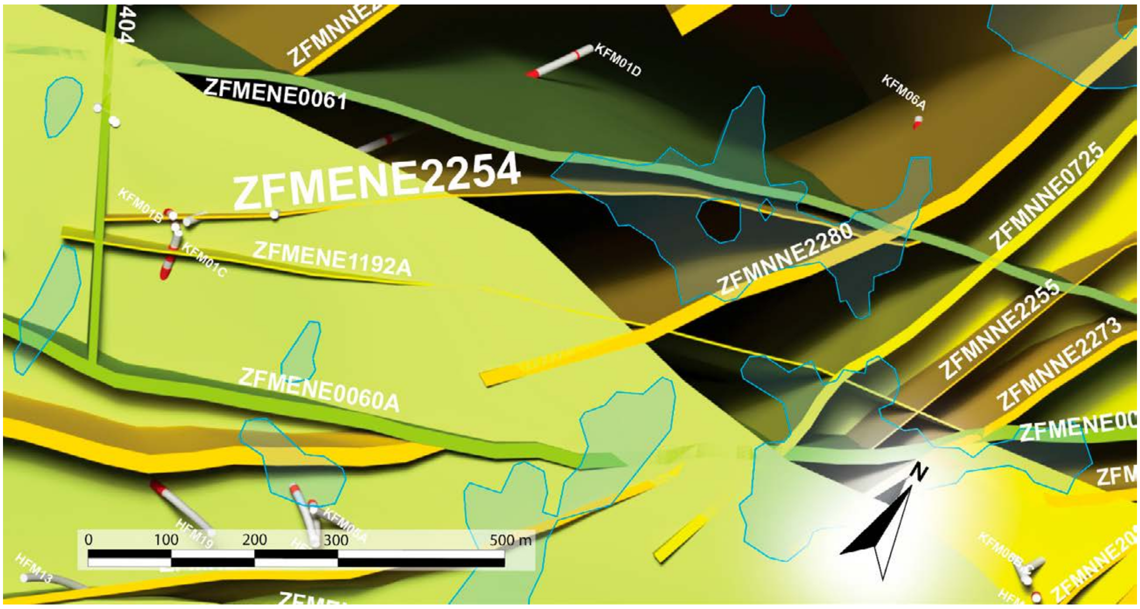
Borehole	PDZ	Target intercept		Geometric intercept		Comment
		Sec_up [m]	Sec_low [m]	Sec_up [m]	Sec_low [m]	
HFM01	DZ1	-	-	3.95	37.50	HFM01 DZ1 is inferred to be a manifestation of ZFMA2.
KFM01A	DZ3	639.00	684.00	641.59	691.21	
KFM01D		-	-	26.06	55.06	

Tunnels:	-	
Lineament and/or seismic indications:	MFM2254G.	2

MODELLING PROCEDURE

At the surface, corresponds to the low magnetic lineament MFM2254G. Modelled down to 1000 m depth, using the dip estimated by connecting lineament MFM2254G with the borehole intersection 639-684 m in KFM01A (DZ3). Deformation zone plane placed at fixed point 662 m in KFM01A. The zone is also intersected by HFM01 DZ1 but inferred to be a manifestation of ZFMA2.

ENE	ZFMENE2254	Version number	4	Total object CL	14



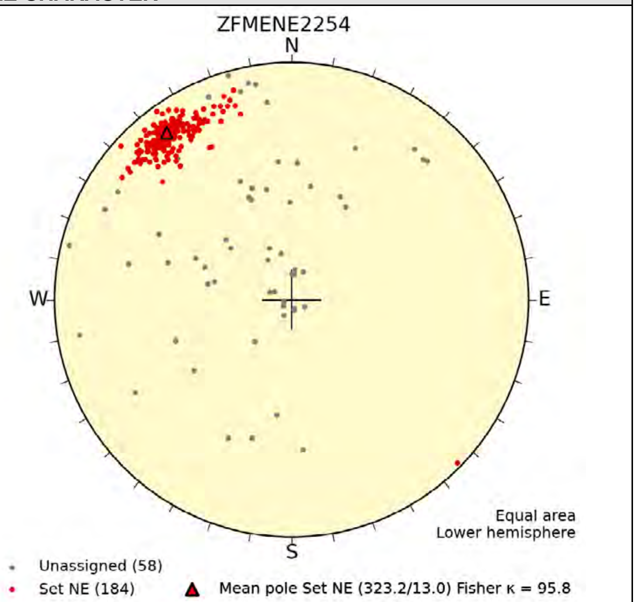
OBJECT CONFIDENCE ESTIMATE

Category	Object CL	Comment
INTERPRETATION		
Data source	2	MFM2254G, HFM01, KFM01A, KFM01D (No SHI interpreted)
Results of interpretation	3	High confidence observations in KFM01A.
INFORMATION DENSITY		
Number of observation points	2	3
Distribution of observation points	1	More than 600 m between the subsurface observation points.
INTERPOLATION		
Geometry	1	Geometry supported by a lineament and a single intercept.
Geological indicators	1	Indirect support by geophysical data.
EXTRAPOLATION		
Dip direction	2	Extrapolation in dip direction supported by subsurface obs. point. Strike length of the modelled zone < 2000 m.
Strike direction	2	Partly or no support by surface lineament. Supported by geological concept and subsurface observation points.

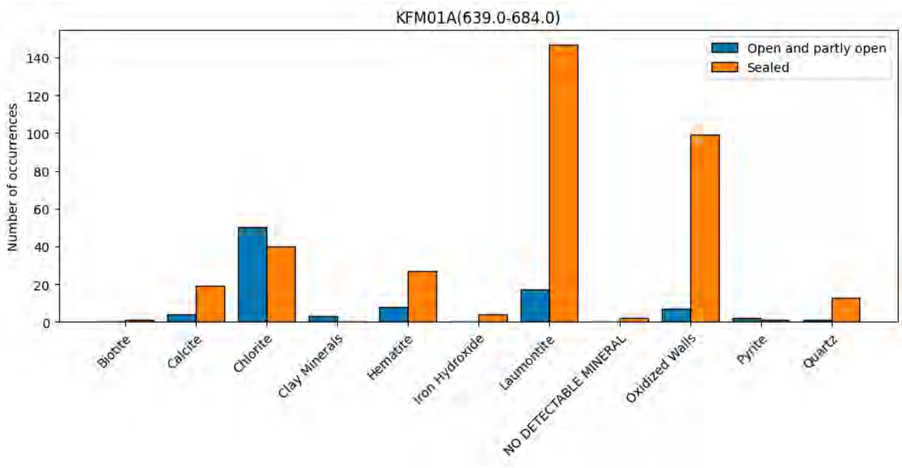
FRACTURE CHARACTER

Orientation: (strike/dip right-hand-rule)	Set NE: 53.2°/77.0°
Frequency:	Boreholes: KFM01A, KFM01D

FRACTURE TYPE	TERZAGHI-WEIGHED P10
Open and partly open	1.1 m-1
Sealed	5.0 m-1
Sealed network	0.0 % of DZ intercept
Crush	0.0 % of DZ intercept

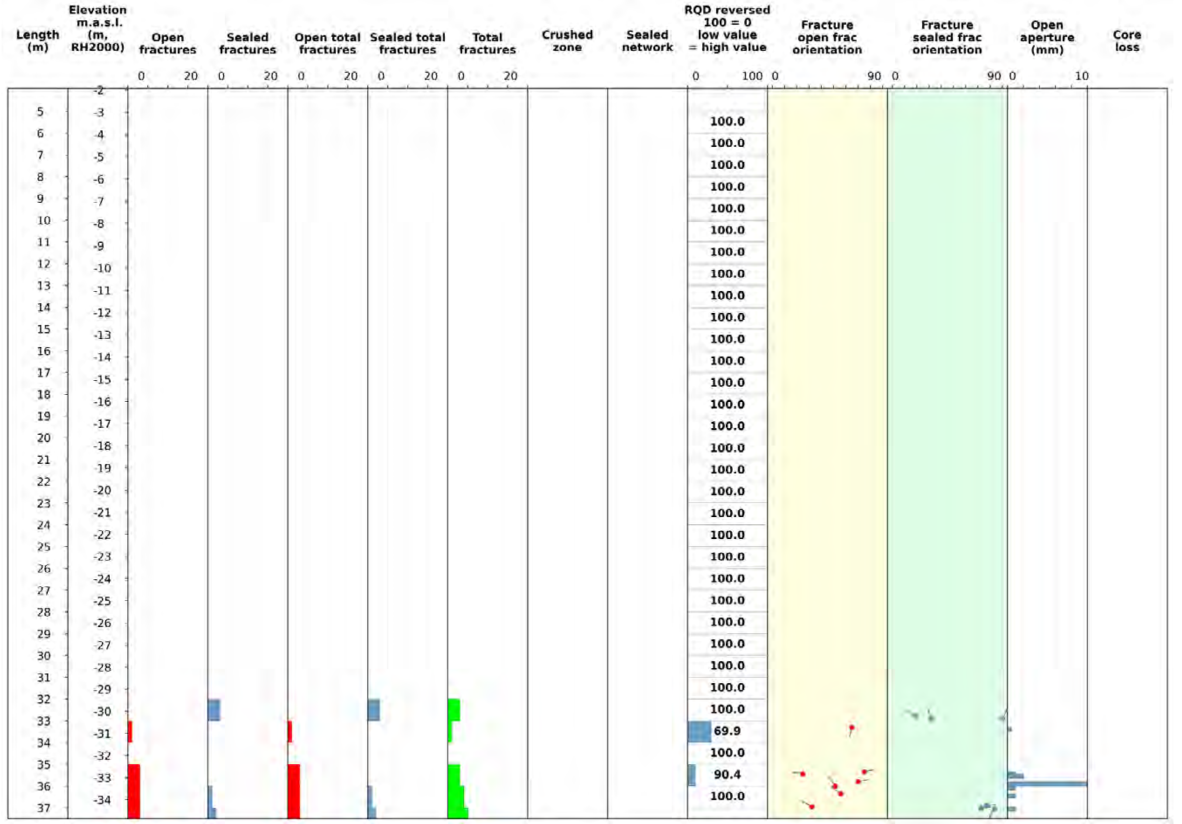


RQD:	min:16, max:100, mean:97

ENE	ZFMENE2254	Version number	4	Total object CL	14
Fracture fill mineralogy:					

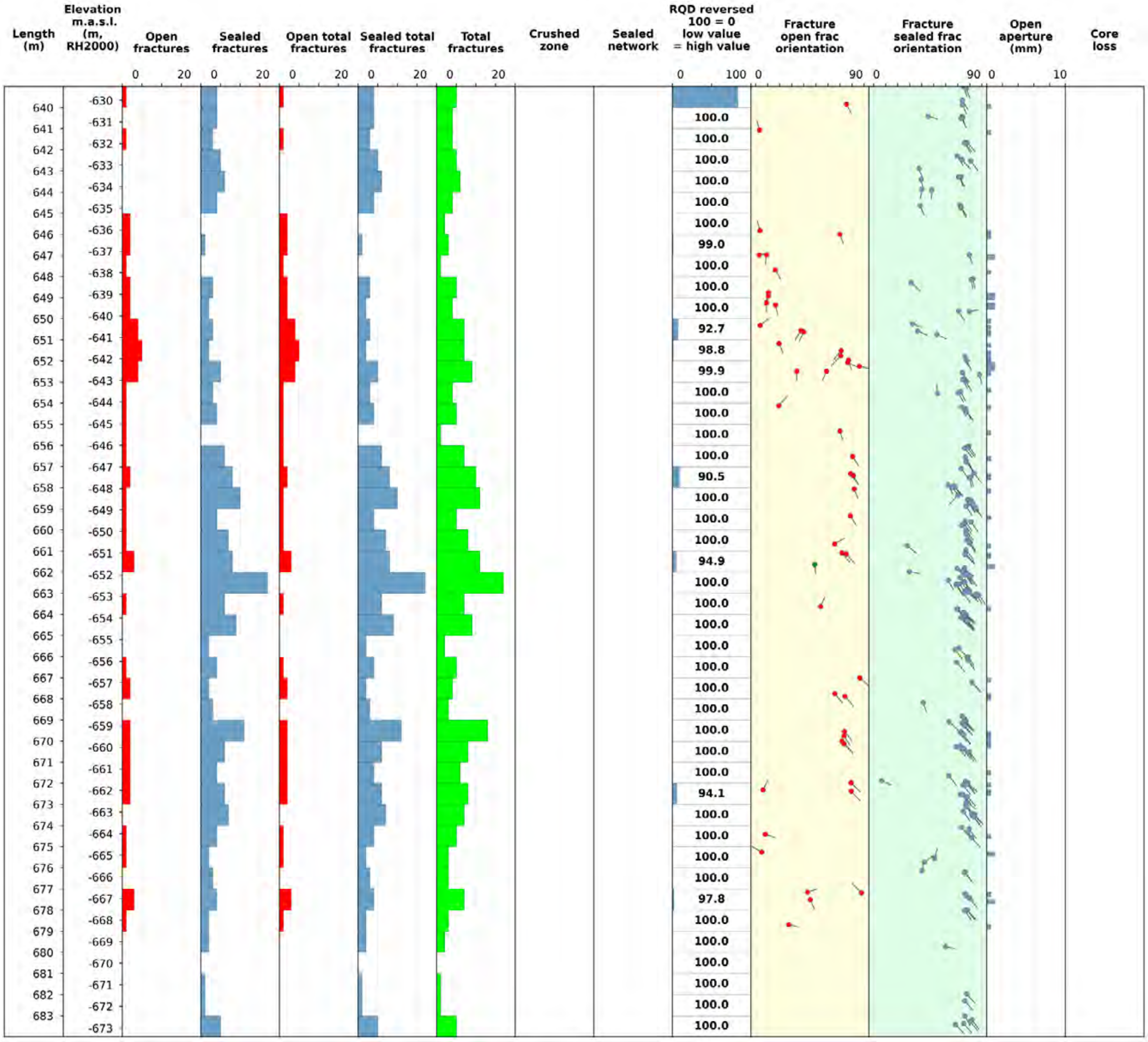
ENE	ZFMENE2254	Version number	4	Total object CL	14
INDIVIDUAL INTERCEPTS					

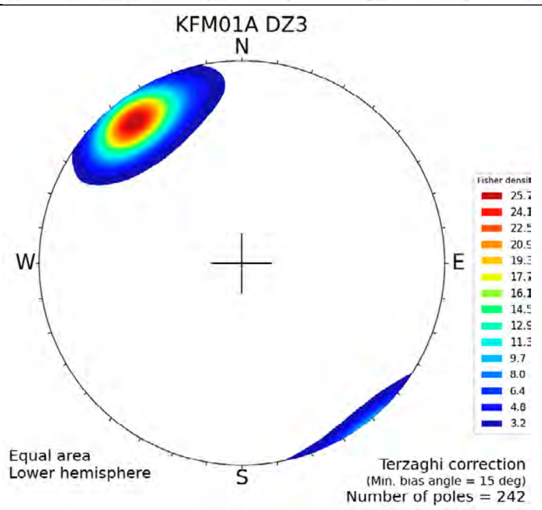
HFM01 DZ1 (3.95-37.5 m)

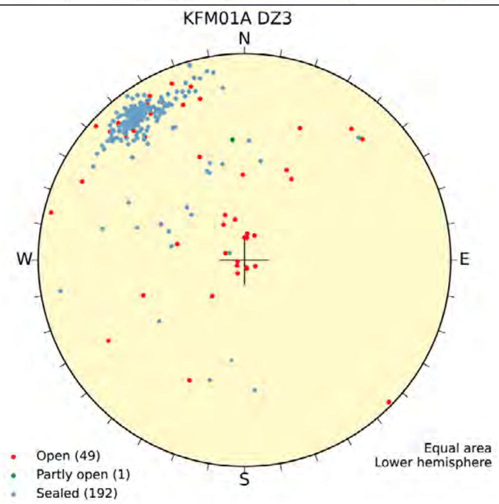


ENE	ZFMENE2254	Version number	4	Total object CL	14

KFM01A DZ3 (639.0-684.0 m)





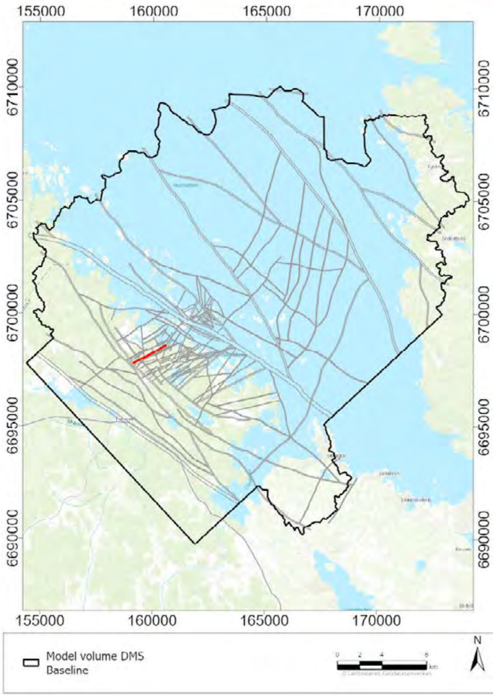


KFM01D (26.06-55.06 m)

No data available

ENE	ZFMENE2320		Version number	5	Total object CL	22

GEOLOGICAL CHARACTER		Property CL
Deformation style:	Brittle	3
Deformation description:	Steep faults with ENE-WSW strike show strike-slip displacement, one of which have dextral strike-slip. Steep NNW-SSE faults show strike slip displacement, four of which have sinistral strike-slip. A steep fault with SE strike shows dextral strike-slip displacement. Gently dipping faults show dip-slip or oblique-slip movement, the latter with a dominant strike-slip component.	
Alteration:		3
- First order:	Oxidation	
- Second order:	Chloritization	
- Third order:	Quartz dissolution	
Fracture orientation and type:	Steeply dipping fractures with WSW, NNW-SSE, ENE-WSE, NNE, and SE strike are conspicuous in boreholes. Dominated by sealed followed by open and partly open fractures.	2
Fracture comment:	No data available.	
Fracture fill mineralogy:	Calcite, chlorite, laumontite, hematite/adularia, prehnite, pyrite, quartz, clay minerals.	



OBJECT GEOMETRY	
Strike/dip:	242°/81°
Length:	1715 m
Mean thickness:	25 m (16 - 51 m)
Max depth:	-1700 m
Geometrical constraints:	ZFMNW0017, ZFMNE2308, Topo 40m grid Max error 20m, 1 Surface Planar Cut(s).

BASIS FOR MODELLING

Zone based on surface lineaments and borehole observations.

Outcrops: -

Boreholes:

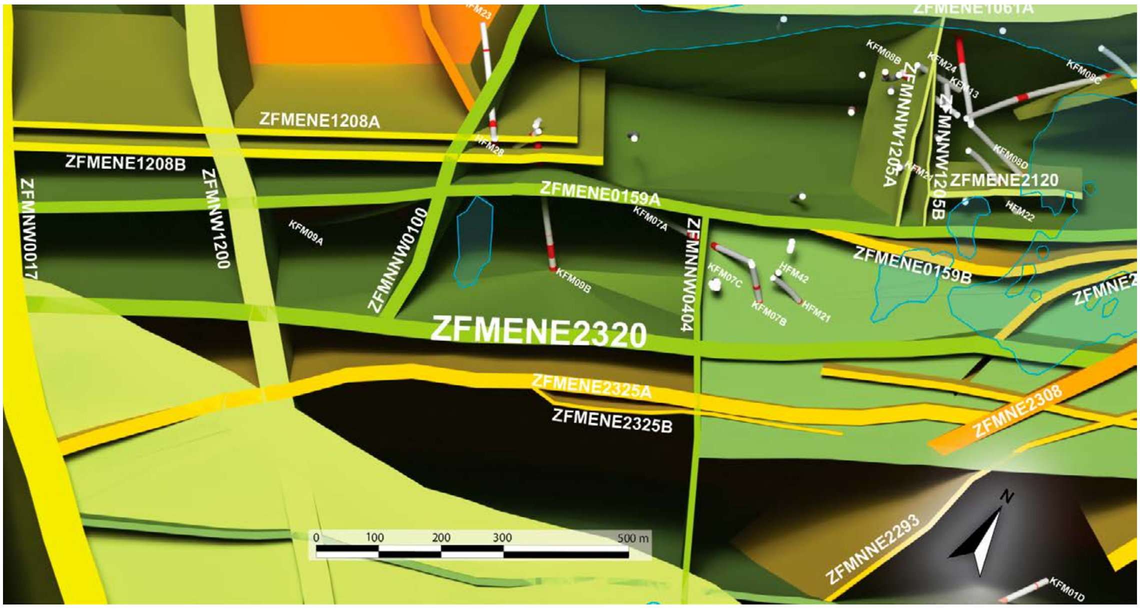
Borehole	PDZ	Target intercept		Geometric intercept		Comment
		Sec_up [m]	Sec_low [m]	Sec_up [m]	Sec_low [m]	
KFM07B	DZ4	225.00	245.00	219.49	252.27	
KFM07C	DZ2	308.00	388.00	338.34	417.50	
KFM07C	DZ3	429.00	439.00	338.34	417.50	
KFM08D	DZ6	582.00	634.00	582.13	635.50	
KFM08D	DZ7	582.00	634.00	582.13	635.50	
KFM09B	DZ3	363.00	413.00	376.25	409.15	

Tunnels:	-	
Lineament and/or seismic indications:	MFM2320G.	2

MODELLING PROCEDURE

At the surface, corresponds to the low magnetic lineament MFM2320G and its inferred continuation to the south-west. Modelled down to 1700 m depth, using the dip estimated by connecting lineament MFM2320G and its inferred continuation to the south-west with the borehole intersections 225-245 m in KFM07B (DZ4), 308-388 m and 429-439 m in KFM07C (DZ2 and DZ3, respectively), 582-634 m in KFM08D (DZ6, DZ7 and intermediate borehole interval) and 363-413 m in KFM09B (DZ3). Deformation zone plane placed at fixed points 236 m in KFM07B, 352 m in KFM07C, 598 m in KFM08D and 387 m in KFM09B. Decreased radar penetration also along the borehole interval 232-240 m in KFM07B.

ENE	ZFMENE2320	Version number	5	Total object CL	22



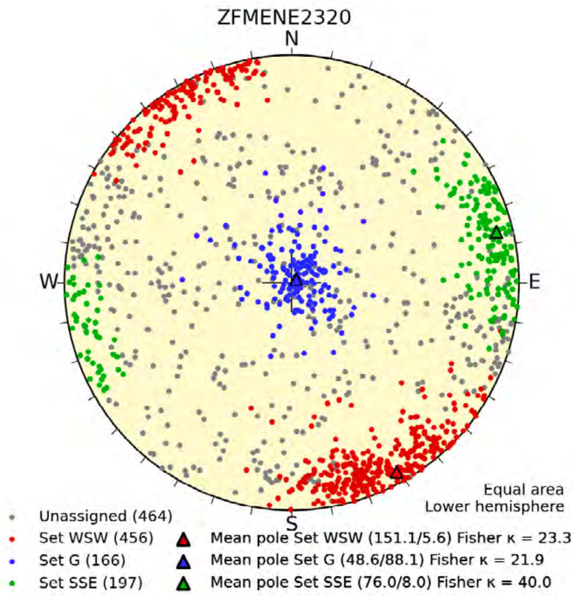
OBJECT CONFIDENCE ESTIMATE

Category	Object CL	Comment
INTERPRETATION		
Data source	2	MFM2320G, KFM07B, KFM07C, KFM08D, KFM09B
Results of interpretation	3	High confidence observations in multiple boreholes.
INFORMATION DENSITY		
Number of observation points	3	>4
Distribution of observation points	3	Even distribution of obs. points.
INTERPOLATION		
Geometry	3	Several obs. points from depth where fracture filled minerals supporting interpolation in horizontal direction for the entire zone.
Geological indicators	3	Interpolation supported by key geological parameters, foremost fracture orientation pattern.
EXTRAPOLATION		
Dip direction	2	Extrapolation in dip direction supported by subsurface obs. point. Strike length of the modelled zone < 2000 m.
Strike direction	3	Conceptual understanding of the site and that the entire modelled zone is supported by the lineament.

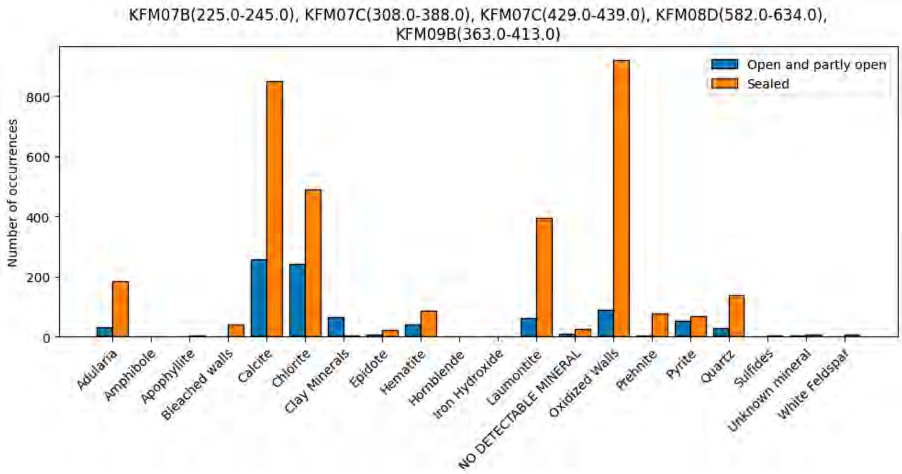
FRACTURE CHARACTER

Orientation: (strike/dip right-hand-rule)	Set WSW: 241.1°/84.4° Set G: 138.6°/1.9° Set SSE: 166.0°/82.0°
Frequency:	Boreholes: KFM09B, KFM07C, KFM07B, KFM08D

FRACTURE TYPE	TERZAGHI-WEIGHED P10
Open and partly open	3.7 m-1
Sealed	16.5 m-1
Sealed network	6.5 % of DZ intercept
Crush	0.7 % of DZ intercept



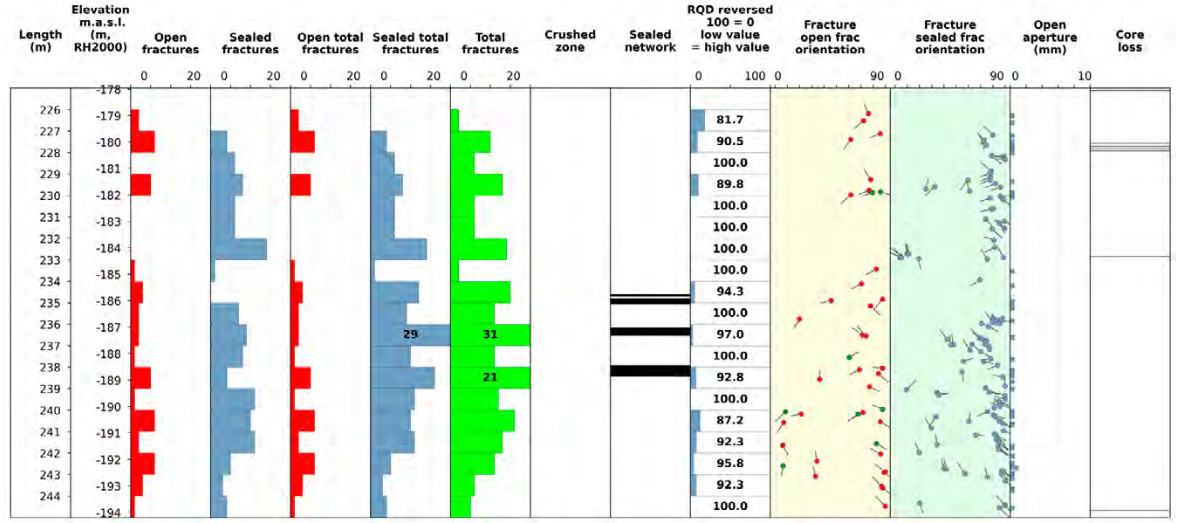
RQD:	min:68, max:100, mean:98

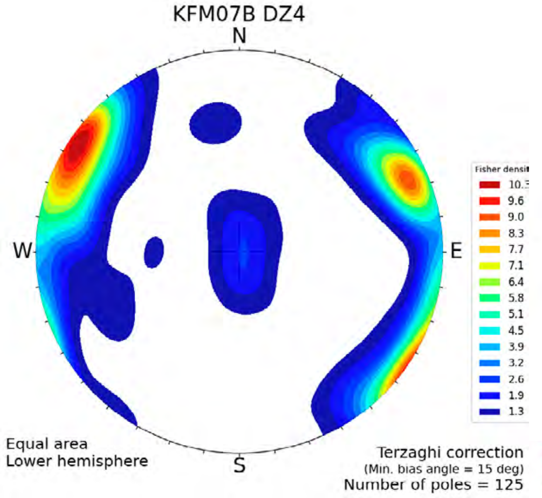
ENE	ZFMENE2320	Version number	5	Total object CL	22
Fracture fill mineralogy:					

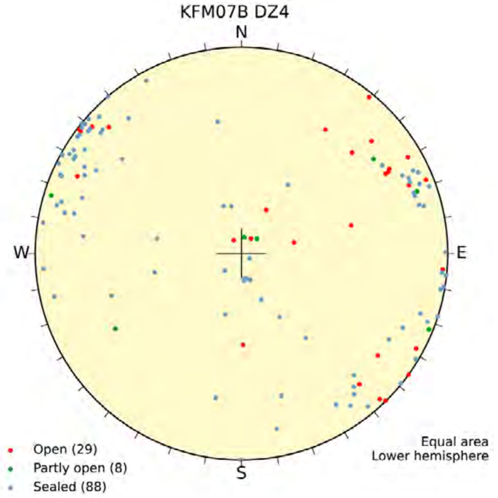
ENE	ZFMENE2320	Version number	5	Total object CL	22

INDIVIDUAL INTERCEPTS

KFM07B DZ4 (225.0-245.0 m)

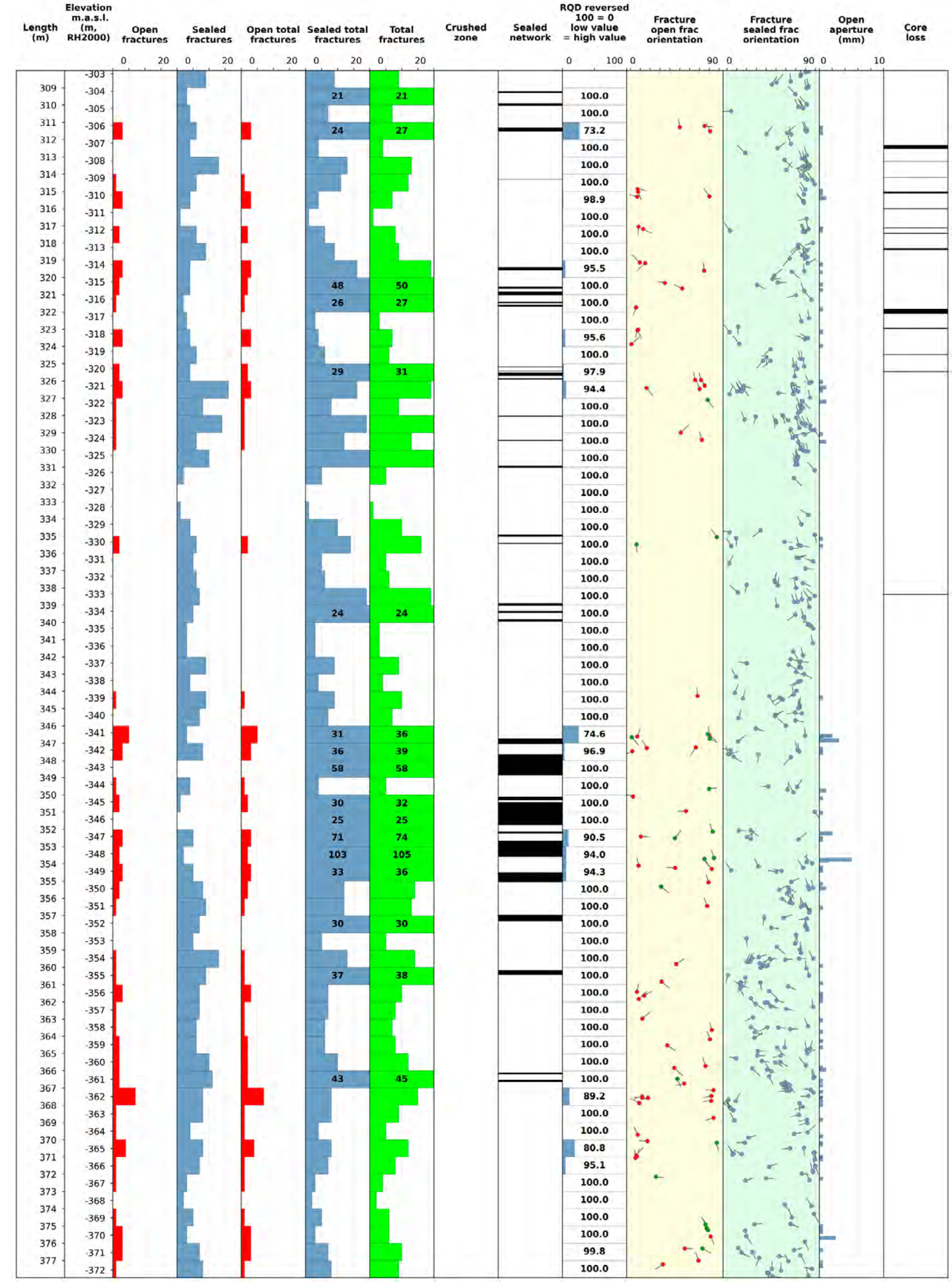




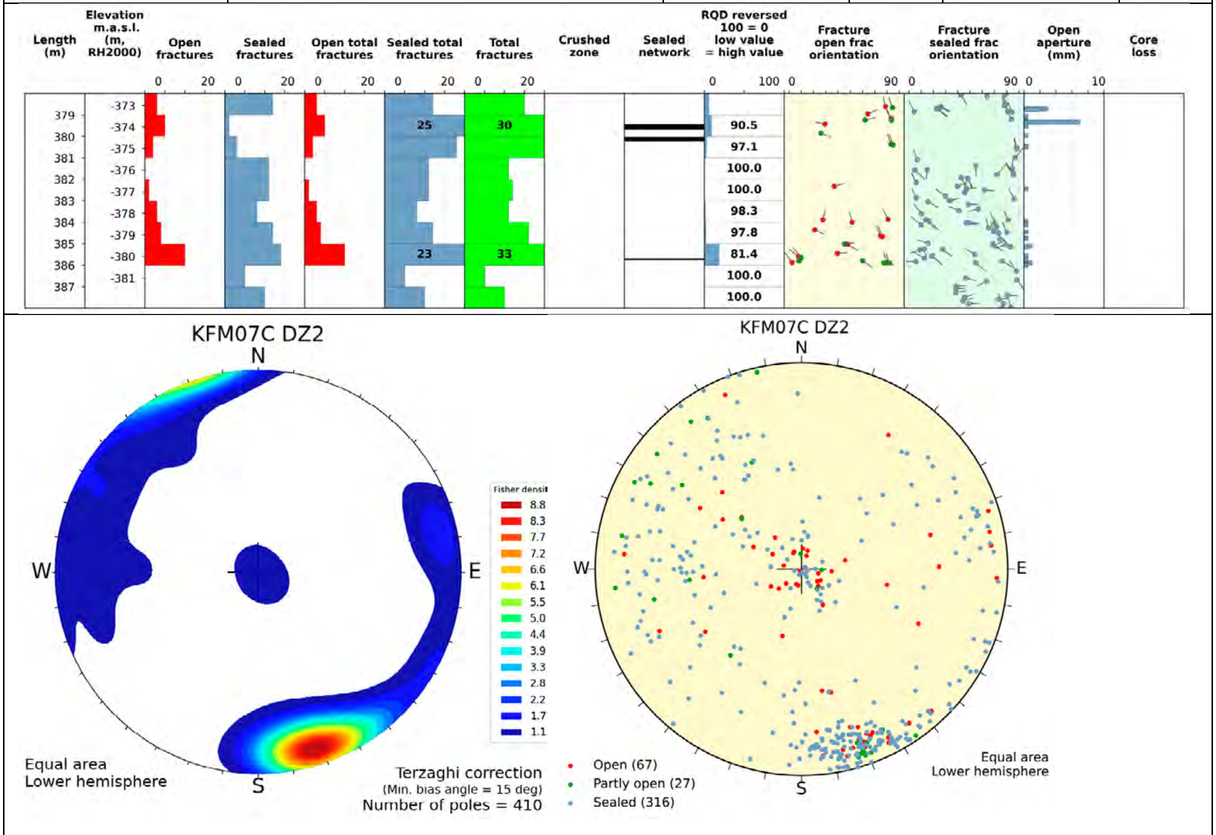


ENE	ZFMENE2320	Version number	5	Total object CL	22

KFM07C DZ2 (308.0-388.0 m)

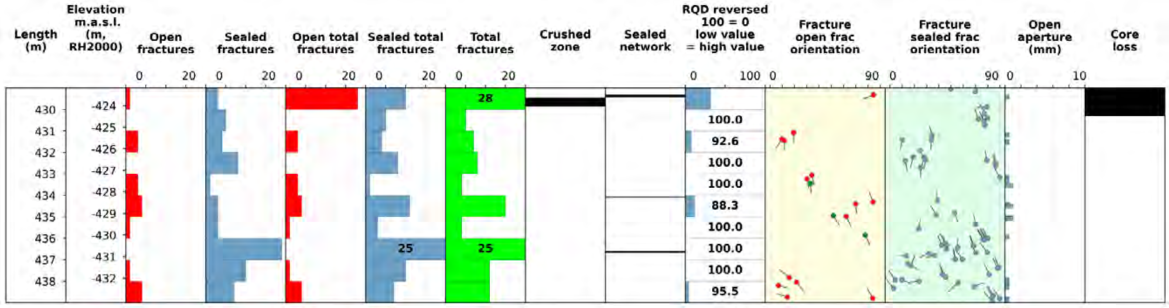


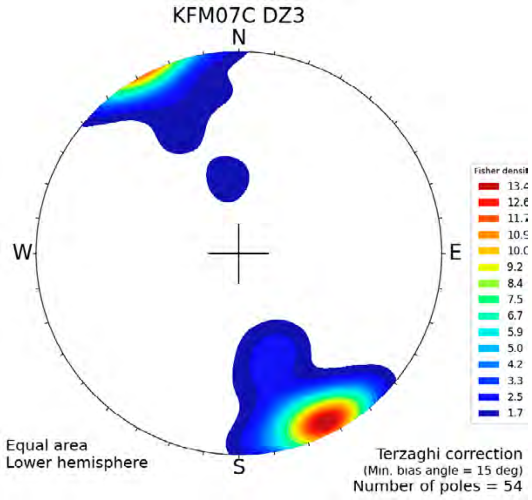
ENE	ZFMENE2320	Version number	5	Total object CL	22

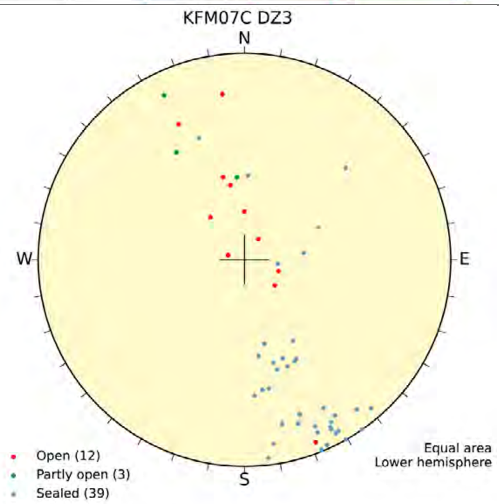


ENE	ZFMENE2320	Version number	5	Total object CL	22

KFM07C DZ3 (429.0-439.0 m)

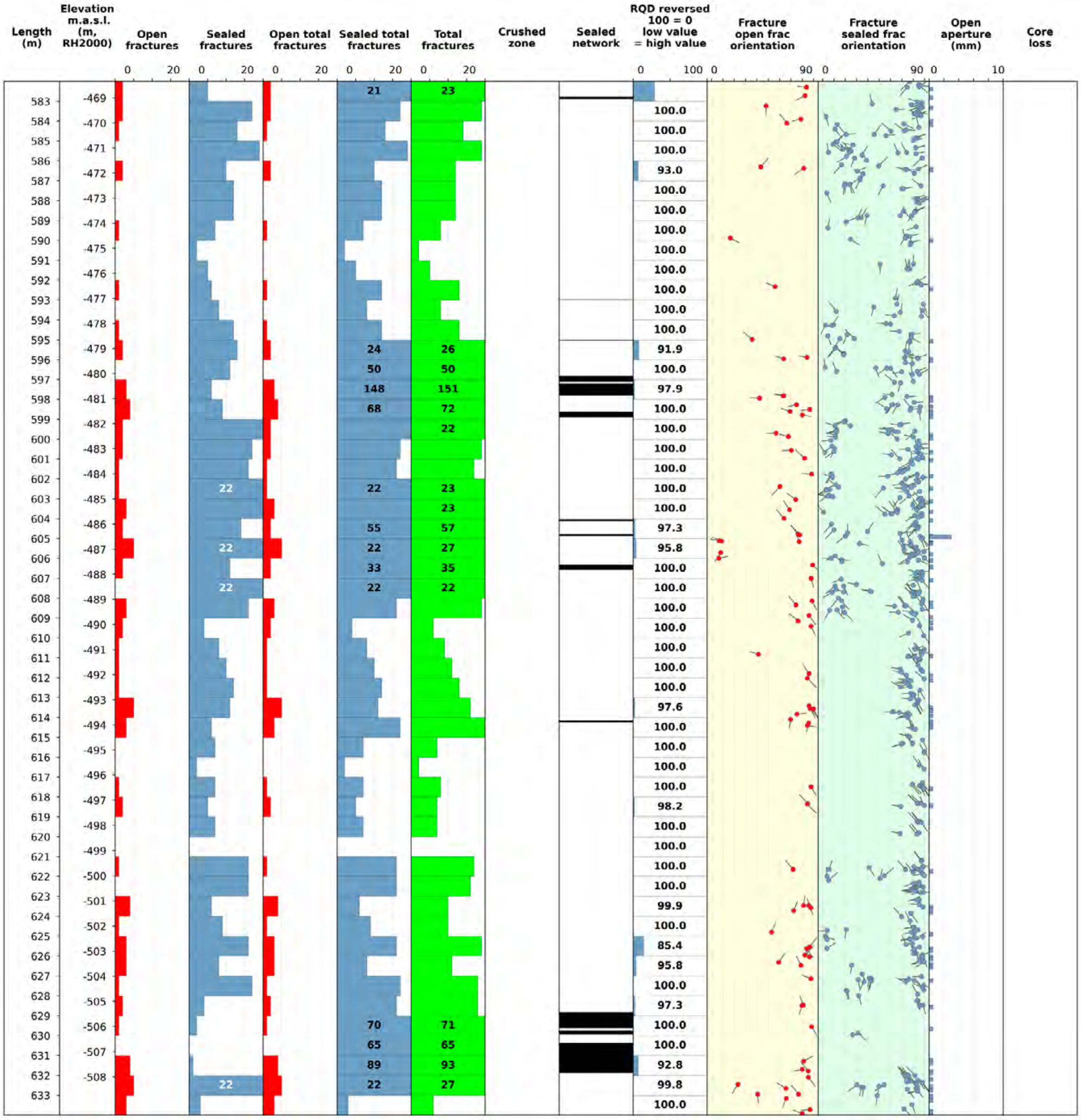


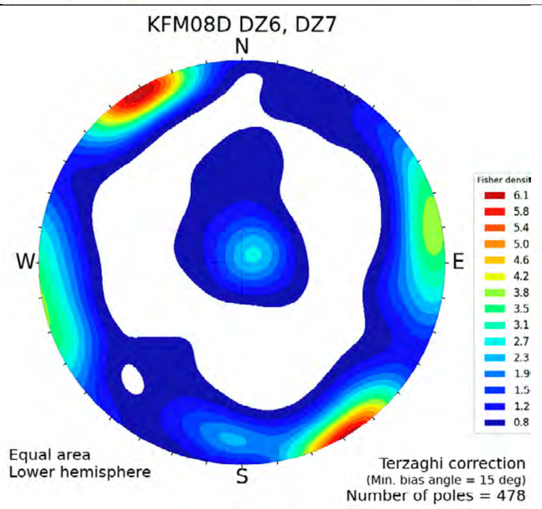


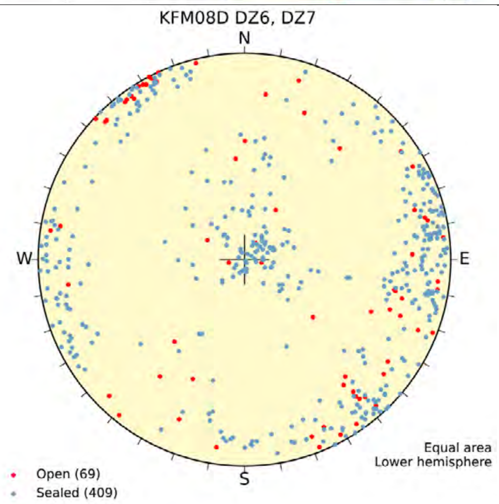


ENE	ZFMENE2320	Version number	5	Total object CL	22

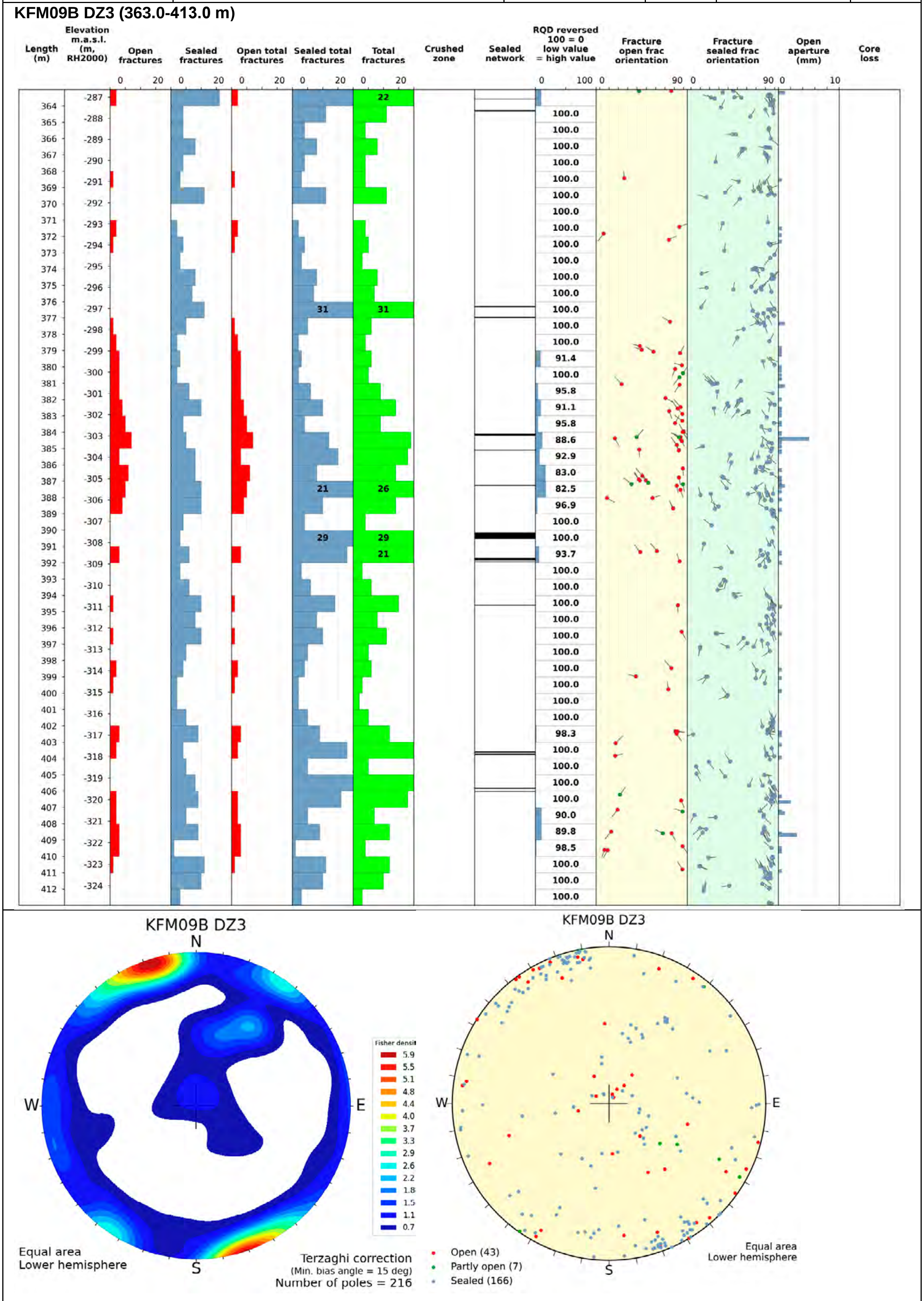
KFM08D DZ6, DZ7 (582.0-634.0 m)





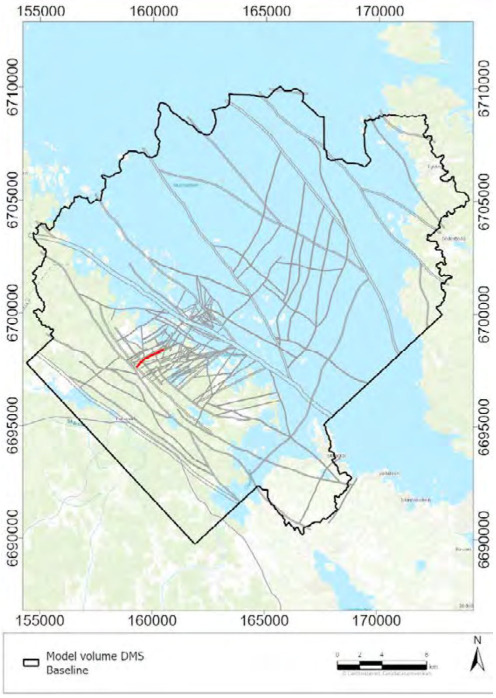


ENE	ZFMENE2320	Version number	5	Total object CL	22



ENE	ZFMENE2325A	Version number	4	Total object CL	15

GEOLOGICAL CHARACTER		Property CL
Deformation style:	Brittle	3
Deformation description:	Steeply dipping faults with SSE strike show sinistral strike-slip, oblique-slip with both normal-dextral and reverse-sinistral displacements, and dip-slip displacement.	
Alteration:		3
- First order:	Oxidation	
- Second order:	Not observed	
- Third order:	Not observed	
Fracture orientation and type:	Steeply dipping fractures that vary in strike from ENE to NE to SSE are prominent. Sealed fractures dominates. Quantitative estimate and span include sealed fracture networks.	2
Fracture comment:	No data available.	
Fracture fill mineralogy:	Calcite, chlorite, laumontite, hematite/adularia, clay minerals, epidote, quartz.	



OBJECT GEOMETRY	
Strike/dip:	239°/82°
Length:	1496 m
Mean thickness:	23 m (3 - 50 m)
Max depth:	-1500 m
Geometrical constraints:	ZFMNW0017, ZFMNE2308, Topo 40m grid Max error 20m, 1 Surface Planar Cut(s).

BASIS FOR MODELLING

Zone based on surface lineaments and borehole observations.

Outcrops: -

Boreholes:

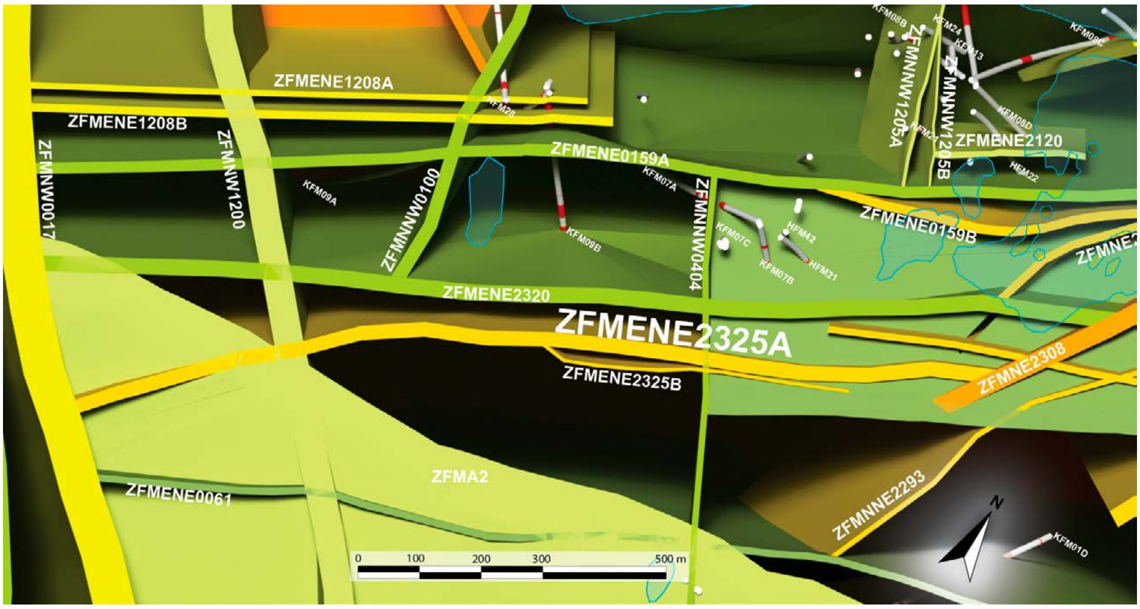
Borehole	PDZ	Target intercept		Geometric intercept		Comment
		Sec_up [m]	Sec_low [m]	Sec_up [m]	Sec_low [m]	
KFM09B	DZ4	520.00	550.00	520.51	549.71	

Tunnels:	-	
Lineament and/or seismic indications:	MFM2325G.	2

MODELLING PROCEDURE

At the surface, corresponds to the low magnetic lineament MFM2325G and its inferred continuation to the south-west. Modelled down to 1400 m depth, using the dip estimated by connecting lineament MFM2325G and its inferred continuation to the south-west with the borehole intersection 520-550 m in KFM09B (DZ4). Deformation zone plane placed at fixed point 528 m in KFM09B. Decreased radar penetration also along the borehole interval 522-529 m.

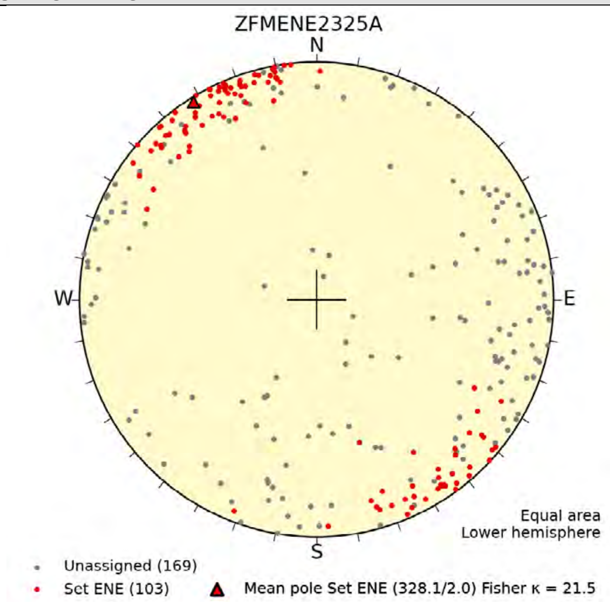
ENE	ZFMENE2325A	Version number	4	Total object CL	15



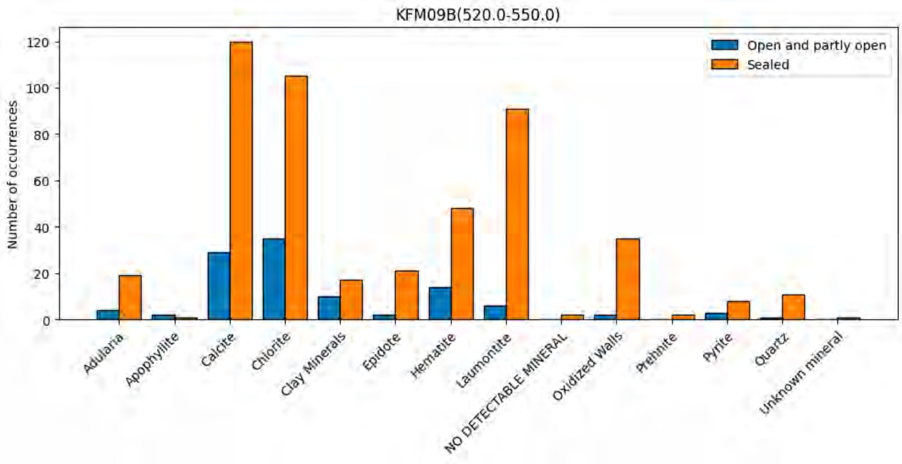
OBJECT CONFIDENCE ESTIMATE

Category	Object CL	Comment
INTERPRETATION		
Data source	2	MFM2325G, KFM09B
Results of interpretation	3	High confidence observations in KMF09B.
INFORMATION DENSITY		
Number of observation points	2	2
Distribution of observation points	1	Single observation point at depth and a surface lineament.
INTERPOLATION		
Geometry	1	Limited data from depth. Based mainly on surface data.
Geological indicators	1	Single observation point at depth. Zone modelled mainly based on surface geophysical data.
EXTRAPOLATION		
Dip direction	2	Extrapolation in dip direction supported by subsurface obs. point. Strike length of the modelled zone < 2000 m.
Strike direction	3	Conceptual understanding of the site and that the entire modelled zone is supported by the lineament.

FRACTURE CHARACTER

Orientation: (strike/dip right-hand-rule)	Set ENE: 58.1°/88.0°	
Frequency:	Boreholes: KFM09B	
RQD:	min:72, max:100, mean:97	

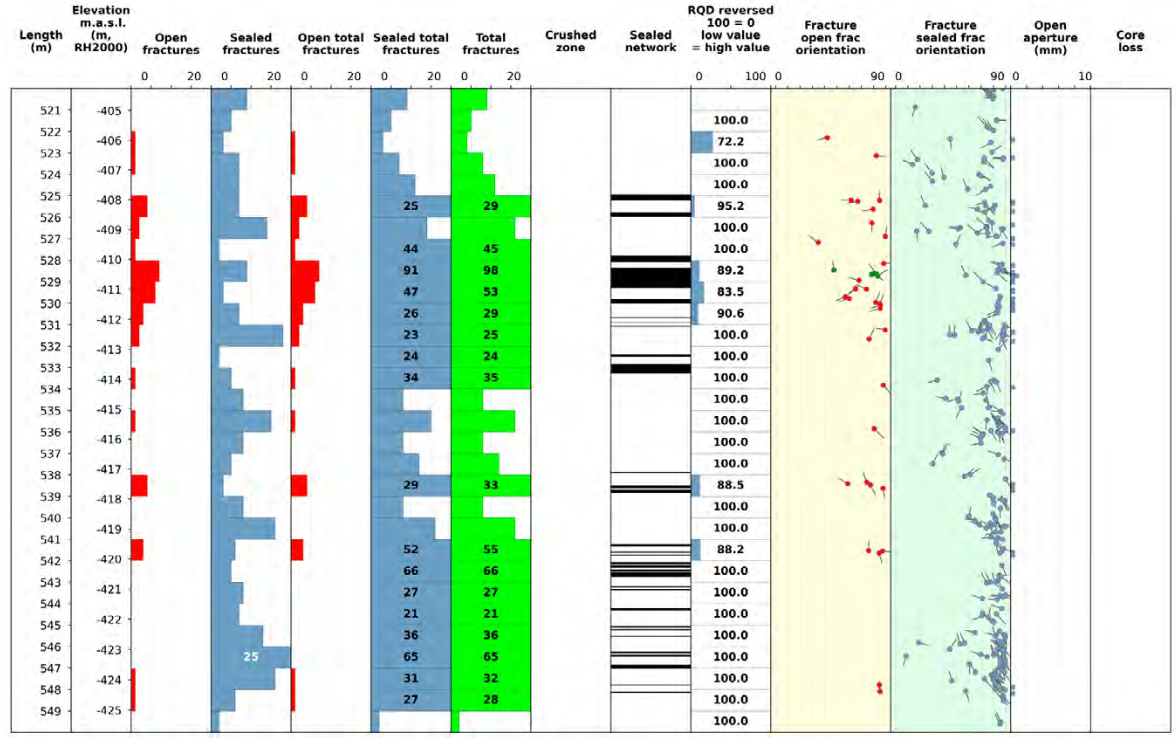
FRACTURE TYPE	TERZAGHI-WEIGHED P10
Open and partly open	2.8 m-1
Sealed	16.4 m-1
Sealed network	15.0 % of DZ intercept
Crush	0.0 % of DZ intercept

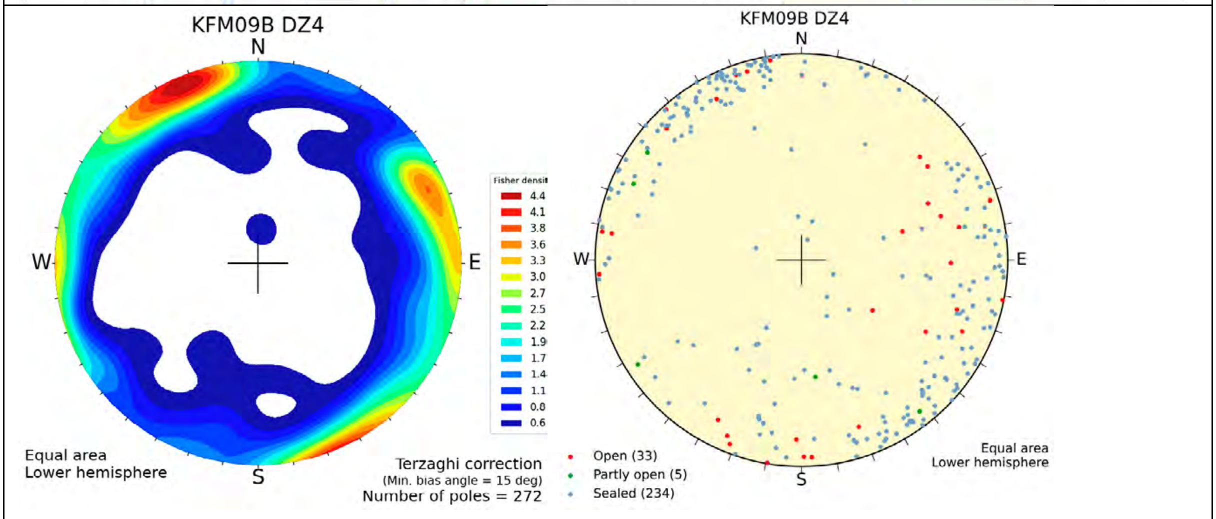
ENE	ZFMENE2325A	Version number	4	Total object CL	15
Fracture fill mineralogy:					

ENE	ZFMENE2325A	Version number	4	Total object CL	15

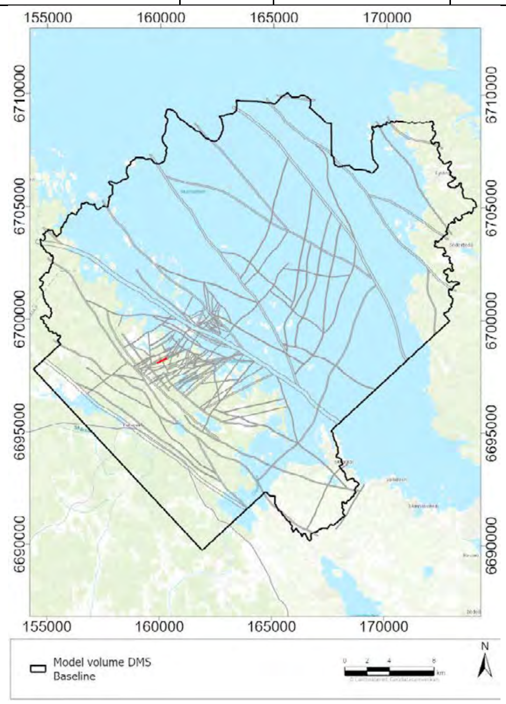
INDIVIDUAL INTERCEPTS

KFM09B DZ4 (520.0-550.0 m)





ENE	ZFMENE2325B	Version number	5	Total object CL	14



GEOLOGICAL CHARACTER		Property CL
Deformation style:	Brittle	3
Deformation description:	Steeply dipping faults with ENE-WSW strike show strike-slip displacement excepth one that shows dextral strike-slip.	
Alteration:		3
- First order:	Oxidation	
- Second order:	Quartz dissolution	
- Third order:	Not observed	
Fracture orientation and type:	Steeply dipping fractures with ENE strike are prominent. Sealed fractures dominates. Quantitative estimate and span include sealed fracture networks.	2
Fracture comment:	No data available.	
Fracture fill mineralogy:	Chlorite, calcite, laumontite, clay minerals, hematite/adularia, quartz, pyrite. Epidote on gently dipping fractures.	

OBJECT GEOMETRY	
Strike/dip:	247°/81°
Length:	511 m
Mean thickness:	6 m (2 - 36 m)
Max depth:	-550 m
Geometrical constraints:	ZFMENE2325A, Topo 40m grid Max error 20m, 1 Surface Planar Cut(s), 1 UNIVERSE Planar Cut(s).

BASIS FOR MODELLING

Zone based on surface lineaments and a borehole observation.

Outcrops: -

Boreholes:

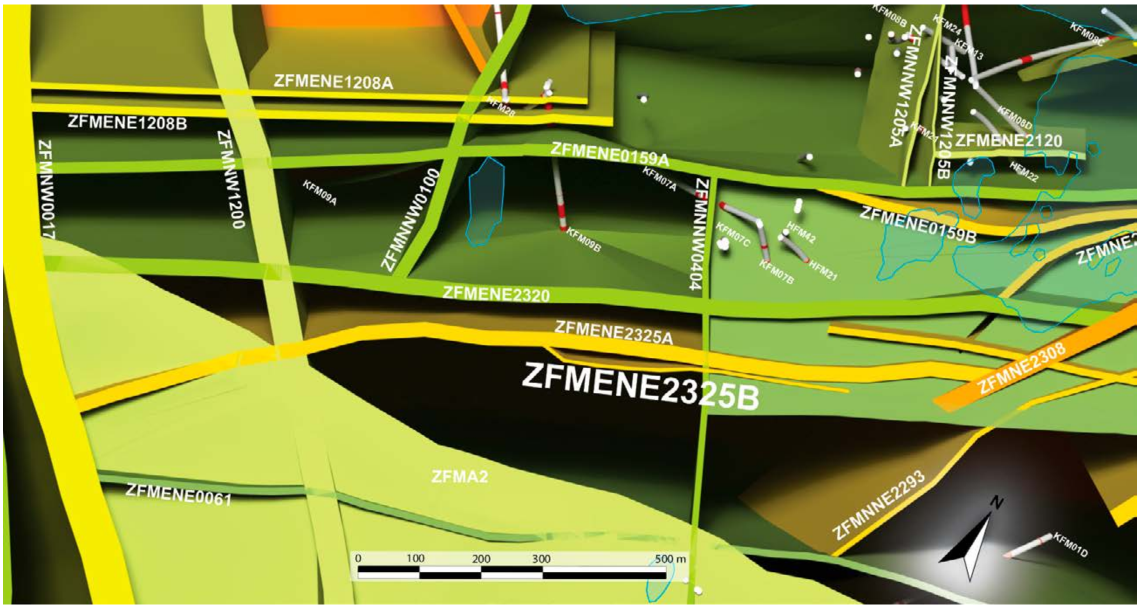
Borehole	PDZ	Target intercept		Geometric intercept		Comment
		Sec_up [m]	Sec_low [m]	Sec_up [m]	Sec_low [m]	
KFM09B	DZ5	561.00	574.00	566.21	573.21	

Tunnels:	-	
Lineament and/or seismic indications:	MFM2056G.	1

MODELLING PROCEDURE

At the surface, corresponds to the low magnetic lineament MFM2056G and its inferred continuation to the south-west. Modelled as a splay from zone ZFMENE2325A, using the dip estimated by connecting lineament MFM2056G and its inferred continuation to the south-west with the borehole intersection 561-574 m in KFM09B (DZ5). Deformation zone plane placed at fixed point 567 m in KFM09B. Decreased radar penetration also along the borehole interval 566-573 m.

ENE	ZFMENE2325B	Version number	5	Total object CL	14



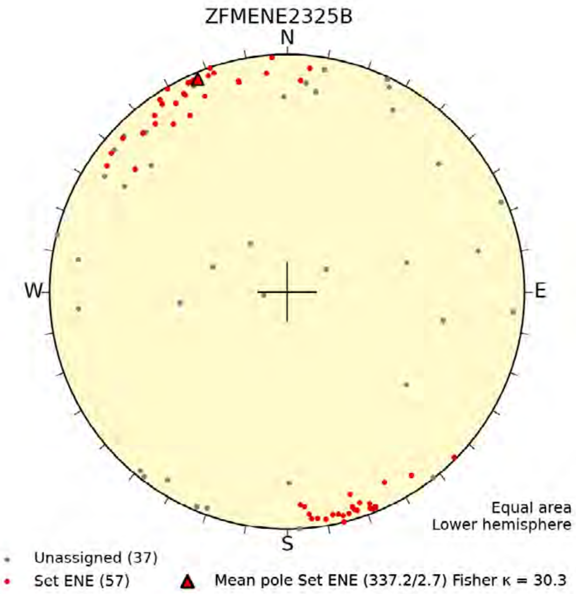
OBJECT CONFIDENCE ESTIMATE

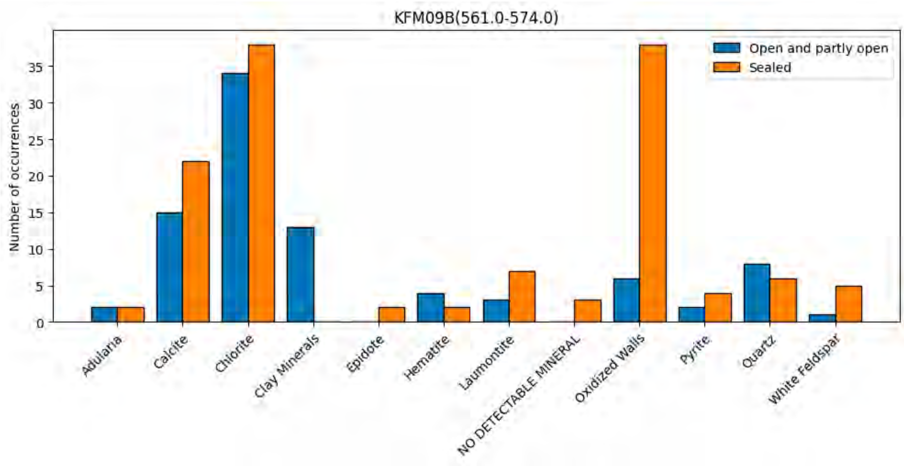
Category	Object CL	Comment
INTERPRETATION		
Data source	2	MFM2056G, KFM09B
Results of interpretation	3	High confidence observation in KFM09B.
INFORMATION DENSITY		
Number of observation points	2	2
Distribution of observation points	1	Single observation point at depth and a surface lineament.
INTERPOLATION		
Geometry	1	Limited data from depth. Based mainly on surface data.
Geological indicators	1	Single observation point at depth. Zone modelled mainly based on surface geophysical data.
EXTRAPOLATION		
Dip direction	2	Extrapolation in dip direction supported by subsurface obs. point. Strike length of the modelled zone < 2000 m.
Strike direction	2	Extrapolation supported by surface geophysical data, subsurface observation points and geological conceptual understanding of the site.

FRACTURE CHARACTER

Orientation: (strike/dip right-hand-rule)	Set ENE: 67.2°/87.3°	
Frequency:	Boreholes: KFM09B	
RQD:	min:46, max:100, mean:91	

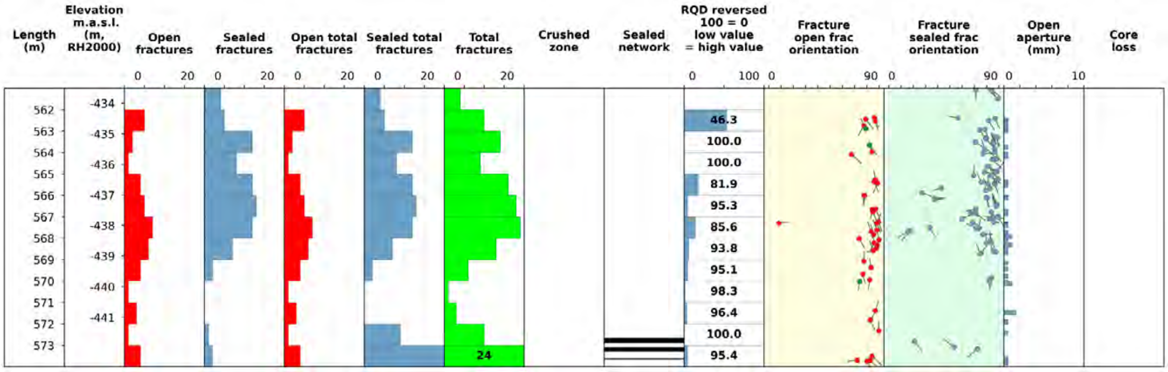
FRACTURE TYPE	TERZAGHI-WEIGHED P10
Open and partly open	6.4 m-1
Sealed	12.0 m-1
Sealed network	3.7 % of DZ intercept
Crush	0.0 % of DZ intercept

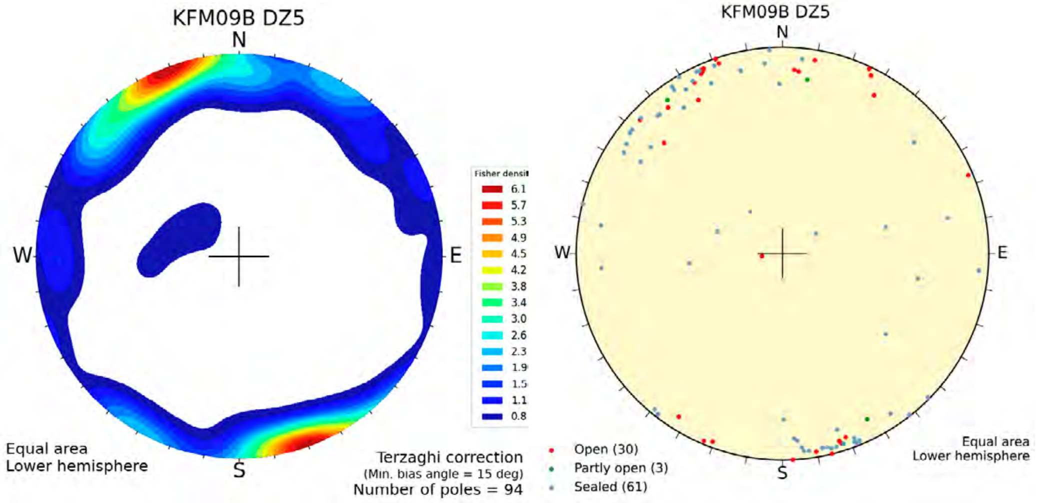


ENE	ZFMENE2325B	Version number	5	Total object CL	14
Fracture fill mineralogy:					

ENE	ZFMENE2325B	Version number	5	Total object CL	14
INDIVIDUAL INTERCEPTS					

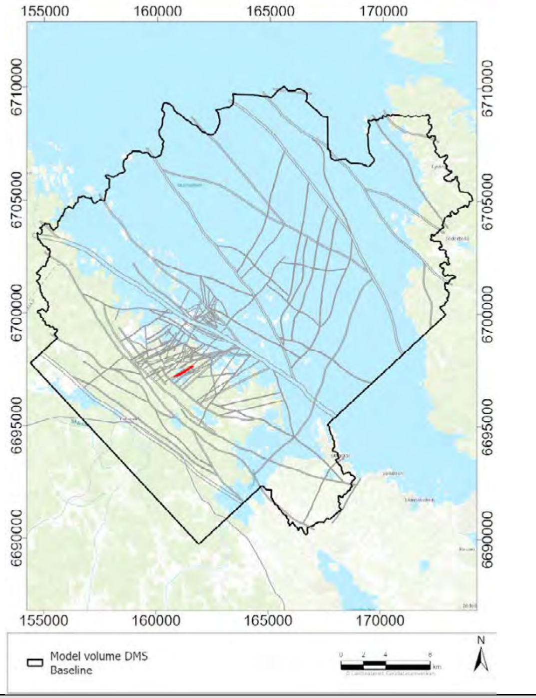
KFM09B DZ5 (561.0-574.0 m)





ENE	ZFMENE2383	Version number	5	Total object CL	14

GEOLOGICAL CHARACTER		Property CL
Deformation style:	Brittle	3
Deformation description:	No data available.	
Alteration:		
- First order:	Oxidation	3
- Second order:	Not observed	
- Third order:	Not observed	
Fracture orientation and type:	Steeply dipping fractures with NE strike dominates. Dominated by sealed followed by open and partly open fractures. Quantitative estimate and span include sealed fracture networks.	2
Fracture comment:	No data available.	
Fracture fill mineralogy:	Calcite, chlorite, hematite/adularia, laumontite, quartz, pyrite.	



OBJECT GEOMETRY

Strike/dip:	241°/80°
Length:	953 m
Mean thickness:	36 m (2 - 36 m)
Max depth:	-1267 m
Geometrical constraints:	ZFMENE0103A, Topo 40m grid Max error 20m, 1 UNIVERSE Planar Cut(s).

BASIS FOR MODELLING

Zone based on surface lineaments and a borehole observation.

Outcrops:	-

Boreholes:

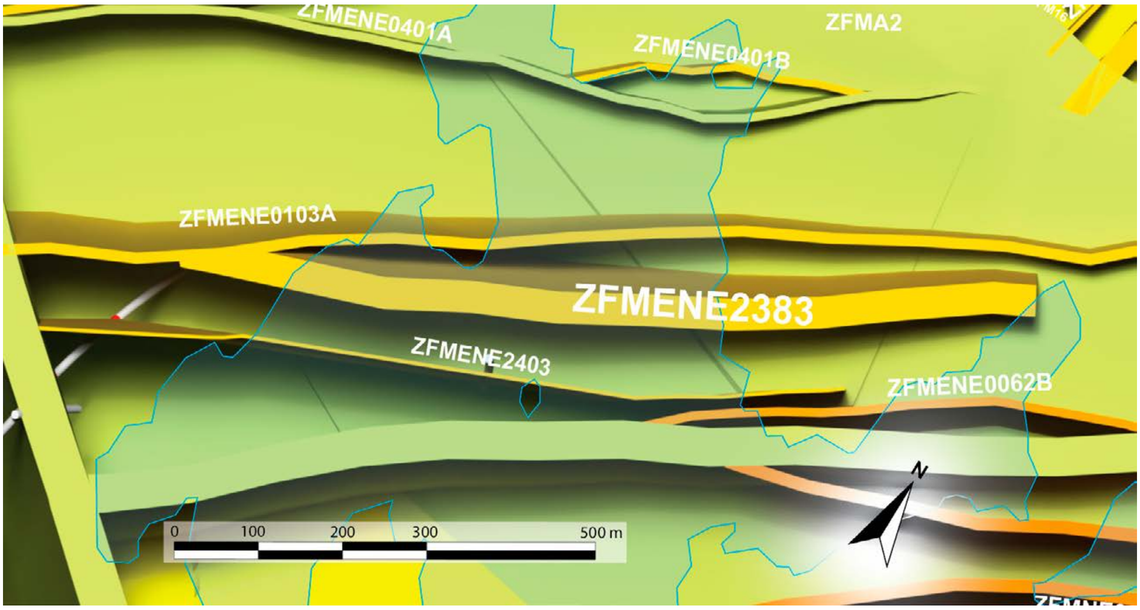
Borehole	PDZ	Target intercept		Geometric intercept		Comment
		Sec_up [m]	Sec_low [m]	Sec_up [m]	Sec_low [m]	
KFM05A	DZ5	936.00	992.00	935.92	992.90	950-992 m added (cf. Table 3-2 in Stephens et al. 2007).

Tunnels:	-	
Lineament and/or seismic indications:	MFM2383G.	2

MODELLING PROCEDURE

At the surface, corresponds to the low magnetic lineament MFM2383G. Modelled down to 1000 m depth, using the dip estimated by connecting lineament MFM2383G with the borehole intersection 936-992 m in KFM05A (DZ5 and extension along borehole interval 950-992 m). Deformation zone plane placed at fixed point 959 m in KFM05A.

ENE	ZFMENE2383	Version number	5	Total object CL	14



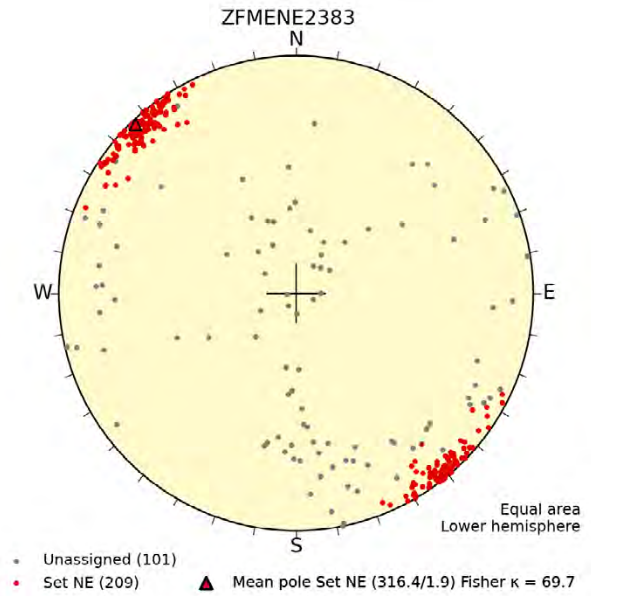
OBJECT CONFIDENCE ESTIMATE

Category	Object CL	Comment
INTERPRETATION		
Data source	2	MFM2383G, KFM05A
Results of interpretation	2	Medium confidence observation in KFM05A.
INFORMATION DENSITY		
Number of observation points	2	2
Distribution of observation points	1	Single observation point at depth and a surface lineament.
INTERPOLATION		
Geometry	1	Limited data from depth. Based mainly on surface data.
Geological indicators	1	Single observation point at depth. Zone modelled mainly based on surface geophysical data.
EXTRAPOLATION		
Dip direction	2	Extrapolation in dip direction supported by subsurface obs. point. Strike length of the modelled zone < 2000 m.
Strike direction	3	Conceptual understanding of the site and that the entire modelled zone is supported by the lineament.

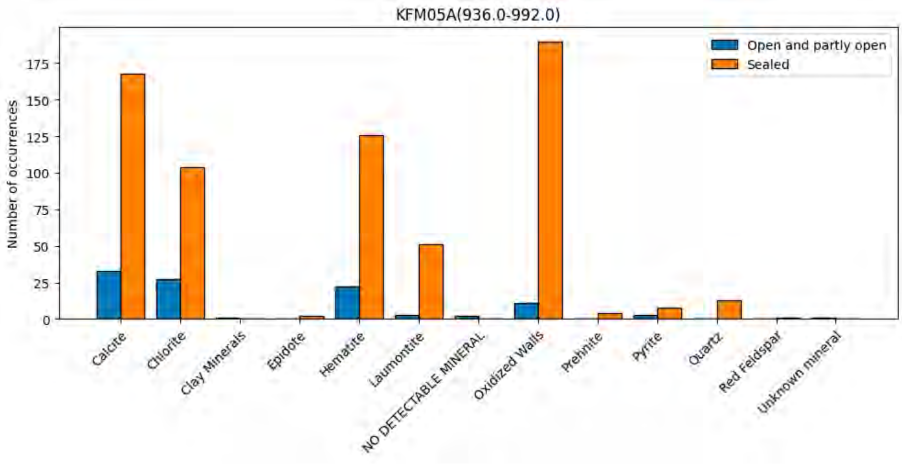
FRACTURE CHARACTER

Orientation: (strike/dip right-hand-rule)	Set NE: 46.4°/88.1°
Frequency:	Boreholes: KFM05A

FRACTURE TYPE	TERZAGHI-WEIGHED P10
Open and partly open	1.3 m-1
Sealed	10.1 m-1
Sealed network	4.6 % of DZ intercept
Crush	0.0 % of DZ intercept

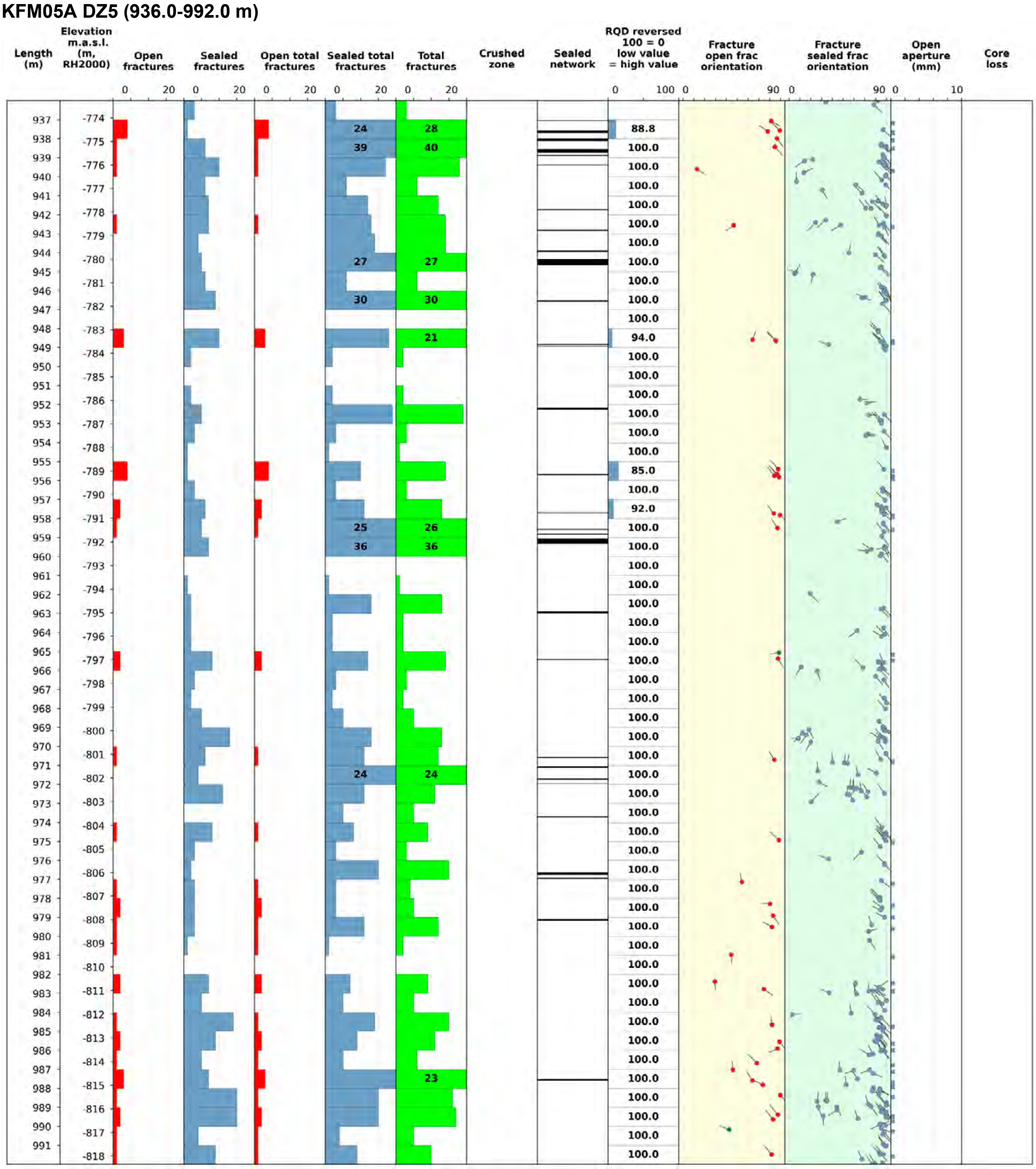


RQD:	min:85, max:100, mean:99

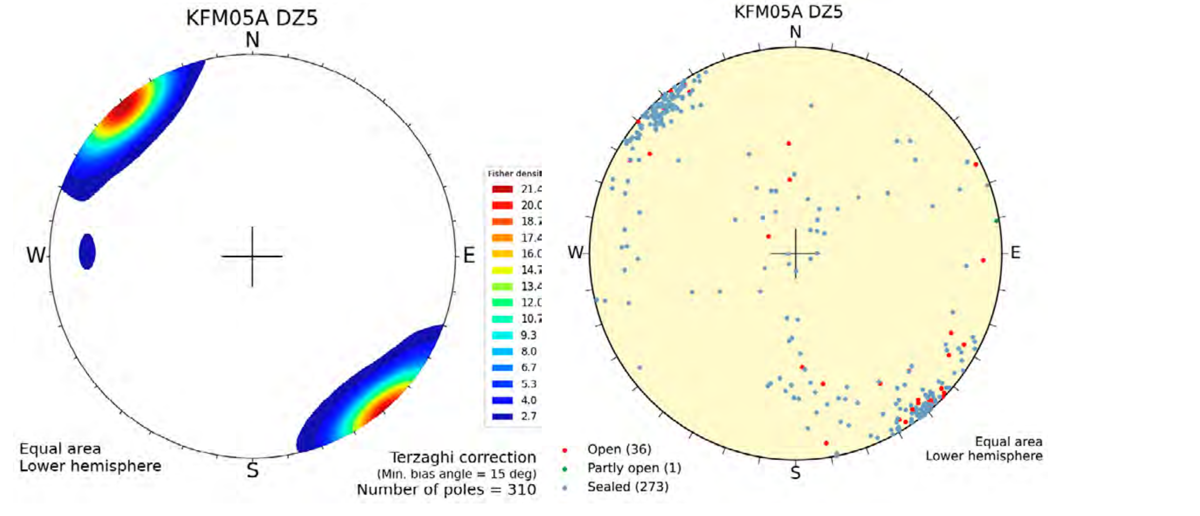
ENE	ZFMENE2383	Version number	5	Total object CL	14
Fracture fill mineralogy:					

ENE	ZFMENE2383	Version number	5	Total object CL	14
INDIVIDUAL INTERCEPTS					

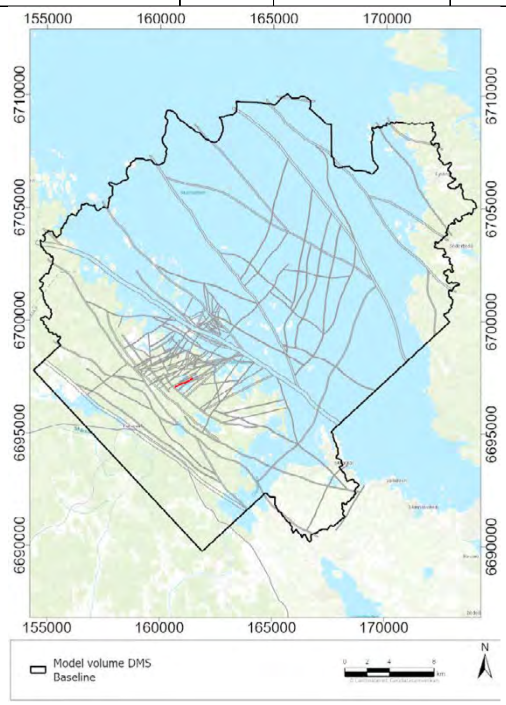
KFM05A DZ5 (936.0-992.0 m)



ENE	ZFMENE2383	Version number	5	Total object CL	14



ENE	ZFMENE2403	Version number	5	Total object CL	13



GEOLOGICAL CHARACTER		Property CL
Deformation style:	Brittle	3
Deformation description:	No data available.	
Alteration:		
- First order:	Oxidation	3
- Second order:	Not observed	
- Third order:	Not observed	
Fracture orientation and type:	Steeply dipping fractures that strike SW and SE, as well as gently dipping fractures are present. Sealed fractures dominates. Quantitative estimate and span include sealed fracture networks.	2
Fracture comment:	No data available.	
Fracture fill mineralogy:	Calcite, laumontite, chlorite, epidote, hematite/adularia prehnite.	

OBJECT GEOMETRY	
Strike/dip:	244°/90°
Length:	957 m
Mean thickness:	4 m (2 - 36 m)
Max depth:	-950 m
Geometrical constraints:	ZFMWNW0123, Topo 40m grid Max error 20m, 1 Surface Planar Cut(s), 1 UNIVERSE Planar Cut(s).

BASIS FOR MODELLING

Zone based on surface lineaments and a borehole observation.

Outcrops:	-

Boreholes:

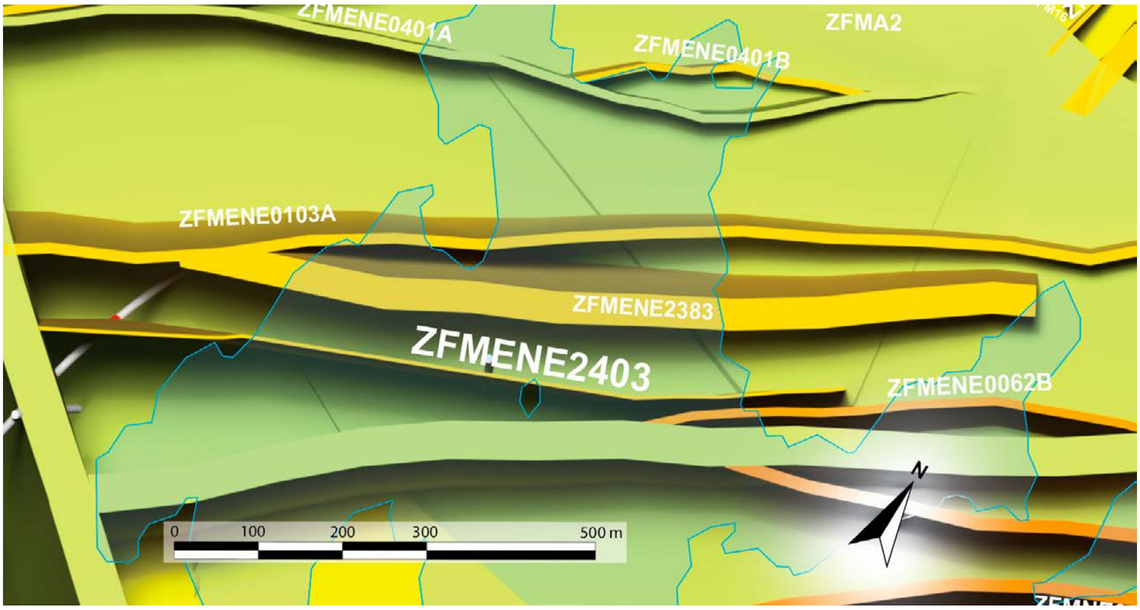
Borehole	PDZ	Target intercept		Geometric intercept		Comment
		Sec_up [m]	Sec_low [m]	Sec_up [m]	Sec_low [m]	
HFM32		-	-	141.56	164.36	
KFM10A		275.00	284.00	275.36	284.00	275-284 m inferred to be a DZ (cf. Table 3-2 in Stephens et al. 2007). Not recognized in SHI.

Tunnels:	-	
Lineament and/or seismic indications:	MFM2403G.	2

MODELLING PROCEDURE

At the surface, corresponds to the low magnetic lineament MFM2403G. Modelled down to 950 m depth, using the dip estimated by connecting lineament MFM2403G with the borehole intersection 275-284 m in KFM10A. Deformation zone plane placed at fixed point 281 m in KFM10A.

ENE	ZFMENE2403	Version number	5	Total object CL	13



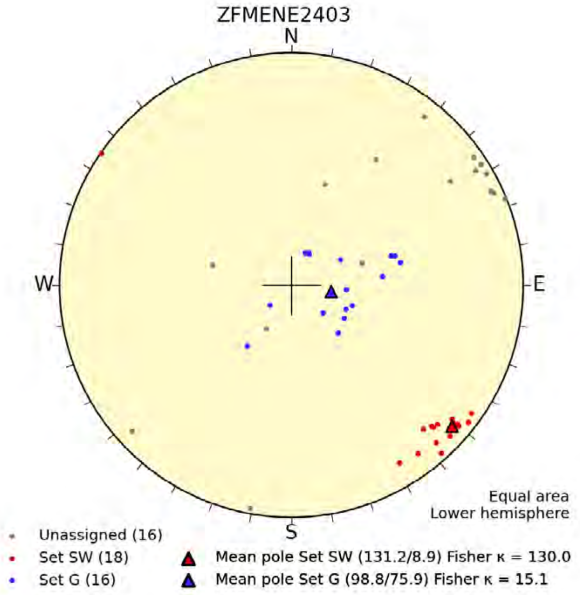
OBJECT CONFIDENCE ESTIMATE

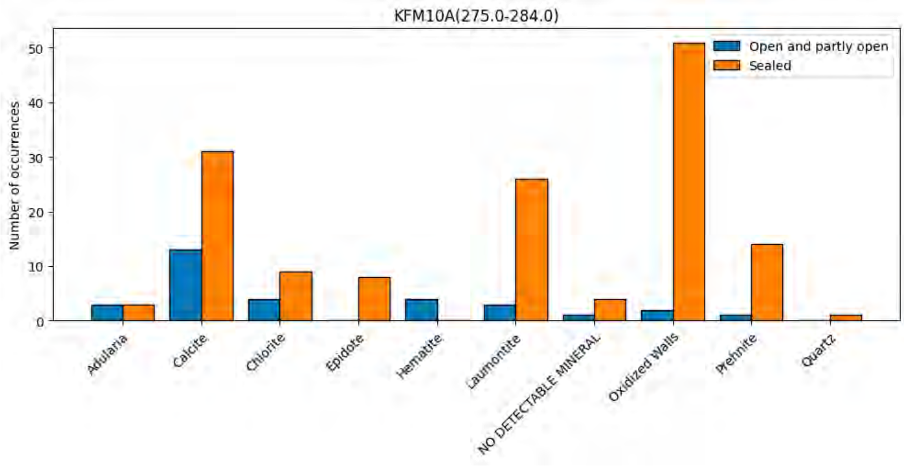
Category	Object CL	Comment
INTERPRETATION		
Data source	2	MFM2403G, HFM32 (not recognized in SHI), KFM10A
Results of interpretation	1	Low confidence in KFM10A in 275-284 m, which is only inferred to be a DZ (cf. Table 3-2 in Stephens et al. 2007).
INFORMATION DENSITY		
Number of observation points	2	2
Distribution of observation points	1	Single observation point in the form of a lineament.
INTERPOLATION		
Geometry	1	Limited data from depth. Based mainly on surface data.
Geological indicators	1	Indirect support by geophysical data.
EXTRAPOLATION		
Dip direction	2	Extrapolation in dip direction supported by subsurface obs. point. Strike length of the modelled zone < 2000 m.
Strike direction	3	Conceptual understanding of the site and that the entire modelled zone is supported by the lineament.

FRACTURE CHARACTER

Orientation: (strike/dip right-hand-rule)	Set SW: 221.2°/81.1° Set G: 188.8°/14.1°	
Frequency:	Boreholes: KFM10A	
RQD:	min:40, max:100, mean:91	

FRACTURE TYPE	TERZAGHI-WEIGHED P10
Open and partly open	3.4 m-1
Sealed	21.7 m-1
Sealed network	15.0 % of DZ intercept
Crush	0.0 % of DZ intercept

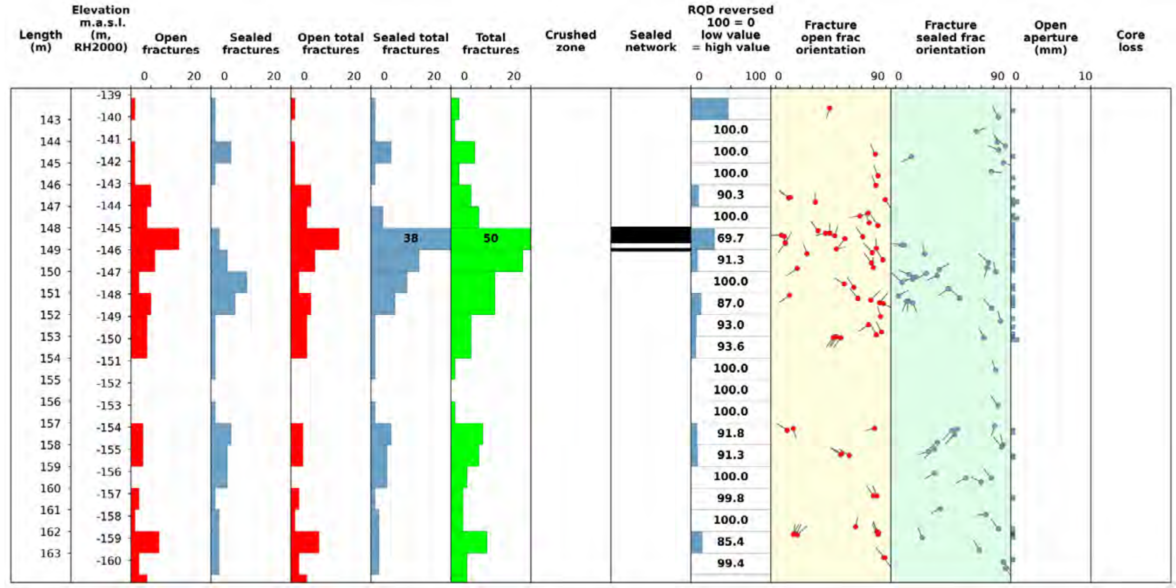


ENE	ZFMENE2403	Version number	5	Total object CL	13
Fracture fill mineralogy:					

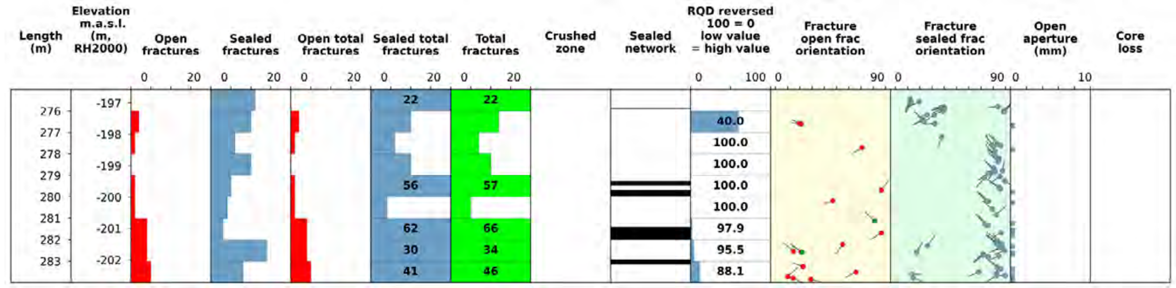
ENE	ZFMENE2403	Version number	5	Total object CL	13

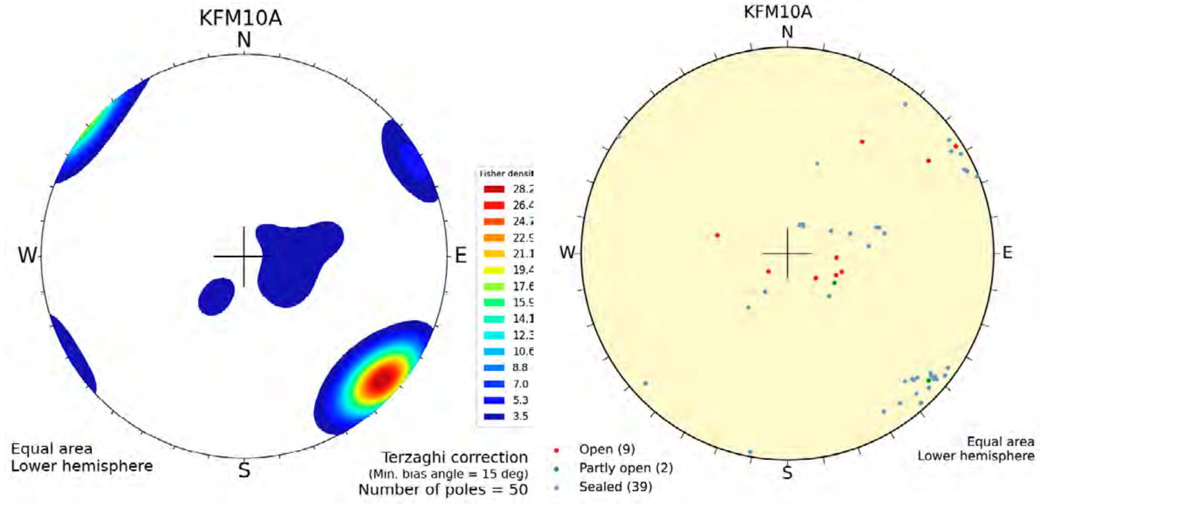
INDIVIDUAL INTERCEPTS

HFM32 (141.56-164.36 m)



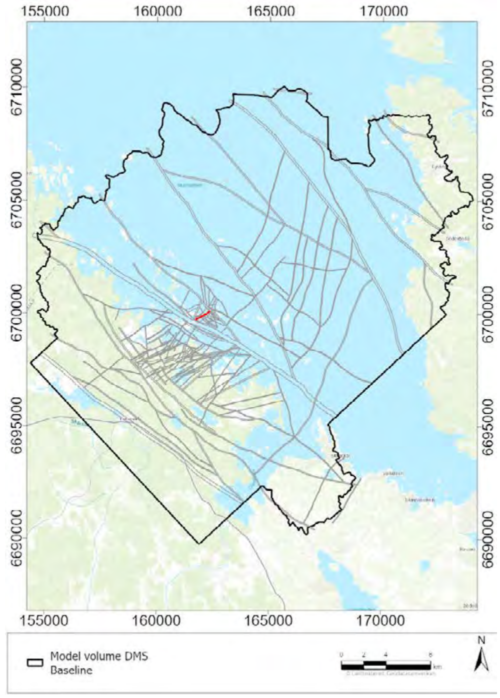
KFM10A (275.0-284.0 m)





ENE	ZFMENE3115	Version number	9	Total object CL	22

GEOLOGICAL CHARACTER		Property CL
Deformation style:	Brittle	3
Deformation description:	No data available.	
Alteration:		3
- First order:	Oxidation	
- Second order:	Argillization	
- Third order:	Quartz dissolution	
Fracture orientation and type:	Steeply dipping ENE fractures. Dominated by sealed followed by open and partly open fractures.	
Fracture comment:	Fractures aperture up to 1 mm.	
Fracture fill mineralogy:	Predominant minerals in sealed fractures are calcite, chlorite and laumontite and in open fractures are chlorite, calcite and hematite.	



OBJECT GEOMETRY	
Strike/dip:	238°/84°
Length:	797 m
Mean thickness:	10 m (2 - 36 m)
Max depth:	-1050 m
Geometrical constraints:	Topo 40m grid Max error 20m, ZFMWNW0001, ZFMNW0805A, ZFMNW0002, ZFMWNW1035, 1 Surface Planar Cut(s).

BASIS FOR MODELLING

Zone based on surface lineaments and a borehole observation.

Outcrops:	-

Boreholes:

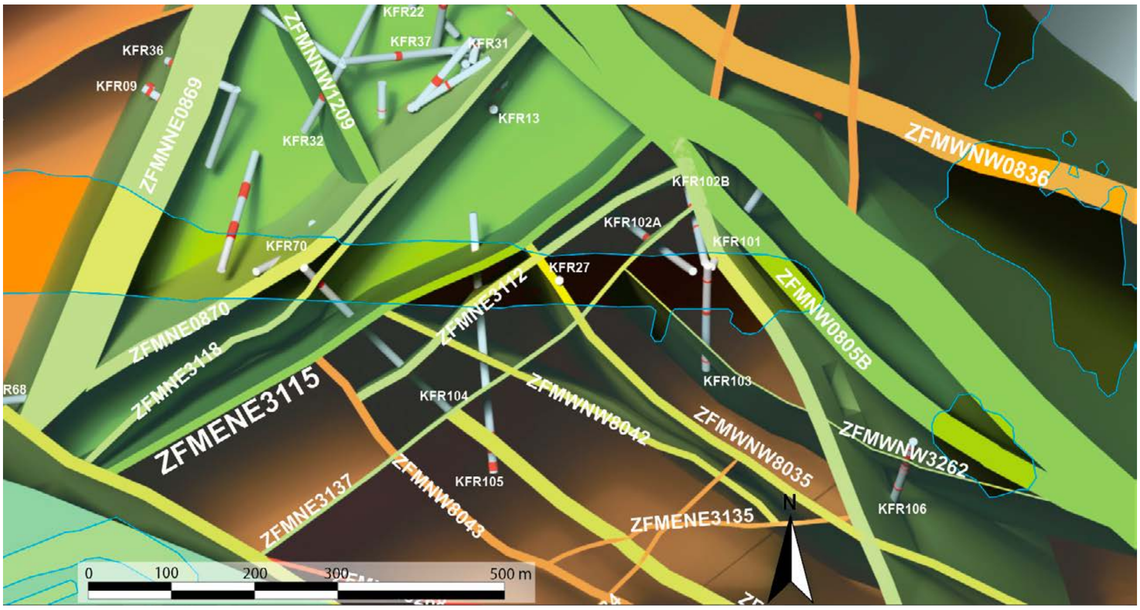
Borehole	PDZ	Target intercept		Geometric intercept		Comment
		Sec_up [m]	Sec_low [m]	Sec_up [m]	Sec_low [m]	
KFR102A	DZ3	422.00	503.00	446.49	475.59	
KFR104	DZ2	149.00	154.00	135.57	158.26	
KFR105	DZ1	45.00	52.00	43.24	53.88	
KFR118	DZ1	22.60	36.40	10.20	77.69	

Tunnels:	-	
Lineament and/or seismic indications:	MFM3115G, MSFR08116, MSFR10001.	1

MODELLING PROCEDURE

The position of the zone on the ground surface is based on the lineaments MFM3115G, MSFR08116 and MSFR10001 defined by magnetic minima (Isaksson et al. 2007 and SFR model version 1.0) with further extension to the south-west to allow termination at ZFMWNW1035. Forward modelling of magnetic data along profiles 20 and 42 (see Appendix 6, Curtis et al. 2011) provide weak support for the modelled zone thickness and the subvertical dip to the north-west. The zone is intersected by borehole KFR102A (422-503, DZ3), KFR104 (149-154, DZ2), KFR105 (45-52, DZ1) and KFR118 (22.6-36-4, DZ1). Deformation zone is placed at fixed point 462,5 in KFR102A, 151,5 in KFR104 and 48,5 in KFR105.

ENE	ZFMENE3115	Version number	9	Total object CL	22



OBJECT CONFIDENCE ESTIMATE

Category	Object CL	Comment
INTERPRETATION		
Data source	2	MFM3115G, KFR102A, KFR104, KFR105, KFR118
Results of interpretation	3	High confidence observations in multiple boreholes.
INFORMATION DENSITY		
Number of observation points	3	>4
Distribution of observation points	3	Multiple obs. point evenly distributed.
INTERPOLATION		
Geometry	3	Geometry supported by multiple subsurface obs. points.
Geological indicators	3	Interpolation supported by key geological parameters, foremost fracture orientation pattern.
EXTRAPOLATION		
Dip direction	2	Extrapolation in dip direction supported by subsurface obs. point. Strike length of the modelled zone < 2000 m.
Strike direction	3	Zone modelled length < 2000 m. Intersected in multiple boreholes. High confidence in this category based on conceptual understanding of the site.

FRACTURE CHARACTER

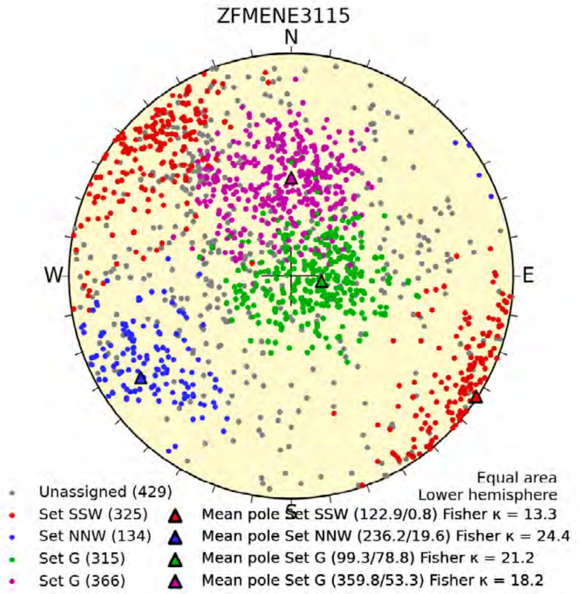
Orientation: (strike/dip right-hand-rule)

Set SSW: 212.9°/89.2°
Set NNW: 326.2°/70.4°
Set G: 189.3°/11.2°
Set G: 89.8°/36.7°

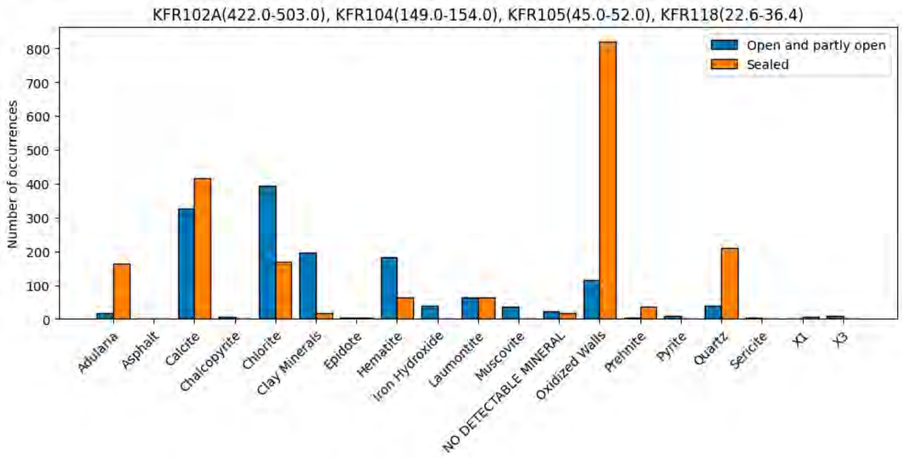
Frequency:

Boreholes: KFR118, KFR102A, KFR104, KFR105

FRACTURE TYPE	TERZAGHI-WEIGHED P10
Open and partly open	8.3 m-1
Sealed	13.8 m-1
Sealed network	35.2 % of DZ intercept
Crush	1.2 % of DZ intercept

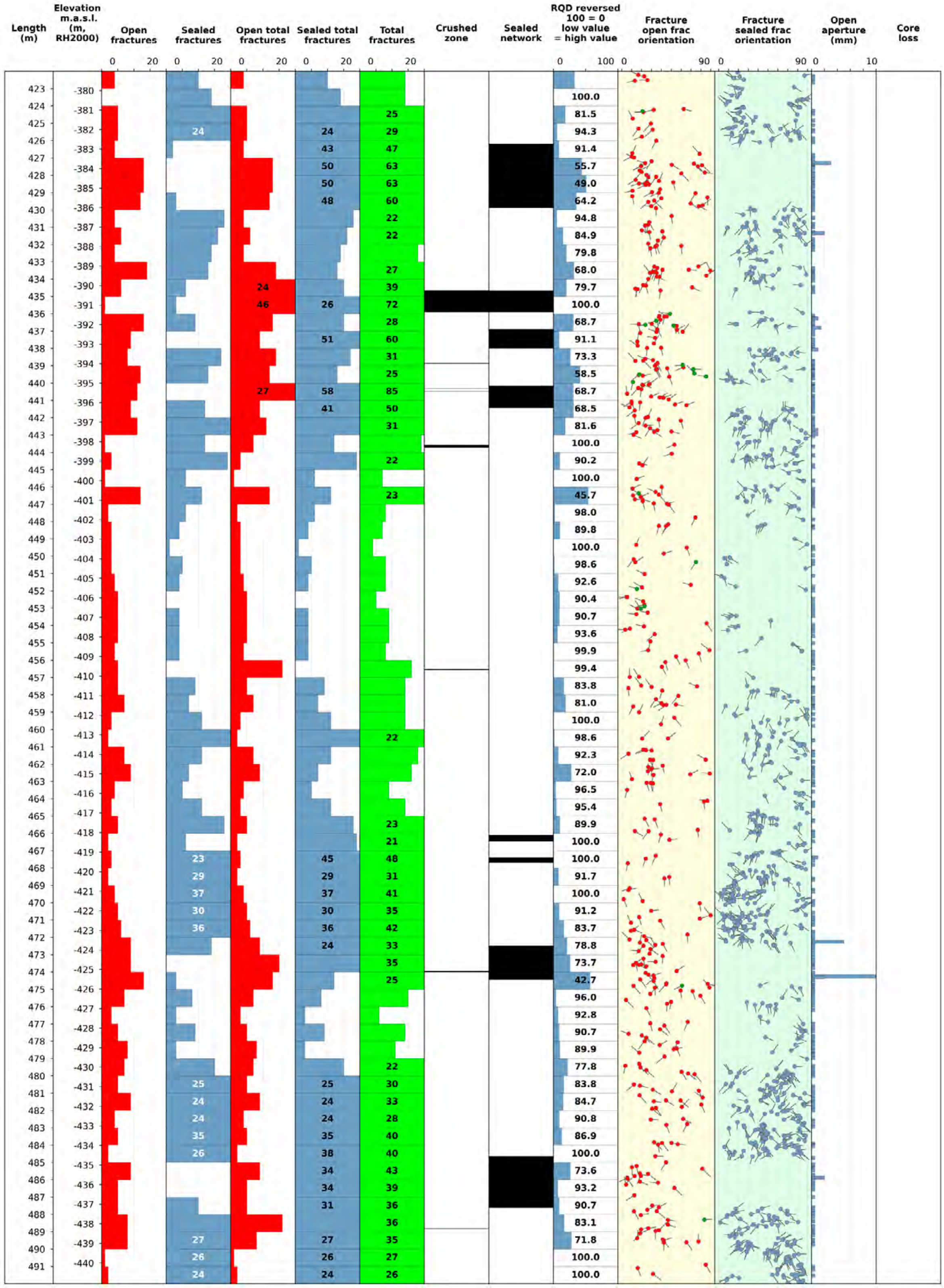


RQD: min:26, max:100, mean:88

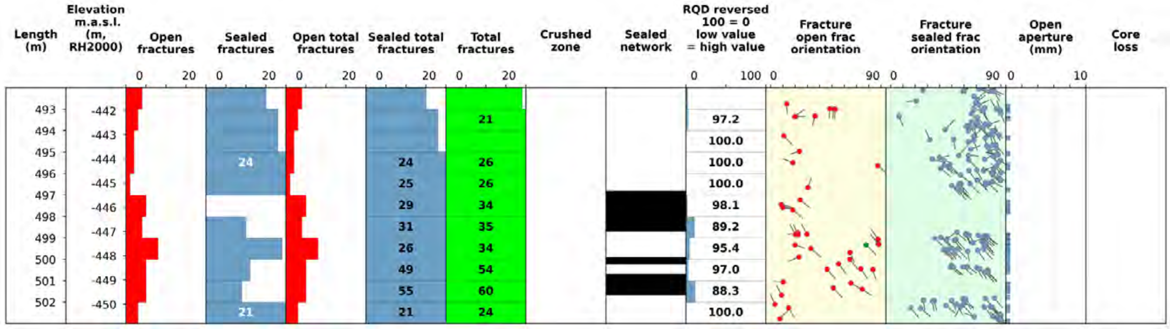
ENE	ZFMENE3115	Version number	9	Total object CL	22
Fracture fill mineralogy:					

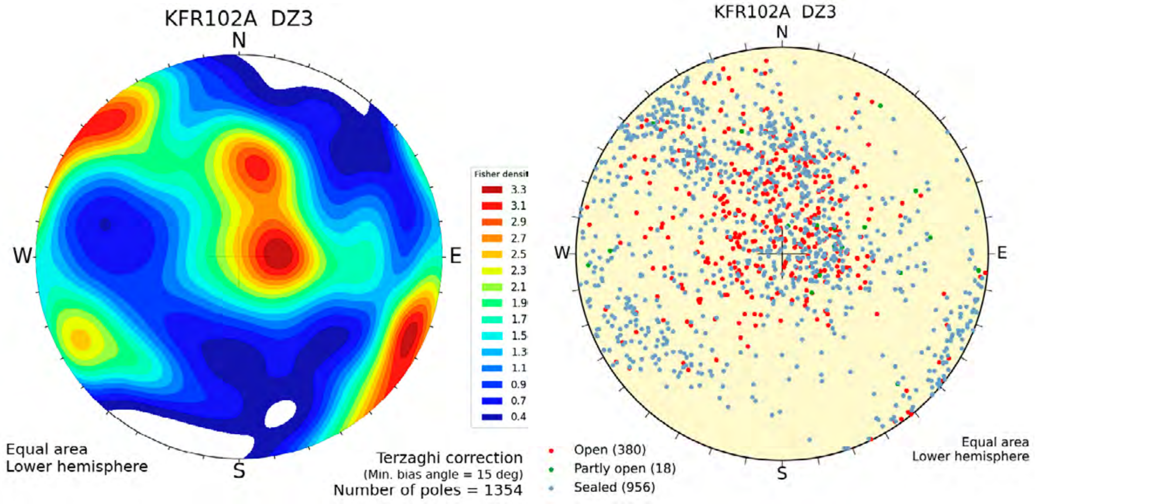
ENE	ZFMENE3115	Version number	9	Total object CL	22
INDIVIDUAL INTERCEPTS					

KFR102A DZ3 (422.0-503.0 m)

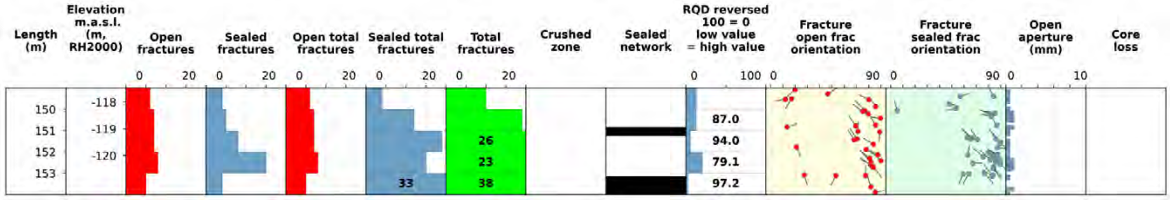


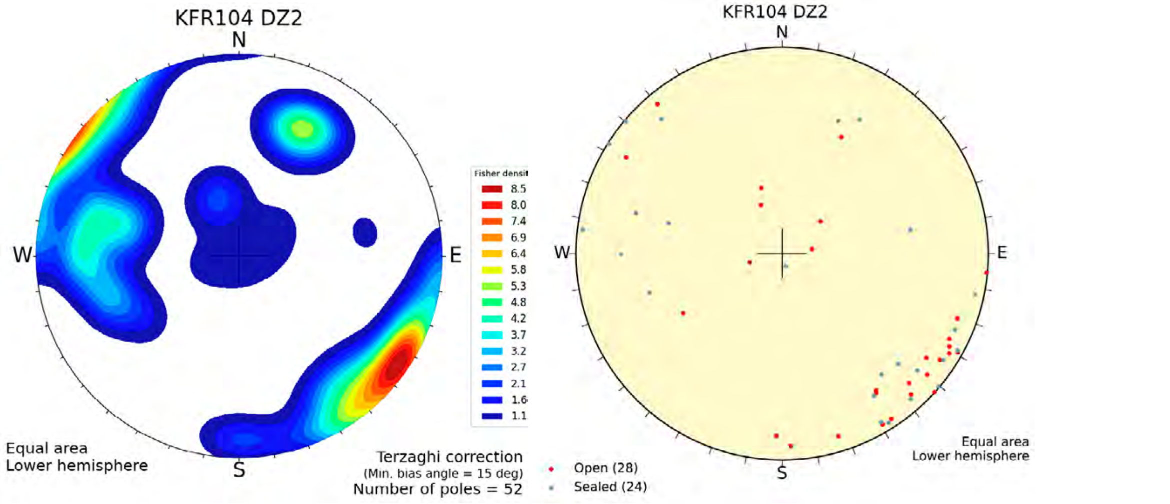
ENE	ZFMENE3115	Version number	9	Total object CL	22





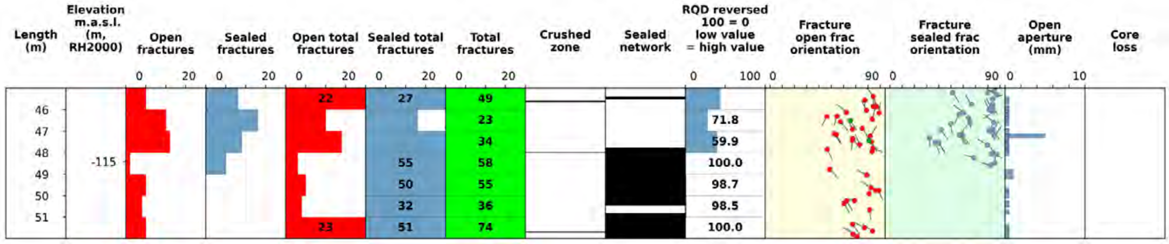
KFR104 DZ2 (149.0-154.0 m)

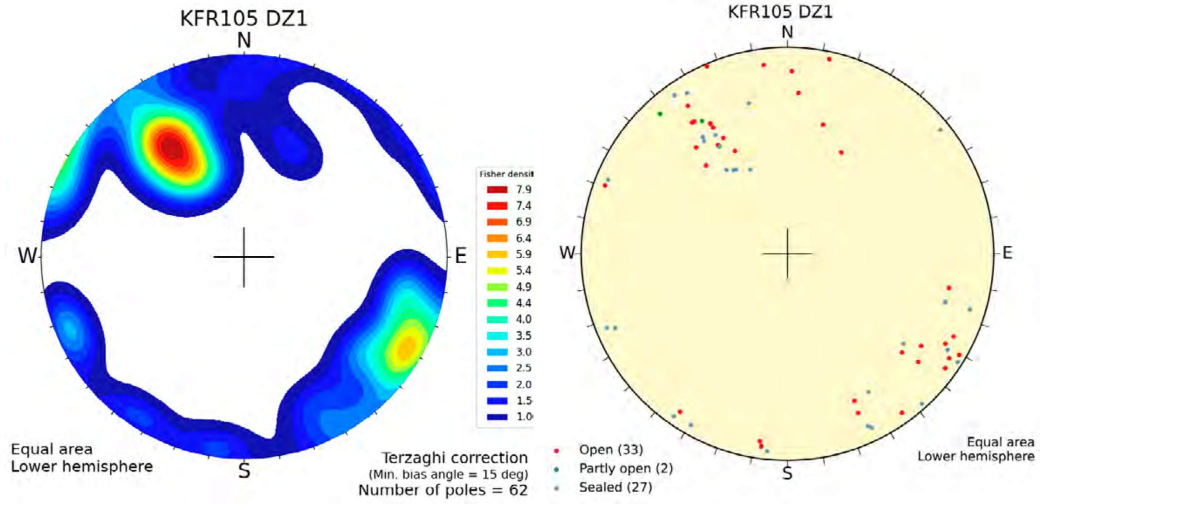




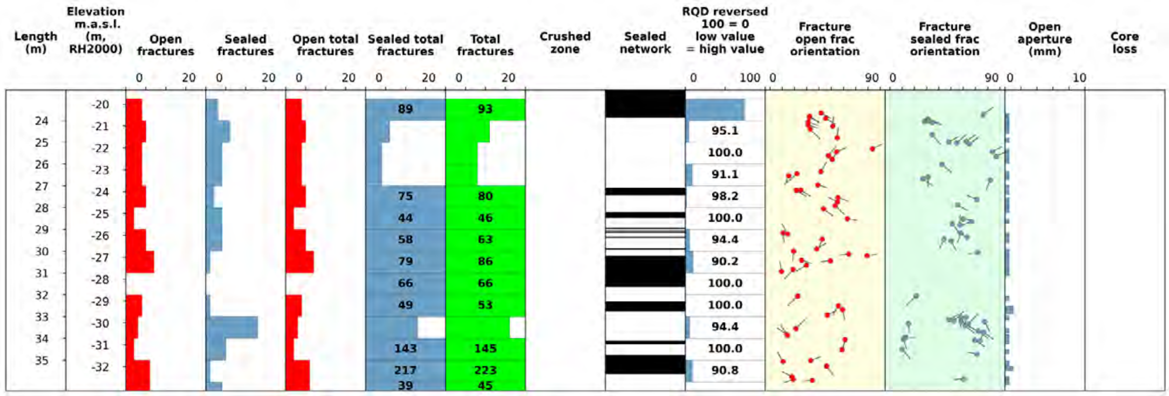
ENE	ZFMENE3115	Version number	9	Total object CL	22

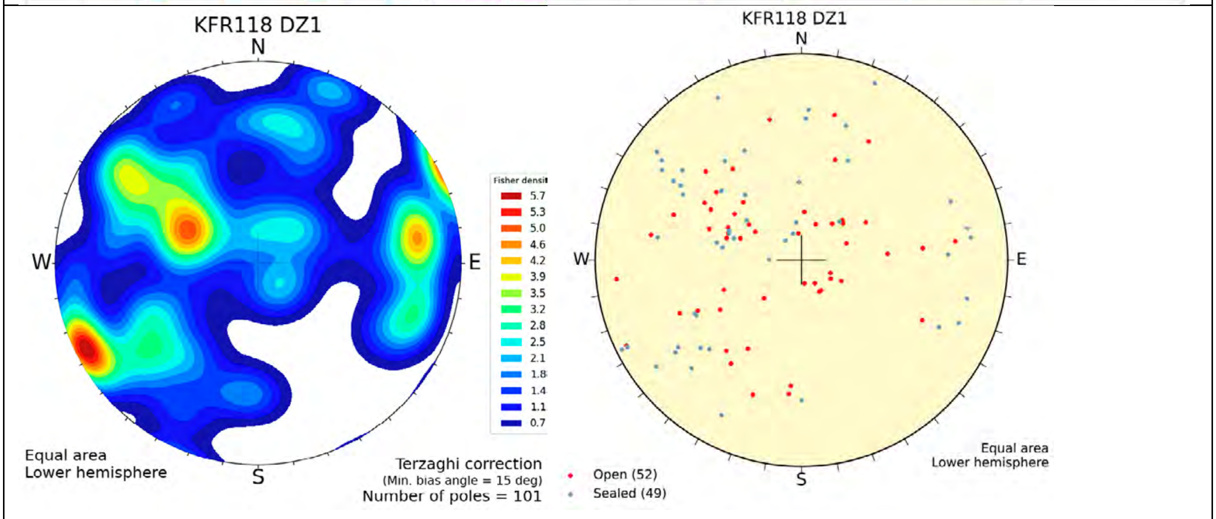
KFR105 DZ1 (45.0-52.0 m)





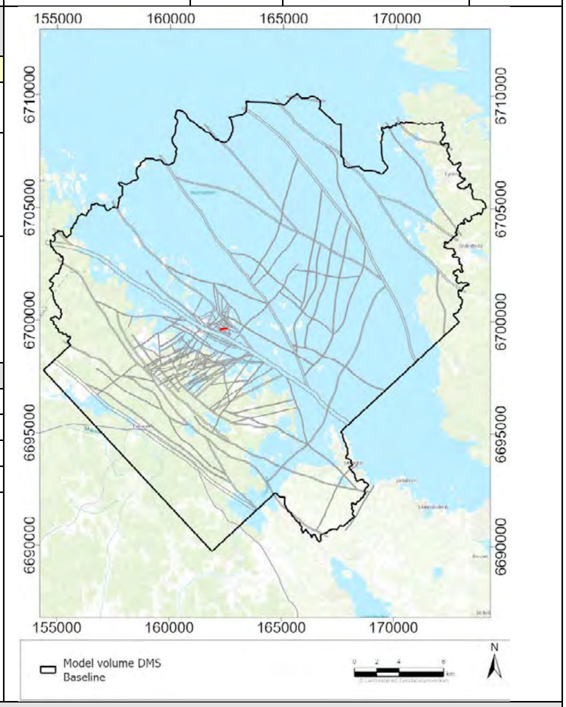
KFR118 DZ1 (22.6-36.4 m)





ENE	ZFMENE3135	Version number	7	Total object CL	10

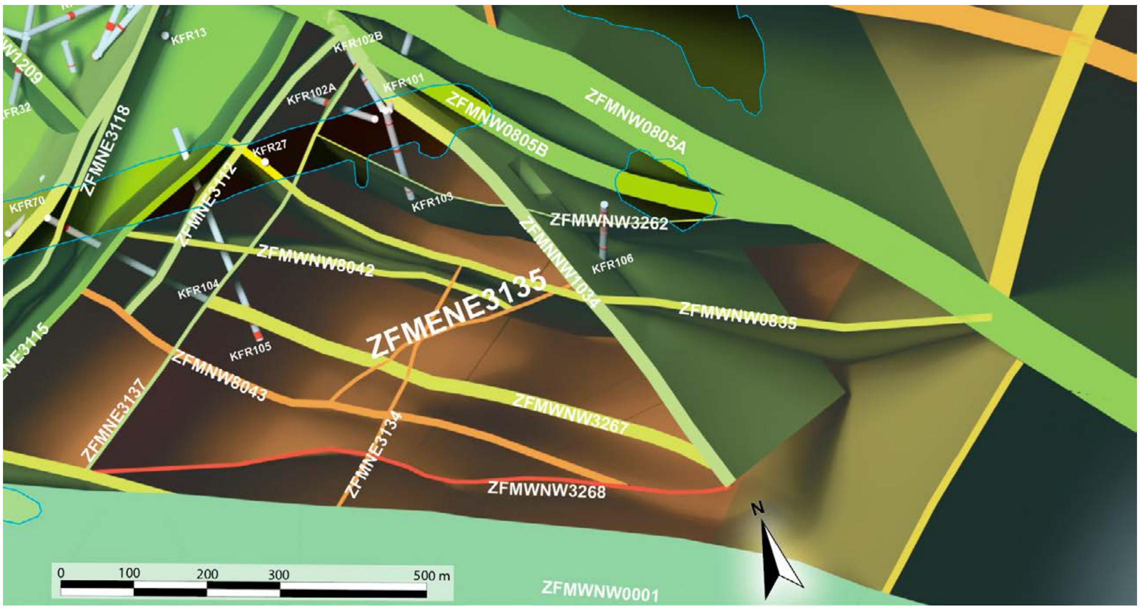
GEOLOGICAL CHARACTER		Property CL
Deformation style:	Brittle	2
Deformation description:	No data available.	
Alteration:		
- First order:	Not observed	
- Second order:	Not observed	
- Third order:	Not observed	
Fracture orientation and type:	No data available.	
Fracture comment:	No data available.	
Fracture fill mineralogy:	No data available.	



OBJECT GEOMETRY	
Strike/dip:	82°/90°
Length:	370 m
Mean thickness:	5 m (1 - 13 m)
Max depth:	-520 m
Geometrical constraints:	ZFMNW8043, ZFMNNW1034, Topo 40m grid Max error 20m, 1 Surface Planar Cut(s).

BASIS FOR MODELLING		
Zone based on surface lineament.		
Outcrops:	-	
Boreholes: -		
Tunnels:	-	
Lineament and/or seismic indications:	MSFR08113.	1

MODELLING PROCEDURE
Based on magnetic lineament MSFR08113 in SFR model version 1.0 that is a modification of lineament MFM3135G in Forsmark model stage 2.3 (Isaksson et al. 2007).



ENE	ZFMENE3135	Version number	7	Total object CL	10

OBJECT CONFIDENCE ESTIMATE

Category	Object CL	Comment
INTERPRETATION		
Data source	1	MFM3135G
Results of interpretation	1	Low confidence in lineament MFM3135G.
INFORMATION DENSITY		
Number of observation points	1	1
Distribution of observation points	1	Single observation point in the form of a lineament.
INTERPOLATION		
Geometry	1	Geometry supported by surface geophysical data.
Geological indicators	1	Indirect support by geophysical data.
EXTRAPOLATION		
Dip direction	1	No subsurface obs. point, supported only by surface data. High uncertainty in dip-direction. Strike length of the modelled zone < 2000 m.
Strike direction	3	Conceptual understanding of the site and that the entire modelled zone is supported by the lineament.

FRACTURE CHARACTER

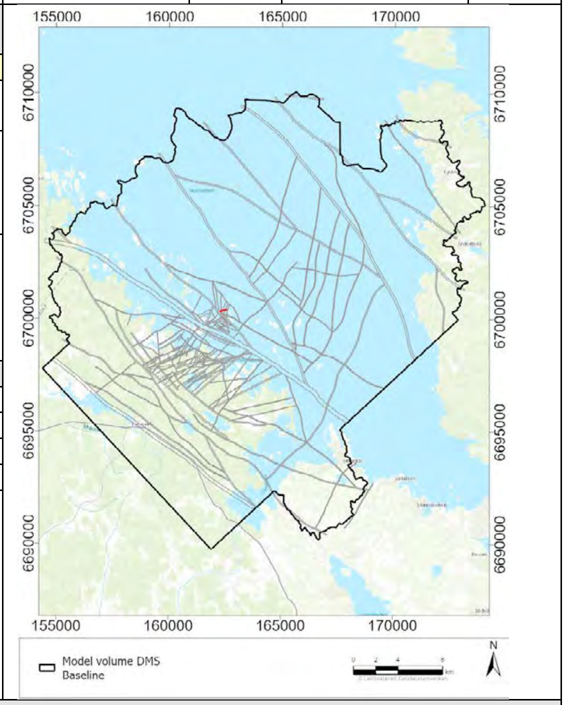
No data available

INDIVIDUAL INTERCEPTS

No data available

ENE	ZFMENE3151	Version number	4	Total object CL	10

GEOLOGICAL CHARACTER		Property CL
Deformation style:	Brittle	2
Deformation description:	No data available.	
Alteration:		
- First order:	Not observed	
- Second order:	Not observed	
- Third order:	Not observed	
Fracture orientation and type:	No data available.	
Fracture comment:	No data available.	
Fracture fill mineralogy:	No data available.	



OBJECT GEOMETRY	
Strike/dip:	76°/90°
Length:	419 m
Mean thickness:	5 m (1 - 13 m)
Max depth:	-420 m
Geometrical constraints:	ZFMNNE3264, ZFMNW0805A, Topo 40m grid Max error 20m, 1 Surface Planar Cut(s).

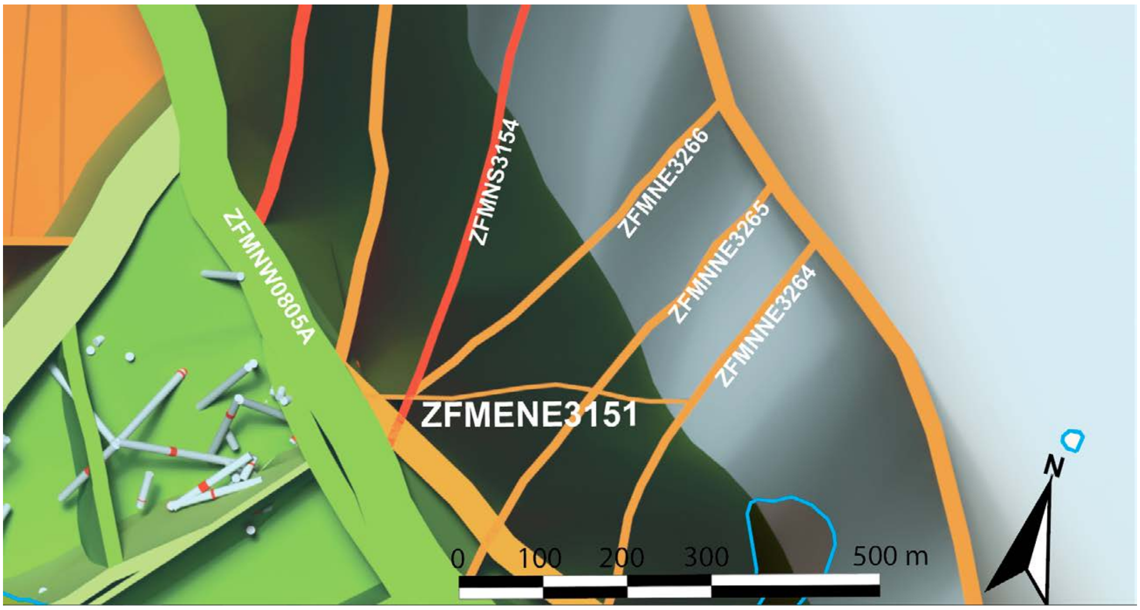
BASIS FOR MODELLING

Zone based on surface lineaments and pattern of surrounding deformtaion zones.

Outcrops:	-	
Boreholes: -		
Tunnels:	-	
Lineament and/or seismic indications:	MSFR08005.	1

MODELLING PROCEDURE

The position of the zone at the ground surface is based on a modification to the magnetic lineament MSFR08005 (SFR modelling work). The lineament was originally inferred to cross ZFMNW0805A and to continue a short distance on the western side of the zone. This extension was not considered likely conceptually and the zone was terminated against ZFMNW0805A. The number from the associated, Forsmark stage 2.3 lineament MFM3151G Isaksson et al. (2007) has been maintained for traceability between the different versions of the lineament interpretation. Forward modelling of magnetic data along profiles 7, 8 and 34 (see Appendix 6 in Curtis et al. 2011) support the inferred vertical dip of the inferred zone, whereas profile 9 indicates a very steep dip to the north-west.



ENE	ZFMENE3151	Version number	4	Total object CL	10

OBJECT CONFIDENCE ESTIMATE

Category	Object CL	Comment
INTERPRETATION		
Data source	1	MFM3151G
Results of interpretation	1	Low confidence in lineament MFM3151G.
INFORMATION DENSITY		
Number of observation points	1	1
Distribution of observation points	1	Single observation point in the form of a lineament.
INTERPOLATION		
Geometry	1	Geometry supported by surface geophysical data.
Geological indicators	1	Indirect support by geophysical data.
EXTRAPOLATION		
Dip direction	1	No subsurface obs. point, supported only by surface data. High uncertainty in dip-direction. Strike length of the modelled zone < 2000 m.
Strike direction	3	Conceptual understanding of the site and that the entire modelled zone is supported by the lineament.

FRACTURE CHARACTER

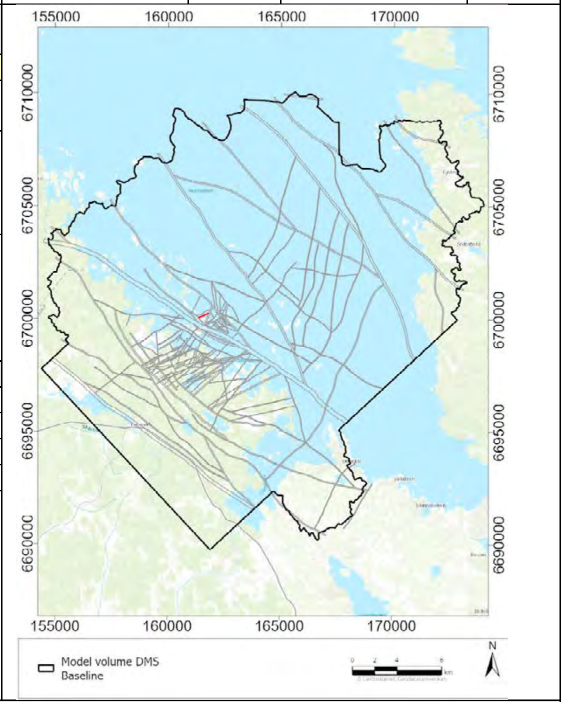
No data available

INDIVIDUAL INTERCEPTS

No data available

ENE	ZFMENE8031		Version number	4	Total object CL	10

GEOLOGICAL CHARACTER		Property CL
Deformation style:	Brittle	2
Deformation description:	No data available.	
Alteration:		
- First order:	Not observed	
- Second order:	Not observed	
- Third order:	Not observed	
Fracture orientation and type:	No data available.	
Fracture comment:	No data available.	
Fracture fill mineralogy:	No data available.	



OBJECT GEOMETRY	
Strike/dip:	65°/90°
Length:	537 m
Mean thickness:	5 m (2 - 36 m)
Max depth:	-540 m
Geometrical constraints:	ZFMNNE0869, ZFMWNW1035, Topo 40m grid Max error 20m, 1 Surface Planar Cut(s).

BASIS FOR MODELLING

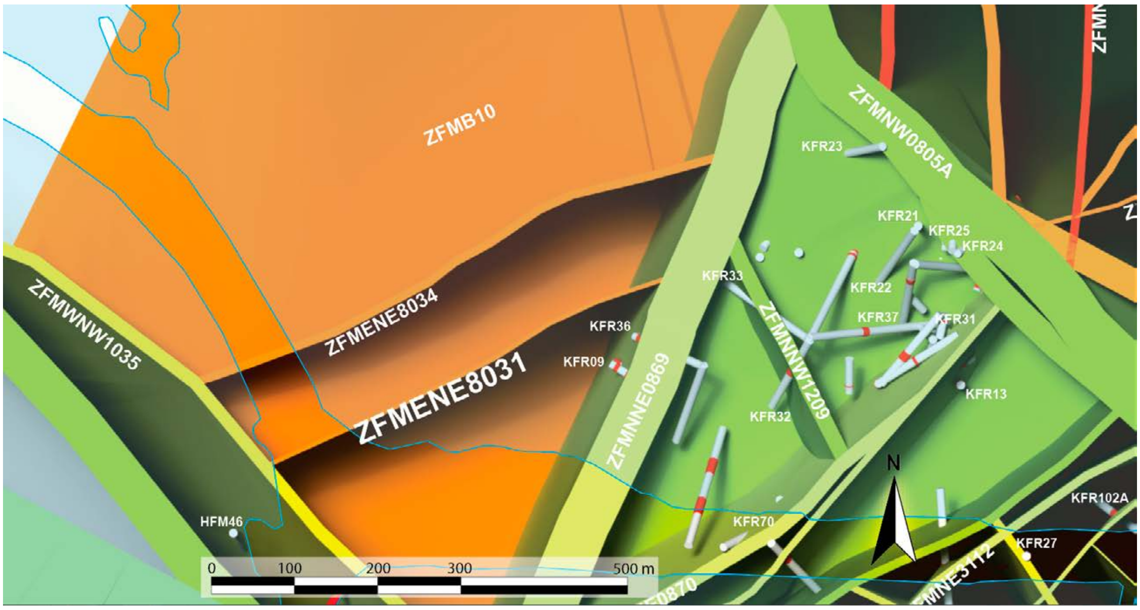
Zone based on surface lineaments and pattern of surrounding deformation zones.

Outcrops:	-	
Boreholes: -		
Tunnels:	-	
Lineament and/or seismic indications:	MSFR08031.	1

MODELLING PROCEDURE

The position of the zone at the ground surface is based on a modification of the SFR version 1.0 lineament MSFR08031. The DZ trace terminates at ZFMNNE0869 to the NE whereas the lineament extends further to the NE. However, the existence of a zone coupled with the lineament in this position is not supported by tunnel mapping. The DZ trace has a greater extent in the SW where it terminates at ZFMWNW1035, whereas the lineament ends at the general boundary of an area where the magnetic field is 'disturbed' and prevents further interpretation. The initial hypothesis was that the zone dips gently to moderately to the SE. However, any dip between 20 and 70 degrees to the SE would generate a significant intercept in the SFR tunnels and caverns as well as boreholes and nothing significant with such an orientation has been noted. The remaining alternatives are a subvertical to northwards dip. The zone has been modelled as vertical since there is no actual evidence for a northerly dip. Forward magnetic modelling has been performed along profiles 27, 28, 29 and 30 (see Appendix 6 in Curtis et al. 2011). The anomaly pattern is weak and the results have a high uncertainty. The clearest indicator is from profile 27 where the modelling supports a subvertical dip to the inferred zone. No real indications of orientation can be obtained from profile 28, while profiles 29 and 30 indicate a "slight dip towards the south-east" though the uncertainty is high. The inversion modelling gives no clear indications as regards orientation.

ENE	ZFMENE8031	Version number	4	Total object CL	10



OBJECT CONFIDENCE ESTIMATE

Category	Object CL	Comment
INTERPRETATION		
Data source	1	MSFR08031
Results of interpretation	1	Low confidence in lineament MSFR08031.
INFORMATION DENSITY		
Number of observation points	1	1
Distribution of observation points	1	Single observation point in the form of a lineament.
INTERPOLATION		
Geometry	1	Geometry supported by surface geophysical data.
Geological indicators	1	Indirect support by geophysical data.
EXTRAPOLATION		
Dip direction	1	No subsurface obs. point, supported only by surface data. High uncertainty in dip-direction. Strike length of the modelled zone < 2000 m.
Strike direction	3	Conceptual understanding of the site and that the entire modelled zone is supported by the lineament.

FRACTURE CHARACTER

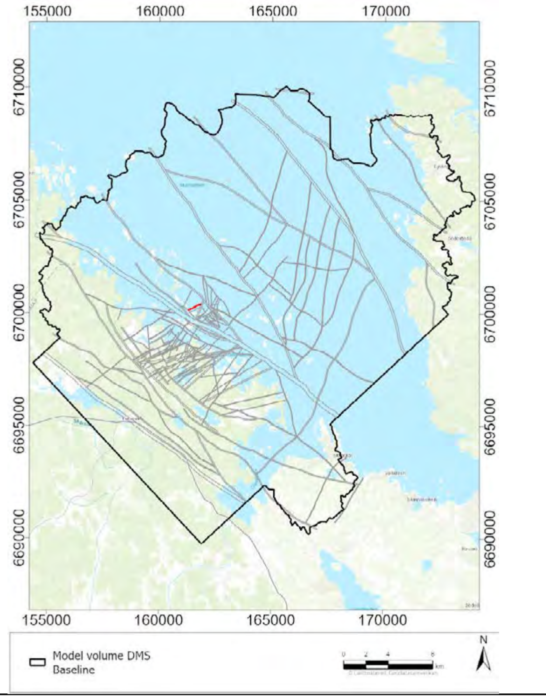
No data available

INDIVIDUAL INTERCEPTS

No data available

ENE	ZFMENE8034	Version number	4	Total object CL	10

GEOLOGICAL CHARACTER		Property CL
Deformation style:	Brittle	2
Deformation description:	No data available.	
Alteration:		
- First order:	Not observed	
- Second order:	Not observed	
- Third order:	Not observed	
Fracture orientation and type:	No data available.	
Fracture comment:	No data available.	
Fracture fill mineralogy:	No data available.	



OBJECT GEOMETRY	
Strike/dip:	69°/90°
Length:	683 m
Mean thickness:	10 m (2 - 36 m)
Max depth:	-680 m
Geometrical constraints:	ZFMNNE0869, ZFMWNW1035, ZFMNW0002, Topo 40m grid Max error 20m, 1 Surface Planar Cut(s).

BASIS FOR MODELLING

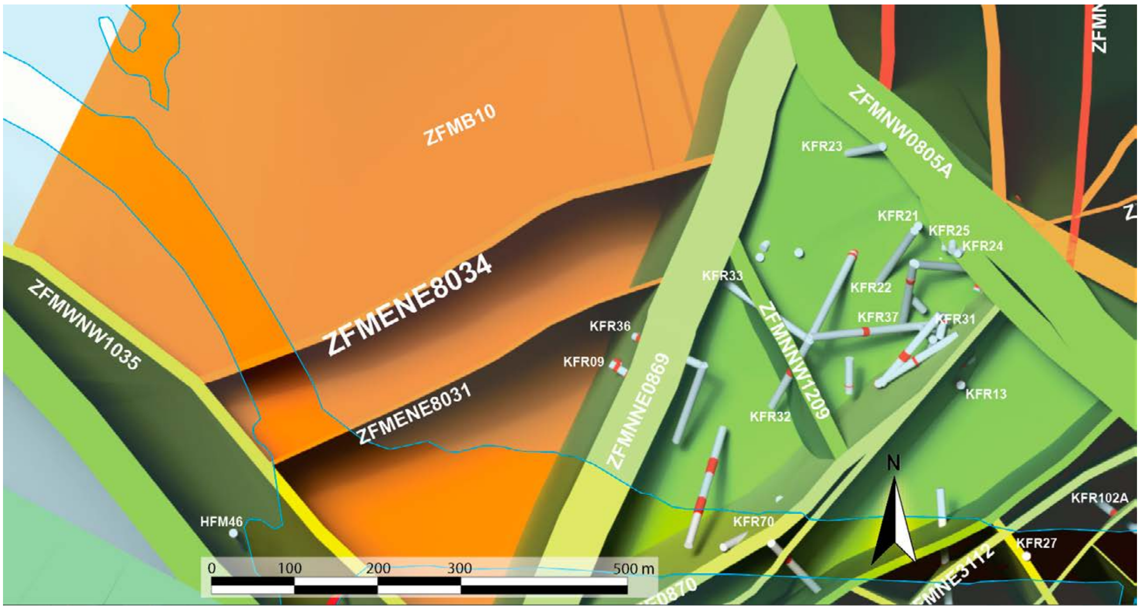
Zone based on surface lineaments and pattern of surrounding deformation zones.

Outcrops:	-	
Boreholes: -		
Tunnels:	-	
Lineament and/or seismic indications:	MSFR08034.	1

MODELLING PROCEDURE

In the early stage of the modelling work, the main supporting evidence for the inferred dip and general orientation of this zone was seismic reflector A1 Juhlin and Palm (2005). Subsequently, after the reprocessing of the seismic data Juhlin and Zhang (2010), the existence of this reflector to the north of the Singö zone has been discounted, in accordance with the interpretation already made in Forsmark model stage 2.2 (Stephens et al. 2007). Consequently the dip and detailed alignment of the zone were also revaluated. Attempts have been made, in combination with the interpretation of H1 and H3 Carlsson et al. (1985), to generate a sub-horizontal zone lying above the existing SFR facility. This geometry was not supported by the position of the lineament. Other dips to the south were also investigated but the main range would generate intercepts in the existing facility that are not supported by the tunnel and cavern geological mapping. Consequently, the zone has been modelled as vertical and is interpreted as being a member of the ENE sub-set with properties similar to the other zones in this sub-set.

ENE	ZFMENE8034	Version number	4	Total object CL	10



OBJECT CONFIDENCE ESTIMATE

Category	Object CL	Comment
INTERPRETATION		
Data source	1	MSFR08092
Results of interpretation	1	Low confidence in the lineament MSFR08092.
INFORMATION DENSITY		
Number of observation points	1	1
Distribution of observation points	1	Single observation point in the form of a lineament.
INTERPOLATION		
Geometry	1	Geometry supported by surface geophysical data.
Geological indicators	1	Indirect support by geophysical data.
EXTRAPOLATION		
Dip direction	1	No subsurface obs. point, supported only by surface data. High uncertainty in dip-direction. Strike length of the modelled zone < 2000 m.
Strike direction	3	Conceptual understanding of the site and that the entire modelled zone is supported by the lineament.

FRACTURE CHARACTER

No data available

INDIVIDUAL INTERCEPTS

No data available

G	ZFMF1	Version number	5	Total object CL	18

No figure available

GEOLOGICAL CHARACTER		Property CL
Deformation style:	Brittle	3
Deformation description:	Lower part of DZ6 in KFM02A show strike-slip or reverse dip slip displacements on the dominant gently dipping faults. Both dextral and sinistral strike-slip movement observed. Gently dipping faults along DZ5 in KFM02B show dip-slip displacement or oblique-slip displacement with significant reverse dip-slip component. Steeply dipping faults along DZ5 and DZ6 in KFM02B show strike-slip, sinistral strike-slip or oblique-slip with dextral normal displacement.	
Alteration:		3
- First order:	Oxidation	
- Second order:	Not observed	
- Third order:	Not observed	
Fracture orientation and type:	Fractures that dip gently to the south-east and south dominates. Sealed fractures dominates. Open and partly open fractures present as well as fracture networks and crush zones.	2
Fracture comment:	No data available.	
Fracture fill mineralogy:	Chlorite, calcite, hematite/adularia, prehnite, epidote, clay minerals, laumontite. Note also high frequency of fractures with no mineral coating/filling (in KFM02A).	

OBJECT GEOMETRY	
Strike/dip:	72°/10°
Length:	-
Mean thickness:	44 m (20 - 50 m)
Max depth:	-805 m
Geometrical constraints:	ZFMWNW0001, ZFMWNW0123, ZFMENE0062A, ZFMA3, 1 Surface Planar Cut(s).

BASIS FOR MODELLING

Zone based on surface lineaments and borehole observations. Corresponds to seismic reflector F1, the position of which in 3D space has been attained from Cosma et al. (2003). Modelled as a splay to ZFMA3.

Outcrops: -

Boreholes:

Borehole	PDZ	Target intercept		Geometric intercept		Comment
		Sec_up [m]	Sec_low [m]	Sec_up [m]	Sec_low [m]	
KFM02A	DZ6	476.00	520.00	475.67	519.43	SHI DZ divided into two separate zones at 417-442 m and 476-520 m (cf. Table 3-2 in Stephens et al. 2007). Fractured rock between 442 and 476 m inferred to be affected by DZ.
KFM02B	DZ5	462.00	512.00	472.03	515.63	
KFM02B	DZ6	462.00	512.00	472.03	515.63	

Tunnels:	-	
Lineament and/or seismic indications:	F1.	2

G	ZFMF1	Version number	5	Total object CL	18

MODELLING PROCEDURE

Corresponds to seismic reflector F1, the position of which in 3D space has been attained from Cosma et al. (2003). Modelled as a splay from ZFMA3 with termination also against ZFMWNW0001, ZFMENE0062A and ZFMWNW0123. Termination towards the north-west steered by the absence of this zone in especially borehole KFM05A. Deformation zone plane placed at fixed point 513 m along part of DZ6 (476-520 m) in KFM02A. The modelled zone also intersects KFM02B along the lower part of DZ5, along DZ6 and along the rock interval between these two inferred zones. Low radar amplitude also observed at 514-518 m in KFM02A.

No figure available.

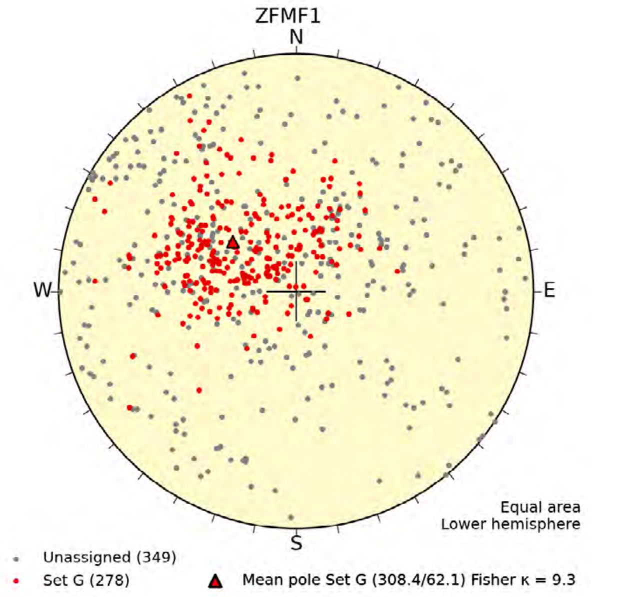
OBJECT CONFIDENCE ESTIMATE

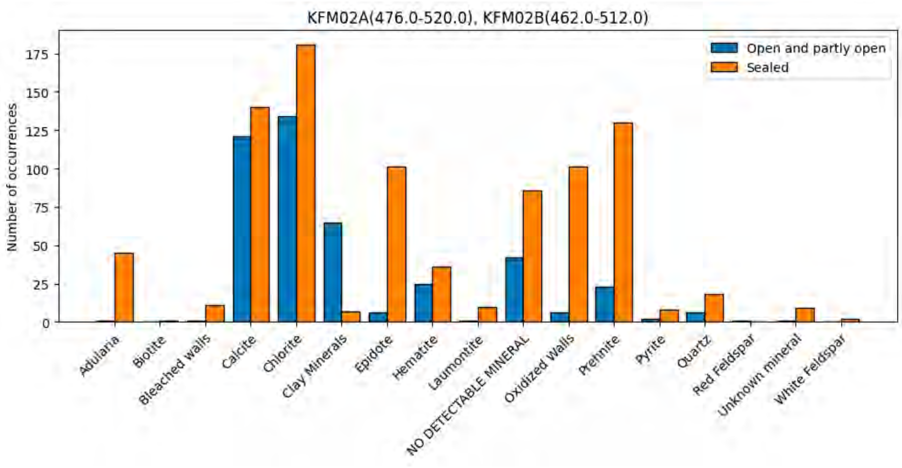
Category	Object CL	Comment
INTERPRETATION		
Data source	2	F1, KFM02A, KFM02B
Results of interpretation	3	High confidence observations in multiple boreholes.
INFORMATION DENSITY		
Number of observation points	2	2
Distribution of observation points	1	Two subsurface obs. points only ca. 50 m apart. However, the zone is modelled more than 3000 m in horizontal direction.
INTERPOLATION		
Geometry	3	Geometry supported by multiple subsurface obs. points.
Geological indicators	3	Interpolation supported by key geological parameters, foremost fracture orientation pattern.
EXTRAPOLATION		
Dip direction	2	Extrapolated based on information from seismic reflector F1. Truncated by steeply dipping zones ZFMWNW0001, ZFMWNW0123, ZFMENE0062A, ZFMA3.
Strike direction	2	Extrapolated and modelled based on information from seismic reflector F1. Truncated by steeply dipping zones ZFMWNW0001, ZFMWNW0123, ZFMENE0062A, ZFMA3.

FRACTURE CHARACTER

Orientation: (strike/dip right-hand-rule)	Set G: 38.4°/27.9°
Frequency:	Boreholes: KFM02B, KFM02A
RQD:	min:1, max:100, mean:94

FRACTURE TYPE	TERZAGHI-WEIGHED P10
Open and partly open	4.4 m-1
Sealed	11.4 m-1
Sealed network	5.5 % of DZ intercept
Crush	0.6 % of DZ intercept



<table>
<tr><td>G</td><td>ZFMF1</td><td>Version number</td><td>5</td><td>Total object CL</td><td>18</td></tr>
<tr><td>Fracture fill mineralogy:</td><td colspan="5">
</td></tr>
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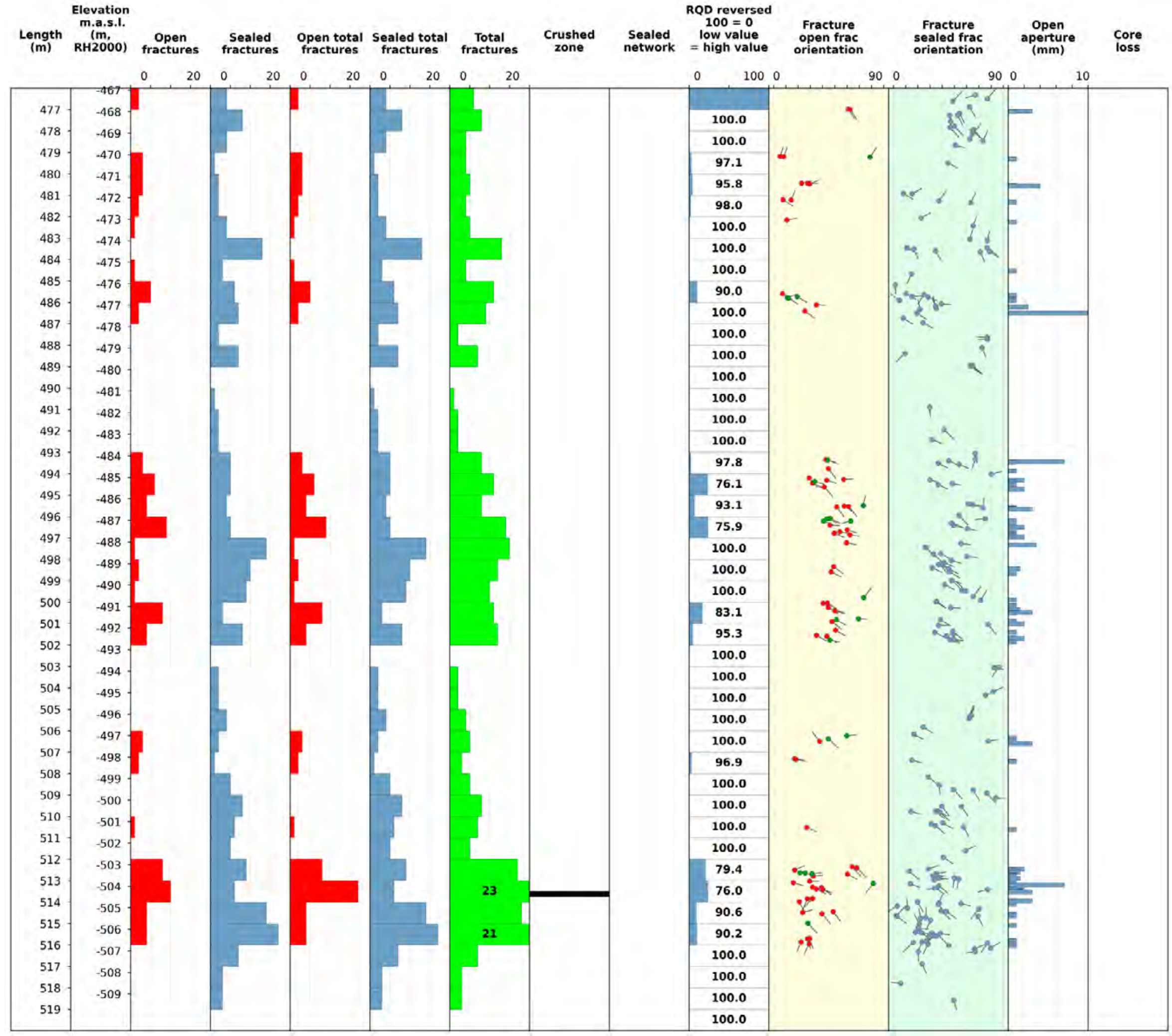
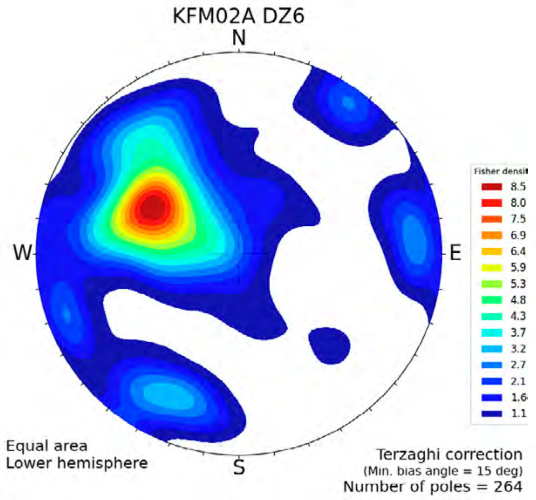
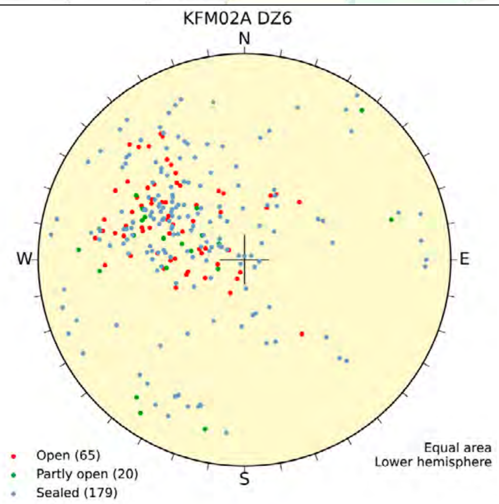
G	ZFMF1	Version number	5	Total object CL	18

INDIVIDUAL INTERCEPTS

KFM02A DZ6 (476.0-520.0 m)

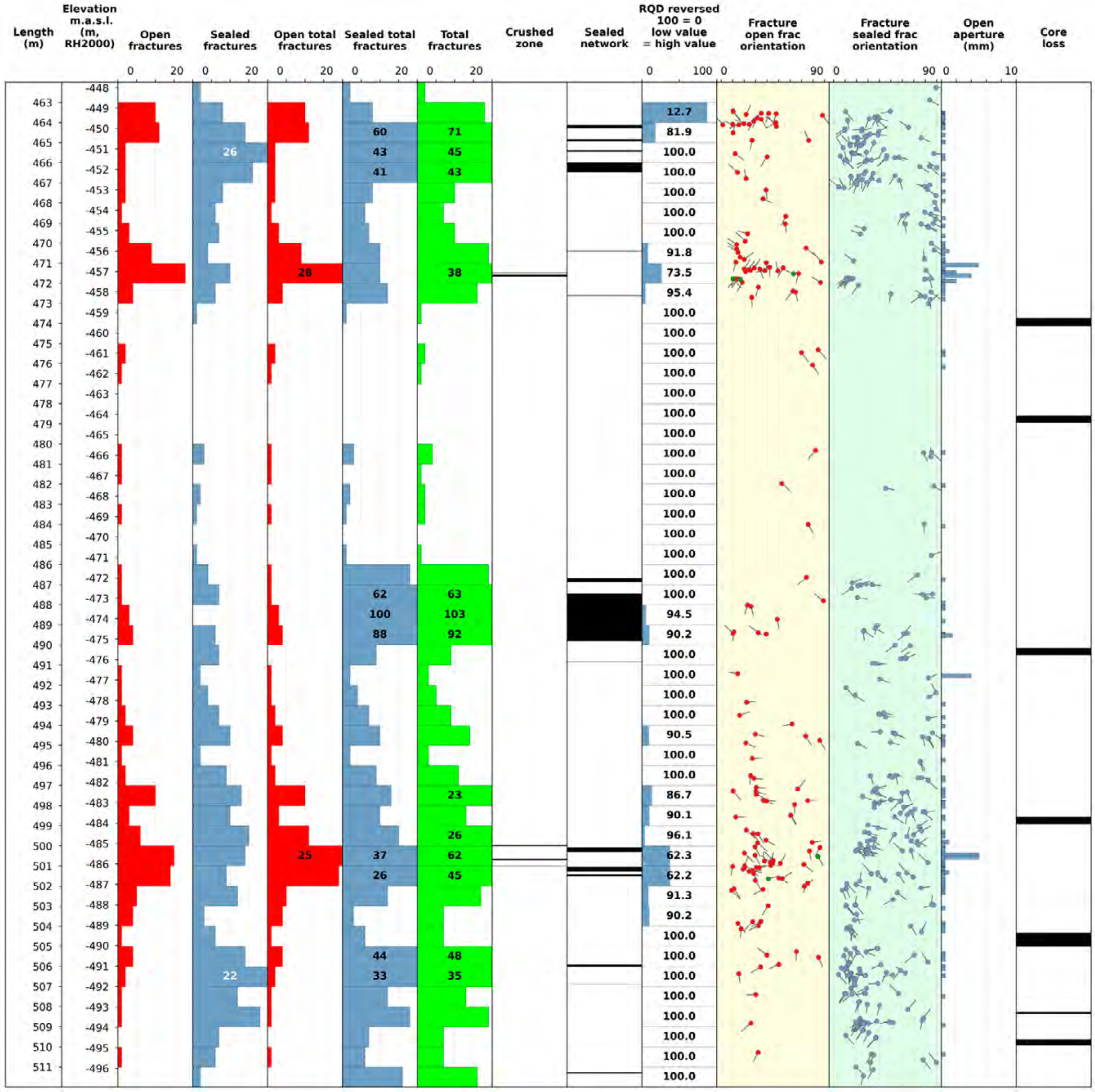


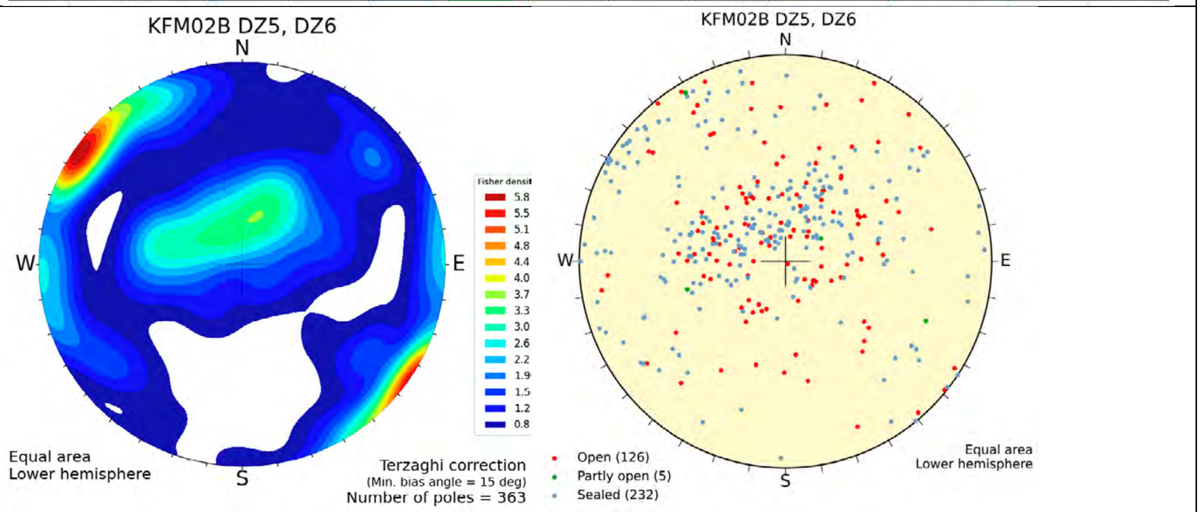




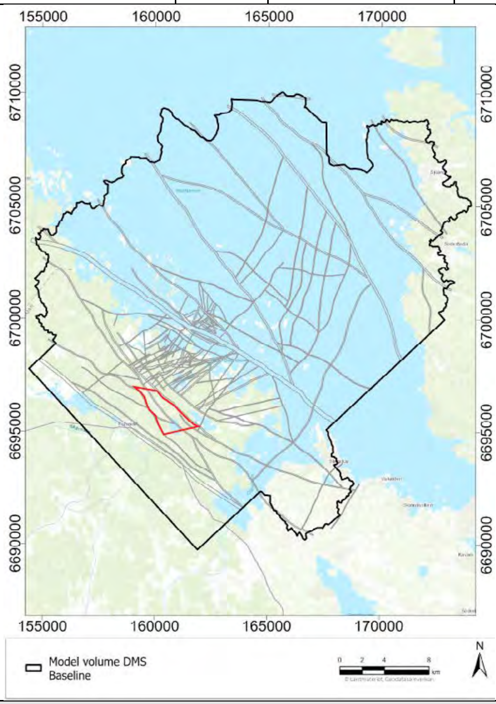
G	ZFMF1	Version number	5	Total object CL	18

KFM02B DZ5, DZ6 (462.0-512.0 m)





G	ZFMJ1		Version number	7	Total object CL	10
GEOLOGICAL CHARACTER		**Property CL**				
Deformation style:	Brittle	1				
Deformation description:	No data available.					
Alteration:						
- First order:	Not observed					
- Second order:	Not observed					
- Third order:	Not observed					
Fracture orientation and type:	No data available.					
Fracture comment:	No data available.					
Fracture fill mineralogy:	No data available.					
OBJECT GEOMETRY						
Strike/dip:	120°/45°					
Length:	-					
Mean thickness:	15 m (6 - 32 m)					
Max depth:	-1684 m					
Geometrical constraints:	ZFMNW0029, ZFMNW0036, ZFMNW0017, 1 UNIVERSE Planar Cut(s).					



BASIS FOR MODELLING		
Corresponds to seismic reflector J1, the position of which in 3D space has been attained from Cosma et al. (2006). based on seismic reflector and pattern of surrounding steeply dipping zones.		
Outcrops:	-	
Boreholes: -		
Tunnels:	-	
Lineament and/or seismic indications:	J1.	3

MODELLING PROCEDURE

Corresponds to seismic reflector J1, the position of which in 3D space has been attained from Cosma et al. (2006). Terminated against ZFMNW0017, ZFMNW0029 and ZFMWNW0036.

G	ZFMJ1	Version number	7	Total object CL	10

OBJECT CONFIDENCE ESTIMATE

Category	Object CL	Comment
INTERPRETATION		
Data source	1	J1
Results of interpretation	3	High confidence in the seismic reflector J1.
INFORMATION DENSITY		
Number of observation points	1	1
Distribution of observation points	1	Single observation point in the form of a seismic reflector.
INTERPOLATION		
Geometry	1	Geometry supported by surface geophysical data.
Geological indicators	1	Indirect support by geophysical data.
EXTRAPOLATION		
Dip direction	1	Extrapolated based on information from seismic reflector J1. Truncated by steeply dipping zones ZZFMNW0029 ZFMNW003, ZFMNW0017.
Strike direction	1	Extrapolated and modelled based on information from seismic reflector J1. Truncated by steeply dipping zones ZZFMNW0029 ZFMNW003, ZFMNW0017.

FRACTURE CHARACTER

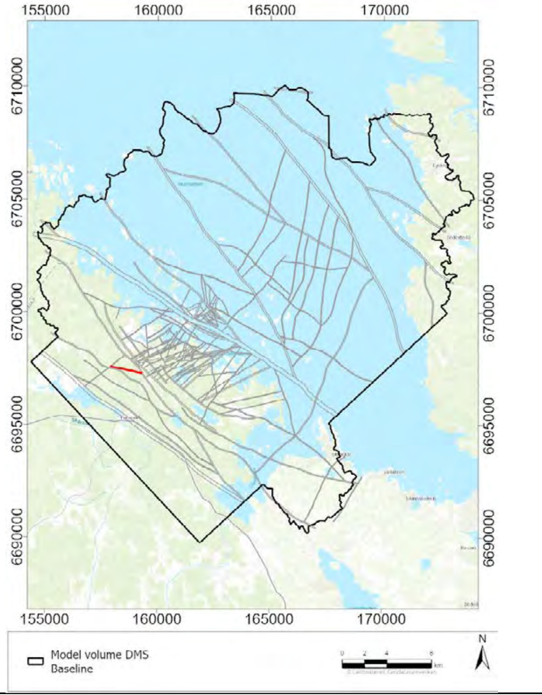
No data available

INDIVIDUAL INTERCEPTS

No data available

G	ZFMJ2	Version number	4	Total object CL	10

GEOLOGICAL CHARACTER		Property CL
Deformation style:	Brittle	1
Deformation description:	No data available.	
Alteration:		
- First order:	Not observed	
- Second order:	Not observed	
- Third order:	Not observed	
Fracture orientation and type:	No data available.	
Fracture comment:	No data available.	
Fracture fill mineralogy:	No data available.	
OBJECT GEOMETRY		
Strike/dip:	102°/37°	
Length:	1430 m	
Mean thickness:	15 m (6 - 32 m)	
Max depth:	-1545 m	
Geometrical constraints:	ZFMNW0003, ZFMWNW0004, ZFMK1, Topo 40m grid Max error 20m, 1 UNIVERSE Planar Cut(s).	



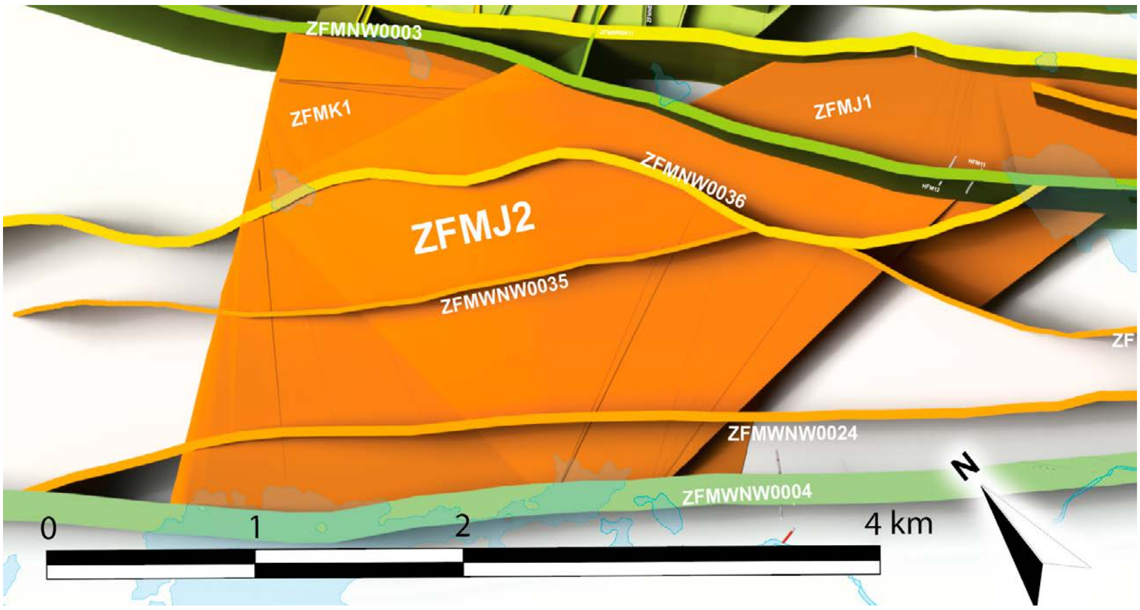
BASIS FOR MODELLING

Corresponds to seismic reflector J2, the position of which in 3D space has been attained from Cosma et al. (2006). based on seismic reflector and pattern of surrounding steeply dipping zones.

Outcrops:	-	
Boreholes: -		
Tunnels:	-	
Lineament and/or seismic indications:	J2.	3

MODELLING PROCEDURE

Corresponds to seismic reflector J2, the position, of which in 3D space has been attained from Cosma et al. (2006). Terminated against ZFMNW0003, ZFMWNW0004 and ZFMK1.



G	ZFMJ2	Version number	4	Total object CL	10

OBJECT CONFIDENCE ESTIMATE

Category	Object CL	Comment
INTERPRETATION		
Data source	1	J2
Results of interpretation	3	High confidence in the seismic reflector J2.
INFORMATION DENSITY		
Number of observation points	1	1
Distribution of observation points	1	Single observation point in the form of a seismic reflector.
INTERPOLATION		
Geometry	1	Geometry supported by surface geophysical data.
Geological indicators	1	Indirect support by geophysical data.
EXTRAPOLATION		
Dip direction	1	Extrapolated based on information from seismic reflector J2. Truncated by steeply and gently dipping zones ZFMNW0003, ZFMWNW0004, ZFMK1.
Strike direction	1	Extrapolated and modelled based on information from seismic reflector J2. Truncated by steeply and gently dipping zones ZFMNW0003, ZFMWNW0004, ZFMK1.

FRACTURE CHARACTER

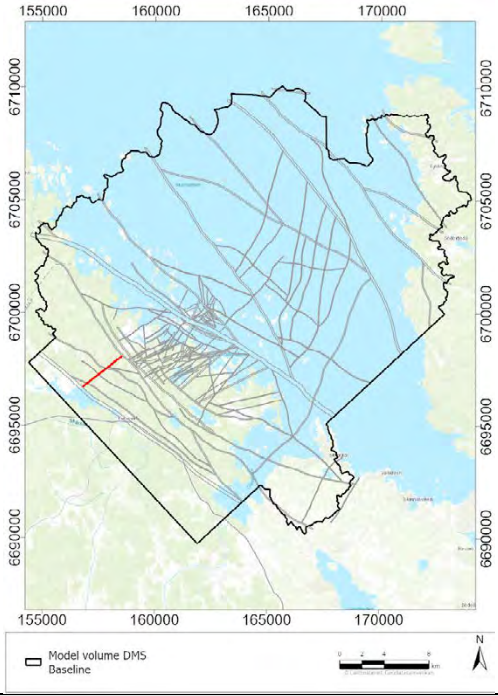
No data available

INDIVIDUAL INTERCEPTS

No data available

G	ZFMK1	Version number	3	Total object CL	11

GEOLOGICAL CHARACTER		Property CL
Deformation style:	Brittle	1
Deformation description:	No data available.	
Alteration:		
- First order:	Not observed	
- Second order:	Not observed	
- Third order:	Not observed	
Fracture orientation and type:	No data available.	
Fracture comment:	No data available.	
Fracture fill mineralogy:	No data available.	



OBJECT GEOMETRY	
Strike/dip:	52°/40°
Length:	2333 m
Mean thickness:	15 m (6 - 32 m)
Max depth:	-2100 m
Geometrical constraints:	ZFMWNW0004, ZFMNW0003, Topo 40m grid Max error 20m.

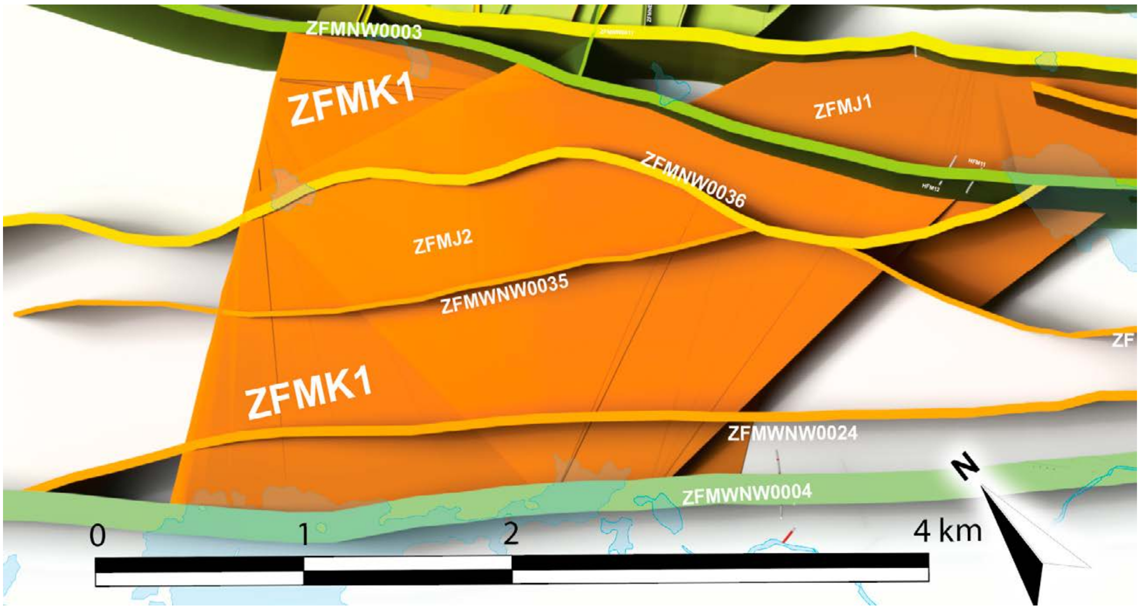
BASIS FOR MODELLING

Corresponds to seismic reflector K1, the position of which in 3D space has been attained from Cosma et al. (2006). based on seismic reflector and pattern of surrounding steeply dipping zones.

Outcrops:	-	
Boreholes: -		
Tunnels:	-	
Lineament and/or seismic indications:	K1.	3

MODELLING PROCEDURE

Corresponds to seismic reflector K1, the, position of which in 3D space has been attained from Cosma et al., (2006). Modelled to the base of the model volume with termination, against ZFMNW003 and ZFMWNW0004.



G	ZFMK1	Version number	3	Total object CL	11

OBJECT CONFIDENCE ESTIMATE

Category	Object CL	Comment
INTERPRETATION		
Data source	1	K1
Results of interpretation	3	High confidence in the seismic reflector K1.
INFORMATION DENSITY		
Number of observation points	1	1
Distribution of observation points	1	Single observation point in the form of a seismic reflector.
INTERPOLATION		
Geometry	1	Geometry supported by surface geophysical data.
Geological indicators	1	Indirect support by geophysical data.
EXTRAPOLATION		
Dip direction	1	Extrapolated and modelled based on information from seismic reflector K1. Truncated against steeply dipping zones ZFMNW0003, ZFMWNW0004. Open-ended in downdip direction.
Strike direction	2	Conceptual constraints. Truncated against steeply dipping zones ZFMNW0003, ZFMWNW0004.

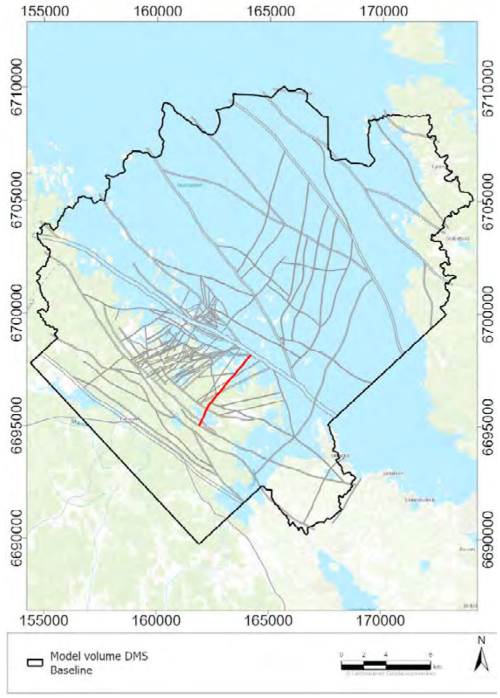
FRACTURE CHARACTER

No data available

INDIVIDUAL INTERCEPTS

No data available

NE	ZFMNE0065		Version number	3	Total object CL	17



GEOLOGICAL CHARACTER		Property CL
Deformation style:	Brittle	3
Deformation description:	No data available.	
Alteration:		3
- First order:	Oxidation	
- Second order:	Not observed	
- Third order:	Not observed	
Fracture orientation and type:	Fractures with both steep and gentle dips to the south-east dominates. Gently dipping fractures are highly variable in orientation. Dominance of open fractures followed by sealed and partly open. Quantitative estimate and span include sealed fracture networks.	1
Fracture comment:	No data available.	
Fracture fill mineralogy:	Chlorite, calcite, quartz.	

OBJECT GEOMETRY	
Strike/dip:	38°/70°
Length:	4003 m
Mean thickness:	26 m (15 - 64 m)
Max depth:	-2100 m
Geometrical constraints:	ZFMWNW0019, ZFMWNW0001, Topo 40m grid Max error 20m.

BASIS FOR MODELLING

Zone based on surface lineaments and borehole observations.

Outcrops:	-

Boreholes:

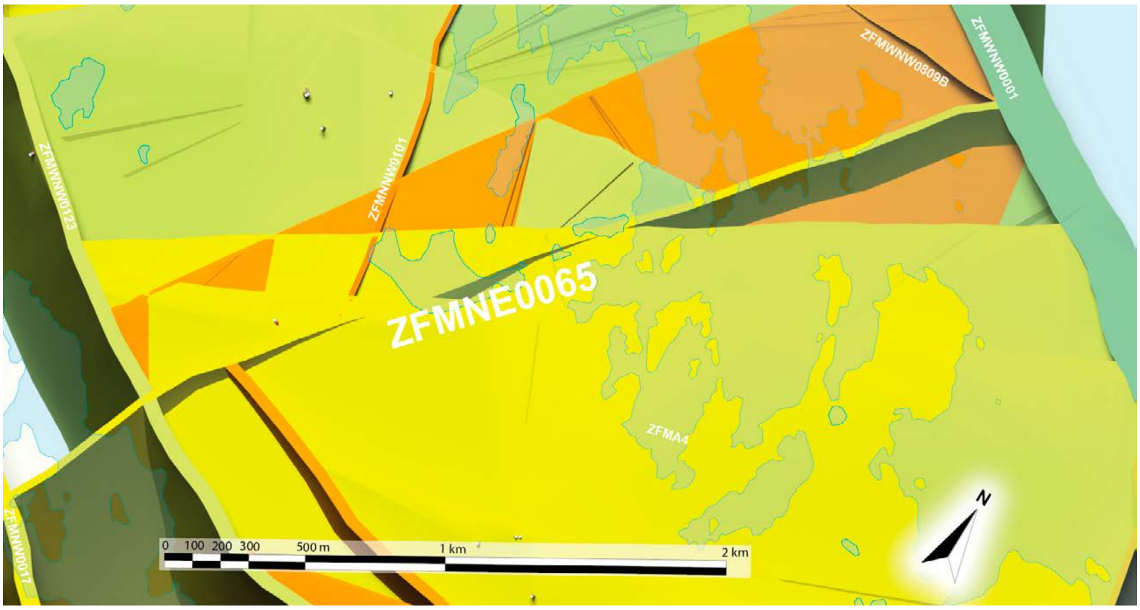
Borehole	PDZ	Target intercept		Geometric intercept		Comment
		Sec_up [m]	Sec_low [m]	Sec_up [m]	Sec_low [m]	
HFM18	DZ3	119.00	148.00	119.11	147.59	ZFMA7 also intersects DZ3.
HFM26		161.00	202.70	158.36	202.67	Target intercept defined by RU2. Geophysical signature similar to that observed in vuggy granite along other boreholes.

Tunnels:	-	
Lineament and/or seismic indications:	MFM0065.	3

MODELLING PROCEDURE

At the surface, corresponds to the low magnetic lineament MFM0065. Modelled to the base of the model volume, using the dip estimated by connecting lineament MFM0065 with the borehole intersections 119-148 m in HFM18 (DZ3) and 161-203 m in HFM26 (RU2 with altered, red-stained bedrock). Deformation zone plane placed at fixed points 144 m in HFM18 and 165 m in HFM26. The gently dipping zone ZFMA7 is also modelled to intersect borehole HFM18 along DZ3. For this reason, there are difficulties to separate the influence of zones ZFMNE0065 and ZFMA7 along this borehole interval.

NE	ZFMNE0065	Version number	3	Total object CL	17

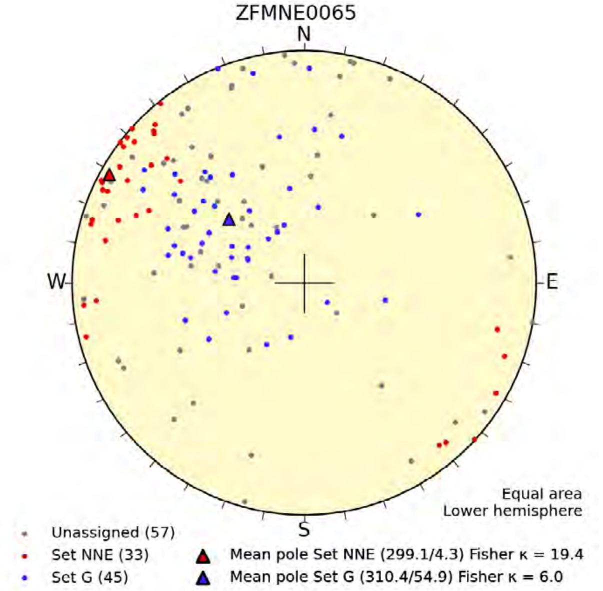


OBJECT CONFIDENCE ESTIMATE

Category	Object CL	Comment
INTERPRETATION		
Data source	2	MFM0065A0, HFM18, HFM26
Results of interpretation	3	High confidence observation in HFM18.
INFORMATION DENSITY		
Number of observation points	2	2
Distribution of observation points	2	Two intercepts c. > 500m in between and the lineament considered as an outlier. Three scattered observation points.
INTERPOLATION		
Geometry	1	Surface and two sub. surface observation point (zone not defined by SHI of HFM26) do not lend much support for interpolation alternatives.
Geological indicators	1	Single observation point at depth. Zone modelled mainly based on surface geophysical data.
EXTRAPOLATION		
Dip direction	3	Extrapolated to the base of the model volume. Strike length of the modelled zone > 2000 m.
Strike direction	3	Conceptual understanding of the site and that the entire modelled zone is supported by the lineament.

NE	ZFMNE0065	Version number	3	Total object CL	17

FRACTURE CHARACTER

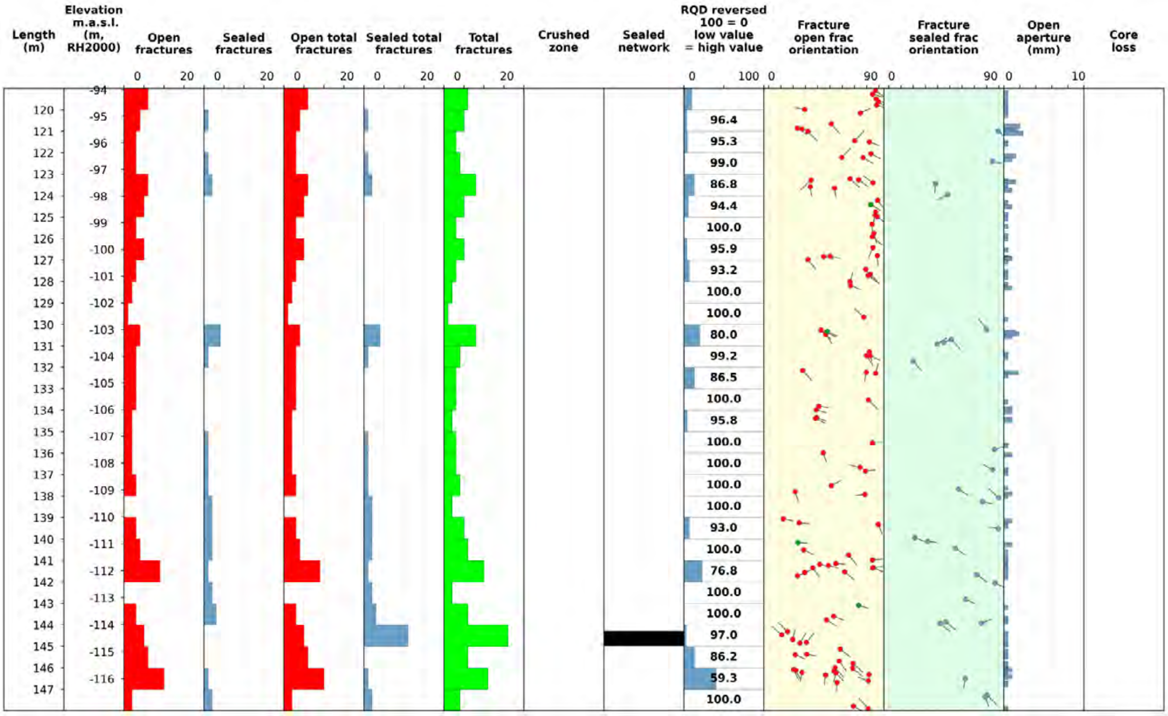
Orientation: (strike/dip right-hand-rule)	Set NNE: 29.1°/85.7° Set G: 40.4°/35.1°	
Frequency:	Boreholes: -	
RQD:	--	
Fracture fill mineralogy:	No data available	

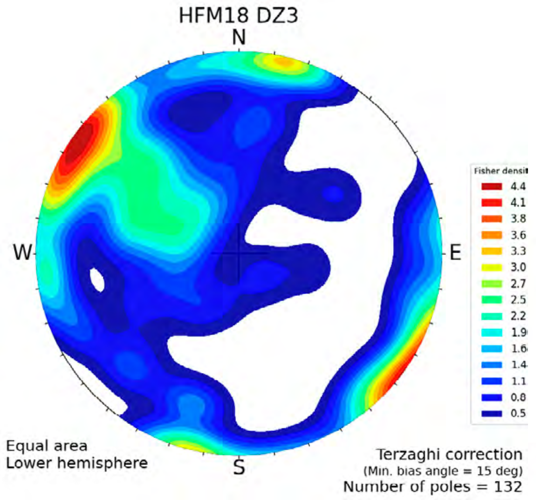
FRACTURE TYPE	TERZAGHI-WEIGHED P10
Open and partly open	0.0 m-1
Sealed	0.0 m-1
Sealed network	0.0 % of DZ intercept
Crush	0.0 % of DZ intercept

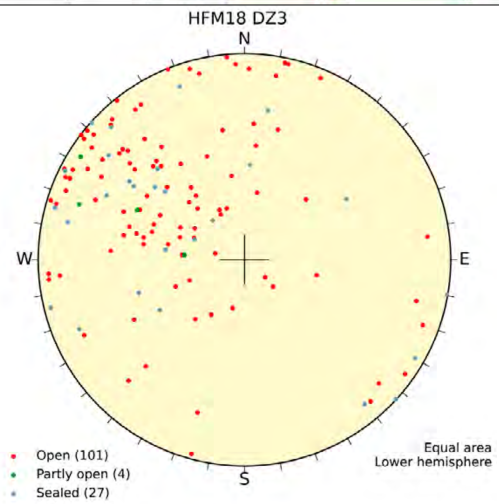
NE	ZFMNE0065	Version number	3	Total object CL	17

INDIVIDUAL INTERCEPTS

HFM18 DZ3 (119.0-148.0 m)

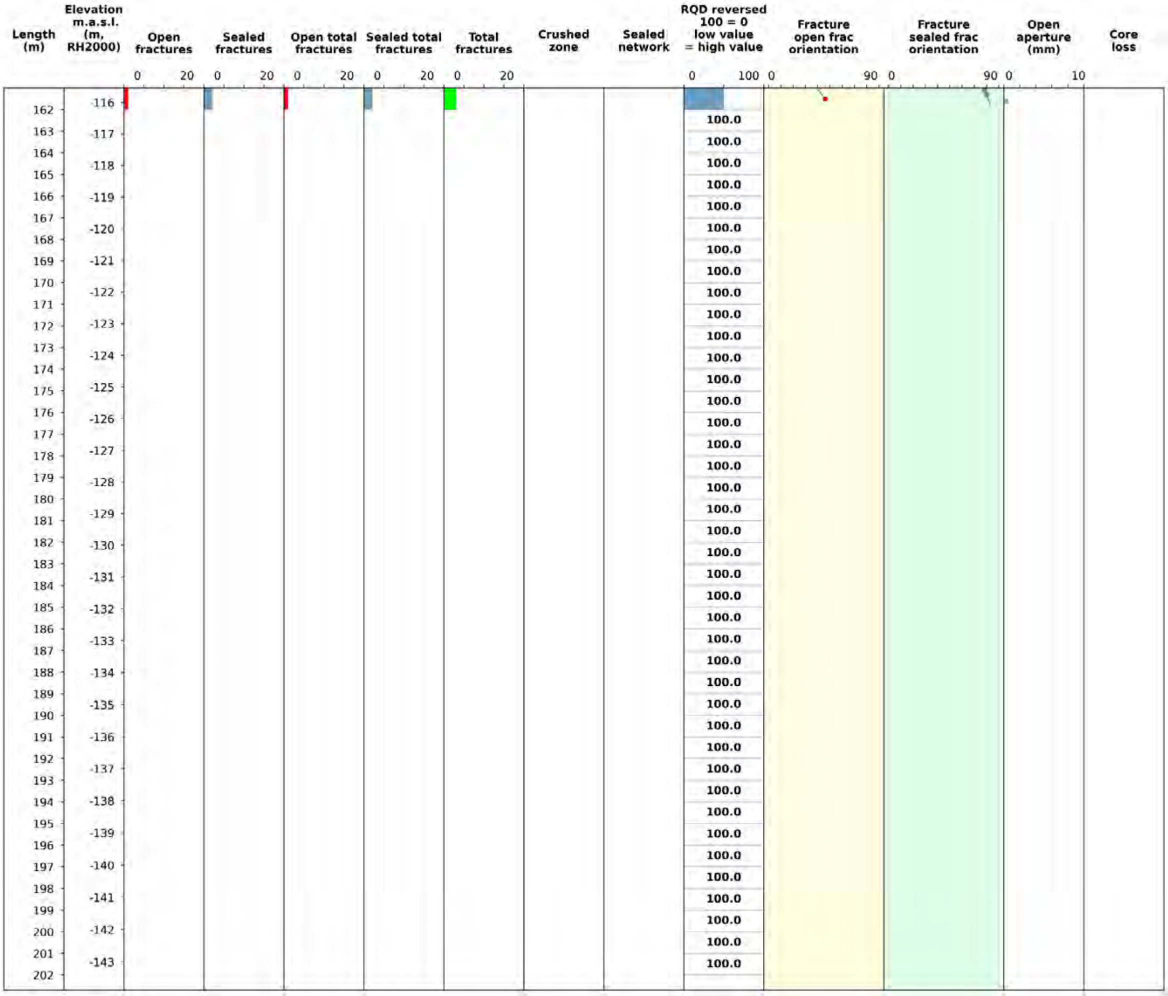


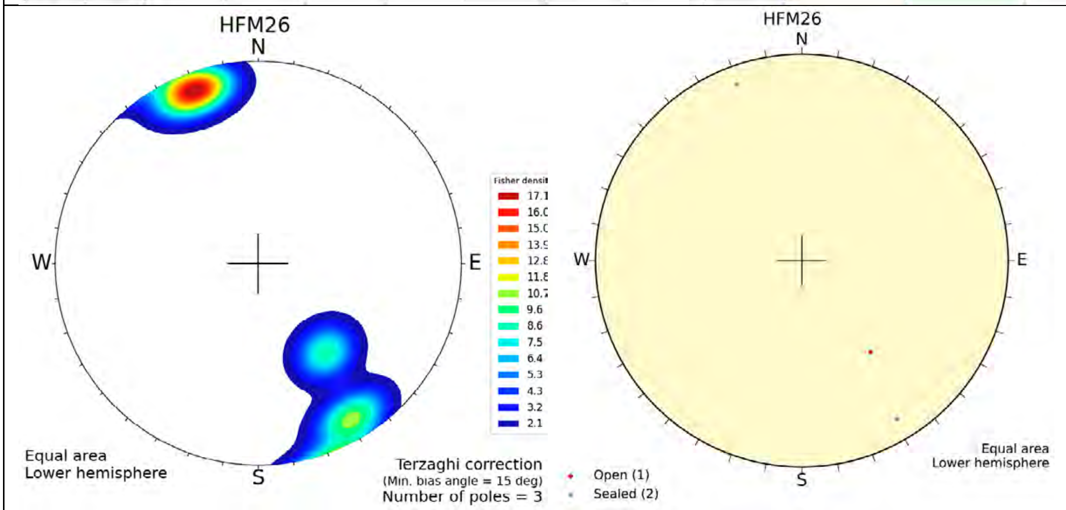




NE	ZFMNE0065	Version number	3	Total object CL	17

HFM26 (161.0-202.7 m)

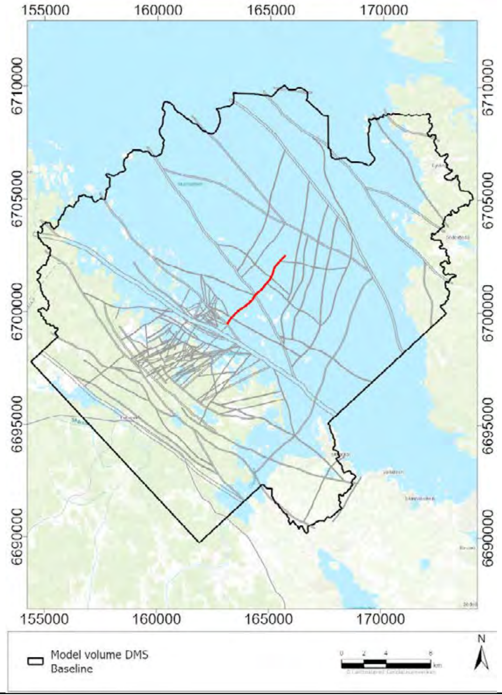




NE	ZFMNE0808A	Version number	4	Total object CL	14

GEOLOGICAL CHARACTER		Property CL
Deformation style:	Brittle	1
Deformation description:	No data available.	
Alteration:		2
- First order:	Oxidation	
- Second order:	Not observed	
- Third order:	Not observed	
Fracture orientation and type:	No data available.	
Fracture comment:	No data available.	
Fracture fill mineralogy:	No data available.	

OBJECT GEOMETRY	
Strike/dip:	220°/80°
Length:	4077 m
Mean thickness:	30 m (15 - 64 m)
Max depth:	-2100 m
Geometrical constraints:	ZFMNW0805A, Topo 40m grid Max error 20m, 1 UNIVERSE Planar Cut(s).



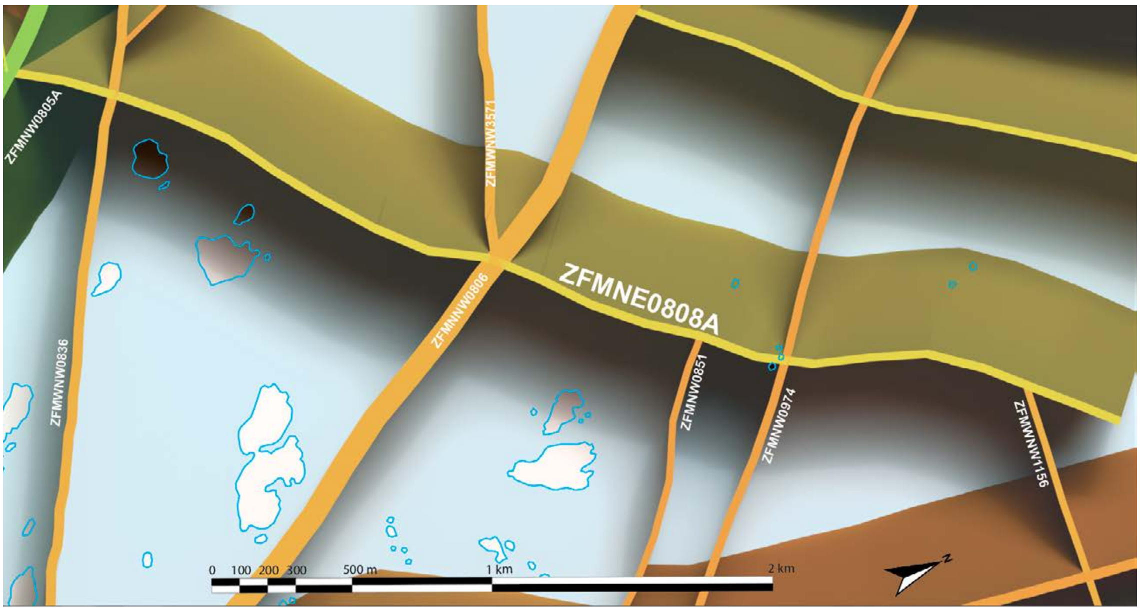
BASIS FOR MODELLING

Zone based on surface lineaments. Zone ZFMNE0808 consists of several segments, ZFMNE0808A and ZFMNE0808B and ZFMNE0808C, judged to constitute elements of one and the same structure.

Outcrops:	-	
Boreholes: -		
Tunnels:	-	
Lineament and/or seismic indications:	MFM0808A0.	3

MODELLING PROCEDURE

Zone ZFMNE0808 consists of different segments, the most prominent of which is denoted ZFMNE0808A. These segments are judged to constitute elements of one and the same structure. At the surface, corresponds to the low magnetic lineaments MFM0808A0, MFM0808B0 and MFM0808C0. Modelled to the base of the model volume with a dip of 80 degrees to the NW based on comparison with high confidence, steeply dipping zones with NNE strike.



NE	ZFMNE0808A	Version number	4	Total object CL	14

OBJECT CONFIDENCE ESTIMATE

Category	Object CL	Comment
INTERPRETATION		
Data source	1	MFM0808A
Results of interpretation	3	High confidence in the lineament MFM0808A.
INFORMATION DENSITY		
Number of observation points	1	1
Distribution of observation points	1	Single observation point in the form of a lineament.
INTERPOLATION		
Geometry	1	Geometry supported by surface geophysical data.
Geological indicators	1	Indirect support by geophysical data.
EXTRAPOLATION		
Dip direction	3	Extrapolated to the base of the model volume. Strike length of the modelled zone > 2000 m.
Strike direction	3	Conceptual understanding of the site and that the entire modelled zone is supported by the lineament.

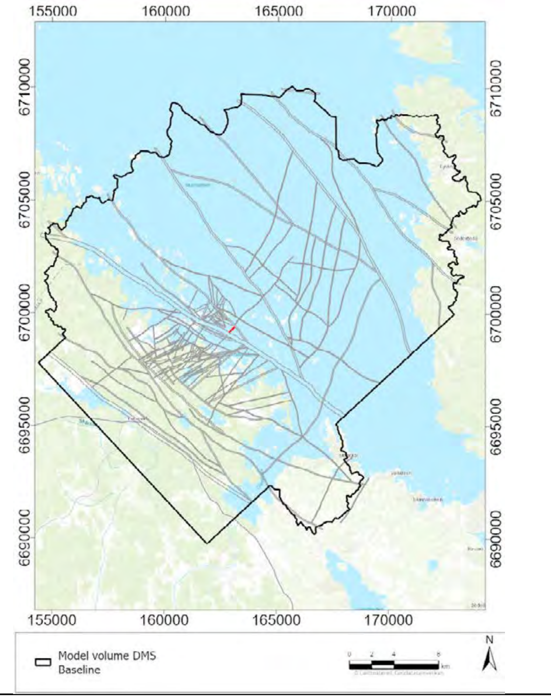
FRACTURE CHARACTER

No data available

INDIVIDUAL INTERCEPTS

No data available

NE	ZFMNE0808B		Version number	3	Total object CL	14
GEOLOGICAL CHARACTER		**Property CL**				
Deformation style:	Brittle	1				
Deformation description:	No data available.					
Alteration:						
- First order:	Oxidation	2				
- Second order:	Not observed					
- Third order:	Not observed					
Fracture orientation and type:	No data available.					
Fracture comment:	No data available.					
Fracture fill mineralogy:	No data available.					



OBJECT GEOMETRY	
Strike/dip:	228°/80°
Length:	488 m
Mean thickness:	10 m (1 - 13 m)
Max depth:	-2100 m
Geometrical constraints:	ZFMNW0805A, ZFMWNW0001, Topo 40m grid Max error 20m.

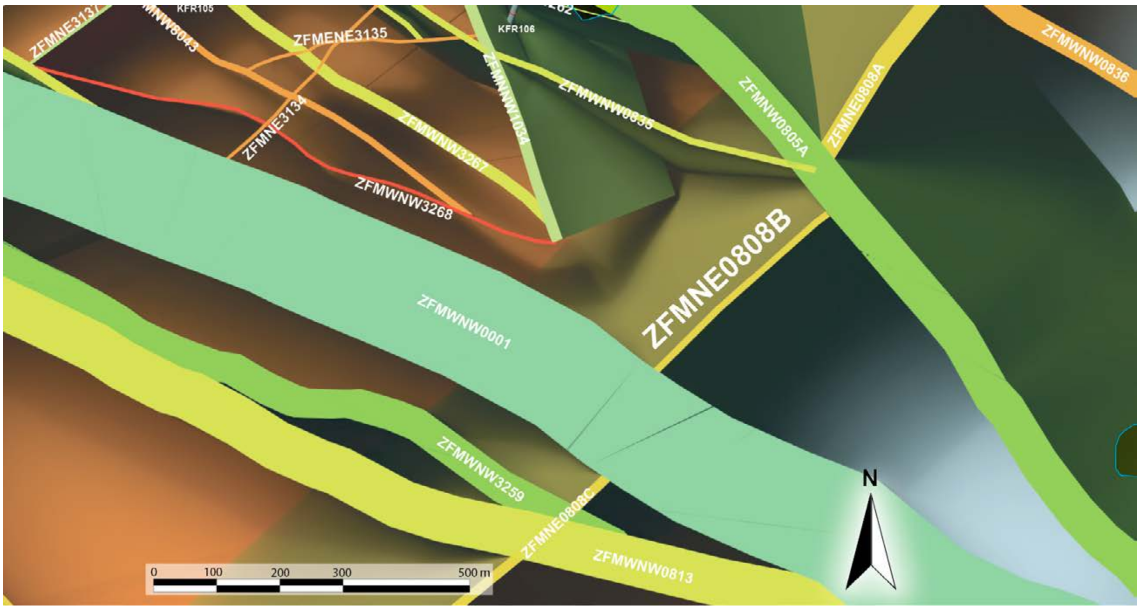
BASIS FOR MODELLING

Zone based on surface lineaments. Zone ZFMNE0808 consists of several segments, ZFMNE0808A and ZFMNE0808B and ZFMNE0808C, judged to constitute elements of one and the same structure.

Outcrops:	-	
Boreholes: -		
Tunnels:	-	
Lineament and/or seismic indications:	MFM0808B0.	3

MODELLING PROCEDURE

Zone ZFMNE0808 consists of different segments, the most prominent of which is denoted ZFMNE0808A. These segments are judged to constitute elements of one and the same structure. At the surface, corresponds to the low magnetic lineaments MFM0808A0, MFM0808B0 and MFM0808C0. Modelled to the base of the model volume with a dip of 80 degrees to the NW based on comparison with high confidence, steeply dipping zones with NNE strike.



NE	ZFMNE0808B	Version number	3	Total object CL	14

OBJECT CONFIDENCE ESTIMATE

Category	**Object CL**	**Comment**
INTERPRETATION		
Data source	1	MFM0808B
Results of interpretation	3	High confidence in the lineament MFM0808B.
INFORMATION DENSITY		
Number of observation points	1	1
Distribution of observation points	1	Single observation point in the form of a lineament.
INTERPOLATION		
Geometry	1	Geometry supported by surface geophysical data.
Geological indicators	1	Indirect support by geophysical data.
EXTRAPOLATION		
Dip direction	3	Extrapolated to the base of the model volume. Strike length of the modelled zone > 2000 m.
Strike direction	3	Conceptual understanding of the site and that the entire modelled zone is supported by the lineament.

FRACTURE CHARACTER

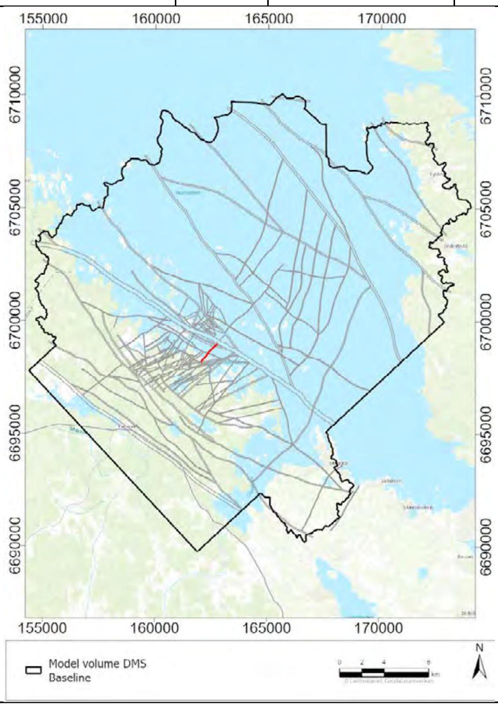
No data available

INDIVIDUAL INTERCEPTS

No data available

NE	ZFMNE0808C	Version number	4	Total object CL	14

GEOLOGICAL CHARACTER		Property CL
Deformation style:	Brittle	1
Deformation description:	No data available.	
Alteration:		2
- First order:	Oxidation	
- Second order:	Not observed	
- Third order:	Not observed	
Fracture orientation and type:	No data available.	
Fracture comment:	No data available.	
Fracture fill mineralogy:	No data available.	
OBJECT GEOMETRY		
Strike/dip:	222°/80°	
Length:	1179 m	
Mean thickness:	15 m (3 - 50 m)	
Max depth:	-2100 m	
Geometrical constraints:	ZFMWNW0001, Topo 40m grid Max error 20m, 1 UNIVERSE Planar Cut(s).	



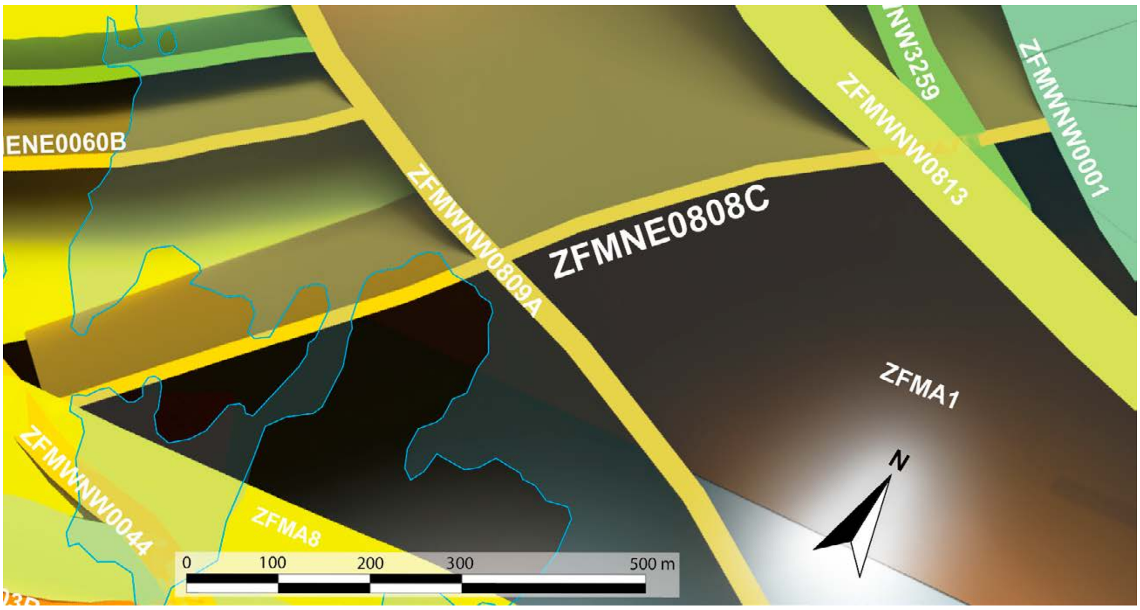
BASIS FOR MODELLING

Zone based on surface lineaments. Zone ZFMNE0808 consists of several segments, ZFMNE0808A and ZFMNE0808B and ZFMNE0808C, judged to constitute elements of one and the same structure.

Outcrops:	-	
Boreholes: -		
Tunnels:	-	
Lineament and/or seismic indications:	MFM0808C0.	3

MODELLING PROCEDURE

Zone ZFMNE0808 consists of different segments, the most prominent of which is denoted ZFMNE0808A. These segments are judged to constitute elements of one and the same structure. At the surface, corresponds to the low magnetic lineaments MFM0808A0, MFM0808B0 and MFM0808C0. Modelled to the base of the model volume with a dip of 80 degrees to the NW based on comparison with high confidence, steeply dipping zones with NNE strike.



NE	ZFMNE0808C	Version number	4	Total object CL	14

OBJECT CONFIDENCE ESTIMATE

Category	Object CL	Comment
INTERPRETATION		
Data source	1	MFM0808C
Results of interpretation	3	High confidence in the lineament MFM0808C.
INFORMATION DENSITY		
Number of observation points	1	1
Distribution of observation points	1	Single observation point in the form of a lineament.
INTERPOLATION		
Geometry	1	Geometry supported by surface geophysical data.
Geological indicators	1	Indirect support by geophysical data.
EXTRAPOLATION		
Dip direction	3	Extrapolated to the base of the model volume. Strike length of the modelled zone > 2000 m.
Strike direction	3	Conceptual understanding of the site and that the entire modelled zone is supported by the lineament.

FRACTURE CHARACTER

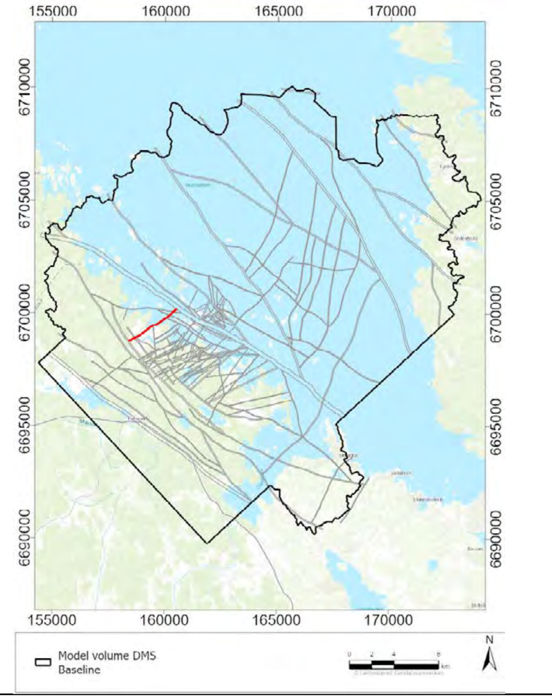
No data available

INDIVIDUAL INTERCEPTS

No data available

NE	ZFMNE0810	Version number	3	Total object CL	12

GEOLOGICAL CHARACTER		Property CL
Deformation style:	Brittle	1
Deformation description:	No data available.	
Alteration:		1
- First order:	Oxidation	
- Second order:	Not observed	
- Third order:	Not observed	
Fracture orientation and type:	No data available.	
Fracture comment:	No data available.	
Fracture fill mineralogy:	No data available.	



OBJECT GEOMETRY	
Strike/dip:	225°/80°
Length:	2671 m
Mean thickness:	25 m (3 - 50 m)
Max depth:	-2100 m
Geometrical constraints:	ZFMWNW0001, ZFMNW0017, Topo 40m grid Max error 20m.

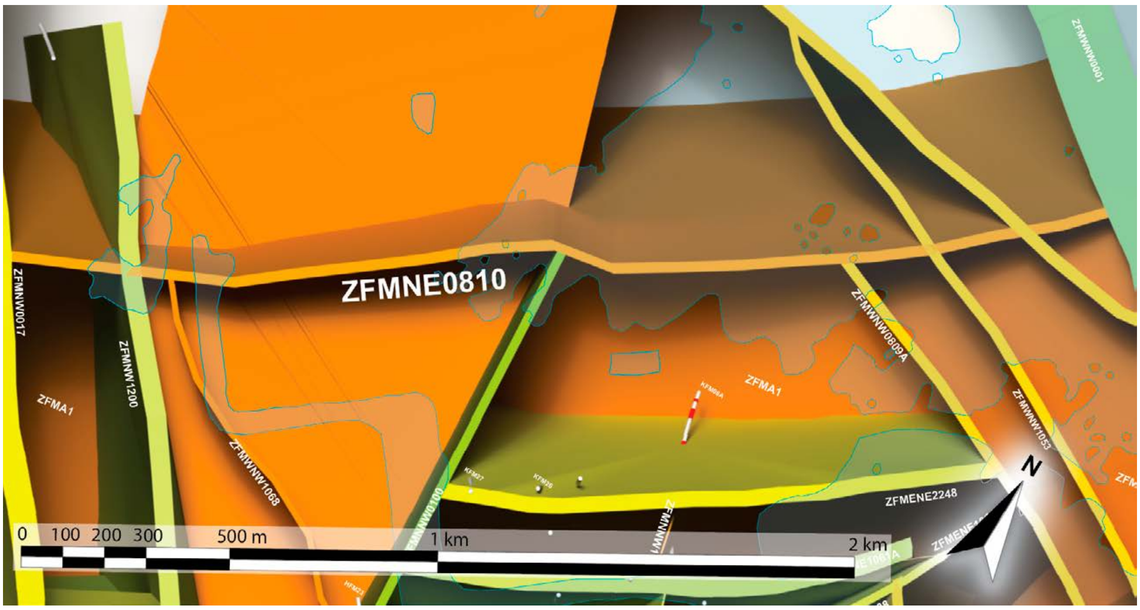
BASIS FOR MODELLING

Zone based on surface lineament.

Outcrops:	-	
Boreholes: -		
Tunnels:	-	
Lineament and/or seismic indications:	MFM0810.	1

MODELLING PROCEDURE

At the surface, corresponds to the low magnetic lineament MFM0810. This lineament is defined partly by a magnetic minimum and partly by a depression in the bedrock surface, the form of which has been recognised on the basis of an analysis of old refraction seismic data Isaksson and Keisu (2005). Modelled to the base of the model volume with a dip of 80 degrees to the north-west based on comparison with high-confidence zone ZFMENE2254, which lies to the south-east.



NE	ZFMNE0810	Version number	3	Total object CL	12

OBJECT CONFIDENCE ESTIMATE

Category	Object CL	Comment
INTERPRETATION		
Data source	1	MFM0810
Results of interpretation	1	Low confidence in lineament MFM0810.
INFORMATION DENSITY		
Number of observation points	1	1
Distribution of observation points	1	Single observation point in the form of a lineament.
INTERPOLATION		
Geometry	1	Geometry supported by surface geophysical data.
Geological indicators	1	Indirect support by geophysical data.
EXTRAPOLATION		
Dip direction	3	Extrapolated to the base of the model volume. Strike length of the modelled zone > 2000 m.
Strike direction	3	Conceptual understanding of the site and that the entire modelled zone is supported by the lineament.

FRACTURE CHARACTER

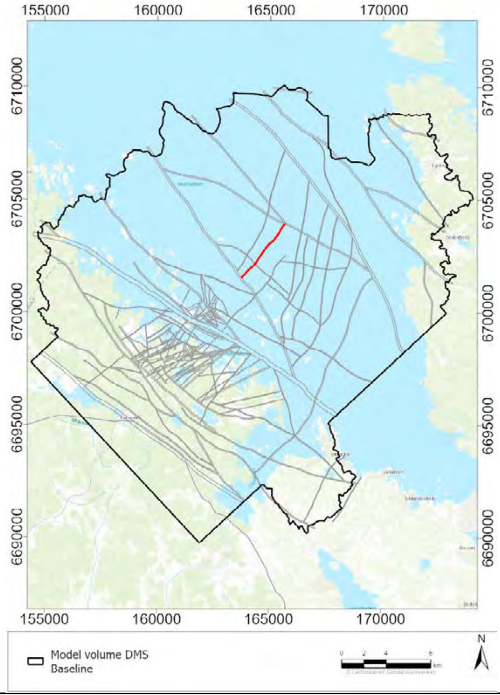
No data available

INDIVIDUAL INTERCEPTS

No data available

NE	ZFMNE0842	Version number	3	Total object CL	14

GEOLOGICAL CHARACTER		Property CL
Deformation style:	Brittle	1
Deformation description:	No data available.	
Alteration:		1
- First order:	Oxidation	
- Second order:	Not observed	
- Third order:	Not observed	
Fracture orientation and type:	No data available.	
Fracture comment:	No data available.	
Fracture fill mineralogy:	No data available.	



OBJECT GEOMETRY	
Strike/dip:	219°/80°
Length:	3149 m
Mean thickness:	25 m (15 - 64 m)
Max depth:	-2100 m
Geometrical constraints:	ZFMNNW0806, ZFMWNW0853, Topo 40m grid Max error 20m.

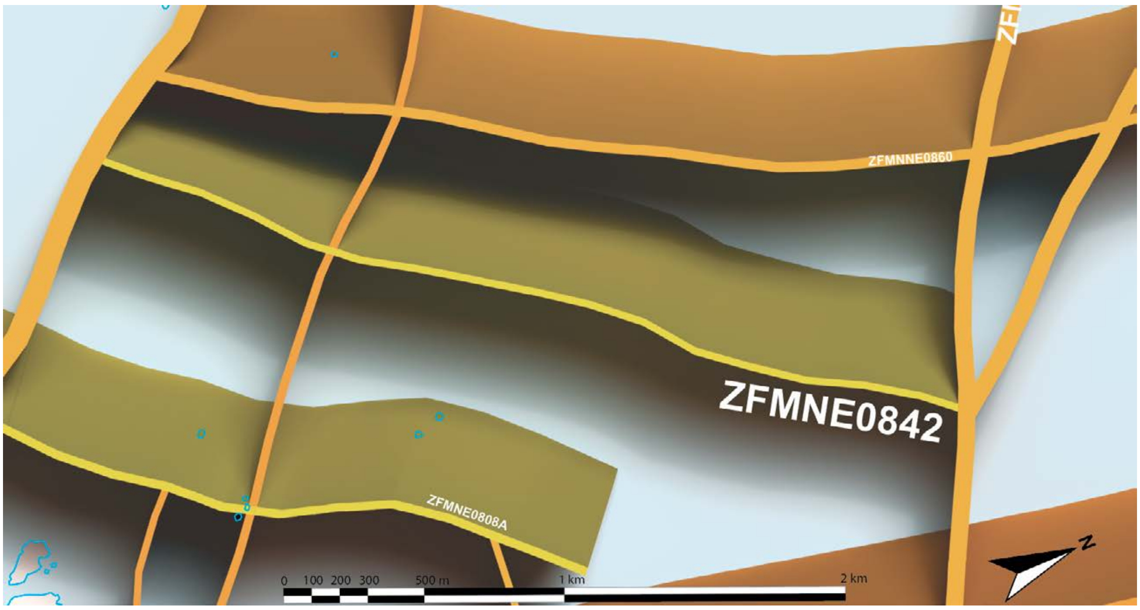
BASIS FOR MODELLING

Zone based on surface lineaments and pattern of surrounding deformation zones. .

Outcrops:	-	
Boreholes: -		
Tunnels:	-	
Lineament and/or seismic indications:	MFM0842.	3

MODELLING PROCEDURE

At the surface, corresponds to the low magnetic lineament MFM0842. Modelled to the base of the model volume with a dip of 80 degrees to the WNW based on comparison with high confidence, steeply dipping zones with NNE strike.



NE	ZFMNE0842	Version number	3	Total object CL	14

OBJECT CONFIDENCE ESTIMATE

Category	Object CL	Comment
INTERPRETATION		
Data source	1	MFM0842
Results of interpretation	3	High confidence in the lineament MFM0842.
INFORMATION DENSITY		
Number of observation points	1	1
Distribution of observation points	1	Single observation point in the form of a lineament.
INTERPOLATION		
Geometry	1	Geometry supported by surface geophysical data.
Geological indicators	1	Indirect support by geophysical data.
EXTRAPOLATION		
Dip direction	3	Extrapolated to the base of the model volume. Strike length of the modelled zone > 2000 m.
Strike direction	3	Conceptual understanding of the site and that the entire modelled zone is supported by the lineament.

FRACTURE CHARACTER

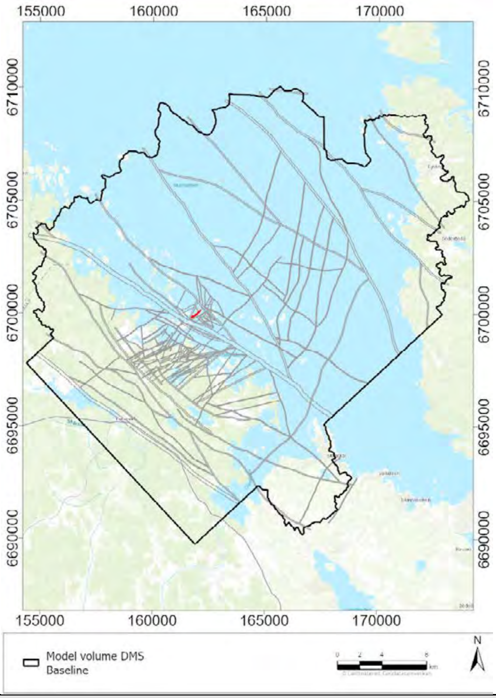
No data available

INDIVIDUAL INTERCEPTS

No data available

NE	ZFMNE0870	Version number	4	Total object CL	21

GEOLOGICAL CHARACTER		Property CL
Deformation style:	Brittle-Ductile	1
Deformation description:	No data available.	
Alteration:		
- First order:	Not observed	
- Second order:	Not observed	
- Third order:	Not observed	
Fracture orientation and type:	No data available.	
Fracture comment:	No data available.	
Fracture fill mineralogy:	No data available.	
OBJECT GEOMETRY		
Strike/dip:	234°/76°	
Length:	572 m	
Mean thickness:	16 m (2 - 36 m)	
Max depth:	-560 m	
Geometrical constraints:	ZFMNW0805B, ZFMNE3118, ZFMNNE0869, Topo 40m grid Max error 20m, ZFMNW0805A, 1 Surface Planar Cut(s).	



BASIS FOR MODELLING

Adopted from geological model for SFR Axelsson and Hansen (1997). Based on Intersection along SFR tunnels and boreholes, seismic refraction data.

Outcrops: -

Boreholes:

Borehole	PDZ	Target intercept		Geometric intercept		Comment
		Sec_up [m]	Sec_low [m]	Sec_up [m]	Sec_low [m]	
HFR101	DZ1	28.00	41.00	19.14	46.16	An interval with slightly increased frequency of steeply dipping (> 65°) fractures, striking SW occurs at approximately 28–41 m length of DZ1. Control point added at 33.02 m, and 28-41 m is taken as target intercept.
KFR02	DZ1	32.50	37.50	0.00	60.98	
KFR03	DZ2	48.00	95.95	36.39	101.60	
KFR03	DZ3	48.00	95.95	36.39	101.60	
KFR03	DZ4	48.00	95.95	36.39	101.60	
KFR04	DZ2	14.00	63.00	2.73	67.68	
KFR05		-	-	103.05	131.40	
KFR20		-	-	108.61	109.68	
KFR31	DZ2	228.76	232.00	222.74	242.10	
KFR53		-	-	18.73	37.01	No SHI available.
KFR54	DZ2	27.00	40.00	25.31	42.17	
KFR55	DZ2	17.00	38.00	17.18	42.67	Subdivision of DZ2 between ZFMNE0870 and ZFMNE3118.
KFR68	DZ1	71.59	105.13	-	-	No geometrical intercept. Note: KFR68 is interpreted as intercepting the meeting point between ZFMNNE0869 and ZFMNE0870. Since the BH lacks fracture orientation data it is impossible to correlate the PDZ with any specific steeply dipping zone. Thus, the PDZ is

NE	ZFMNE0870	Version number	4	Total object CL	21

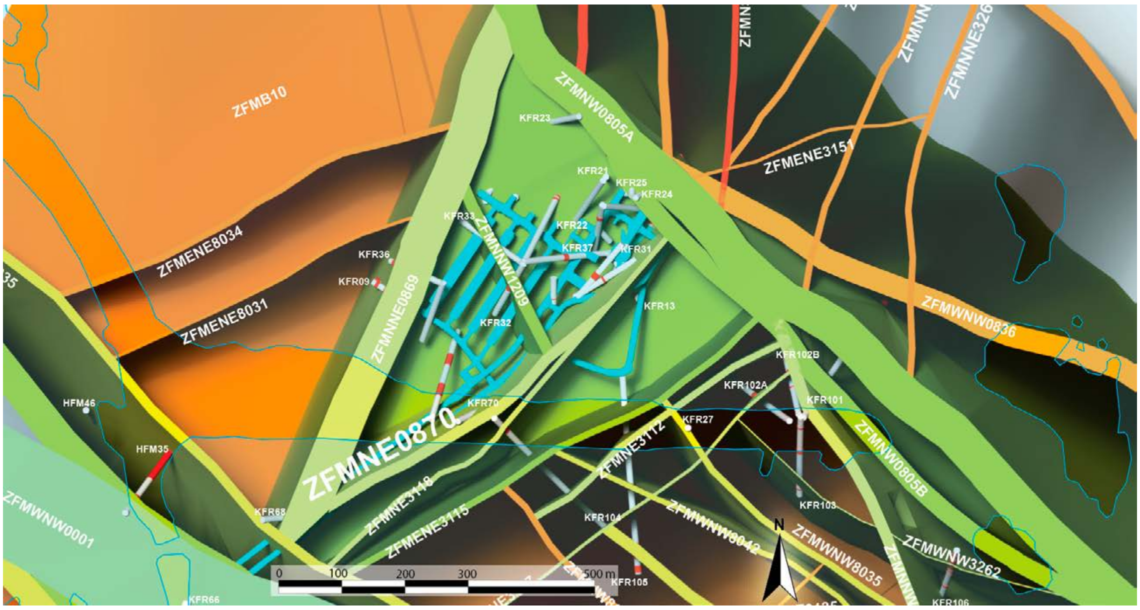
						taken as target intercept for both ZFMNE0870 and ZFMNNE0869.
KFR68	DZ2	71.59	105.13	-	-	No geometrical intercept. Note: KFR68 is interpreted as intercepting the meeting point between ZFMNNE0869 and ZFMNE0870. Since the BH lacks fracture orientation data it is impossible to correlate the PDZ with any specific steeply dipping zone. Thus, the PDZ is taken as target intercept for both ZFMNE0870 and ZFMNNE0869.
KFR70		-	-	34.67	102.71	Judging from the photographs of the drill cores there is no obvious indication of a possible zone along the geometric intercept. The fracture frequency is generally less than 10 fractures/m and oxidation or other alterations cannot be distinguished. No target intercept has been defined.
KFR7C		-	-	0.00	28.72	The geometrical intercept is at the modelled zone margin. No target intercept is defined.
KFR7C	DZ1	6.23	7.15	0.00	28.72	The intercept is considered to be dominated by ZFM871. However, a short section between 6.23–7.15 m contains laumontite filled fractures with low alpha angles that are taken to represent ZFMNE0870.

Tunnels:	DT target intercept 0+535 - 0+570 m, geometric intercept 0+470 - 0+600 m. DT - BT connection tunnel at 0+610 m. BT target intercept 0+640 - 0+690 m, geometric intercept 0+620 - 0+780 m. BT target intercept 0+888 - 0+907 m, geometric intercept 0+860 - 0+925 m. BT target intercept 1+020 - 1+050 m, geometric intercept 1+017 - 1+050 m. NBT target intercept -, geometric intercept 0+000 - 0+010 m.
Lineament and/or seismic indications:	S8110, S8117, S8114.

MODELLING PROCEDURE

Adopted from geological model for SFR (Axelsson and Hansen 1997). Extended so as to be truncated against ZFMNNE0869 and ZFMNW0805 and modelled to a depth of 1000 m. Inferred to be a minor zone. This zone corresponds to zone 9 in earlier SFR models (see, for example, Axelsson and Hansen 1997). It was renamed ZFMNE0870 in the Forsmark stage 2.2 model Stephens et al. (2007). It has been remodelled in SFR model version 1.0 to extend from ZFMNW1035 and ZFMNNE0869 in the south-west to ZFMNW0805A/B and ZFMNE3118 in the north-east. The earlier subdivision into two sections (ZFMNE0870A and ZFMNE0870B) with an offset at ZFMWNW3262 has been rejected, based on a lack of support from new borehole data. Axelsson and Hansen (1997) state that this zone is, for most of its length, a water-bearing gouge-filled joint. Mylonitization was also recorded and, if correctly interpreted (cataclastic rock?), indicates a ductile origin whilst the clay gouge indicates brittle reactivation. Flush-water loss and water leakage in the BT from 5/640-5/690 were also recorded. The surface position, based on a projection of tunnel mapping results, lacks a corresponding magnetic lineament and ZFMNE0870 is not crossed by a seismic refraction survey profile. The central part of the zone lies beneath the pier corresponding to an area where the magnetic field is disturbed. The zone has been modelled as an undulating surface based on multiple tunnel intercepts and correlation with borehole SHI results.

NE	ZFMNE0870	Version number	4	Total object CL	21

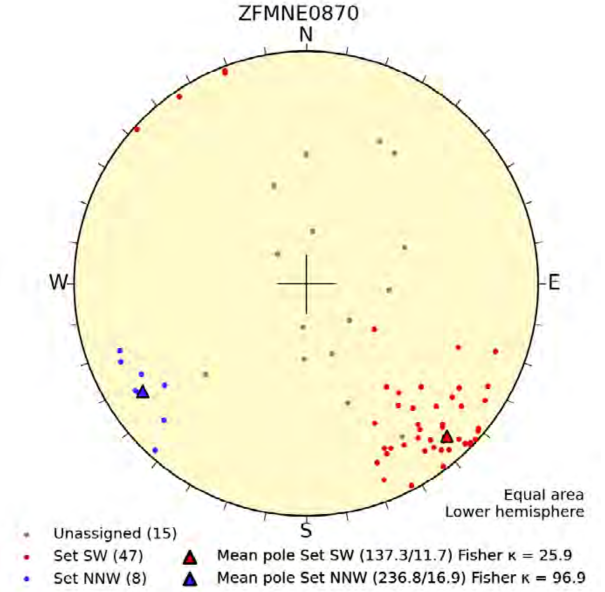
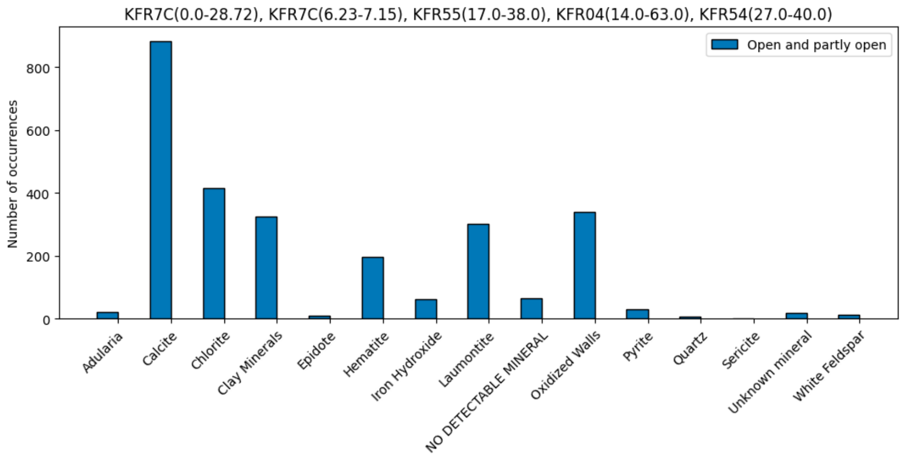


OBJECT CONFIDENCE ESTIMATE

Category	Object CL	Comment
INTERPRETATION		
Data source	3	KFR02, KFR03, KFR7C, KFR20, KFR31, KFR53, KFR54, KFR55, KFR70, tDZ40, tDZ56, tDZ66 and tDZ80. The surface position, based on a projection of tunnel mapping results, lacks a corresponding magnetic lineament.
Results of interpretation	3	High confidence observations in multiple boreholes.
INFORMATION DENSITY		
Number of observation points	3	>4
Distribution of observation points	2	Two clusters and the lineament considered as an outlier.
INTERPOLATION		
Geometry	3	One strong alternative based on observations of the zone in tunnels and drill holes in SFR.
Geological indicators	3	Interpolation supported by key geological parameters, foremost fracture orientation pattern.
EXTRAPOLATION		
Dip direction	2	Extrapolation in dip direction supported by subsurface obs. point. Strike length of the modelled zone < 2000 m.
Strike direction	2	Supported by geological concept and surface lineament. Strike length of the modelled zone < 2000 m.

NE	ZFMNE0870	Version number	4	Total object CL	21

FRACTURE CHARACTER

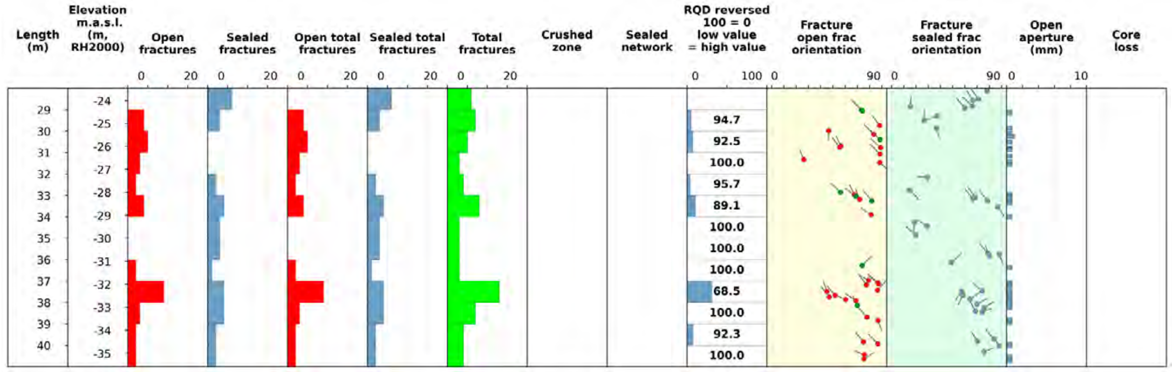
Orientation: (strike/dip right-hand-rule)	Set SW: 227.3°/78.3° Set NNW: 326.8°/73.1°	
Frequency:	Boreholes: KFR31, KFR53, KFR55, KFR7C, KFR54, KFR05, KFR03, KFR68, KFR70, KFR02, KFR04, KFR20	
RQD:	min:5, max:100, mean:62	
Fracture fill mineralogy:		

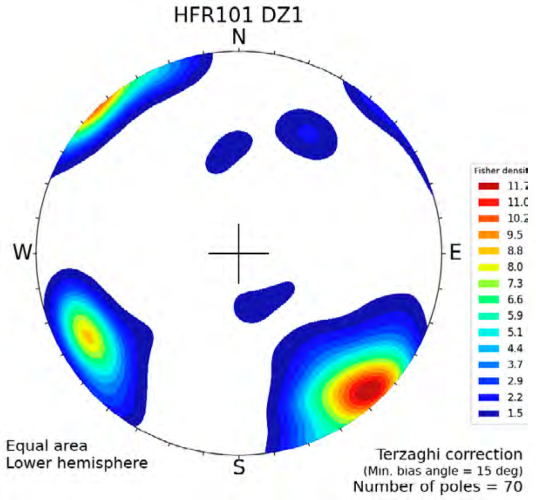
FRACTURE TYPE	TERZAGHI-WEIGHED P10
Open and partly open	4.4 m-1
Sealed	0.0 m-1
Sealed network	0.0 % of DZ intercept
Crush	0.1 % of DZ intercept

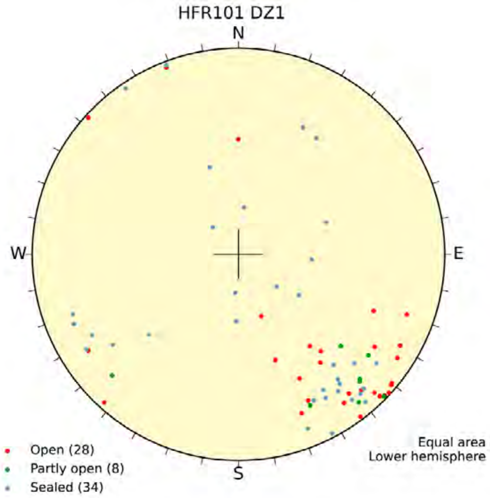
NE	ZFMNE0870	Version number	4	Total object CL	21

INDIVIDUAL INTERCEPTS

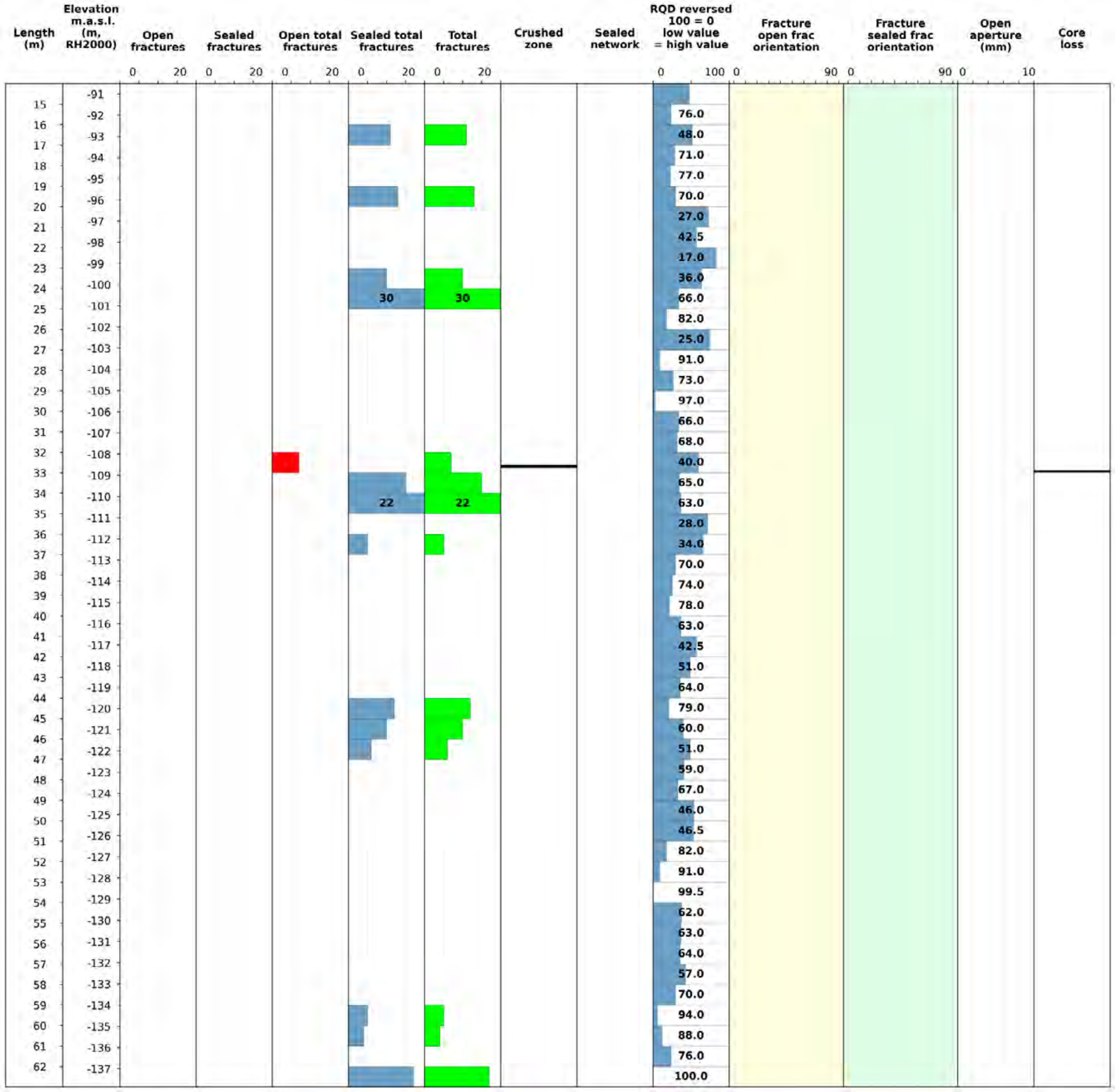
HFR101 DZ1 (28.0-41.0 m)







NE	ZFMNE0870	Version number	4	Total object CL	21
KFR02 DZ1 (32.5-37.5 m)					
No data available					
KFR03 DZ2, DZ3, DZ4 (48.0-95.95 m)					
No data available					
KFR04 DZ2 (14.0-63.0 m)					



NE	ZFMNE0870	Version number	4	Total object CL	21

KFR05 (103.05-131.4 m)

No data available

KFR20 (108.61-109.68 m)

No data available

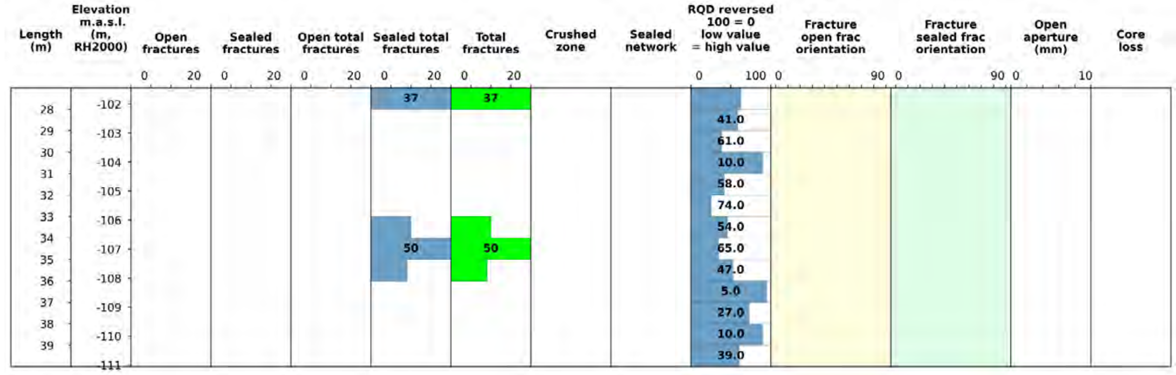
KFR31 DZ2 (228.76-232.0 m)

No data available

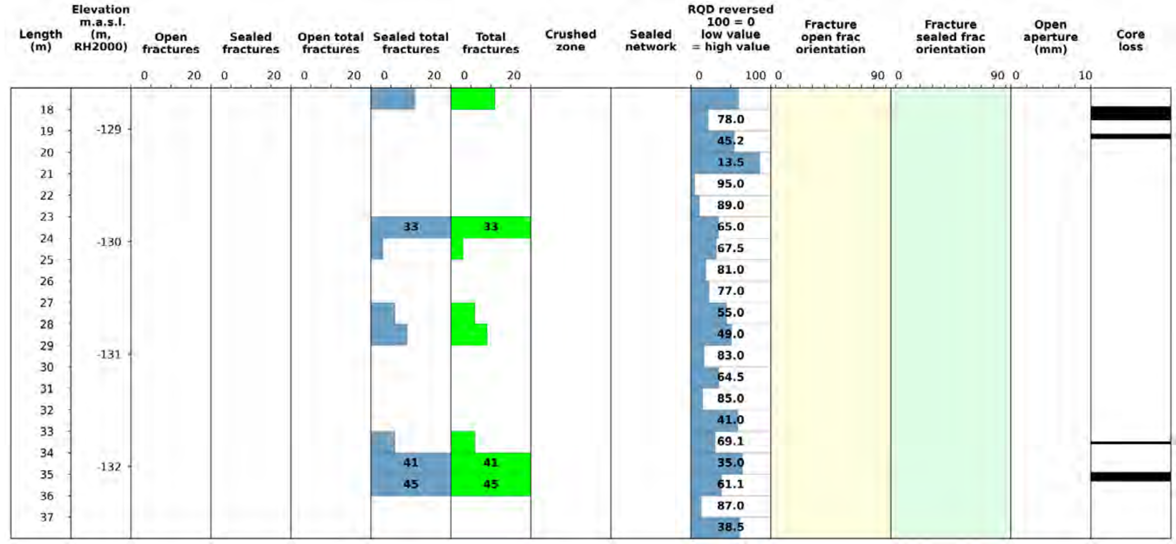
KFR53 (18.73-37.01 m)

No data available

KFR54 DZ2 (27.0-40.0 m)



KFR55 DZ2 (17.0-38.0 m)



NE	ZFMNE0870	Version number	4	Total object CL	21

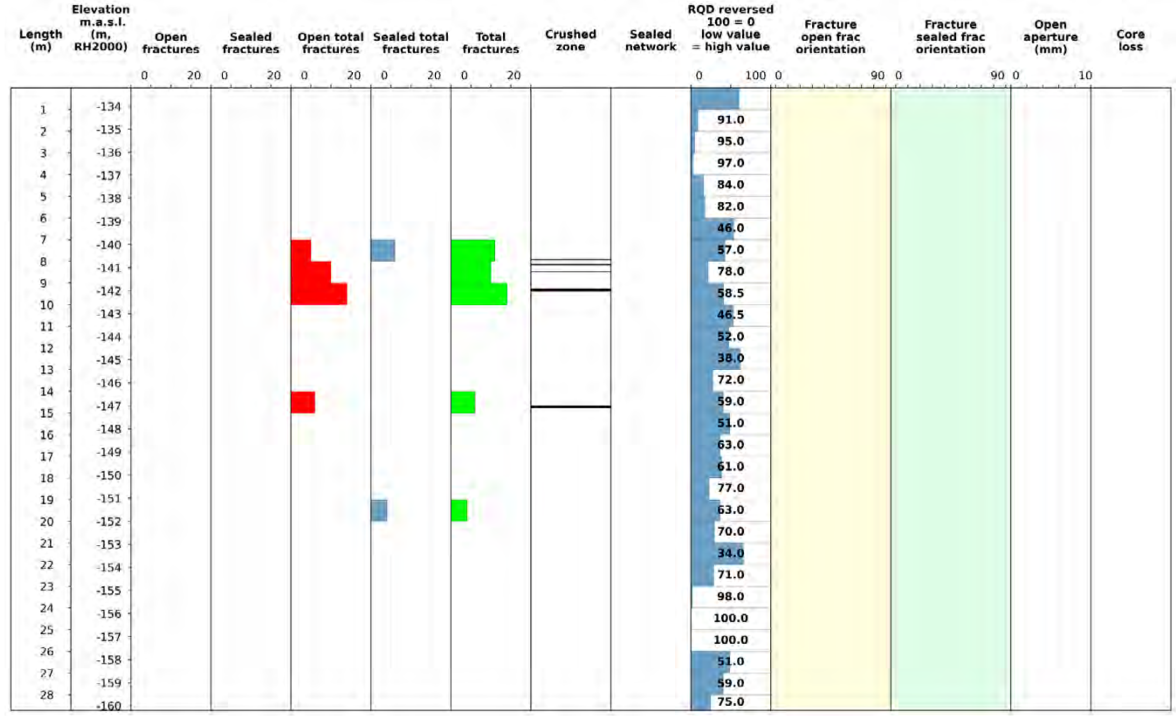
KFR68 DZ1, DZ2 (71.59-105.13 m)

No data available

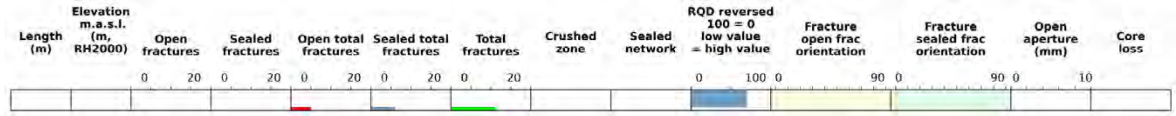
KFR70 (34.67-102.71 m)

No data available

KFR7C (0.0-28.72 m)



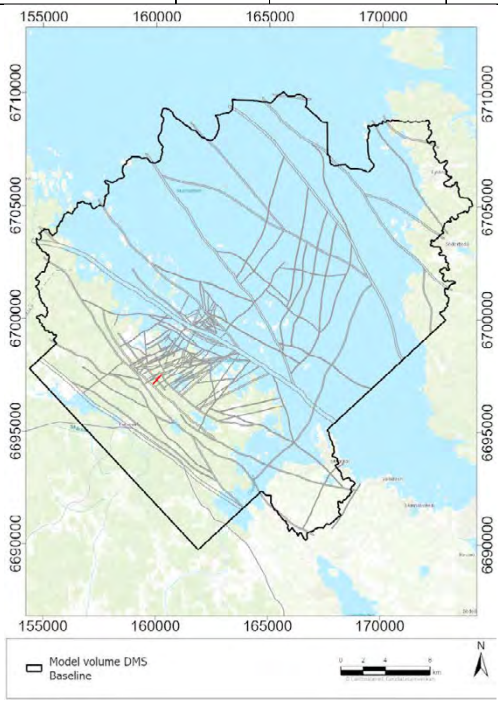
KFR7C DZ1 (6.23-7.15 m)



NE	ZFMNE1188	Version number	9	Total object CL	19

GEOLOGICAL CHARACTER		Property CL
Deformation style:	Brittle	3
Deformation description:	In the borehole, steeply dipping faults, which strike SE and ESE, parallel to the ductile fabric, show both strike-slip and dip-slip movement. One of these faults shows sinistral strike-slip displacement. Dextral strike-slip component of displacement along with steeply dipping fault with SE strike at the surface. The strike-slip faulting is inferred to be related, in a conjugate manner, to approximately EW compression.	
Alteration:		3
- First order:	Oxidation	
- Second order:	Not observed	
- Third order:	Not observed	
Fracture orientation and type:	Fracture set with SE strike and steep dip to the SW is prominent. Steeply dipping fractures with SW strike and more gently-dipping fractures are also conspicuous. Difficulties to interpret significance of fracture orientation data, since zone strikes more or less parallel to borehole KFM04A and is situated along or close to the borehole. Dominance of sealed fractures. Quantitative estimate and span include sealed fracture networks.	2
Fracture comment:	No data available.	
Fracture fill mineralogy:	Chlorite, calcite, hematite/adularia, laumontite, clay minerals, quartz, prehnite, pyrite, epidote (only along steeply dipping NW fractures).	

OBJECT GEOMETRY	
Strike/dip:	222°/87°
Length:	606 m
Mean thickness:	6 m (2 - 36 m)
Max depth:	-600 m
Geometrical constraints:	ZFMNW0017, ZFMWNW0123, Topo 40m grid Max error 20m, 1 Surface Planar Cut(s).



NE	ZFMNE1188	Version number	9	Total object CL	19

BASIS FOR MODELLING

Zone based on surface outcrop and borehole observations.

Outcrops: AFM001097

Boreholes:

Borehole	PDZ	Target intercept		Geometric intercept		Comment
		Sec_up [m]	Sec_low [m]	Sec_up [m]	Sec_low [m]	
KFM04A		290.00	370.00	289.47	471.36	
KFM04A	DZ4	412.00	462.00	289.47	471.36	290-370 m inferred to be a DZ (cf. Table 3-2 in Stephens et al. 2007).

Tunnels: -

Lineament and/or seismic indications: -

MODELLING PROCEDURE

Identified at the surface along excavation AFM001097 at drill site 4. Modelled down to 600 m depth, using the dip estimated by connecting the surface occurrence at drill site 4 with borehole intervals 290-370 m and 412-462 m (DZ4) in KFM04A. Deformation zone plane placed at fixed point 430 m in KFM04A. Zone strikes more or less parallel to borehole KFM04A and is situated along and close to the borehole. Inferred truncation against ZFMNW0017 and ZFMWNW0123. Inferred to be a minor zone.

NE	ZFMNE1188	Version number	9	Total object CL	19

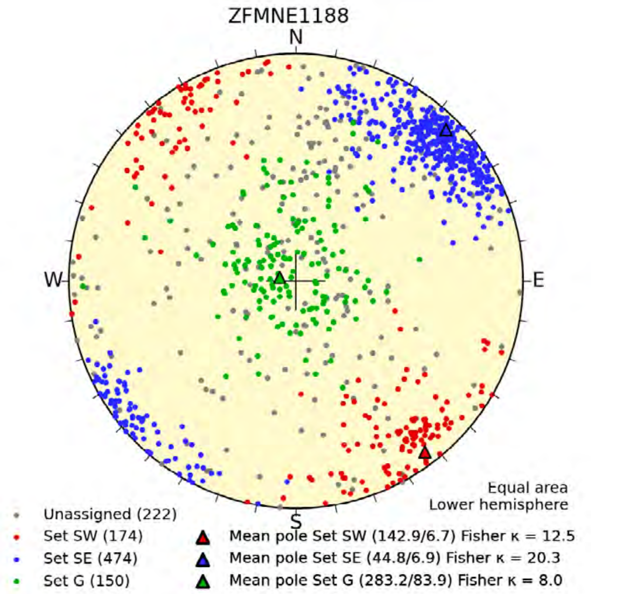
OBJECT CONFIDENCE ESTIMATE

Category	Object CL	Comment
INTERPRETATION		
Data source	3	KFM04A, AFM001097
Results of interpretation	3	High confidence observation in KFM04A.
INFORMATION DENSITY		
Number of observation points	2	2
Distribution of observation points	1	Single subsurface obs. point. According to Stephens et al. (2008b) MFM3013G was dropped. Reasoning not clarified. The zone is traceable for c. 30 m on outcrop scale and runs parallel to drill hole direction for c. 50 m, thus argument can only be made for a single obs. point.
INTERPOLATION		
Geometry	3	Geometry supported by a single obs. point coupled to information retrieved from outcrop AFM001097. The zone runs almost parallel to the drill hole direction for c. 50 m according to interpreted SHI.
Geological indicators	2	Interpolation supported by data from outcrops.
EXTRAPOLATION		
Dip direction	2	Extrapolation in dip direction supported by subsurface obs. point. Strike length of the modelled zone < 2000 m.
Strike direction	3	Zone modelled length < 2000 m. Intersected in a borehole and observed on outcrop. High confidence in this category based on conceptual understanding of the site.

FRACTURE CHARACTER

Orientation: (strike/dip right-hand-rule)

Set SW: 232.9°/83.3°
Set SE: 134.8°/83.1°
Set G: 13.2°/6.1°

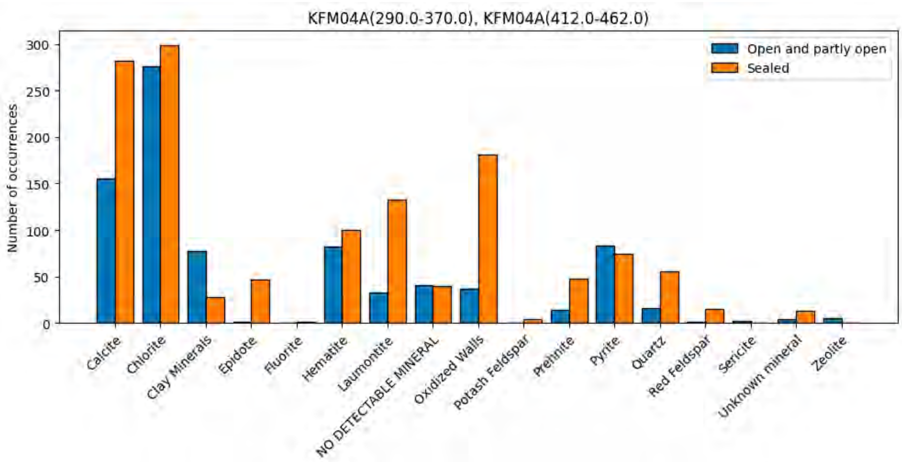


Frequency: Boreholes: KFM04A

FRACTURE TYPE	TERZAGHI-WEIGHED P10
Open and partly open	5.5 m-1
Sealed	12.2 m-1
Sealed network	19.0 % of DZ intercept
Crush	0.1 % of DZ intercept

RQD: min:32, max:100, mean:95

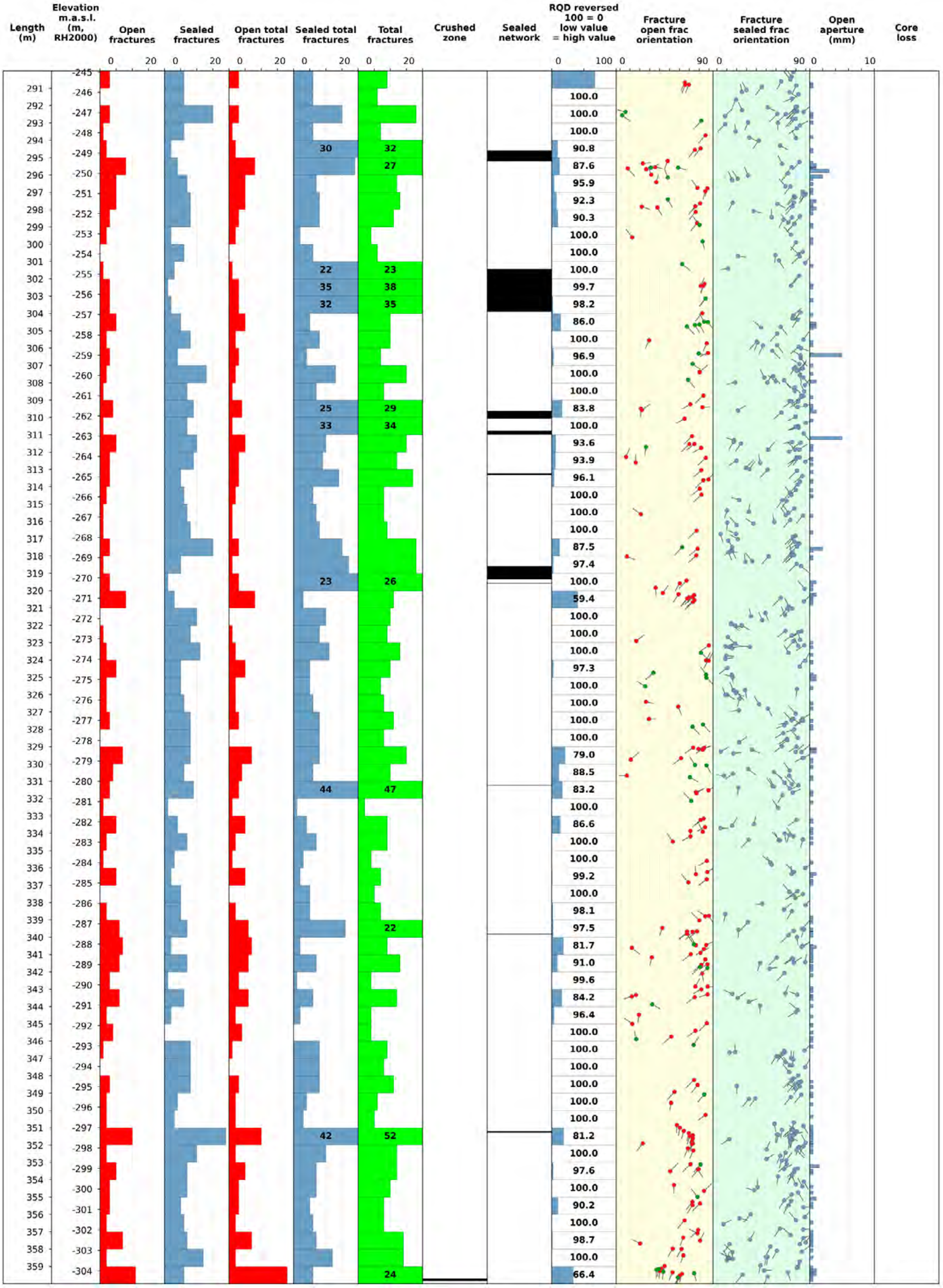
Fracture fill mineralogy:



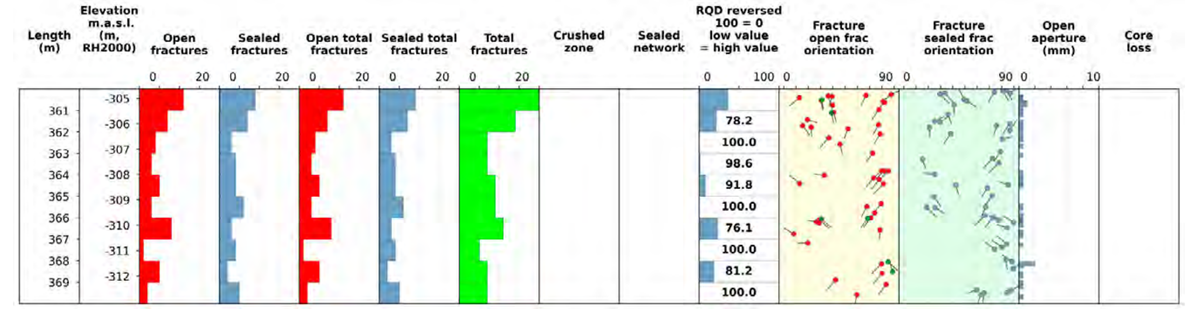
NE	ZFMNE1188	Version number	9	Total object CL	19

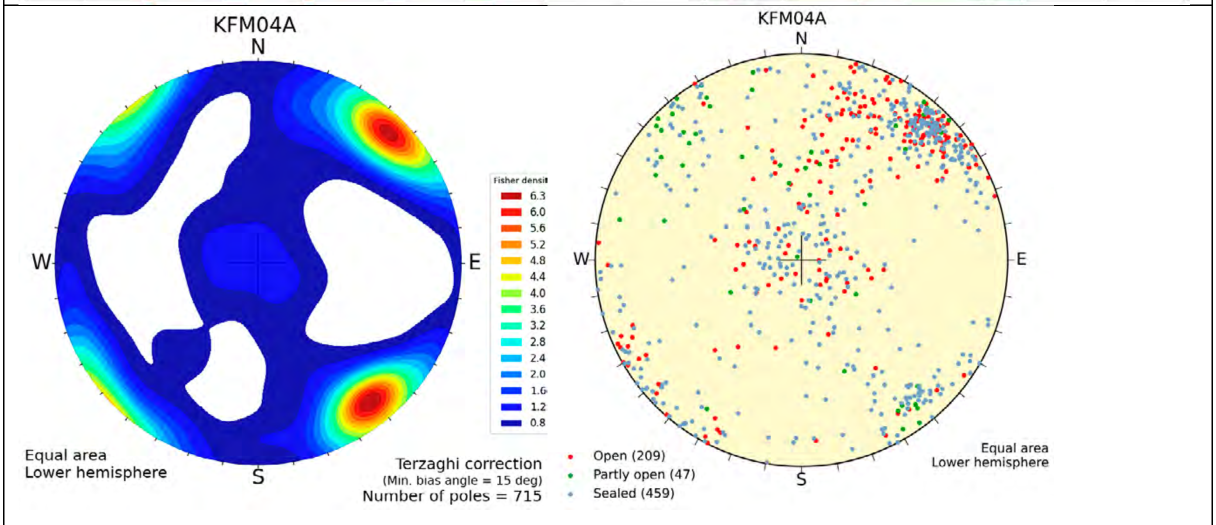
INDIVIDUAL INTERCEPTS

KFM04A (290.0-370.0 m)



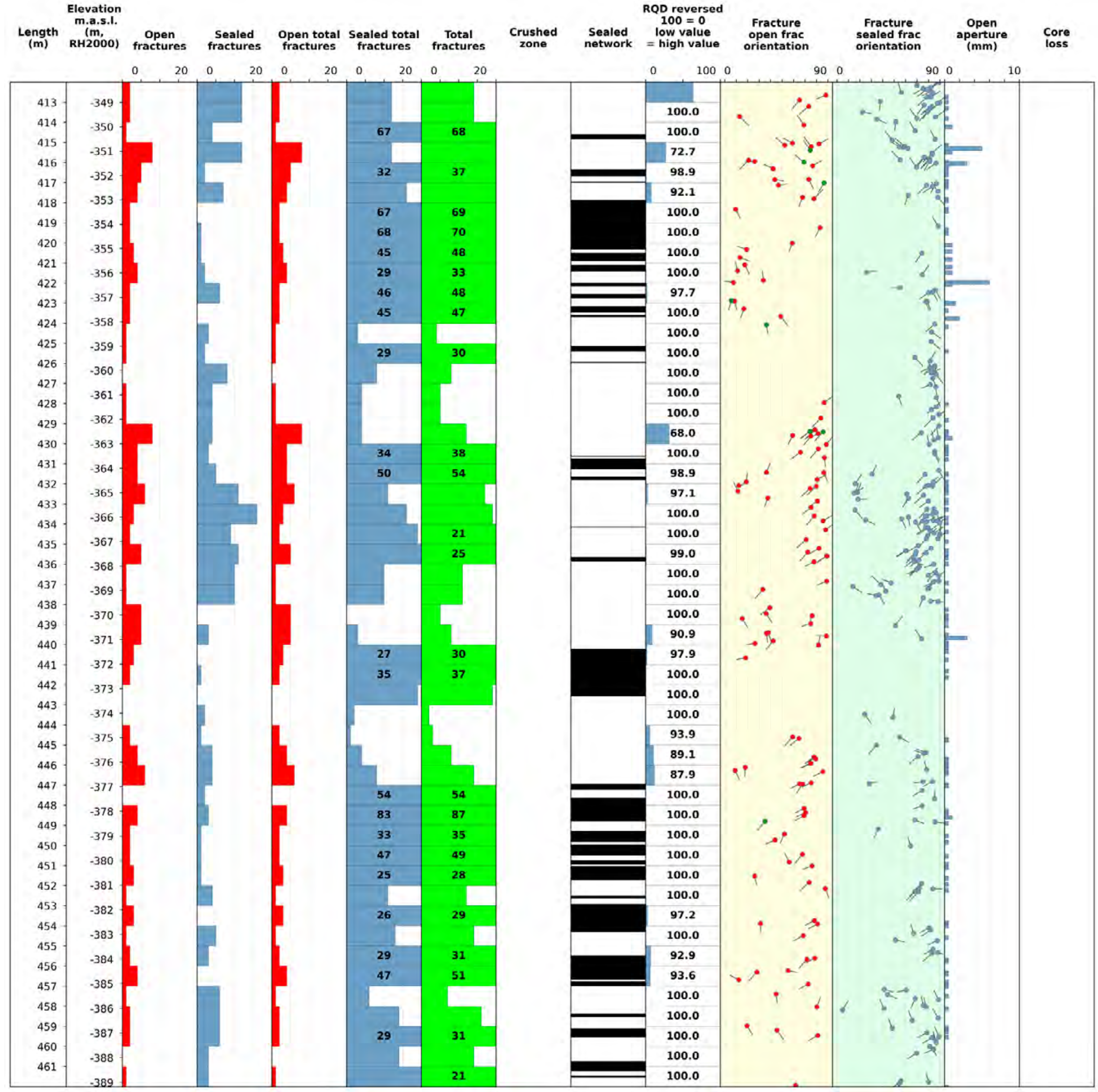
NE	ZFMNE1188	Version number	9	Total object CL	19

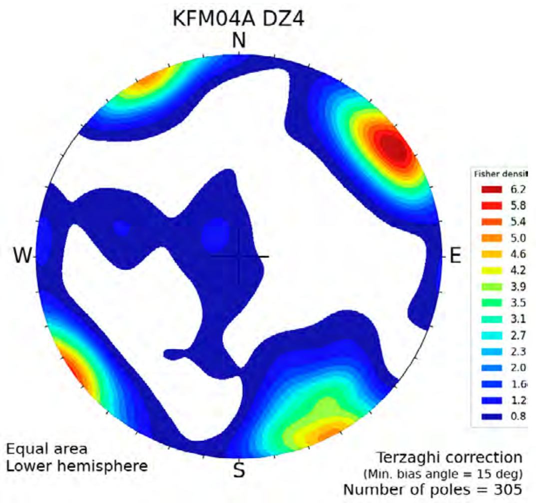


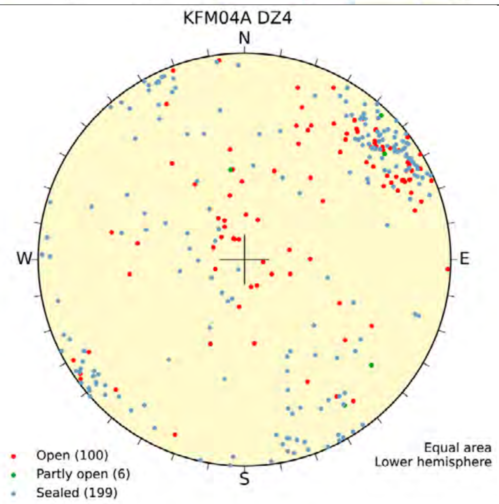


NE	ZFMNE1188	Version number	9	Total object CL	19

KFM04A DZ4 (412.0-462.0 m)

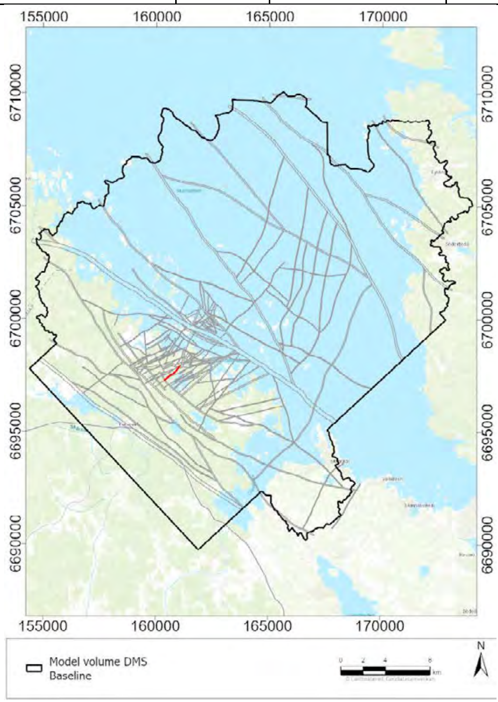






NE	ZFMNE2282	Version number	6	Total object CL	15

GEOLOGICAL CHARACTER		Property CL
Deformation style:	Brittle	3
Deformation description:	Steeply dipping fault with SW strike shows strike slip displacement. Steeply dipping fault that strikes SE shows oblique-slip displacement.	
Alteration:		3
- First order:	Oxidation	
- Second order:	Not observed	
- Third order:	Not observed	
Fracture orientation and type:	Fracture set with WSW strike and steep dip is prominent. Fractures with other orientations, including gently dipping fractures, are also present. Sealed fractures dominates. Quantitative estimate and span include sealed fracture networks.	2
Fracture comment:	No data available.	
Fracture fill mineralogy:	Chlorite, calcite, hematite/adularia, laumontite, prehnite, clay minerals, epidote.	



OBJECT GEOMETRY	
Strike/dip:	48°/81°
Length:	955 m
Mean thickness:	10 m (2 - 36 m)
Max depth:	-950 m
Geometrical constraints:	ZFMENE0060A, ZFMENE0401A, Topo 40m grid Max error 20m, 1 Surface Planar Cut(s).

BASIS FOR MODELLING

Zone based on surface lineaments and borehole observations.

Outcrops:	-
Boreholes:	

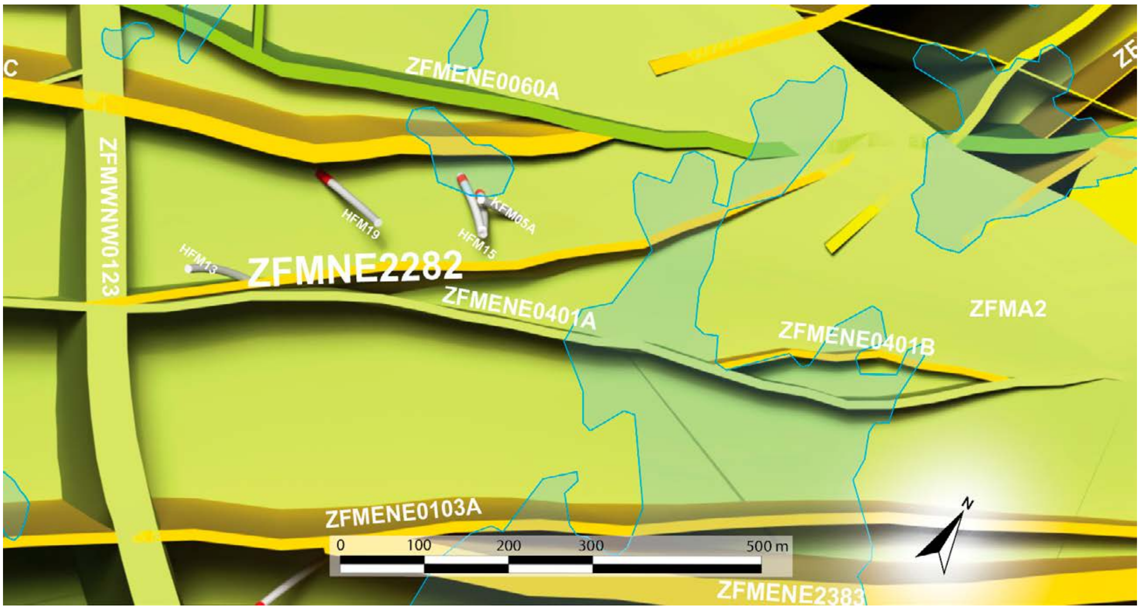
Borehole	PDZ	Target intercept		Geometric intercept		Comment
		Sec_up [m]	Sec_low [m]	Sec_up [m]	Sec_low [m]	
KFM05A	DZ2	395.00	436.00	396.41	436.48	395-416 m added (cf. Table 3-2 in Stephens et al. 2007).

Tunnels:	-	
Lineament and/or seismic indications:	MFM2282G.	2

MODELLING PROCEDURE

At the surface, corresponds to the low magnetic lineament MFM2282G. Modelled down to 850 m depth, using the dip estimated by connecting lineament MFM2282G with the borehole intersection 395-436 m in KFM05A (DZ2 and its extension along borehole interval 395-416 m). Deformation zone plane placed at fixed point 430 m in KFM05A. Decreased radar penetration also along the borehole interval 426- 433 m.

NE	ZFMNE2282	Version number	6	Total object CL	15



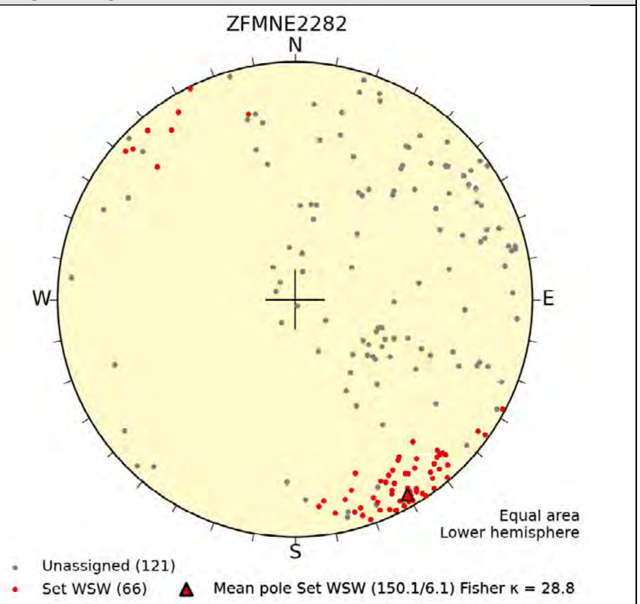
OBJECT CONFIDENCE ESTIMATE

Category	Object CL	Comment
INTERPRETATION		
Data source	2	MFM2282G, KFM05A
Results of interpretation	3	High confidence observation in KFM05A.
INFORMATION DENSITY		
Number of observation points	2	2
Distribution of observation points	1	Single observation point at depth and a surface lineament.
INTERPOLATION		
Geometry	1	Geometry supported by a lineament and a single intercept.
Geological indicators	1	Indirect support by geophysical data.
EXTRAPOLATION		
Dip direction	2	Extrapolation in dip direction supported by subsurface obs. point. Strike length of the modelled zone < 2000 m.
Strike direction	3	Conceptual understanding of the site and that the entire modelled zone is supported by the lineament.

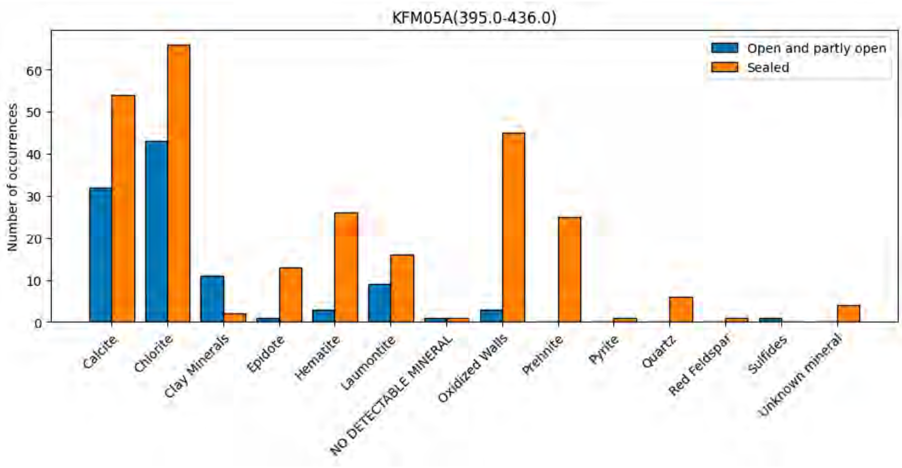
FRACTURE CHARACTER

Orientation: (strike/dip right-hand-rule)	Set WSW: 240.1°/83.9°
Frequency:	Boreholes: KFM05A

FRACTURE TYPE	TERZAGHI-WEIGHED P10
Open and partly open	2.4 m-1
Sealed	7.9 m-1
Sealed network	12.9 % of DZ intercept
Crush	0.0 % of DZ intercept



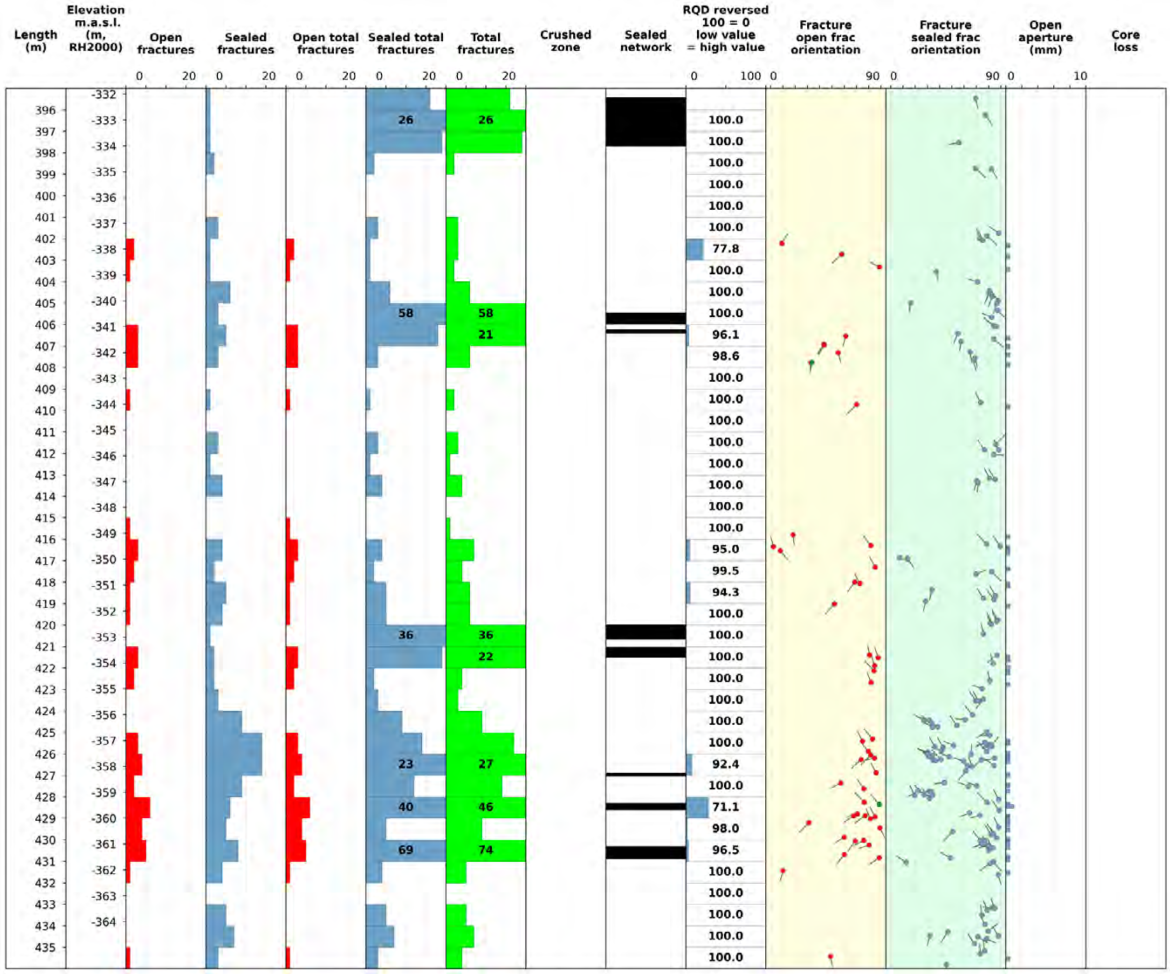
RQD:	min:71, max:100, mean:98

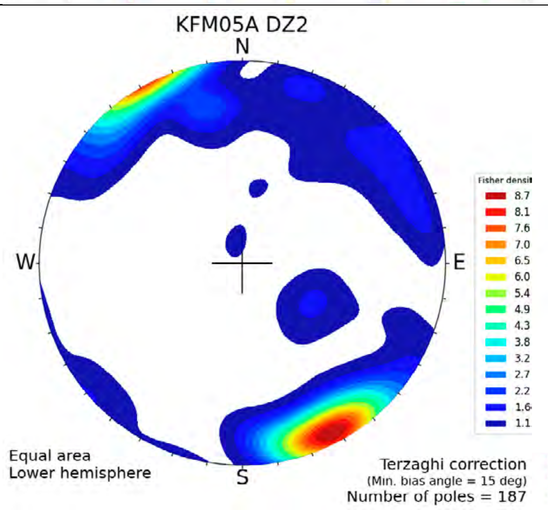
NE	ZFMNE2282	Version number	6	Total object CL	15
Fracture fill mineralogy:					

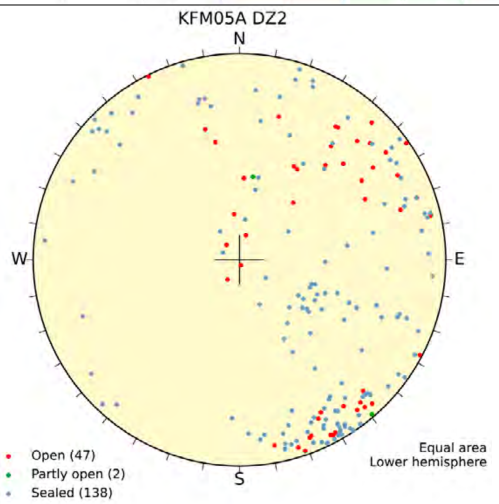
NE	ZFMNE2282	Version number	6	Total object CL	15

INDIVIDUAL INTERCEPTS

KFM05A DZ2 (395.0-436.0 m)

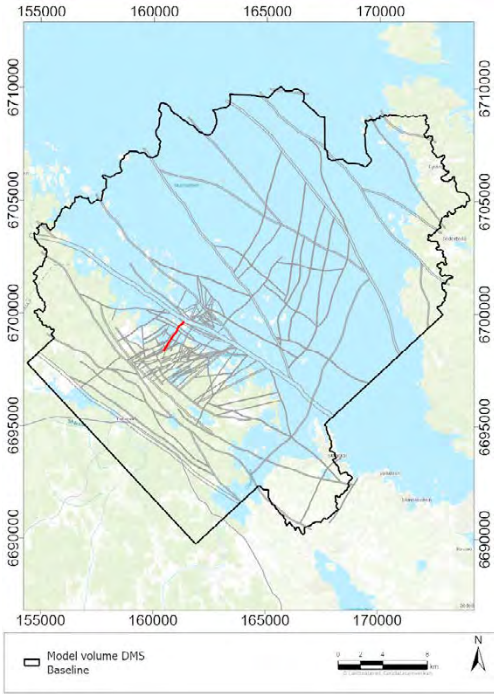






NE	ZFMNE2308	Version number	6	Total object CL	13

GEOLOGICAL CHARACTER		Property CL
Deformation style:	Brittle	3
Deformation description:	No data available.	
Alteration:		3
- First order:	Oxidation	
- Second order:	Not observed	
- Third order:	Not observed	
Fracture orientation and type:	Steeply dipping fractures that strike NE-SW to NNESSW and NNW-SSE as well as gently dipping fractures are conspicuous. Steeply dipping fractures with NWSE strike are also present. Quantitative estimate and span include sealed fracture networks.	2
Fracture comment:	No data available.	
Fracture fill mineralogy:	Chlorite, calcite, hematite/adularia, quartz and other minerals. Some clay minerals and epidote are also present.	



OBJECT GEOMETRY	
Strike/dip:	216°/84°
Length:	1697 m
Mean thickness:	30 m (3 - 50 m)
Max depth:	-1700 m
Geometrical constraints:	ZFMWNW0001, Topo 40m grid Max error 20m, 1 Surface Planar Cut(s), 1 UNIVERSE Planar Cut(s).

BASIS FOR MODELLING

Zone based on surface lineaments and borehole observations.

Outcrops: -

Boreholes:

Borehole	PDZ	Target intercept Sec_up [m]	Target intercept Sec_low [m]	Geometric intercept Sec_up [m]	Geometric intercept Sec_low [m]	Comment
KFM08D	DZ8	644.00	689.00	644.03	689.12	

Tunnels:	-	
Lineament and/or seismic indications:	MFM2308G.	1

MODELLING PROCEDURE

At the surface, corresponds to the low magnetic lineament MFM2308G and its inferred continuation to the north-east. Modelled using the dip estimated by connecting lineament MFM2308G with the borehole intersection 644-689 m in KFM08D (DZ8). Deformation zone plane placed at fixed point 660 m in KFM08D.

NE	ZFMNE2308	Version number	6	Total object CL	13

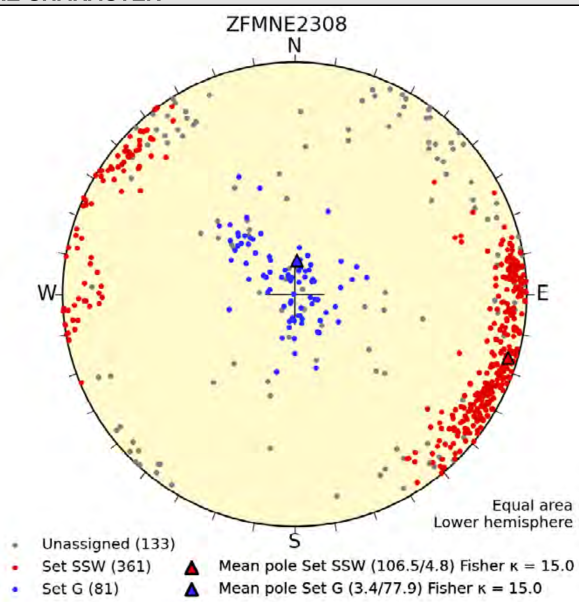
OBJECT CONFIDENCE ESTIMATE

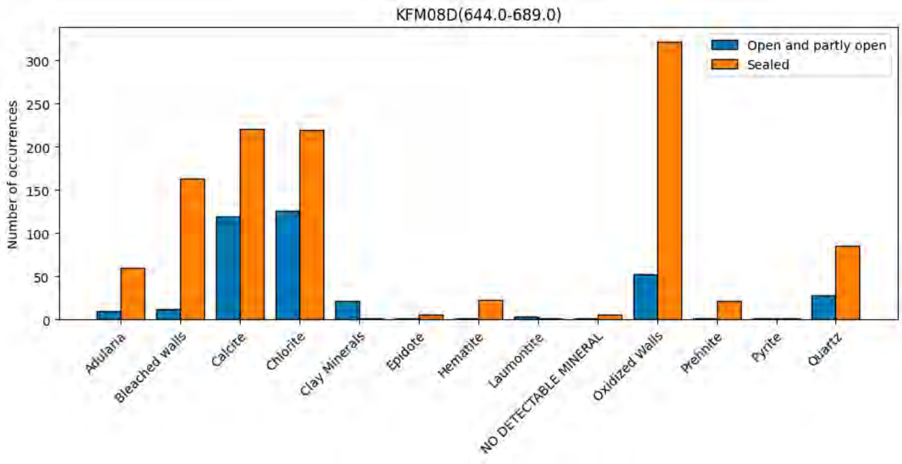
Category	Object CL	Comment
INTERPRETATION		
Data source	2	MFM2308G, KFM08D
Results of interpretation	2	Medium confidence observation in KFM08D.
INFORMATION DENSITY		
Number of observation points	2	2
Distribution of observation points	1	Single observation point at depth and a surface lineament.
INTERPOLATION		
Geometry	1	Geometry supported by a lineament and a single intercept.
Geological indicators	1	Indirect support by geophysical data.
EXTRAPOLATION		
Dip direction	2	Extrapolation in dip direction supported by subsurface obs. point. Strike length of the modelled zone < 2000 m.
Strike direction	2	Partly support by surface lineament. Supported by geological concept and subsurface observation points.

FRACTURE CHARACTER

Orientation: (strike/dip right-hand-rule)	Set SSW: 196.5°/85.2° Set G: 93.4°/12.1°
Frequency:	Boreholes: KFM08D
RQD:	min:62, max:100, mean:96

FRACTURE TYPE	TERZAGHI-WEIGHED P10
Open and partly open	5.5 m-1
Sealed	23.0 m-1
Sealed network	2.2 % of DZ intercept
Crush	0.0 % of DZ intercept

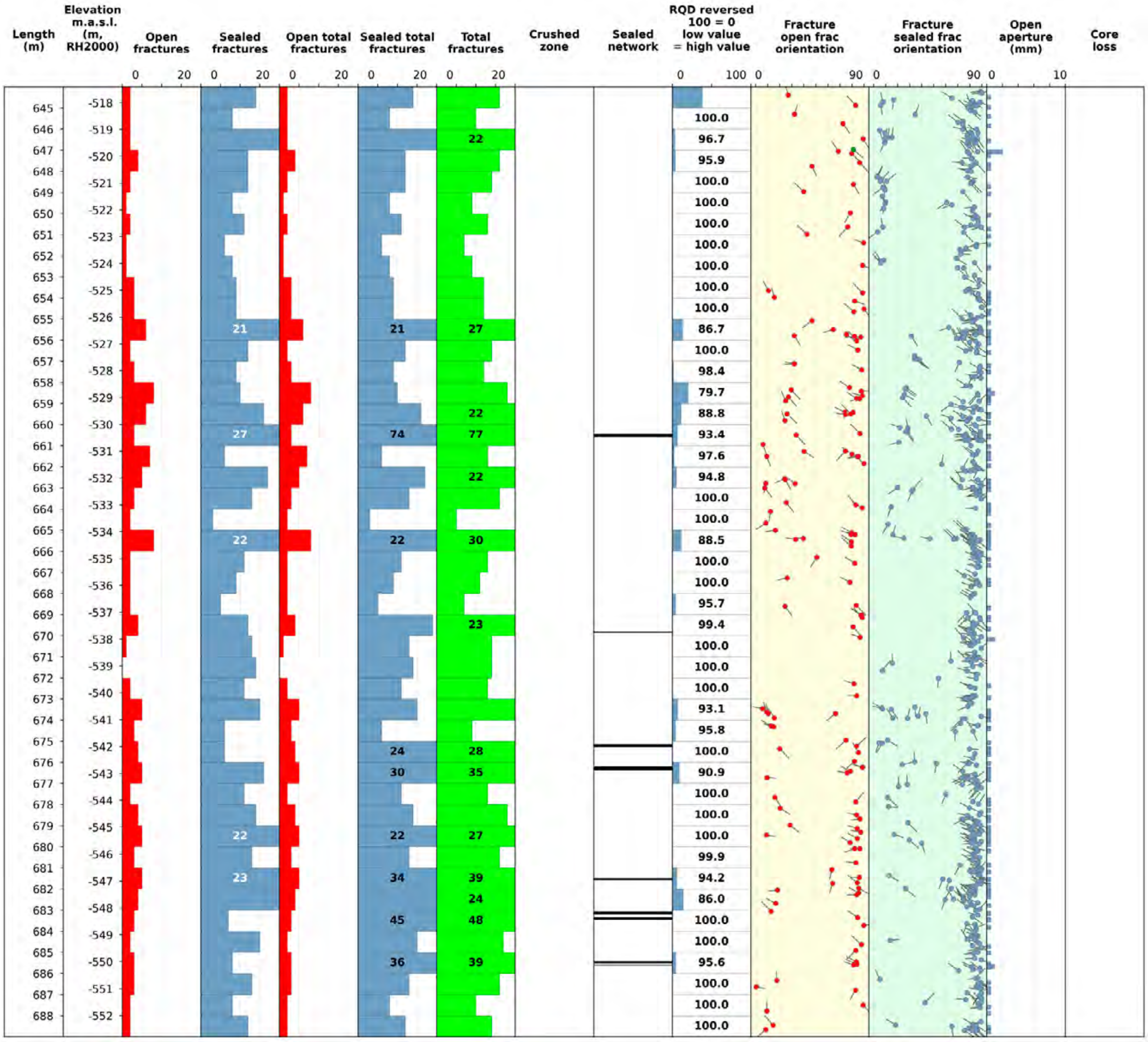


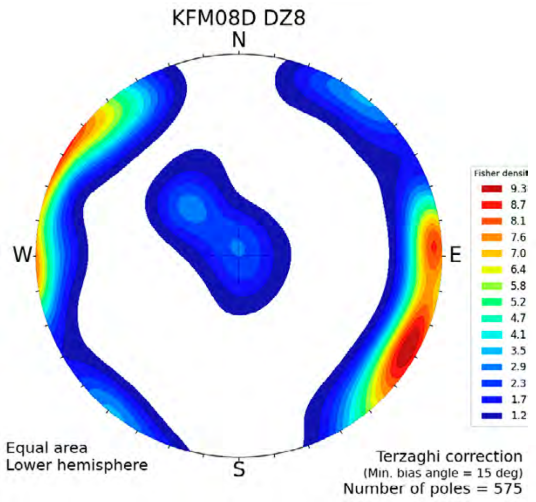
NE	ZFMNE2308	Version number	6	Total object CL	13
Fracture fill mineralogy:					

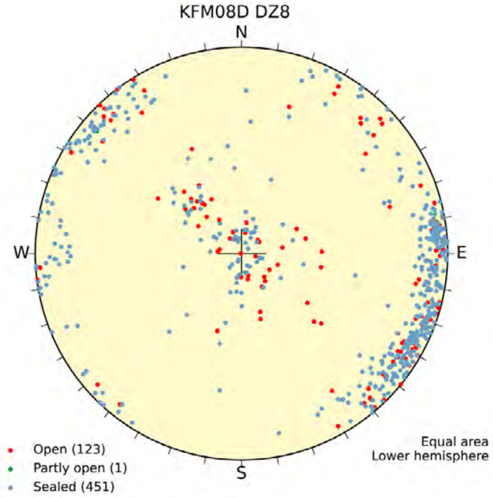
NE	ZFMNE2308	Version number	6	Total object CL	13

INDIVIDUAL INTERCEPTS

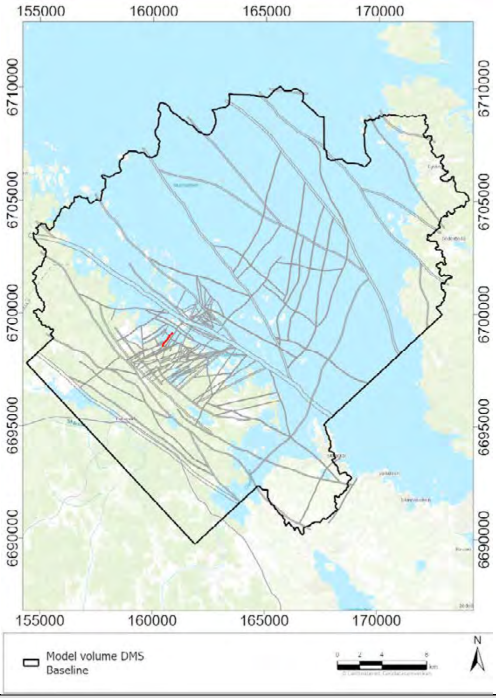
KFM08D DZ8 (644.0-689.0 m)







NE	ZFMNE2309		Version number	7	Total object CL	15



GEOLOGICAL CHARACTER		Property CL
Deformation style:	Brittle	1
Deformation description:	No data available.	
Alteration:		2
- First order:	Oxidation	
- Second order:	Not observed	
- Third order:	Not observed	
Fracture orientation and type:	No data available.	
Fracture comment:	No data available.	
Fracture fill mineralogy:	No data available.	

OBJECT GEOMETRY	
Strike/dip:	37°/90°
Length:	801 m
Mean thickness:	13 m (2 - 36 m)
Max depth:	-800 m
Geometrical constraints:	ZFMNE2308, ZFMENE2320, Topo 40m grid Max error 20m, 1 Surface Planar Cut(s), 2 UNIVERSE Planar Cut(s).

BASIS FOR MODELLING

Zone based on surface lineaments.

Outcrops:	-

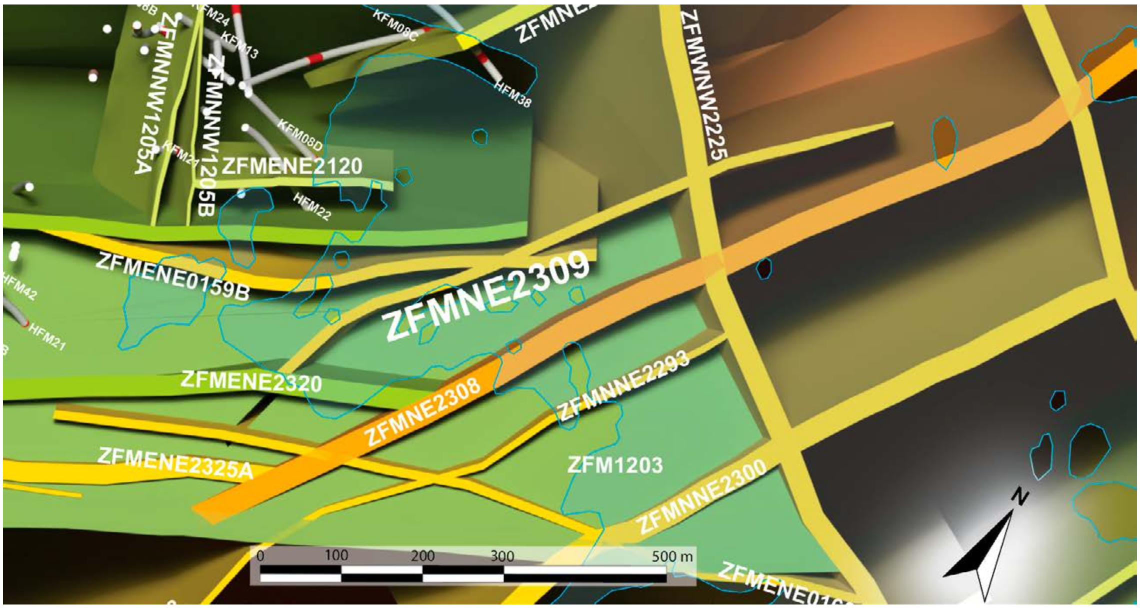
Boreholes:

Borehole	PDZ	Target intercept		Geometric intercept		Comment
		Sec_up [m]	Sec_low [m]	Sec_up [m]	Sec_low [m]	
KFM08D	DZ5	546.00	571.00	546.98	571.01	

Tunnels:	-	
Lineament and/or seismic indications:	MFM2309G.	2

MODELLING PROCEDURE

At the surface, corresponds to the low magnetic lineaments MFM2309G. Modelled to a depth of 800 m with a dip of 80 degrees to the WNW based on comparison with high confidence, steeply-dipping zones with NNE strike. Inferred to be a minor zone. Zone intersected by KFM08D (546-571, DZ5) with fix point placed at 562 m.



NE	ZFMNE2309	Version number	7	Total object CL	15

OBJECT CONFIDENCE ESTIMATE

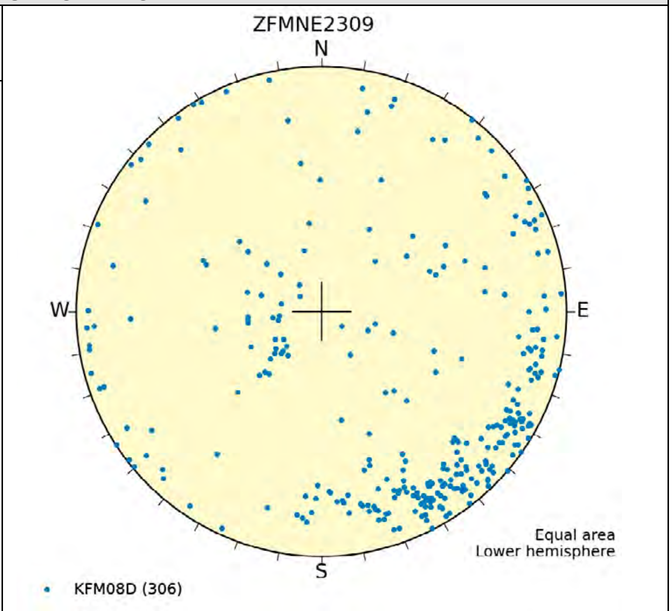
Category	Object CL	Comment
INTERPRETATION		
Data source	2	MFM2309G, KFM08D
Results of interpretation	3	High confidence observation in KFM08D.
INFORMATION DENSITY		
Number of observation points	2	2
Distribution of observation points	1	Single observation point at depth and a surface lineament.
INTERPOLATION		
Geometry	1	Geometry supported by a lineament and a single intercept.
Geological indicators	1	Indirect support by geophysical data.
EXTRAPOLATION		
Dip direction	2	Extrapolation in dip direction supported by subsurface obs. point. Strike length of the modelled zone < 2000 m.
Strike direction	3	Conceptual understanding of the site and that the entire modelled zone is supported by the lineament.

FRACTURE CHARACTER

Orientation: (strike/dip right-hand-rule): --

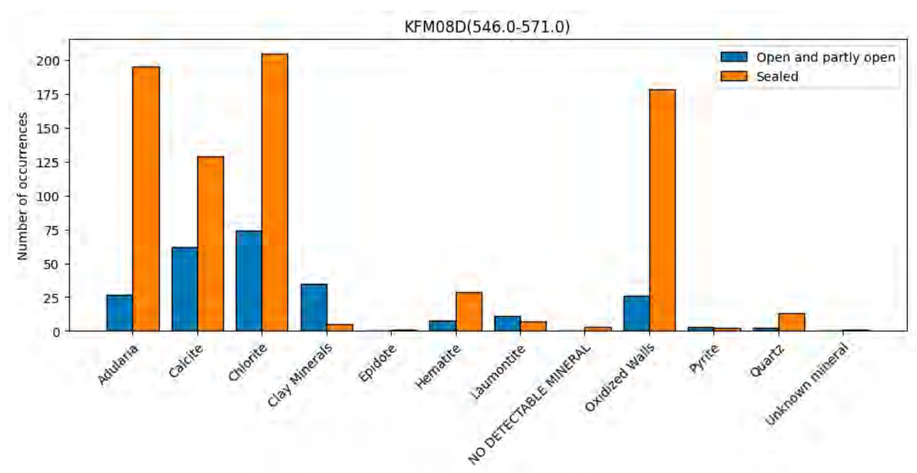
Frequency: Boreholes: KFM08D

FRACTURE TYPE	TERZAGHI-WEIGHED P10
Open and partly open	5.6 m-1
Sealed	25.6 m-1
Sealed network	3.9 % of DZ intercept
Crush	0.0 % of DZ intercept



RQD: min:17, max:100, mean:93

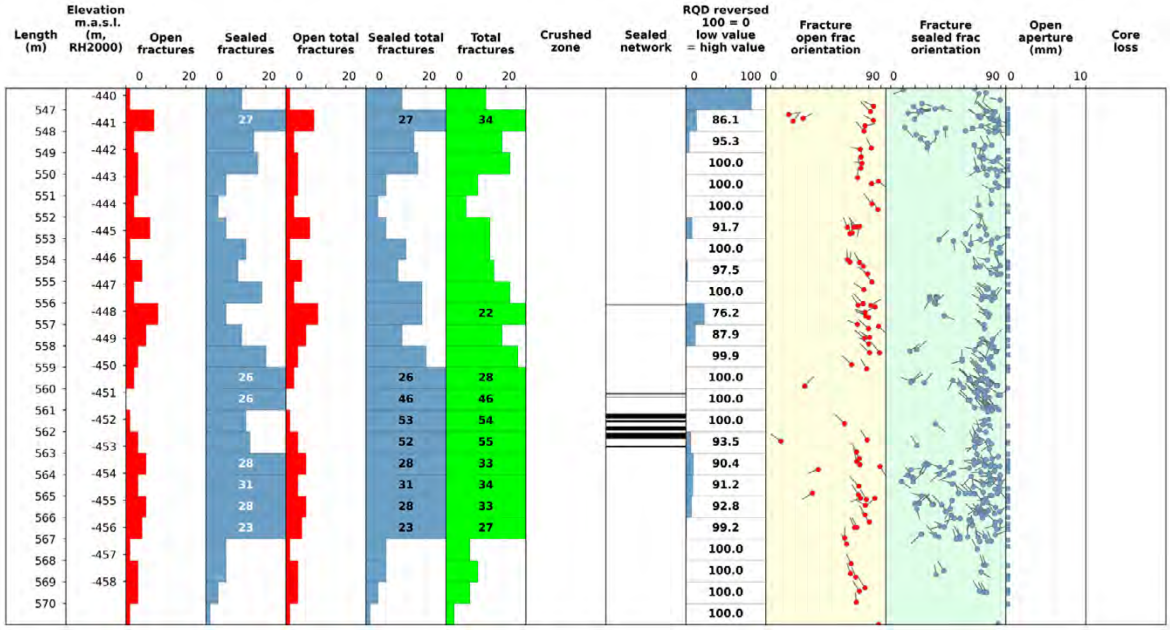
Fracture fill mineralogy:

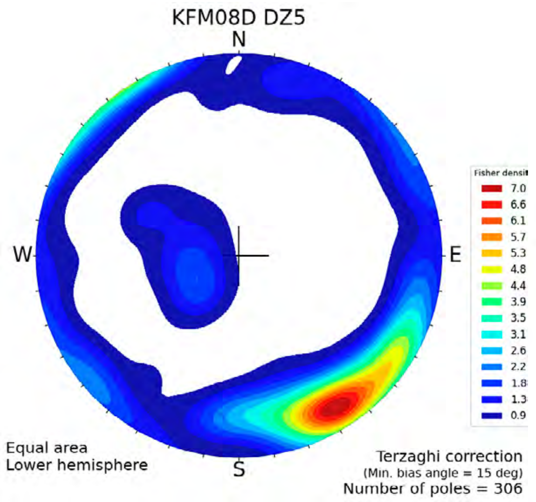


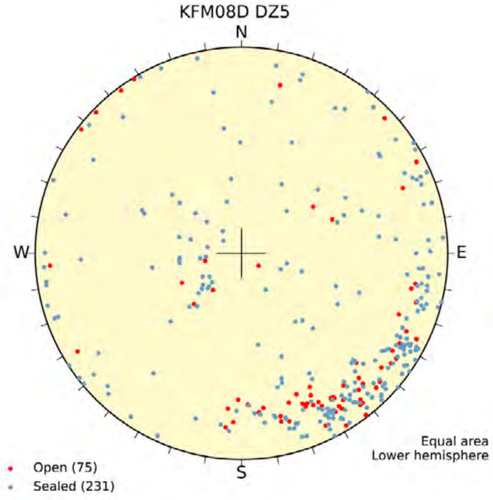
NE	ZFMNE2309	Version number	7	Total object CL	15

INDIVIDUAL INTERCEPTS

KFM08D DZ5 (546.0-571.0 m)

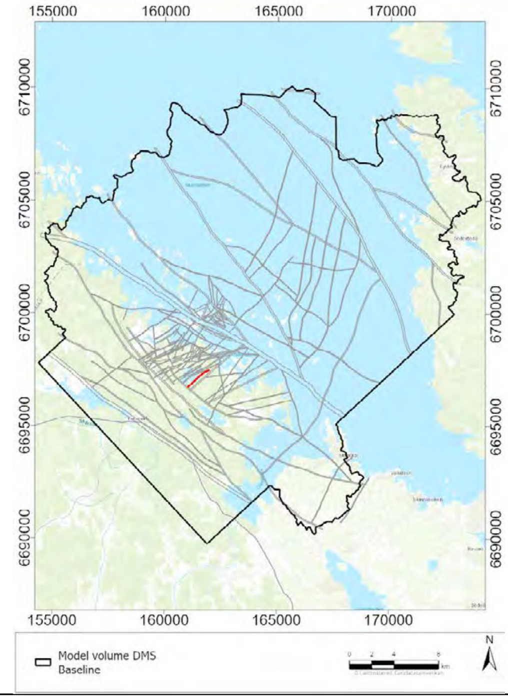






NE	ZFMNE2332	Version number	5	Total object CL	11

GEOLOGICAL CHARACTER		Property CL
Deformation style:	Brittle	1
Deformation description:	No data available.	
Alteration:		2
- First order:	Oxidation	
- Second order:	Not observed	
- Third order:	Not observed	
Fracture orientation and type:	No data available.	
Fracture comment:	No data available.	
Fracture fill mineralogy:	No data available.	
OBJECT GEOMETRY		
Strike/dip:	49°/85°	
Length:	1270 m	
Mean thickness:	15 m (3 - 50 m)	
Max depth:	-1250 m	
Geometrical constraints:	ZFMWNW0123, Topo 40m grid Max error 20m, 1 Surface Planar Cut(s), 1 UNIVERSE Planar Cut(s).	



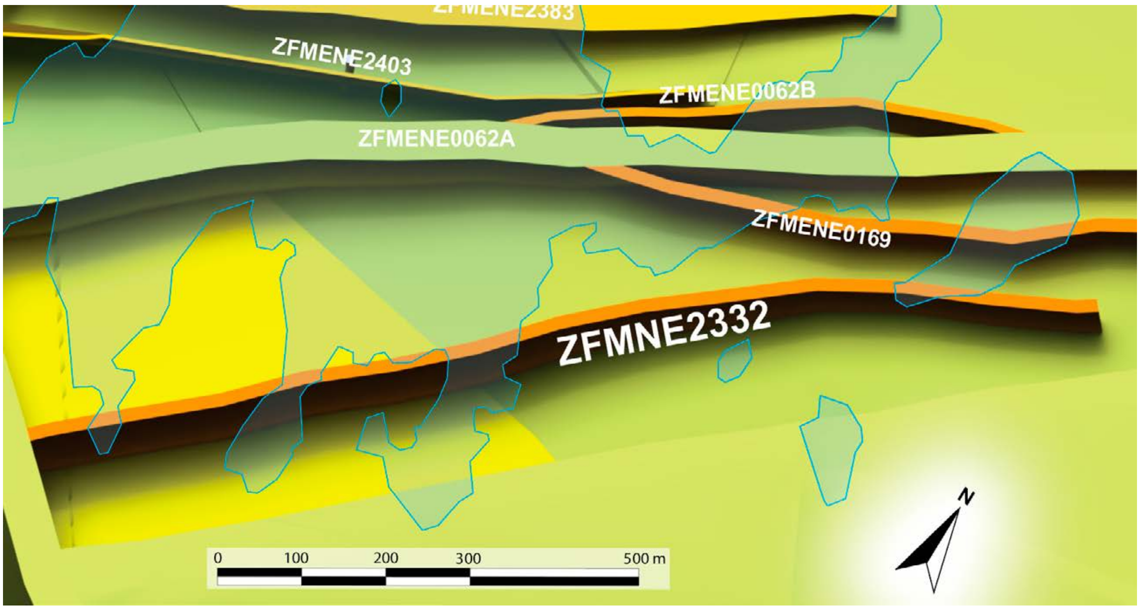
BASIS FOR MODELLING

Zone based on surface lineaments.

Outcrops:	-	
Boreholes: -		
Tunnels:	-	
Lineament and/or seismic indications:	MFM2332G0.	2

MODELLING PROCEDURE

At the surface, corresponds to the low magnetic lineament MFM2332G0 and its inferred continuation to the north-east. Modelled to a depth of 1450 m with a dip of 85 degrees based on a comparison with zone ZFMENE0062A that is situated to the north-west.



NE	ZFMNE2332	Version number	5	Total object CL	11

OBJECT CONFIDENCE ESTIMATE

Category	Object CL	Comment
INTERPRETATION		
Data source	1	MFM2332G0
Results of interpretation	2	Medium confidence in lineament MFM2332G0.
INFORMATION DENSITY		
Number of observation points	1	1
Distribution of observation points	1	Single observation point in the form of a lineament.
INTERPOLATION		
Geometry	1	Geometry supported by surface geophysical data.
Geological indicators	1	Indirect support by geophysical data.
EXTRAPOLATION		
Dip direction	1	No subsurface obs. point, supported only by surface data. High uncertainty in dip-direction. Strike length of the modelled zone < 2000 m.
Strike direction	3	Conceptual understanding of the site and that the entire modelled zone is supported by the lineament.

FRACTURE CHARACTER

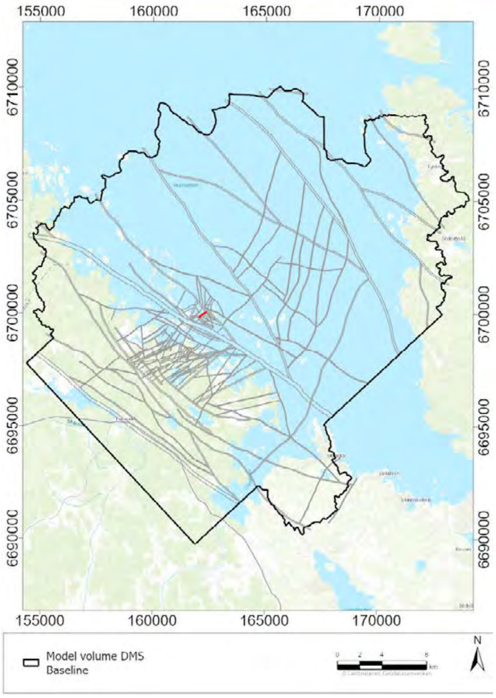
No data available

INDIVIDUAL INTERCEPTS

No data available

NE	ZFMNE3112	Version number	4	Total object CL	19

GEOLOGICAL CHARACTER		Property CL
Deformation style:	Brittle	3
Deformation description:	Minor cohesive breccias present in three of the BH intercepts.	
Alteration:		3
- First order:	Oxidation	
- Second order:	Lamontization	
- Third order:	Carbonatization	
Fracture orientation and type:	Fracture set with ENE strike dominate followed by NNW and NNE set. Sealed fracture networks observed. Occurrence of sealed and open fractures.	
Fracture comment:	Fracture apertures up to 0.5 mm with a single aperture at 3 mm (KFR104, SHI DZ3 268-283m).	
Fracture fill mineralogy:	Chlorite, laumontite, hematite, adularia and calcite.	



OBJECT GEOMETRY	
Strike/dip:	235°/89°
Length:	474 m
Mean thickness:	10 m (1 - 13 m)
Max depth:	-500 m
Geometrical constraints:	ZFMNW8043, ZFMNW0805B, Topo 40m grid Max error 20m, 1 Surface Planar Cut(s).

BASIS FOR MODELLING

Zone based on surface lineaments and borehole observations.

Outcrops:	-

Boreholes:

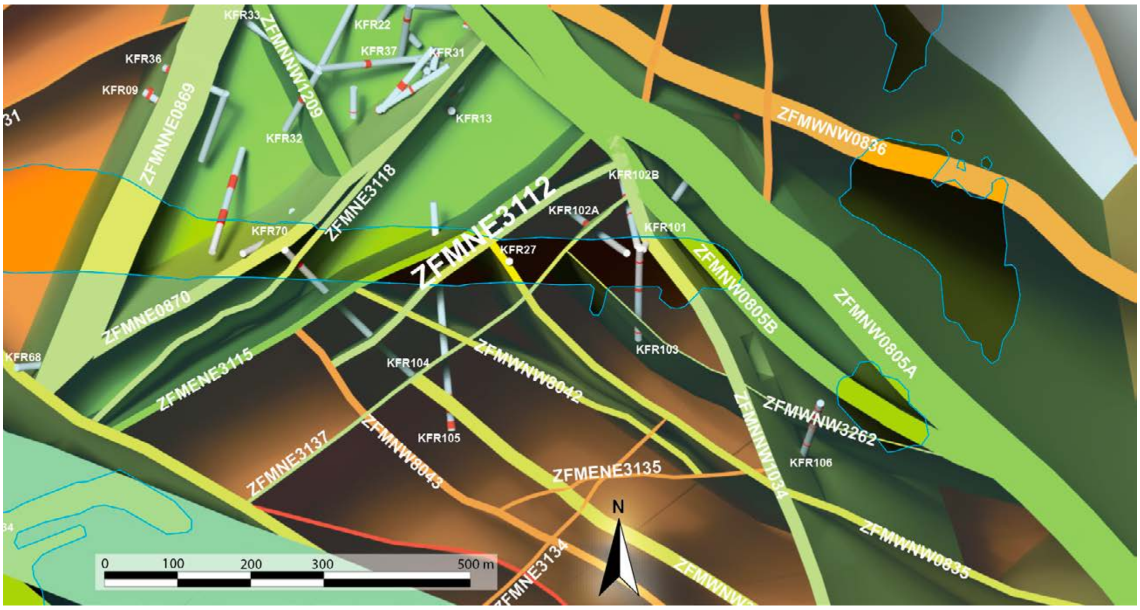
Borehole	PDZ	Target intercept		Geometric intercept		Comment
		Sec_up [m]	Sec_low [m]	Sec_up [m]	Sec_low [m]	
KFR102A	DZ2	302.00	325.00	299.74	323.06	
KFR102B	DZ4	173.00	180.00	169.96	180.07	
KFR104	DZ3	268.00	283.00	265.72	283.00	
KFR105	DZ2	88.50	96.50	87.40	100.05	

Tunnels:	-	
Lineament and/or seismic indications:	MFM3112G.	1

MODELLING PROCEDURE

The position of the zone at the ground surface is based on a projection from the interpreted borehole correlations, with only a weak and partial agreement with the lineament MFM3112G defined by a magnetic minimum (Isaksson et al. 2007). The central part of this zone lies beneath the pier where the magnetic field is disturbed and hinders lineament interpretation. The zone is intersected by KFR102A (302-325, DZ2), KFR102B (173-180, DZ4), KFR104 (268-283, DZ3) and KFR105 (88,5-96,5, DZ2). Fixed points placed at 313,5 m in KFR102A, 176,5 m in KFR102B, 275,5 m in KFR104 and 92,5 m in KFR105.

NE	ZFMNE3112	Version number	4	Total object CL	19



OBJECT CONFIDENCE ESTIMATE

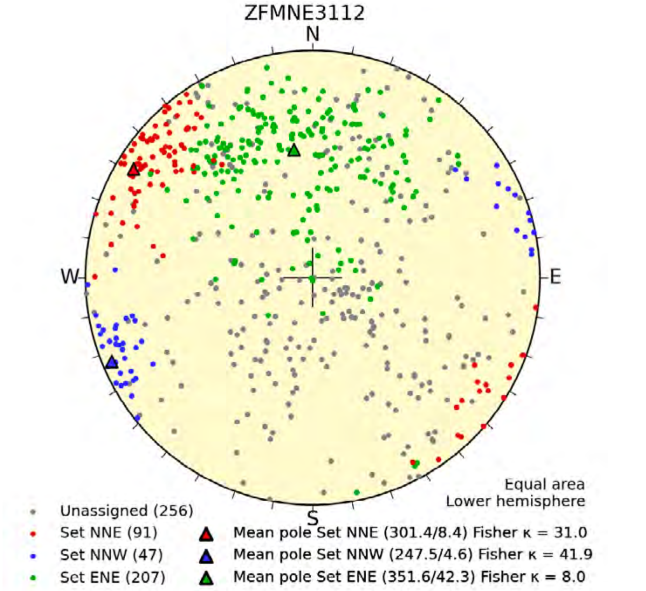
Category	Object CL	Comment
INTERPRETATION		
Data source	2	MFM3112G. However, the modelled zone do not follow the lineament precisely, KFR102A, KFR102B, KFR104, KFR105
Results of interpretation	3	High confidence observations in multiple boreholes.
INFORMATION DENSITY		
Number of observation points	3	>4
Distribution of observation points	3	Even distribution of obs. points.
INTERPOLATION		
Geometry	2	The zone has been observed in multiple boreholes (SHI interpret.) strengthening the current modelled geometry although the current geometric interpretation do not follow surface lineament precisely, henceforth there is the possibility that the zone continues SW and not truncated by ZFMNW8043.
Geological indicators	2	Interpolation supported by mineral fillings within fractures from boreholes.
EXTRAPOLATION		
Dip direction	2	Extrapolation in dip direction supported by subsurface obs. point. Strike length of the modelled zone < 2000 m.
Strike direction	2	Partly support by surface lineament. Supported by geological concept and subsurface observation points.

NE	ZFMNE3112	Version number	4	Total object CL	19

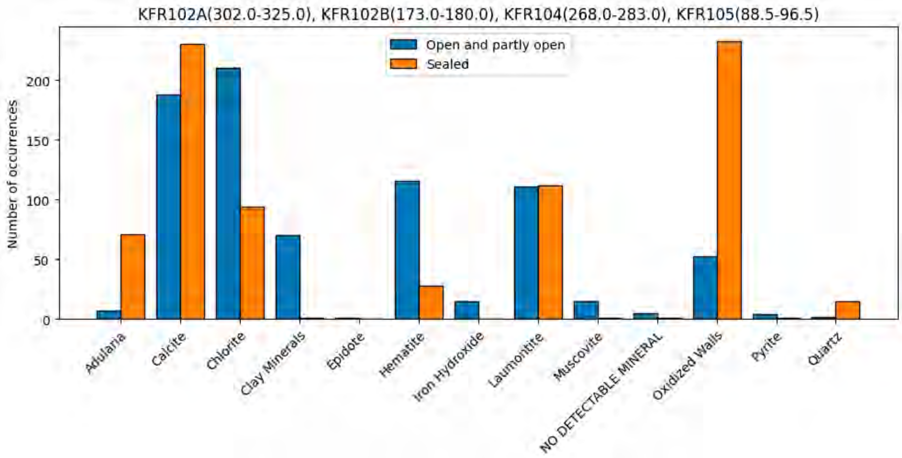
FRACTURE CHARACTER

Orientation: (strike/dip right-hand-rule)	Set NNE: 31.4°/81.6° Set NNW: 337.5°/85.4° Set ENE: 81.6°/47.7°
Frequency:	Boreholes: KFR102A, KFR102B, KFR105, KFR104

FRACTURE TYPE	TERZAGHI-WEIGHED P10
Open and partly open	8.0 m-1
Sealed	14.1 m-1
Sealed network	35.9 % of DZ intercept
Crush	1.2 % of DZ intercept



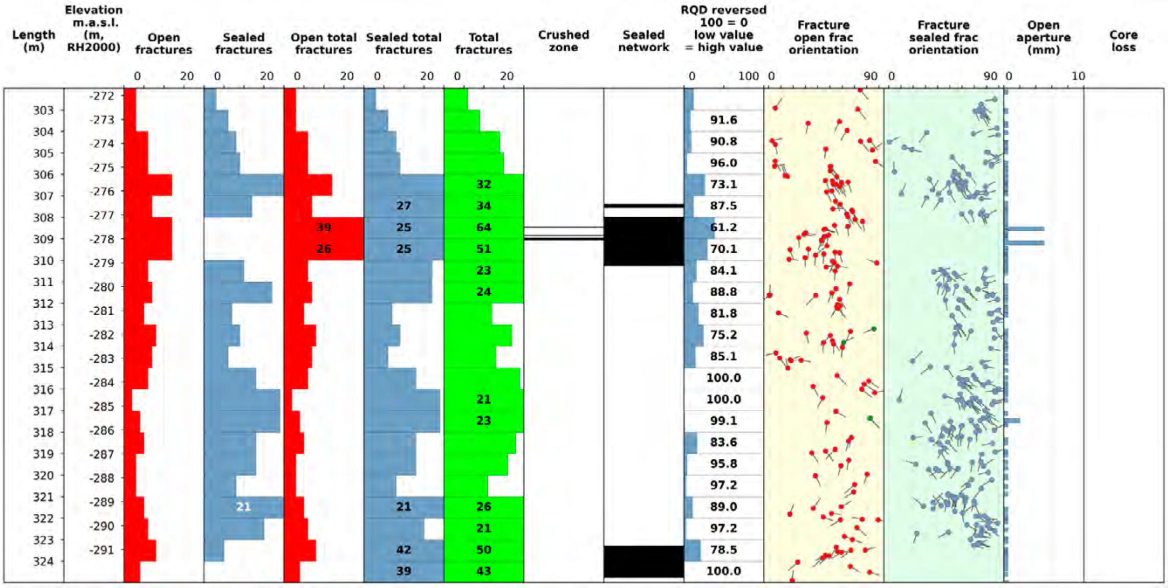
RQD:	min:42, max:100, mean:87
Fracture fill mineralogy:	

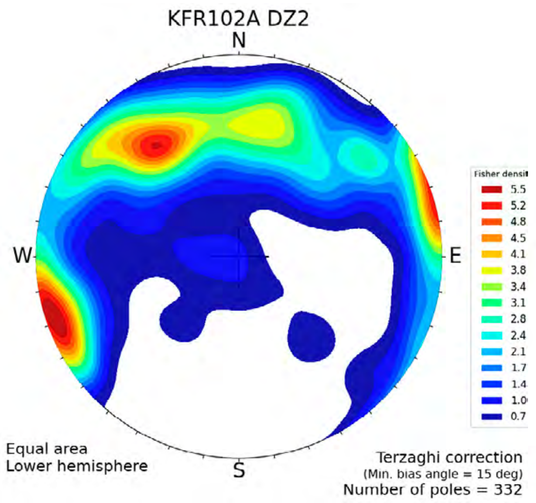


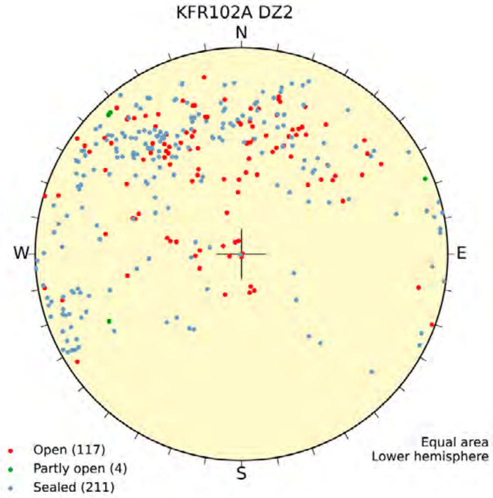
NE	ZFMNE3112	Version number	4	Total object CL	19

INDIVIDUAL INTERCEPTS

KFR102A DZ2 (302.0-325.0 m)

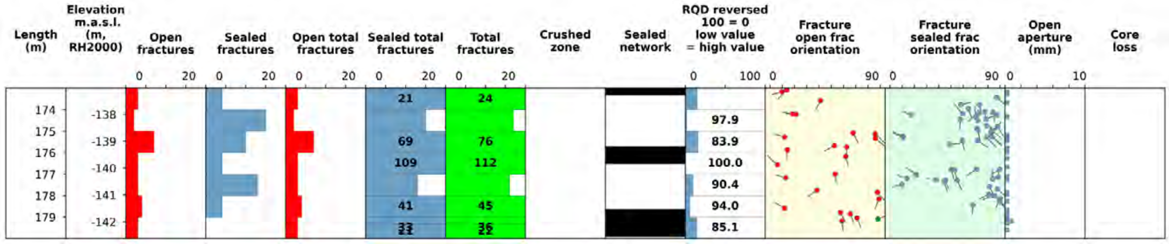


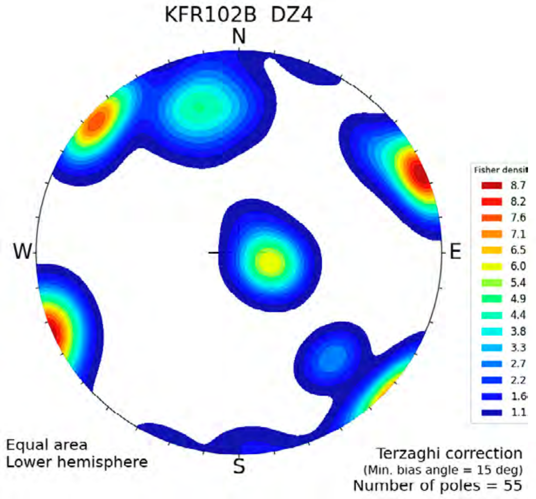


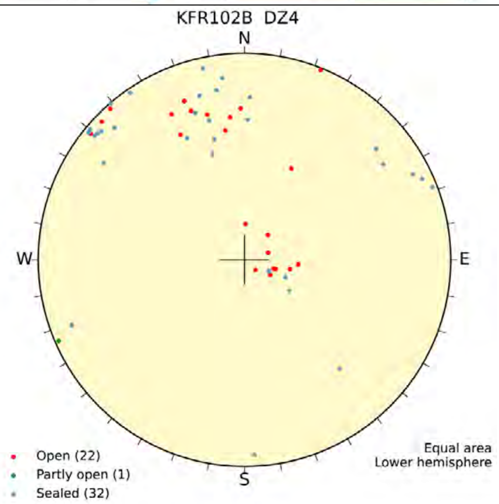


NE	ZFMNE3112	Version number	4	Total object CL	19

KFR102B DZ4 (173.0-180.0 m)

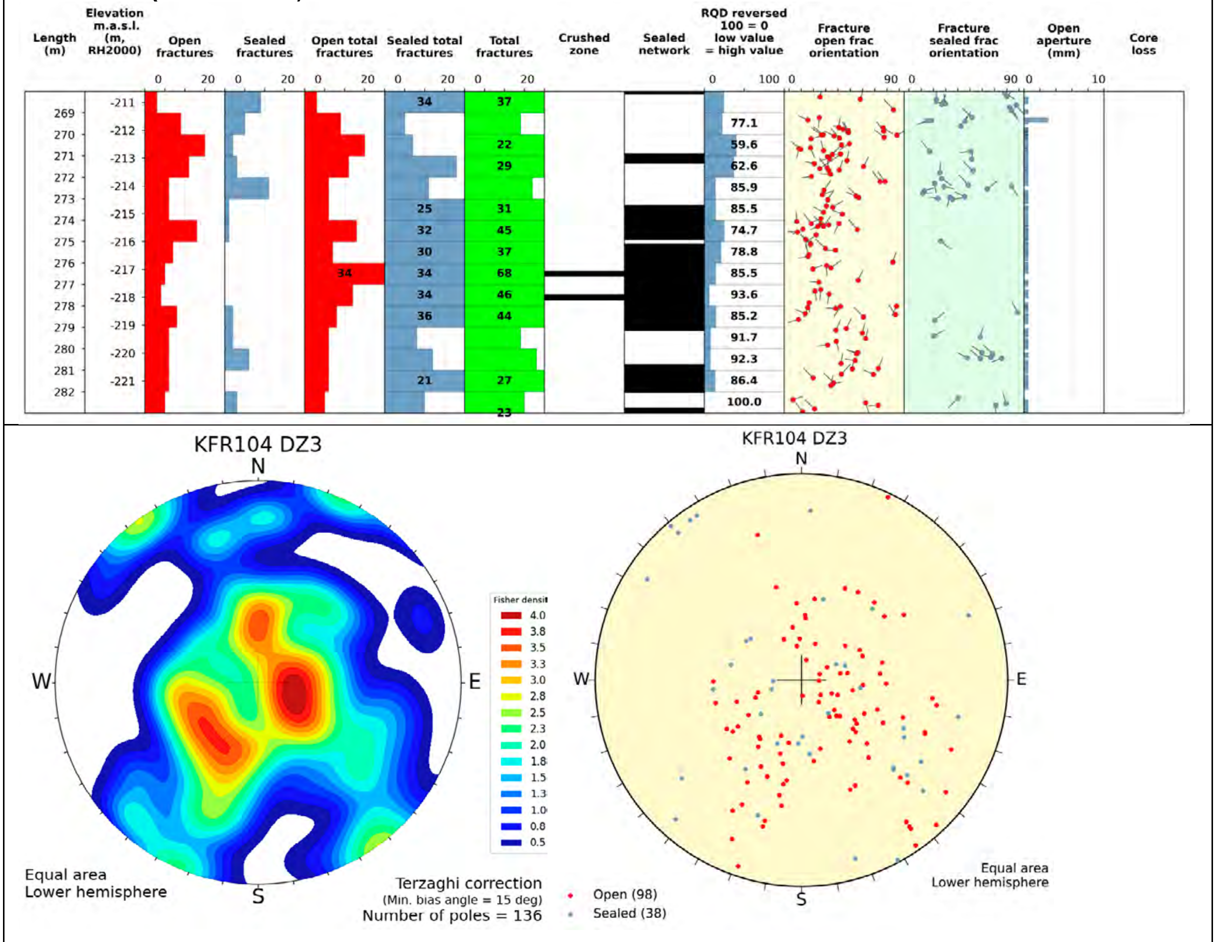






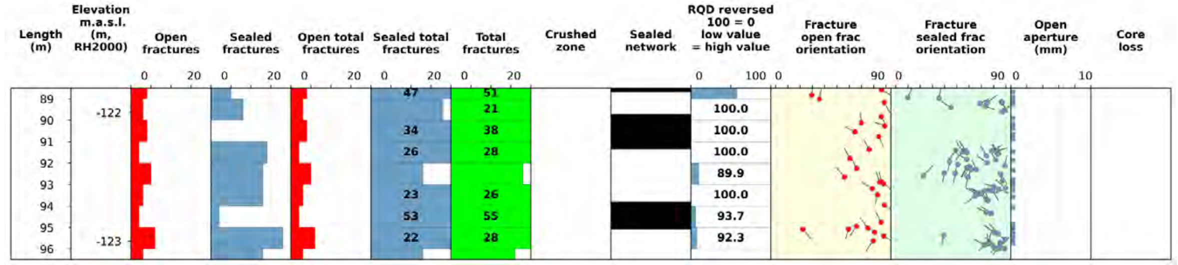
NE	ZFMNE3112	Version number	4	Total object CL	19

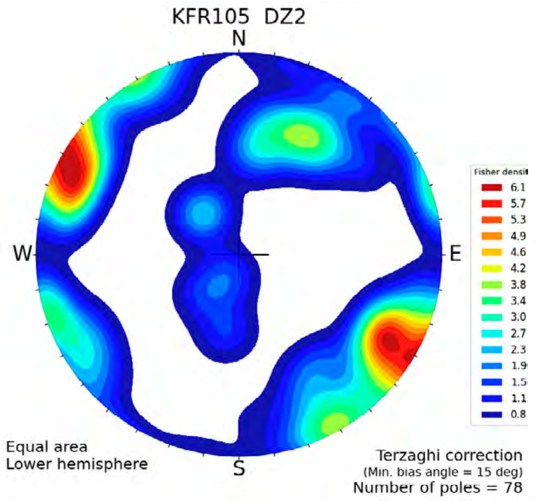
KFR104 DZ3 (268.0-283.0 m)

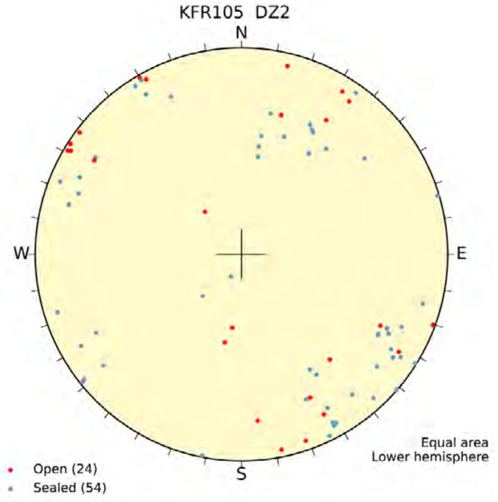


NE	ZFMNE3112	Version number	4	Total object CL	19

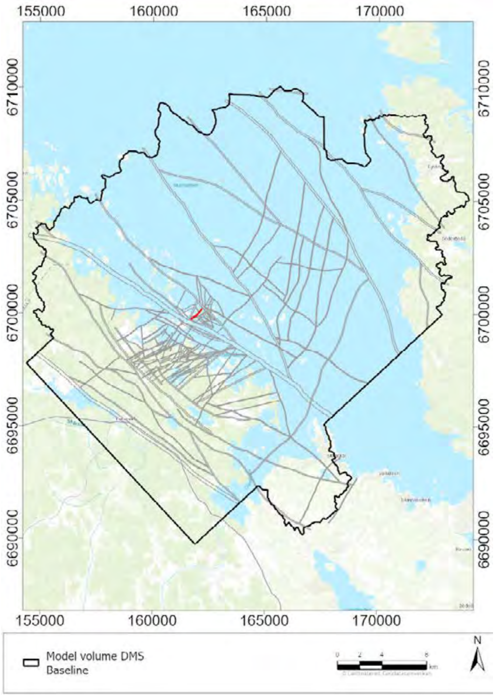
KFR105 DZ2 (88.5-96.5 m)







NE	ZFMNE3118	Version number	4	Total object CL	21



GEOLOGICAL CHARACTER		Property CL
Deformation style:	Brittle	3
Deformation description:	Inferred minor brittle-ductile shear zone at 200.25–200.54 m in HFR101 DZ3. Cohesive breccia in KFR104 DZ1.	
Alteration:		3
- First order:	Oxidation	
- Second order:	Quartz dissolution	
- Third order:	Not observed	
Fracture orientation and type:	Fracture set with SSW strike dipping to WNW dominates. Occurrence of open and sealed fractures as well as sealed fracture networks.	
Fracture comment:	No data available.	
Fracture fill mineralogy:	Calcite, chlorite, laumontite and hematite.	

OBJECT GEOMETRY

Strike/dip:	46°/84°
Length:	743 m
Mean thickness:	8 m (2 - 36 m)
Max depth:	-750 m
Geometrical constraints:	ZFMNW0805B, ZFMWNW1035, ZFMENE3115, Topo 40m grid Max error 20m, ZFMNW0805A, 1 Surface Planar Cut(s).

BASIS FOR MODELLING

Modified after zone 12 Carlsson et al. (1985). Zone based on surface lineaments, borehole and tunnel observations.

Outcrops: -

Boreholes:

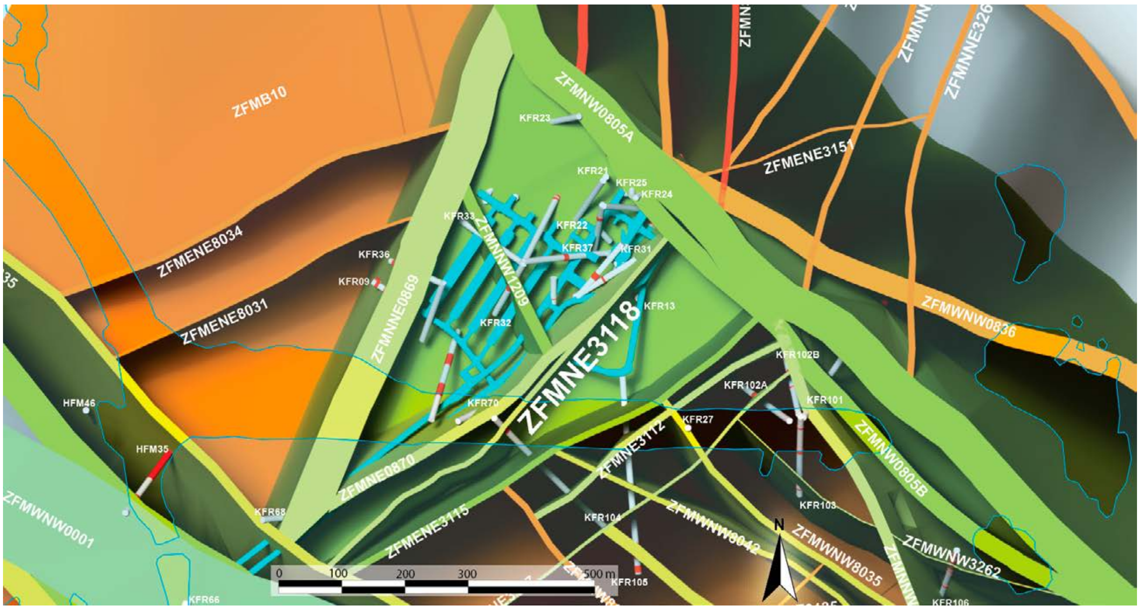
Borehole	PDZ	Target intercept		Geometric intercept		Comment
		Sec_up [m]	Sec_low [m]	Sec_up [m]	Sec_low [m]	
HFR101	DZ3	190.00	202.00	183.31	203.33	
KFR104	DZ1	30.00	45.50	29.64	46.12	
KFR113		-	-	1.28	2.40	No SHI available.
KFR114		-	-	1.92	2.20	No SHI available.
KFR115		-	-	0.00	1.65	No SHI available.
KFR116		-	-	0.79	2.59	No SHI available.
KFR13	DZ3	47.50	61.00	43.88	76.60	
KFR53		-	-	0.00	5.64	No SHI available.
KFR54	DZ1	0.00	2.50	0.00	7.32	
KFR55	DZ2	8.00	17.00	8.36	17.20	Subdivision of DZ2 between ZFMNE0870 and ZFMNE3118.

Tunnels:	BT/ST target intercept 1+166 - ?, geometric intercept 1+130 - 1+166 m. NBT target intercept 0+055 - 0+059 m, geometric intercept 0+055 - 0+059 m. NBT target intercept 0+295 - 0+340 m, geometric intercept 0+295 - 0+315 m.	
Lineament and/or seismic indications:	MSFR08111.	1

MODELLING PROCEDURE

Modified after zone 12 (Carlsson et al. 1985). The position of the zone at the ground surface in the south-west coincides with the magnetic lineament MSFR08111 in SFR model version 1.0, itself an update of MFM3118G (Isaksson et al. 2007). The main central section of the zone lies beneath the pier in an area where the magnetic field is disturbed and hinders lineament interpretation. Intercepted by multiple borholes and observed in tunnels in SFR. Target intercept defined by tDZ73 in Appendix 2 (Curtis et al. 2011). NBT: 0+055-0+059 target intercept based on shotcrete coverage marked in the detailed tunnel mapping. Earlier interpreted as zone 12 by /Carlsson et al. 1985/ with an intercept of 8+060.

NE	ZFMNE3118	Version number	4	Total object CL	21

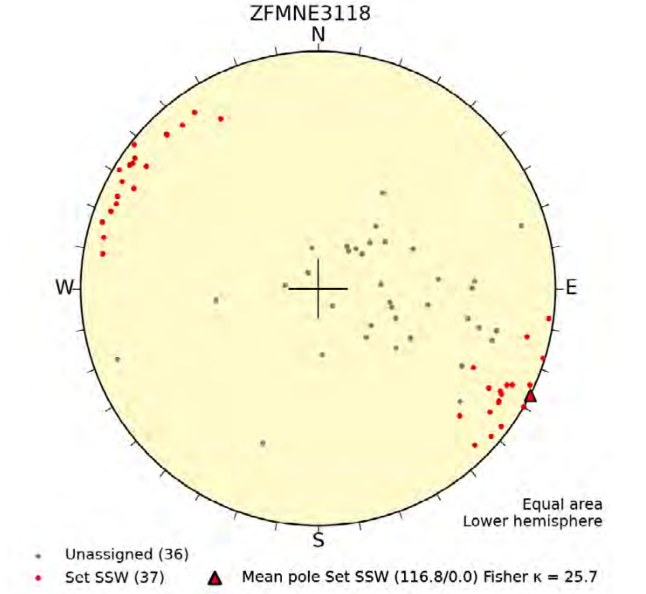
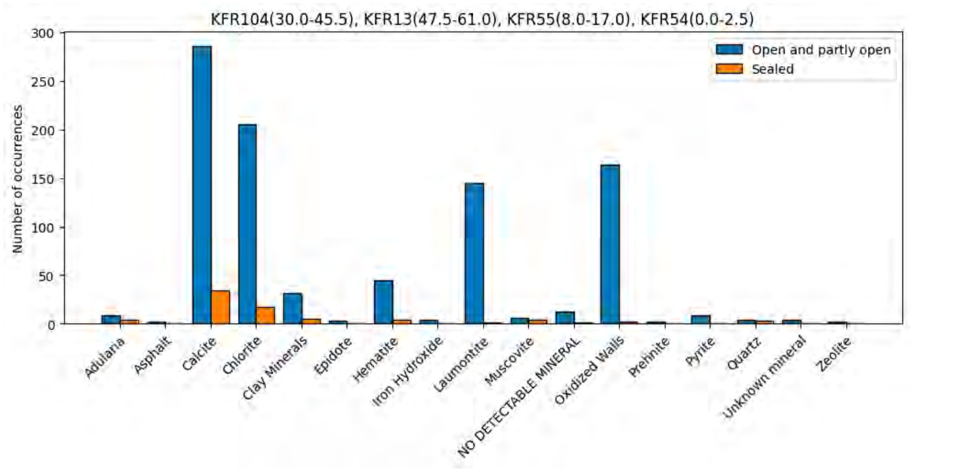


OBJECT CONFIDENCE ESTIMATE

Category	Object CL	Comment
INTERPRETATION		
Data source	3	MFM3118G, HFR101, KFR13, KFR53, KFR54, KFR55,KFR104, KFR113, KFR114, KFR115, KFR116, tDZ73, BT/ST, NBT
Results of interpretation	3	High confidence observation in KFR54 and KFR55 and tunnel observations.
INFORMATION DENSITY		
Number of observation points	3	>4
Distribution of observation points	2	Two clusters and the lineament considered as an outlier.
INTERPOLATION		
Geometry	3	One strong alternative based on fracture mineralogy in multiple boreholes.
Geological indicators	3	Interpolation supported by mineral fillings within fractures from boreholes and tunnels.
EXTRAPOLATION		
Dip direction	2	Extrapolation in dip direction supported by subsurface obs. points. Strike length of the modelled zone < 2000 m.
Strike direction	2	Partly or no support by surface lineament. Supported by geological concept and subsurface observation points.

NE	ZFMNE3118	Version number	4	Total object CL	21

FRACTURE CHARACTER

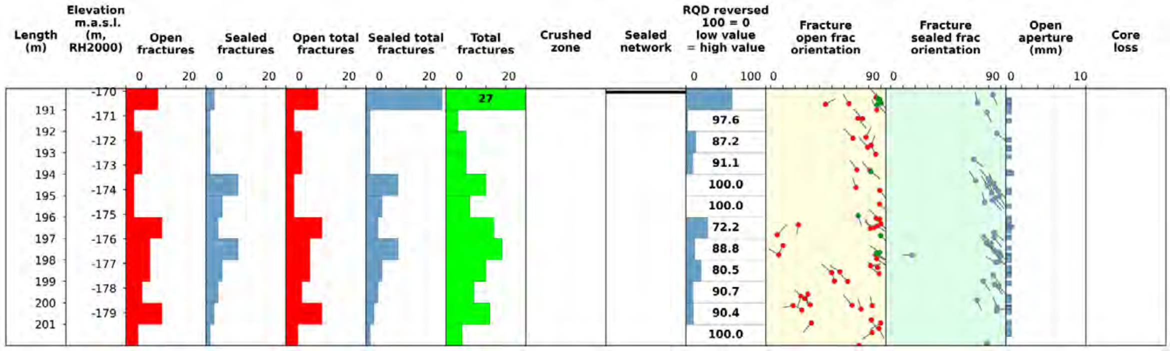
Orientation: (strike/dip right-hand-rule)	Set SSW: 206.8°/90.0°	
Frequency:	Boreholes: KFR53, KFR113, KFR13, KFR115, KFR55, KFR116, KFR54, KFR104, KFR114	
RQD:	min:6, max:100, mean:65	
Fracture fill mineralogy:		

FRACTURE TYPE	TERZAGHI-WEIGHED P10
Open and partly open	6.9 m-1
Sealed	0.6 m-1
Sealed network	3.3 % of DZ intercept
Crush	0.0 % of DZ intercept

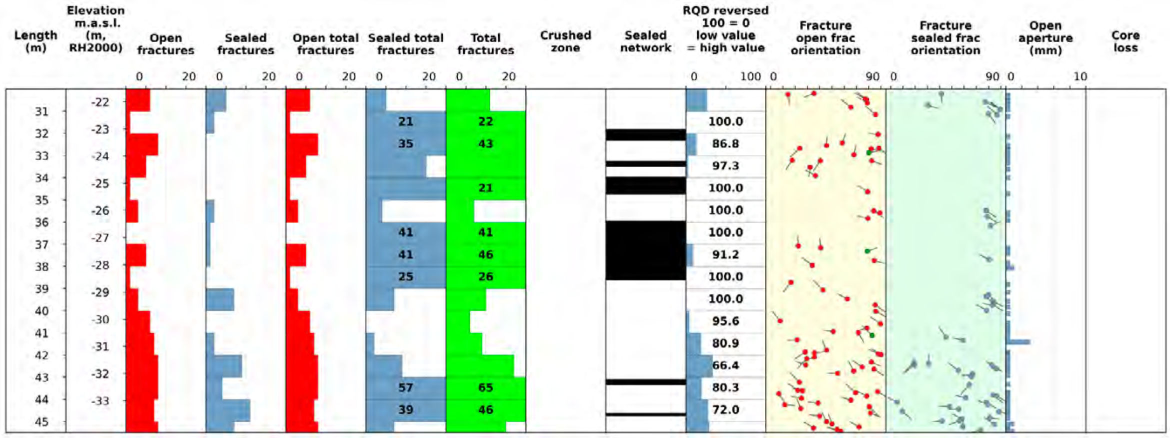
NE	ZFMNE3118	Version number	4	Total object CL	21

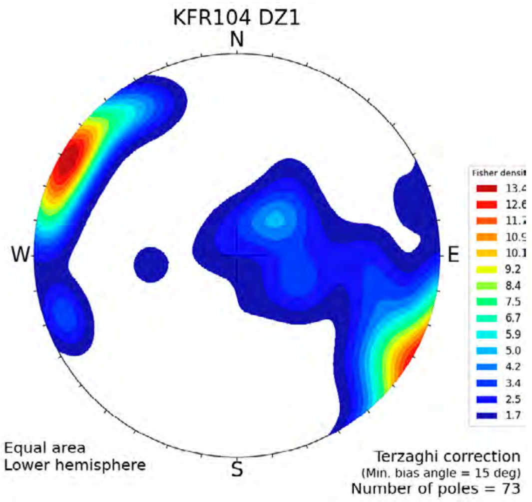
INDIVIDUAL INTERCEPTS

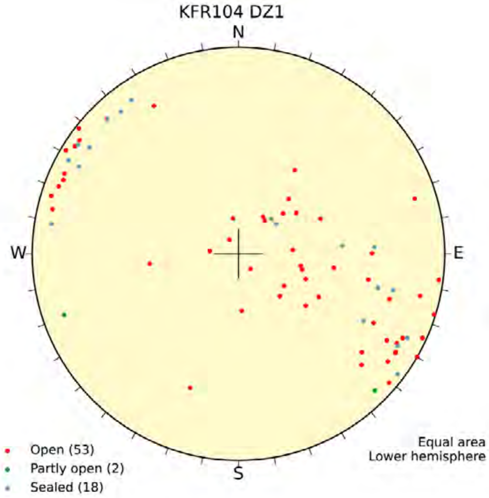
HFR101 DZ3 (190.0-202.0 m)



KFR104 DZ1 (30.0-45.5 m)







NE	ZFMNE3118	Version number	4	Total object CL	21

KFR113 (1.28-2.4 m)

No data available

KFR114 (1.92-2.2 m)

No data available

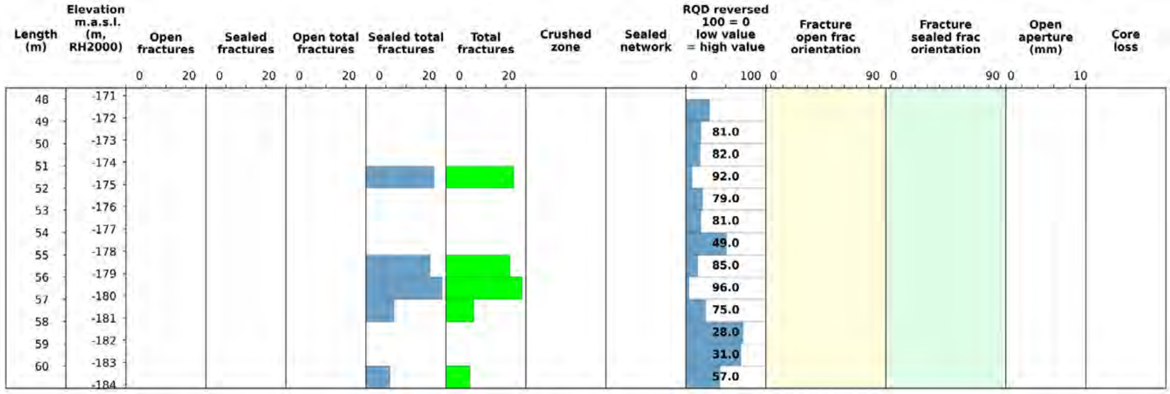
KFR115 (0.0-1.65 m)

No data available

KFR116 (0.79-2.59 m)

No data available

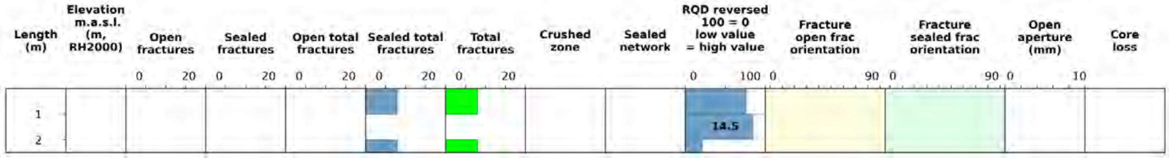
KFR13 DZ3 (47.5-61.0 m)



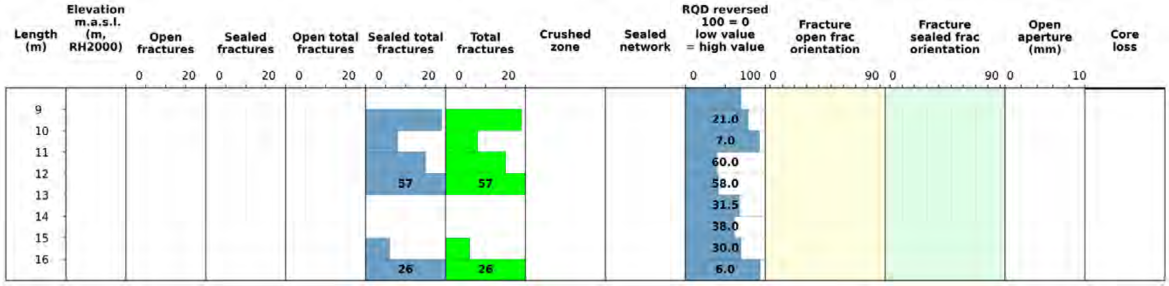
KFR53 (0.0-5.64 m)

No data available

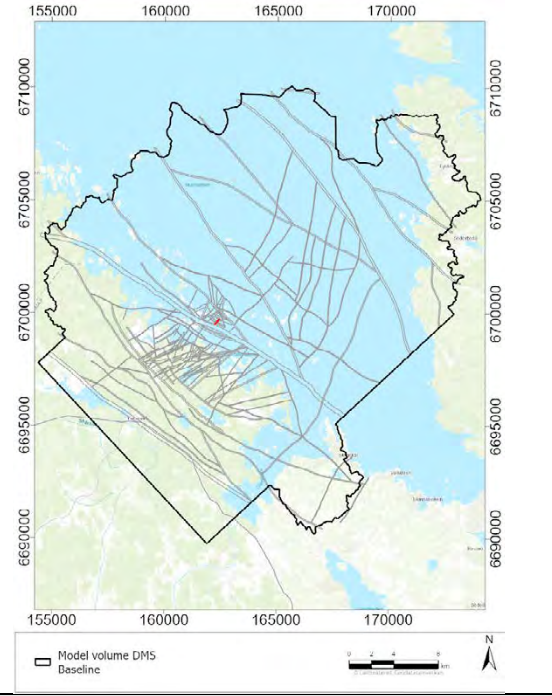
KFR54 DZ1 (0.0-2.5 m)



KFR55 DZ2 (8.0-17.0 m)



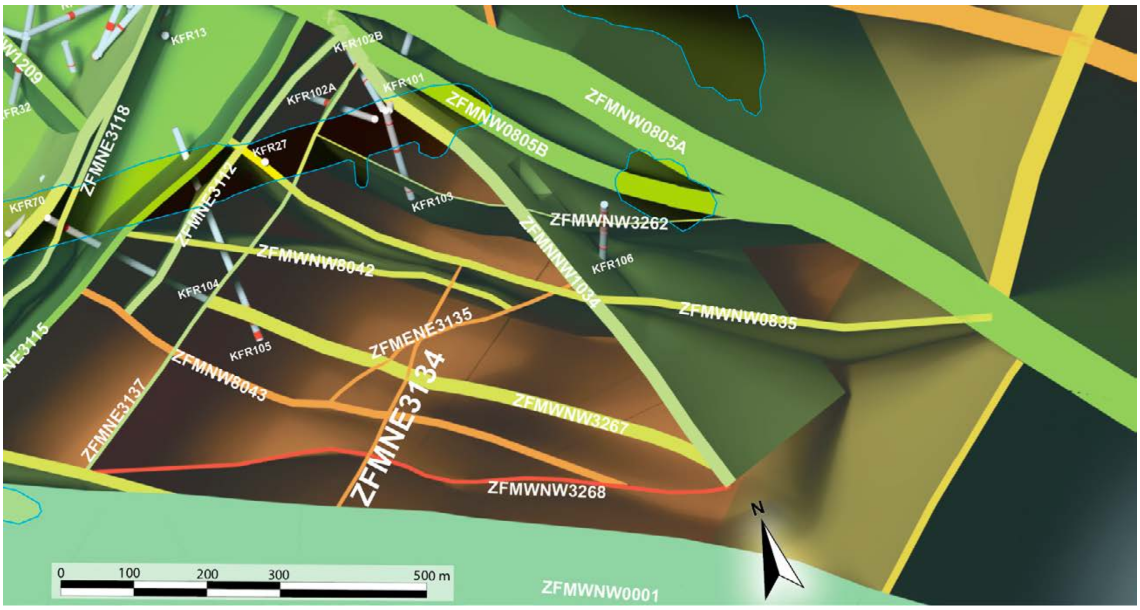
NE	ZFMNE3134		Version number	4	Total object CL	10
GEOLOGICAL CHARACTER		**Property CL**				
Deformation style:	Brittle	2				
Deformation description:	No data available.					
Alteration:						
- First order:	Not observed					
- Second order:	Not observed					
- Third order:	Not observed					
Fracture orientation and type:	No data available.					
Fracture comment:	No data available.					
Fracture fill mineralogy:	No data available.					
OBJECT GEOMETRY						
Strike/dip:	43°/90°					
Length:	373 m					
Mean thickness:	5 m (1 - 13 m)					
Max depth:	-370 m					
Geometrical constraints:	ZFMWNW0835, ZFMWNW1035, Topo 40m grid Max error 20m, ZFMWNW0001, 1 Surface Planar Cut(s).					



BASIS FOR MODELLING		
Zone based on surface lineaments.		
Outcrops:	-	
Boreholes: -		
Tunnels:	-	
Lineament and/or seismic indications:	MSFR10005, MSFR10011.	1

MODELLING PROCEDURE

The position of the zone at the ground surface is based on a linking of lineaments MSFR10005 and MSFR10011 defined by magnetic minima in the SFR model version 1.0, earlier represented by MFM3134G in Forsmark stage 2.3 (Isaksson et al. 2007). The zone modelled thickness and vertical dip are default values.



NE	ZFMNE3134	Version number	4	Total object CL	10

OBJECT CONFIDENCE ESTIMATE

Category	Object CL	Comment
INTERPRETATION		
Data source	1	MFM3134G
Results of interpretation	1	Low confidence in lineament MFM3134G.
INFORMATION DENSITY		
Number of observation points	1	1
Distribution of observation points	1	Single observation point in the form of a lineament.
INTERPOLATION		
Geometry	1	Geometry supported by a lineament and a single intercept.
Geological indicators	1	Indirect support by geophysical data.
EXTRAPOLATION		
Dip direction	1	No subsurface obs. point, supported only by surface data. High uncertainty in dip-direction. Strike length of the modelled zone < 2000 m.
Strike direction	3	Conceptual understanding of the site and that the entire modelled zone is supported by the lineament.

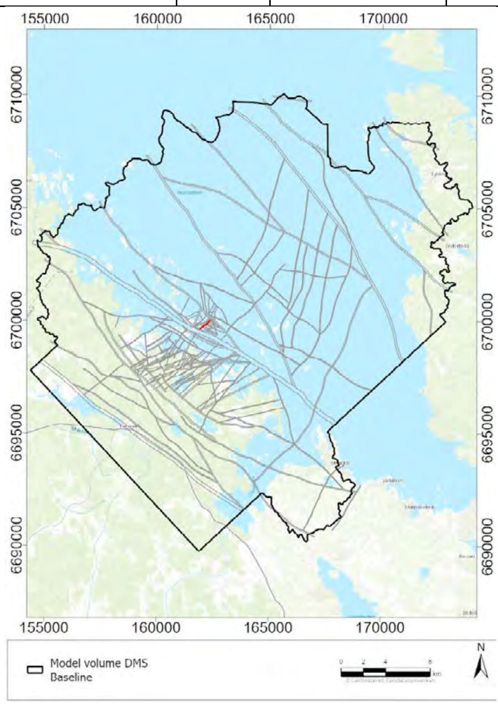
FRACTURE CHARACTER

No data available

INDIVIDUAL INTERCEPTS

No data available

NE	ZFMNE3137	Version number	8	Total object CL	20



GEOLOGICAL CHARACTER		Property CL
Deformation style:	Brittle	3
Deformation description:	No data available.	
Alteration:		3
- First order:	Oxidation	
- Second order:	Not observed	
- Third order:	Not observed	
Fracture orientation and type:	Fracture dominated by NE striking set followed by NNW set. Occurrence of sealed and open fractures.	
Fracture comment:	Fracture apertures 0.5 mm or less.	
Fracture fill mineralogy:	Predominant minerals in sealed and open fractures are laumontite, adularia, calcite and chlorite. Predominant minerals in sealed fracture networks are adularia, laumontite, chlorite and calcite.	

OBJECT GEOMETRY	
Strike/dip:	231°/90°
Length:	659 m
Mean thickness:	5 m (2 - 36 m)
Max depth:	-860 m
Geometrical constraints:	ZFMWNW1035, ZFMNNW1034, ZFMNW0805B, Topo 40m grid Max error 20m, ZFMWNW0001, 1 Surface Planar Cut(s).

BASIS FOR MODELLING

Zone based on surface lineaments and borehole observations.

Outcrops: -

Boreholes:

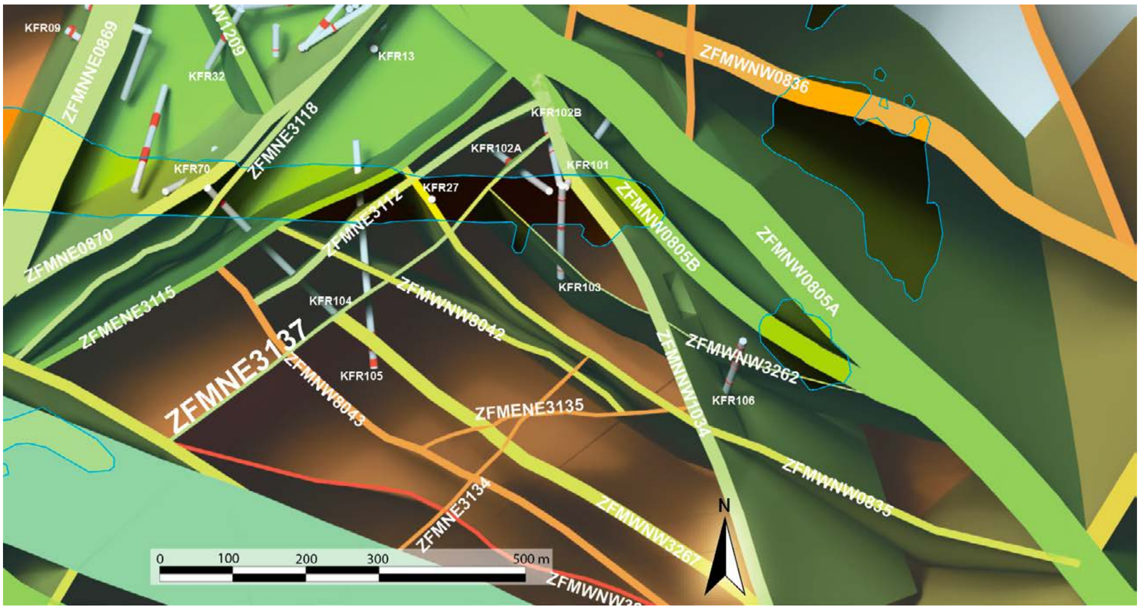
Borehole	PDZ	Target intercept Sec_up [m]	Target intercept Sec_low [m]	Geometric intercept Sec_up [m]	Geometric intercept Sec_low [m]	Comment
KFR102A	DZ1	149.00	161.00	147.82	160.86	
KFR102B	DZ2	109.00	114.00	106.85	116.24	
KFR104	DZ4	382.00	387.00	381.06	388.65	
KFR105		191.00	205.00	203.95	209.69	There is no SHI DZ interpreted in the position of the target intercept in KFR105. However, the modelled geometry generates an intercept in KFR105 with a section of core that coincides with an interval of increased frequency of steeply dipping fractures that strike NE at 191 to 193 m length. In and 15 mm, respectively, along with NE-striking crush at 202.7–203.8 and 204.2–204.8 m with piece lengths of 30 addition, two NE-striking sealed networks at 205.0–205.05 m.

Tunnels:	-	
Lineament and/or seismic indications:	MSFR10004.	1

NE	ZFMNE3137	Version number	8	Total object CL	20

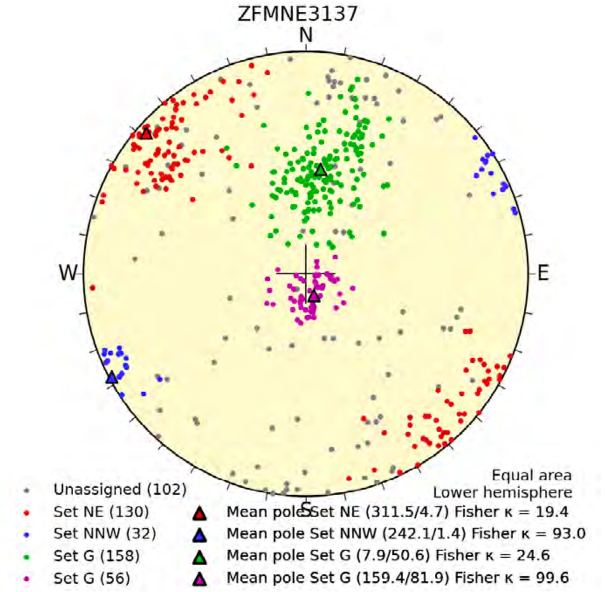
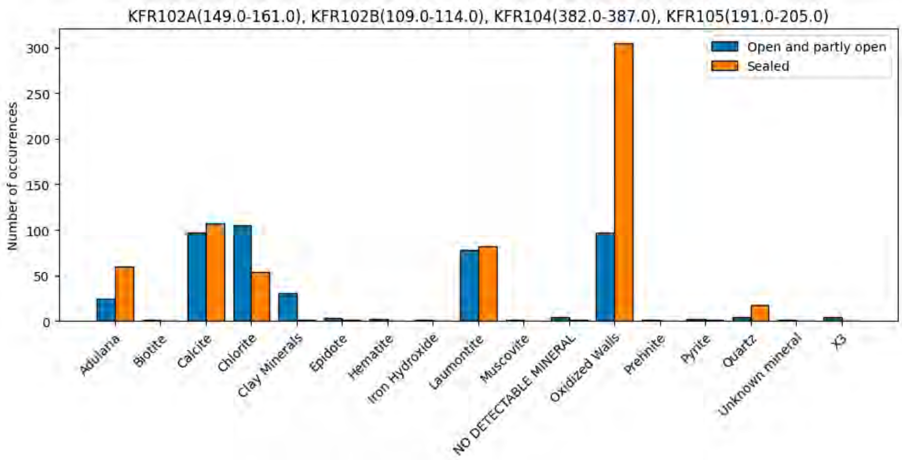
MODELLING PROCEDURE

The position of the zone at the ground surface is based on the magnetic lineament MSFR10004 in SFR model version 1.0, i.e. modified lineament MFM3137G in Forsmark stage 2.3 (Isaksson et al. 2007), with an extension through the disturbed magnetic area below the pier allowing correlation with new borehole information. Forward modelling of magnetic data along profile 40 (see Appendix 6) supports the modelled vertical dip of the zone. Zone intercepted by KFR102A 149-161 m (DZ1), KFR102B 109-114 m (DZ2), KFR104 382-387 m and KFR105 191-205 m.



OBJECT CONFIDENCE ESTIMATE

Category	Object CL	Comment
INTERPRETATION		
Data source	2	MSFR10004, KFR1012A, KFR102B, KFR104, KFR105
Results of interpretation	3	High confidence observation in KFR102B and KFR104.
INFORMATION DENSITY		
Number of observation points	3	>4
Distribution of observation points	3	Cluster of borehole intersections and a lineament as an outlier.
INTERPOLATION		
Geometry	2	One strong interpolation alternative.
Geological indicators	3	Interpolation supported by mineral fillings within fractures from boreholes.
EXTRAPOLATION		
Dip direction	2	Extrapolation in dip direction supported by subsurface obs. point. Strike length of the modelled zone < 2000 m.
Strike direction	2	Partly support by surface lineament. Supported by geological concept and subsurface observation points.

<table>
<tr><td>NE</td><td>ZFMNE3137</td><td>Version number</td><td>8</td><td>Total object CL</td><td>20</td></tr>
<tr><td colspan="6">FRACTURE CHARACTER</td></tr>
<tr><td>Orientation:
(strike/dip right-hand-rule)</td><td>Set NE: 41.5°/85.3°
Set NNW: 332.1°/88.6°
Set G: 97.9°/39.4°
Set G: 249.4°/8.1°</td><td colspan="4" rowspan="2">
</td></tr>
<tr><td>Frequency:</td><td>Boreholes: KFR102A, KFR102B, KFR105, KFR104
<table>
<tr><td>FRACTURE TYPE</td><td>TERZAGHI-WEIGHED P10</td></tr>
<tr><td>Open and partly open</td><td>7.7 m-1</td></tr>
<tr><td>Sealed</td><td>17.5 m-1</td></tr>
<tr><td>Sealed network</td><td>28.7 % of DZ intercept</td></tr>
<tr><td>Crush</td><td>0.0 % of DZ intercept</td></tr>
</table></td></tr>
<tr><td>RQD:</td><td>min:27, max:100, mean:88</td><td colspan="4"></td></tr>
<tr><td>Fracture fill mineralogy:</td><td colspan="5">
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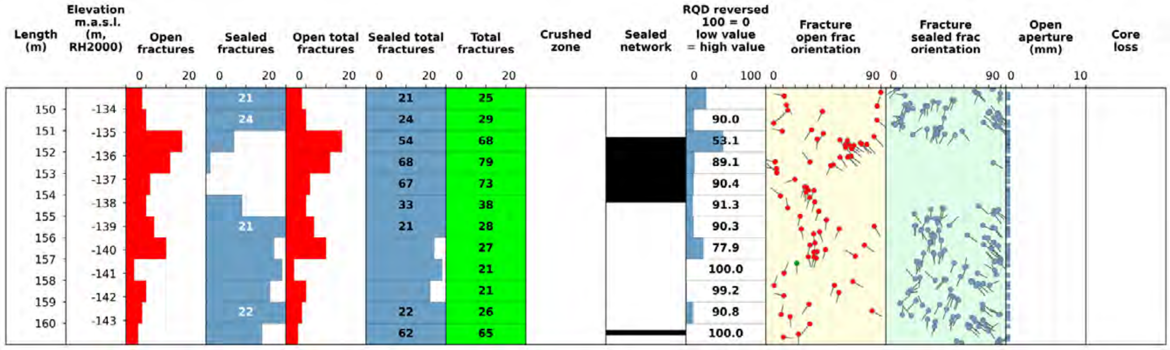
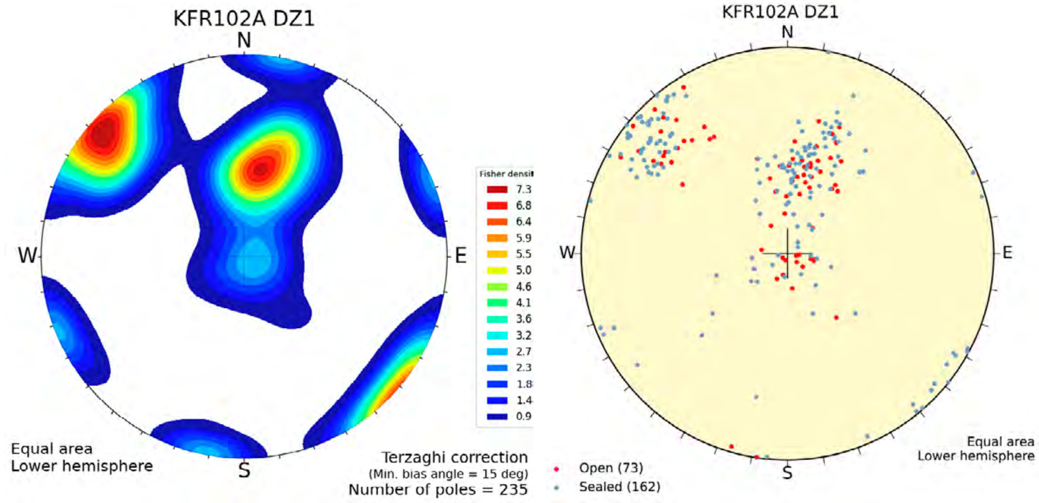
NE	ZFMNE3137	Version number	8	Total object CL	20

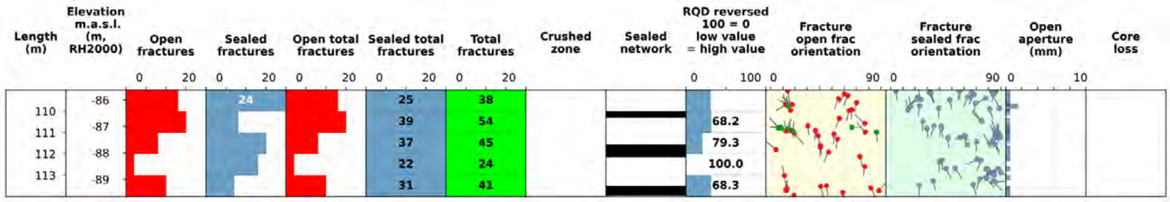
INDIVIDUAL INTERCEPTS

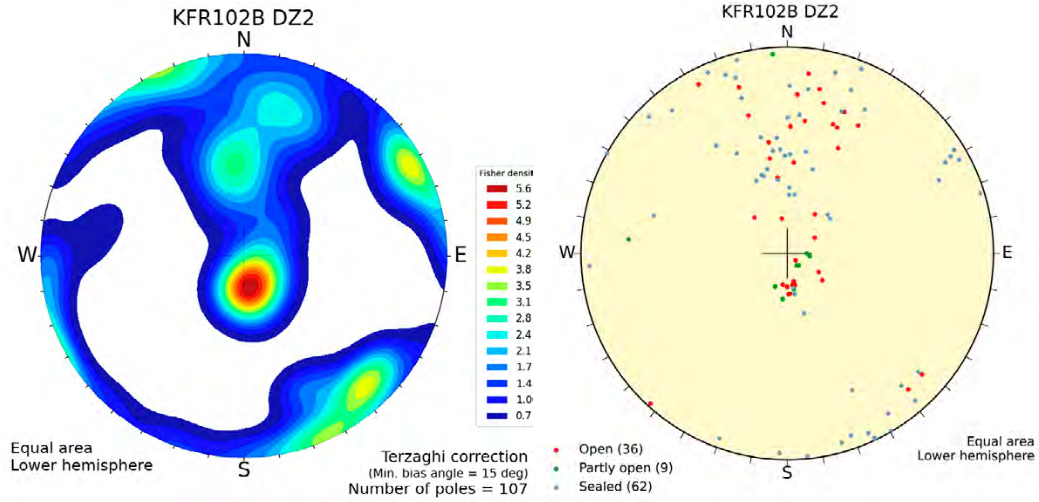
KFR102A DZ1 (149.0-161.0 m)





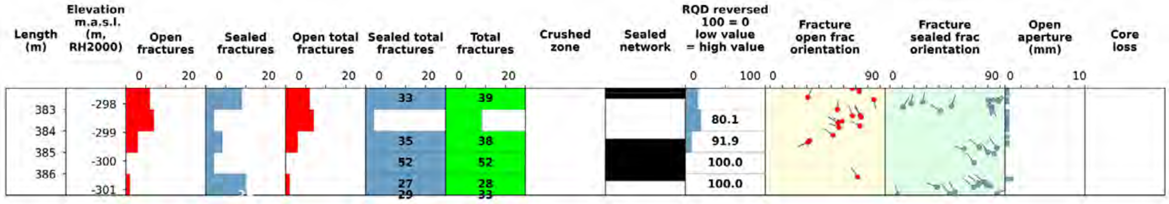
KFR102B DZ2 (109.0-114.0 m)

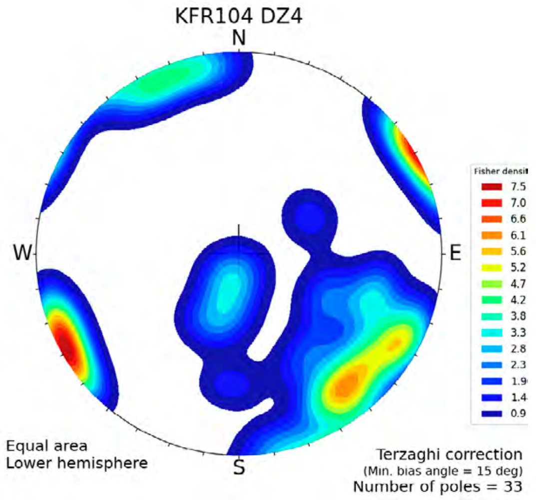


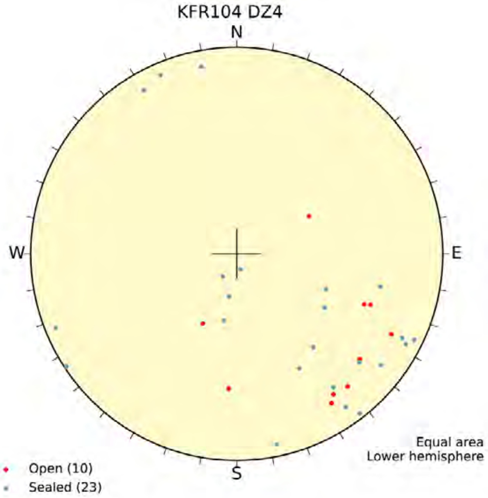


NE	ZFMNE3137	Version number	8	Total object CL	20

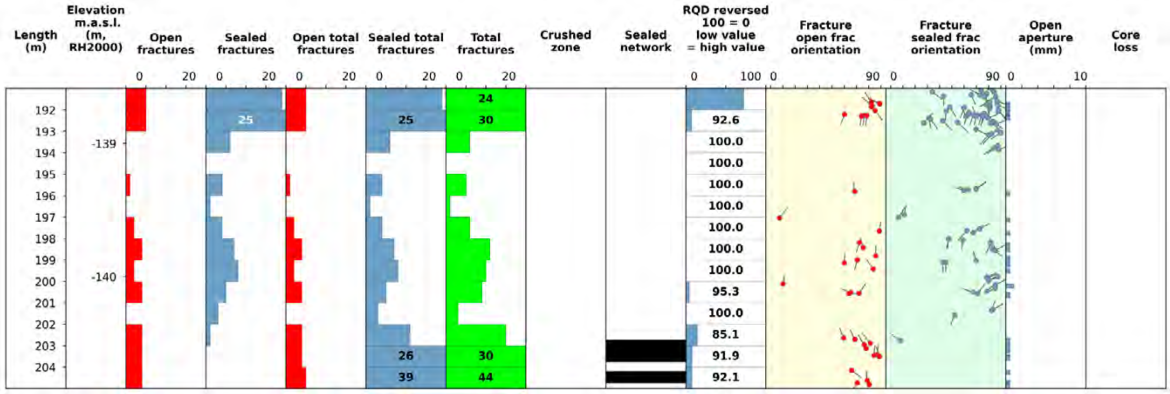
KFR104 DZ4 (382.0-387.0 m)

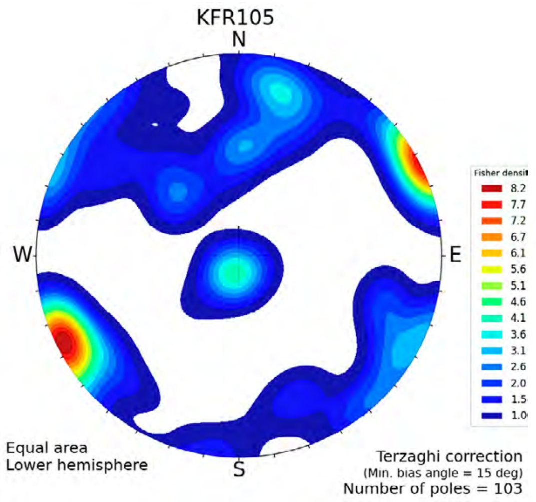


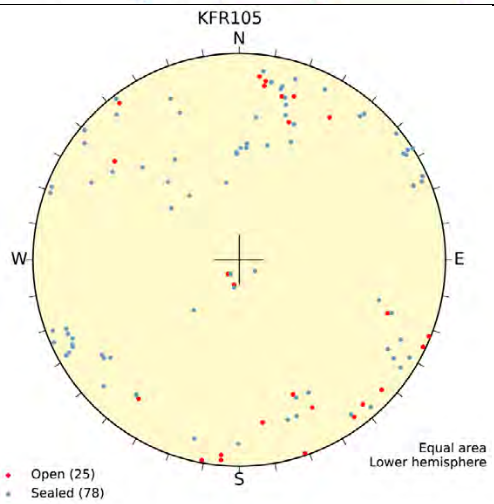




KFR105 (191.0-205.0 m)

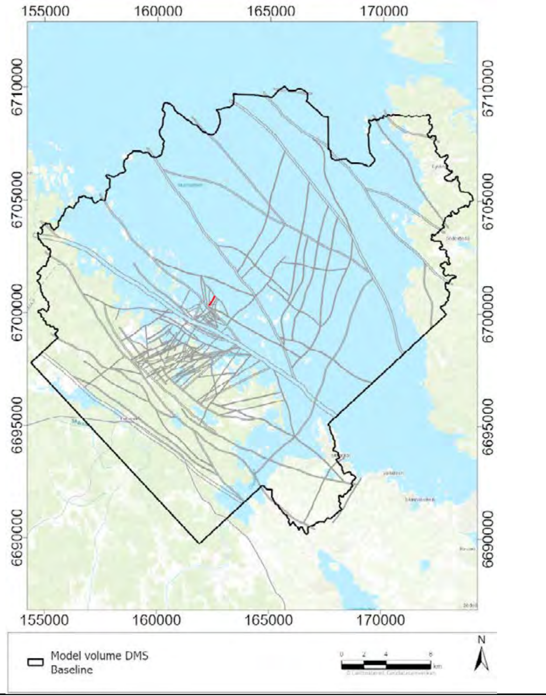






NE	ZFMNE3266		Version number	8	Total object CL	10

GEOLOGICAL CHARACTER		Property CL
Deformation style:	Brittle	2
Deformation description:	No data available.	
Alteration:		
- First order:	Not observed	
- Second order:	Not observed	
- Third order:	Not observed	
Fracture orientation and type:	No data available.	
Fracture comment:	No data available.	
Fracture fill mineralogy:	No data available.	



OBJECT GEOMETRY	
Strike/dip:	36°/90°
Length:	497 m
Mean thickness:	10 m (1 - 13 m)
Max depth:	-500 m
Geometrical constraints:	ZFMNW0805A, ZFMNS3154, Topo 40m grid Max error 20m, ZFMNW0997, 1 Surface Planar Cut(s).

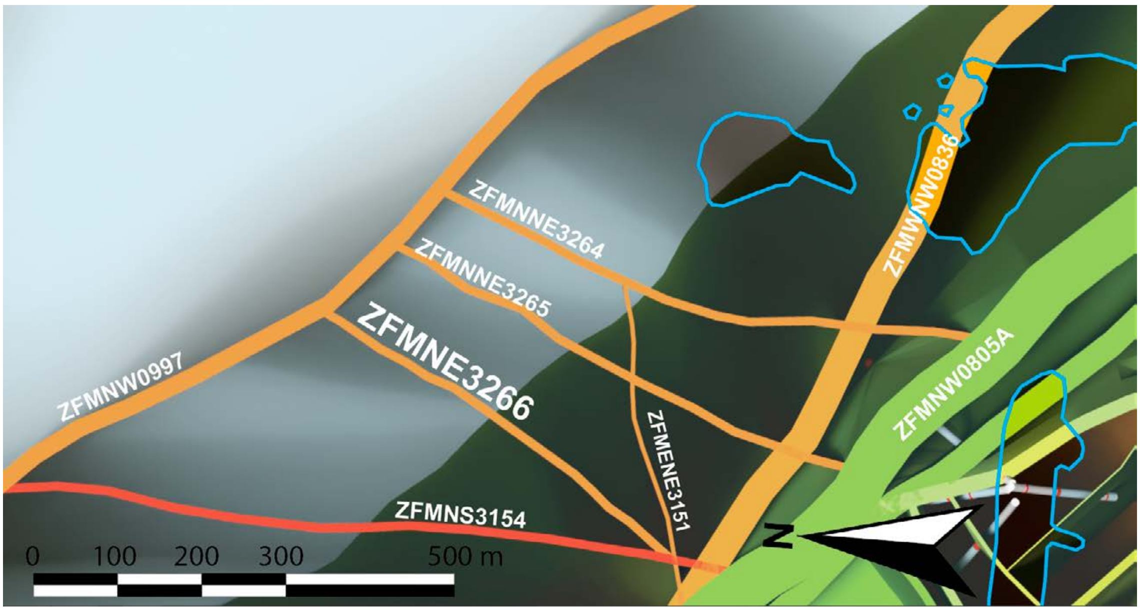
BASIS FOR MODELLING

Zone based on surface lineaments.

Outcrops:	-	
Boreholes: -		
Tunnels:	-	
Lineament and/or seismic indications:	MFM3266G.	1

MODELLING PROCEDURE

The position of the zone at the ground surface is based on the magnetic lineament MFM3266G in Forsmark stage 2.3 (Isaksson et al. 2007). There has been a very minor update resulting in lineament MSFR08009 in the SFR model version 1.0 interpretation. The stage 2.3 number has been maintained to aid traceability between different versions of the lineament interpretation.



NE	ZFMNE3266	Version number	8	Total object CL	10

OBJECT CONFIDENCE ESTIMATE

Category	Object CL	Comment
INTERPRETATION		
Data source	1	MSFR08009
Results of interpretation	1	Low confidence in lineament MSFR08009.
INFORMATION DENSITY		
Number of observation points	1	1
Distribution of observation points	1	Single observation point in the form of a lineament.
INTERPOLATION		
Geometry	1	Geometry supported by surface geophysical data.
Geological indicators	1	Indirect support by geophysical data.
EXTRAPOLATION		
Dip direction	1	No subsurface obs. point, supported only by surface data. High uncertainty in dip-direction. Strike length of the modelled zone < 2000 m.
Strike direction	3	Conceptual understanding of the site and that the entire modelled zone is supported by the lineament.

FRACTURE CHARACTER

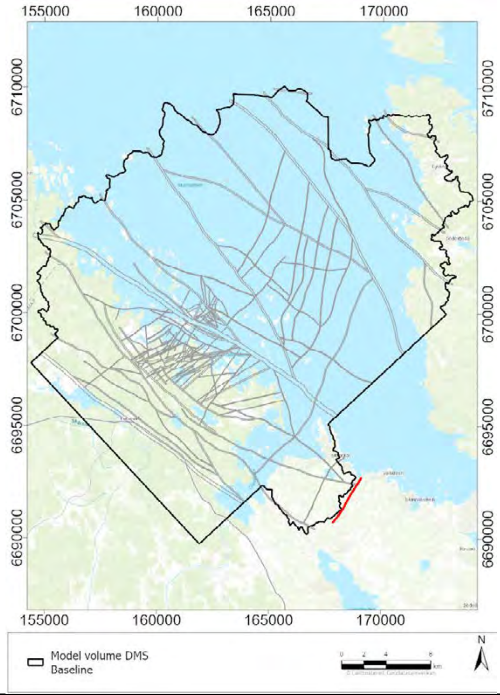
No data available

INDIVIDUAL INTERCEPTS

No data available

NE	ZFMNE3542	Version number	4	Total object CL	9

GEOLOGICAL CHARACTER		Property CL
Deformation style:	No data available	
Deformation description:	No data available.	
Alteration:		
- First order:	Not observed	
- Second order:	Not observed	
- Third order:	Not observed	
Fracture orientation and type:	No data available.	
Fracture comment:	No data available.	
Fracture fill mineralogy:	No data available.	
OBJECT GEOMETRY		
Strike/dip:	215°/80°	
Length:	4545 m	
Mean thickness:	30 m (15 - 64 m)	
Max depth:	-2100 m	
Geometrical constraints:	ZFMNW0016, Topo 40m grid Max error 20m, 2 Surface Planar Cut(s).	



BASIS FOR MODELLING		
Zone based on surface lineament.		
Outcrops:	-	
Boreholes: -		
Tunnels:	-	
Lineament and/or seismic indications:	MFM3542.	2
MODELLING PROCEDURE		
-		

NE	ZFMNE3542	Version number	4	Total object CL	9

OBJECT CONFIDENCE ESTIMATE

Category	Object CL	Comment
INTERPRETATION		
Data source	1	MFM3542
Results of interpretation	2	Medium confidence in lineament MFM3542.
INFORMATION DENSITY		
Number of observation points	1	1
Distribution of observation points	1	Single observation point in the form of a lineament.
INTERPOLATION		
Geometry	1	Geometry supported by surface geophysical data.
Geological indicators	1	Indirect support by geophysical data.
EXTRAPOLATION		
Dip direction	1	No subsurface obs. point, supported only by surface data. High uncertainty in dip-direction. Strike length of the modelled zone < 2000 m.
Strike direction	1	Conceptual understanding of the site and that the entire regional modelled zone is supported by the lineament.

FRACTURE CHARACTER

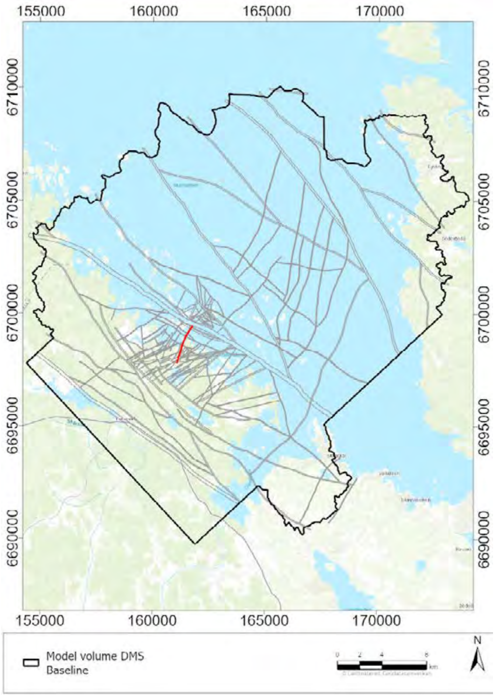
No data available

INDIVIDUAL INTERCEPTS

No data available

NNE	ZFMNNE0725		Version number	6	Total object CL	16

GEOLOGICAL CHARACTER		Property CL
Deformation style:	Brittle	3
Deformation description:	Steeply dipping faults with ENE and ESE strike characterised by oblique slip displacement with strong, yet variable strike slip component. Dextral strike-slip component dominant on a steeply dipping fault with NW strike (chlorite and calcite). Sinistral strike-slip component dominant on a steeply dipping fault with WSW strike (calcite) Dextral strike-slip component dominant on a steeply dipping fault with NNE strike (chlorite and laumontite).	
Alteration:		3
- First order:	Oxidation	
- Second order:	Quartz dissolution	
- Third order:	Not observed	
Fracture orientation and type:	Steeply dipping fractures that strike SSW dominates. Gently dipping fractures as well as steeply dipping fractures with ESE or NW strike are also present. Dominance of sealed fractures. Quantitative estimate and span include sealed fracture networks.	2
Fracture comment:	No data available.	
Fracture fill mineralogy:	Chlorite, calcite, quartz, hematite/adularia, laumontite.	



OBJECT GEOMETRY	
Strike/dip:	201°/83°
Length:	1913 m
Mean thickness:	12 m (3 - 50 m)
Max depth:	-1900 m
Geometrical constraints:	Topo 40m grid Max error 20m, ZFMWNW0001, 1 Surface Planar Cut(s).

BASIS FOR MODELLING

Zone based on surface lineaments and borehole observations.

Outcrops: -

Boreholes:

Borehole	PDZ	Target intercept		Geometric intercept		Comment
		Sec_up [m]	Sec_low [m]	Sec_up [m]	Sec_low [m]	
KFM06A	DZ7	740.00	775.00	741.47	773.27	

Tunnels:	-	
Lineament and/or seismic indications:	MFM0725G.	2

MODELLING PROCEDURE

At the surface, corresponds to the low magnetic lineament MFM0725G. Modelled down to 1250 m depth, using the dip estimated by connecting lineament MFM0725G with the borehole intersection 740-775 m in KFM06A (DZ7). Deformation zone plane placed at fixed point 770 m in KFM06A. This point is also situated along an interval of low radar amplitude (768-773 m).

NNE	ZFMNNE0725	Version number	6	Total object CL	16

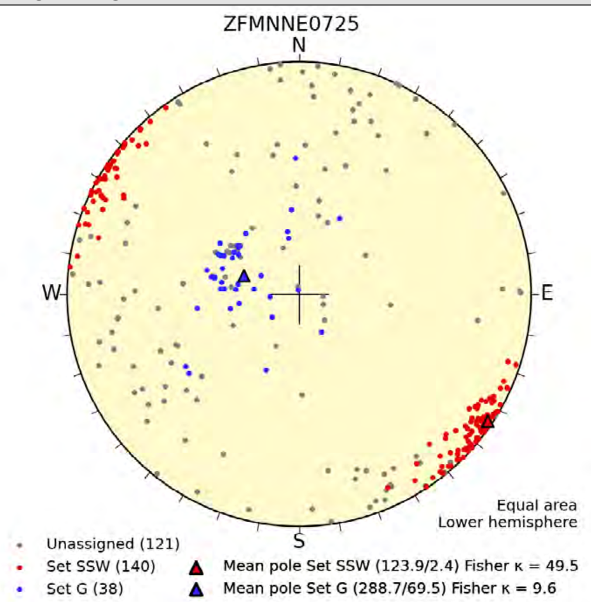
OBJECT CONFIDENCE ESTIMATE

Category	Object CL	Comment
INTERPRETATION		
Data source	2	MFM0725G, KFM06A
Results of interpretation	3	High confidence observation in KFM06A.
INFORMATION DENSITY		
Number of observation points	2	2
Distribution of observation points	1	Single observation point at depth.
INTERPOLATION		
Geometry	2	Projected surface length c. 2000 m, ends with a blind end in SW direction within ZFMNE2282.
Geological indicators	1	Indirect support by geophysical data.
EXTRAPOLATION		
Dip direction	2	Extrapolation in dip direction supported by subsurface obs. point. Strike length of the modelled zone < 2000 m.
Strike direction	3	Conceptual understanding of the site and that the entire modelled zone is supported by the lineament.

FRACTURE CHARACTER

Orientation: (strike/dip right-hand-rule)	Set SSW: 213.9°/87.6° Set G: 18.7°/20.5°
Frequency:	Boreholes: KFM06A

FRACTURE TYPE	TERZAGHI-WEIGHED P10
Open and partly open	4.1 m-1
Sealed	14.3 m-1
Sealed network	3.6 % of DZ intercept
Crush	1.6 % of DZ intercept



RQD:	min:16, max:100, mean:95

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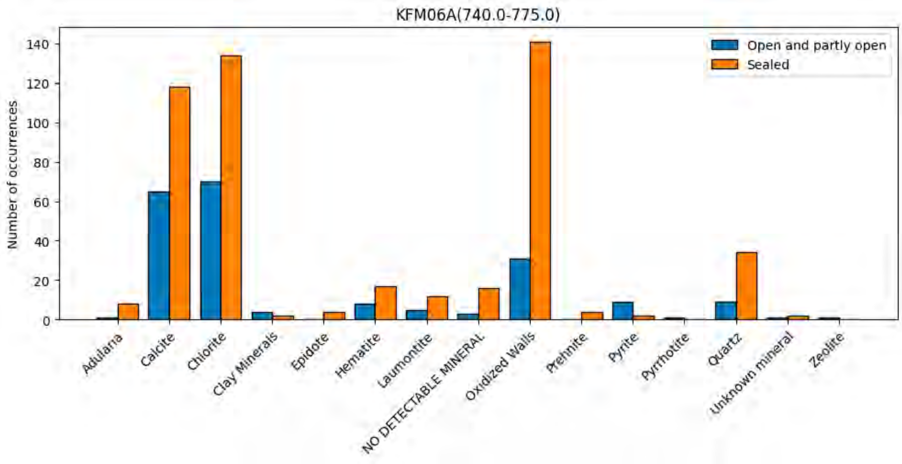
<tr><td>Fracture fill mineralogy:</td><td colspan="5">
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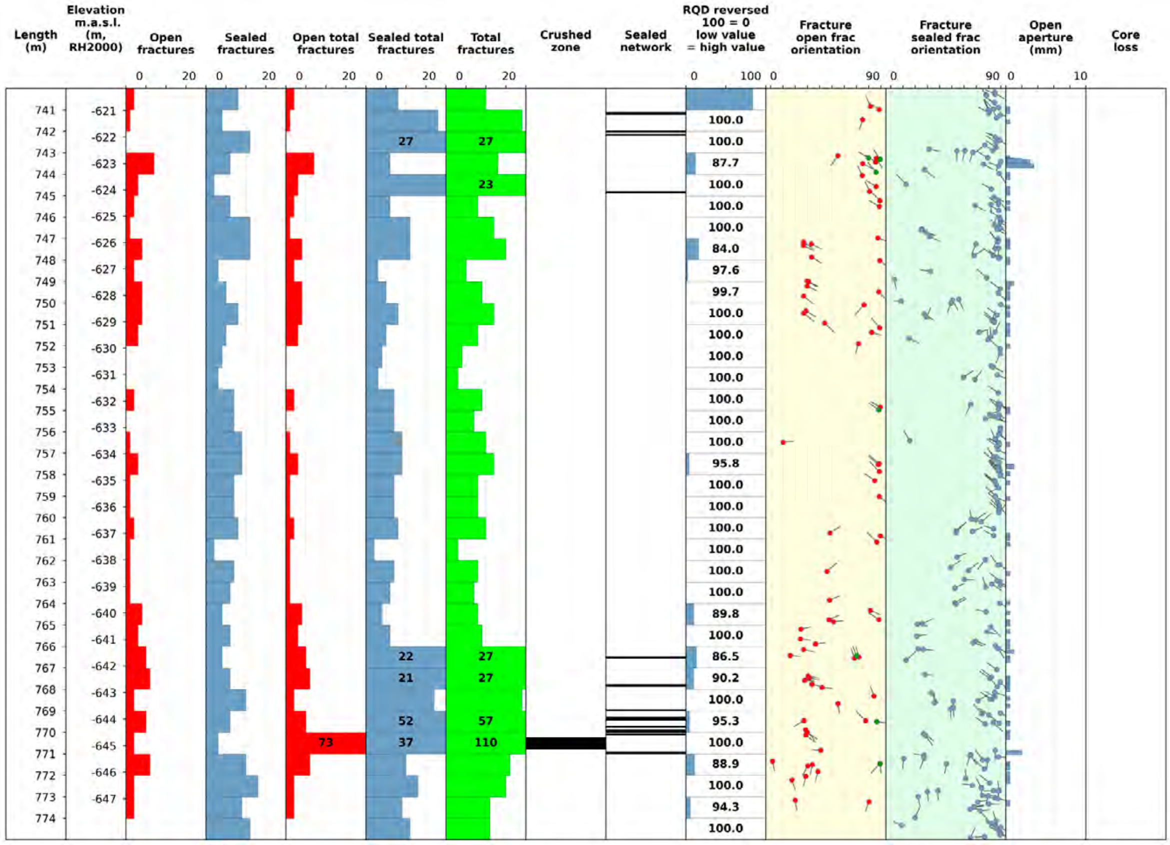
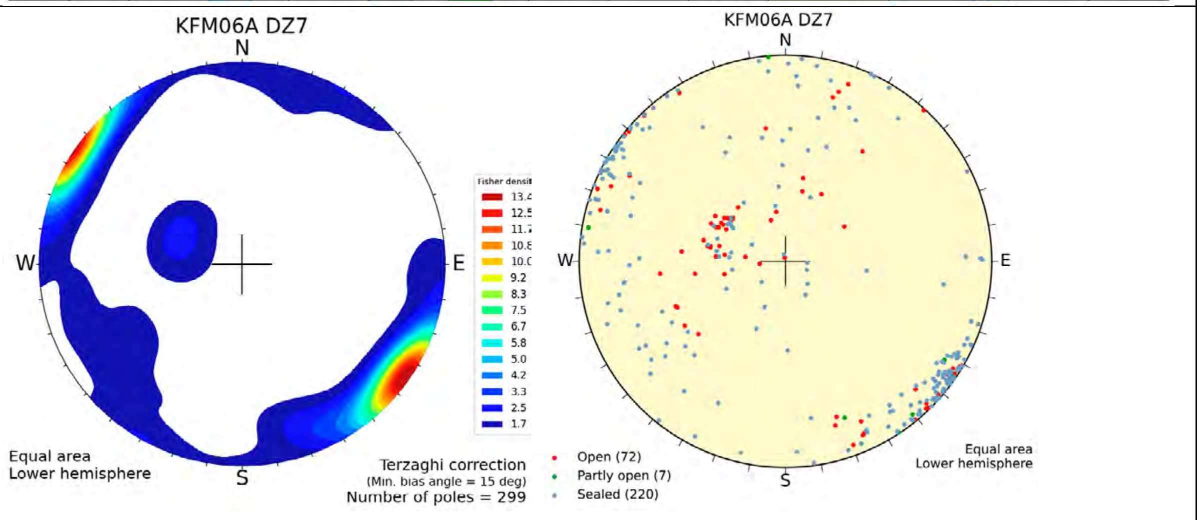
NNE	ZFMNNE0725	Version number	6	Total object CL	16

INDIVIDUAL INTERCEPTS

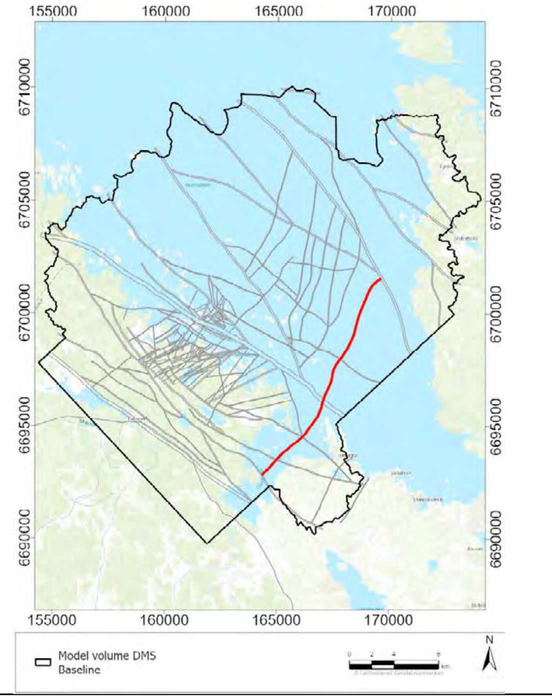
KFM06A DZ7 (740.0-775.0 m)





NNE	ZFMNNE0828	Version number	6	Total object CL	11

GEOLOGICAL CHARACTER		Property CL
Deformation style:	Brittle	1
Deformation description:	No data available.	
Alteration:		2
- First order:	Oxidation	
- Second order:	Not observed	
- Third order:	Not observed	
Fracture orientation and type:	No data available.	
Fracture comment:	No data available.	
Fracture fill mineralogy:	No data available.	



OBJECT GEOMETRY	
Strike/dip:	208°/80°
Length:	10490 m
Mean thickness:	50 m (50 - 200 m)
Max depth:	-2100 m
Geometrical constraints:	ZFMNW0016, Topo 40m grid Max error 20m, ZFMNW0854.

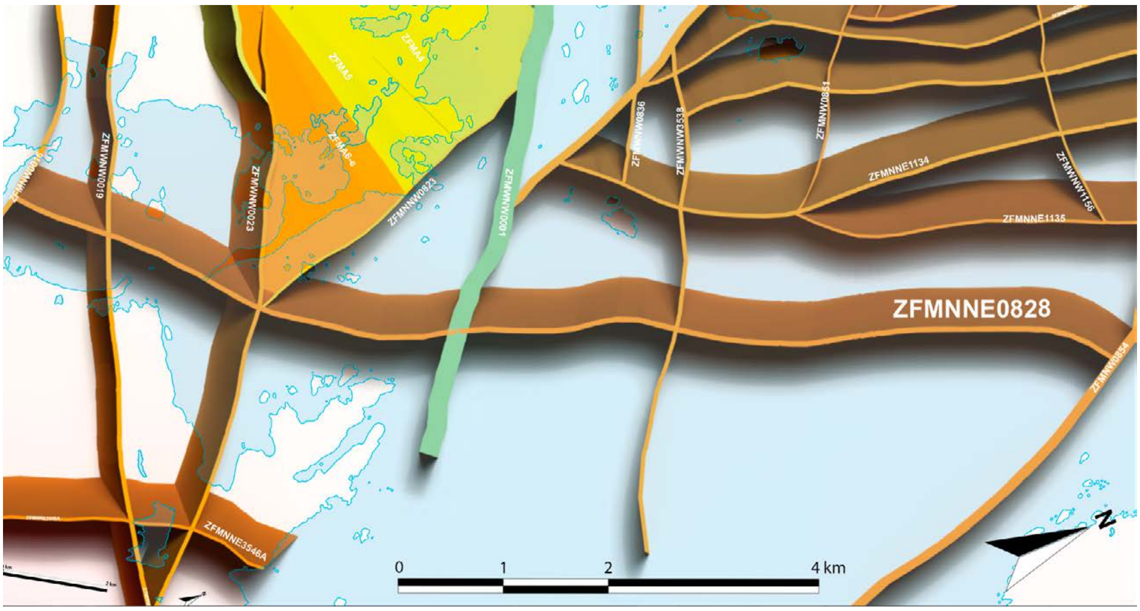
BASIS FOR MODELLING

Zone based on surface lineaments.

Outcrops:	-	
Boreholes: -		
Tunnels:	-	
Lineament and/or seismic indications:	MFM0828.	2

MODELLING PROCEDURE

At the surface, corresponds to the low magnetic lineament MFM0828. Modelled to the base of the model volume with a dip of 80 degrees to the WNW based on comparison with high confidence, steeply dipping zones with NNE strike.



NNE	ZFMNNE0828	Version number	6	Total object CL	11

OBJECT CONFIDENCE ESTIMATE

Category	Object CL	Comment
INTERPRETATION		
Data source	1	MFM0828, MFM2019
Results of interpretation	2	Medium confidence in lineament MFM0828 and MFM2019.
INFORMATION DENSITY		
Number of observation points	1	1
Distribution of observation points	1	Single observation point in the form of lineaments.
INTERPOLATION		
Geometry	1	Geometry supported by surface geophysical data.
Geological indicators	1	Indirect support by geophysical data.
EXTRAPOLATION		
Dip direction	1	No subsurface obs. point, supported only by surface data. High uncertainty in dip-direction. Strike length of the modelled zone < 2000 m.
Strike direction	3	Conceptual understanding of the site and that the entire modelled zone is supported by the lineament.

FRACTURE CHARACTER

No data available

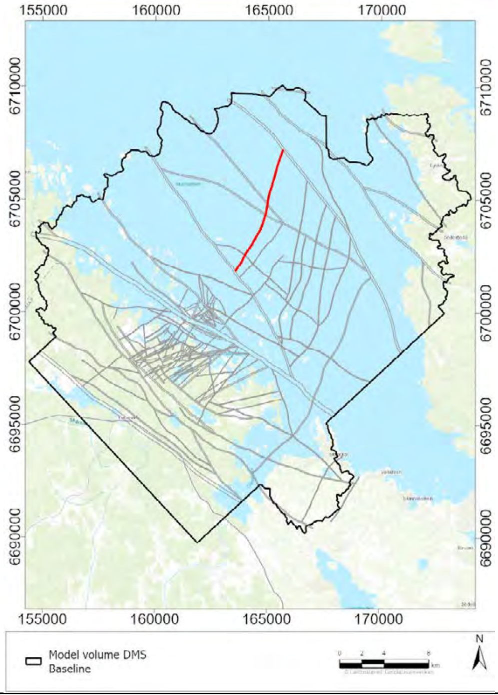
INDIVIDUAL INTERCEPTS

No data available

NNE	ZFMNNE0860		Version number	3	Total object CL	12

GEOLOGICAL CHARACTER		Property CL
Deformation style:	Brittle	1
Deformation description:	No data available.	
Alteration:		2
- First order:	Oxidation	
- Second order:	Not observed	
- Third order:	Not observed	
Fracture orientation and type:	No data available.	
Fracture comment:	No data available.	
Fracture fill mineralogy:	No data available.	

OBJECT GEOMETRY	
Strike/dip:	200°/80°
Length:	5921 m
Mean thickness:	35 m (15 - 64 m)
Max depth:	-2100 m
Geometrical constraints:	ZFMNNW0806, ZFMNW0854, Topo 40m grid Max error 20m.



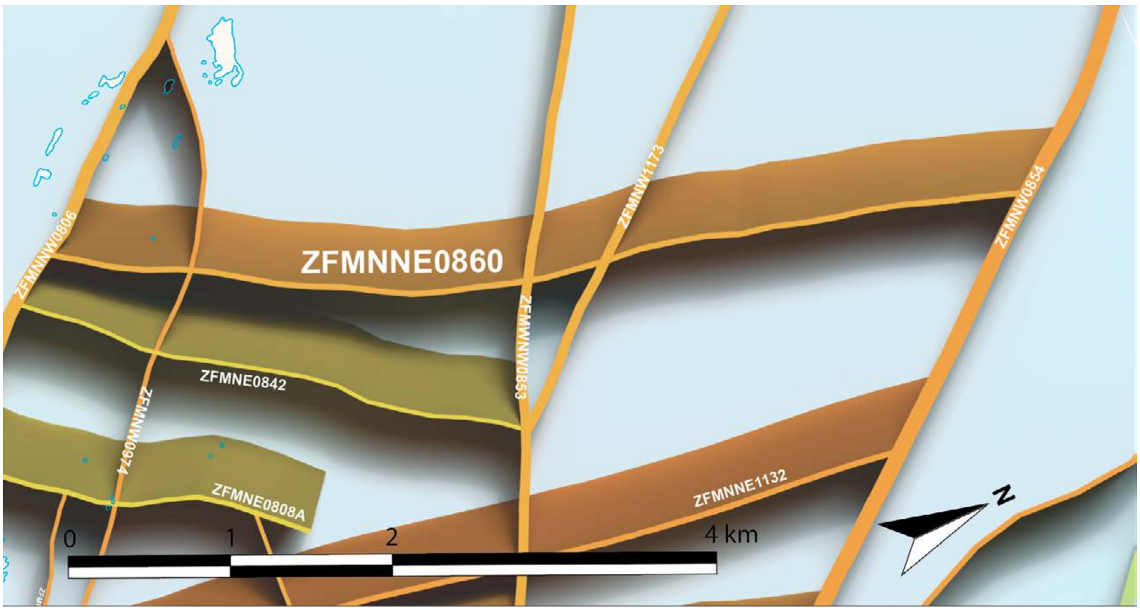
BASIS FOR MODELLING

Zone based on surface lineaments.

Outcrops:	-	
Boreholes: -		
Tunnels:	-	
Lineament and/or seismic indications:	MFM0860.	3

MODELLING PROCEDURE

At the surface, corresponds to the low magnetic lineament MFM0860. Modelled to base of model volume with a dip of 80 degrees to the WNW based on comparison with high confidence, steeply dipping zones with NNE strike.



NNE	ZFMNNE0860	Version number	3	Total object CL	12

OBJECT CONFIDENCE ESTIMATE

Category	Object CL	Comment
INTERPRETATION		
Data source	1	MFM0860, MFM2019
Results of interpretation	3	High confidence in lineament MFM0860 and MFM2019.
INFORMATION DENSITY		
Number of observation points	1	1
Distribution of observation points	1	Single observation point in the form of lineaments.
INTERPOLATION		
Geometry	1	Geometry supported by surface geophysical data.
Geological indicators	1	Indirect support by geophysical data.
EXTRAPOLATION		
Dip direction	1	No subsurface obs. point, supported only by surface data. High uncertainty in dip-direction. Strike length of the modelled zone < 2000 m.
Strike direction	3	Conceptual understanding of the site and that the entire modelled zone is supported by the lineament.

FRACTURE CHARACTER

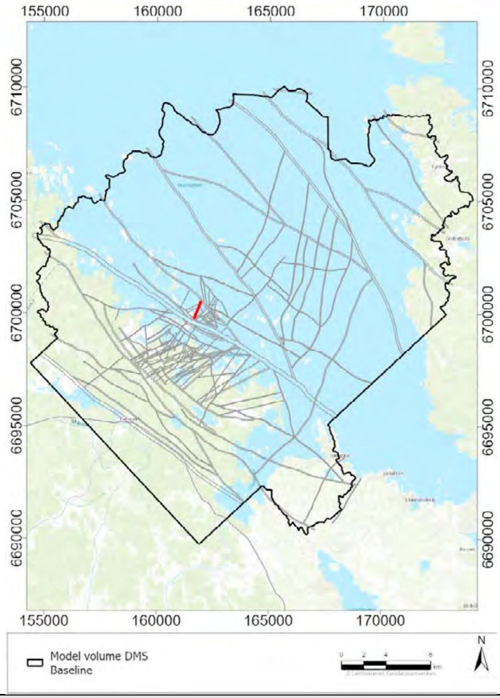
No data available

INDIVIDUAL INTERCEPTS

No data available

NNE	ZFMNNE0869	Version number	4	Total object CL	21

GEOLOGICAL CHARACTER		Property CL
Deformation style:	Brittle	3
Deformation description:	Cohesive breccias present in KFR36 DZ1.	
Alteration:		3
- First order:	Oxidation	
- Second order:	Not observed	
- Third order:	Not observed	
Fracture orientation and type:	No data available.	
Fracture comment:	No data available.	
Fracture fill mineralogy:	Calcite, hematite and adularia, chlorite and laumontite.	



OBJECT GEOMETRY	
Strike/dip:	203°/86°
Length:	902 m
Mean thickness:	60 m (20 - 60 m)
Max depth:	-900 m
Geometrical constraints:	ZFMNW0805A, ZFMWNW1035, ZFMNW0002, Topo 40m grid Max error 20m, 1 Surface Planar Cut(s).

BASIS FOR MODELLING

Zone based on surface lineaments, borehole and tunnel observations.

Outcrops:	-

Boreholes:

Borehole	PDZ	Target intercept		Geometric intercept		Comment
		Sec_up [m]	Sec_low [m]	Sec_up [m]	Sec_low [m]	
KFR09	DZ1	0.00	58.70	0.00	59.54	
KFR10	DZ1	-	-	0.00	97.48	Judging from the photographs of the drill cores there is a frequency of broken fractures that locally exceeds 10 fractures/m along the target interval. Oxidation of varying degrees occurs frequently throughout the interval 0–97 m. Both the fracture frequency and occurrence of oxidation resembles that for DZ1 in KFR09 DZ1 and KFR36 D1, but is generally slightly lower and less conspicuous, respectively. Thus, ZFMNNE0869 may well have its intersection in this interval, but a specific target intercept cannot be defined.
KFR36	DZ1	45.00	115.50	27.84	118.85	
KFR68	DZ2	71.59	105.13	43.91	128.03	Note: KFR68 is interpreted as intercepting the meeting point between ZFMNNE0869 and ZFMNE0870. Since the BH lacks fracture orientation data it is impossible to correlate the PDZ with any specific steeply dipping zone. Thus, the PDZ is taken as target inte lacks

NNE	ZFMNNE0869	Version number	4	Total object CL	21

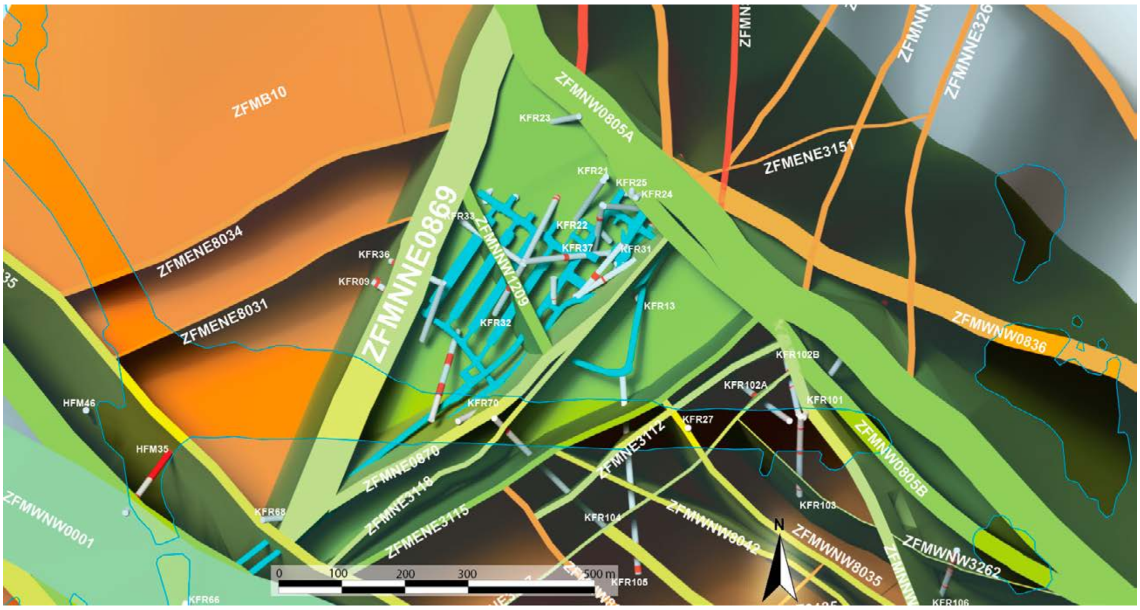
						fracture orientation data it is impossible to correlate the PDZ with any specific steeply dipping zone. Thus, the PDZ is taken as target intercept for both ZFMNE0870 and ZFMNNE0869.
KFR68	DZ1	71.59	105.13	43.91	128.03	Note: KFR68 is interpreted as intercepting the meeting point between ZFMNNE0869 and ZFMNE0870. Since the BH lacks fracture orientation data it is impossible to correlate the PDZ with any specific steeply dipping zone. Thus, the PDZ is taken as target inte lacks fracture orientation data it is impossible to correlate the PDZ with any specific steeply dipping zone. Thus, the PDZ is taken as target intercept for both ZFMNE0870 and ZFMNNE0869.

Tunnels:	DT target intercept: 0+430 0+540 m, geometric intercept 0+430- 0+555 m. BT target intercept: 0+350 0+450 m, geometric intercept 0+357 0+482 m.	
Lineament and/or seismic indications:	MSFR08089.	1

MODELLING PROCEDURE

This zone corresponds to zone 3 in earlier SFR models (see for example Axelsson and Hansen 1997). It was renamed ZFMNNE0869 in the Forsmark stage 2.2 model Stephens et al. (2007) and modelled to a depth of 1050m. The position of the central section of the zone at the ground surface is based on the lineament MSFR08089. The zone has been extended further to the NNE to terminate against ZFMNW0805A based on the reprocessing and re-evaluation of magnetic data. However, adjustments to zone ZFMNW0805A have resulted in a minor adjustment of the trace length of zone ZFMNNE0869 at the ground surface compared with that presented in Stephens et al. (2007). In the SSE, the zone terminates at the surface at ZFMWNW1035 and at depth at ZFMNW0002. The orientation 201/86 involves only a slight adjustment compared with earlier models (200/80 in Stephens et al. (2007). However, the zone thickness has been modified considerably in accordance with current SKB single hole interpretation (SHI) based methodology. The thickness has been increased from 10 m to 60 m based on the results of the geological SHI from KFR09 and KFR36 and the indications as presented on the tunnel mapping overview drawings, all of which support an increased modelled thickness. The earlier thinner interpretation Axelsson and Hansen (1997) did not include the mapped parallel structures shown in the tunnel mapping though the reasoning is not clear. The zone is interpreted to be a composite zone consisting of several narrower high-strain segments (sub-zones) that diverge and converge in a complex pattern Axelsson and Hansen (1997). The zone is crossed by four seismic refraction profiles Keisu and Isaksson (2004). Two profiles indicate minor low velocity anomalies while velocities generally lie in the range of 4000–5000 m/s. Forward modelling of magnetic data along profile 18 (see Appendix 6, Curtis et al. 2011) suggests a sub-vertical dip. For further detail see Curtis et al. (2011).

NNE	ZFMNNE0869	Version number	4	Total object CL	21



OBJECT CONFIDENCE ESTIMATE

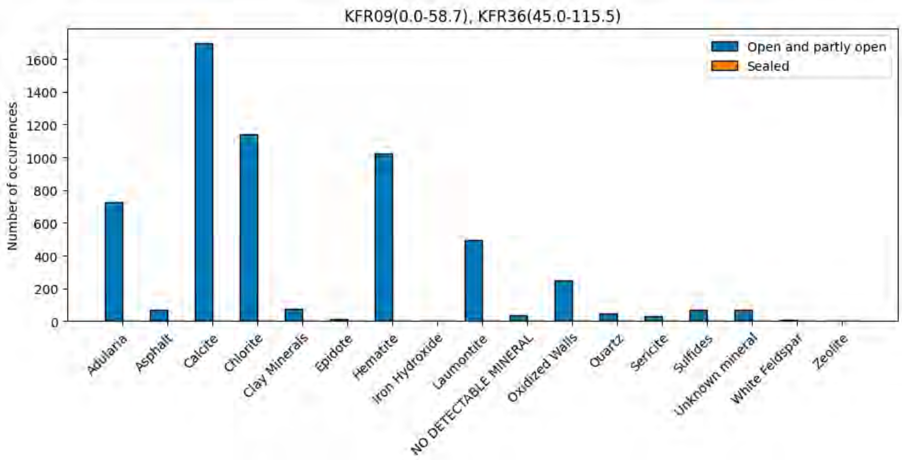
Category	Object CL	Comment
INTERPRETATION		
Data source	3	MSFR08089, KFR09, KFR10, KFR36, KFR68, intercepts the SFR operations and construction tunnels.
Results of interpretation	3	High confidence observation in KFR09, KFR36 and SFR tunnels.
INFORMATION DENSITY		
Number of observation points	3	>4
Distribution of observation points	2	Cluster of borehole intersections with support from tunnels and a lineament as an outlier.
INTERPOLATION		
Geometry	3	Geometry supported by multiple subsurface obs. points.
Geological indicators	3	Interpolation supported by mineral fillings within fractures from boreholes and tunnels.
EXTRAPOLATION		
Dip direction	2	Extrapolation in dip direction supported by subsurface obs. point. Strike length of the modelled zone < 2000 m.
Strike direction	2	Partly or no support by surface lineament. Supported by geological concept and subsurface observation points.

NNE	ZFMNNE0869	Version number	4	Total object CL	21

FRACTURE CHARACTER

Orientation: (strike/dip right-hand-rule)	--
Frequency:	Boreholes: KFR10, KFR68, KFR36, KFR09

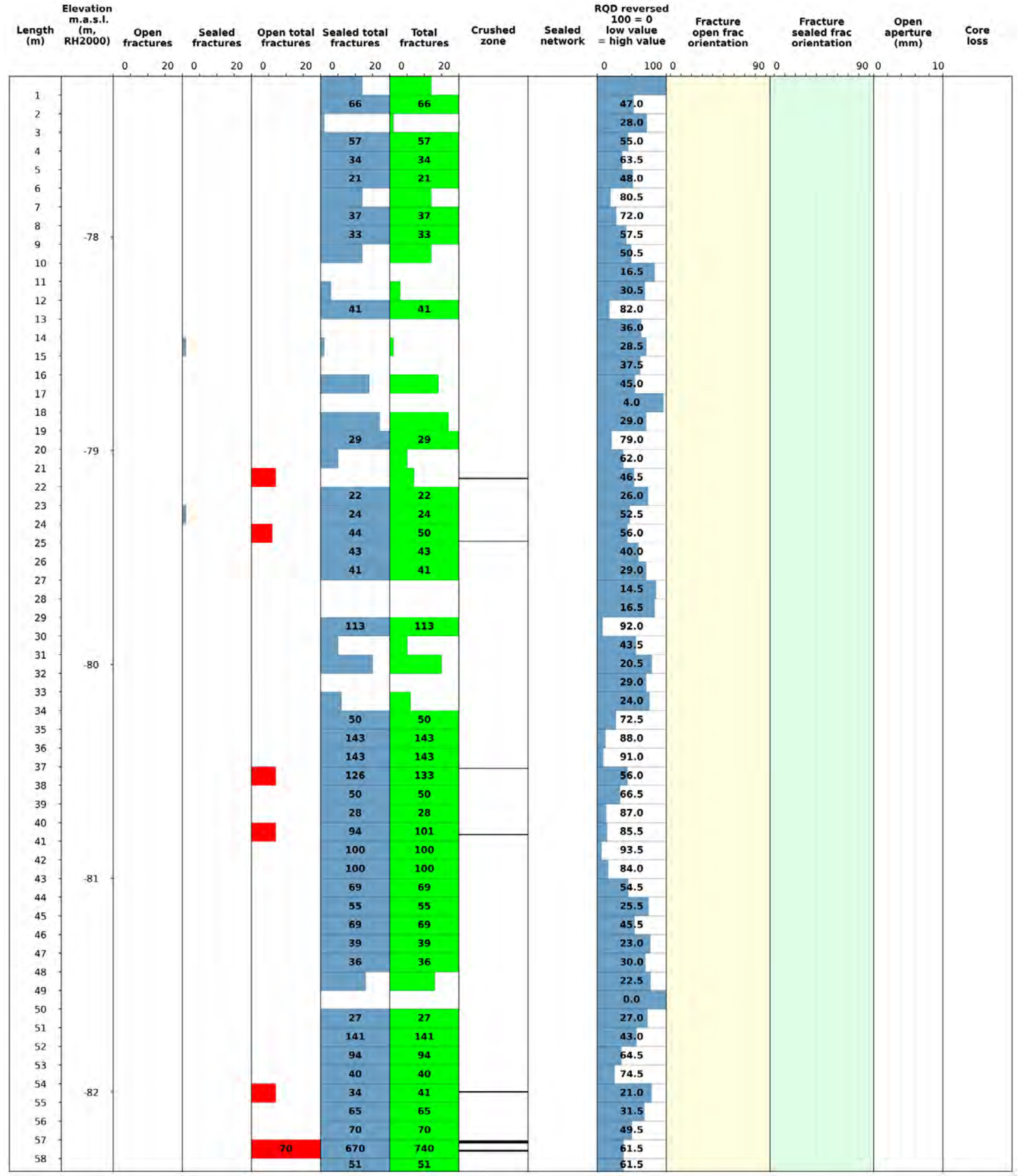
FRACTURE TYPE	TERZAGHI-WEIGHED P10
Open and partly open	8.0 m-1
Sealed	0.0 m-1
Sealed network	0.0 % of DZ intercept
Crush	0.9 % of DZ intercept

RQD:	min:0, max:94, mean:44
Fracture fill mineralogy:	

NNE	ZFMNNE0869	Version number	4	Total object CL	21

INDIVIDUAL INTERCEPTS

KFR09 DZ1 (0.0-58.7 m)

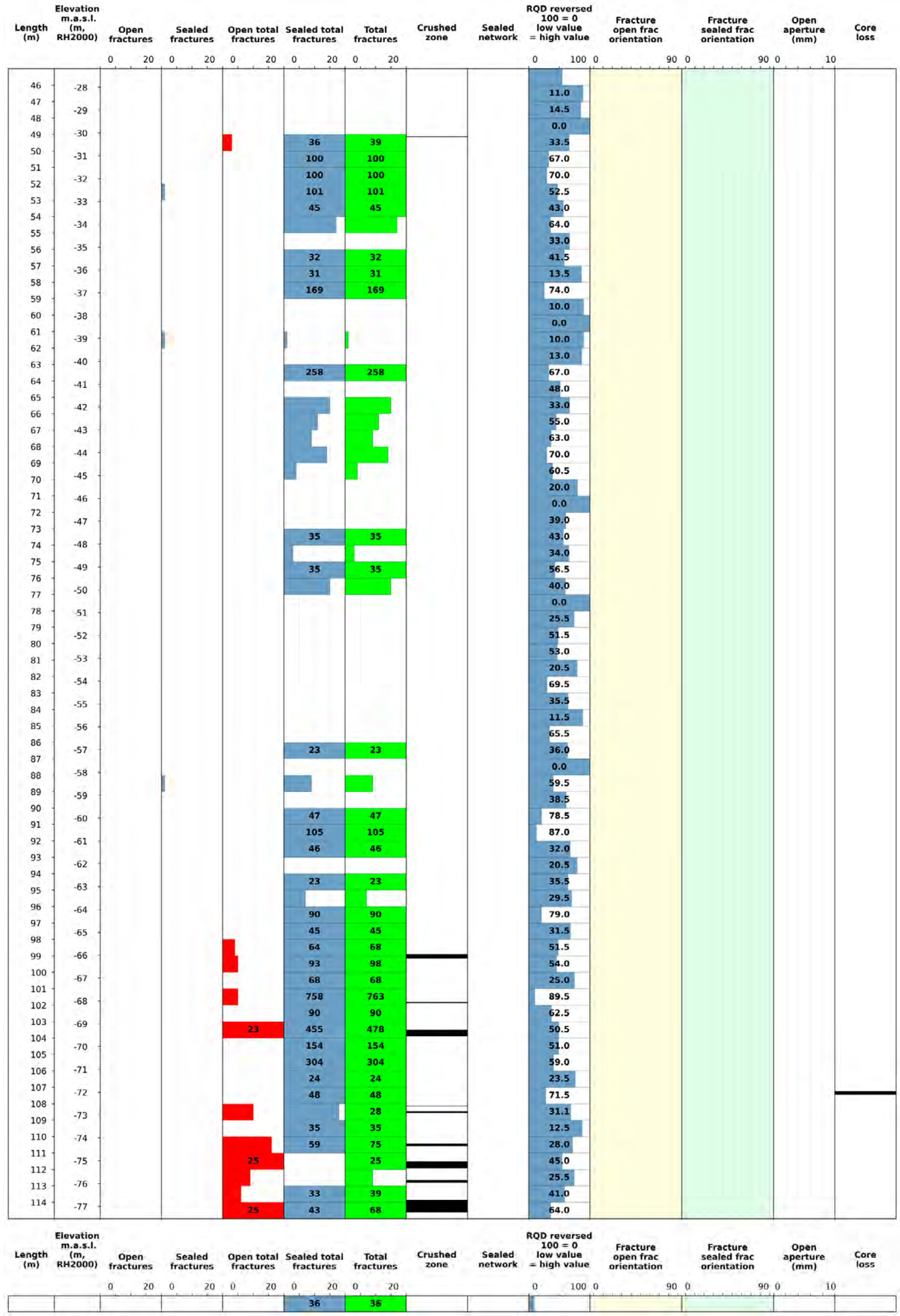


NNE	ZFMNNE0869	Version number	4	Total object CL	21

KFR10 DZ1 (0.0-97.48 m)

No data available

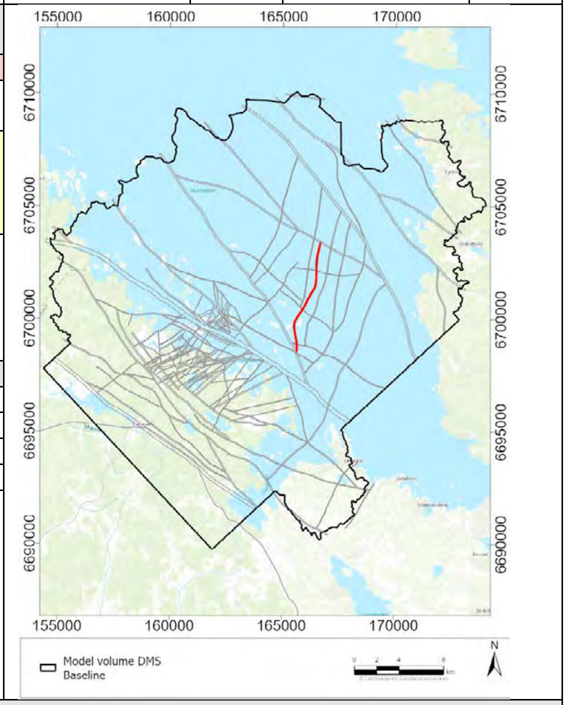
KFR36 DZ1 (45.0-115.5 m)



NNE	ZFMNNE0869	Version number	4	Total object CL	21
KFR68 DZ2, DZ1 (71.59-105.13 m)					
No data available					

NNE	ZFMNNE0929	Version number	3	Total object CL	10

GEOLOGICAL CHARACTER		Property CL
Deformation style:	Brittle	1
Deformation description:	No data available.	
Alteration:		2
- First order:	Oxidation	
- Second order:	Not observed	
- Third order:	Not observed	
Fracture orientation and type:	No data available.	
Fracture comment:	No data available.	
Fracture fill mineralogy:	No data available.	



OBJECT GEOMETRY	
Strike/dip:	195°/80°
Length:	5199 m
Mean thickness:	35 m (15 - 64 m)
Max depth:	-2100 m
Geometrical constraints:	ZFMNNW0806, ZFMWNW0853, Topo 40m grid Max error 20m.

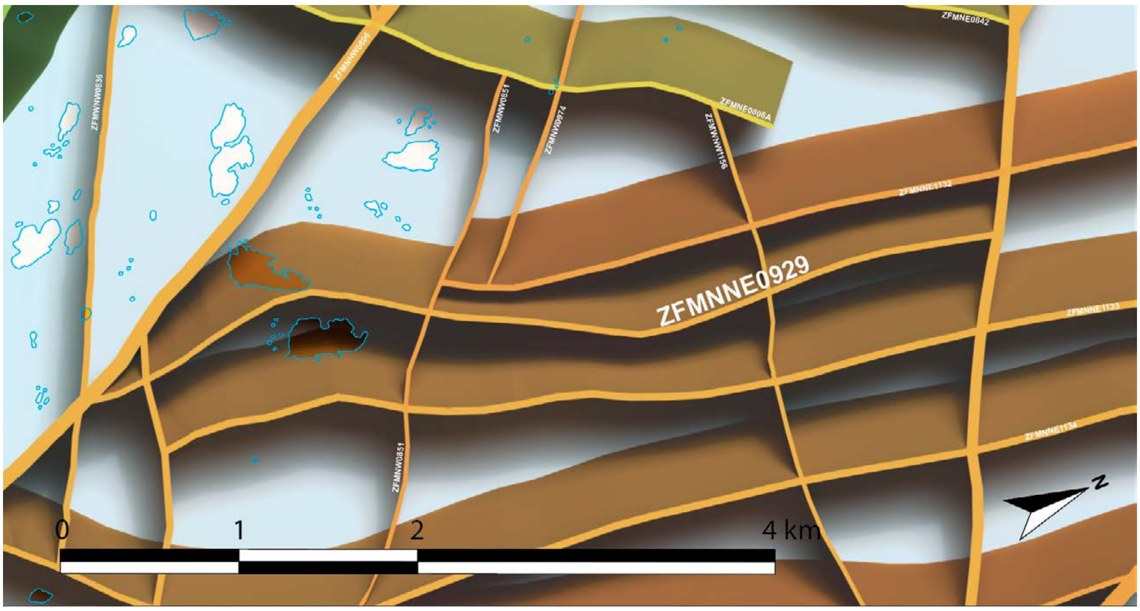
BASIS FOR MODELLING

Zone based on surface lineaments.

Outcrops:	-	
Boreholes: -		
Tunnels:	-	
Lineament and/or seismic indications:	MFM0929.	1

MODELLING PROCEDURE

At the surface, corresponds to the low magnetic lineament MFM0929. Modelled to the base of the model volume with a dip of 80 degrees to the WNW based on comparison with high confidence, steeply dipping zones with NNE strike.



NNE	ZFMNNE0929	Version number	3	Total object CL	10

OBJECT CONFIDENCE ESTIMATE

Category	Object CL	Comment
INTERPRETATION		
Data source	1	MFM0929
Results of interpretation	1	Low confidence in lineament MFM0929.
INFORMATION DENSITY		
Number of observation points	1	1
Distribution of observation points	1	Single observation point in the form of a lineament.
INTERPOLATION		
Geometry	1	Geometry supported by surface geophysical data.
Geological indicators	1	Indirect support by geophysical data.
EXTRAPOLATION		
Dip direction	1	No subsurface obs. point, supported only by surface data. High uncertainty in dip-direction. Strike length of the modelled zone < 2000 m.
Strike direction	3	Conceptual understanding of the site and that the entire modelled zone is supported by the lineament.

FRACTURE CHARACTER

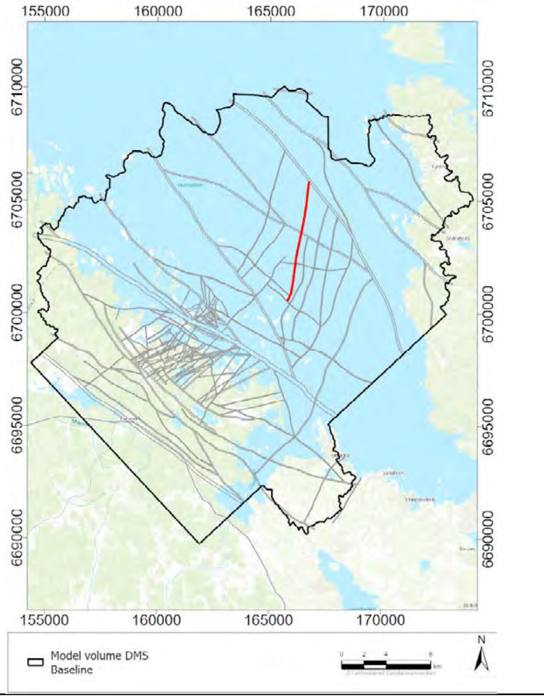
No data available

INDIVIDUAL INTERCEPTS

No data available

NNE	ZFMNNE1132	Version number	3	Total object CL	11

GEOLOGICAL CHARACTER		Property CL
Deformation style:	Brittle	1
Deformation description:	No data available.	
Alteration:		2
- First order:	Oxidation	
- Second order:	Not observed	
- Third order:	Not observed	
Fracture orientation and type:	No data available.	
Fracture comment:	No data available.	
Fracture fill mineralogy:	No data available.	



OBJECT GEOMETRY	
Strike/dip:	190°/80°
Length:	5476 m
Mean thickness:	35 m (15 - 64 m)
Max depth:	-2100 m
Geometrical constraints:	ZFMNW0851, ZFMNW0854, Topo 40m grid Max error 20m.

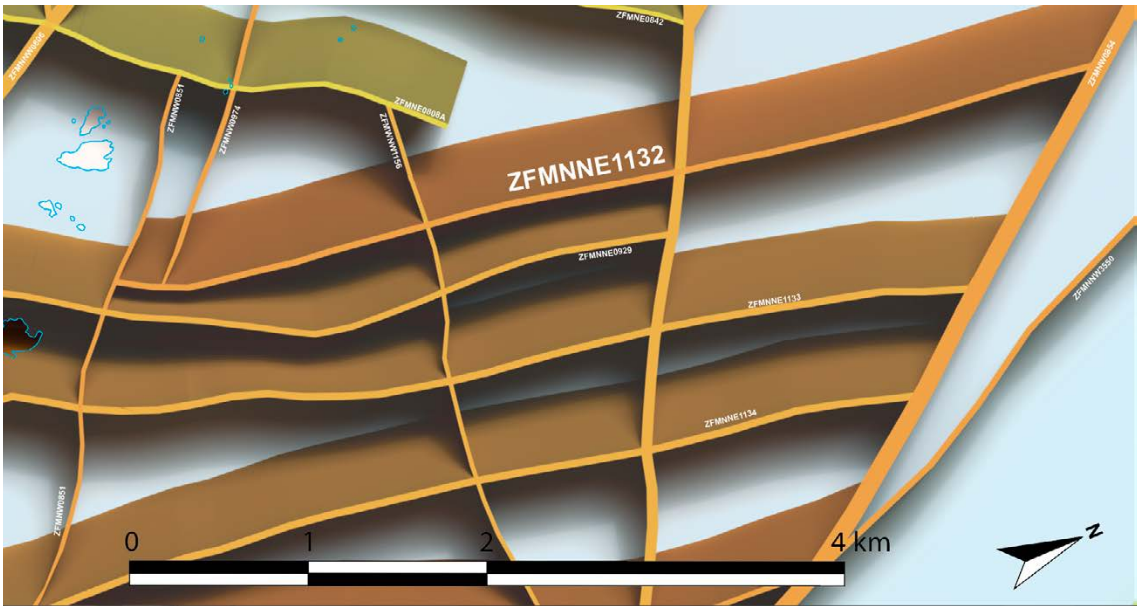
BASIS FOR MODELLING

Zone based on surface lineaments.

Outcrops:	-	
Boreholes: -		
Tunnels:	-	
Lineament and/or seismic indications:	MFM1132.	2

MODELLING PROCEDURE

At the surface, corresponds to the low magnetic lineament MFM1132. Modelled to the base of the model volume with a dip of 80 degrees to the WNW based on comparison with high confidence, steeply dipping zones with NNE strike.



NNE	ZFMNNE1132	Version number	3	Total object CL	11

OBJECT CONFIDENCE ESTIMATE

Category	Object CL	Comment
INTERPRETATION		
Data source	1	MFM1132
Results of interpretation	2	Medium confidence in lineament MFM1132.
INFORMATION DENSITY		
Number of observation points	1	1
Distribution of observation points	1	Single observation point in the form of a lineament.
INTERPOLATION		
Geometry	1	Geometry supported by surface geophysical data.
Geological indicators	1	Indirect support by geophysical data.
EXTRAPOLATION		
Dip direction	1	No subsurface obs. point, supported only by surface data. High uncertainty in dip-direction. Strike length of the modelled zone < 2000 m.
Strike direction	3	Extrapolation based on surface geophysical data, Conceptual understanding of the site and that the entire modelled zone is supported by the lineament.

FRACTURE CHARACTER

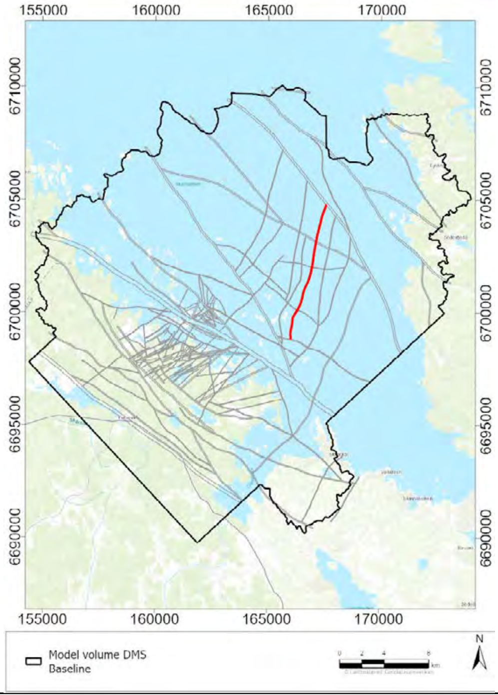
No data available

INDIVIDUAL INTERCEPTS

No data available

NNE	ZFMNNE1133	Version number	6	Total object CL	12

GEOLOGICAL CHARACTER		Property CL
Deformation style:	Brittle	1
Deformation description:	No data available.	
Alteration:		2
- First order:	Oxidation	
- Second order:	Not observed	
- Third order:	Not observed	
Fracture orientation and type:	No data available.	
Fracture comment:	No data available.	
Fracture fill mineralogy:	No data available.	



OBJECT GEOMETRY	
Strike/dip:	195°/80°
Length:	6278 m
Mean thickness:	40 m (15 - 64 m)
Max depth:	-2100 m
Geometrical constraints:	Topo 40m grid Max error 20m, ZFMNW0854, ZFMWNW3538.

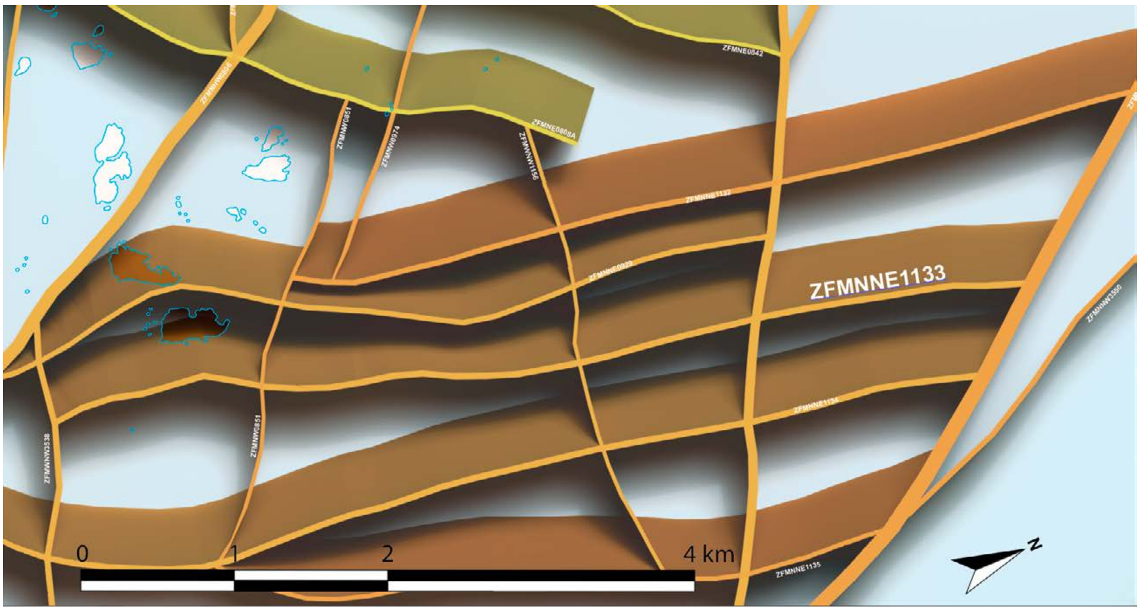
BASIS FOR MODELLING

Zone based on surface lineaments.

Outcrops:	-	
Boreholes: -		
Tunnels:	-	
Lineament and/or seismic indications:	MFM1132.	3

MODELLING PROCEDURE

At the surface, corresponds to the low magnetic lineament MFM1133. Modelled to the base of the model volume with a dip of 80 degrees to the WNW based on comparison with high confidence, steeply dipping zones with NNE strike.



NNE	ZFMNNE1133	Version number	6	Total object CL	12

OBJECT CONFIDENCE ESTIMATE

Category	Object CL	Comment
INTERPRETATION		
Data source	1	MFM1133
Results of interpretation	3	High confidence in lineament MFM1133.
INFORMATION DENSITY		
Number of observation points	1	1
Distribution of observation points	1	Single observation point in the form of a lineament.
INTERPOLATION		
Geometry	1	Geometry supported by surface geophysical data.
Geological indicators	1	Indirect support by geophysical data.
EXTRAPOLATION		
Dip direction	1	No subsurface obs. point, supported only by surface data. High uncertainty in dip-direction. Strike length of the modelled zone < 2000 m.
Strike direction	3	Conceptual understanding of the site and that the entire modelled zone is supported by the lineament.

FRACTURE CHARACTER

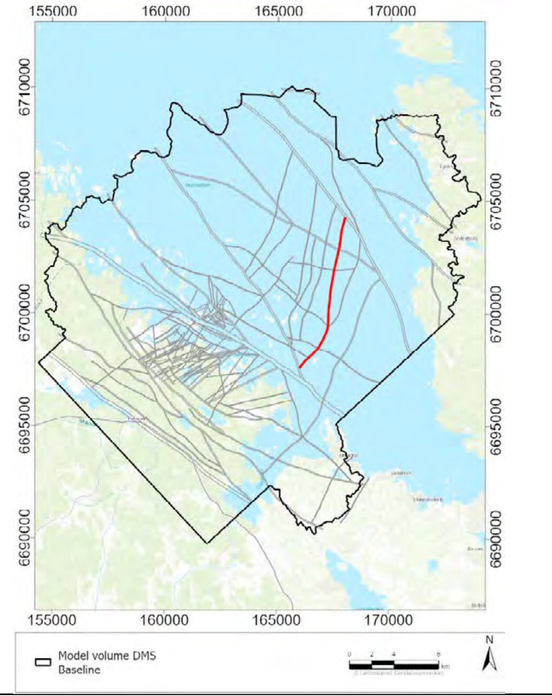
No data available

INDIVIDUAL INTERCEPTS

No data available

NNE	ZFMNNE1134	Version number	3	Total object CL	12

GEOLOGICAL CHARACTER		Property CL
Deformation style:	Brittle	1
Deformation description:	No data available.	
Alteration:		2
- First order:	Oxidation	
- Second order:	Not observed	
- Third order:	Not observed	
Fracture orientation and type:	No data available.	
Fracture comment:	No data available.	
Fracture fill mineralogy:	No data available.	



OBJECT GEOMETRY	
Strike/dip:	193°/80°
Length:	7280 m
Mean thickness:	40 m (15 - 64 m)
Max depth:	-2100 m
Geometrical constraints:	ZFMNW0854, ZFMNNW0806, Topo 40m grid Max error 20m.

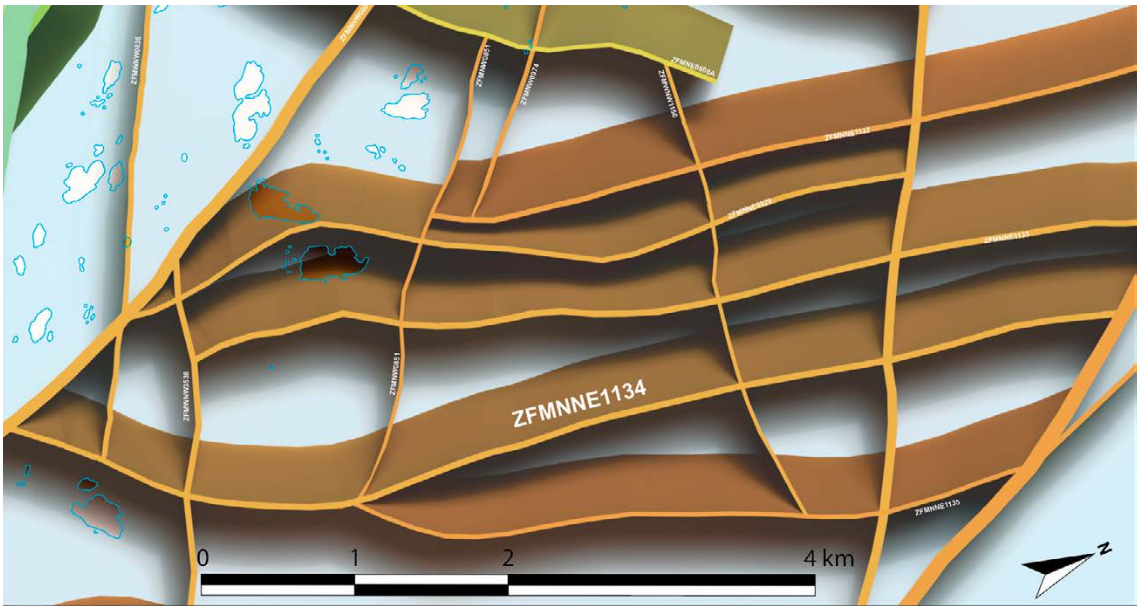
BASIS FOR MODELLING

Zone based on surface lineaments.

Outcrops:	-	
Boreholes: -		
Tunnels:	-	
Lineament and/or seismic indications:	MFM1134.	3

MODELLING PROCEDURE

At the surface, corresponds to the low magnetic lineament MFM1134. Modelled to the base of the model volume with a dip of 80 degrees to the WNW based on comparison with high confidence, steeply dipping zones with NNE strike.



NNE	ZFMNNE1134	Version number	3	Total object CL	12

OBJECT CONFIDENCE ESTIMATE

Category	Object CL	Comment
INTERPRETATION		
Data source	1	MFM1134
Results of interpretation	3	High confidence in lineament MFM1134.
INFORMATION DENSITY		
Number of observation points	1	1
Distribution of observation points	1	Single observation point in the form of a lineament.
INTERPOLATION		
Geometry	1	Geometry supported by surface geophysical data.
Geological indicators	1	Indirect support by geophysical data.
EXTRAPOLATION		
Dip direction	1	No subsurface obs. point, supported only by surface data. High uncertainty in dip-direction. Strike length of the modelled zone < 2000 m.
Strike direction	3	Conceptual understanding of the site and that the entire modelled zone is supported by the lineament.

FRACTURE CHARACTER

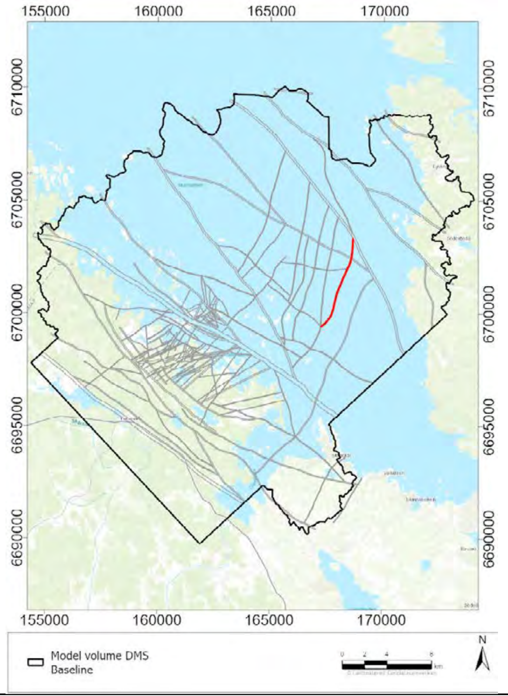
No data available

INDIVIDUAL INTERCEPTS

No data available

NNE	ZFMNNE1135	Version number	3	Total object CL	10

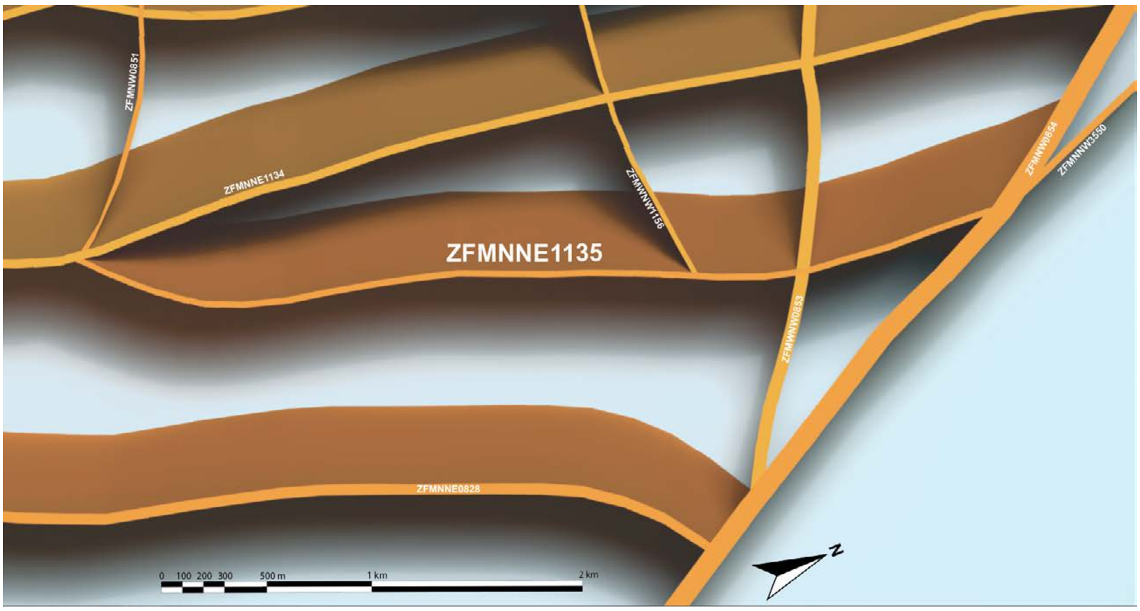
GEOLOGICAL CHARACTER		Property CL
Deformation style:	Brittle	1
Deformation description:	No data available.	
Alteration:		2
- First order:	Oxidation	
- Second order:	Not observed	
- Third order:	Not observed	
Fracture orientation and type:	No data available.	
Fracture comment:	No data available.	
Fracture fill mineralogy:	No data available.	
OBJECT GEOMETRY		
Strike/dip:	196°/80°	
Length:	4378 m	
Mean thickness:	30 m (15 - 64 m)	
Max depth:	-2100 m	
Geometrical constraints:	ZFMNNE1134, ZFMNW0854, Topo 40m grid Max error 20m.	



BASIS FOR MODELLING		
Zone based on surface lineaments.		
Outcrops:	-	
Boreholes: -		
Tunnels:	-	
Lineament and/or seismic indications:	MFM1135.	1

MODELLING PROCEDURE

At the surface, corresponds to the low magnetic lineament MFM1135. Modelled to the base of the model volume with a dip of 80 degrees to the WNW based on comparison with high confidence, steeply dipping zones with NNE strike.



NNE	ZFMNNE1135	Version number	3	Total object CL	10

OBJECT CONFIDENCE ESTIMATE

Category	Object CL	Comment
INTERPRETATION		
Data source	1	MFM1135
Results of interpretation	1	Low confidence in lineament MFM1135.
INFORMATION DENSITY		
Number of observation points	1	1
Distribution of observation points	1	Single observation point in the form of a lineament.
INTERPOLATION		
Geometry	1	Geometry supported by surface geophysical data.
Geological indicators	1	Indirect support by geophysical data.
EXTRAPOLATION		
Dip direction	1	No subsurface obs. point, supported only by surface data. High uncertainty in dip-direction. Strike length of the modelled zone < 2000 m.
Strike direction	3	Conceptual understanding of the site and that the entire modelled zone is supported by the lineament.

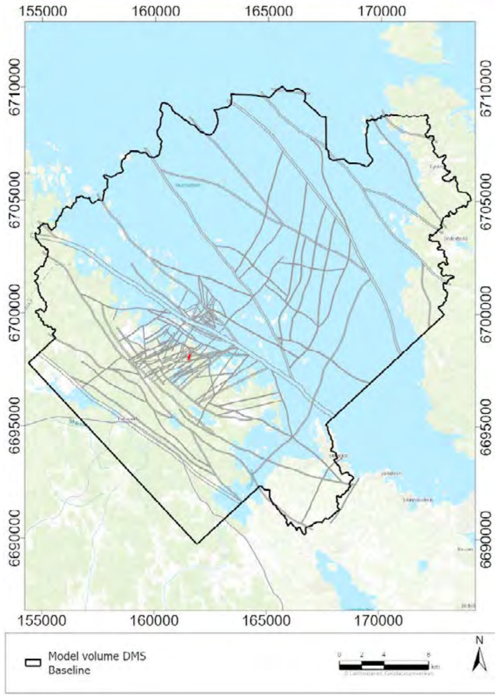
FRACTURE CHARACTER

No data available

INDIVIDUAL INTERCEPTS

No data available

NNE	ZFMNNE2008	Version number	5	Total object CL	14



GEOLOGICAL CHARACTER		Property CL
Deformation style:	Brittle	3
Deformation description:	No data available.	
Alteration:		3
- First order:	Oxidation	
- Second order:	Not observed	
- Third order:	Not observed	
Fracture orientation and type:	Few data in each set. Steeply dipping fractures that strike WSW as well as gently dipping fractures are conspicuous. Sealed and open fractures. Quantitative estimate and span include a crush zone.	2
Fracture comment:	No data available.	
Fracture fill mineralogy:	Calcite, chlorite, hematite/adularia, clay minerals.	

OBJECT GEOMETRY	
Strike/dip:	200°/84°
Length:	328 m
Mean thickness:	6 m (1 - 13 m)
Max depth:	-330 m
Geometrical constraints:	ZFMWNW0044, ZFMENE0060B, Topo 40m grid Max error 20m, 1 Surface Planar Cut(s), 1 UNIVERSE Planar Cut(s).

BASIS FOR MODELLING

Zone based on surface lineaments and borehole observations.

Outcrops:	-

Boreholes:

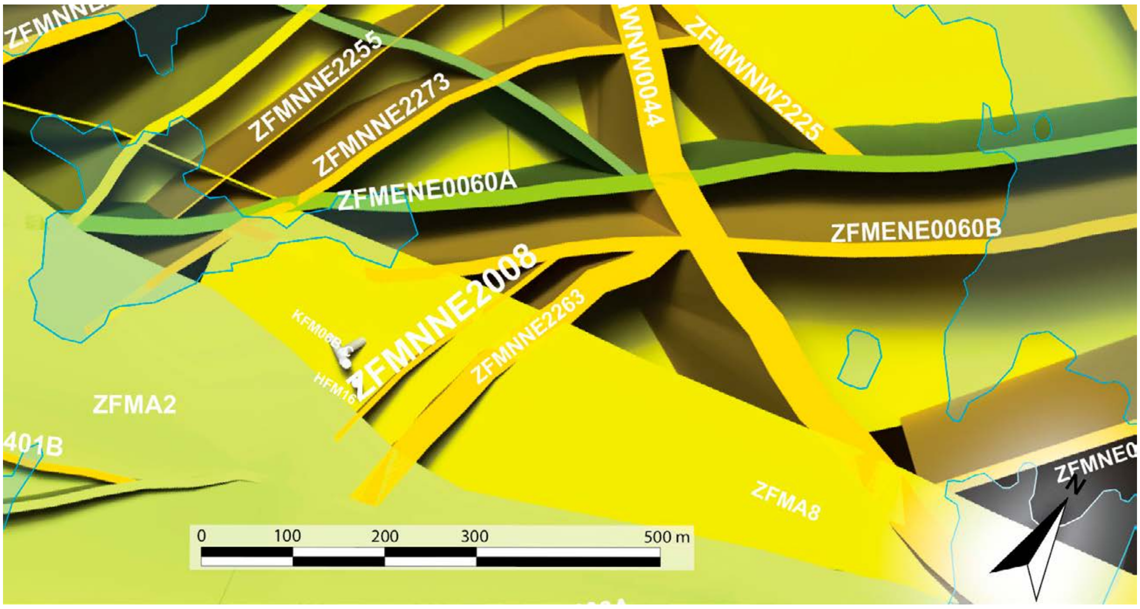
Borehole	PDZ	Target intercept		Geometric intercept		Comment
		Sec_up [m]	Sec_low [m]	Sec_up [m]	Sec_low [m]	
KFM06C		283.00	306.00	282.41	303.53	283-306 m inferred to be a DZ (cf. Table 3-2 in Stephens et al. 2007). Not recognized in SHI.

Tunnels:	-	
Lineament and/or seismic indications:	MFM2008G.	2

MODELLING PROCEDURE

At the surface, corresponds to the low magnetic lineament MFM2008G. Modelled down to 450 m depth, using the dip estimated by connecting lineament MFM2008G with the borehole intersection 283-306 m in KFM06C. Deformation zone plane placed at fixed point 293 m in KFM06C. Inferred to be a minor zone.

NNE	ZFMNNE2008	Version number	5	Total object CL	14



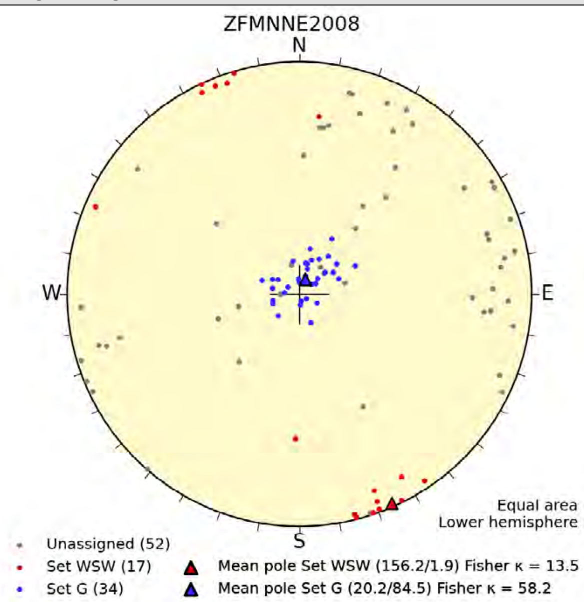
OBJECT CONFIDENCE ESTIMATE

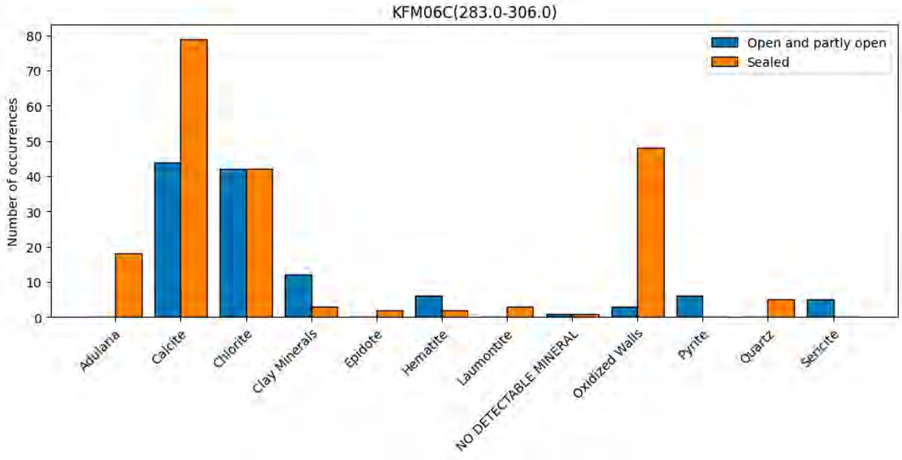
Category	Object CL	Comment
INTERPRETATION		
Data source	2	MFM2008G, KFM06C
Results of interpretation	2	KFM06C : 283–306 m inferred to be a DZ according to Table 3-2 in Stephens et al. (2007) (Confidence L=?,) Not recognized in SHI, Intercept at c. 250 m.
INFORMATION DENSITY		
Number of observation points	2	2
Distribution of observation points	1	Single observation point at depth and a surface lineament.
INTERPOLATION		
Geometry	1	Geometry supported by a lineament and a single intercept.
Geological indicators	1	Single observation point at depth. Zone modelled mainly based on surface geophysical data.
EXTRAPOLATION		
Dip direction	2	Extrapolation in dip direction supported by subsurface obs. point. Strike length of the modelled zone < 2000 m.
Strike direction	3	Conceptual understanding of the site and that the entire modelled zone is supported by the lineament.

FRACTURE CHARACTER

Orientation: (strike/dip right-hand-rule)	Set WSW: 246.2°/88.1° Set G: 110.2°/5.5°
Frequency:	Boreholes: KFM06C

FRACTURE TYPE	TERZAGHI-WEIGHED P10
Open and partly open	2.6 m-1
Sealed	9.7 m-1
Sealed network	0.0 % of DZ intercept
Crush	0.4 % of DZ intercept

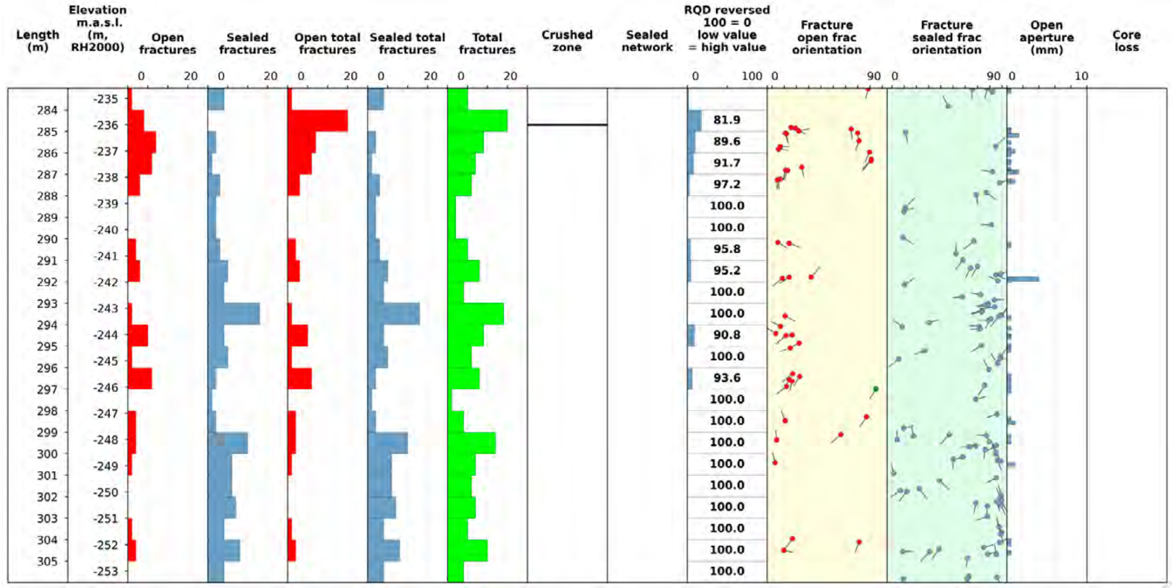


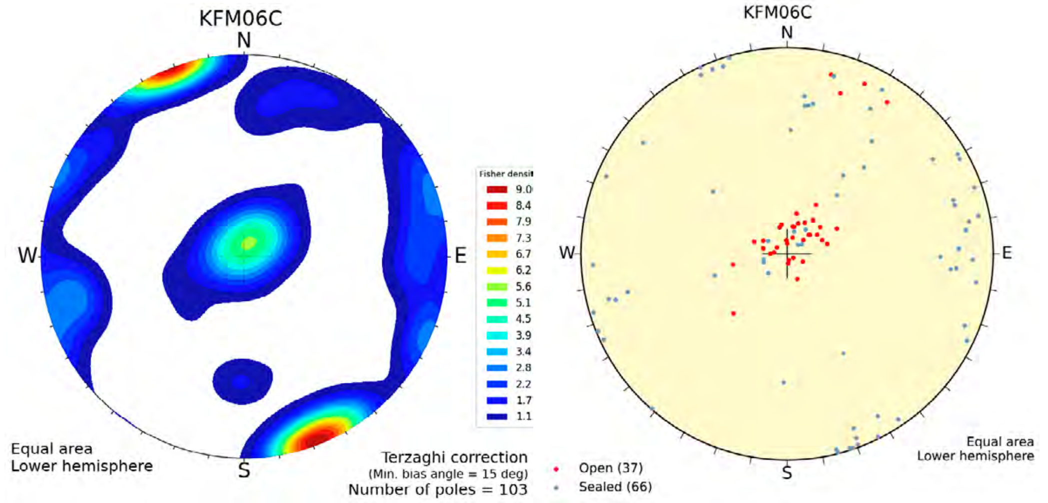
NNE	ZFMNNE2008	Version number	5	Total object CL	14
RQD:	min:82, max:100, mean:97				
Fracture fill mineralogy:					

NNE	ZFMNNE2008	Version number	5	Total object CL	14

INDIVIDUAL INTERCEPTS

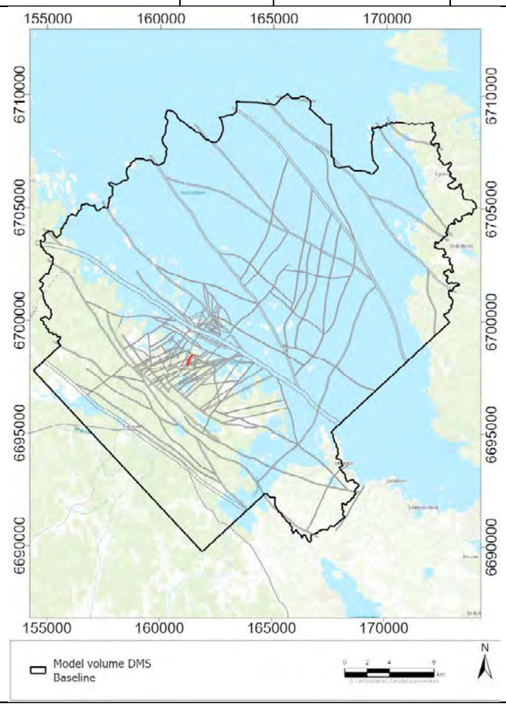
KFM06C (283.0-306.0 m)





NNE	ZFMNNE2255	Version number	4	Total object CL	14

GEOLOGICAL CHARACTER		Property CL
Deformation style:	Brittle	3
Deformation description:	No data available.	
Alteration:		3
- First order:	Oxidation	
- Second order:	Not observed	
- Third order:	Not observed	
Fracture orientation and type:	Steeply dipping fractures that strike NNE are prominent. Sealed fractures dominates. Quantitative estimate and span include a sealed fracture network.	2
Fracture comment:	No data available.	
Fracture fill mineralogy:	Chlorite, calcite, quartz, hematite/adularia, clay minerals.	



OBJECT GEOMETRY	
Strike/dip:	203°/81°
Length:	585 m
Mean thickness:	2 m (2 - 36 m)
Max depth:	-580 m
Geometrical constraints:	ZFMWNW0044, ZFMENE0060A, Topo 40m grid Max error 20m, 1 Surface Planar Cut(s).

BASIS FOR MODELLING

Zone based on surface lineaments and borehole observations.

Outcrops: -

Boreholes:

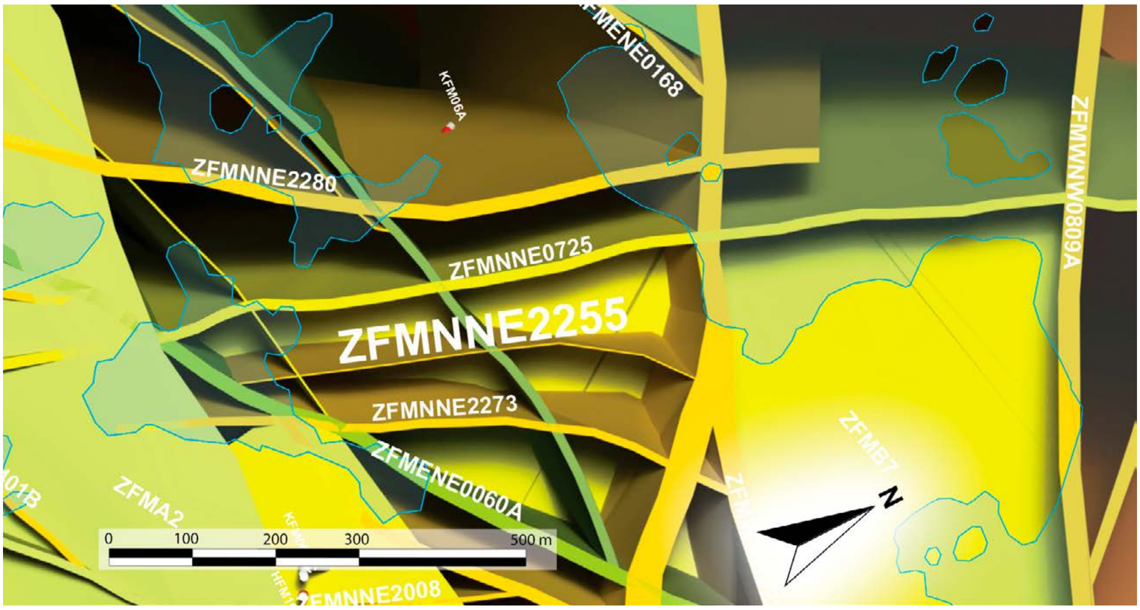
Borehole	PDZ	Target intercept		Geometric intercept		Comment
		Sec_up [m]	Sec_low [m]	Sec_up [m]	Sec_low [m]	
KFM06A	DZ5	619.00	624.00	619.15	624.58	

Tunnels:	-	
Lineament and/or seismic indications:	MFM2255G.	2

MODELLING PROCEDURE

At the surface, corresponds to the low magnetic lineament MFM2255G. Modelled down to 500 m depth, using the dip estimated by connecting lineament MFM2255G with the borehole intersection 619-624 m in KFM06A (DZ5). Deformation zone plane placed at fixed point 622 m in KFM06A. This point is also situated along an interval of low radar amplitude (620-625 m). Inferred to be a minor zone.

NNE	ZFMNNE2255	Version number	4	Total object CL	14



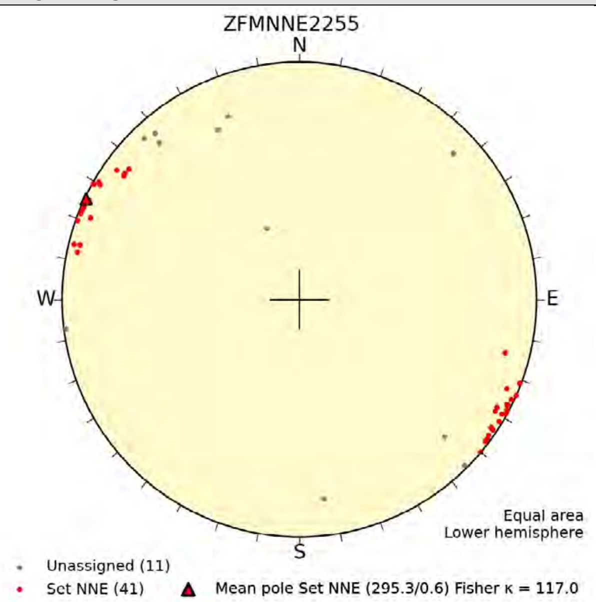
OBJECT CONFIDENCE ESTIMATE

Category	Object CL	Comment
INTERPRETATION		
Data source	2	MFM2255G, KFM06A
Results of interpretation	2	Medium confidence observation in KFM06A.
INFORMATION DENSITY		
Number of observation points	2	2
Distribution of observation points	1	Single observation point at depth and a surface lineament.
INTERPOLATION		
Geometry	1	Geometry supported by a lineament and a single intercept.
Geological indicators	1	Single observation point at depth. Zone modelled mainly based on surface geophysical data.
EXTRAPOLATION		
Dip direction	2	Extrapolation in dip direction supported by subsurface obs. point. Strike length of the modelled zone < 2000 m.
Strike direction	3	Conceptual understanding of the site and that the entire modelled zone is supported by the lineament.

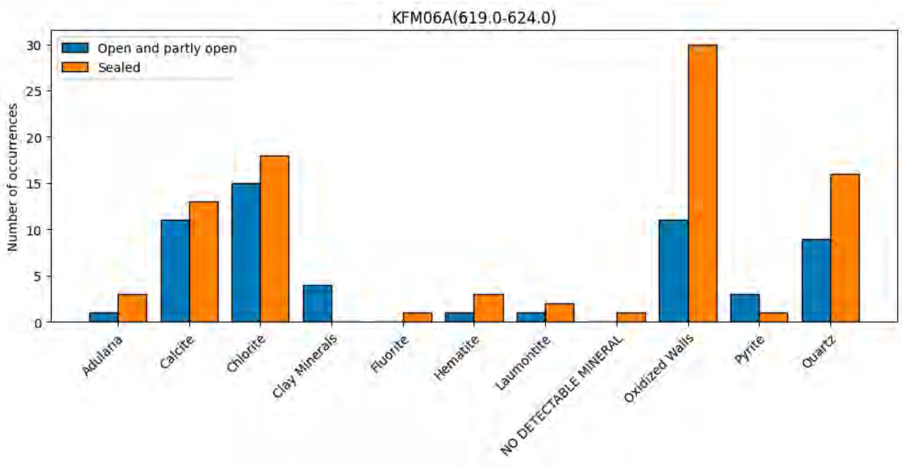
FRACTURE CHARACTER

Orientation: (strike/dip right-hand-rule)	Set NNE: 25.3°/89.4°
Frequency:	Boreholes: KFM06A

FRACTURE TYPE	TERZAGHI-WEIGHED P10
Open and partly open	6.0 m-1
Sealed	15.2 m-1
Sealed network	3.3 % of DZ intercept
Crush	0.0 % of DZ intercept



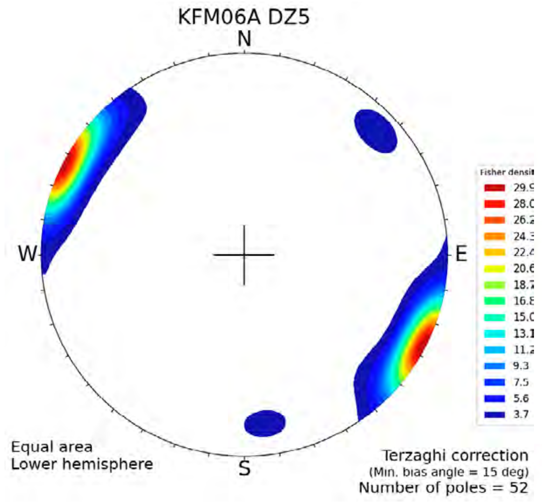
RQD:	min:53, max:100, mean:86

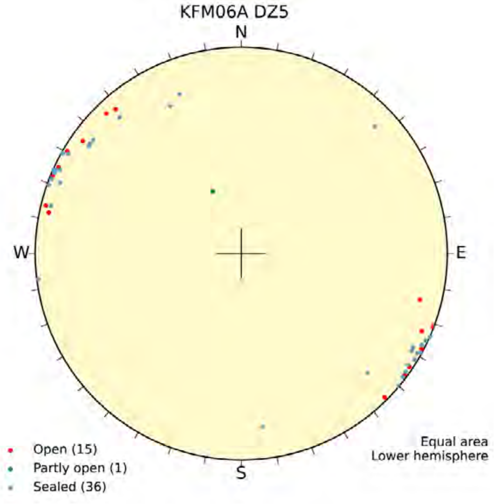
NNE	ZFMNNE2255	Version number	4	Total object CL	14
Fracture fill mineralogy:					

NNE	ZFMNNE2255	Version number	4	Total object CL	14

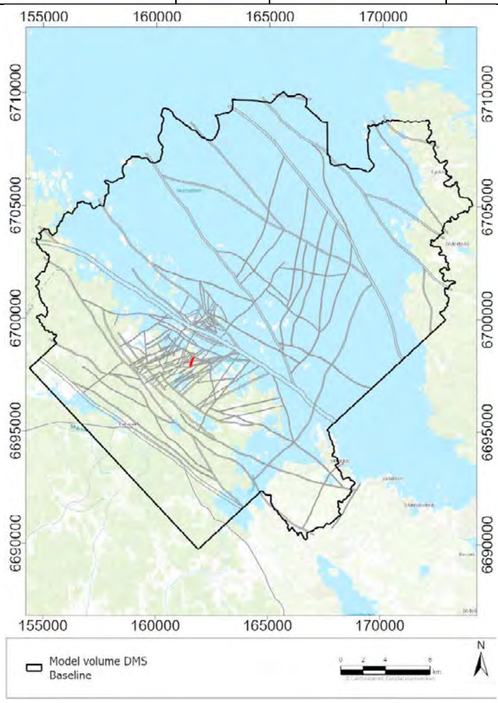
INDIVIDUAL INTERCEPTS

KFM06A DZ5 (619.0-624.0 m)





NNE	ZFMNNE2263	Version number	5	Total object CL	15



GEOLOGICAL CHARACTER		Property CL
Deformation style:	Brittle	3
Deformation description:	No data available.	
Alteration:		3
- First order:	Oxidation	
- Second order:	Quartz dissolution	
- Third order:	Not observed	
Fracture orientation and type:	Steeply dipping fractures that strike SW and dip steeply to the NW, are conspicuous. Steeply dipping fractures that strike SSE as well as gently to moderately dipping fractures are also present. Sealed fractures dominates. Quantitative estimate and span include sealed fracture networks.	2
Fracture comment:	No data available.	
Fracture fill mineralogy:	Chlorite, calcite, hematite/adularia, clay minerals, quartz. High frequency of fractures that dip gently to the NW with no identified mineral coating/filling.	

OBJECT GEOMETRY	
Strike/dip:	199°/83°
Length:	449 m
Mean thickness:	30 m (2 - 30 m)
Max depth:	-450 m
Geometrical constraints:	ZFMENE0401A, ZFMWNW0044, ZFMENE0060B, Topo 40m grid Max error 20m, 1 Surface Planar Cut(s).

BASIS FOR MODELLING

Zone based on surface lineaments and borehole observations.

Outcrops:	-

Boreholes:

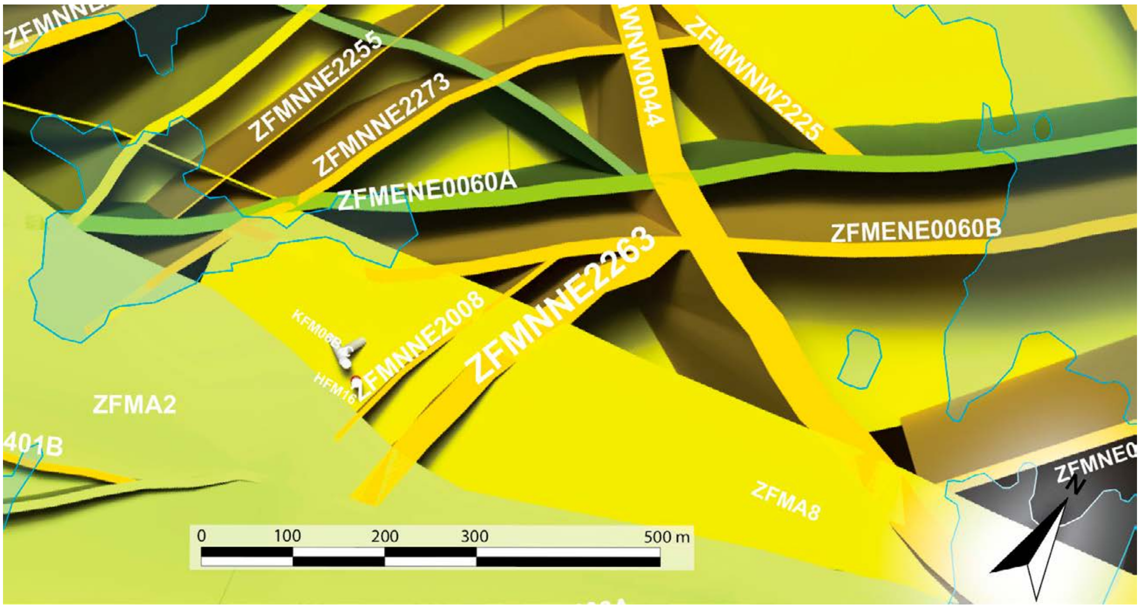
Borehole	PDZ	Target intercept		Geometric intercept		Comment
		Sec_up [m]	Sec_low [m]	Sec_up [m]	Sec_low [m]	
KFM06C	DZ3	415.00	489.00	414.43	485.20	

Tunnels:	-	
Lineament and/or seismic indications:	MFM2263G.	1

MODELLING PROCEDURE

At the surface, corresponds to the low magnetic lineament MFM2263G. Modelled down to 500 m depth, using the dip estimated by connecting lineament MFM2263G with the borehole intersection 415-489 m in KFM06C (DZ3). Deformation zone plane placed at fixed point 467 m in KFM06C. Decreased radar penetration also along the borehole interval 466-471 m. Inferred to be a minor zone.

NNE	ZFMNNE2263	Version number	5	Total object CL	15



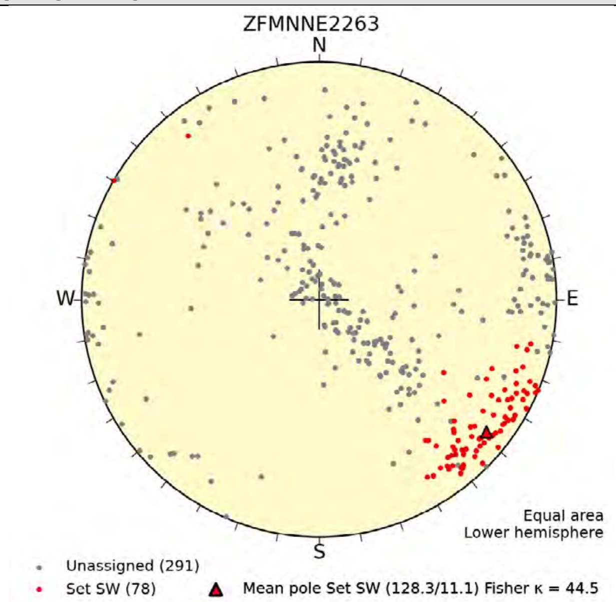
OBJECT CONFIDENCE ESTIMATE

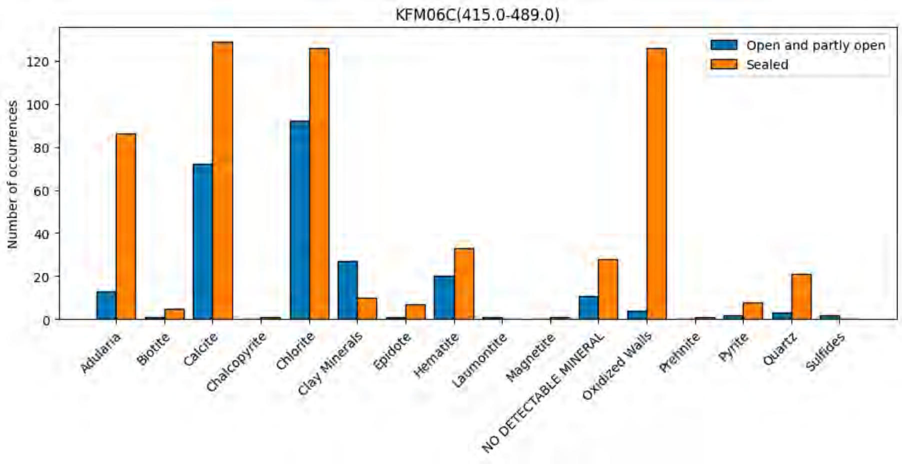
Category	Object CL	Comment
INTERPRETATION		
Data source	2	MFM2263G, KFM06C
Results of interpretation	3	High confidence observation in KFM06C.
INFORMATION DENSITY		
Number of observation points	2	2
Distribution of observation points	1	Single observation point at depth and a surface lineament.
INTERPOLATION		
Geometry	1	Geometry supported by a lineament and a single intercept.
Geological indicators	1	Single observation point at depth. Zone modelled mainly based on surface geophysical data.
EXTRAPOLATION		
Dip direction	2	Extrapolation in dip direction supported by subsurface obs. point. Strike length of the modelled zone < 2000 m.
Strike direction	3	Conceptual understanding of the site and that the entire modelled zone is supported by the lineament.

FRACTURE CHARACTER

Orientation: (strike/dip right-hand-rule)	Set SW: 218.3°/78.9°	
Frequency:	Boreholes: KFM06C	
RQD:	min:67, max:100, mean:98	

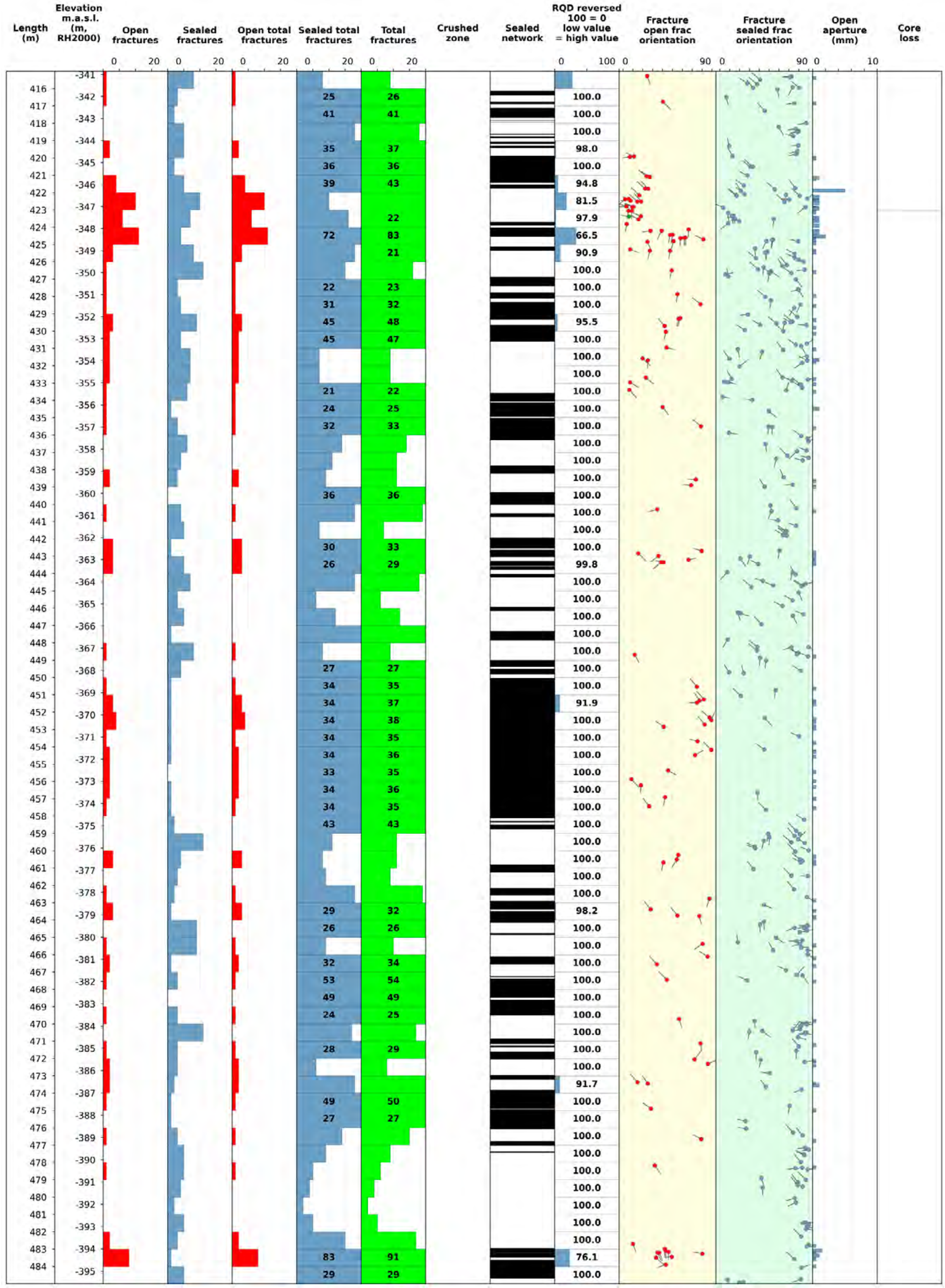
FRACTURE TYPE	TERZAGHI-WEIGHED P10
Open and partly open	2.8 m-1
Sealed	8.5 m-1
Sealed network	47.2 % of DZ intercept
Crush	0.0 % of DZ intercept



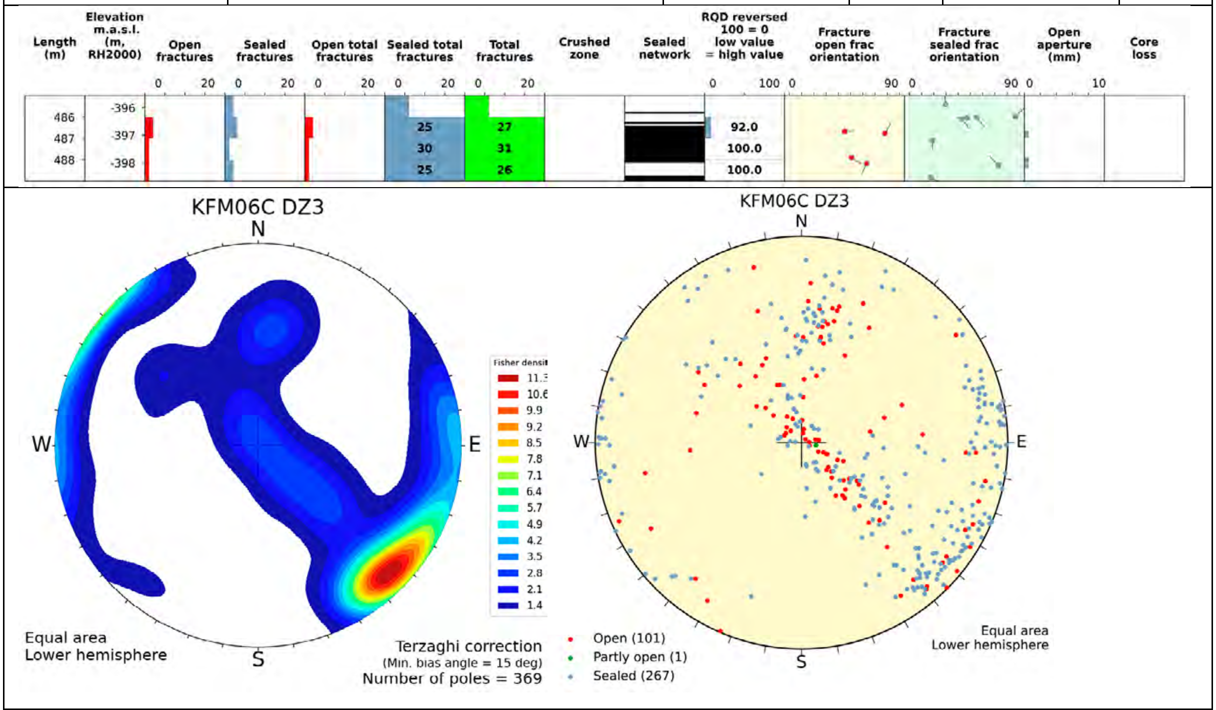
NNE	ZFMNNE2263	Version number	5	Total object CL	15
Fracture fill mineralogy:					

NNE	ZFMNNE2263	Version number	5	Total object CL	15
INDIVIDUAL INTERCEPTS					

KFM06C DZ3 (415.0-489.0 m)

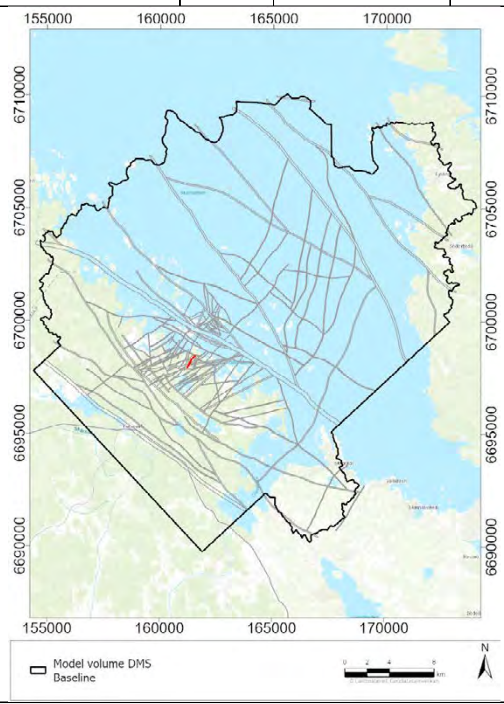


NNE	ZFMNNE2263	Version number	5	Total object CL	15



NNE	ZFMNNE2273	Version number	6	Total object CL	13

GEOLOGICAL CHARACTER		Property CL
Deformation style:	Brittle	3
Deformation description:	No data available.	
Alteration:		
- First order:	Oxidation	3
- Second order:	Not observed	
- Third order:	Not observed	
Fracture orientation and type:	Steeply dipping fractures that dip to the SW are prominent. Sealed fractures dominates. Quantitative estimate and span include sealed fracture networks.	2
Fracture comment:	No data available.	
Fracture fill mineralogy:	Calcite, chlorite, hematite/adularia, quartz, prehnite.	



OBJECT GEOMETRY	
Strike/dip:	210°/77°
Length:	744 m
Mean thickness:	10 m (2 - 36 m)
Max depth:	-740 m
Geometrical constraints:	ZFMWNW2225, Topo 40m grid Max error 20m, 1 Surface Planar Cut(s), 1 UNIVERSE Planar Cut(s).

BASIS FOR MODELLING

Zone based on surface lineaments and borehole observations.

Outcrops:	-

Boreholes:

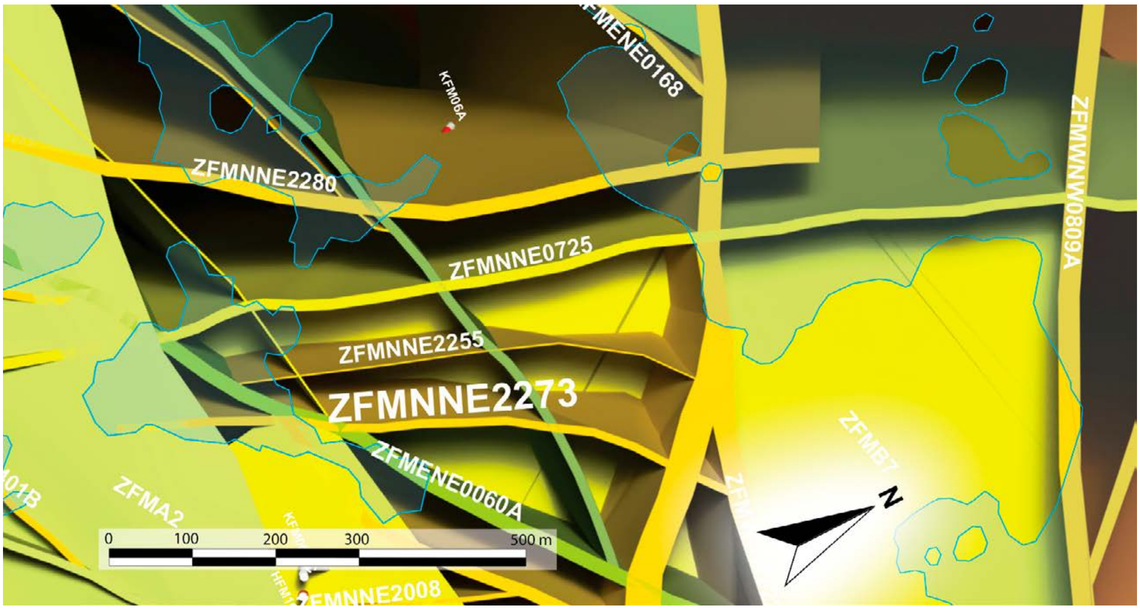
Borehole	PDZ	Target intercept		Geometric intercept		Comment
		Sec_up [m]	Sec_low [m]	Sec_up [m]	Sec_low [m]	
KFM06A		518.00	545.00	517.07	544.97	518-545 inferred to be a DZ (cf. Table 3-2 in Stephens et al. 2007).

Tunnels:	-	
Lineament and/or seismic indications:	MFM2273G.	3

MODELLING PROCEDURE

At the surface, corresponds to the low magnetic lineament MFM2273G. Modelled down to 650 m depth, using the dip estimated by connecting lineament MFM2273G with the borehole intersection 518-545 m in KFM06A. Deformation zone plane placed at fixed point 530 m in KFM06A. Inferred to be a minor zone.

NNE	ZFMNNE2273	Version number	6	Total object CL	13



OBJECT CONFIDENCE ESTIMATE

Category	Object CL	Comment
INTERPRETATION		
Data source	2	MFM2273G, KFM06A
Results of interpretation	1	Low confidence in KFM06A in 518-545, which is only inferred to be a DZ (cf. Table 3-2 in Stephens et al. 2007).
INFORMATION DENSITY		
Number of observation points	2	2
Distribution of observation points	1	Single observation point at depth and a surface lineament.
INTERPOLATION		
Geometry	1	Geometry supported by a lineament and a single intercept.
Geological indicators	1	Single observation point at depth. Zone modelled mainly based on surface geophysical data.
EXTRAPOLATION		
Dip direction	2	Extrapolation in dip direction supported by subsurface obs. point. Strike length of the modelled zone < 2000 m.
Strike direction	3	Conceptual understanding of the site and that the entire modelled zone is supported by the lineament.

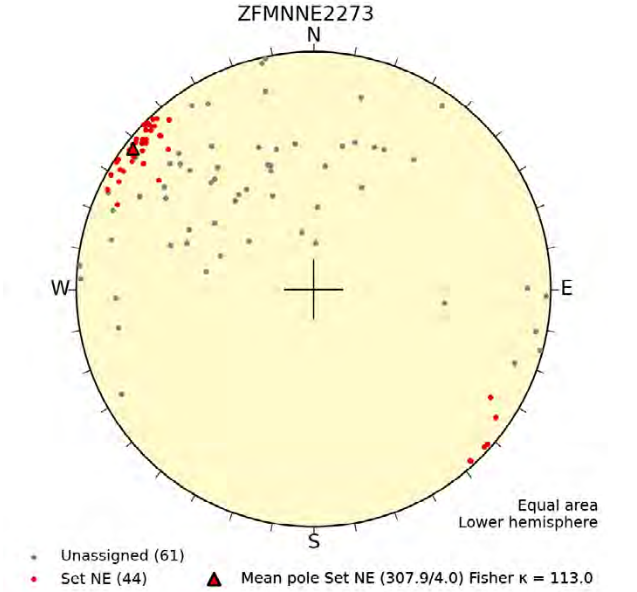
FRACTURE CHARACTER

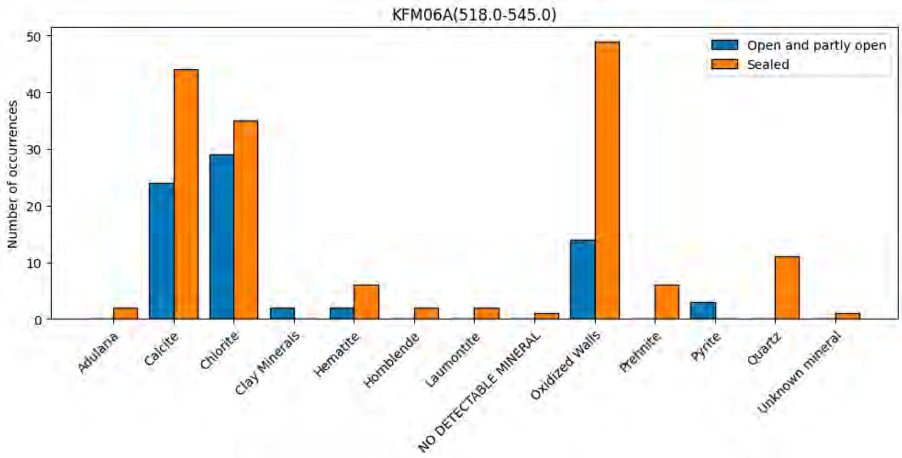
Orientation: (strike/dip right-hand-rule): Set NE: 37.9°/86.0°

Frequency: Boreholes: KFM06A

FRACTURE TYPE	TERZAGHI-WEIGHED P10
Open and partly open	1.6 m-1
Sealed	5.3 m-1
Sealed network	1.0 % of DZ intercept
Crush	0.0 % of DZ intercept

RQD: min:26, max:100, mean:96

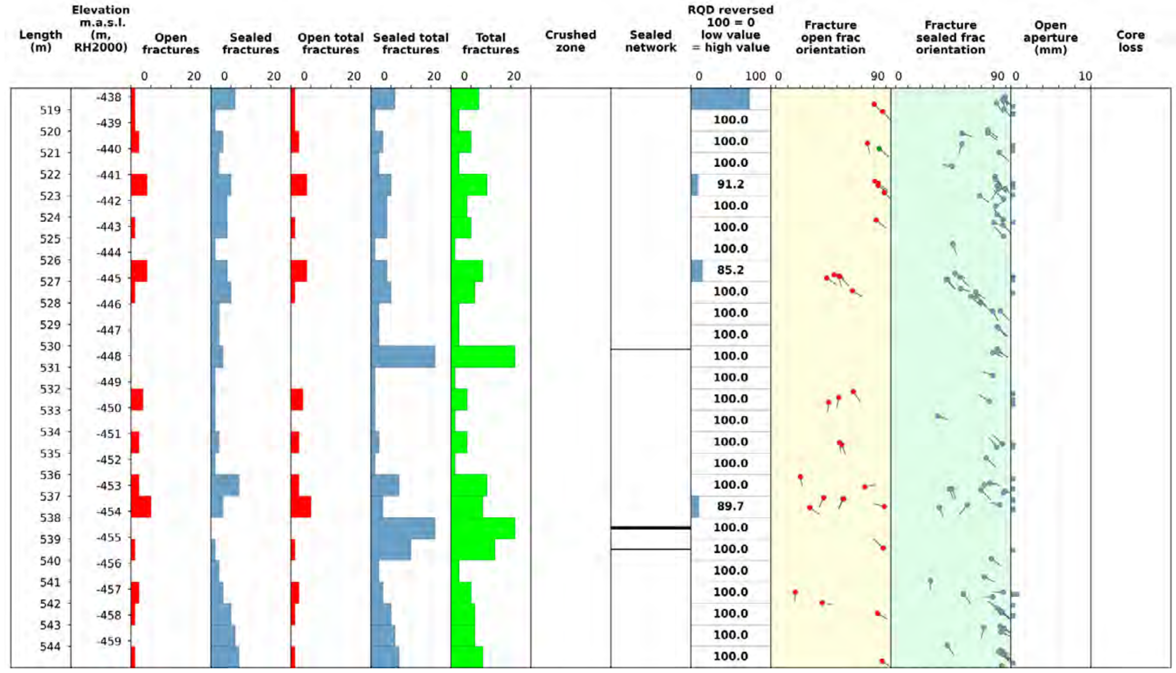


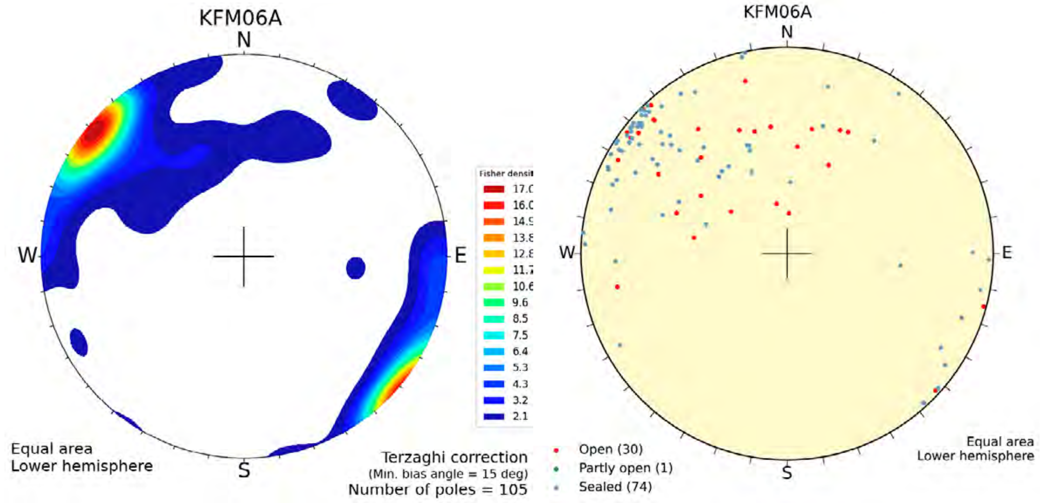
NNE	ZFMNNE2273	Version number	6	Total object CL	13
Fracture fill mineralogy:					

NNE	ZFMNNE2273	Version number	6	Total object CL	13

INDIVIDUAL INTERCEPTS

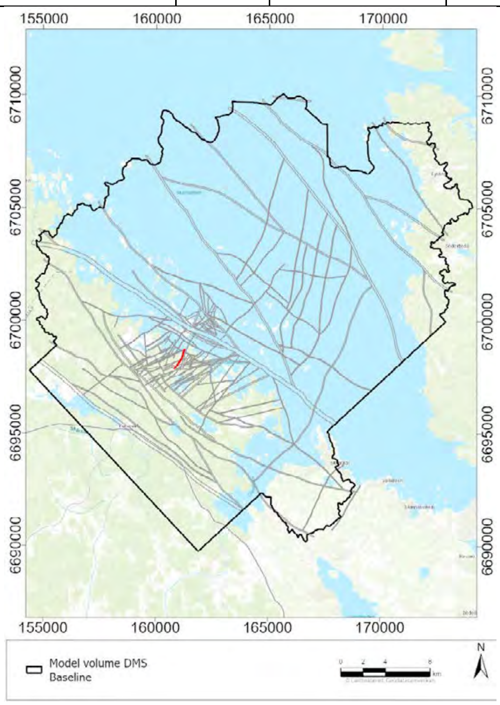
KFM06A (518.0-545.0 m)





NNE	ZFMNNE2280		Version number	12	Total object CL	15

GEOLOGICAL CHARACTER		Property CL
Deformation style:	Brittle	3
Deformation description:	Steeply dipping fault with NNE strike shows dominant strike-slip movement. Steeply dipping fault with SW strike shows normal dip slip movement. Gently dipping faults with variable dips to the west and south show oblique movement with dominant dextral strike slip and subordinate normal dip-slip components.	
Alteration:		3
- First order:	Oxidation	
- Second order:	Not observed	
- Third order:	Not observed	
Fracture orientation and type:	Steeply dipping fractures with NNE strike and gently dipping fractures dominates. Sealed fractures dominates. Quantitative estimate and span include sealed fracture networks.	2
Fracture comment:	No data available.	
Fracture fill mineralogy:	Chlorite, calcite, hematite/adularia, laumontite, quartz. Epidote along fractures with gentle to moderate dips to the SE and steep dips with NW strike.	



OBJECT GEOMETRY	
Strike/dip:	208°/84°
Length:	1033 m
Mean thickness:	17 m (3 - 50 m)
Max depth:	-1050 m
Geometrical constraints:	Topo 40m grid Max error 20m, 1 Surface Planar Cut(s).

BASIS FOR MODELLING

Zone based on surface lineaments and borehole observations.

Outcrops: -

Boreholes:

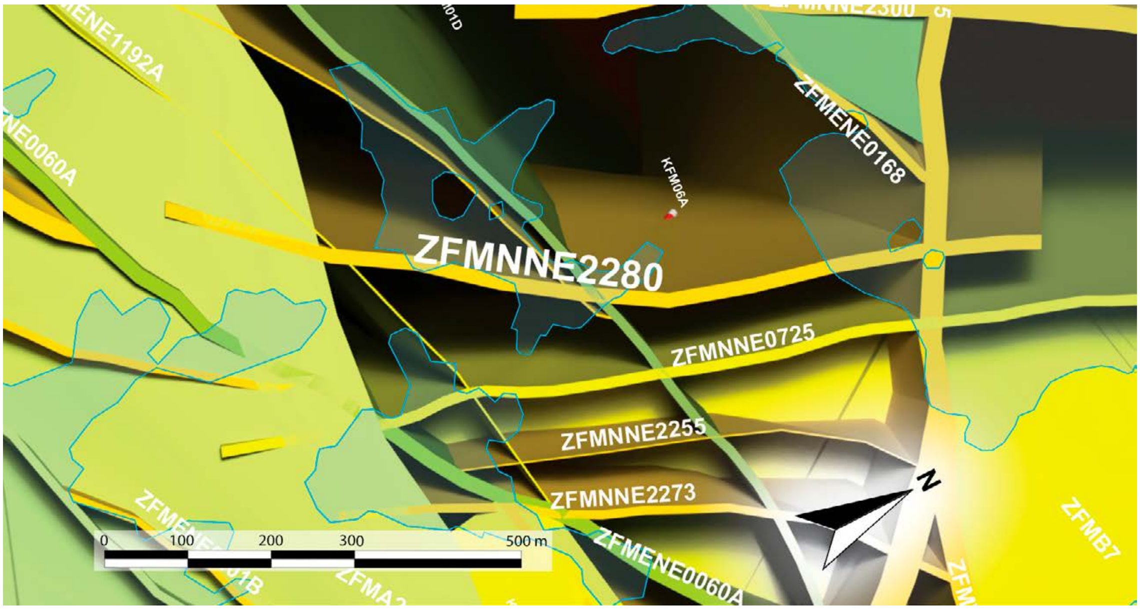
Borehole	PDZ	Target intercept		Geometric intercept		Comment
		Sec_up [m]	Sec_low [m]	Sec_up [m]	Sec_low [m]	
KFM06A	DZ11	950.00	990.00	949.55	990.07	

Tunnels:	-	
Lineament and/or seismic indications:	MFM2280G.	2

MODELLING PROCEDURE

At the surface, corresponds to the low magnetic lineament MFM2280G. Modelled down to 1050 m depth, using the dip estimated by connecting lineament MFM2280G with the borehole intersection 950-990 m in KFM06A (DZ11). Deformation zone plane placed at fixed point 976 m in KFM06A.

NNE	ZFMNNE2280	Version number	12	Total object CL	15



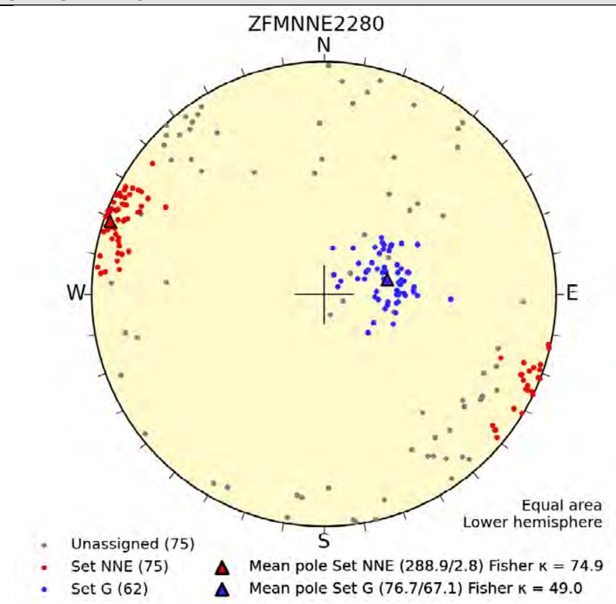
OBJECT CONFIDENCE ESTIMATE

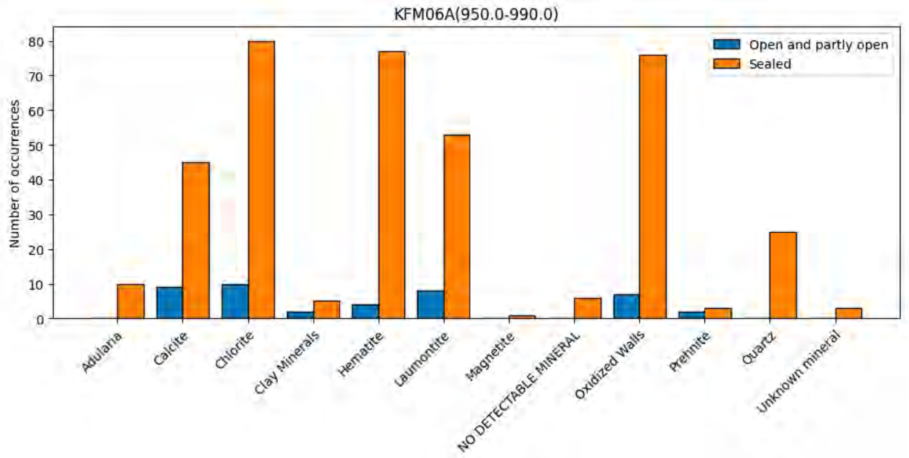
Category	Object CL	Comment
INTERPRETATION		
Data source	2	MFM2280G, KFM06A
Results of interpretation	3	High confidence observation in KFM06A.
INFORMATION DENSITY		
Number of observation points	2	2
Distribution of observation points	1	Single observation point at depth and a surface lineament.
INTERPOLATION		
Geometry	1	One subsurface obs. point but the zone is extrapolated in horizontal direction mainly following interpreted surface lineament. Multiple zones with similar strike adding strong support.
Geological indicators	1	Single observation point at depth. Zone modelled mainly based on surface geophysical data.
EXTRAPOLATION		
Dip direction	2	Extrapolation in dip direction supported by subsurface obs. point. Strike length of the modelled zone < 2000 m.
Strike direction	3	Conceptual understanding of the site and that the entire modelled zone is supported by the lineament.

FRACTURE CHARACTER

Orientation: (strike/dip right-hand-rule)	Set NNE: 18.9°/87.2° Set G: 166.7°/22.9°
Frequency:	Boreholes: KFM06A

FRACTURE TYPE	TERZAGHI-WEIGHED P10
Open and partly open	0.8 m-1
Sealed	10.3 m-1
Sealed network	2.7 % of DZ intercept
Crush	0.0 % of DZ intercept

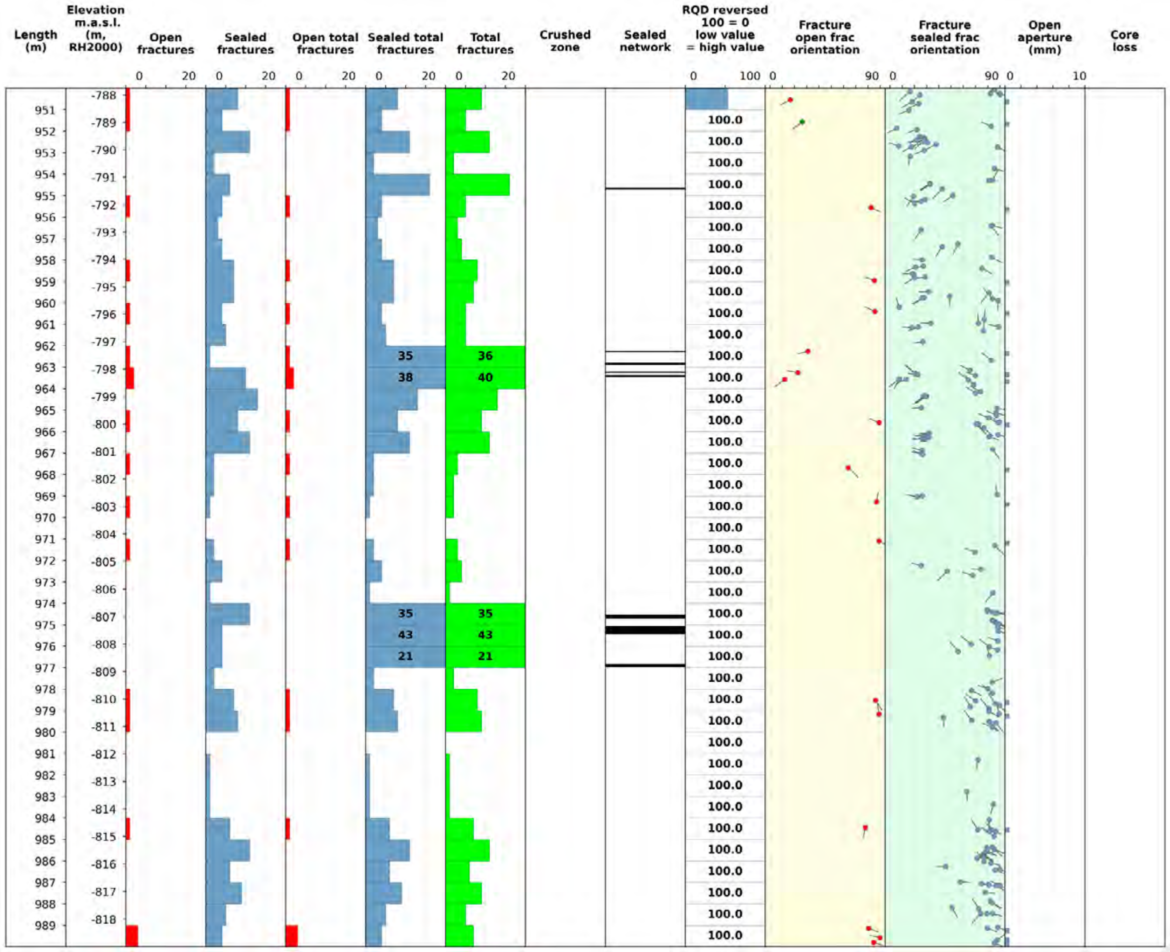


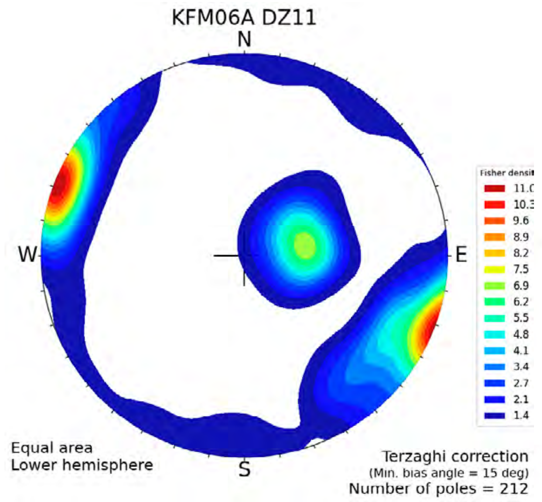
NNE	ZFMNNE2280	Version number	12	Total object CL	15
RQD:	min:47, max:100, mean:99				
Fracture fill mineralogy:					

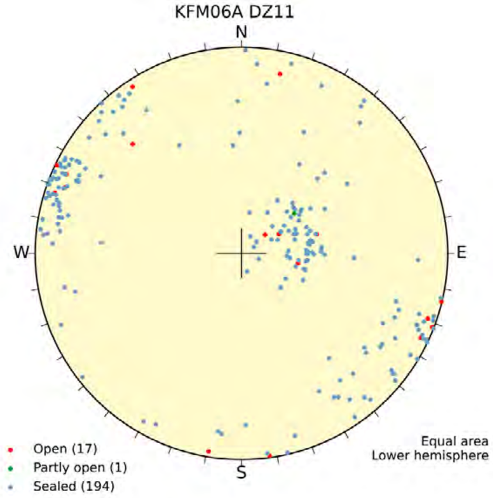
NNE	ZFMNNE2280	Version number	12	Total object CL	15

INDIVIDUAL INTERCEPTS

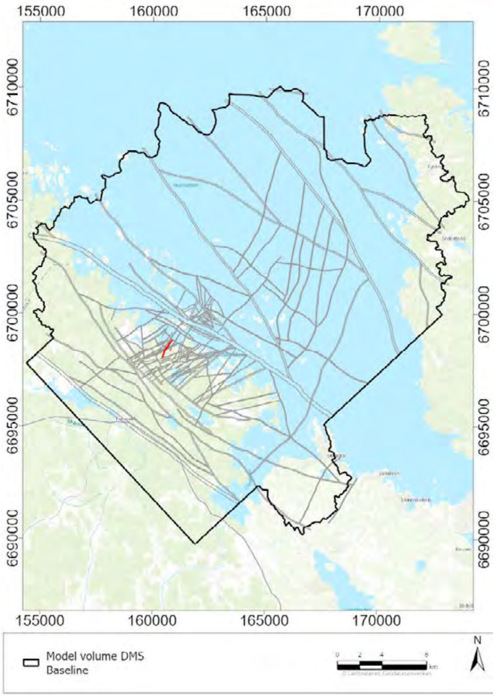
KFM06A DZ11 (950.0-990.0 m)







NNE	ZFMNNE2293	Version number	4	Total object CL	14



GEOLOGICAL CHARACTER		Property CL
Deformation style:	Brittle	3
Deformation description:	No data available.	
Alteration:		3
- First order:	Oxidation	
- Second order:	Not observed	
- Third order:	Not observed	
Fracture orientation and type:	Steeply dipping fractures that strike NNE-SSW are prominent. Gently dipping fractures are also present. Quantitative estimate and span include sealed fracture networks.	2
Fracture comment:	No data available.	
Fracture fill mineralogy:	Calcite, chlorite, hematite/adularia, quartz and other minerals.	

OBJECT GEOMETRY	
Strike/dip:	210°/80°
Length:	944 m
Mean thickness:	8 m (2 - 36 m)
Max depth:	-950 m
Geometrical constraints:	ZFMWNW2225, ZFMENE0061, Topo 40m grid Max error 20m, 1 Surface Planar Cut(s).

BASIS FOR MODELLING

Zone based on surface lineaments and borehole observations.

Outcrops:	-

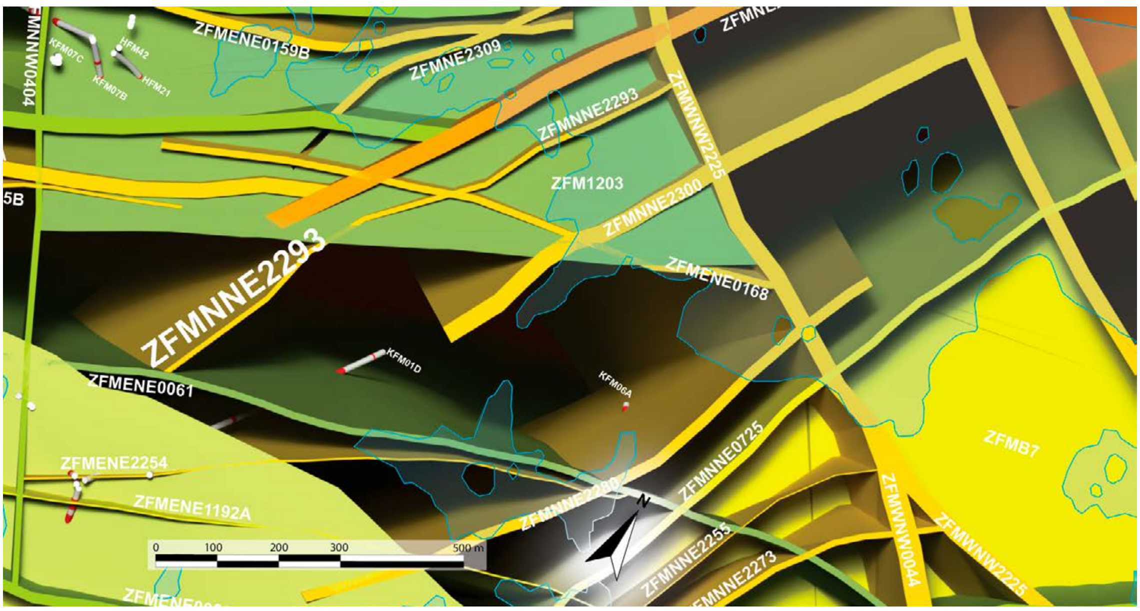
Boreholes:

Borehole	PDZ	Target intercept		Geometric intercept		Comment
		Sec_up [m]	Sec_low [m]	Sec_up [m]	Sec_low [m]	
KFM08D	DZ9	737.00	749.00	737.26	748.66	

Tunnels:	-	
Lineament and/or seismic indications:	MFM2300G.	2

MODELLING PROCEDURE

At the surface, corresponds to the low magnetic lineament MFM2300G. Modelled to a depth of -950 m using the dip estimated by connecting lineament MFM2293G with the borehole intersection 737-749 m in KFM08D (DZ9). Deformation zone plane placed at fixed point 746 m in KFM08D.



NNE	ZFMNNE2293	Version number	4	Total object CL	14

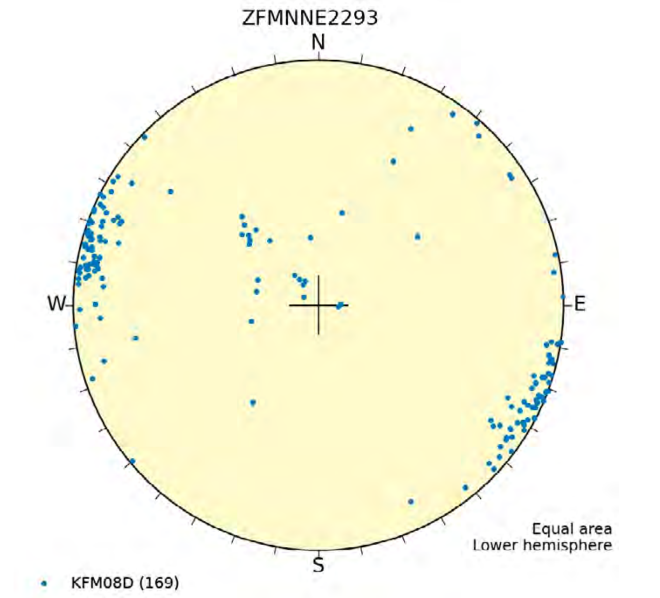
OBJECT CONFIDENCE ESTIMATE

Category	Object CL	Comment
INTERPRETATION		
Data source	2	MFM2293G, KFM08D
Results of interpretation	2	Medium confidence observation in KFM08D.
INFORMATION DENSITY		
Number of observation points	2	2
Distribution of observation points	1	Single observation point at depth and a surface lineament.
INTERPOLATION		
Geometry	1	Geometry supported by a lineament and a single intercept.
Geological indicators	1	Single observation point at depth. Zone modelled mainly based on surface geophysical data.
EXTRAPOLATION		
Dip direction	2	Extrapolation in dip direction supported by subsurface obs. point. Strike length of the modelled zone < 2000 m.
Strike direction	3	Conceptual understanding of the site and that the entire modelled zone is supported by the lineament.

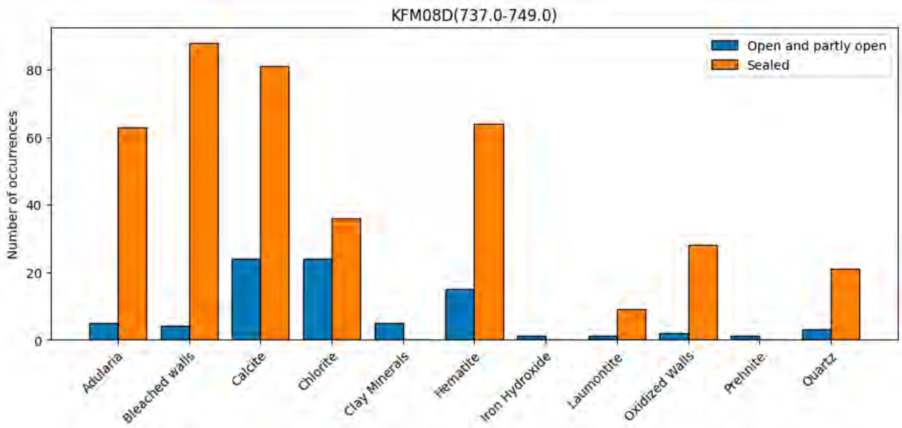
FRACTURE CHARACTER

Orientation: (strike/dip right-hand-rule)	--	
Frequency:	Boreholes: KFM08D	
RQD:	min:46, max:100, mean:91	

FRACTURE TYPE	TERZAGHI-WEIGHED P10
Open and partly open	4.6 m-1
Sealed	24.4 m-1
Sealed network	1.6 % of DZ intercept
Crush	0.0 % of DZ intercept



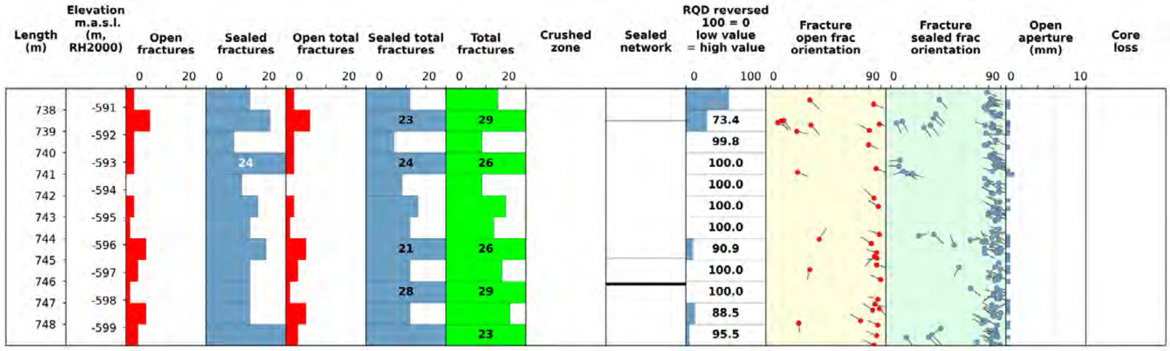
Fracture fill mineralogy:

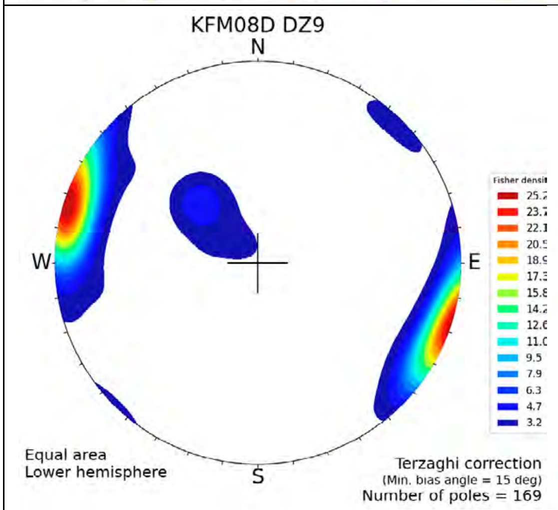


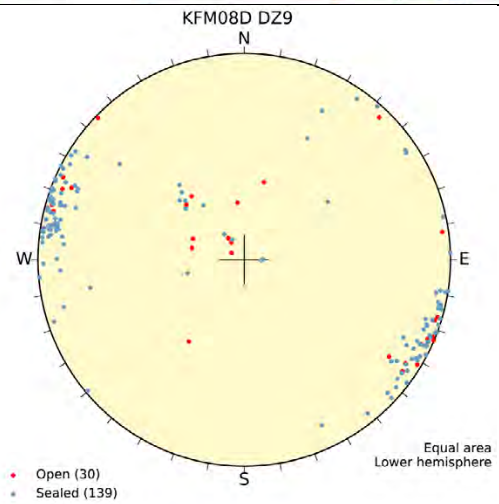
NNE	ZFMNNE2293	Version number	4	Total object CL	14

INDIVIDUAL INTERCEPTS

KFM08D DZ9 (737.0-749.0 m)

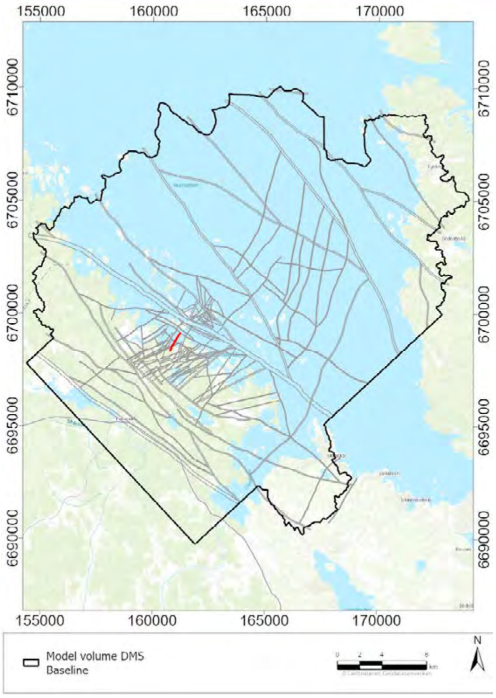






NNE	ZFMNNE2300	Version number	5	Total object CL	15

GEOLOGICAL CHARACTER		Property CL
Deformation style:	Brittle	3
Deformation description:	Gently to moderately south dipping faults show reverse displacement. A steeply dipping fault with SSW strike shows strike slip displacement.	
Alteration:		3
- First order:	Oxidation	
- Second order:	Quartz dissolution	
- Third order:	Not observed	
Fracture orientation and type:	Red-stained bedrock with fine-grained hematite dissemination. Quartz dissolution documented at around 933 m. Quantitative estimate and span include sealed fracture networks.	2
Fracture comment:	No data available.	
Fracture fill mineralogy:	Chlorite, calcite, clay minerals, hematite/adularia, quartz and other minerals.	



OBJECT GEOMETRY

Strike/dip:	210°/79°
Length:	942 m
Mean thickness:	28 m (2 - 36 m)
Max depth:	-940 m
Geometrical constraints:	ZFMWNW0809A, Topo 40m grid Max error 20m, 1 Surface Planar Cut(s), 1 UNIVERSE Planar Cut(s).

BASIS FOR MODELLING

Zone based on surface lineaments and borehole observations.

Outcrops: -

Boreholes:

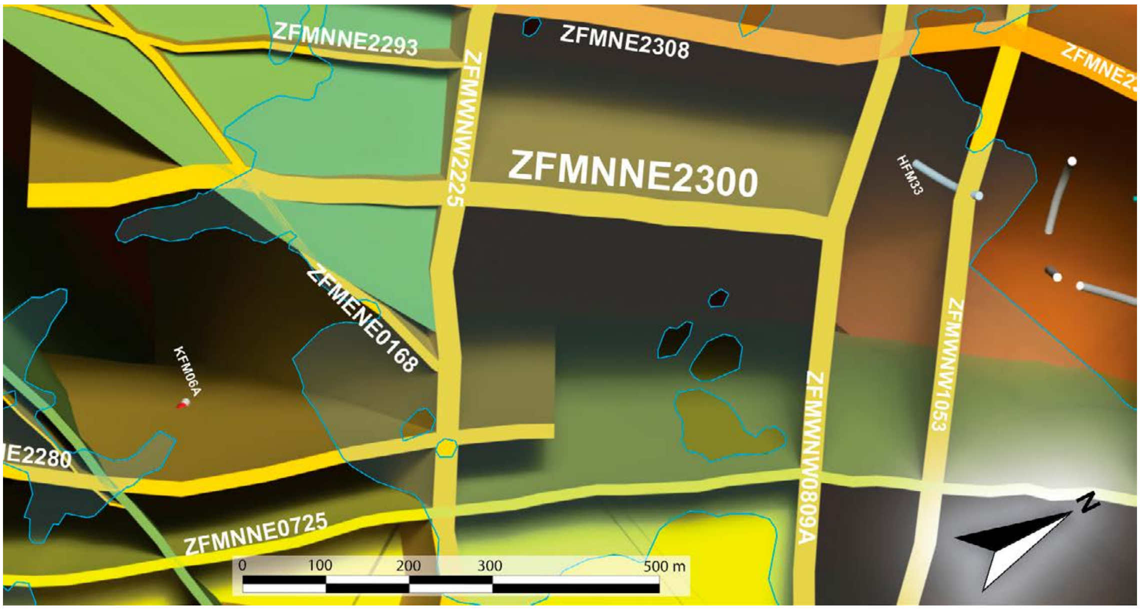
Borehole	PDZ	Target intercept		Geometric intercept		Comment
		Sec_up [m]	Sec_low [m]	Sec_up [m]	Sec_low [m]	
KFM08D	DZ12	903.00	941.75	902.83	941.96	

Tunnels:	-	
Lineament and/or seismic indications:	MFM2300G.	2

MODELLING PROCEDURE

At the surface, corresponds to the low magnetic lineament MFM2300G. Modelled to a depth of 1000 m using the dip estimated by connecting lineament MFM2308G with the borehole intersection 903 m to base of borehole (942 m) in KFM08D (DZ12). Deformation zone plane placed at fixed point 926 m in KFM08D. Borehole interval 924-929 m also corresponds to a prominent low amplitude section in the radar data.

NNE	ZFMNNE2300	Version number	5	Total object CL	15



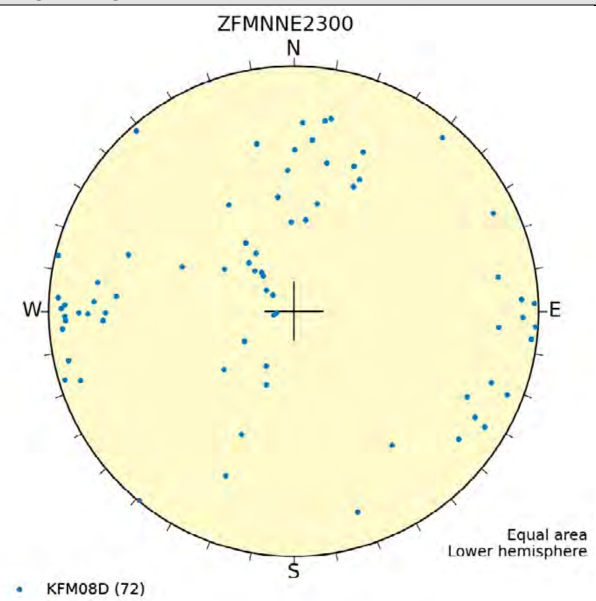
OBJECT CONFIDENCE ESTIMATE

Category	Object CL	Comment
INTERPRETATION		
Data source	2	MFM2300G, KFM08D
Results of interpretation	3	High confidence observation in KFM08D.
INFORMATION DENSITY		
Number of observation points	2	2
Distribution of observation points	1	Single observation point at depth and a surface lineament.
INTERPOLATION		
Geometry	1	Geometry supported by a lineament and a single intercept.
Geological indicators	1	Single observation point at depth. Zone modelled mainly based on surface geophysical data.
EXTRAPOLATION		
Dip direction	2	Extrapolation in dip direction supported by subsurface obs. point. Strike length of the modelled zone < 2000 m.
Strike direction	3	Conceptual understanding of the site and that the entire modelled zone is supported by the lineament.

FRACTURE CHARACTER

Orientation: (strike/dip right-hand-rule)	--
Frequency:	Boreholes: KFM08D

FRACTURE TYPE	TERZAGHI-WEIGHED P10
Open and partly open	5.1 m-1
Sealed	11.2 m-1
Sealed network	8.2 % of DZ intercept
Crush	0.4 % of DZ intercept



RQD:	min:78, max:100, mean:94

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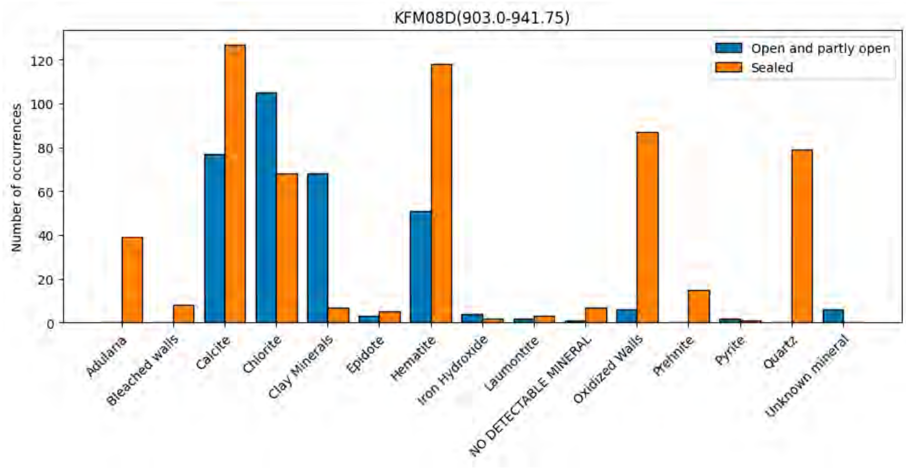
<tr><td>Fracture fill mineralogy:</td><td colspan="5">
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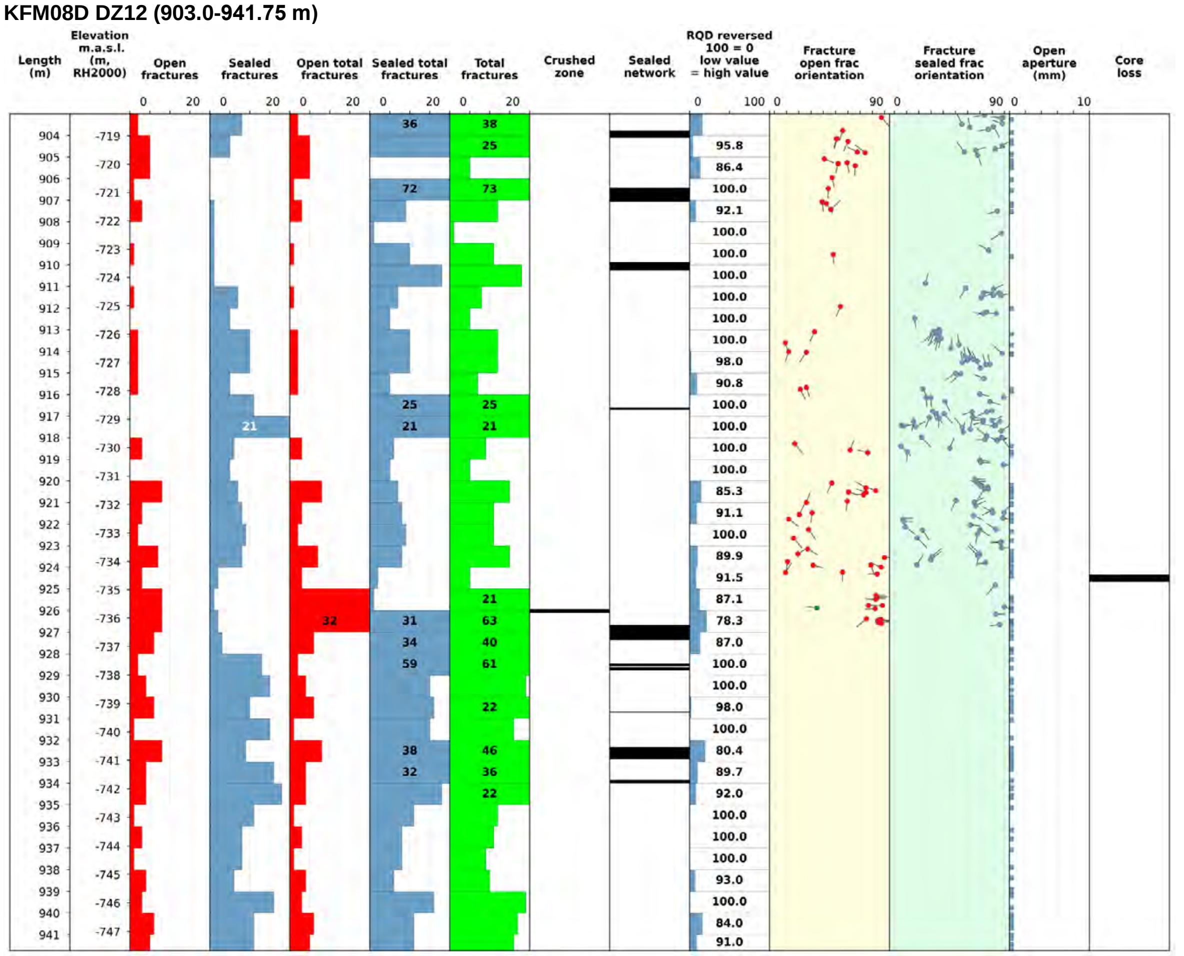
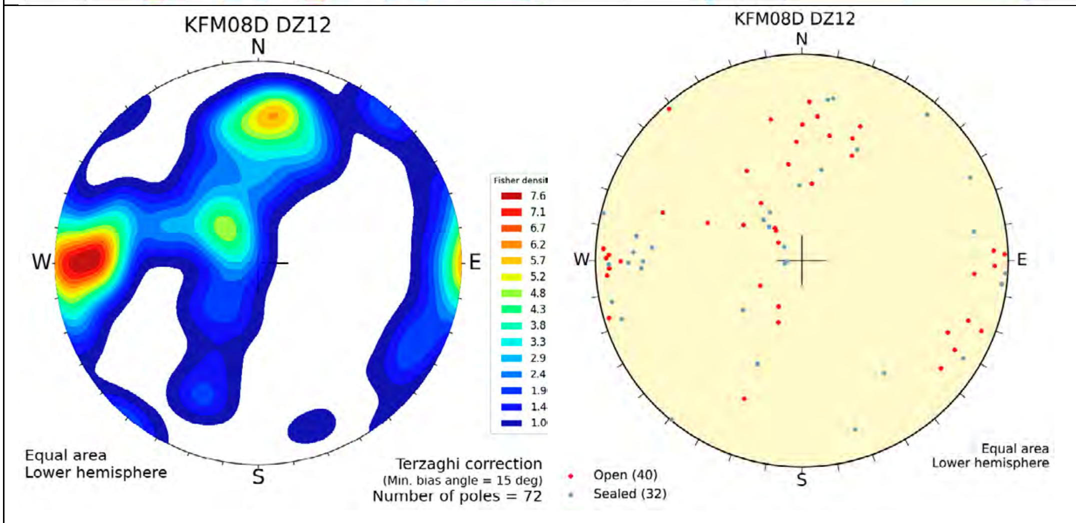
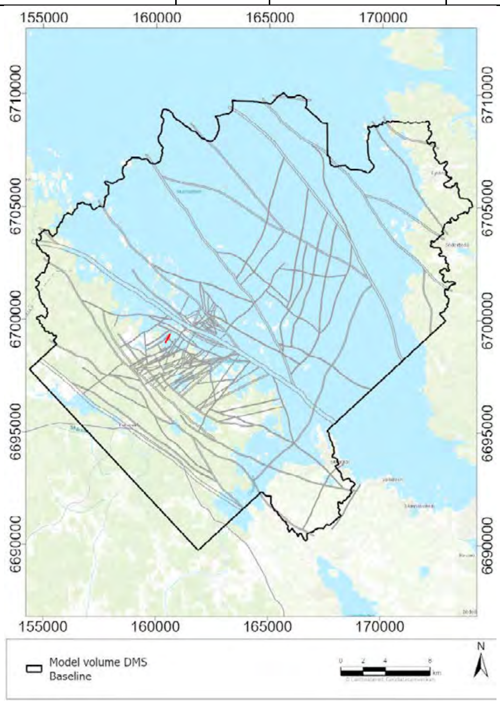
NNE	ZFMNNE2300	Version number	5	Total object CL	15
INDIVIDUAL INTERCEPTS					

KFM08D DZ12 (903.0-941.75 m)





NNE	ZFMNNE2312		Version number	6	Total object CL	18



GEOLOGICAL CHARACTER		Property CL
Deformation style:	Brittle	3
Deformation description:	No data available.	
Alteration:		3
- First order:	Oxidation	
- Second order:	Quartz dissolution	
- Third order:	Not observed	
Fracture orientation and type:	Steeply dipping fractures that strike SSW and gently dipping fractures form prominent sets. Steeply dipping fractures that strike NW are also present. Fractures in HFM38, which has a different azimuth and plunge, show a similar orientation pattern. Sealed fractures dominates. Quantitative estimate and span include sealed fracture networks.	2
Fracture comment:	No data available.	
Fracture fill mineralogy:	Calcite, chlorite, hematite/adularia, quartz, epidote.	

OBJECT GEOMETRY	
Strike/dip:	208°/87°
Length:	435 m
Mean thickness:	19 m (2 - 20 m)
Max depth:	-500 m
Geometrical constraints:	Topo 40m grid Max error 20m, ZFMENE1061B, ZFMENE1061A, 1 Surface Planar Cut(s), 1 UNIVERSE Planar Cut(s).

BASIS FOR MODELLING

Zone based on surface lineaments and borehole observations.

Outcrops:	-

Boreholes:

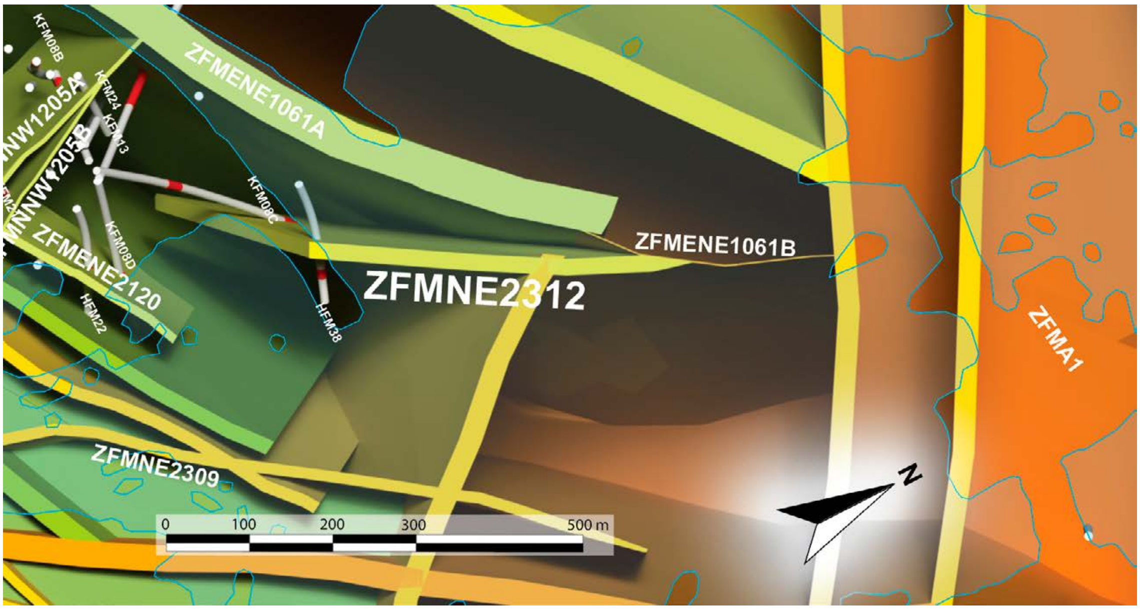
Borehole	PDZ	Target intercept		Geometric intercept		Comment
		Sec_up [m]	Sec_low [m]	Sec_up [m]	Sec_low [m]	
HFM38	DZ1	149.00	164.00	104.82	130.49	
KFM08C	DZ2	419.00	542.00	423.69	540.44	

Tunnels:	-	
Lineament and/or seismic indications:	MFM2312G.	2

MODELLING PROCEDURE

At the surface, corresponds to the low magnetic lineament MFM2312G. Modelled using the dip estimated by connecting lineament MFM2312G with the borehole intersections 419-542 m in KFM08C (DZ2) and 149-164 m in HFM38 (DZ1). Truncated against ZFMENE1061A and ZFMENE1061B. Deformation zone plane placed at fixed points 518 m in KFM08C and 158 m in HFM38. Decreased radar penetration also along the borehole interval 518-535 m in KFM08C. Inferred to be a minor zone.

NNE	ZFMNNE2312	Version number	6	Total object CL	18



OBJECT CONFIDENCE ESTIMATE

Category	Object CL	Comment
INTERPRETATION		
Data source	2	MFM2312G, HFM38, KFM08C
Results of interpretation	3	High confidence observation in KFM08C.
INFORMATION DENSITY		
Number of observation points	2	3
Distribution of observation points	2	Two subsurface obs. point can be considered as a cluster and the surface lineament as an outlier.
INTERPOLATION		
Geometry	2	The zone is bound by ZFMENE1061A and ZFMENE1061B but it has a blind end in SW/SSW direction.
Geological indicators	2	Some discrepancies in the geological data.
EXTRAPOLATION		
Dip direction	2	Extrapolation in dip direction supported by subsurface obs. point. Strike length of the modelled zone < 2000 m.
Strike direction	3	Conceptual understanding of the site and that the entire modelled zone is supported by the lineament.

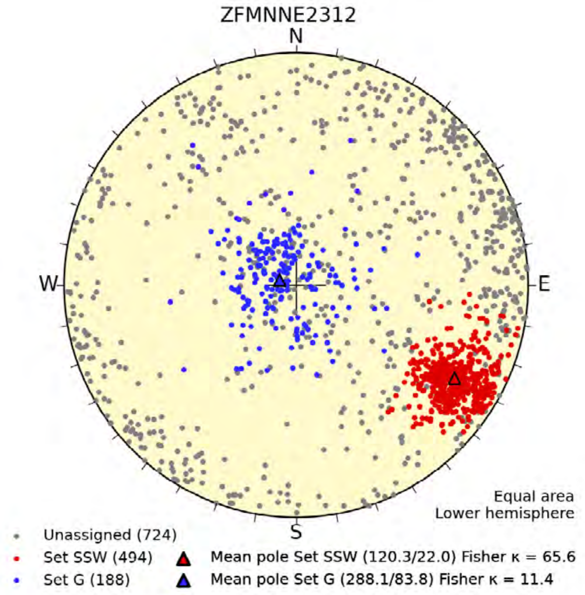
FRACTURE CHARACTER

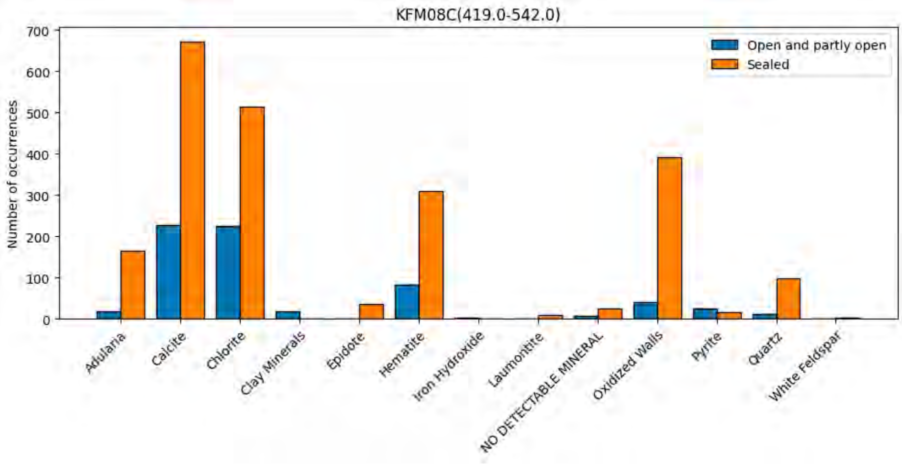
Orientation: (strike/dip right-hand-rule): Set SSW: 210.3°/68.0°; Set G: 18.1°/6.2°

Frequency: Boreholes: KFM08C

FRACTURE TYPE	TERZAGHI-WEIGHED P10
Open and partly open	4.1 m-1
Sealed	17.5 m-1
Sealed network	1.3 % of DZ intercept
Crush	0.0 % of DZ intercept

RQD: min:54, max:100, mean:97

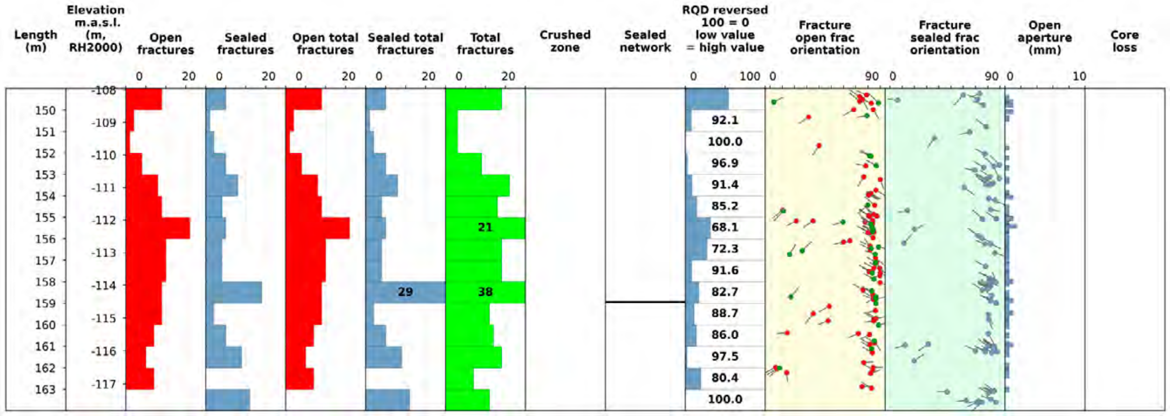


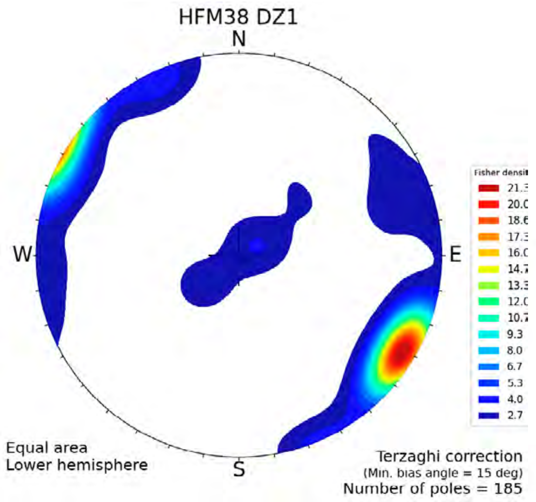
NNE	ZFMNNE2312	Version number	6	Total object CL	18
Fracture fill mineralogy:					

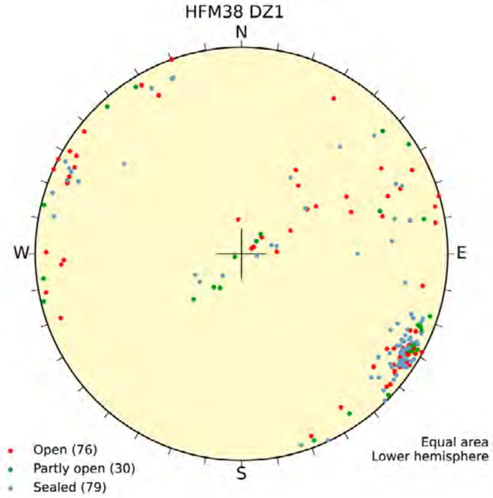
NNE	ZFMNNE2312	Version number	6	Total object CL	18

INDIVIDUAL INTERCEPTS

HFM38 DZ1 (149.0-164.0 m)

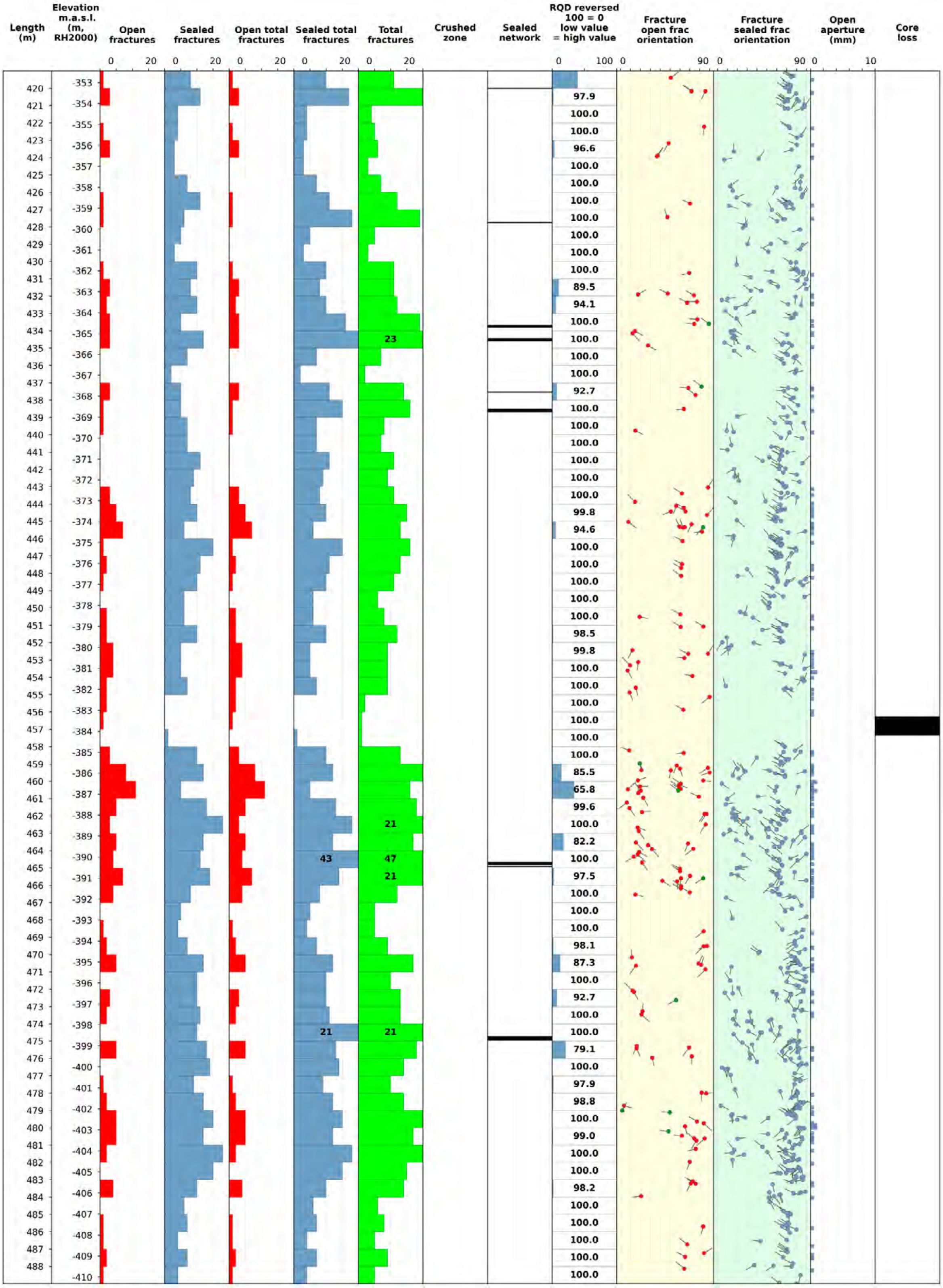




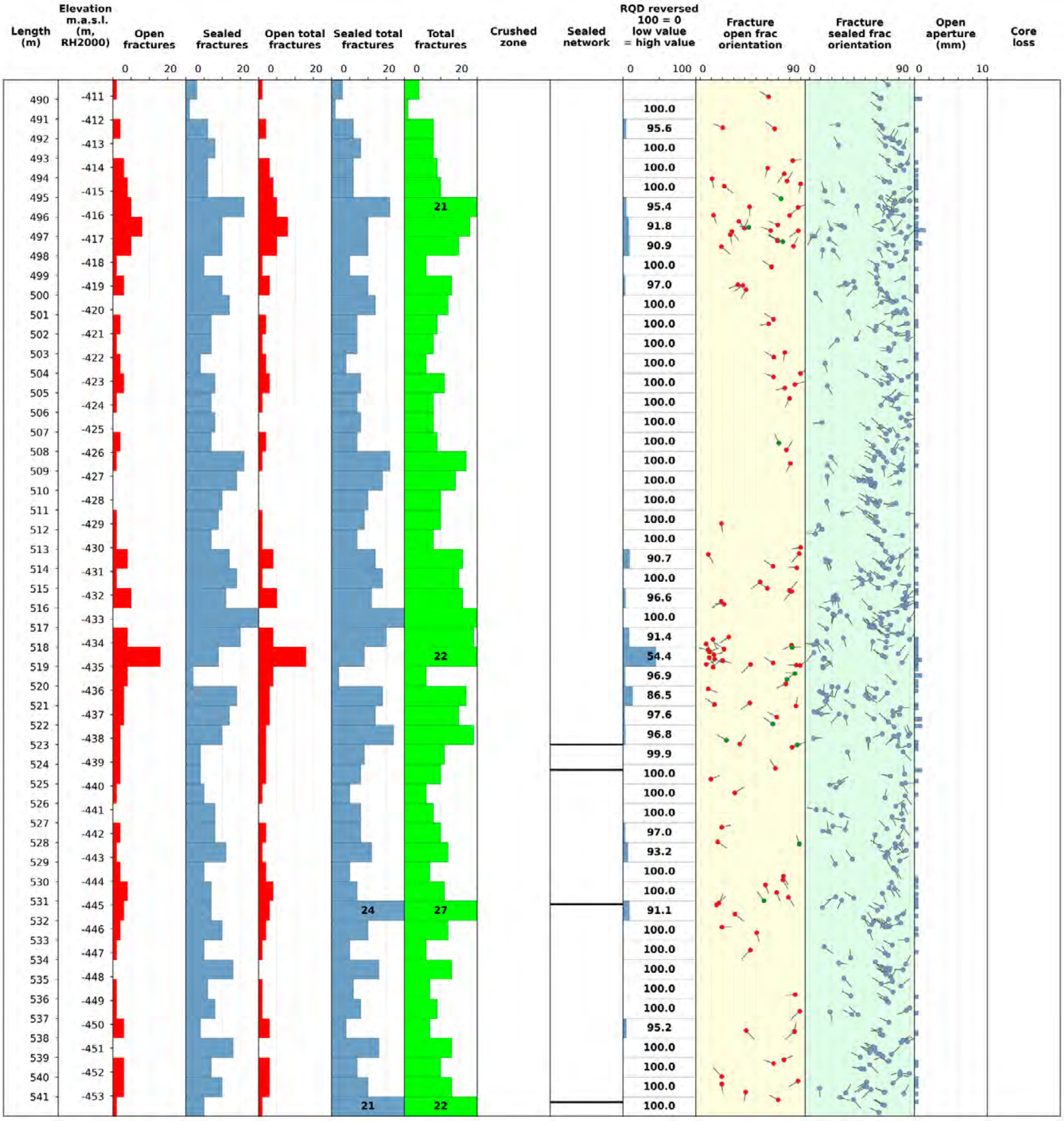


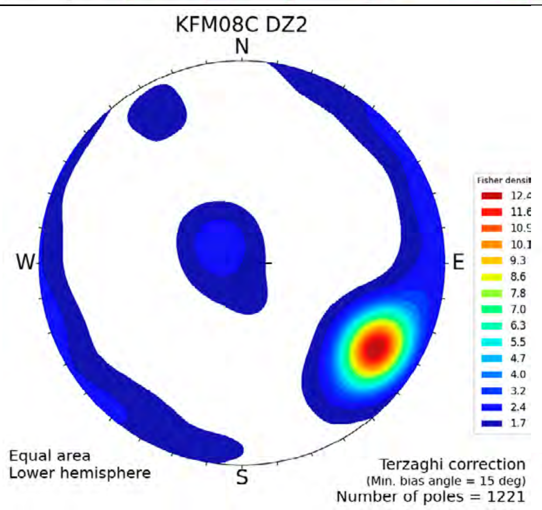
NNE	ZFMNNE2312	Version number	6	Total object CL	18

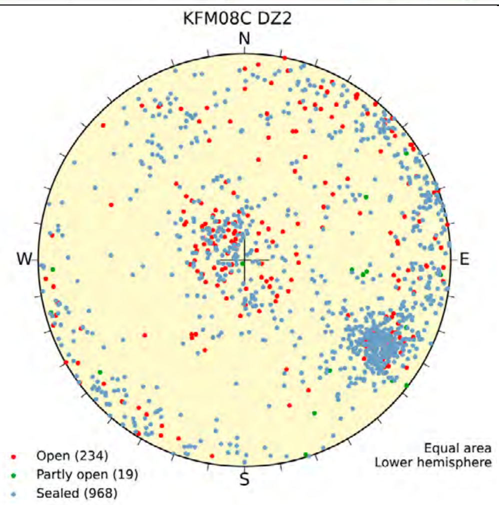
KFM08C DZ2 (419.0-542.0 m)



NNE	ZFMNNE2312	Version number	6	Total object CL	18

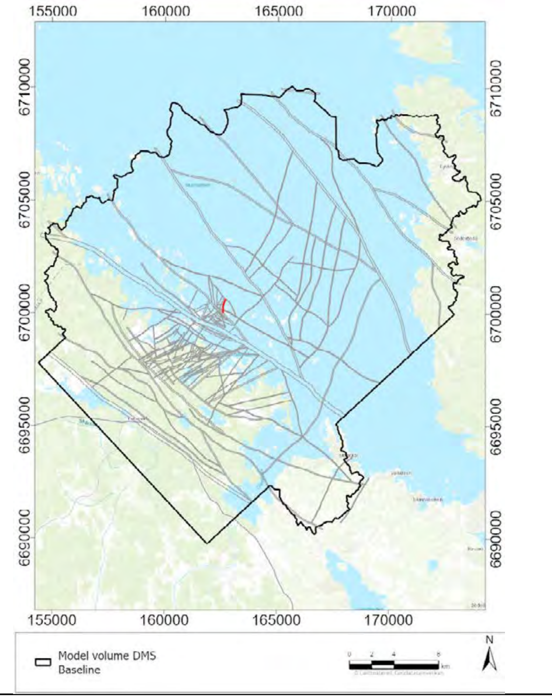






NNE	ZFMNNE3264	Version number	9	Total object CL	10

GEOLOGICAL CHARACTER		Property CL
Deformation style:	Brittle	2
Deformation description:	No data available.	
Alteration:		
- First order:	Not observed	
- Second order:	Not observed	
- Third order:	Not observed	
Fracture orientation and type:	No data available.	
Fracture comment:	No data available.	
Fracture fill mineralogy:	No data available.	



OBJECT GEOMETRY	
Strike/dip:	10°/90°
Length:	678 m
Mean thickness:	10 m (2 - 36 m)
Max depth:	-680 m
Geometrical constraints:	ZFMNW0805A, Topo 40m grid Max error 20m, ZFMNW0997, 1 Surface Planar Cut(s).

BASIS FOR MODELLING

Zone based on surface lineaments.

Outcrops:	-	
Boreholes: -		
Tunnels:	-	
Lineament and/or seismic indications:	MSFR08001.	2

MODELLING PROCEDURE

The position of the zone at the ground surface is based on the magnetic lineament MSFR08001 in SFR model version 1.0, itself an update of lineament MFM3264G in Forsmark stage 2.3 (Isaksson et al. 2007). The stage 2.3 number in the zone name has been maintained for traceability of the zone between different versions of lineament interpretation. Forward modelling of magnetic data along profile 36 (see Appendix 6) weakly supports the inferred vertical dip of the inferred zone, while profile 35 (see Appendix 6, Cutis et al. 2011) gives a weak indication of a subvertical dip towards the west. The modelled zone thickness is a default value.

NNE	ZFMNNE3264	Version number	9	Total object CL	10

OBJECT CONFIDENCE ESTIMATE

Category	Object CL	Comment
INTERPRETATION		
Data source	1	MFM3264G
Results of interpretation	2	Medium confidence in lineament MFM3264G.
INFORMATION DENSITY		
Number of observation points	1	1
Distribution of observation points	1	Single observation point in the form of a lineament.
INTERPOLATION		
Geometry	1	Geometry supported by surface geophysical data.
Geological indicators	1	Indirect support by geophysical data.
EXTRAPOLATION		
Dip direction	1	No subsurface obs. point, supported only by surface data. High uncertainty in dip-direction. Strike length of the modelled zone < 2000 m.
Strike direction	2	Supported by geological concept and partly by surface lineament.

FRACTURE CHARACTER

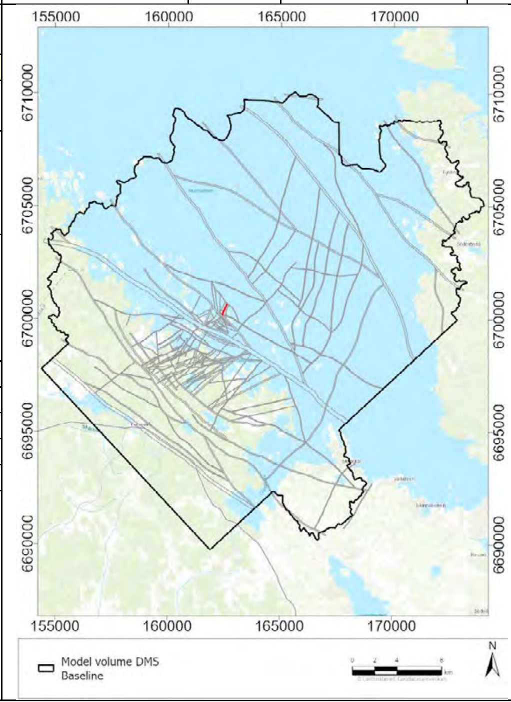
No data available

INDIVIDUAL INTERCEPTS

No data available

NNE	ZFMNNE3265	Version number	9	Total object CL	11

GEOLOGICAL CHARACTER		Property CL
Deformation style:	Brittle	2
Deformation description:	No data available.	
Alteration:		
- First order:	Not observed	
- Second order:	Not observed	
- Third order:	Not observed	
Fracture orientation and type:	No data available.	
Fracture comment:	No data available.	
Fracture fill mineralogy:	No data available.	



OBJECT GEOMETRY	
Strike/dip:	22°/90°
Length:	608 m
Mean thickness:	10 m (2 - 36 m)
Max depth:	-610 m
Geometrical constraints:	ZFMNW0805A, Topo 40m grid Max error 20m, ZFMNW0997, 1 Surface Planar Cut(s).

BASIS FOR MODELLING		
Zone based on surface lineaments.		
Outcrops:	-	
Boreholes: -		
Tunnels:	-	
Lineament and/or seismic indications:	MFM3265G.	2

MODELLING PROCEDURE

The position of the zone at the ground surface is based on the magnetic lineament MFM3265G Isaksson et al. (2007), itself essentially the same as a linking of lineaments MSFR08002 and MSFR08003 in the SFR model version 1.0 interpretation. The forward modelling of magnetic data along profiles 9, 35 and 36 (see Appendix 6, Curtis et al. 2011) support the inferred vertical dip of the zone. The modelled zone thickness is a default value.

NNE	ZFMNNE3265	Version number	9	Total object CL	11

OBJECT CONFIDENCE ESTIMATE

Category	Object CL	Comment
INTERPRETATION		
Data source	1	MFM3265G
Results of interpretation	2	Medium confidence in lineament MFM3265G.
INFORMATION DENSITY		
Number of observation points	1	1
Distribution of observation points	1	Single observation point in the form of a lineament.
INTERPOLATION		
Geometry	1	Geometry supported by surface geophysical data.
Geological indicators	1	Indirect support by geophysical data.
EXTRAPOLATION		
Dip direction	1	No subsurface obs. point, supported only by surface data. High uncertainty in dip-direction. Strike length of the modelled zone < 2000 m.
Strike direction	3	Conceptual understanding of the site and that the entire modelled zone is supported by the lineament.

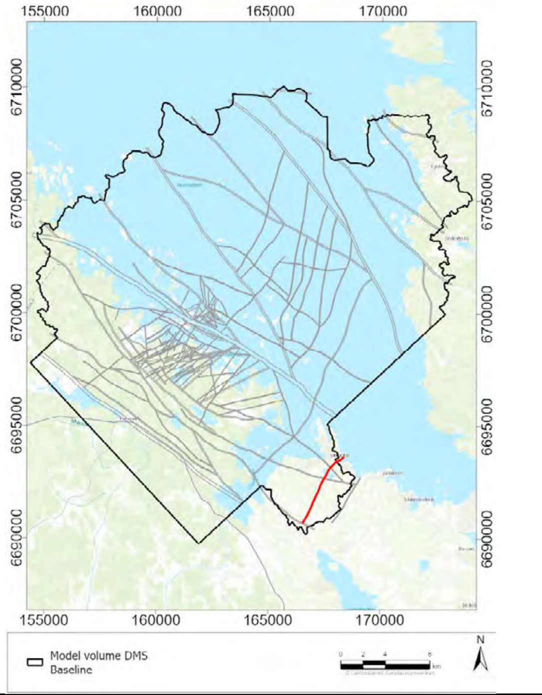
FRACTURE CHARACTER

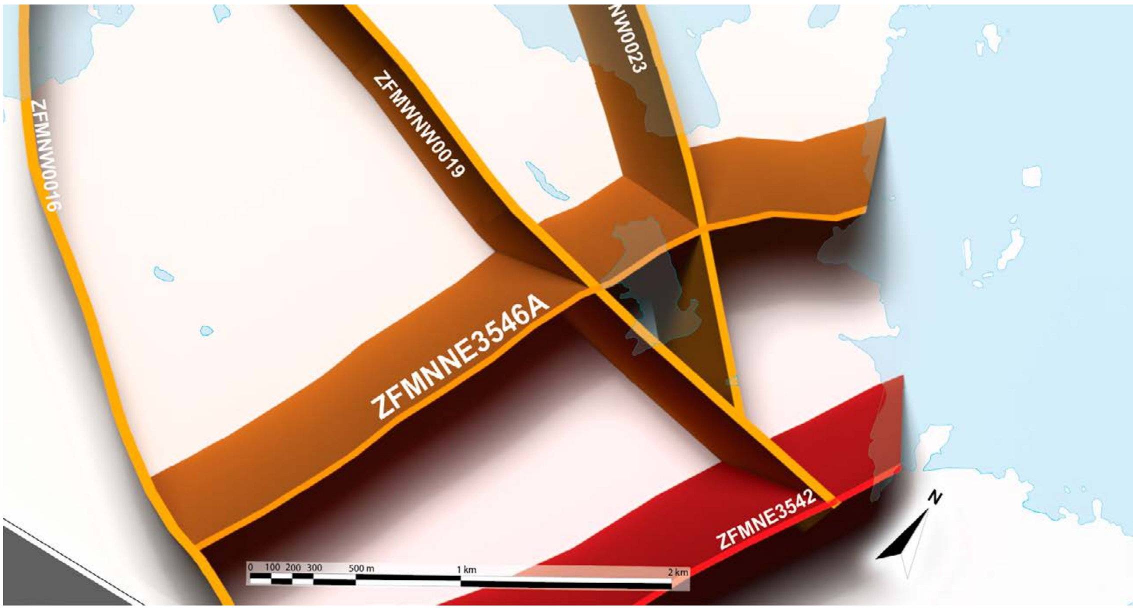
No data available

INDIVIDUAL INTERCEPTS

No data available

NNE	ZFMNNE3546A		Version number	5	Total object CL	11
GEOLOGICAL CHARACTER		**Property CL**				
Deformation style:	No data available					
Deformation description:	No data available. Zone based on lineament maps in the catchment area.					
Alteration:						
- First order:	Not observed					
- Second order:	Not observed					
- Third order:	Not observed					
Fracture orientation and type:	No data available.					
Fracture comment:	No data available.					
Fracture fill mineralogy:	No data available.					
OBJECT GEOMETRY						
Strike/dip:	214°/80°					
Length:	4673 m					
Mean thickness:	30 m (15 - 64 m)					
Max depth:	-2100 m					
Geometrical constraints:	Topo 40m grid Max error 20m, ZFMNW0016, 1 Surface Planar Cut(s), 1 UNIVERSE Planar Cut(s).					
BASIS FOR MODELLING						
Zone based on surface lineaments.						
Outcrops:	-					
Boreholes: -						
Tunnels:	-					
Lineament and/or seismic indications:	MFM3546.					2
MODELLING PROCEDURE						
-						





NNE	ZFMNNE3546A	Version number	5	Total object CL	11

OBJECT CONFIDENCE ESTIMATE

Category	Object CL	Comment
INTERPRETATION		
Data source	1	MFM0806 merged
Results of interpretation	2	Medium confidence in lineament MFM0806.
INFORMATION DENSITY		
Number of observation points	1	1
Distribution of observation points	1	Single observation point in the form of a lineament.
INTERPOLATION		
Geometry	1	Geometry supported by surface geophysical data.
Geological indicators	1	Indirect support by geophysical data.
EXTRAPOLATION		
Dip direction	1	No subsurface obs. point, supported only by surface data. High uncertainty in dip-direction. Strike length of the modelled zone < 2000 m.
Strike direction	3	Conceptual understanding of the site and that the entire modelled zone is supported by the lineament.

FRACTURE CHARACTER

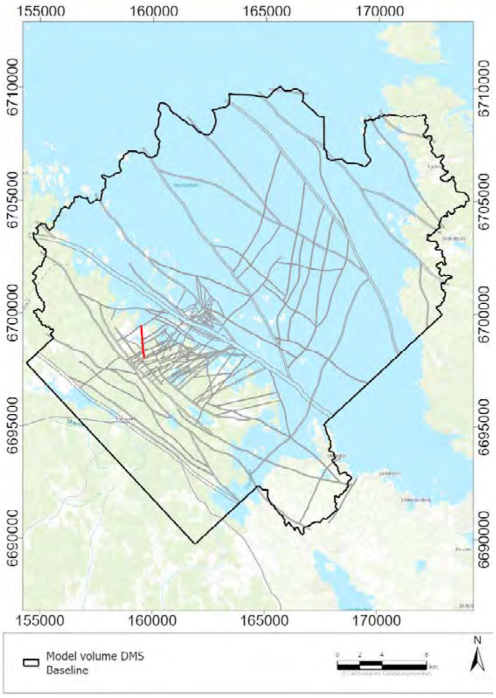
No data available

INDIVIDUAL INTERCEPTS

No data available

NNW	ZFMNNW0100	Version number	4	Total object CL	22

GEOLOGICAL CHARACTER		Property CL
Deformation style:	Brittle-Ductile	3
Deformation description:	Dominant set of fault-slip data consists of steeply dipping faults with NNW-SSE strike, strike-slip displacement, both sinistral and dextral. Subordinate sets include steeply dipping faults with ENE strike shows strike-slip displacement. Steeply dipping faults with NNW and ENE strike shows highly oblique-slip or dip-slip displacement. Gently dipping faults shows dip-slip or strike-slip displacement.	
Alteration:		3
- First order:	Oxidation	
- Second order:	Not observed	
- Third order:	Not observed	
Fracture orientation and type:	Variable orientation of fractures. Steeply dipping fractures that strike NNW and WSW are conspicuous. Gently dipping fractures are also present. Dominance of sealed fractures. Quantitative estimate and span include several sealed fracture networks and a crush zone.	2
Fracture comment:	No data available.	
Fracture fill mineralogy:	Chlorite, calcite, hematite/adularia, laumontite, quartz, pyrite, clay minerals.	



OBJECT GEOMETRY	
Strike/dip:	174°/88°
Length:	1423 m
Mean thickness:	22 m (3 - 50 m)
Max depth:	-1400 m
Geometrical constraints:	ZFMNE0810, ZFMENE2320, Topo 40m grid Max error 20m, 1 Surface Planar Cut(s).

BASIS FOR MODELLING

Zone based on surface lineaments and borehole observations.

Outcrops: -

Boreholes:

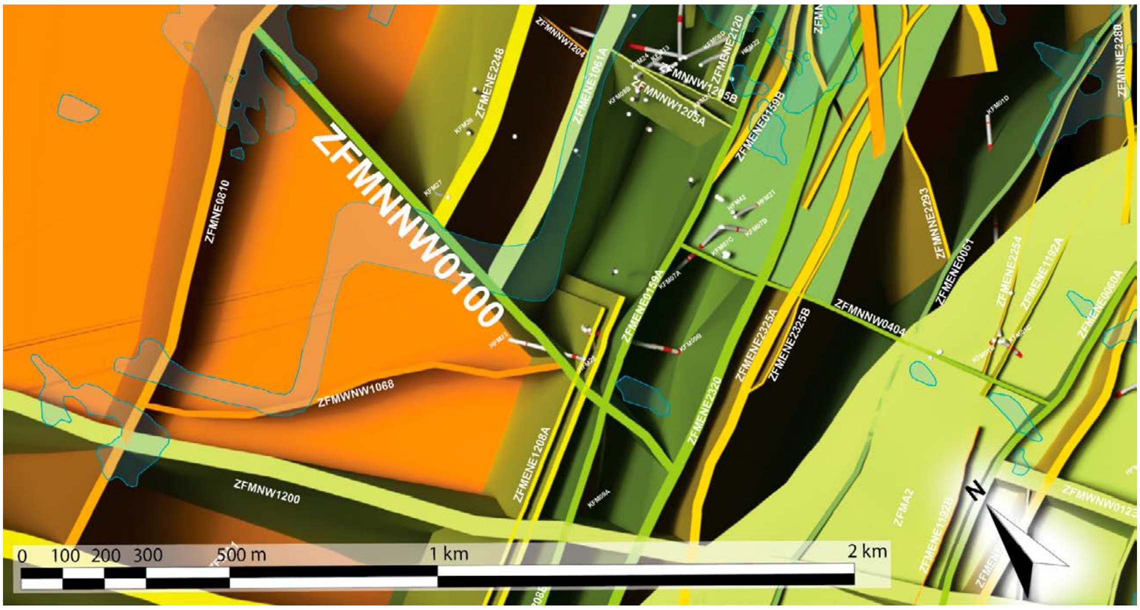
Borehole	PDZ	Target intercept		Geometric intercept		Comment
		Sec_up [m]	Sec_low [m]	Sec_up [m]	Sec_low [m]	
HFM23	DZ2	82.00	95.00	66.44	105.20	
KFM07A	DZ4	920.00	999.22	944.41	986.80	Divided into three separate zones at 803-840 m, 857-897 m and 920-999 m (cf. Table 3-2 in Stephens et al. 2007). Fractured rocks between these modelled zones inferred to be affected by DZ.
KFM09A	DZ3	217.00	280.00	217.28	280.20	

Tunnels:	-
Lineament and/or seismic indications:	MFM0100.

NNW	**ZFMNNW0100**	Version number	**4**	Total object CL	**22**

MODELLING PROCEDURE

At the surface, corresponds to the low magnetic lineament MFM0100 and low velocity seismic refraction anomalies (Isaksson and Keisu, 2005, RSLV01 in Figure 5-33 in SKB, 2005). Modelled to a depth of 1650 m using dip estimated by connecting lineament MFM0100 at the surface with the borehole intervals 920-999 m in KFM07A (part of DZ4) and 217-280 m in KFM09A (DZ3). Zone ZFMB8 also modelled to intersect borehole interval 920-999 m along part of DZ4 in KFM07A and zone ZFMENE0159A also modelled to intersect DZ3 in KFM09A. Deformation zone plane placed at fixed points 970 m in KFM07A and 244 m in KFM09A. Decreased radar penetration also along the borehole interval 960-972 m in KFM07A. Zone ZFMNNW0100 also intersects borehole interval 82-95 m in HFM23 (DZ2).



OBJECT CONFIDENCE ESTIMATE

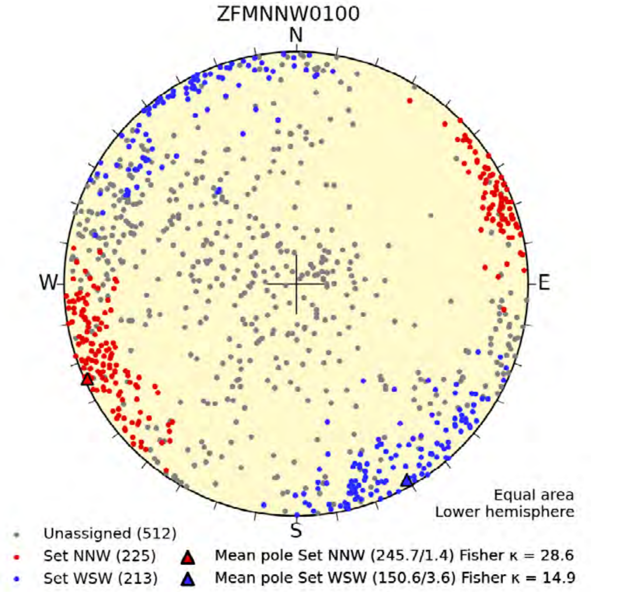
Category	Object CL	Comment
INTERPRETATION		
Data source	2	MFM0100, HFM23, KFM07A, KFM09A
Results of interpretation	3	High confidence observation in KFM07A and KFM09A.
INFORMATION DENSITY		
Number of observation points	3	4
Distribution of observation points	3	Even distribution of obs. points.
INTERPOLATION		
Geometry	3	Geometry supported by multiple subsurface obs. points.
Geological indicators	3	Interpolation supported by key geological parameters, foremost fracture orientation pattern.
EXTRAPOLATION		
Dip direction	2	Extrapolation in dip direction supported by subsurface obs. point. Strike length of the modelled zone < 2000 m.
Strike direction	3	Zone modelled length < 2000 m. Intersected in multiple boreholes. High confidence in this category based on conceptual understanding of the site. Trace length > 400 m. Truncated against high conf. Zone ZFMENE2320.

NNW	ZFMNNW0100	Version number	4	Total object CL	22

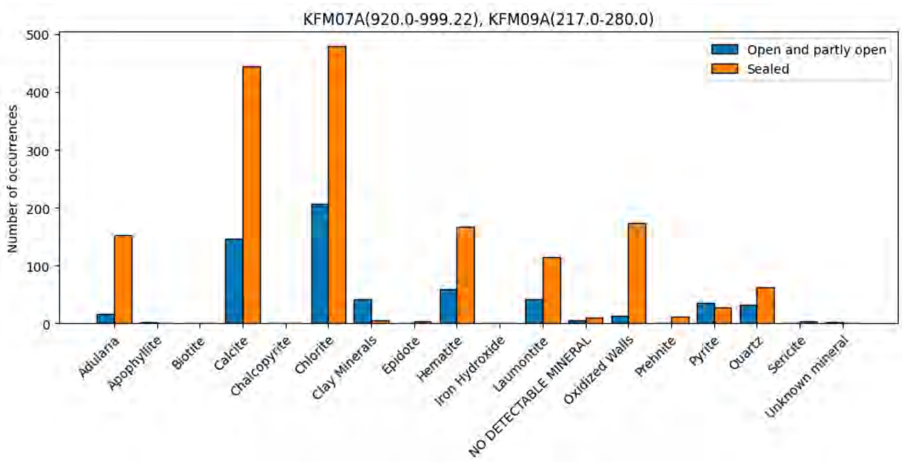
FRACTURE CHARACTER

Orientation: (strike/dip right-hand-rule)	Set NNW: 335.7°/88.6° Set WSW: 240.6°/86.4°
Frequency:	Boreholes: KFM07A, KFM09A

FRACTURE TYPE	TERZAGHI-WEIGHED P10
Open and partly open	4.0 m-1
Sealed	10.8 m-1
Sealed network	21.4 % of DZ intercept
Crush	0.7 % of DZ intercept



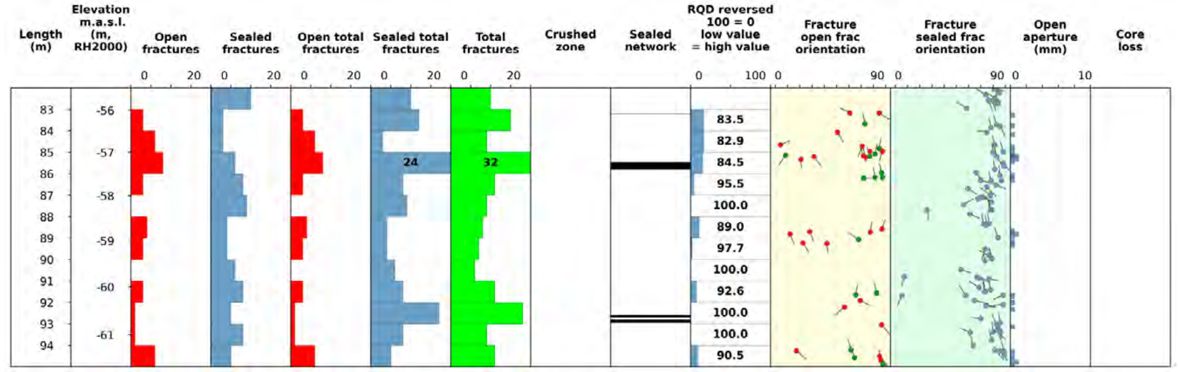
RQD:	min:45, max:100, mean:98
Fracture fill mineralogy:	



NNW	ZFMNNW0100	Version number	4	Total object CL	22

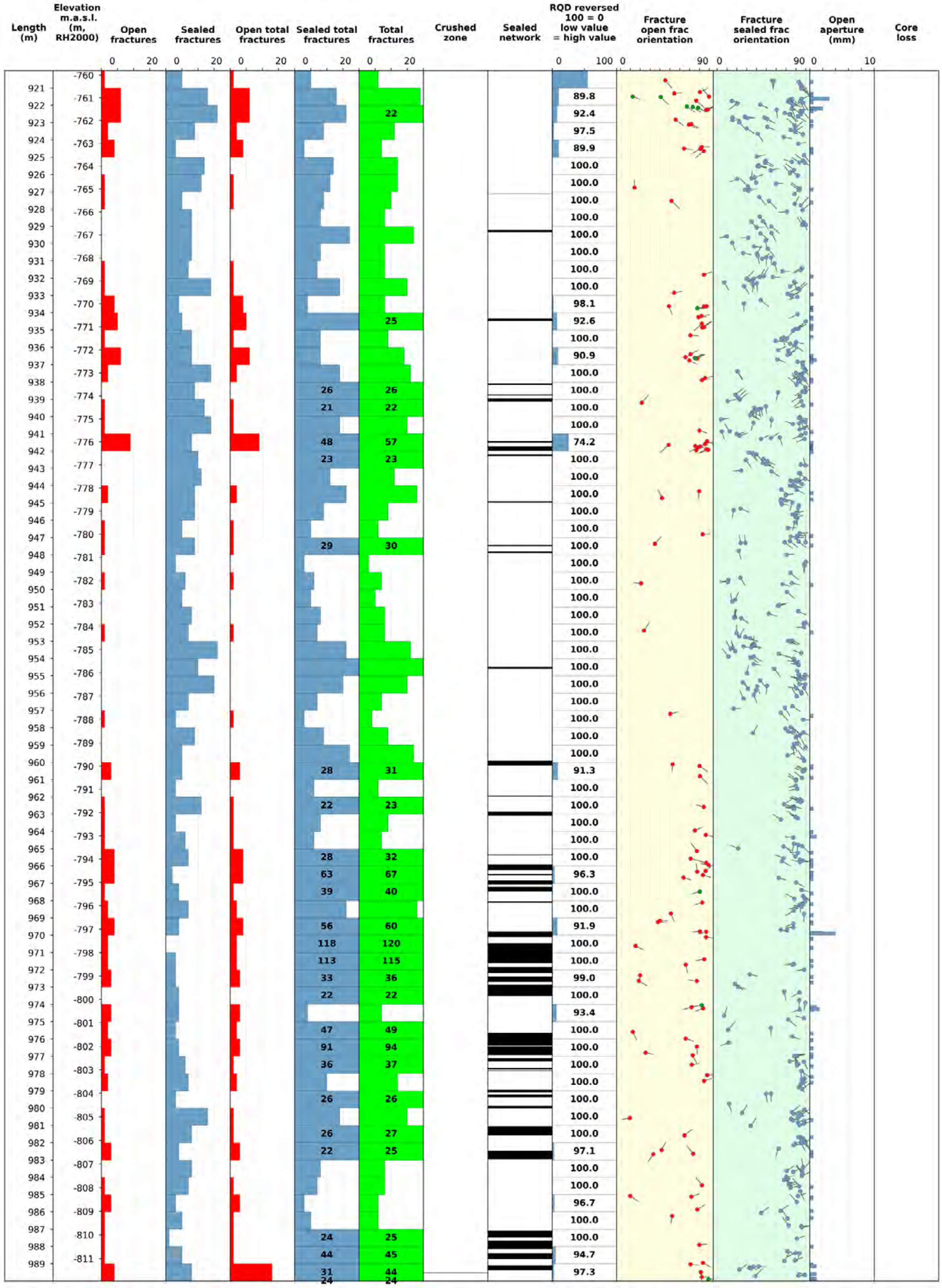
INDIVIDUAL INTERCEPTS

HFM23 DZ2 (82.0-95.0 m)

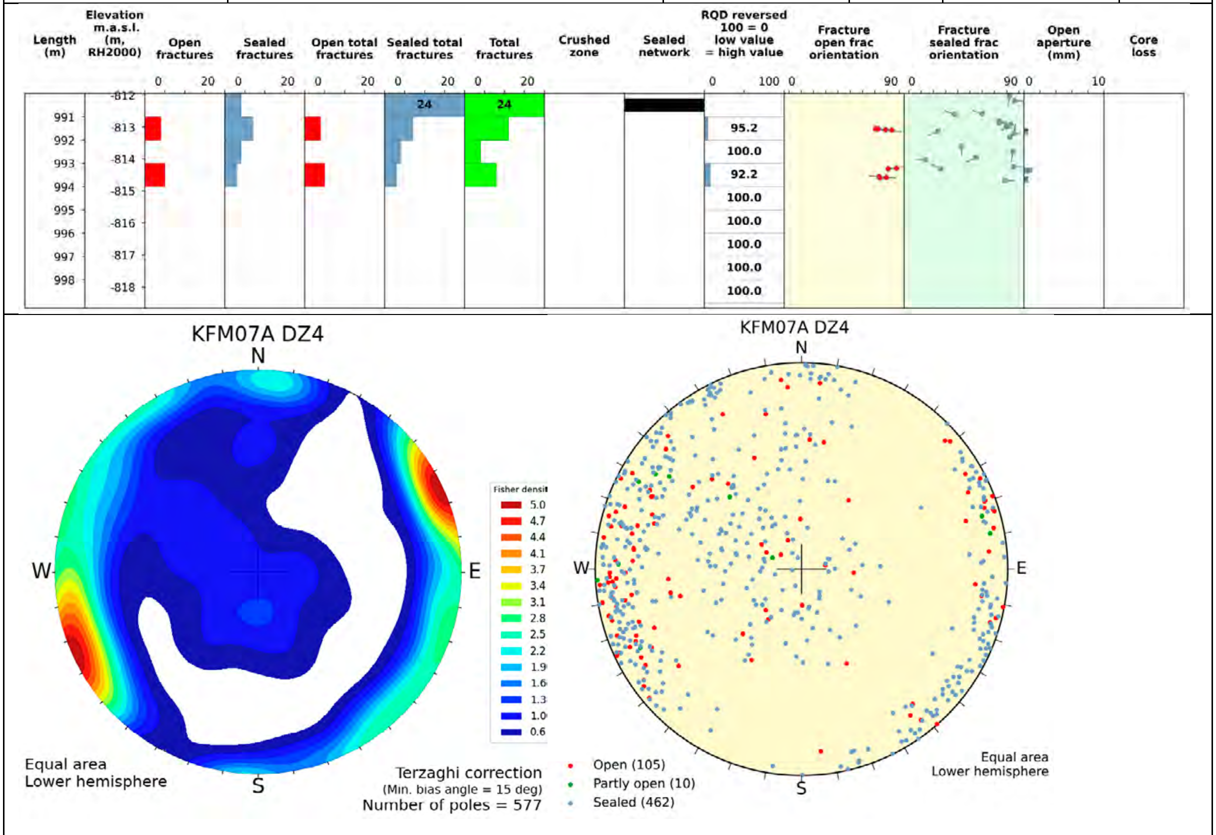


NNW	ZFMNNW0100	Version number	4	Total object CL	22

KFM07A DZ4 (920.0-999.22 m)

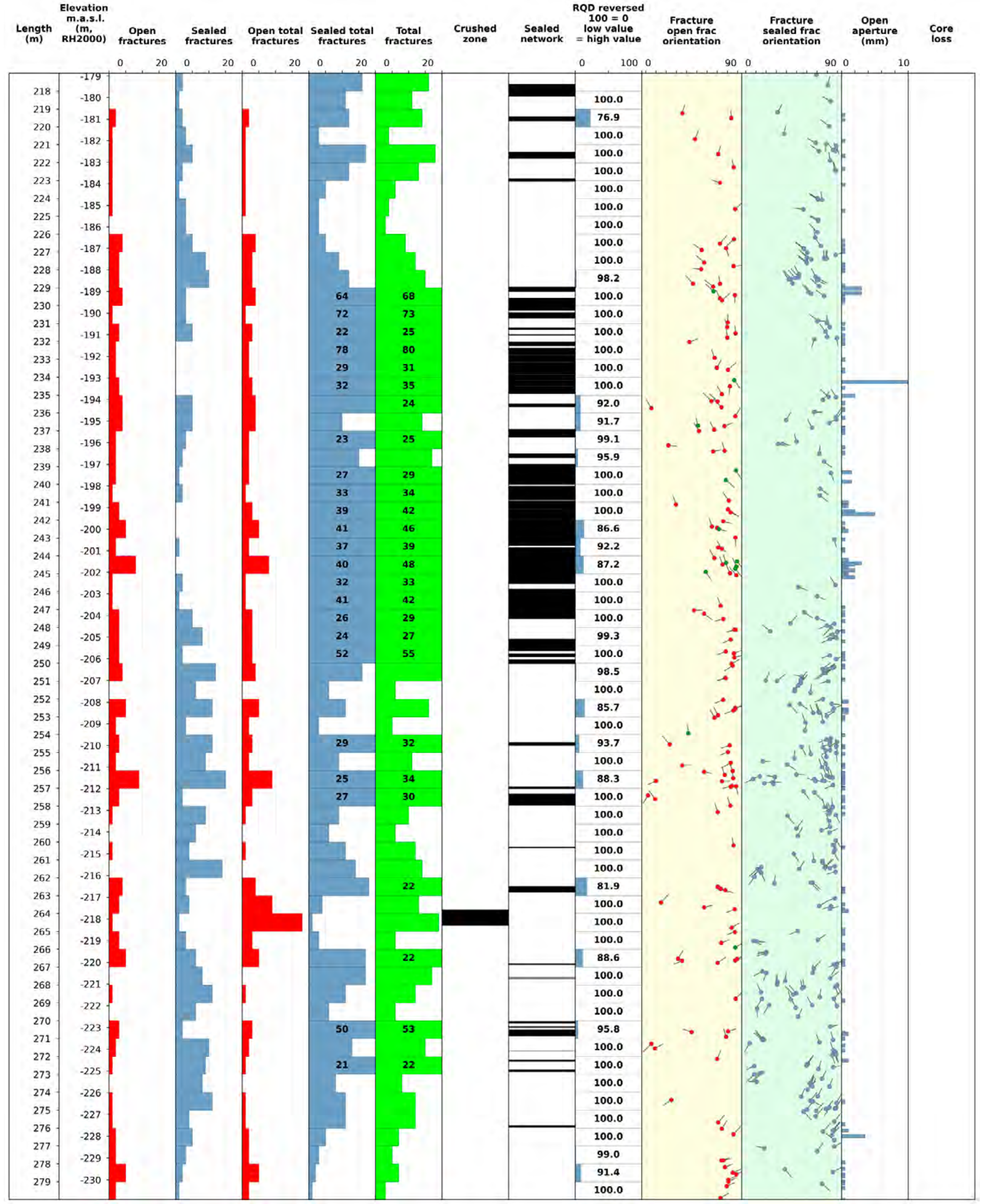


NNW	ZFMNNW0100	Version number	4	Total object CL	22

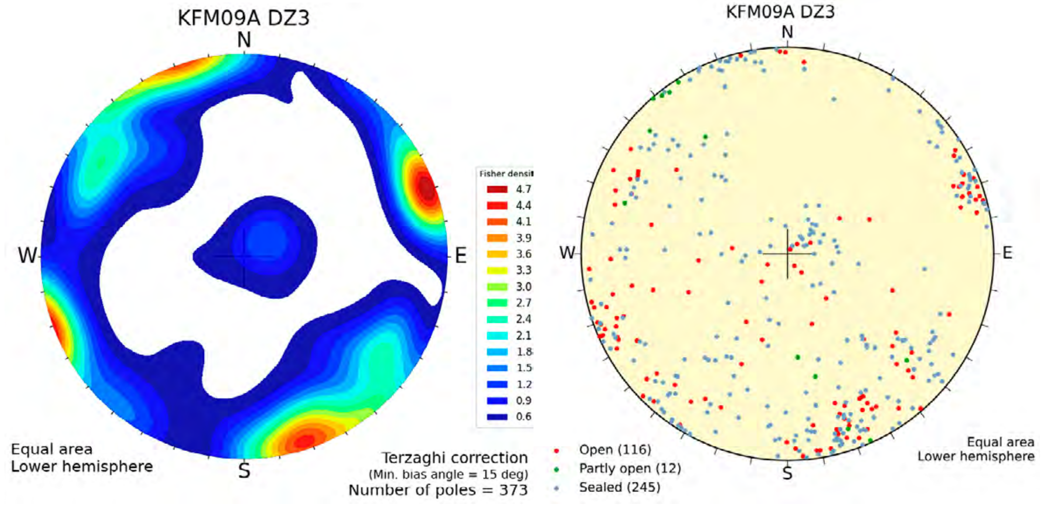


NNW	ZFMNNW0100	Version number	4	Total object CL	22

KFM09A DZ3 (217.0-280.0 m)

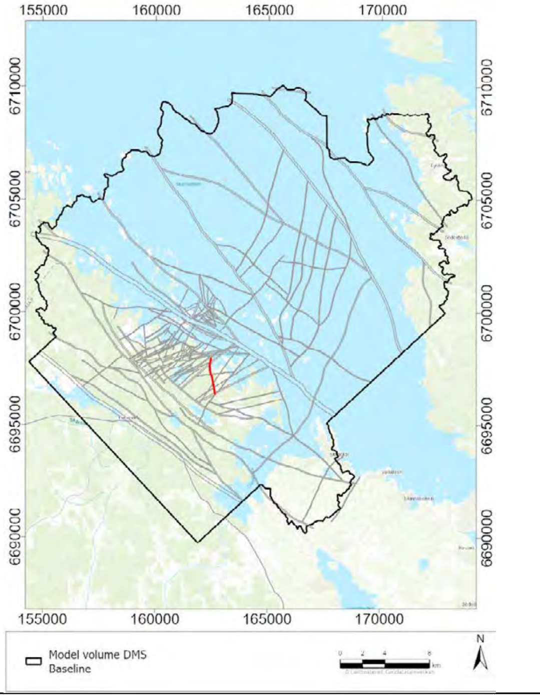


NNW	ZFMNNW0100	Version number	4	Total object CL	22



NNW	ZFMNNW0101	Version number	3	Total object CL	11

GEOLOGICAL CHARACTER		Property CL
Deformation style:	Brittle	1
Deformation description:	No data available.	
Alteration:		2
- First order:	Oxidation	
- Second order:	Not observed	
- Third order:	Not observed	
Fracture orientation and type:	No data available.	
Fracture comment:	No data available.	
Fracture fill mineralogy:	No data available.	
OBJECT GEOMETRY		
Strike/dip:	171°/90°	
Length:	1726 m	
Mean thickness:	20 m (3 - 50 m)	
Max depth:	-2100 m	
Geometrical constraints:	ZFMENE0062A, ZFMNE0065, Topo 40m grid Max error 20m.	



BASIS FOR MODELLING		
Zone based on surface lineaments.		
Outcrops:	-	
Boreholes: -		
Tunnels:	-	
Lineament and/or seismic indications:	MFM0101.	2

MODELLING PROCEDURE

At the surface, corresponds to the low magnetic lineament MFM0101. Modelled to a depth of 1750 m using an assumed dip of 90 degrees based on a comparison with high confidence, vertical and steeply dipping zones with NNW strike.

NNW	ZFMNNW0101	Version number	3	Total object CL	11

OBJECT CONFIDENCE ESTIMATE

Category	Object CL	Comment
INTERPRETATION		
Data source	1	MFM0101, MFM2469G
Results of interpretation	2	Medium confidence in lineament MFM0101.
INFORMATION DENSITY		
Number of observation points	1	2
Distribution of observation points	1	Single observation point in the form of a lineament.
INTERPOLATION		
Geometry	1	Geometry supported by surface geophysical data.
Geological indicators	1	Indirect support by geophysical data.
EXTRAPOLATION		
Dip direction	1	No subsurface obs. point, supported only by surface data. High uncertainty in dip-direction. Strike length of the modelled zone < 2000 m.
Strike direction	3	Conceptual understanding of the site and that the entire modelled zone is supported by the lineament.

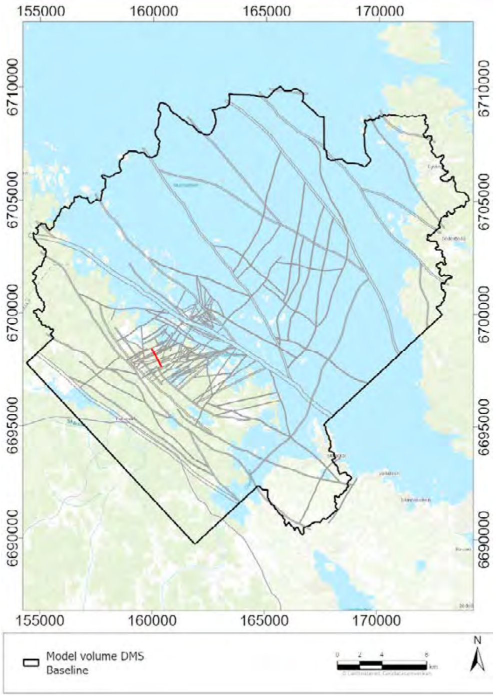
FRACTURE CHARACTER

No data available

INDIVIDUAL INTERCEPTS

No data available

NNW	ZFMNNW0404	Version number	4	Total object CL	22



GEOLOGICAL CHARACTER		Property CL
Deformation style:	Brittle	3
Deformation description:	Steeply dipping faults with NNW strike with chlorite, sometimes accompanied by epidote striae, shows sinistral strike-slip or dip slip with both normal and reverse displacement.	
Alteration:		3
- First order:	Oxidation	
- Second order:	Not observed	
- Third order:	Not observed	
Fracture orientation and type:	Fracture set with NNW strike and steep dip to the east is dominant. A subordinate fracture set that is sub horizontal and fractures with steeper, more variable orientation are also present. Dominance of sealed fractures. Quantitative estimate and span include sealed fracture networks and crush zones.	2
Fracture comment:	No data available.	
Fracture fill mineralogy:	Chlorite, calcite, laumontite, prehnite, quartz, hematite/adularia, epidote.	

OBJECT GEOMETRY	
Strike/dip:	152°/90°
Length:	946 m
Mean thickness:	10 m (2 - 36 m)
Max depth:	-970 m
Geometrical constraints:	ZFMENE0159A, ZFMENE0060A, Topo 40m grid Max error 20m, 1 Surface Planar Cut(s).

BASIS FOR MODELLING

Zone based on surface lineaments and borehole observations.

Outcrops:	-

Boreholes:

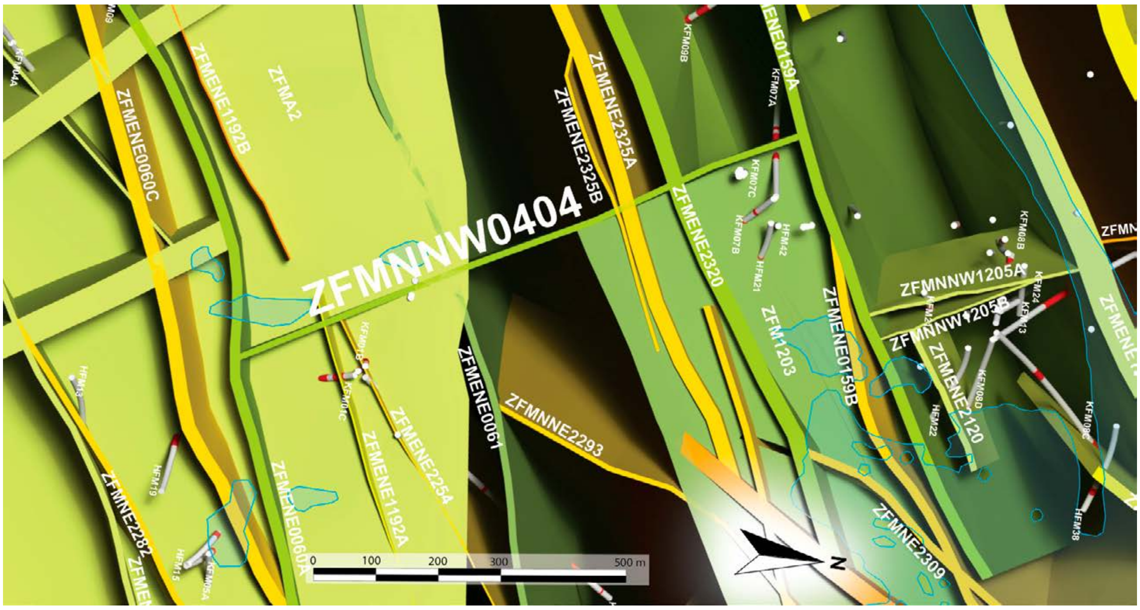
Borehole	PDZ	Target intercept		Geometric intercept		Comment
		Sec_up [m]	Sec_low [m]	Sec_up [m]	Sec_low [m]	
HFM27	DZ3	-	-	66.57	127.50	
KFM01B	DZ3	415.00	454.00	414.87	453.20	
KFM07A	DZ1	108.00	185.00	151.99	173.33	ZFM1203 also intersects DZ1. 183-185 m added (cf. Table 3-2 in Stephens et al. 2007).

Tunnels:	-	
Lineament and/or seismic indications:	MFM1196, 1196G.	2

MODELLING PROCEDURE

At the surface, corresponds to the low magnetic lineament MFM1196. Modelled down to 1000 m using dip estimated by connecting lineament MFM1196 at the surface with the borehole intersections 415-454 m (DZ3) in KFM01B and 108-185 m (DZ1) in KFM07A, with fixed points at 440 m in KFM01B and 165 m in KFM07A. Decreased radar penetration also along the borehole interval 150-170 m in KFM07A. The gently dipping zone ZFM1203 is also modelled to intersect KFM07A along DZ1. For this reason, there are difficulties to separate the influence of zones ZFMNNW0404 and ZFM1203 along DZ1 in KFM07A. Only the lower part of DZ1 in KFM07A is considered to belong to this zone.

NNW	ZFMNNW0404	Version number	4	Total object CL	22



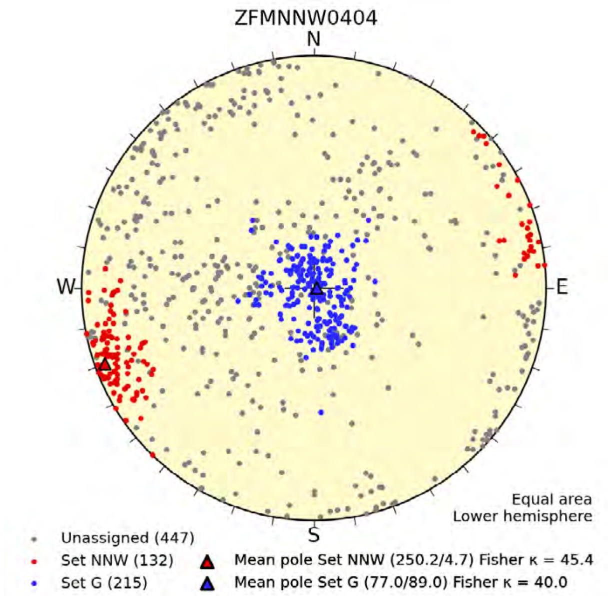
OBJECT CONFIDENCE ESTIMATE

Category	Object CL	Comment
INTERPRETATION		
Data source	2	MFM1196, HFM27, KFM01B, KFM07A
Results of interpretation	3	High confidence observation in KFM01B and KFM07A.
INFORMATION DENSITY		
Number of observation points	3	4
Distribution of observation points	3	Even distribution of obs. points.
INTERPOLATION		
Geometry	3	Geometry supported by SHI interpreted zones, one strong alternative.
Geological indicators	3	Interpolation supported by key geological parameters, foremost fracture orientation pattern.
EXTRAPOLATION		
Dip direction	2	Extrapolation in dip direction supported by subsurface obs. point. Strike length of the modelled zone < 2000 m.
Strike direction	3	Conceptual understanding of the site and that the entire modelled zone is supported by the lineament.

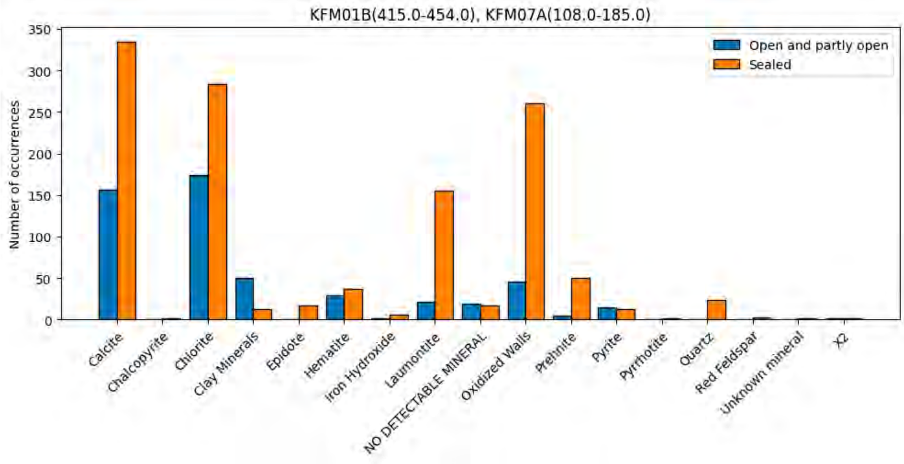
FRACTURE CHARACTER

Orientation: (strike/dip right-hand-rule)	Set NNW: 340.2°/85.3° Set G: 167.0°/1.0°
Frequency:	Boreholes: KFM07A, KFM01B

FRACTURE TYPE	TERZAGHI-WEIGHED P10
Open and partly open	2.6 m-1
Sealed	12.0 m-1
Sealed network	9.9 % of DZ intercept
Crush	0.7 % of DZ intercept

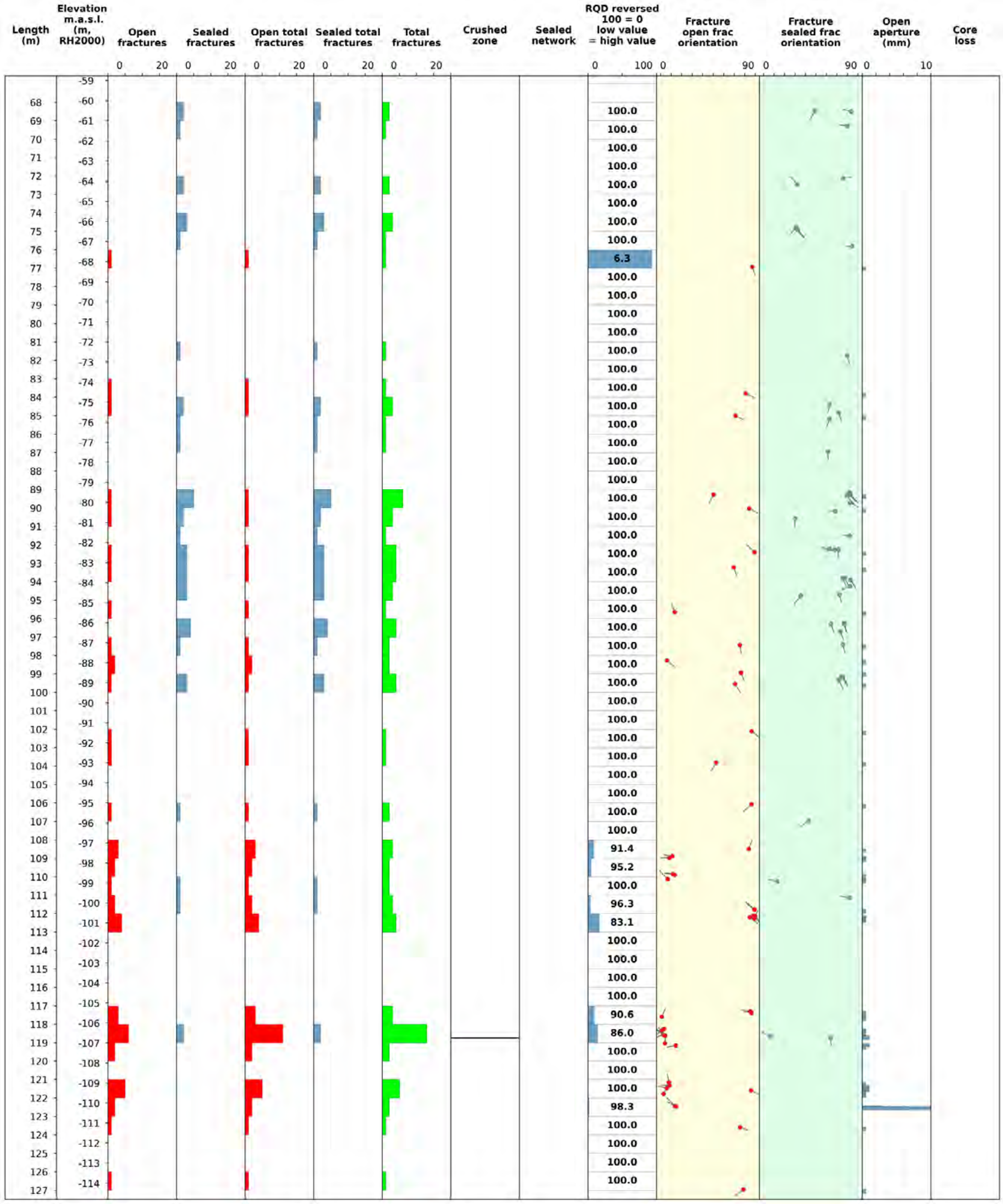


RQD:	min:62, max:100, mean:98

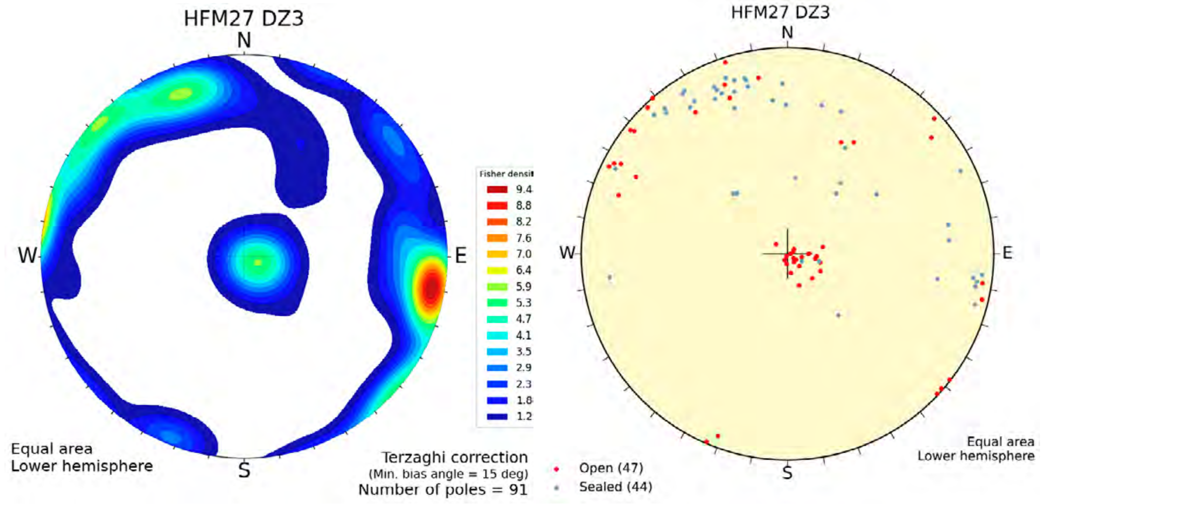
NNW	ZFMNNW0404	Version number	4	Total object CL	22
Fracture fill mineralogy:					

NNW	ZFMNNW0404	Version number	4	Total object CL	22
INDIVIDUAL INTERCEPTS					

HFM27 DZ3 (66.57-127.5 m)

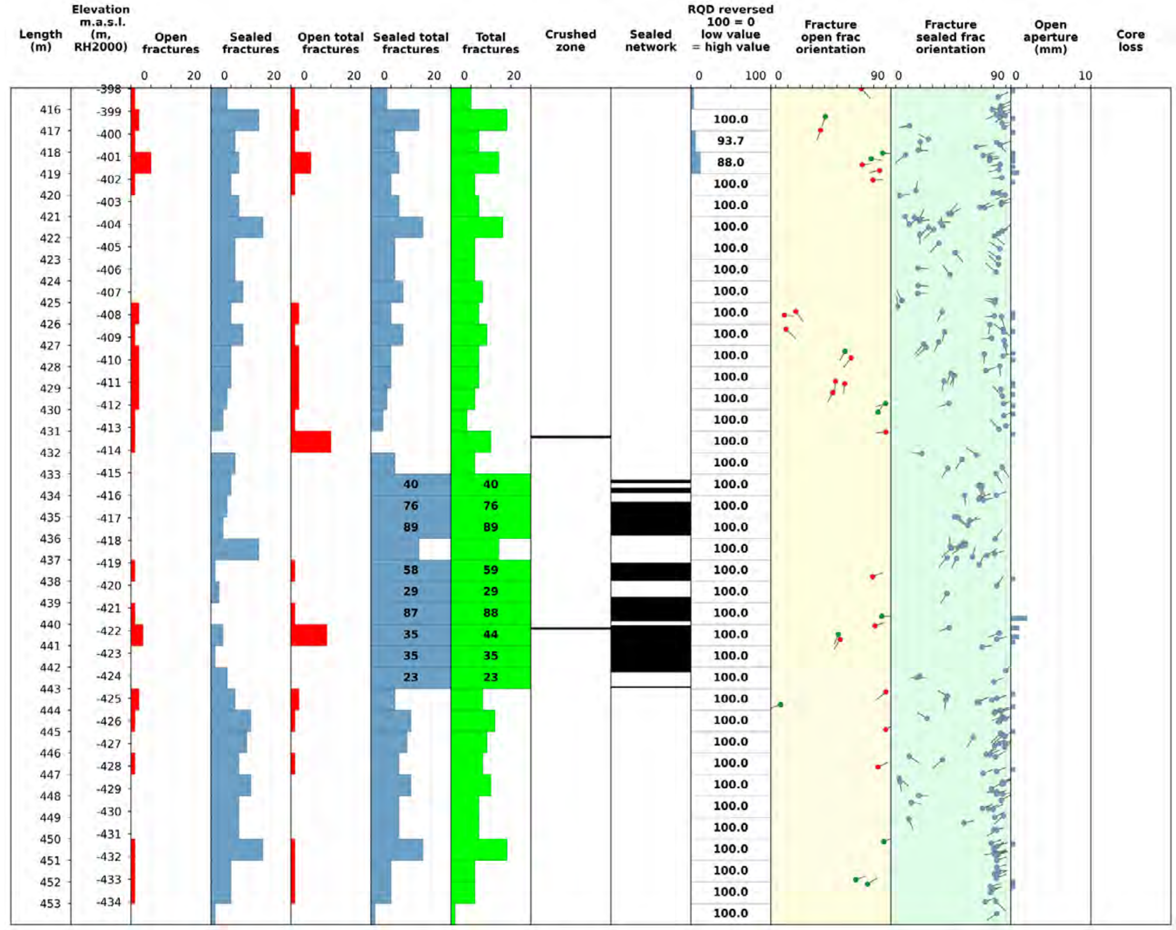


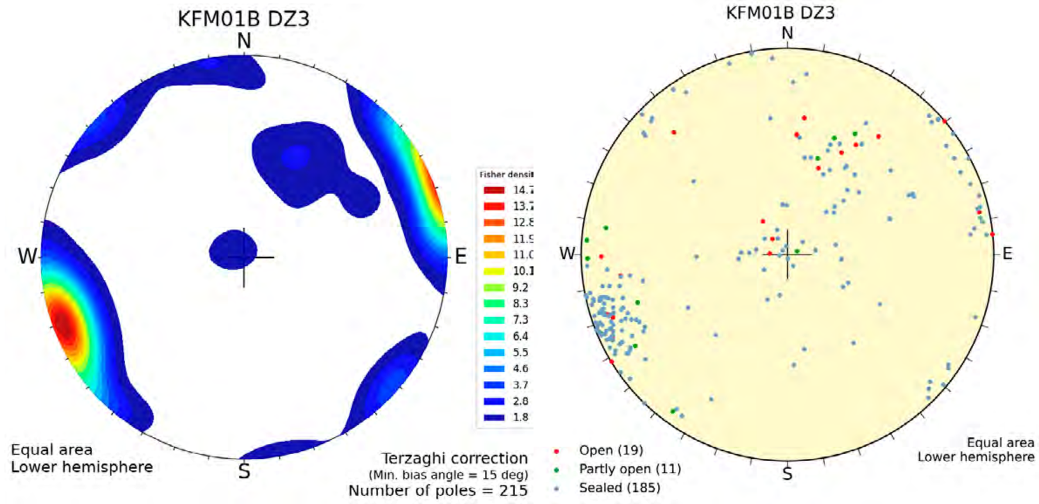
NNW	ZFMNNW0404	Version number	4	Total object CL	22



NNW	ZFMNNW0404	Version number	4	Total object CL	22

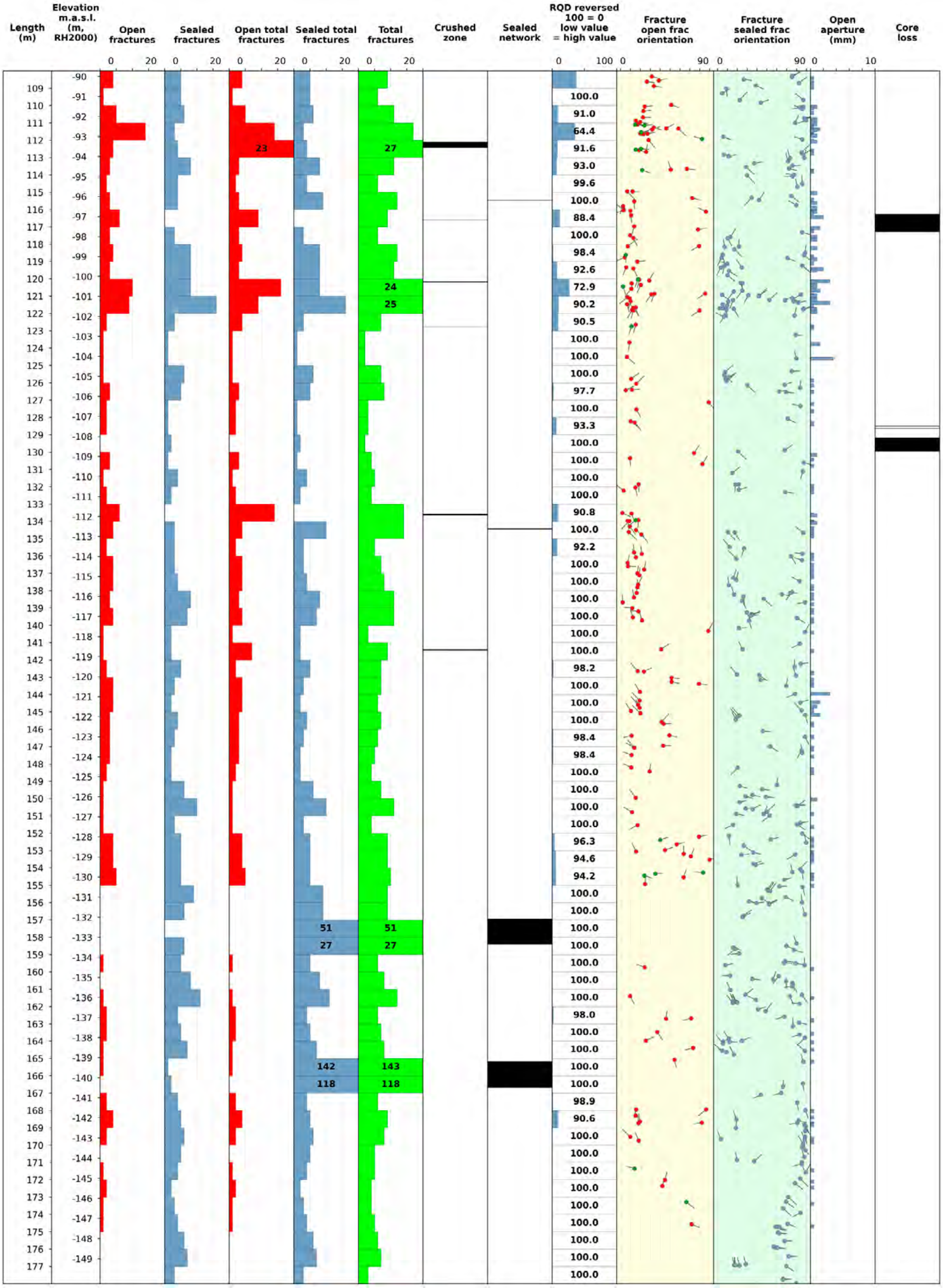
KFM01B DZ3 (415.0-454.0 m)



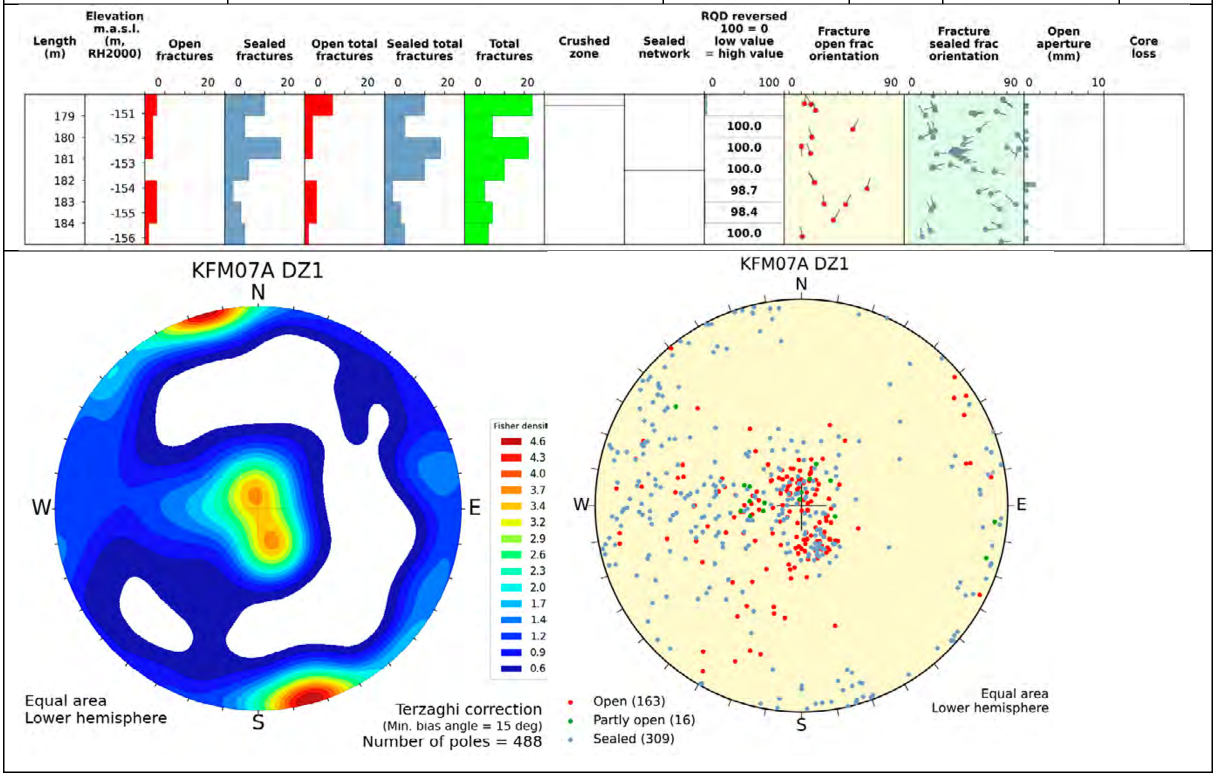


NNW	ZFMNNW0404	Version number	4	Total object CL	22

KFM07A DZ1 (108.0-185.0 m)

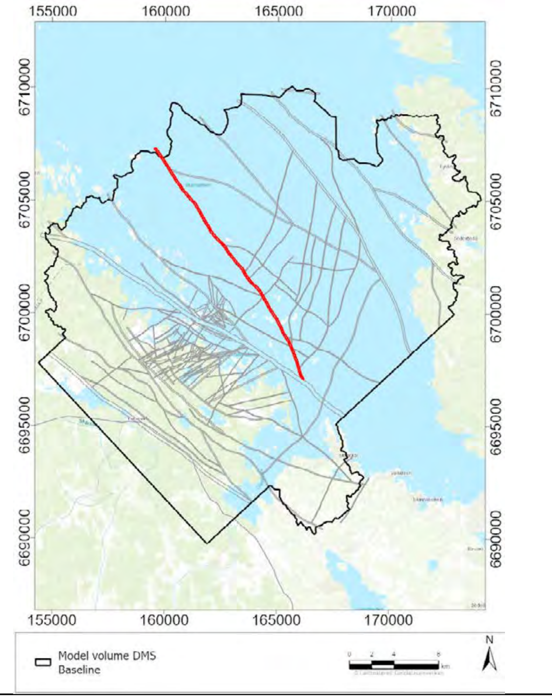


NNW	ZFMNNW0404	Version number	4	Total object CL	22



NNW	ZFMNNW0806	Version number	6	Total object CL	13

GEOLOGICAL CHARACTER		Property CL
Deformation style:	Brittle	1
Deformation description:	No data available.	
Alteration:		2
- First order:	Oxidation	
- Second order:	Not observed	
- Third order:	Not observed	
Fracture orientation and type:	No data available.	
Fracture comment:	No data available.	
Fracture fill mineralogy:	No data available.	



OBJECT GEOMETRY	
Strike/dip:	145°/90°
Length:	22000 m
Mean thickness:	80 m (50 - 200 m)
Max depth:	-2100 m
Geometrical constraints:	ZFMWNW0001, Topo 40m grid Max error 20m, 1 Surface Planar Cut(s).

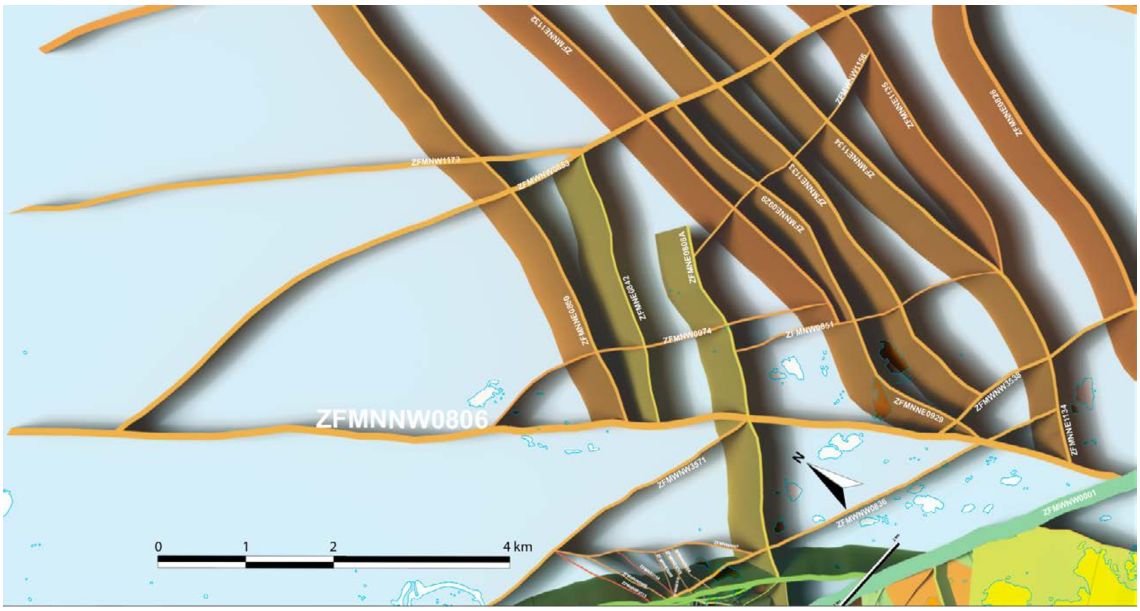
BASIS FOR MODELLING

Zone based on surface lineaments.

Outcrops:	-	
Boreholes: -		
Tunnels:	-	
Lineament and/or seismic indications:	MFM0806 merged.	2

MODELLING PROCEDURE

At the surface, corresponds to the low magnetic lineament MFM0806. Modelled to the base of the model volume using an assumed dip of 90 degrees based on a comparison with high confidence, vertical and steeply dipping zones with WNW strike and NW strike.



NNW	ZFMNNW0806	Version number	6	Total object CL	13

OBJECT CONFIDENCE ESTIMATE

Category	Object CL	Comment
INTERPRETATION		
Data source	1	MFM0806 merged
Results of interpretation	2	Medium confidence in lineament MFM0806.
INFORMATION DENSITY		
Number of observation points	1	1
Distribution of observation points	1	Single observation point in the form of a lineament.
INTERPOLATION		
Geometry	1	Geometry supported by surface geophysical data.
Geological indicators	1	Indirect support by geophysical data.
EXTRAPOLATION		
Dip direction	3	Extrapolated to the base of the model volume. Strike length of the modelled zone > 2000 m.
Strike direction	3	Conceptual understanding of the site and that the entire modelled zone is supported by the lineament.

FRACTURE CHARACTER

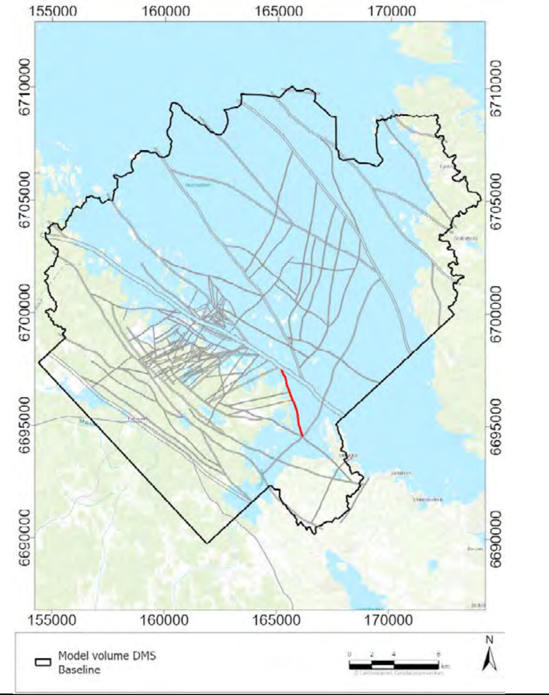
No data available

INDIVIDUAL INTERCEPTS

No data available

NNW	ZFMNNW0823	Version number	3	Total object CL	14

GEOLOGICAL CHARACTER		Property CL
Deformation style:	Brittle	1
Deformation description:	No data available.	
Alteration:		2
- First order:	Oxidation	
- Second order:	Not observed	
- Third order:	Not observed	
Fracture orientation and type:	No data available.	
Fracture comment:	No data available.	
Fracture fill mineralogy:	No data available.	



OBJECT GEOMETRY	
Strike/dip:	162°/90°
Length:	3235 m
Mean thickness:	25 m (15 - 64 m)
Max depth:	-2100 m
Geometrical constraints:	ZFMNNE0828, ZFMWNW0001, Topo 40m grid Max error 20m.

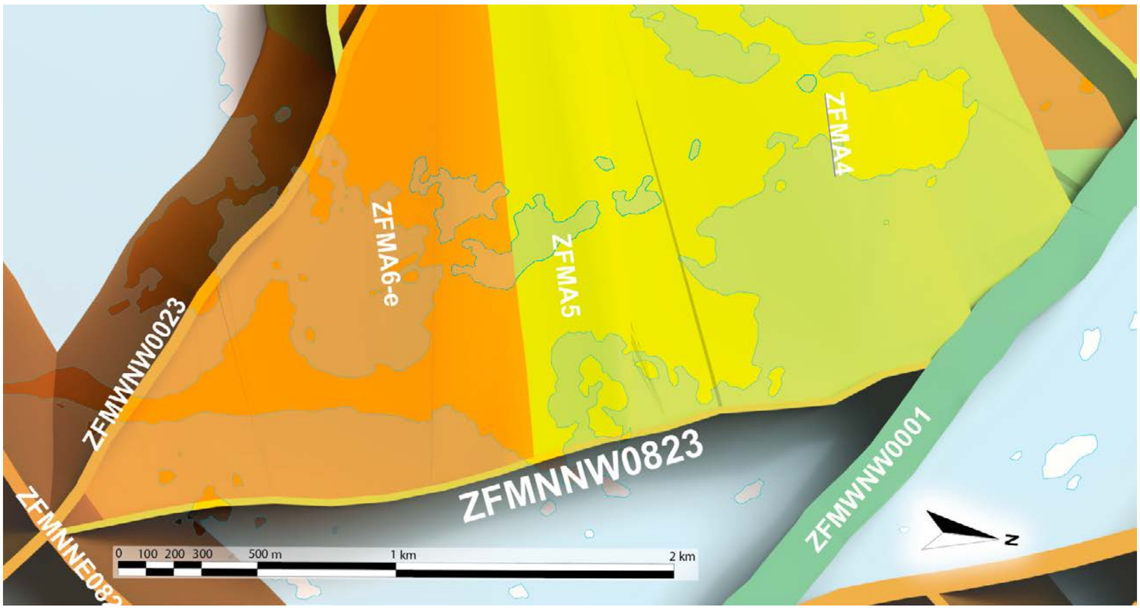
BASIS FOR MODELLING

Zone based on surface lineaments.

Outcrops:	-	
Boreholes: -		
Tunnels:	-	
Lineament and/or seismic indications:	MFM0823.	3

MODELLING PROCEDURE

At the surface, corresponds to the low magnetic lineament MFM0823. Modelled to the base of the model volume using an assumed dip of 90 degrees based on acomparison with high confidence, vertical and steeply dipping zones with NNW strike.



NNW	ZFMNNW0823	Version number	3	Total object CL	14

OBJECT CONFIDENCE ESTIMATE

Category	Object CL	Comment
INTERPRETATION		
Data source	1	MFM0823
Results of interpretation	3	High confidence in lineament MFM0823.
INFORMATION DENSITY		
Number of observation points	1	1
Distribution of observation points	1	Single observation point in the form of a lineament.
INTERPOLATION		
Geometry	1	Geometry supported by surface geophysical data.
Geological indicators	1	Indirect support by geophysical data.
EXTRAPOLATION		
Dip direction	3	Extrapolated to the base of the model volume. Strike length of the modelled zone > 2000 m.
Strike direction	3	Conceptual understanding of the site and that the entire modelled zone is supported by the lineament.

FRACTURE CHARACTER

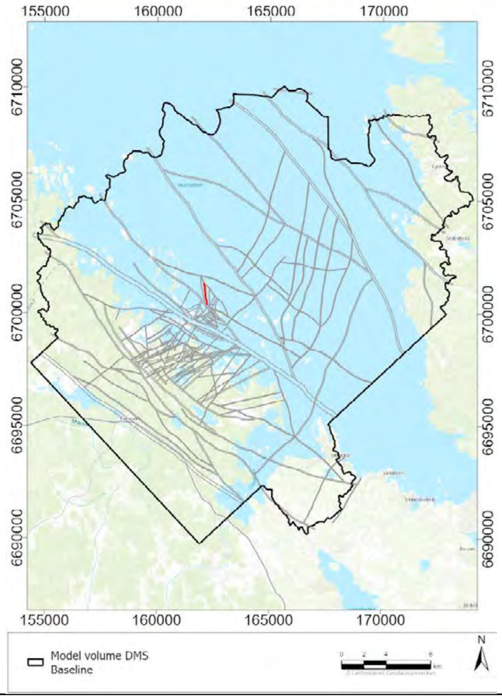
No data available

INDIVIDUAL INTERCEPTS

No data available

NNW	ZFMNNW0999	Version number	9	Total object CL	10

GEOLOGICAL CHARACTER		Property CL
Deformation style:	Brittle	2
Deformation description:	No data available.	
Alteration:		
- First order:	Not observed	
- Second order:	Not observed	
- Third order:	Not observed	
Fracture orientation and type:	No data available.	
Fracture comment:	No data available.	
Fracture fill mineralogy:	No data available.	



OBJECT GEOMETRY	
Strike/dip:	172°/90°
Length:	1065 m
Mean thickness:	15 m (3 - 50 m)
Max depth:	-1050 m
Geometrical constraints:	ZFMNW0805A, Topo 40m grid Max error 20m, ZFMNW0997, 1 Surface Planar Cut(s).

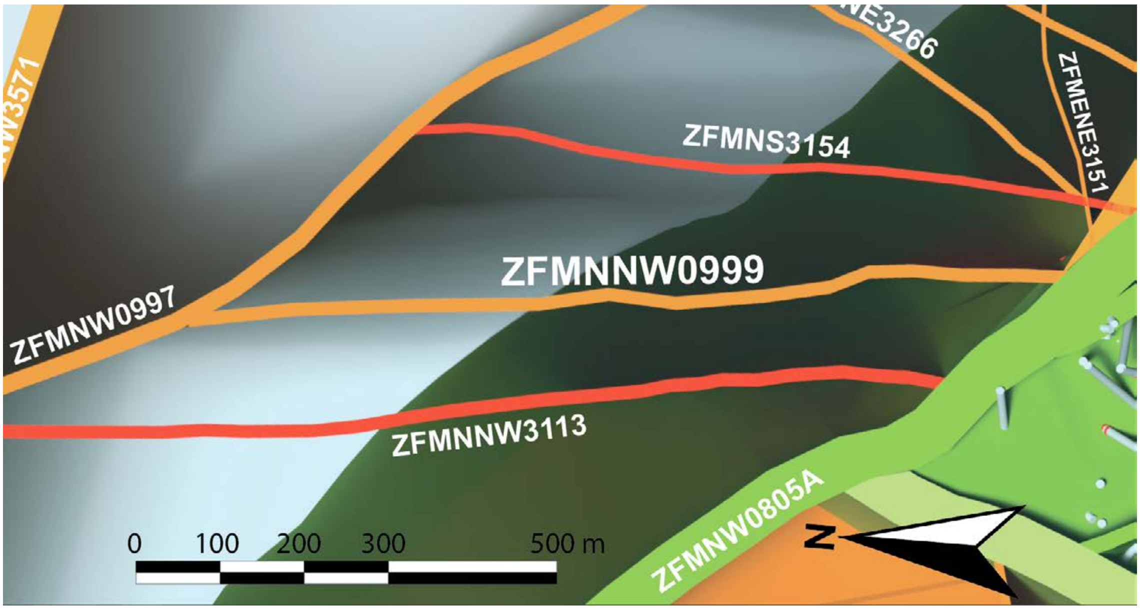
BASIS FOR MODELLING

Zone based on surface lineaments.

Outcrops:	-	
Boreholes: -		
Tunnels:	-	
Lineament and/or seismic indications:	MFM0999G.	2

MODELLING PROCEDURE

ZFMNNW0999 is based on the magnetic lineament MFM0999G in the Forsmark stage 2.3 interpretation (Isaksson et al. 2007). The zone has a length of 692 m terminating at ZFMNW0805A in the south and extending outside of the model area to the north, where MFM0999G terminates at lineament MSFR08078 in the SFR model version 1.0 (an update of Forsmark stage 2.3 lineament MFM3149G in Isaksson et al. (2007). The modelled zone geometry results in an intersection in KFR08 SHI DZ2. However, this interval is inferred as being dominated by ZFMNW0805A and no exclusive evidence for the existence of ZFMNNW0999 has been identified. For this reason, ZFMNNW0999 has been classed as medium confidence. The general thickness and vertical to subvertical dip are supported by the forward modelling of magnetic data along profiles 5 and 6 (see Appendix 6 in Curtis et al. 2011).



NNW	ZFMNNW0999	Version number	9	Total object CL	10

OBJECT CONFIDENCE ESTIMATE

Category	Object CL	Comment
INTERPRETATION		
Data source	1	MFM0999G
Results of interpretation	2	Medium confidence in lineament MFM0999G.
INFORMATION DENSITY		
Number of observation points	1	1
Distribution of observation points	1	Single observation point in the form of a lineament.
INTERPOLATION		
Geometry	1	Geometry supported by surface geophysical data.
Geological indicators	1	Indirect support by geophysical data.
EXTRAPOLATION		
Dip direction	1	No subsurface obs. point, supported only by surface data. High uncertainty in dip-direction. Strike length of the modelled zone < 2000 m.
Strike direction	2	Supported by geological concept and partly by surface lineament.

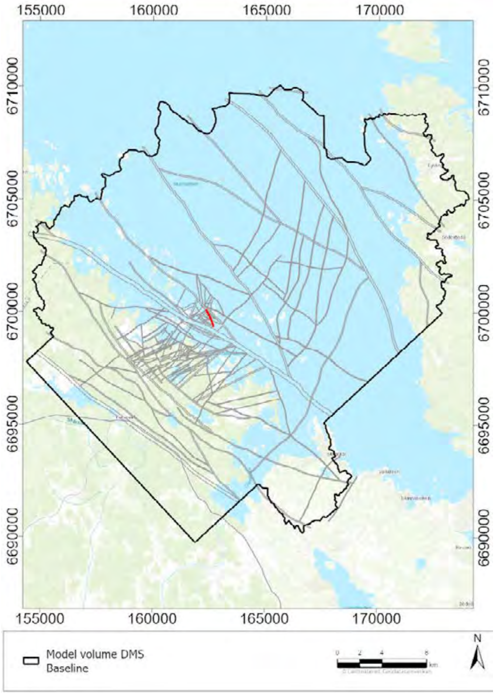
FRACTURE CHARACTER

No data available

INDIVIDUAL INTERCEPTS

No data available

NNW	ZFMNNW1034	Version number	6	Total object CL	20



GEOLOGICAL CHARACTER		Property CL
Deformation style:	Brittle	3
Deformation description:	No data available.	
Alteration:		3
- First order:	Oxidation	
- Second order:	Argillization	
- Third order:	Epidotization	
Fracture orientation and type:	Fracture sets striking E-W are prominent followed by NNW set. Gently dipping fractures are also present. Occurrence of sealed open and partly open fracture. Dominance of sealed fractures.	
Fracture comment:	Fracture apertures generally 0.5 to 2 mm, with one example of 8 mm.	
Fracture fill mineralogy:	Open fractures, calcite, chlorite, clay minerals, pyrite. Sealed fracture, calcite, laumontite, chlorite, epidote, quartz.	

OBJECT GEOMETRY	
Strike/dip:	339°/78°
Length:	882 m
Mean thickness:	17 m (2 - 36 m)
Max depth:	-880 m
Geometrical constraints:	ZFMNW0805A, Topo 40m grid Max error 20m, 1 Surface Planar Cut(s), 1 UNIVERSE Planar Cut(s).

BASIS FOR MODELLING

Zone based on surface lineaments and borehole observations.

Outcrops: -

Boreholes:

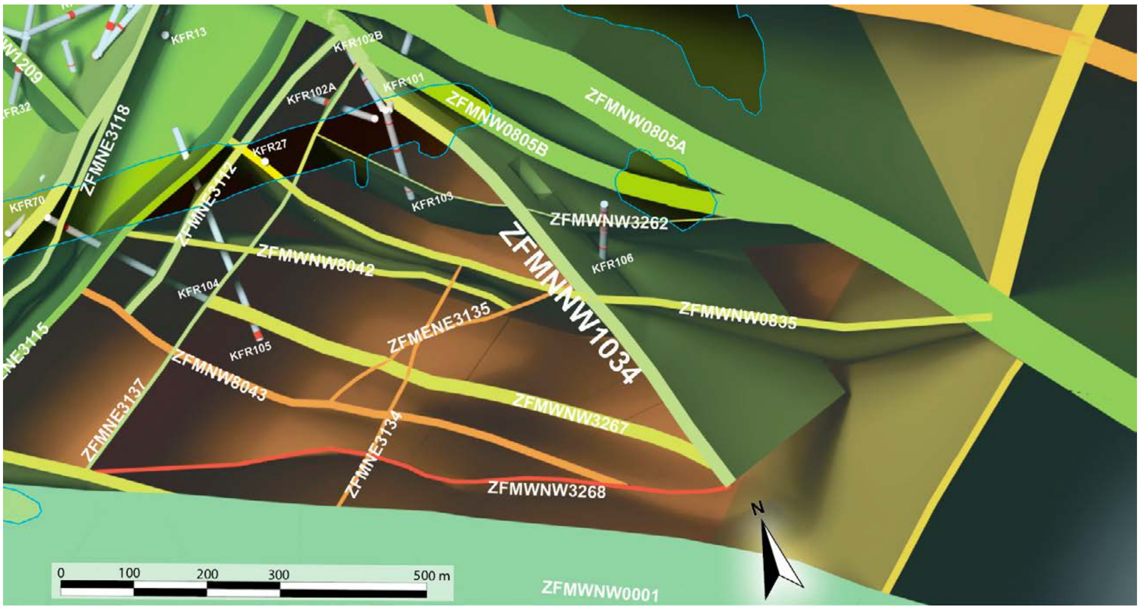
Borehole	PDZ	Target intercept		Geometric intercept		Comment
		Sec_up [m]	Sec_low [m]	Sec_up [m]	Sec_low [m]	
HFR106	DZ2	158.00	182.00	136.62	179.79	
HFR106	DZ3	158.00	182.00	136.62	179.79	
KFR101	DZ1	13.72	88.00	10.56	79.86	
KFR106	DZ7	256.00	266.00	200.89	271.05	

Tunnels:	-	
Lineament and/or seismic indications:	MSFR08100, MSFR08101.	3

MODELLING PROCEDURE

Based on magnetic lineament MFM1034G in Forsmark stage 2.3 (Isaksson et al. 2007) that has been adjusted slightly and updated as lineaments MSFR08100 and MSFR08101 in SFR model version 1.0. Further modification took place in the modelling work at the north-west end, based on information from KFR101 DZ1, where the zone passes through the magnetically disturbed pier area. The general thickness and steep dip to the north-east are supported by the forward modelling of magnetic data along profile 2 (see Appendix 6 in Curtis et al. 2011). The zone is also intersected by KFR106 (256-266, DZ7), HFR106 (158-182, DZ2 and DZ3).

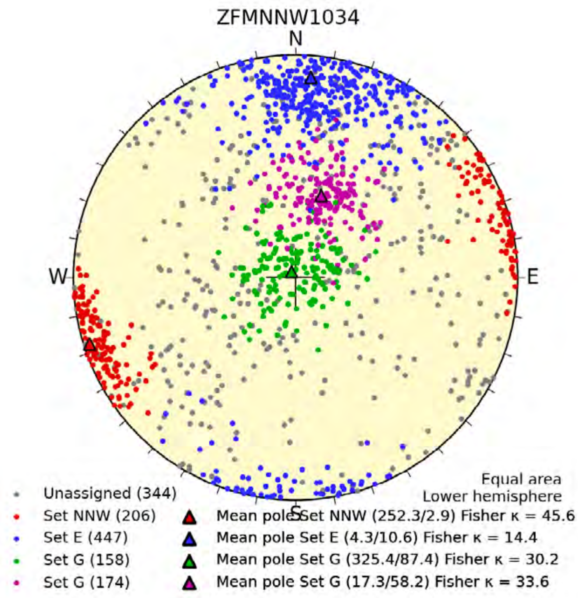
NNW	ZFMNNW1034	Version number	6	Total object CL	20



OBJECT CONFIDENCE ESTIMATE

Category	Object CL	Comment
INTERPRETATION		
Data source	2	MFM1034G, HFR106, KFR101, KFR106
Results of interpretation	3	High confidence observation in KFR106, HFR106.
INFORMATION DENSITY		
Number of observation points	3	4
Distribution of observation points	3	Even distribution of obs. points.
INTERPOLATION		
Geometry	3	Geometry supported by multiple subsurface obs. points.
Geological indicators	2	Some discrepancies in the geological data.
EXTRAPOLATION		
Dip direction	2	Extrapolation in dip direction supported by subsurface obs. point. Strike length of the modelled zone < 2000 m.
Strike direction	2	Supported by geological concept and partly by surface lineament.

FRACTURE CHARACTER

Orientation: (strike/dip right-hand-rule)	Set NNW: 342.3°/87.1° Set E: 94.3°/79.4° Set G: 55.4°/2.6° Set G: 107.3°/31.8°	
Frequency:	Boreholes: KFR101, KFR106	
RQD:	min:41, max:100, mean:88	

FRACTURE TYPE	TERZAGHI-WEIGHED P10
Open and partly open	8.3 m-1
Sealed	18.6 m-1
Sealed network	36.2 % of DZ intercept
Crush	0.7 % of DZ intercept

<table>
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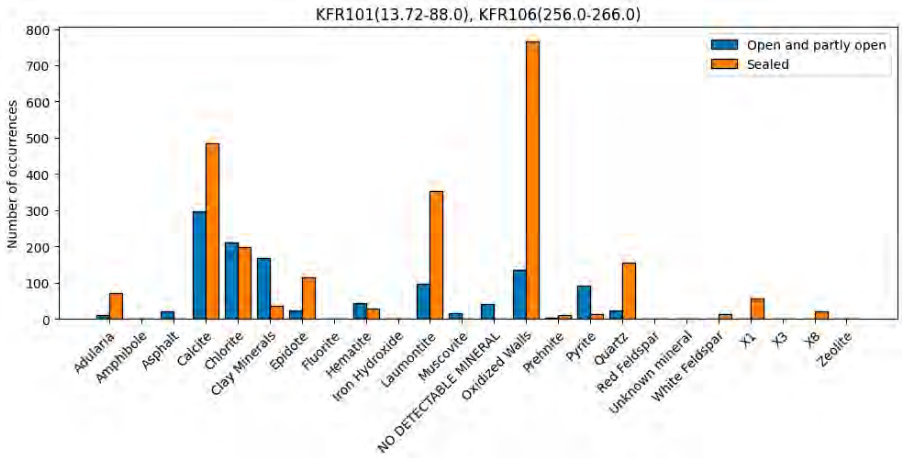
<tr><td>Fracture fill mineralogy:</td><td colspan="5">
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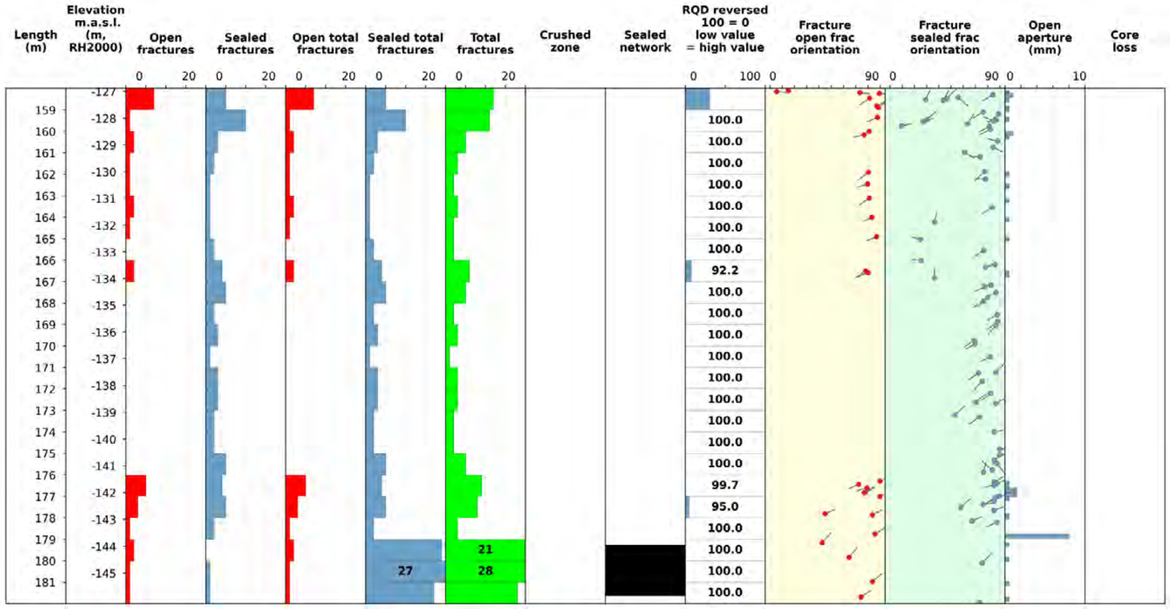
NNW	ZFMNNW1034	Version number	6	Total object CL	20

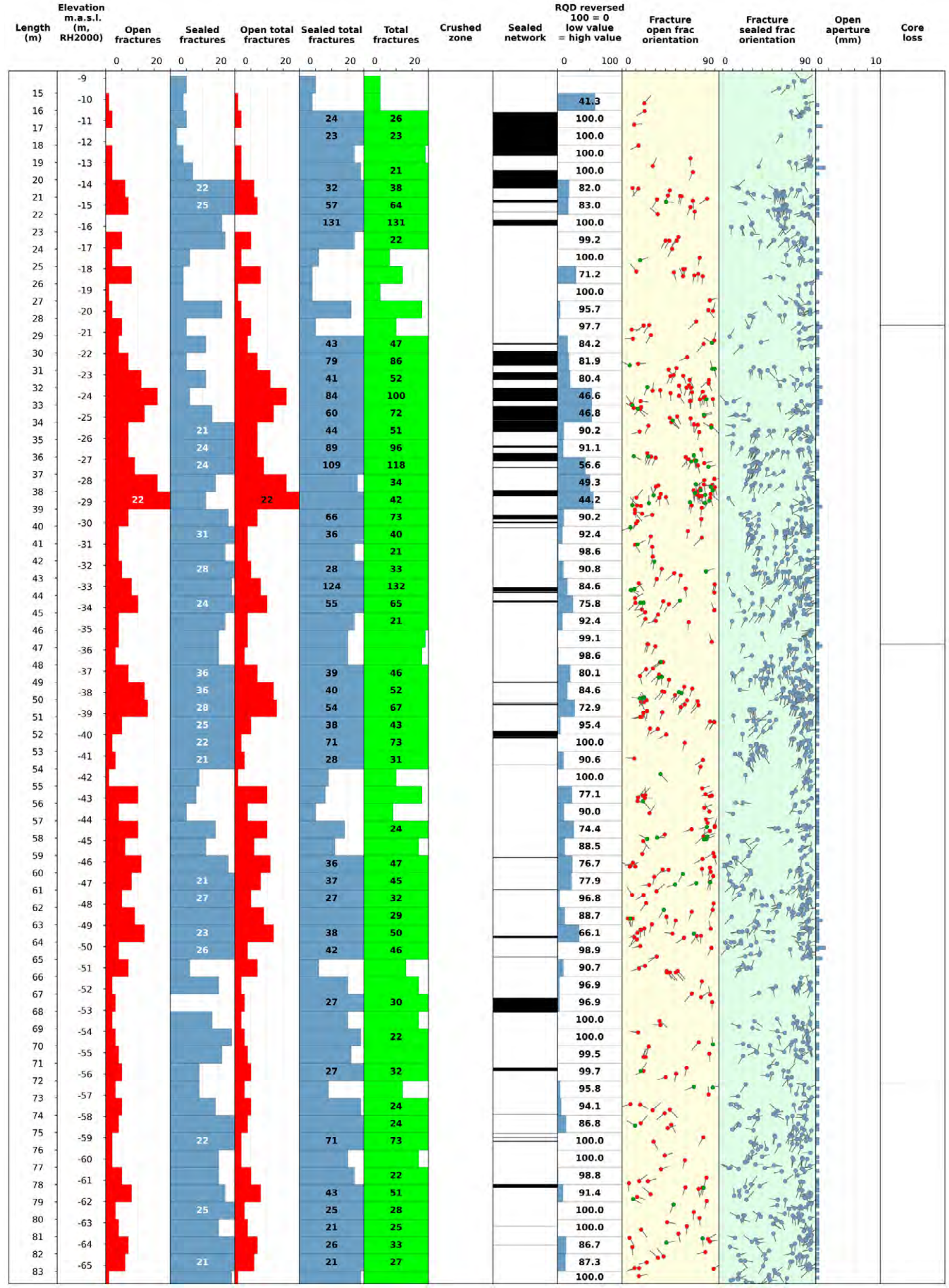
INDIVIDUAL INTERCEPTS

HFR106 DZ2, DZ3 (158.0-182.0 m)

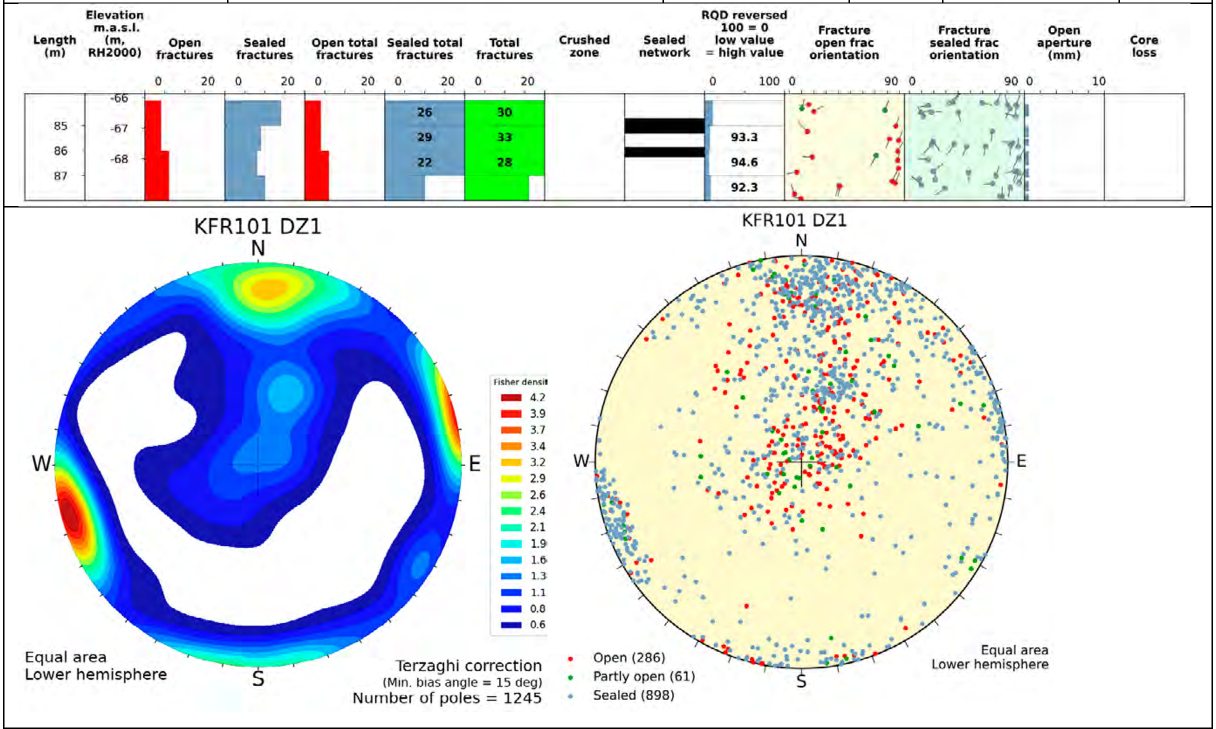


NNW	ZFMNNW1034	Version number	6	Total object CL	20

KFR101 DZ1 (13.72-88.0 m)

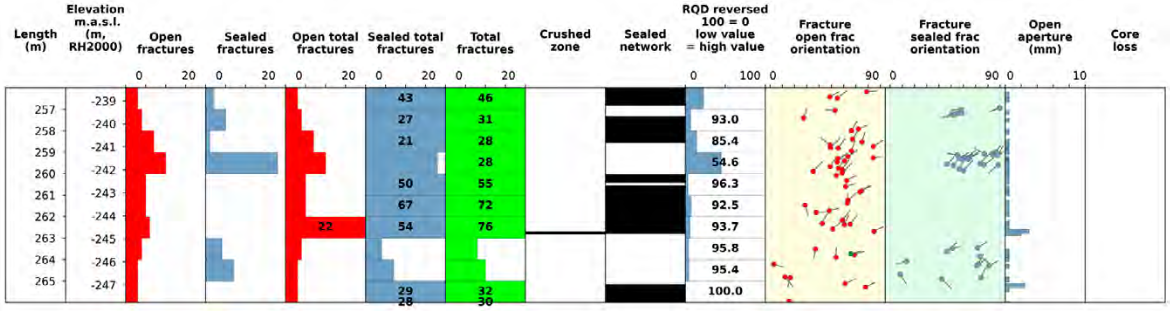


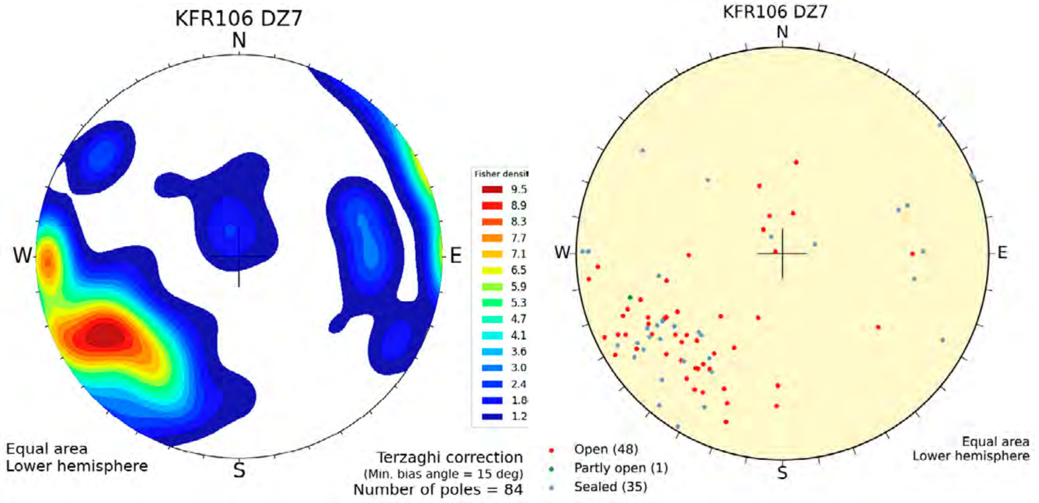
NNW	ZFMNNW1034	Version number	6	Total object CL	20



NNW	ZFMNNW1034	Version number	6	Total object CL	20

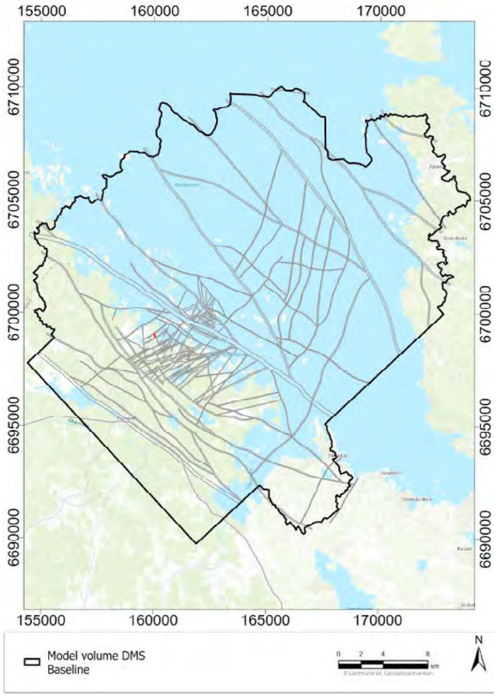
KFR106 DZ7 (256.0-266.0 m)





NNW	ZFMNNW1204	Version number	7	Total object CL	13

GEOLOGICAL CHARACTER		Property CL
Deformation style:	Brittle	3
Deformation description:	Steeply dipping fault with NNW strikeshows strike-slip displacement and chlorite and clay minerals Steeply dipping faults with SW strike shows strike-slip displacement. One fault shows sinistral strike-slip displacement.	
Alteration:		3
- First order:	Oxidation	
- Second order:	Not observed	
- Third order:	Not observed	
Fracture orientation and type:	Fractures that strike NNW are conspicuous. Steeply dipping NE fractures and some gently dipping fractures are also present. Sealed fractures dominates. Quantitative estimate and span include some sealed fracture networks and a crush zone.	2
Fracture comment:	No data available.	
Fracture fill mineralogy:	Calcite, chlorite, hematite/adularia. Clay minerals present in a few fractures, both NNW steeply dipping and gently dipping.	



OBJECT GEOMETRY	
Strike/dip:	347°/85°
Length:	-
Mean thickness:	4 m (1 - 13 m)
Max depth:	-550 m
Geometrical constraints:	ZFMENE1061A, ZFMENE2248, Topo 40m grid Max error 20m, 1 Surface Planar Cut(s).

BASIS FOR MODELLING

Zone based on a borehole observation.

Outcrops:	-

Boreholes:

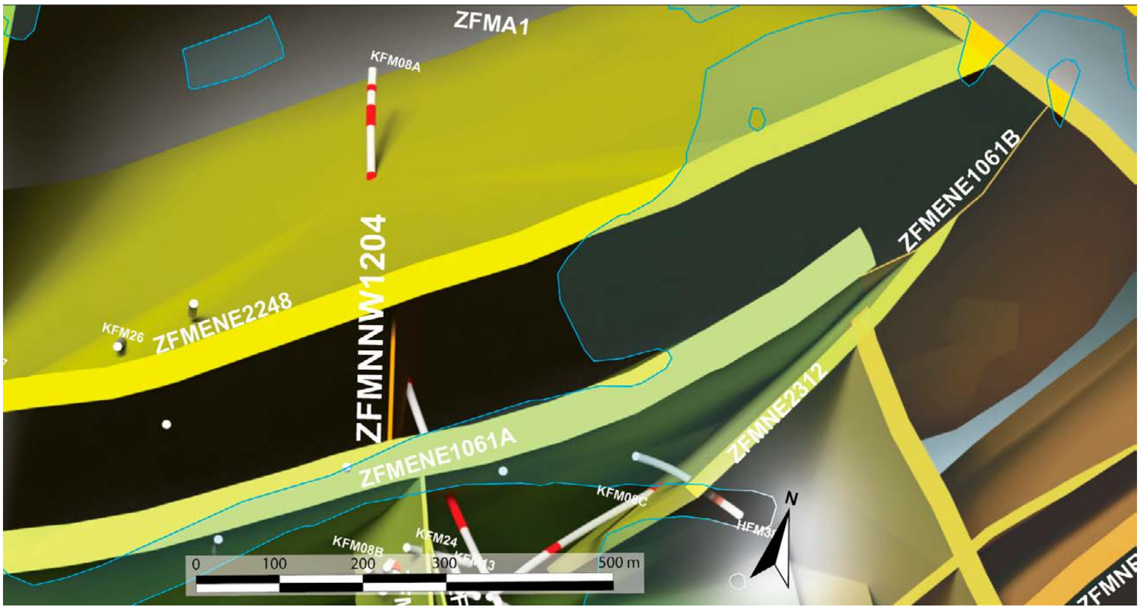
Borehole	PDZ	Target intercept		Geometric intercept		Comment
		Sec_up [m]	Sec_low [m]	Sec_up [m]	Sec_low [m]	
KFM08A	DZ2	479.00	496.00	478.22	494.77	

Tunnels:	-
Lineament and/or seismic indications:	-

MODELLING PROCEDURE

On the basis of the orientation of fractures, the borehole interval 479-496 m in borehole KFM08A (DZ2) is modelled as a brittle deformation zone with NNW strike and steep dip, which developed along the tectonic foliation in the bedrock. Deformation zone plane placed at fixed point 480 m in KFM08A. Decreased radar penetration also along the borehole interval 476-483 m in KFM08A. Truncated against ZFMENE1061A and ZFMENE2248. Inferred to be a minor zone.

NNW	ZFMNNW1204	Version number	7	Total object CL	13



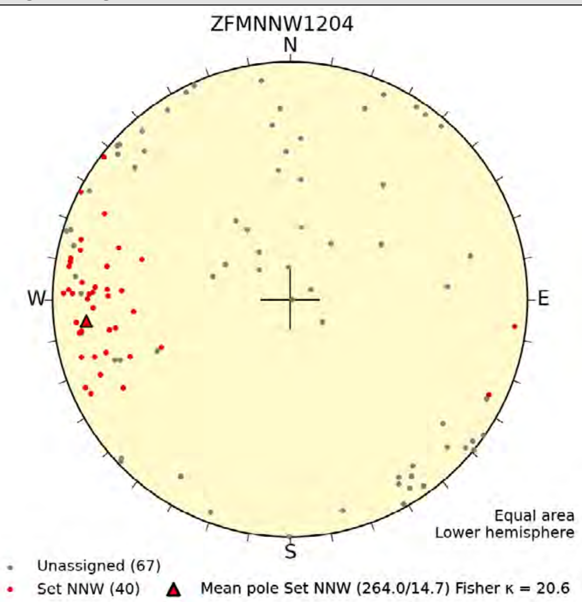
OBJECT CONFIDENCE ESTIMATE

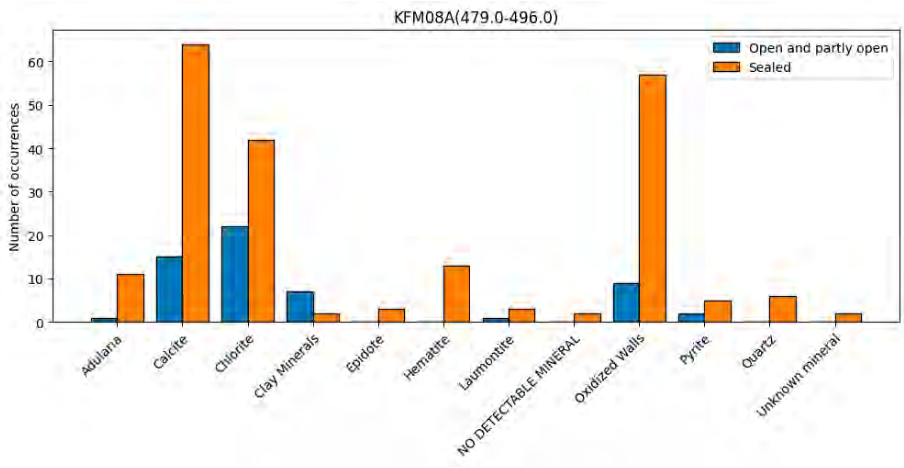
Category	Object CL	Comment
INTERPRETATION		
Data source	2	No surface intersection, modelled from z -200 to -550 m, KFM08A
Results of interpretation	3	High confidence observation in KFM08A.
INFORMATION DENSITY		
Number of observation points	1	1
Distribution of observation points	1	Single observation point at depth and a surface lineament.
INTERPOLATION		
Geometry	1	Geometry supported by a lineament and a single intercept.
Geological indicators	1	Single observation point at depth. Zone modelled mainly based on surface geophysical data.
EXTRAPOLATION		
Dip direction	2	Extrapolation in dip direction supported by subsurface obs. point. Strike length of the modelled zone < 2000 m.
Strike direction	2	Supported by geological concept and subsurface observation points.

FRACTURE CHARACTER

Orientation: (strike/dip right-hand-rule)	Set NNW: 354.0°/75.3°
Frequency:	Boreholes: KFM08A
RQD:	min:79, max:100, mean:98

FRACTURE TYPE	TERZAGHI-WEIGHED P10
Open and partly open	2.2 m-1
Sealed	12.4 m-1
Sealed network	13.8 % of DZ intercept
Crush	0.2 % of DZ intercept

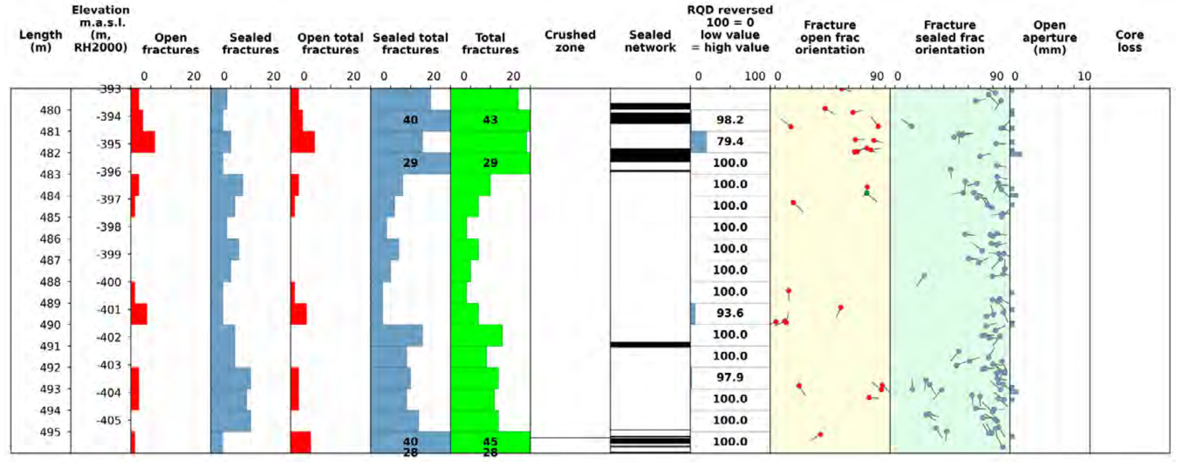


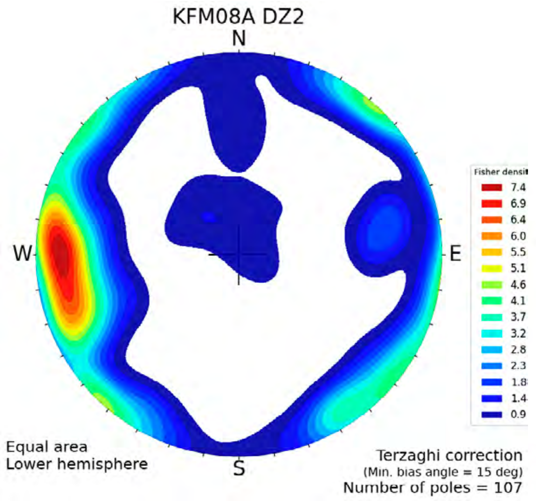
NNW	ZFMNNW1204	Version number	7	Total object CL	13
Fracture fill mineralogy:					

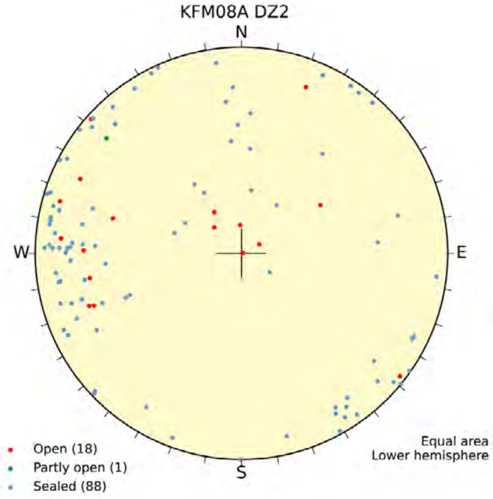
NNW	ZFMNNW1204	Version number	7	Total object CL	13

INDIVIDUAL INTERCEPTS

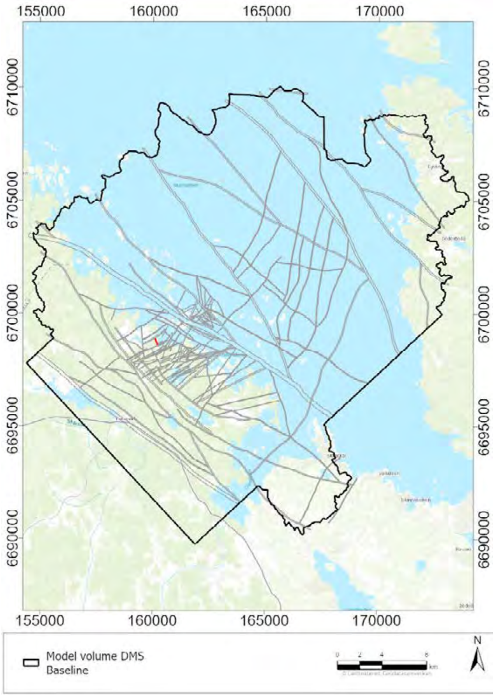
KFM08A DZ2 (479.0-496.0 m)







NNW	ZFMNNW1205A	Version number	5	Total object CL	20



GEOLOGICAL CHARACTER		Property CL
Deformation style:	Brittle	3
Deformation description:	Steeply dipping faults with SSE strike have chlorite, sometimes accompanied by calcite striae with sinistral strike-slip displacement. Fault with gentle dip to the SSE shows chlorite striae and reverse dip-slip displacement.	
Alteration:		3
- First order:	Oxidation	
- Second order:	Chloritization	
- Third order:	Not observed	
Fracture orientation and type:	Fractures that strike SSE form a conspicuous set. Gently dipping fractures and steeply dipping NE fractures are also present. Sealed fractures dominates. Quantitative estimate and span include sealed fracture networks.	2
Fracture comment:	No data available.	
Fracture fill mineralogy:	Calcite, chlorite, laumontite, hematite/adularia, quartz, minor clay minerals.	

OBJECT GEOMETRY	
Strike/dip:	161°/77°
Length:	366 m
Mean thickness:	5 m (1 - 13 m)
Max depth:	-370 m
Geometrical constraints:	ZFMENE0159A, Topo 40m grid Max error 20m, ZFMENE1061A, 1 Surface Planar Cut(s), 1 UNIVERSE Planar Cut(s).

BASIS FOR MODELLING

Zone based on surface and borehole observations. Zone ZFMNNW1205 consists of two segments, ZFMNNW1205A and ZFMNNW1205B, judged to constitute elements of one and the same structure.

Outcrops: -

Boreholes:

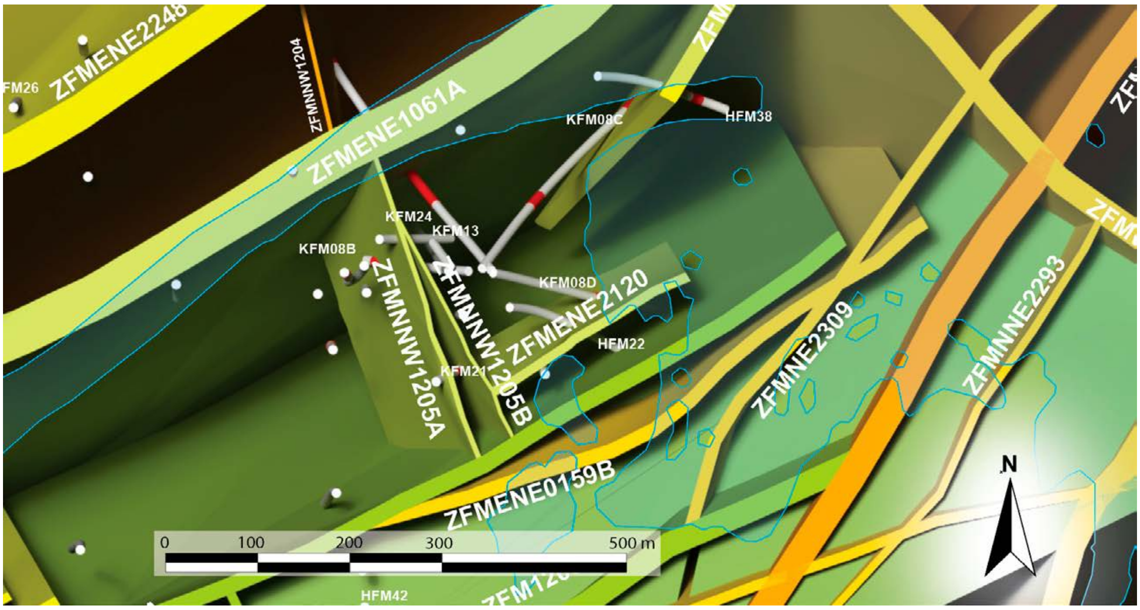
Borehole	PDZ	Target intercept		Geometric intercept		Comment
		Sec_up [m]	Sec_low [m]	Sec_up [m]	Sec_low [m]	
KFM08B	DZ2	167.00	185.00	167.76	184.30	
KFM13	DZ1	37.00	49.00	34.78	42.56	DZ1 also lies within ZFMNNW1205B.
KFM21	DZ1	18.30	27.80	18.59	27.91	

Tunnels:	-	
Lineament and/or seismic indications:	MFM2169G.	2

MODELLING PROCEDURE

On the basis of the orientation of fractures, the borehole intervals 133-140 m and 167-185 m in borehole KFM08B (DZ1 and DZ2, respectively) are modelled as a brittle deformation zone with NNW strike and steep dip, which developed along the tectonic foliation in the bedrock. Deformation zone plane placed at fixed point 176 m in KFM08B. Truncated against ZFMENE0159A and ZFMENE1061A. Inferred to be a minor zone.

NNW	ZFMNNW1205A	Version number	5	Total object CL	20



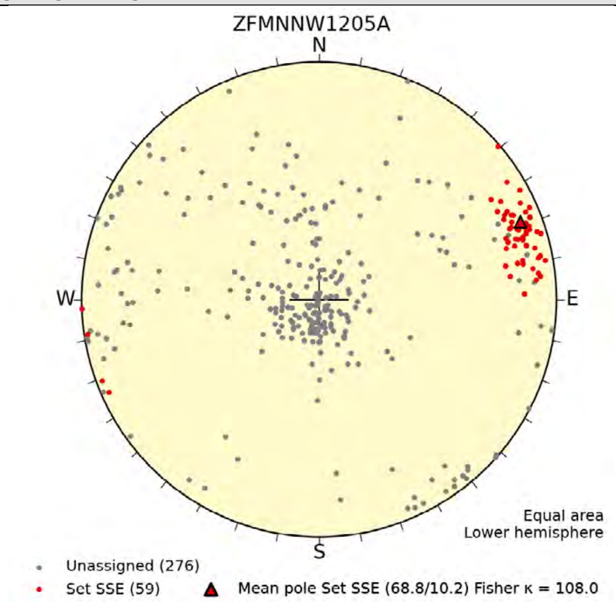
OBJECT CONFIDENCE ESTIMATE

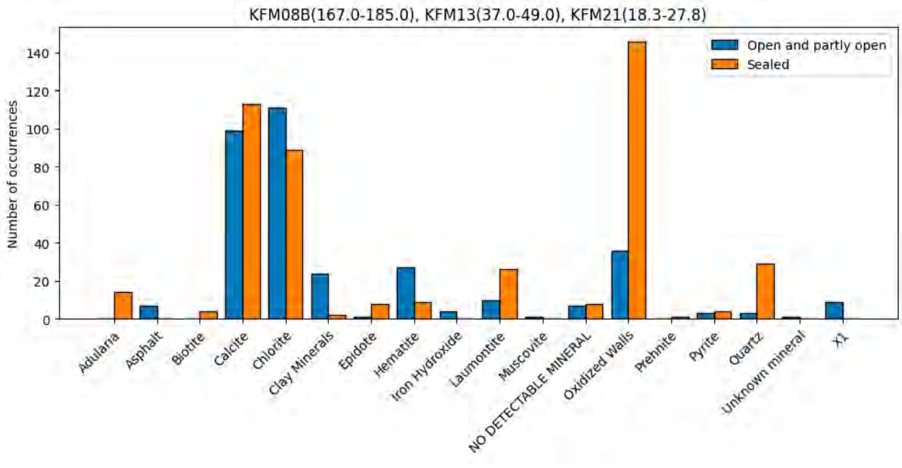
Category	Object CL	Comment
INTERPRETATION		
Data source	2	MFM2169G, KFM08BA, KFM13, KFM21
Results of interpretation	3	High confidence observation in KFM08BA.
INFORMATION DENSITY		
Number of observation points	3	4
Distribution of observation points	2	Cluster of borehole intersections and a lineament as an outlier.
INTERPOLATION		
Geometry	3	One strong interpolation alternative.
Geological indicators	3	Interpolation supported by key geological parameters, foremost fracture orientation pattern.
EXTRAPOLATION		
Dip direction	2	Extrapolation in dip direction supported by subsurface obs. point. Strike length of the modelled zone < 2000 m.
Strike direction	2	Supported by geological concept and partly by surface lineament.

FRACTURE CHARACTER

Orientation: (strike/dip right-hand-rule)	Set SSE: 158.8°/79.8°	
Frequency:	Boreholes: KFM13, KFM21, KFM08B	
RQD:	min:51, max:100, mean:93	

FRACTURE TYPE	TERZAGHI-WEIGHED P10
Open and partly open	5.8 m-1
Sealed	11.1 m-1
Sealed network	7.5 % of DZ intercept
Crush	1.1 % of DZ intercept

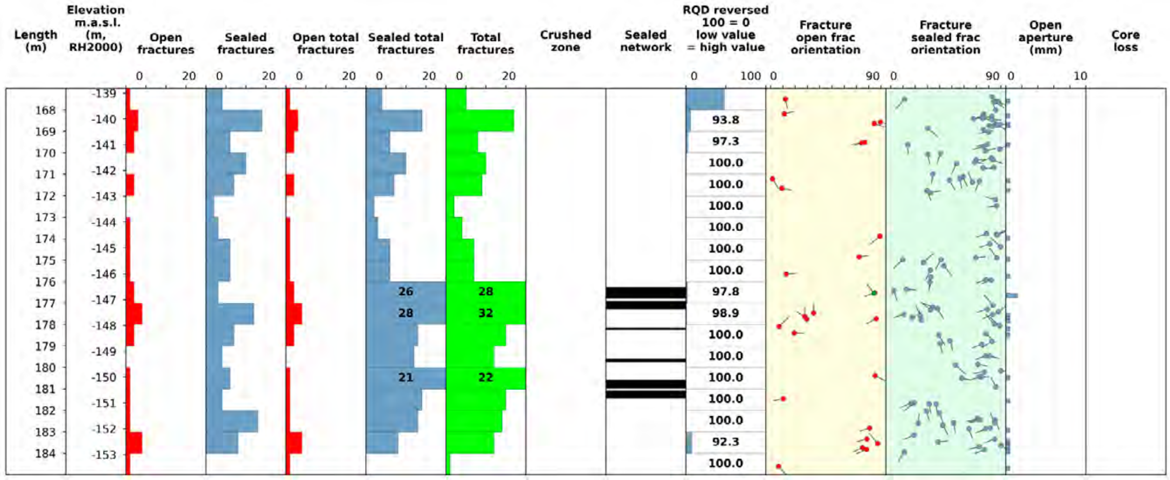


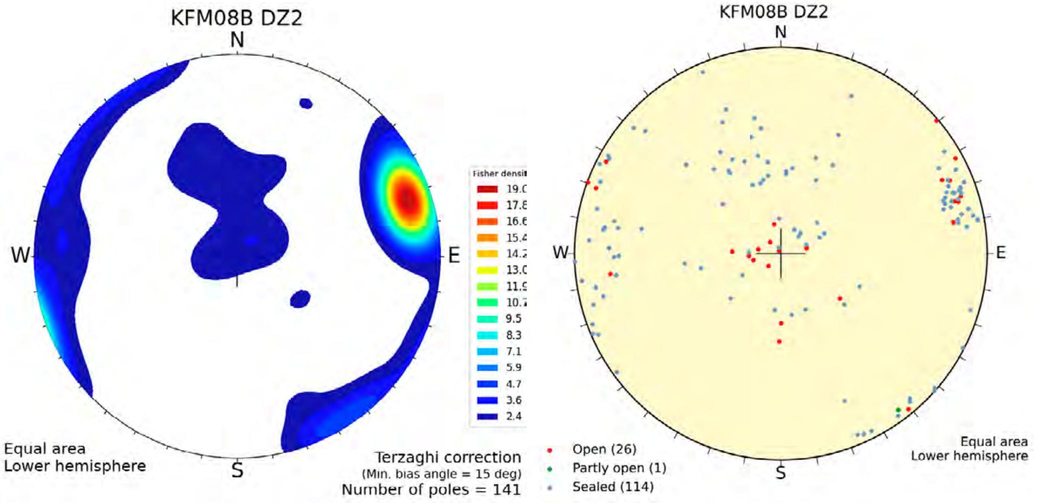
NNW	ZFMNNW1205A	Version number	5	Total object CL	20
Fracture fill mineralogy:					

NNW	ZFMNNW1205A	Version number	5	Total object CL	20

INDIVIDUAL INTERCEPTS

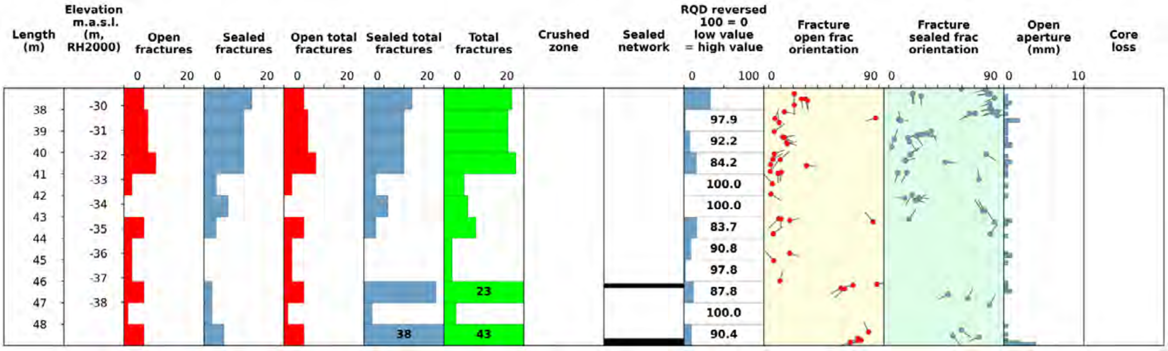
KFM08B DZ2 (167.0-185.0 m)

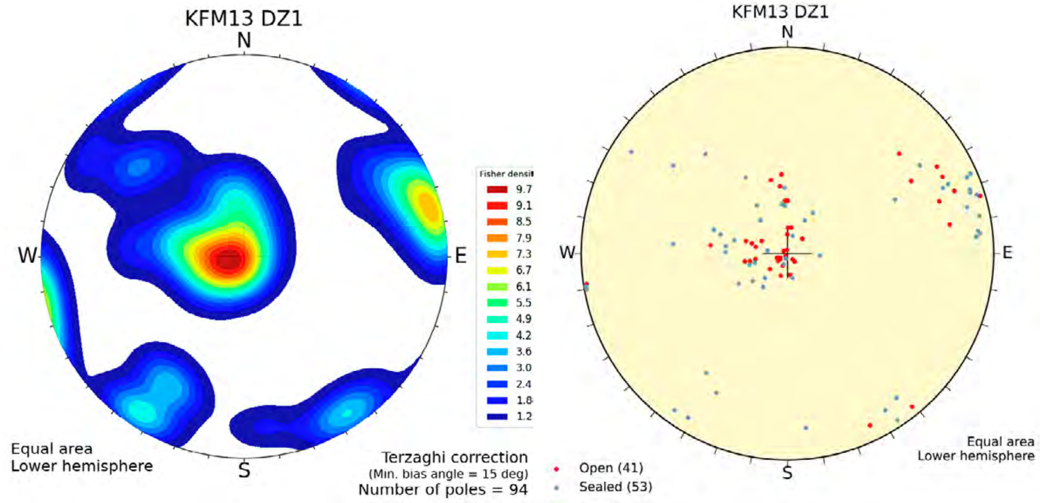




NNW	ZFMNNW1205A	Version number	5	Total object CL	20

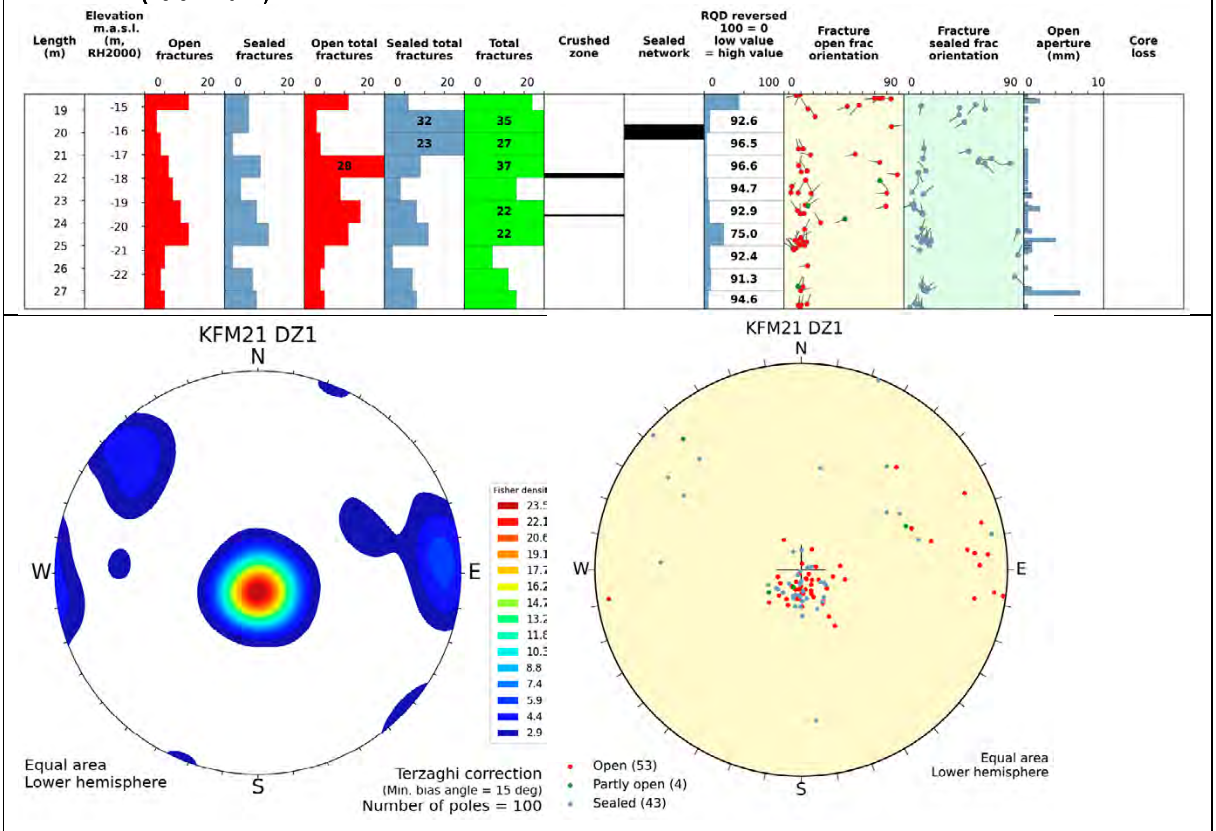
KFM13 DZ1 (37.0-49.0 m)





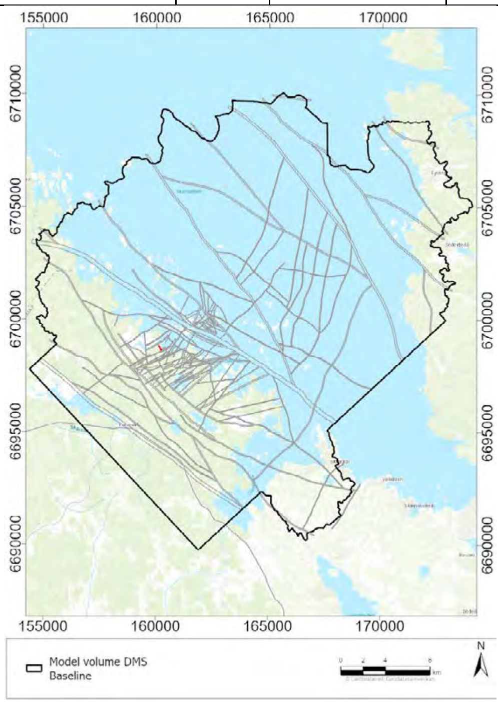
NNW	ZFMNNW1205A	Version number	5	Total object CL	20

KFM21 DZ1 (18.3-27.8 m)



NNW	ZFMNNW1205B	Version number	5	Total object CL	21

GEOLOGICAL CHARACTER		Property CL
Deformation style:	Brittle	3
Deformation description:	Steeply dipping faults with SSE strike shows chlorite, sometimes accompanied by calcite striae with reverse dip-slip displacement.	
Alteration:		3
- First order:	Oxidation	
- Second order:	Not observed	
- Third order:	Not observed	
Fracture orientation and type:	Dominated by NNV-SSO fractures set that dips steeply W. Dominance of sealed fractures. Open fractures are present. Occurrence of sealed fractures networks present.	2
Fracture comment:	Apertures are generally less than 0.5 mm. Few apertures up to 5 mm present.	
Fracture fill mineralogy:	Calcite, chlorite, laumontite and hematite.	



OBJECT GEOMETRY	
Strike/dip:	155°/79°
Length:	284 m
Mean thickness:	4 m (1 - 13 m)
Max depth:	-280 m
Geometrical constraints:	ZFMNNW1205A, ZFMENE0159A, Topo 40m grid Max error 20m, ZFMENE1061A, 1 Surface Planar Cut(s), 1 UNIVERSE Planar Cut(s).

BASIS FOR MODELLING

Zone based on surface lineaments, outcrop and borehole observations. Zone ZFMNNW1205 consists of two segments, ZFMNNW1205A and ZFMNNW1205B, judged to constitute elements of one and the same structure.

Outcrops: AFM001393

Boreholes:

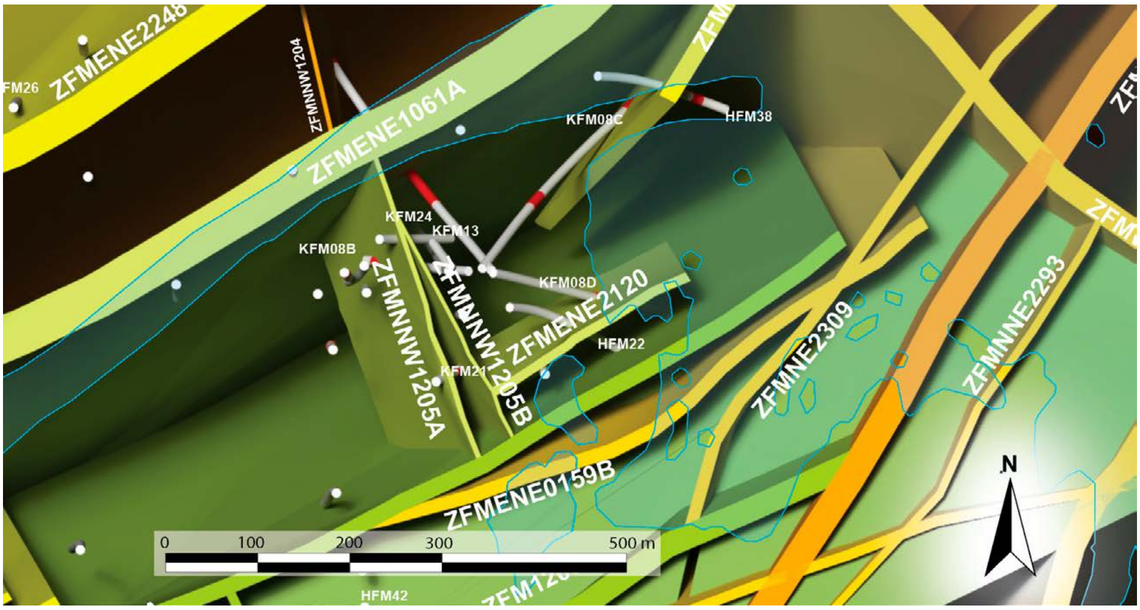
Borehole	PDZ	Target intercept		Geometric intercept		Comment
		Sec_up [m]	Sec_low [m]	Sec_up [m]	Sec_low [m]	
KFM08B	DZ1	133.00	140.00	128.71	142.90	
KFM13	DZ1	37.00	49.00	45.28	51.45	DZ1 also lies within ZFMNNW1205A.
KFM21	DZ3	86.10	94.90	86.50	94.38	

Tunnels:	-	
Lineament and/or seismic indications:	MFM2168G, MFM2169G.	2

MODELLING PROCEDURE

Originally modelled on the basis of outcrop and borehole data from the investigations of the shallow rock mass in the drift area where the zone was named ZFMNNW2168. Later renamed to ZFMNNW1205B in the FPS-Access model (Follin 2019). ZFMNNW1205B is inferred to be a foliation parallel splay or sister to ZFMNNW1205A developed as second order structures due to displacements along ENE-trending zones. Projected towards depth based on three borehole intercepts, where KFM13 PDZ1 is shared with ZFMNNW1205A. Fix points are consequently used for KFM08B PDZ1 and KFM21 PDZ3. Cut-off depth based on the ground surface trace length.

NNW	ZFMNNW1205B	Version number	5	Total object CL	21



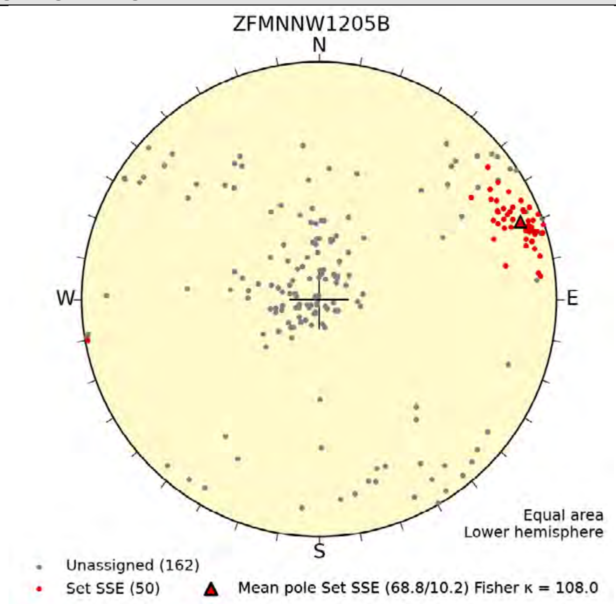
OBJECT CONFIDENCE ESTIMATE

Category	Object CL	Comment
INTERPRETATION		
Data source	3	MFM2168G, KFM08BA, KFM13, KFM21, AFM001393
Results of interpretation	3	High confidence observation in KFM08BA.
INFORMATION DENSITY		
Number of observation points	3	4
Distribution of observation points	2	Cluster of borehole intersections and a lineament as an outlier.
INTERPOLATION		
Geometry	3	One strong interpolation alternative.
Geological indicators	3	Interpolation supported by key geological parameters, foremost fracture orientation pattern.
EXTRAPOLATION		
Dip direction	2	Extrapolation in dip direction supported by subsurface obs. point. Strike length of the modelled zone < 2000 m.
Strike direction	2	Supported by geological concept and partly by surface lineament.

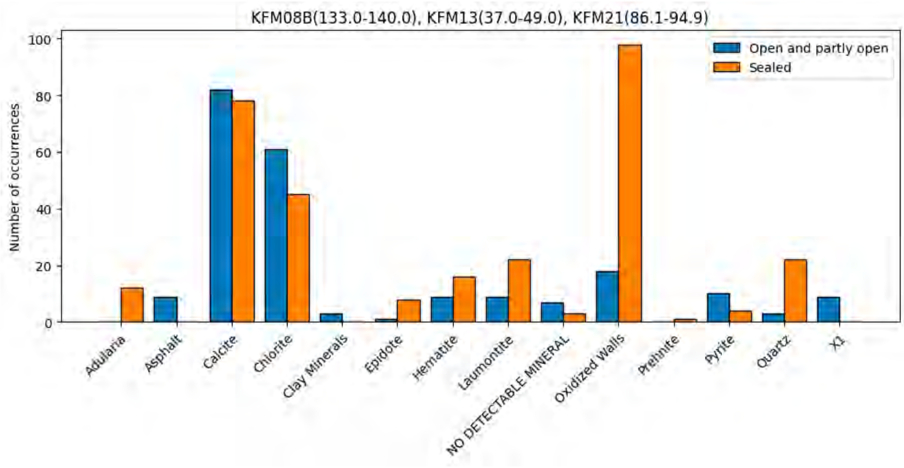
FRACTURE CHARACTER

Orientation: (strike/dip right-hand-rule)	Set SSE: 158.8°/79.8°
Frequency:	Boreholes: KFM13, KFM21, KFM08B

FRACTURE TYPE	TERZAGHI-WEIGHED P10
Open and partly open	4.8 m-1
Sealed	11.6 m-1
Sealed network	4.4 % of DZ intercept
Crush	0.0 % of DZ intercept



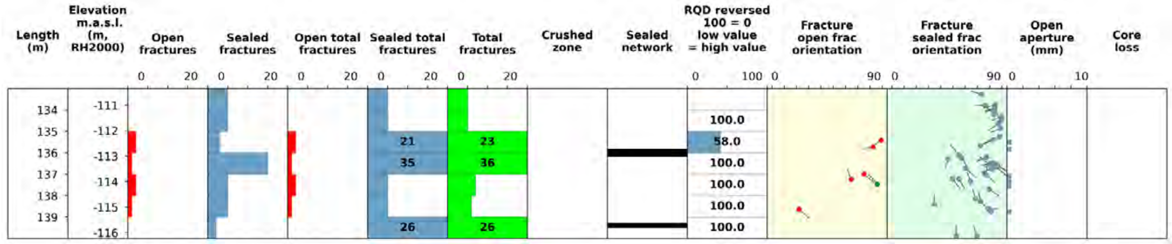
RQD:	min:58, max:100, mean:91

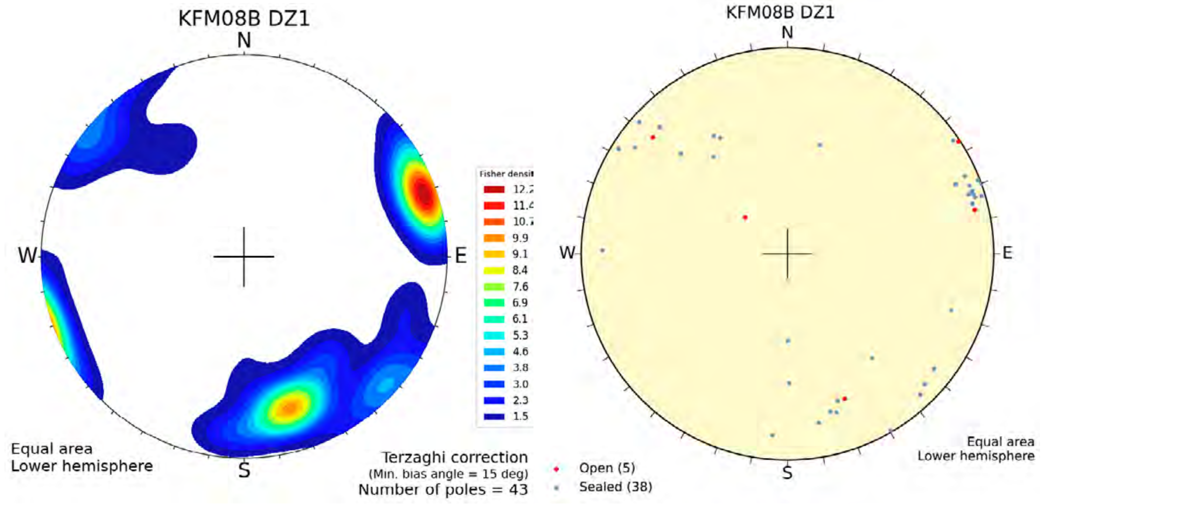
NNW	ZFMNNW1205B	Version number	5	Total object CL	21
Fracture fill mineralogy:					

NNW	ZFMNNW1205B	Version number	5	Total object CL	21

INDIVIDUAL INTERCEPTS

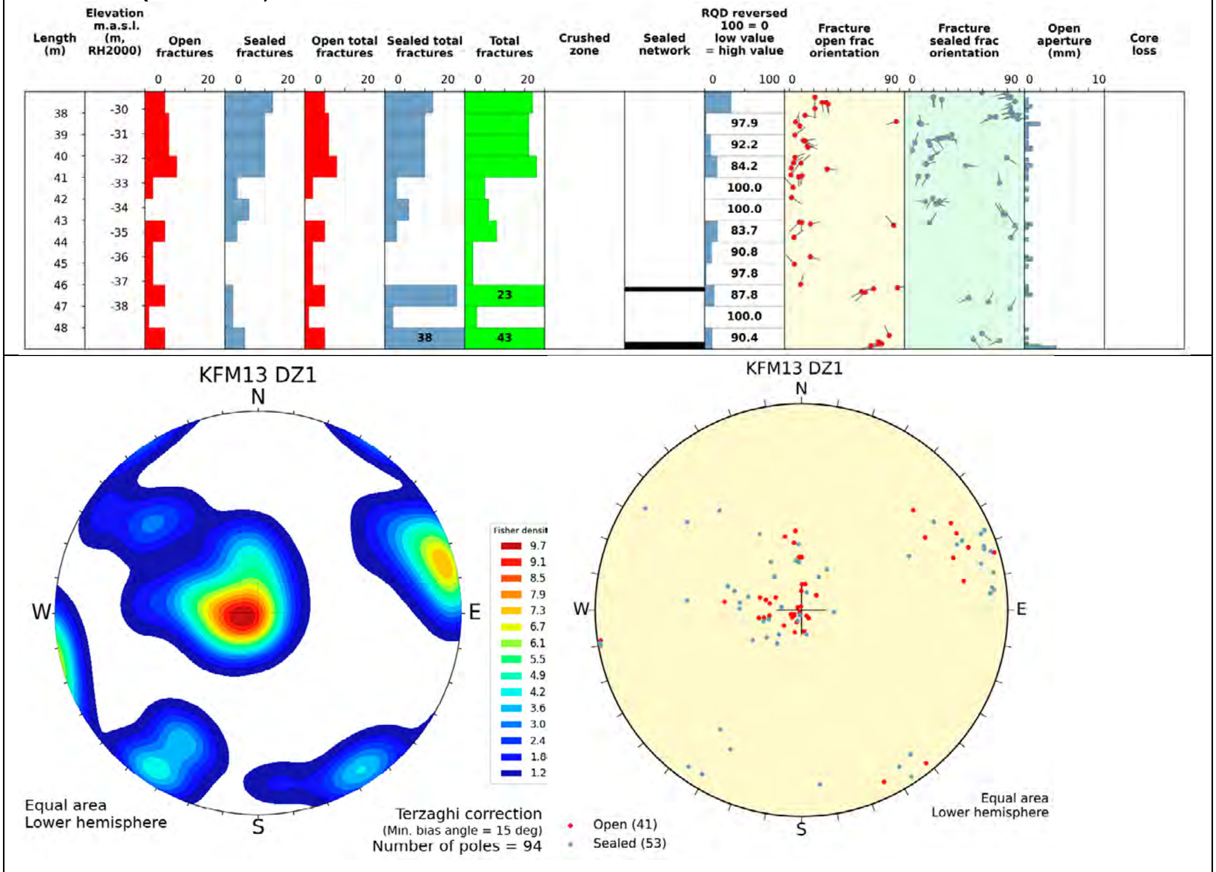
KFM08B DZ1 (133.0-140.0 m)





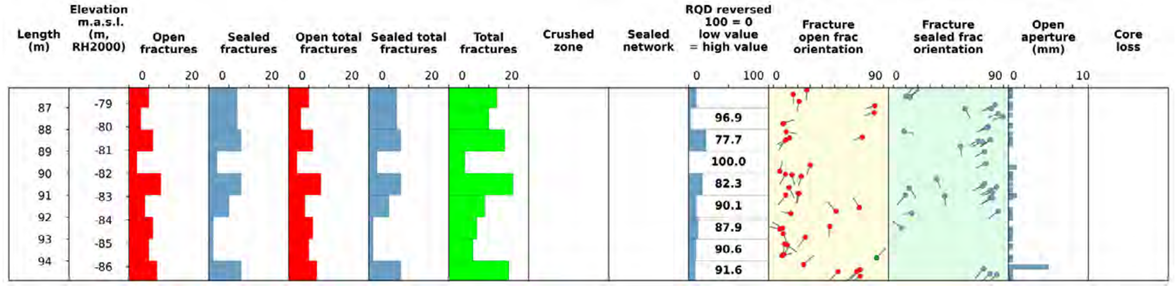
NNW	ZFMNNW1205B	Version number	5	Total object CL	21

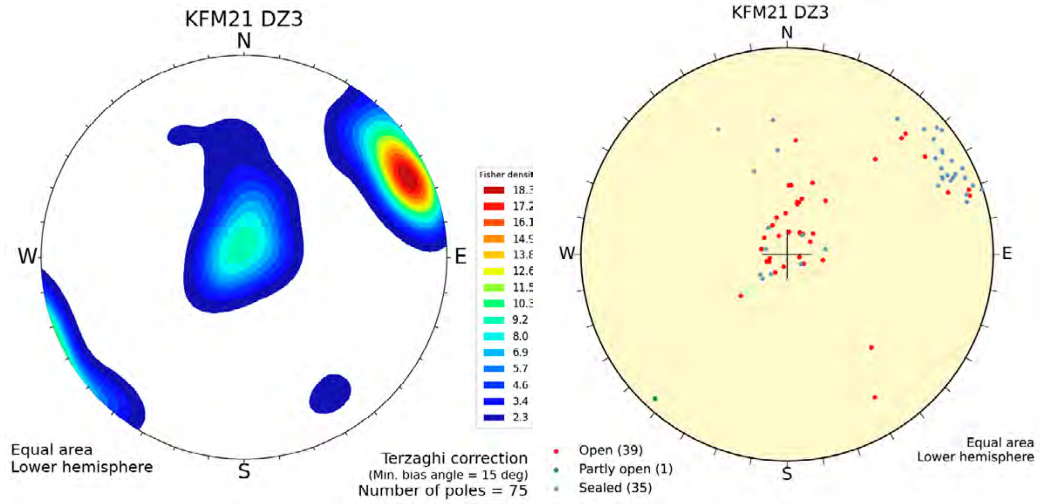
KFM13 DZ1 (37.0-49.0 m)



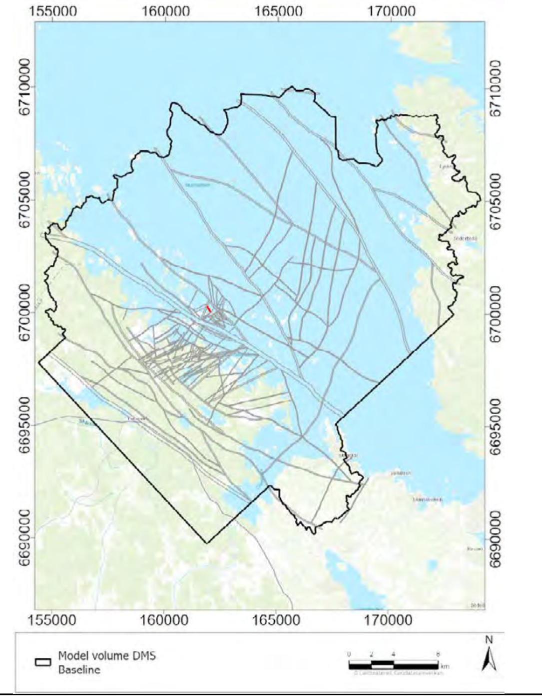
NNW	ZFMNNW1205B	Version number	5	Total object CL	21

KFM21 DZ3 (86.1-94.9 m)





NNW	ZFMNNW1209	Version number	4	Total object CL	22



GEOLOGICAL CHARACTER		Property CL
Deformation style:	Brittle	3
Deformation description:	Minor cohesive breccias and cataclasites present in KFR35 DZ1.	
Alteration:		3
- First order:	Oxidation	
- Second order:	Not observed	
- Third order:	Not observed	
Fracture orientation and type:	No data available.	3
Fracture comment:	No data available.	
Fracture fill mineralogy:	Adularia, calcite, quartz and asphaltite.	

OBJECT GEOMETRY	
Strike/dip:	153°/83°
Length:	337 m
Mean thickness:	18 m (2 - 18 m)
Max depth:	-340 m
Geometrical constraints:	ZFMNNE0869, ZFMNE0870, Topo 40m grid Max error 20m, 1 Surface Planar Cut(s).

BASIS FOR MODELLING

Zone based on surface observations and tunnels intersections.

Outcrops:	-

Boreholes:

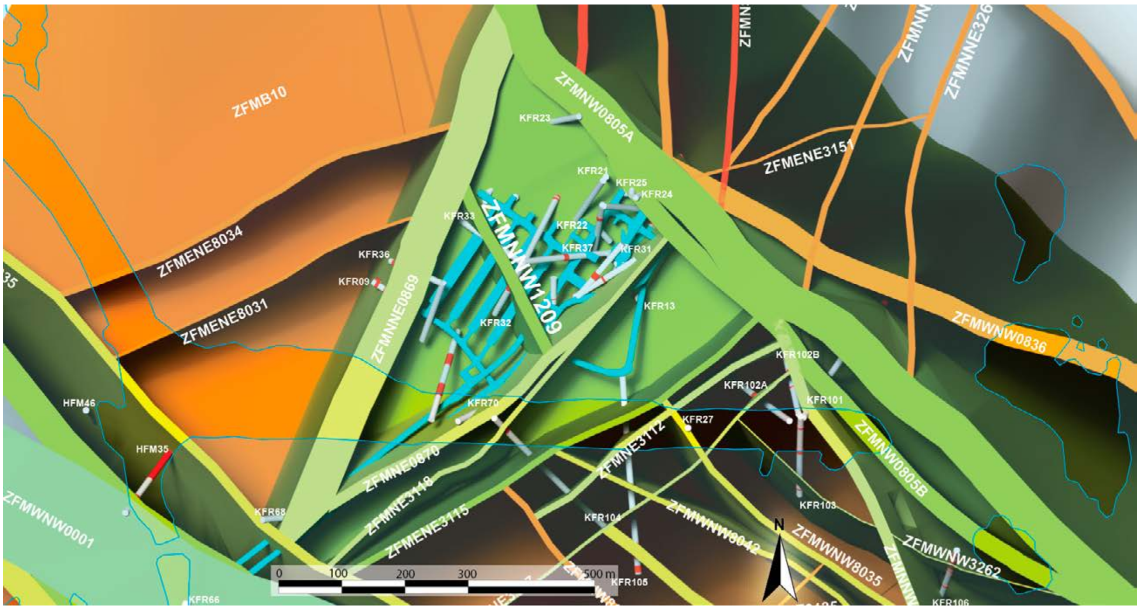
Borehole	PDZ	Target intercept		Geometric intercept		Comment
		Sec_up [m]	Sec_low [m]	Sec_up [m]	Sec_low [m]	
KFR33		-	-	46.09	114.55	No SHI available.
KFR35	DZ1	32.70	70.00	32.88	71.01	

Tunnels:	DT target intercept 0+930 0+930 m, geometric intercept 0+920-0+945 m. BT target intercept 0+893-0+893 m, geometric intercept 0+885-0+907 m. NBT target intercept - , geometric intercept 0+000-0+010 m. 1BTF target intercept 0+100-0+100 m, geometric intercept 0+090-0+117 m. 2BTF target intercept: 0+078-0+080 m, geometric intercept 0+070-0+090 m. BLA target intercept: 0+055-0+060 m, geometric intercept 0+048-0+068 m. BMA target intercept:0+030-0+030 m, geometric intercept 0+030-0+055 m.	
Lineament and/or seismic indications:	MFM3114G.	1

MODELLING PROCEDURE

Adopted from geological model for SFR (Axelsson and Hansen 199). Extended so as to be truncated against ZFMNNE0869 (zone 3 at SFR) and ZFMNE0870 (zone 9 at SFR). Modelled to a depth of 350 m. Inferred to be a minor zone. Intercepted by KFR35 (33-70 m , DZ1).

NNW	ZFMNNW1209	Version number	4	Total object CL	22



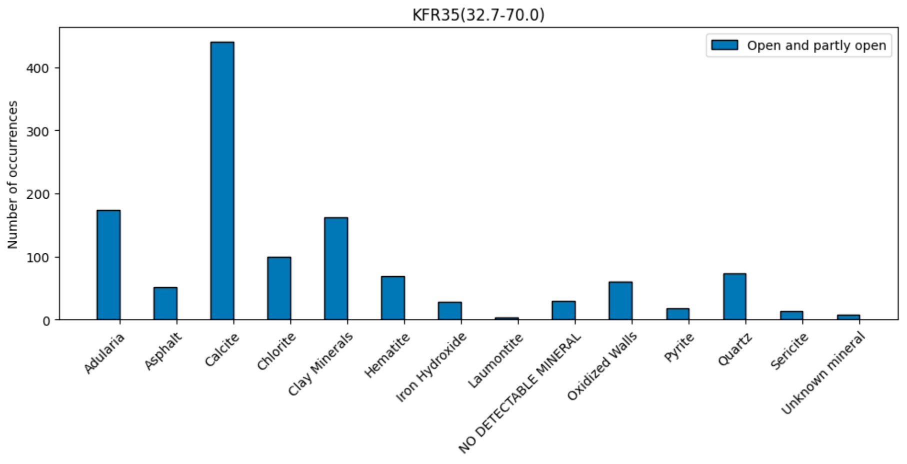
OBJECT CONFIDENCE ESTIMATE

Category	Object CL	Comment
INTERPRETATION		
Data source	3	MFM3114G, KFR33, KFR35, and at least observed in four storage caverns in SFR facility (Axelsson and Hansen 1997).
Results of interpretation	3	High confidence observation in KFR35 and tunnels.
INFORMATION DENSITY		
Number of observation points	3	>4
Distribution of observation points	3	Even distribution of obs. points.
INTERPOLATION		
Geometry	3	One strong interpolation alternative due to observation of the zone from multiple tunnels.
Geological indicators	3	Supported by key geological parameters.
EXTRAPOLATION		
Dip direction	2	Extrapolation in dip direction supported by subsurface obs. point. Strike length of the modelled zone < 2000 m.
Strike direction	2	Supported by geological concept and partly by surface lineament.

FRACTURE CHARACTER

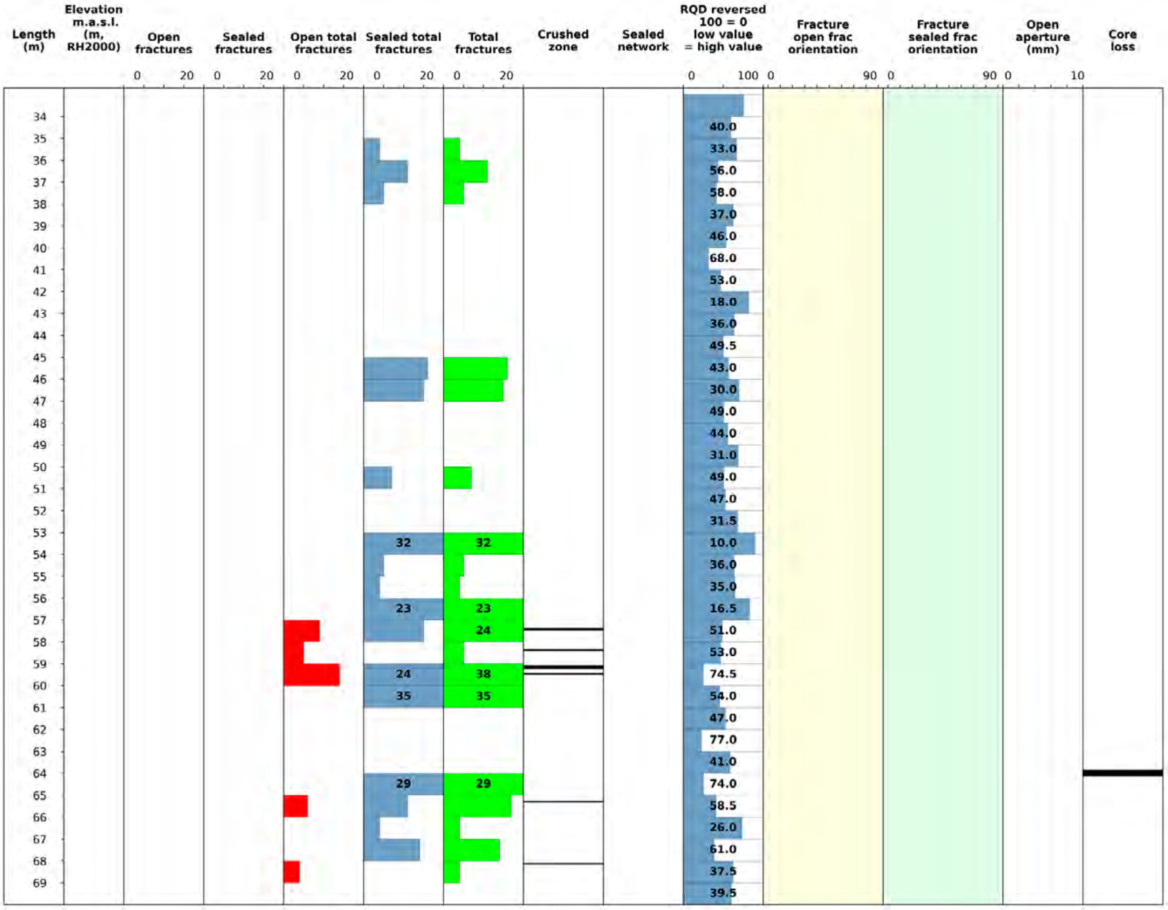
Orientation: (strike/dip right-hand-rule)	--
Frequency:	Boreholes: KFR33, KFR35
RQD:	min:10, max:77, mean:43

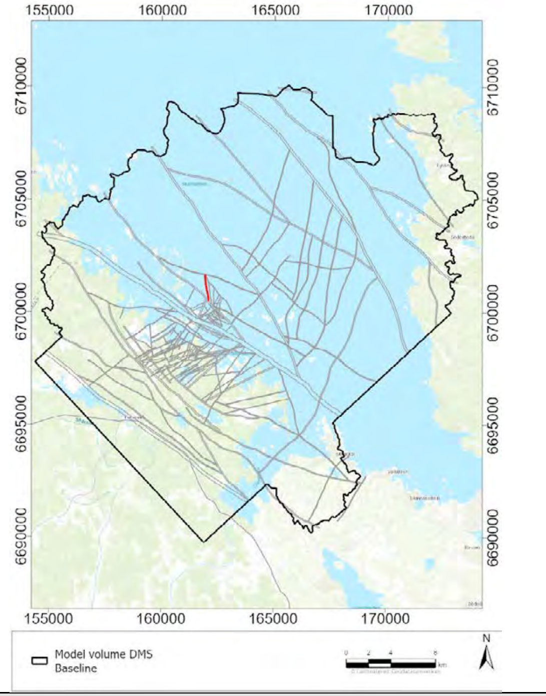
FRACTURE TYPE	TERZAGHI-WEIGHED P10
Open and partly open	9.1 m-1
Sealed	0.0 m-1
Sealed network	0.0 % of DZ intercept
Crush	0.8 % of DZ intercept

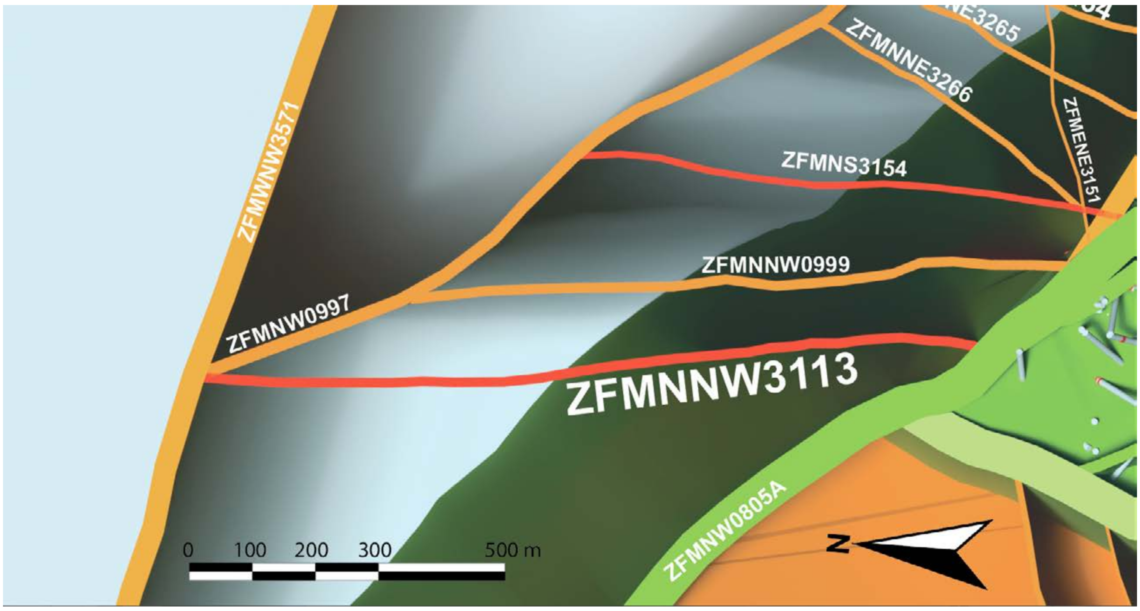
NNW	ZFMNNW1209	Version number	4	Total object CL	22
Fracture fill mineralogy:					

NNW	ZFMNNW1209	Version number	4	Total object CL	22
INDIVIDUAL INTERCEPTS					
KFR33 (46.09-114.55 m)					
No data available					

KFR35 DZ1 (32.7-70.0 m)



NNW	ZFMNNW3113		Version number	11	Total object CL	9
GEOLOGICAL CHARACTER		**Property CL**				
Deformation style:	No data available					
Deformation description:	No data available.					
Alteration:						
- First order:	Not observed					
- Second order:	Not observed					
- Third order:	Not observed					
Fracture orientation and type:	No data available.					
Fracture comment:	No data available.					
Fracture fill mineralogy:	No data available.					
OBJECT GEOMETRY						
Strike/dip:	172°/90°					
Length:	1234 m					
Mean thickness:	15 m (3 - 50 m)					
Max depth:	-1250 m					
Geometrical constraints:	ZFMNW0805A, Topo 40m grid Max error 20m, ZFMWNW3571, 1 Surface Planar Cut(s).					
BASIS FOR MODELLING						
Zone based on surface lineaments.						
Outcrops:	-					
Boreholes: -						
Tunnels:	-					
Lineament and/or seismic indications:	MSFR08079, MFM3581.					1
MODELLING PROCEDURE						
The position of the zone at the ground surface is based on magnetic lineament MSFR08079 in SFR model version 1.0, being a very minor revision of lineament MFM3113G in Forsmark stage 2.3 (Isaksson et al. 2007). The earlier number has been maintained for traceability purposes in different lineament interpretations. The modelled thickness and dip are default values.						



NNW	ZFMNNW3113	Version number	11	Total object CL	9

OBJECT CONFIDENCE ESTIMATE

Category	Object CL	Comment
INTERPRETATION		
Data source	1	MFM3113G, MSFR08079, MFM3581
Results of interpretation	1	Low confidence in lineament MFM3113G.
INFORMATION DENSITY		
Number of observation points	1	1
Distribution of observation points	1	Single observation point in the form of lineaments.
INTERPOLATION		
Geometry	1	Geometry supported by surface geophysical data.
Geological indicators	1	Indirect support by geophysical data.
EXTRAPOLATION		
Dip direction	1	No subsurface obs. point, supported only by surface data. High uncertainty in dip-direction. Strike length of the modelled zone < 2000 m.
Strike direction	2	Supported by geological concept and partly by surface lineament.

FRACTURE CHARACTER

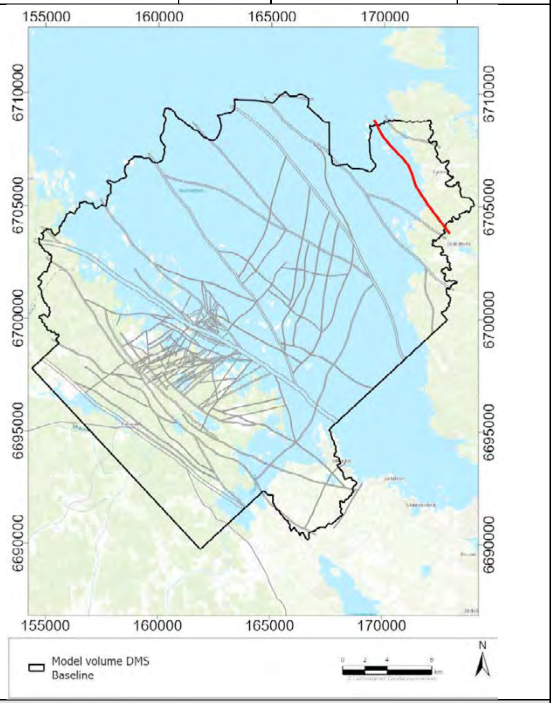
No data available

INDIVIDUAL INTERCEPTS

No data available

NNW	ZFMNNW3524	Version number	3	Total object CL	13

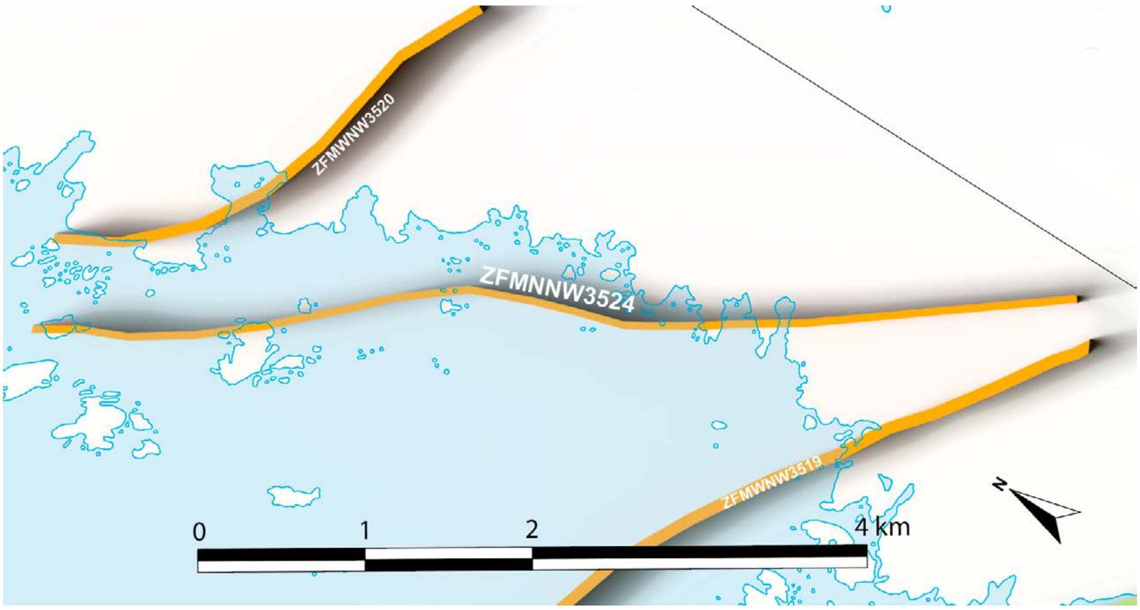
GEOLOGICAL CHARACTER		Property CL
Deformation style:	No data available	
Deformation description:	No data available. Zone based on lineament maps in the catchment area.	
Alteration:		
- First order:	Not observed	
- Second order:	Not observed	
- Third order:	Not observed	
Fracture orientation and type:	No data available.	
Fracture comment:	No data available.	
Fracture fill mineralogy:	No data available.	



OBJECT GEOMETRY	
Strike/dip:	147°/90°
Length:	7671 m
Mean thickness:	45 m (15 - 64 m)
Max depth:	-2100 m
Geometrical constraints:	Topo 40m grid Max error 20m, ZFMWNW3519, 2 Surface Planar Cut(s).

BASIS FOR MODELLING		
Zone based on surface lineament.		
Outcrops:	-	
Boreholes: -		
Tunnels:	-	
Lineament and/or seismic indications:	MFM3524.	2

MODELLING PROCEDURE
-



NNW	ZFMNNW3524	Version number	3	Total object CL	13

OBJECT CONFIDENCE ESTIMATE

Category	Object CL	Comment
INTERPRETATION		
Data source	1	MFM3524
Results of interpretation	2	Medium confidence in lineament MFM3524.
INFORMATION DENSITY		
Number of observation points	1	1
Distribution of observation points	1	Single observation point in the form of a lineament.
INTERPOLATION		
Geometry	1	Geometry supported by surface geophysical data.
Geological indicators	1	Indirect support by geophysical data.
EXTRAPOLATION		
Dip direction	3	Extrapolated to the base of the model volume. Strike length of the modelled zone > 2000 m.
Strike direction	3	Conceptual understanding of the site and that the entire modelled zone is supported by the lineament.

FRACTURE CHARACTER

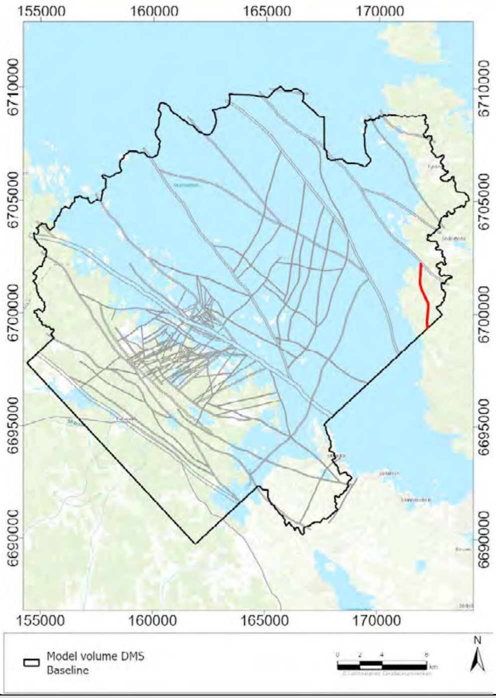
No data available

INDIVIDUAL INTERCEPTS

No data available

NNW	ZFMNNW3534	Version number	3	Total object CL	11

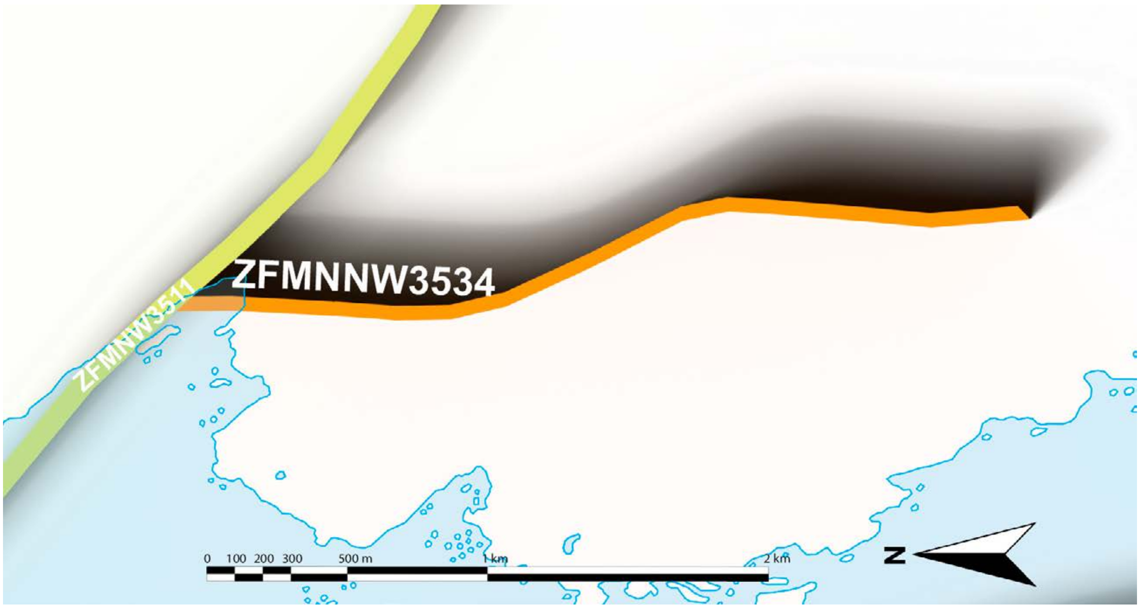
GEOLOGICAL CHARACTER		Property CL
Deformation style:	No data available	
Deformation description:	No data available. Zone based on lineament maps in the catchment area.	
Alteration:		
- First order:	Not observed	
- Second order:	Not observed	
- Third order:	Not observed	
Fracture orientation and type:	No data available.	
Fracture comment:	No data available.	
Fracture fill mineralogy:	No data available.	



OBJECT GEOMETRY	
Strike/dip:	174°/90°
Length:	9158 m
Mean thickness:	50 m (15 - 64 m)
Max depth:	-2100 m
Geometrical constraints:	Topo 40m grid Max error 20m, ZFMNW3511, 1 Surface Planar Cut(s).

BASIS FOR MODELLING		
Zone based on surface lineament.		
Outcrops:	-	
Boreholes: -		
Tunnels:	-	
Lineament and/or seismic indications:	MFM3534.	2

MODELLING PROCEDURE
-



NNW	ZFMNNW3534	Version number	3	Total object CL	11

OBJECT CONFIDENCE ESTIMATE

Category	Object CL	Comment
INTERPRETATION		
Data source	1	MFM3534. The zone is partly based on the interpreted surface lineament.
Results of interpretation	2	Medium confidence in lineament MFM3534.
INFORMATION DENSITY		
Number of observation points	1	1
Distribution of observation points	1	Single observation point in the form of a lineament.
INTERPOLATION		
Geometry	1	Geometry supported by surface geophysical data.
Geological indicators	1	Indirect support by geophysical data.
EXTRAPOLATION		
Dip direction	1	No subsurface obs. point, supported only by surface data. High uncertainty in dip-direction. Strike length of the modelled zone < 2000 m.
Strike direction	3	Conceptual understanding of the site and that the entire modelled zone is supported by the lineament.

FRACTURE CHARACTER

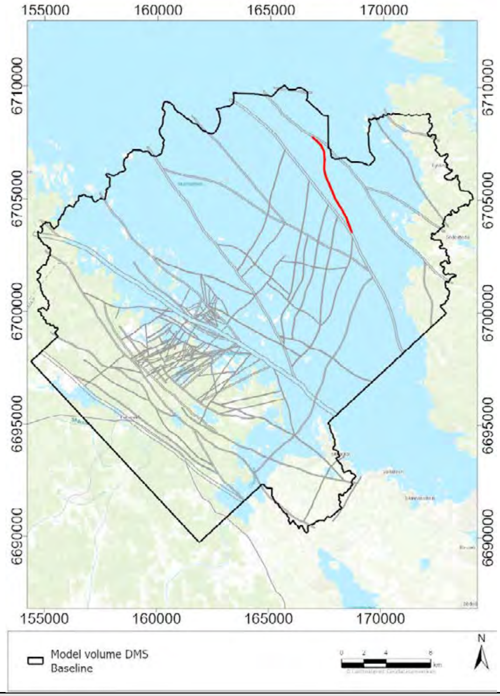
No data available

INDIVIDUAL INTERCEPTS

No data available

NNW	ZFMNNW3550	Version number	3	Total object CL	10

GEOLOGICAL CHARACTER		Property CL
Deformation style:	No data available	
Deformation description:	No data available. Zone based on lineament maps in the catchment area.	
Alteration:		
- First order:	Not observed	
- Second order:	Not observed	
- Third order:	Not observed	
Fracture orientation and type:	No data available.	
Fracture comment:	No data available.	
Fracture fill mineralogy:	No data available.	
OBJECT GEOMETRY		
Strike/dip:	159°/90°	
Length:	5041 m	
Mean thickness:	35 m (15 - 64 m)	
Max depth:	-2100 m	
Geometrical constraints:	Topo 40m grid Max error 20m, ZFMNW0854, ZFMNW3511.	



BASIS FOR MODELLING

Zone based on surface lineament.

Outcrops:	-	
Boreholes: -		
Tunnels:	-	
Lineament and/or seismic indications:	MFM3535.	3

MODELLING PROCEDURE

-

NNW	ZFMNNW3550	Version number	3	Total object CL	10

OBJECT CONFIDENCE ESTIMATE

Category	Object CL	Comment
INTERPRETATION		
Data source	1	MFM3535
Results of interpretation	1	Low confidence in lineament MFM3535.
INFORMATION DENSITY		
Number of observation points	1	1
Distribution of observation points	1	Single observation point in the form of a lineament.
INTERPOLATION		
Geometry	1	Geometry supported by surface geophysical data.
Geological indicators	1	Indirect support by geophysical data.
EXTRAPOLATION		
Dip direction	1	No subsurface obs. point, supported only by surface data. High uncertainty in dip-direction. Strike length of the modelled zone < 2000 m.
Strike direction	3	Conceptual understanding of the site and that the entire modelled zone is supported by the lineament.

FRACTURE CHARACTER

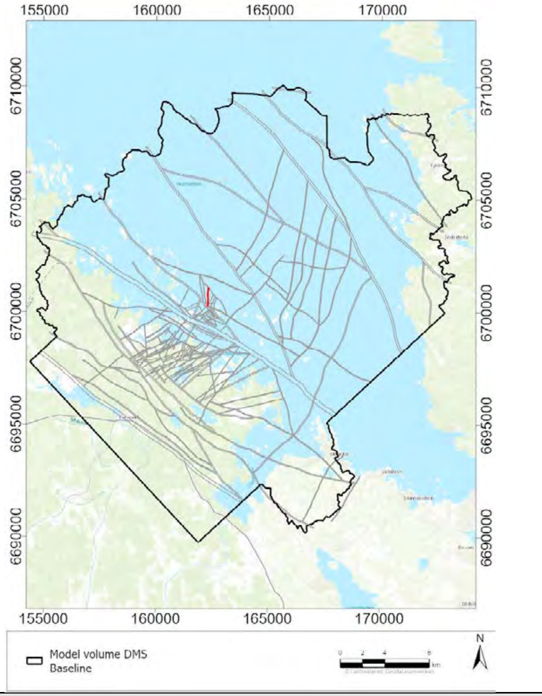
No data available

INDIVIDUAL INTERCEPTS

No data available

NS	ZFMNS3154	Version number	12	Total object CL	9

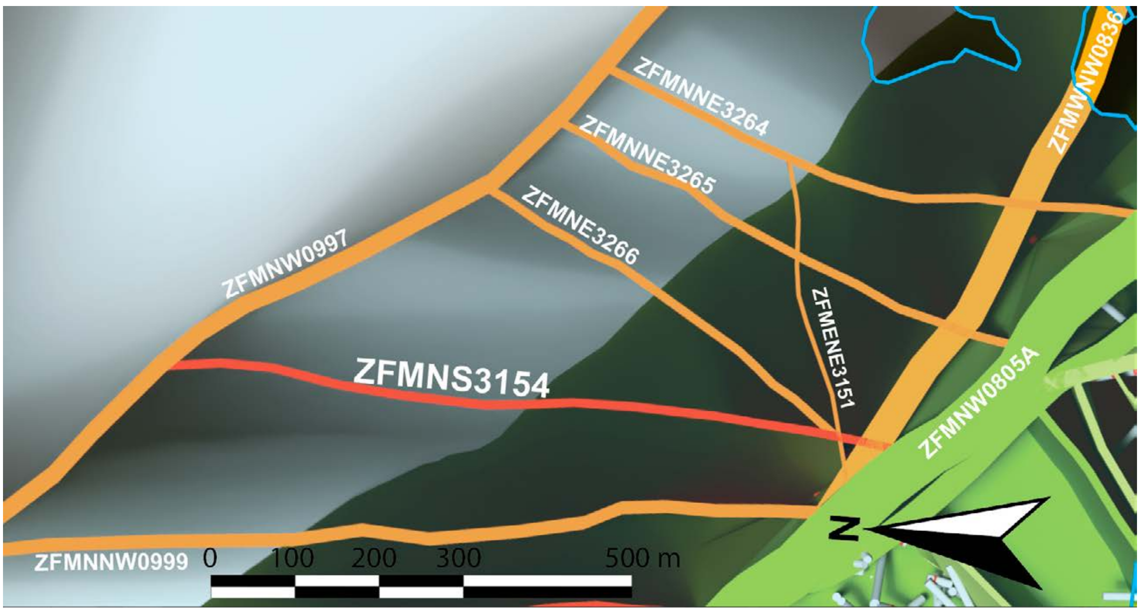
GEOLOGICAL CHARACTER		Property CL
Deformation style:	No data available	
Deformation description:	No data available. Zone based on lineament maps in the catchment area.	
Alteration:		
- First order:	Not observed	
- Second order:	Not observed	
- Third order:	Not observed	
Fracture orientation and type:	No data available.	
Fracture comment:	No data available.	
Fracture fill mineralogy:	No data available.	



OBJECT GEOMETRY	
Strike/dip:	2°/90°
Length:	885 m
Mean thickness:	10 m (2 - 36 m)
Max depth:	-890 m
Geometrical constraints:	ZFMNW0805A, Topo 40m grid Max error 20m, ZFMNW0997, 1 Surface Planar Cut(s).

BASIS FOR MODELLING		
Zone based on surface lineaments.		
Outcrops:	-	
Boreholes: -		
Tunnels:	-	
Lineament and/or seismic indications:	MSFR08012, MSFR08013, MSFR08014, MSFFR08015.	1

MODELLING PROCEDURE
The position of the zone at the ground surface is based on the magnetic lineament MFM3154G (Isaksson et al. 2007). This lineament was subsequently broken up and modelled at a higher resolution as lineaments MSFR08012, MSFR08013, MSFR08014 and MSFFR08015 during SFR model version 1.0. The SFR model version 1.0 interpretation is considered as equally valid as the earlier stage 2.3 interpretation. However, the latter suits more favourably the DZ modelling resolution in the SFR regional model and, for this reason, the earlier name has been maintained. Forward modelling of magnetic data along profiles 5 and 6 (see Appendix 6, Curtis et al. 2011) supports the earlier assumed vertical dip of the zone. The modelled thickness and dip of the zone are default values.



NS	ZFMNS3154	Version number	12	Total object CL	9

OBJECT CONFIDENCE ESTIMATE

Category	Object CL	Comment
INTERPRETATION		
Data source	1	MFM3154G
Results of interpretation	1	Low confidence in lineament MFM3154G.
INFORMATION DENSITY		
Number of observation points	1	1
Distribution of observation points	1	Single observation point in the form of a lineament.
INTERPOLATION		
Geometry	1	Geometry supported by surface geophysical data.
Geological indicators	1	Indirect support by geophysical data.
EXTRAPOLATION		
Dip direction	1	No subsurface obs. point, supported only by surface data. High uncertainty in dip-direction. Strike length of the modelled zone < 2000 m.
Strike direction	2	Supported by geological concept and partly by surface lineament.

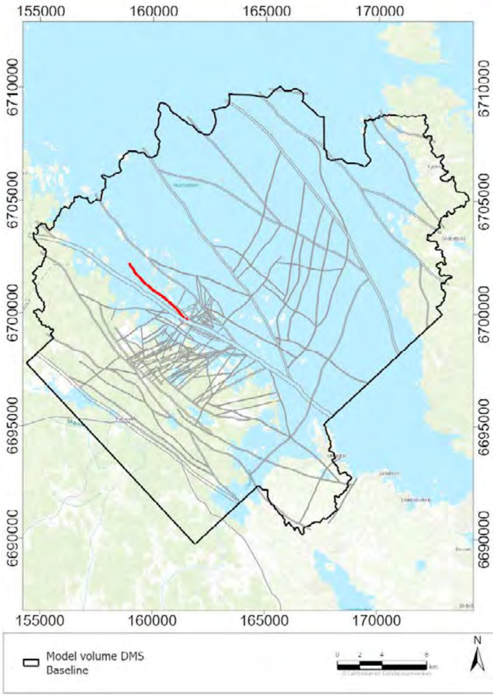
FRACTURE CHARACTER

No data available

INDIVIDUAL INTERCEPTS

No data available

NW	ZFMNW0002	Version number	8	Total object CL	22



GEOLOGICAL CHARACTER		Property CL
Deformation style:	Brittle-Ductile	3
Deformation description:	Deformation zone with low-temperature (greenschist facies) ductile deformation and later, multiple-stage reactivation in the brittle regime. Mylonite, cataclastic texture and fault breccia prominent at several outcrops along the zone. Zone situated within a broad belt (c. 1200 m) of intense high-temperature (amphibolite facies) ductile deformation south-west of the tectonic lens at Forsmark. Dextral strike-slip component of displacement during low-temperature ductile deformation. Shear bands in foliated pegmatite along segment of the zone.	
Alteration:		3
- First order:	Oxidation	
- Second order:	Chloritization	
- Third order:	Not observed	
Fracture orientation and type:	Low fracture frequency along tunnel 3, SFR (open fractures?). No reliable data from SFR boreholes (percussion drilling).	1
Fracture comment:	Open fracture, apertures are generally less than 1 mm, with a few ranging up to 3 mm.	
Fracture fill mineralogy:	Chlorite, calcite.	

OBJECT GEOMETRY	
Strike/dip:	312°/90°
Length:	3895 m
Mean thickness:	50 m (50 - 200 m)
Max depth:	-2100 m
Geometrical constraints:	Topo 40m grid Max error 20m, ZFMWNW0001, 1 UNIVERSE Planar Cut(s).

BASIS FOR MODELLING

Zone based on surface lineaments, outcrop observations, borehole and tunnel observations.

Outcrops: PFM001637

Boreholes:

Borehole	PDZ	Target intercept		Geometric intercept		Comment
		Sec_up [m]	Sec_low [m]	Sec_up [m]	Sec_low [m]	
HFM35	DZ1	24.00	52.50	41.38	54.81	DZ1 also lies within ZFMWNW0001.
HFM35	DZ2	24.00	52.50	41.38	54.81	DZ2 also lies within ZFMWNW0001.

Tunnels:	DT target intercept 0+309 - 0+372 m, geometric intercept 0+310 - 0+365 m, BT target intercept 0+297 - 0+347 m, geometric intercept 0+292 - 0+345 m.	
Lineament and/or seismic indications:	MFM0804 merged.	2

NW	ZFMNW0002	Version number	8	Total object CL	22

MODELLING PROCEDURE

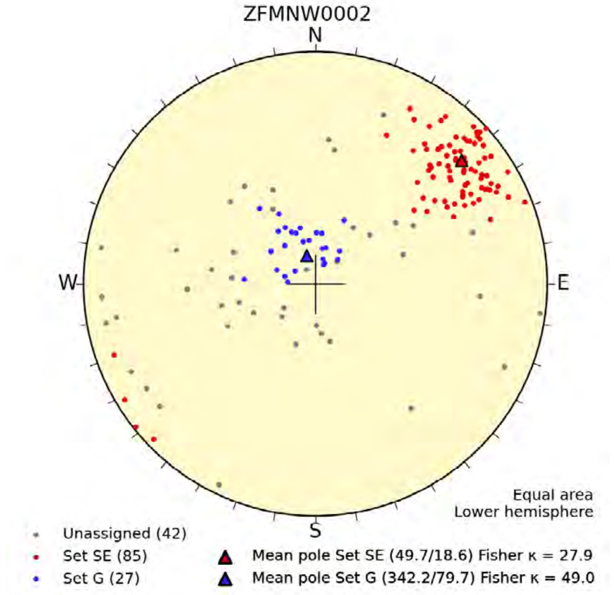
At the surface, corresponds to the low magnetic lineament MFM0804. Modelled to the base of the model volume using dip that has been inferred from data along the near-surface tunnel 3. Zone ZFMNW0002, a splay of the major, regionally significant Singö zone, is itself a regional deformation zone interpreted as having a length of 18 km Stephens et al. (2007). The position of the zone is based on the magnetic lineament MSFR08085 in SFR model version 1.0, which has a slightly modified alignment at its south-east end, both in relation to MFM0804G in the stage 2.3 lineament interpretation Isaksson et al. (2007) and lineament MFM0804 used in the modelling work during model stage 2.2 Stephens et al. (2007). The zone was identified in tunnel 3 at Forsmark (see Fig. 5-9 in Carlsson and Christiansson (1987). The zone was also reported earlier at SFR in Carlsson et al. (1985) as 'zone 1' described as not being very pronounced in the SFR tunnel, consisting of sheet fractured rock and partly crushed rock. The zone was attributed a thickness of 7 to 10 m. The thickness has been modified solely on the basis of reference to the mapping in the SFR DT and BT tunnels. Outside of the SFR regional model volume, in Forsmark tunnel 3 the zone thickness was reported as 75 m. The property assessment by Stephens et al. (2007) for ZFMNW0002 was mainly based on information from the cooling water tunnel of Forsmark reactor 3. In this, ZFMNW0002 is described in terms of low fracture frequency (1 m–1) and ductile deformation characterized.

OBJECT CONFIDENCE ESTIMATE

Category	Object CL	Comment
INTERPRETATION		
Data source	3	MFM0804 merged, HFM35, PFM001637, BT, DT
Results of interpretation	3	High confidence observation in HFM35 and SFR tunnels.
INFORMATION DENSITY		
Number of observation points	3	>4
Distribution of observation points	2	Supported by surface geophysical data and information from tunnels of the SFR facility in addition to borehole intercepts HFM34 and HFM35.
INTERPOLATION		
Geometry	3	Geometry supported by sub-surface information in tunnels of SFR facility and drill hole HFM34 and HFM35.
Geological indicators	2	Interpolation supported by surface geophysical data and outcrop observations.
EXTRAPOLATION		
Dip direction	3	Extrapolated to the base of the model volume. Strike length of the modelled zone > 2000 m.
Strike direction	3	Conceptual understanding of the site and that the entire modelled zone is supported by the lineament.

NW	ZFMNW0002	Version number	8	Total object CL	22
FRACTURE CHARACTER					
Orientation: (strike/dip right-hand-rule)	Set SE: 139.7°/71.4° Set G: 72.2°/10.3°				
Frequency:	Boreholes: -				
RQD:	--				
Fracture fill mineralogy:	No data available				

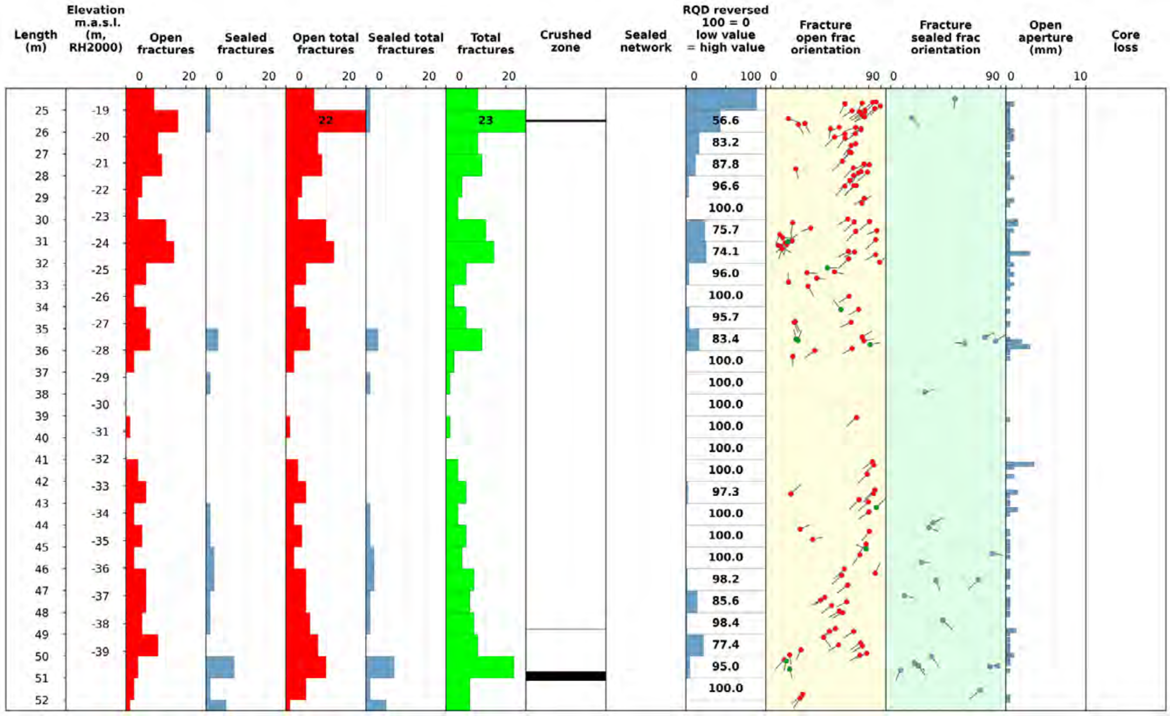
FRACTURE TYPE	TERZAGHI-WEIGHED P10
Open and partly open	0.0 m-1
Sealed	0.0 m-1
Sealed network	0.0 % of DZ intercept
Crush	0.0 % of DZ intercept

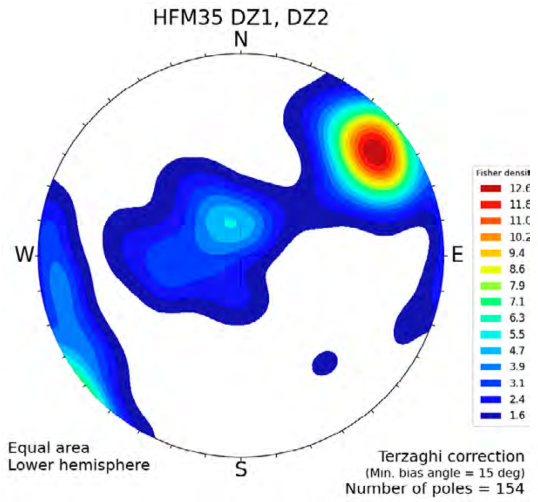


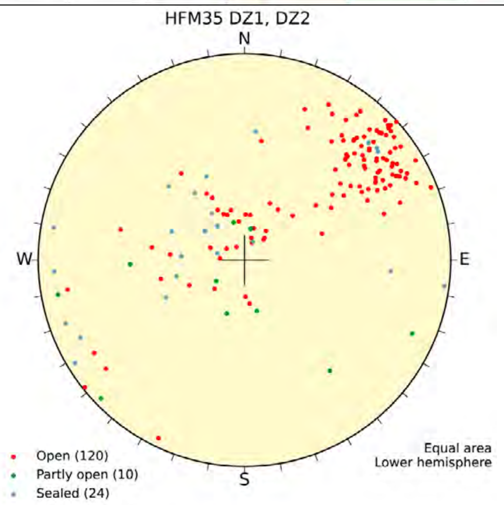
NW	ZFMNW0002	Version number	8	Total object CL	22

INDIVIDUAL INTERCEPTS

HFM35 DZ1, DZ2 (24.0-52.5 m)

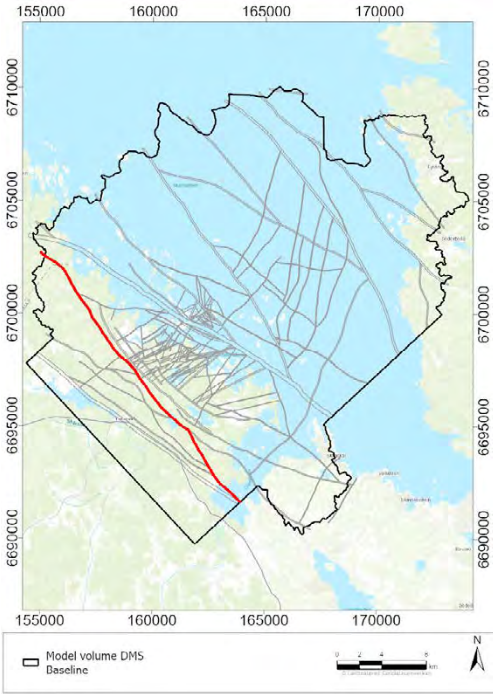






NW	ZFMNW0003	Version number	5	Total object CL	22

GEOLOGICAL CHARACTER		Property CL
Deformation style:	Brittle-Ductile	3
Deformation description:	Deformation zone with low-temperature (greenschist facies) ductile deformation and later, multiple-stage reactivation in the brittle regime. Mylonite, cataclastic texture and fault breccia prominent at several outcrops along the zone. Zone situated within a broad belt (c. 1200 m) of intense high-temperature amphibolite facies) ductile deformation south-west of the tectonic lens at Forsmark. Steeply dipping faults with NNW strike, epidote striae shows sinistral strike slip displacement. NW compression steeply dipping faults with NW strike, epidote striae shows dextral reverse slip displacement and NS compression. Epidote-filled tension gashes along steeply dipping fractures with NS strike indicate EW extension. A fault with gentle dip to SSE, epidote and chlorite striae shows dip-slip displacement. Younger, steeply dipping faults with ENE and NNE to NE strike offset steep NW structures. Inferred conjugate set with sinistral strike-slip and dextral strike-slip displacement, respectively shows NE compression.	
Alteration:		3
- First order:	Oxidation	
- Second order:	Not observed	
- Third order:	Not observed	
Fracture orientation and type:	Steeply dipping fractures that strike SE dominates. Gently dipping and NE steeply-dipping fractures are also present. Dominance of sealed fractures followed by open and partly open. Quantitative estimate and span include sealed fracture networks.	3
Fracture comment:	No data available.	
Fracture fill mineralogy:	Surface geology: Epidote, quartz, calcite, chlorite.	
OBJECT GEOMETRY		
Strike/dip:	141°/85°	
Length:	16790 m	
Mean thickness:	53 m (50 - 200 m)	
Max depth:	-2100 m	
Geometrical constraints:	Topo 40m grid Max error 20m, ZFMWNW0004, 2 Surface Planar Cut(s).	



NW	ZFMNW0003	Version number	5	Total object CL	22

BASIS FOR MODELLING

Zone based on surface lineaments, outcrop and borehole observations.

Outcrops: PFM07086−PFM07095

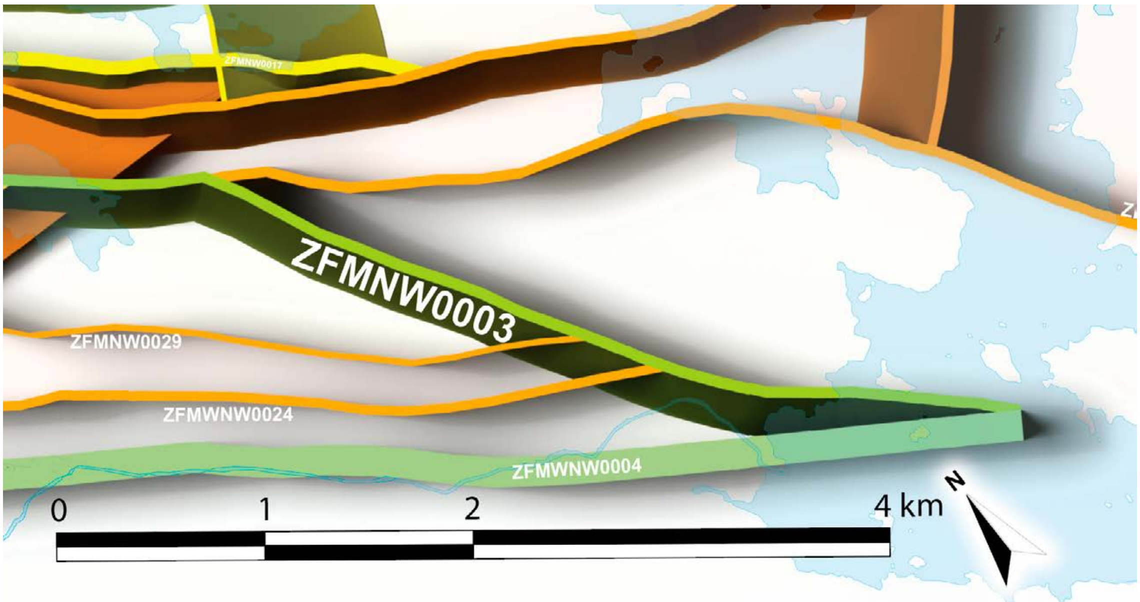
Boreholes:

Borehole	PDZ	Target intercept		Geometric intercept		Comment
		Sec_up [m]	Sec_low [m]	Sec_up [m]	Sec_low [m]	
HFM11	DZ1	83.00	160.00	87.23	161.90	
HFM12	DZ1	91.00	179.00	98.54	183.98	170-179 m added (cf. Table 3-2 in Stephens et al. 2007).

Tunnels:	-	
Lineament and/or seismic indications:	MFM0015 merged.	3

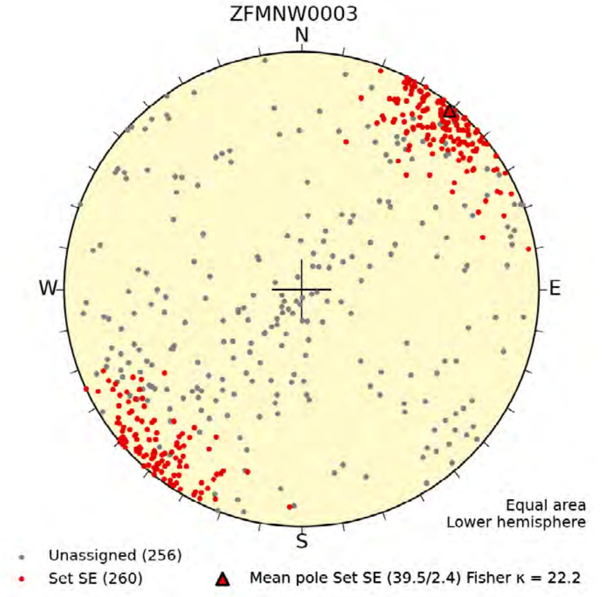
MODELLING PROCEDURE

At the surface, corresponds to the low magnetic lineament MFM0015. Modelled to base of model volume using dip estimated by connecting lineament MFM0015 at the surface with the borehole intersections 83- 160 m in HFM11 (DZ1) and 91-179 m in HFM12 (DZ1 and extension). Deformation zone plane placed in the central part of the more highly fractured intervals in the upper part of DZ1 in HFM11 and in the lower part of DZ1 in HFM12, i.e. the south-western part of the zone.



OBJECT CONFIDENCE ESTIMATE

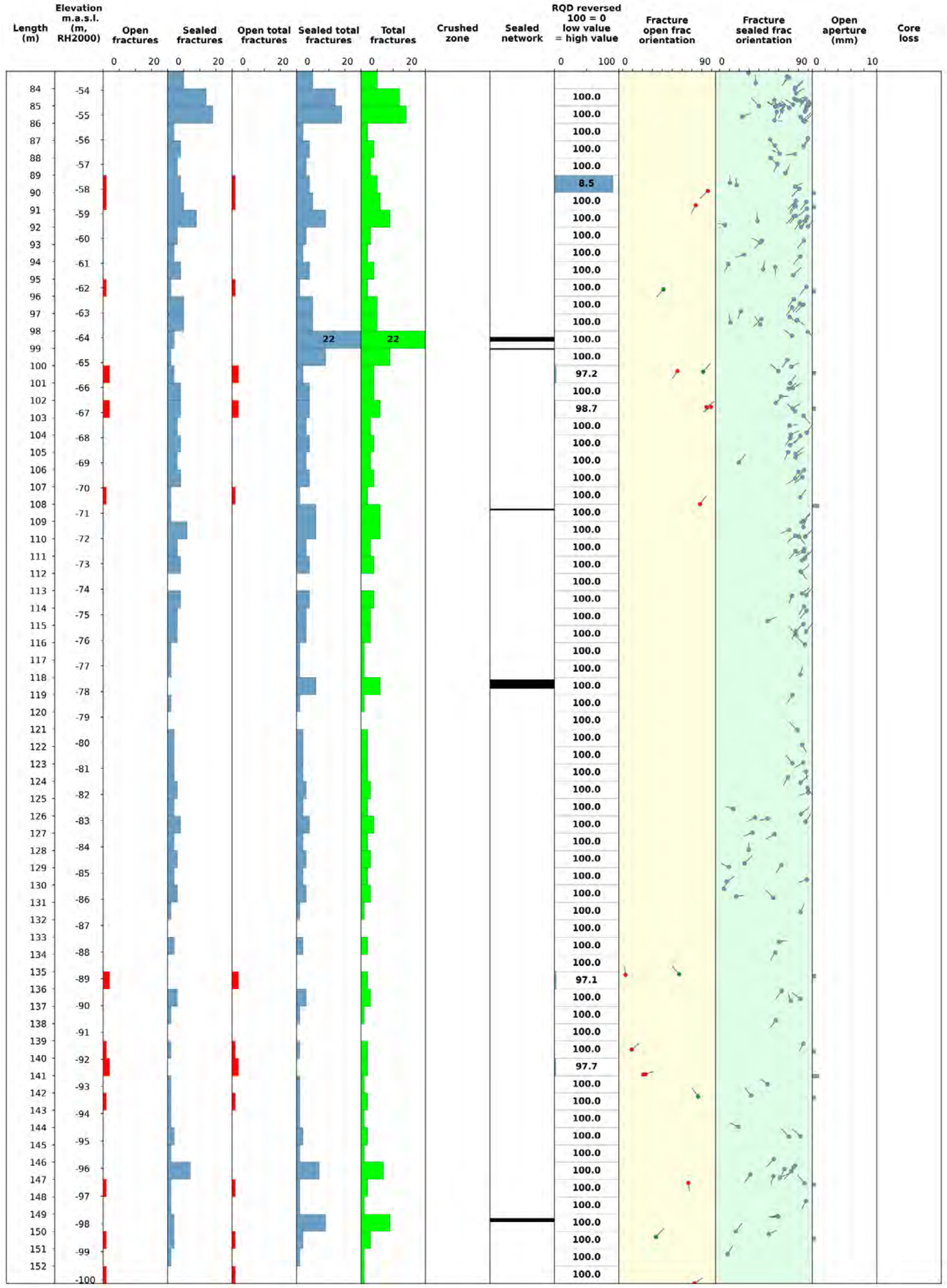
Category	Object CL	Comment
INTERPRETATION		
Data source	3	MFM0015 merged, HFM11, HFM12, PFM001637, PFM000276, PFM007095
Results of interpretation	3	High confidence observation in HFM11 and HFM12.
INFORMATION DENSITY		
Number of observation points	3	>4
Distribution of observation points	2	A group of clustered observation points and at least one or more outliers.
INTERPOLATION		
Geometry	3	Multiple localities mapped at surface supporting one strong alternative.
Geological indicators	2	Interpolation supported by surface geophysical data and outcrop observations.
EXTRAPOLATION		
Dip direction	3	Extrapolated to the base of the model volume. Strike length of the modelled zone > 2000 m.
Strike direction	3	Conceptual understanding of the site and that the entire modelled zone is supported by the lineament.

<table>
<tr><td>NW</td><td>ZFMNW0003</td><td>Version number</td><td>5</td><td>Total object CL</td><td>22</td></tr>
<tr><td colspan="6">FRACTURE CHARACTER</td></tr>
<tr><td>Orientation:
(strike/dip right-hand-rule)</td><td>Set SE: 129.5°/87.6°</td><td colspan="4" rowspan="2">
</td></tr>
<tr><td>Frequency:</td><td>Boreholes: -
<table><tr><td>FRACTURE TYPE</td><td>TERZAGHI-WEIGHED P10</td></tr><tr><td>Open and partly open</td><td>0.0 m-1</td></tr><tr><td>Sealed</td><td>0.0 m-1</td></tr><tr><td>Sealed network</td><td>0.0 % of DZ intercept</td></tr><tr><td>Crush</td><td>0.0 % of DZ intercept</td></tr></table></td></tr>
<tr><td>RQD:</td><td>--</td><td colspan="4"></td></tr>
<tr><td>Fracture fill mineralogy:</td><td colspan="5">No data available</td></tr>
</table>

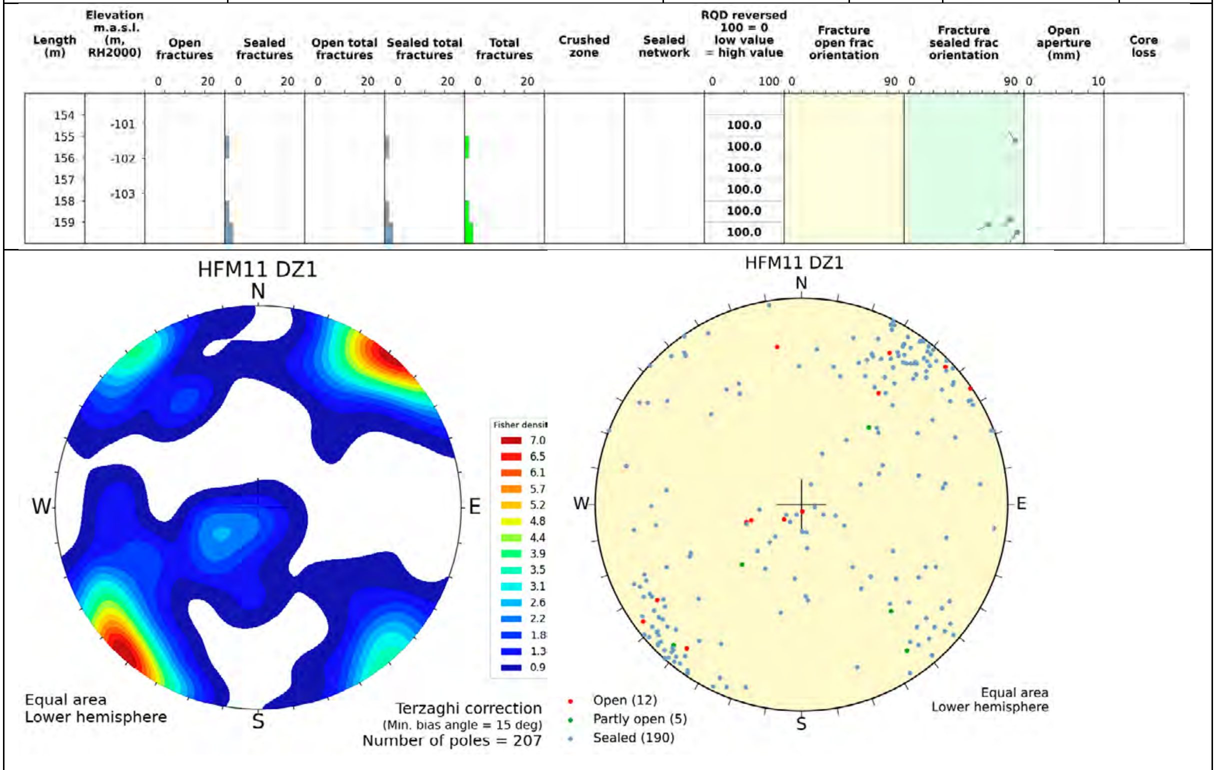
NW	ZFMNW0003	Version number	5	Total object CL	22

INDIVIDUAL INTERCEPTS

HFM11 DZ1 (83.0-160.0 m)

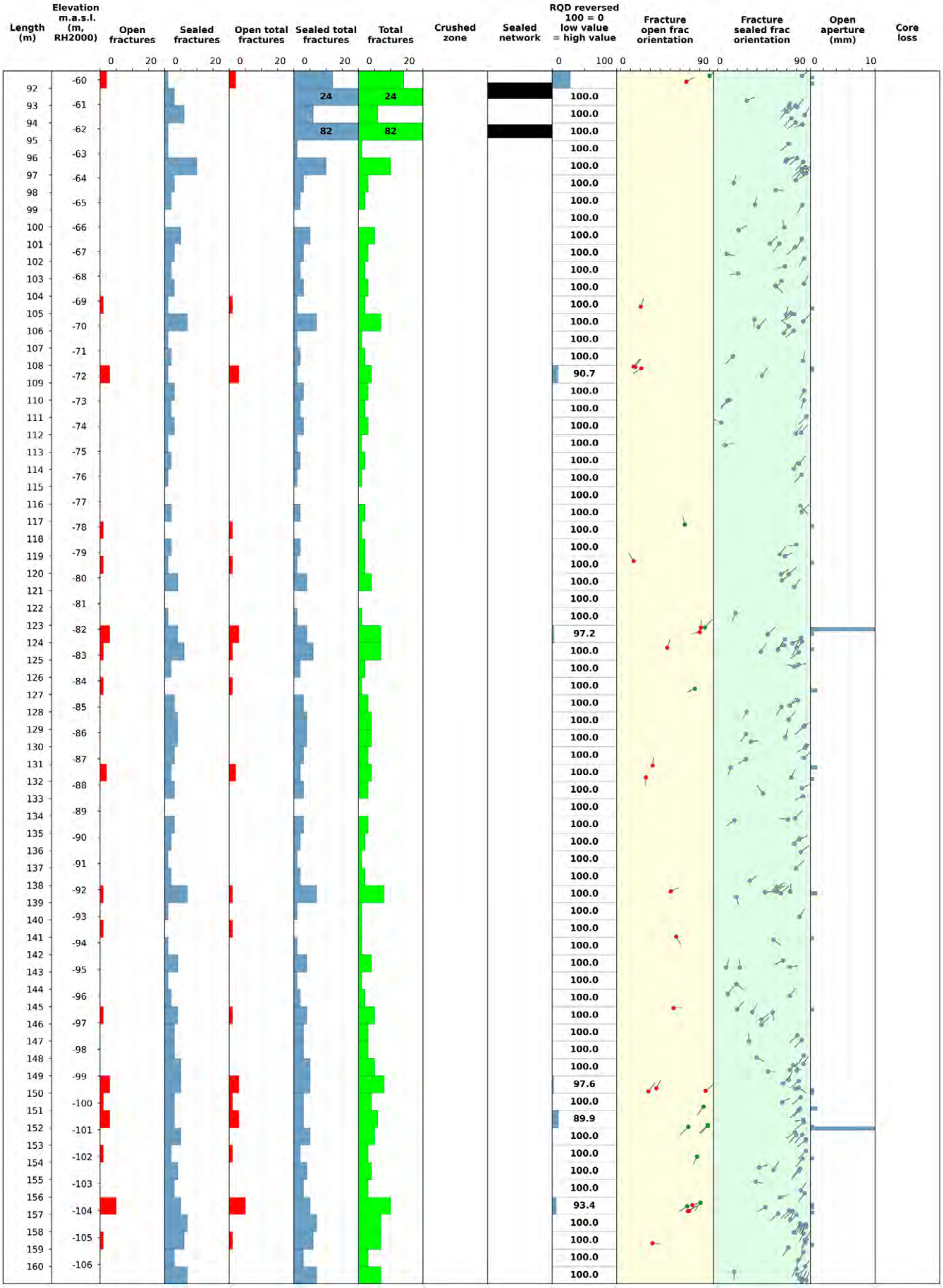


NW	ZFMNW0003	Version number	5	Total object CL	22

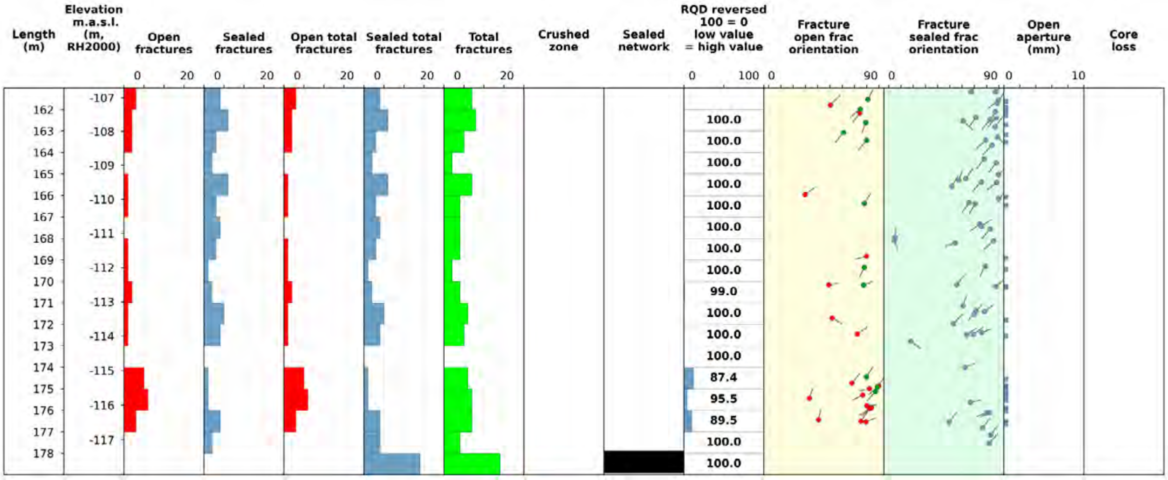


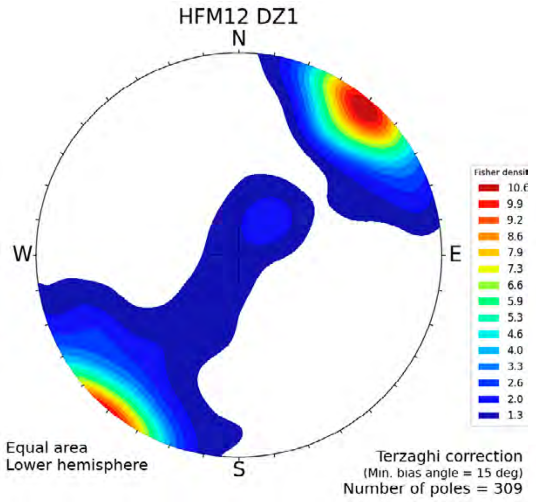
NW	ZFMNW0003	Version number	5	Total object CL	22

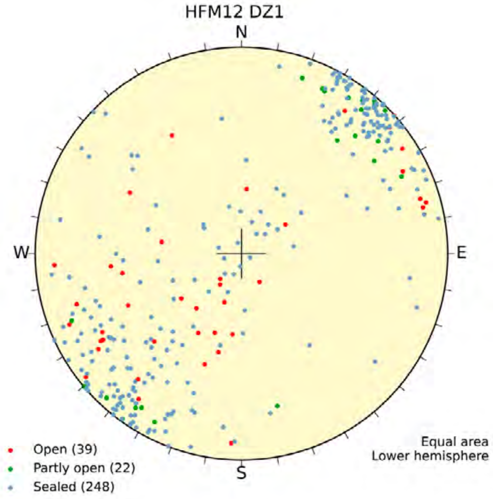
HFM12 DZ1 (91.0-179.0 m)



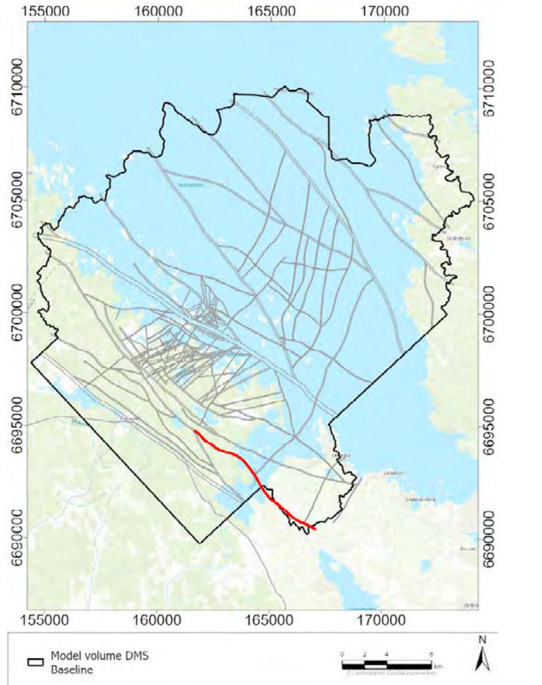
NW	ZFMNW0003	Version number	5	Total object CL	22





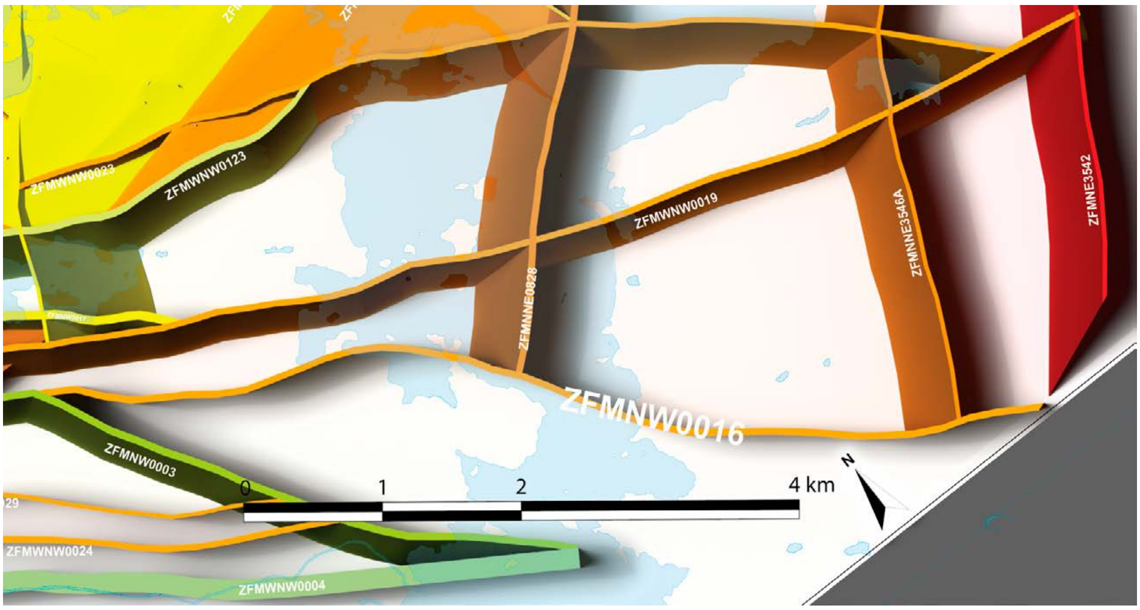


NW	ZFMNW0016		Version number	6	Total object CL	13
GEOLOGICAL CHARACTER		**Property CL**				
Deformation style:	Brittle-Ductile	1				
Deformation description:	No data available.					
Alteration:						
- First order:	Oxidation	2				
- Second order:	Not observed					
- Third order:	Not observed					
Fracture orientation and type:	No data available.					
Fracture comment:	No data available.					
Fracture fill mineralogy:	No data available.					
OBJECT GEOMETRY						
Strike/dip:	131°/90°					
Length:	10081 m					
Mean thickness:	50 m (50 - 200 m)					
Max depth:	-2100 m					
Geometrical constraints:	ZFMNW0003, Topo 40m grid Max error 20m, 1 Surface Planar Cut(s).					



BASIS FOR MODELLING		
Zone based on surface lineaments.		
Outcrops:	-	
Boreholes: -		
Tunnels:	-	
Lineament and/or seismic indications:	MFM0016 merged.	2

MODELLING PROCEDURE
At the surface, corresponds to the low magnetic lineament MFM0016. Modelled to the base of the model volume using an assumed dip of 90 degrees based on a comparison with high confidence, vertical and steeply dipping zones with WNW and NW strike.



NW	ZFMNW0016	Version number	6	Total object CL	13

OBJECT CONFIDENCE ESTIMATE

Category	Object CL	Comment
INTERPRETATION		
Data source	1	MFM0016 merged
Results of interpretation	2	Medium confidence in lineament MFM0016.
INFORMATION DENSITY		
Number of observation points	1	1
Distribution of observation points	1	Single observation point in the form of a lineament.
INTERPOLATION		
Geometry	1	Geometry supported by surface geophysical data.
Geological indicators	1	Indirect support by geophysical data.
EXTRAPOLATION		
Dip direction	3	Extrapolated to the base of the model volume. Strike length of the modelled zone > 2000 m.
Strike direction	3	Conceptual understanding of the site and that the entire modelled zone is supported by the lineament.

FRACTURE CHARACTER

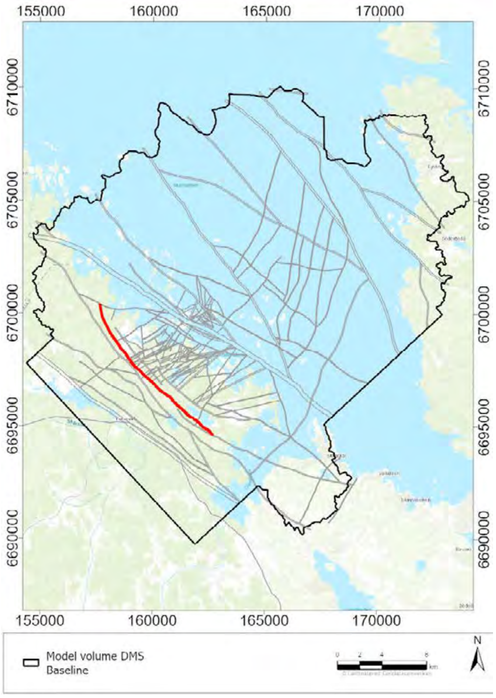
No data available

INDIVIDUAL INTERCEPTS

No data available

NW	ZFMNW0017	Version number	4	Total object CL	16

GEOLOGICAL CHARACTER		Property CL
Deformation style:	Brittle-Ductile	1
Deformation description:	No data available.	
Alteration:		1
- First order:	Oxidation	
- Second order:	Not observed	
- Third order:	Not observed	
Fracture orientation and type:	Fractures that strike SE and dip steeply to the SW dominates. Gently dipping fractures as well as steeply dipping fractures that vary in strike between NE and E are also prominent. Dominance of sealed followed by open and partly open fractures. Quantitative estimate and span include sealed fracture networks and crush zones.	
Fracture comment:	No data available.	
Fracture fill mineralogy:	No data from percussion borehole.	



OBJECT GEOMETRY	
Strike/dip:	137°/85°
Length:	7913 m
Mean thickness:	64 m (15 - 64 m)
Max depth:	-2100 m
Geometrical constraints:	ZFMWNW0137, ZFMWNW0019, Topo 40m grid Max error 20m.

BASIS FOR MODELLING

Zone based on surface lineaments and borehole observations.

Outcrops: -

Boreholes:

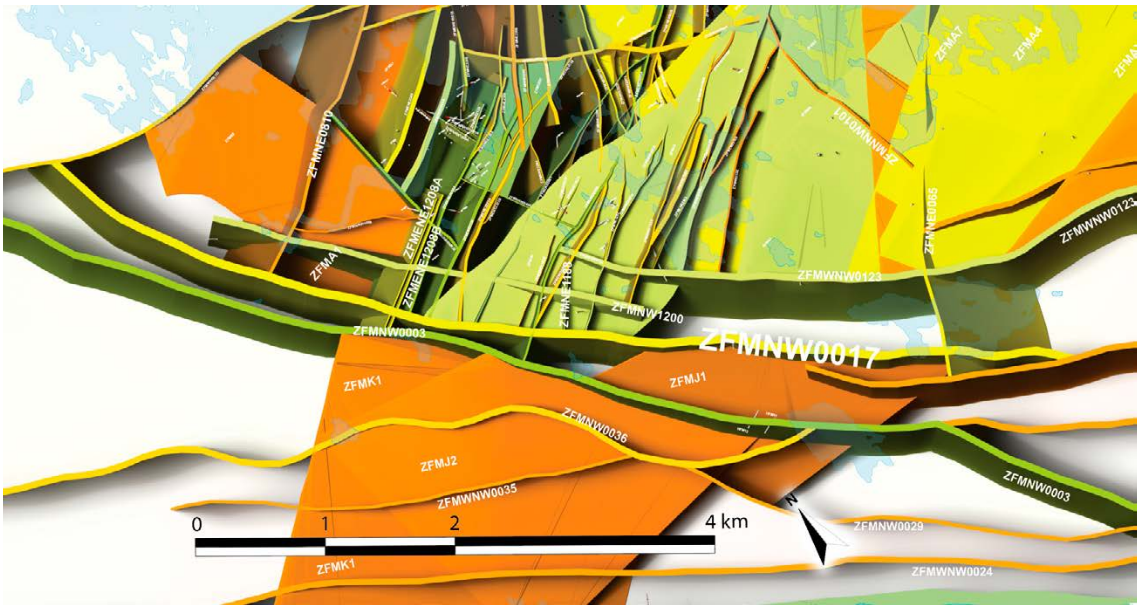
Borehole	PDZ	Target intercept		Geometric intercept		Comment
		Sec_up [m]	Sec_low [m]	Sec_up [m]	Sec_low [m]	
HFM30	DZ1	79.00	200.00	78.60	200.74	

Tunnels:	-	
Lineament and/or seismic indications:	MFM0017.	3

MODELLING PROCEDURE

At the surface, corresponds to the low magnetic lineament MFM0017. Modelled to base of model volume using the dip estimated by connecting lineament MFM0017 with the borehole intersection 79-200 m in HFM30 (DZ1). Deformation zone plane placed within core of zone that occurs along the borehole interval 158-167 m with a fixed point at 158 m. Decreased radar penetration along the borehole interval 158-167 m.

NW	ZFMNW0017	Version number	4	Total object CL	16



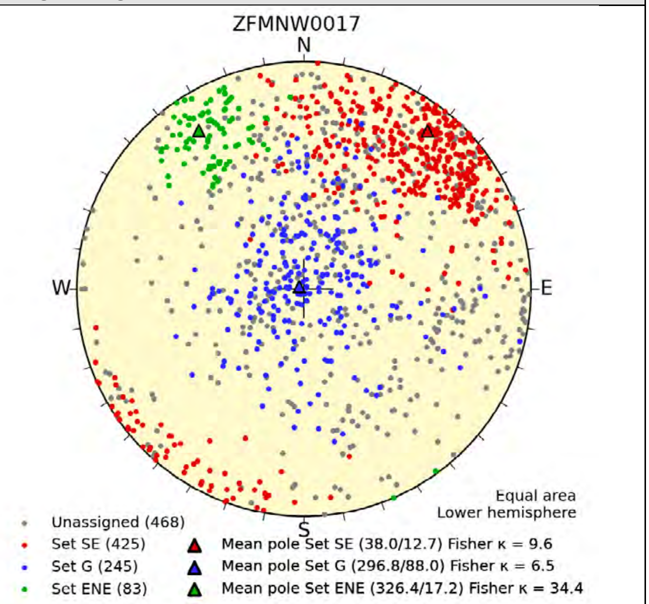
OBJECT CONFIDENCE ESTIMATE

Category	Object CL	Comment
INTERPRETATION		
Data source	2	MFM0017G merged, HFM30
Results of interpretation	3	High confidence observation in HFM30.
INFORMATION DENSITY		
Number of observation points	2	2
Distribution of observation points	1	Single observation point at depth and a surface lineament.
INTERPOLATION		
Geometry	1	Geometry supported by surface geophysical data.
Geological indicators	1	Indirect support by geophysical data.
EXTRAPOLATION		
Dip direction	3	Extrapolated to the base of the model volume. Strike length of the modelled zone > 2000 m.
Strike direction	3	Conceptual understanding of the site and that the entire modelled zone is supported by the lineament.

FRACTURE CHARACTER

Orientation: (strike/dip right-hand-rule)	Set SE: 128.0°/77.3° Set G: 26.8°/2.0° Set ENE: 56.4°/72.8°
Frequency:	Boreholes: -

FRACTURE TYPE	TERZAGHI-WEIGHED P10
Open and partly open	0.0 m-1
Sealed	0.0 m-1
Sealed network	0.0 % of DZ intercept
Crush	0.0 % of DZ intercept

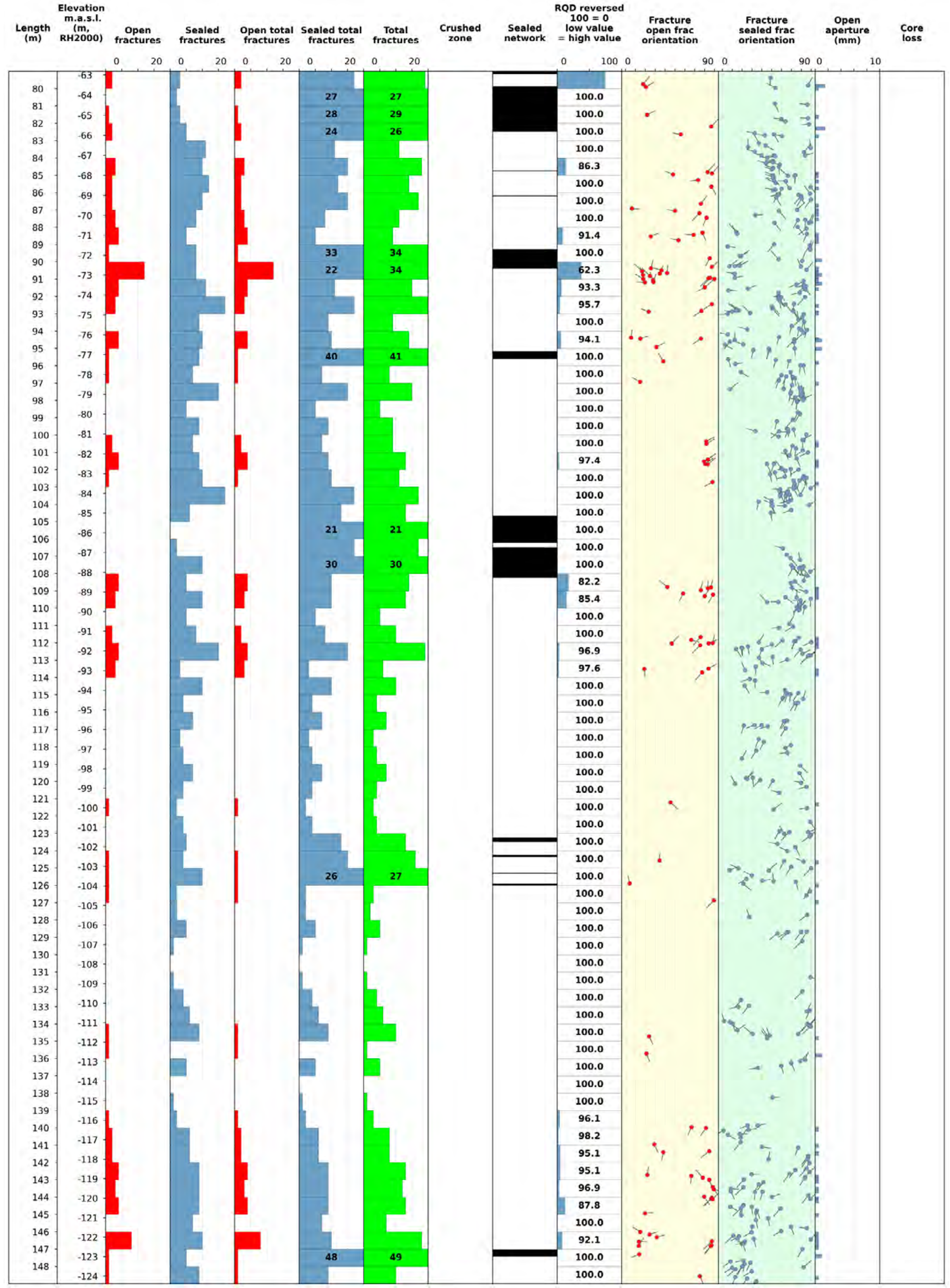


RQD:	--
Fracture fill mineralogy:	No data available

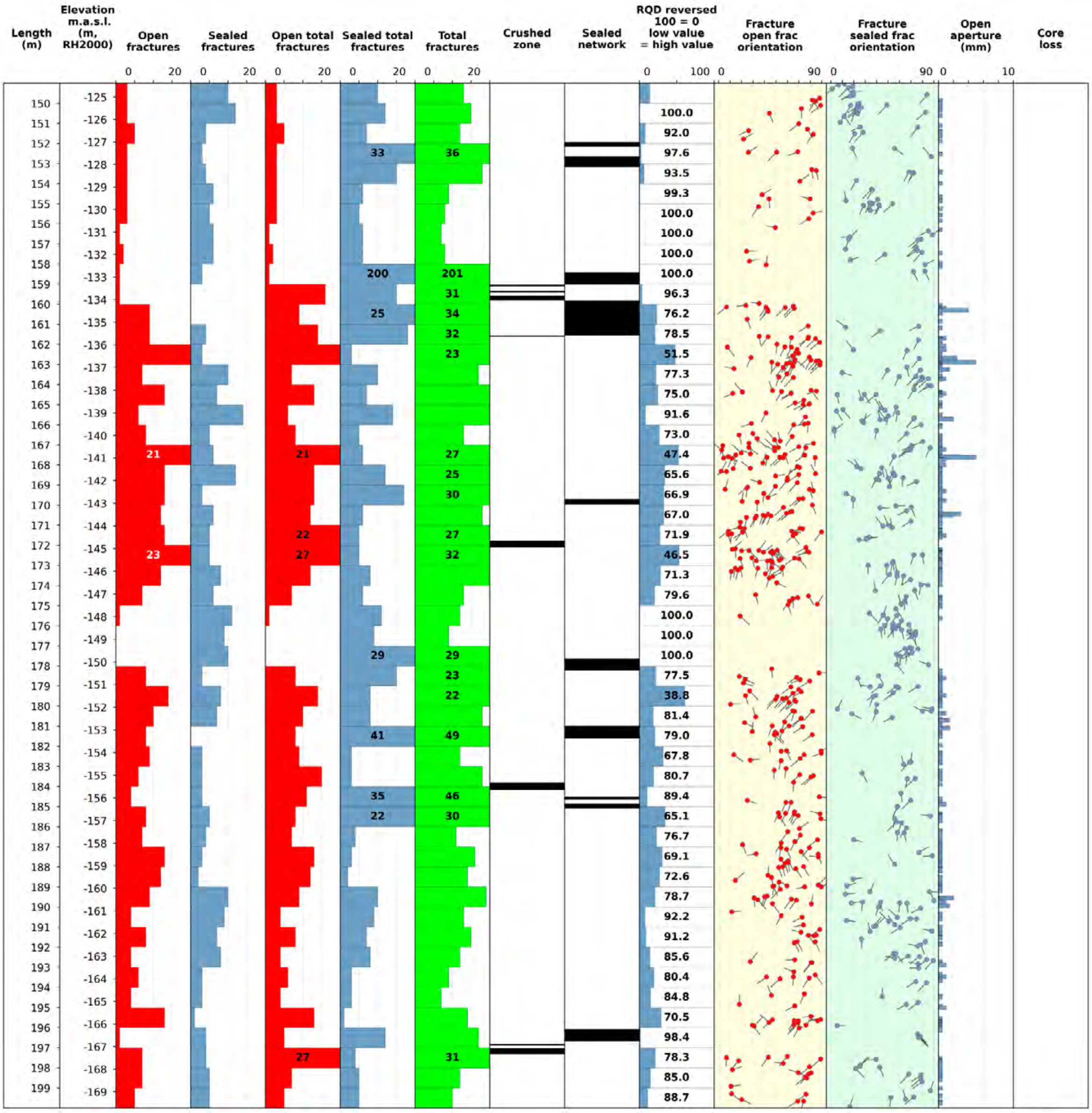
NW	ZFMNW0017	Version number	4	Total object CL	16

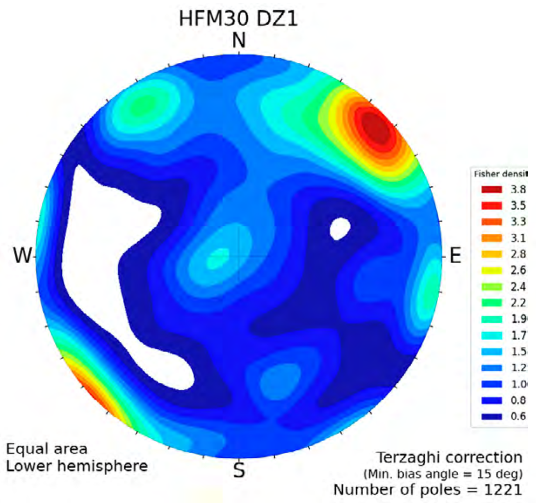
INDIVIDUAL INTERCEPTS

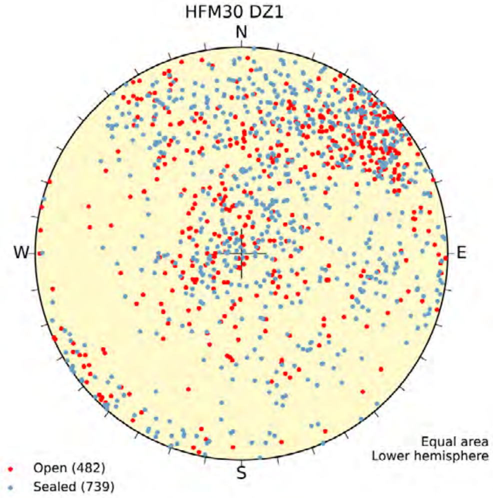
HFM30 DZ1 (79.0-200.0 m)



NW	ZFMNW0017	Version number	4	Total object CL	16

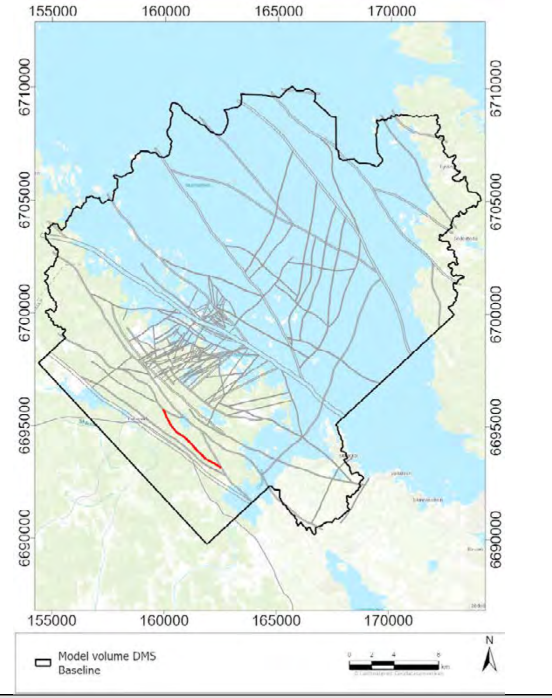






NW	ZFMNW0029		Version number	3	Total object CL	13

GEOLOGICAL CHARACTER		Property CL
Deformation style:	Brittle-Ductile	1
Deformation description:	No data available.	
Alteration:		1
- First order:	Oxidation	
- Second order:	Not observed	
- Third order:	Not observed	
Fracture orientation and type:	No data available.	
Fracture comment:	No data available.	
Fracture fill mineralogy:	No data available.	

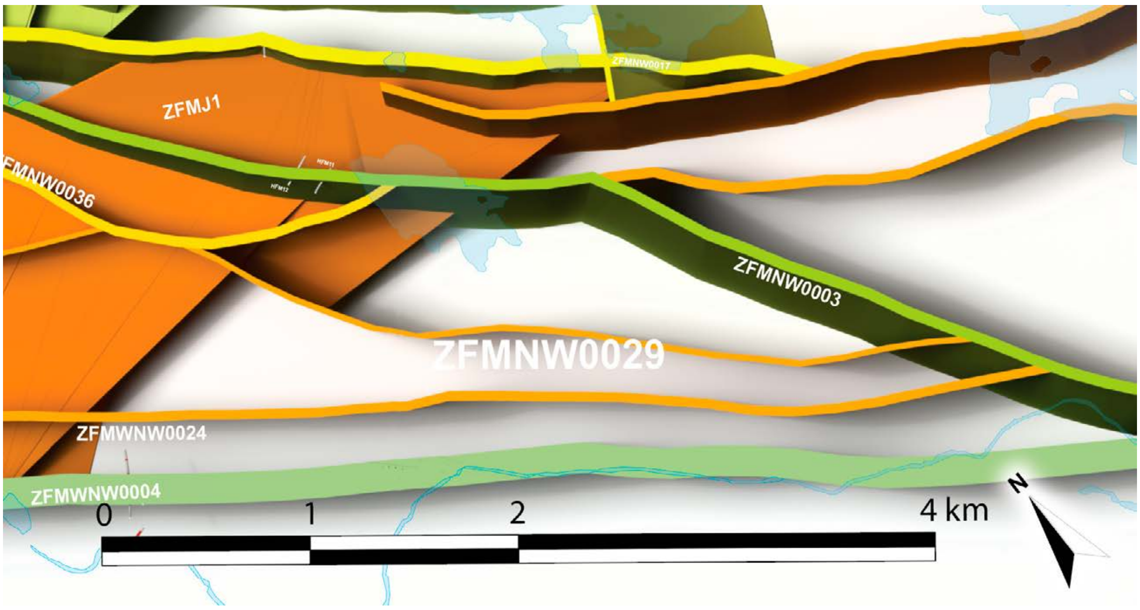


OBJECT GEOMETRY	
Strike/dip:	134°/90°
Length:	3793 m
Mean thickness:	30 m (15 - 64 m)
Max depth:	-2100 m
Geometrical constraints:	ZFMNW0036, ZFMNW0003, Topo 40m grid Max error 20m, 1 Surface Planar Cut(s).

BASIS FOR MODELLING		
Zone based on surface lineaments.		
Outcrops:	-	
Boreholes: -		
Tunnels:	-	
Lineament and/or seismic indications:	MFM0029.	2

MODELLING PROCEDURE

At the surface, corresponds to the low magnetic lineament MFM0029. Modelled to base of model volume using an assumed dip of 90 degrees based on a comparison with high confidence, vertical and steeply dipping zones with WNW and NW strike.



NW	ZFMNW0029	Version number	3	Total object CL	13

OBJECT CONFIDENCE ESTIMATE

Category	Object CL	Comment
INTERPRETATION		
Data source	1	MFM0029
Results of interpretation	2	Medium confidence in lineament MFM0029.
INFORMATION DENSITY		
Number of observation points	1	1
Distribution of observation points	1	Single observation point in the form of a lineament.
INTERPOLATION		
Geometry	1	Geometry supported by surface geophysical data.
Geological indicators	1	Indirect support by geophysical data.
EXTRAPOLATION		
Dip direction	3	Extrapolated to the base of the model volume. Strike length of the modelled zone > 2000 m.
Strike direction	3	Conceptual understanding of the site and that the entire modelled zone is supported by the lineament.

FRACTURE CHARACTER

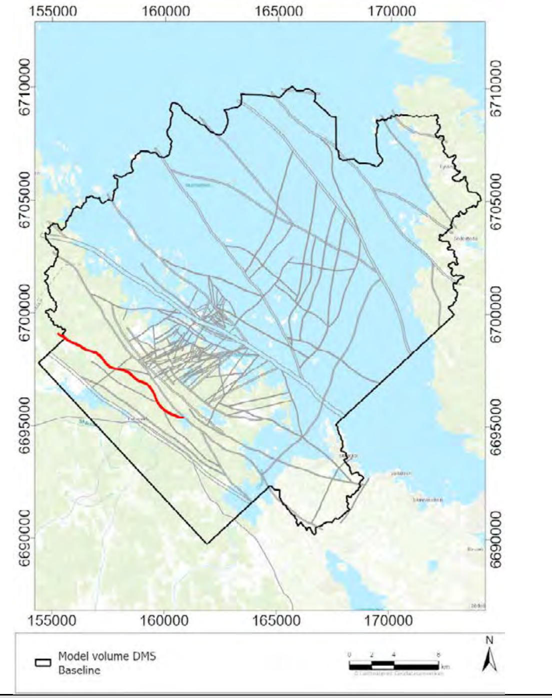
No data available

INDIVIDUAL INTERCEPTS

No data available

NW	ZFMNW0036	Version number	8	Total object CL	14

GEOLOGICAL CHARACTER		Property CL
Deformation style:	Brittle-Ductile	1
Deformation description:	No data available.	
Alteration:		2
- First order:	Oxidation	
- Second order:	Not observed	
- Third order:	Not observed	
Fracture orientation and type:	No data available.	
Fracture comment:	No data available.	
Fracture fill mineralogy:	No data available.	

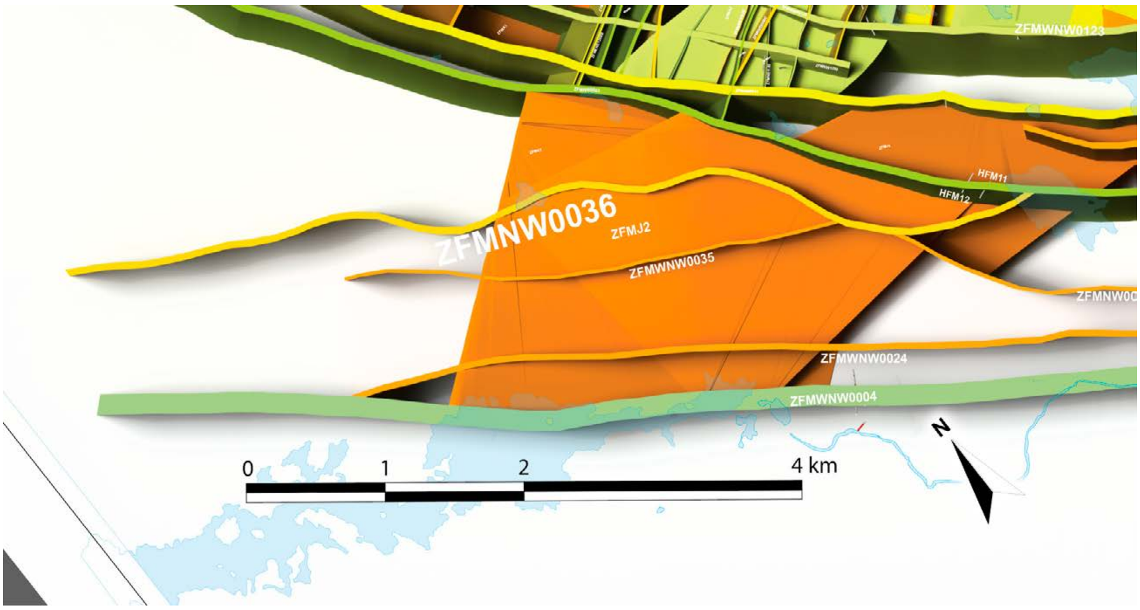


OBJECT GEOMETRY	
Strike/dip:	127°/90°
Length:	10624 m
Mean thickness:	50 m (50 - 200 m)
Max depth:	-2100 m
Geometrical constraints:	ZFMNW0003, Topo 40m grid Max error 20m, 2 Surface Planar Cut(s).

BASIS FOR MODELLING		
Zone based on surface lineaments.		
Outcrops:	-	
Boreholes: -		
Tunnels:	-	
Lineament and/or seismic indications:	MFM0036 merged.	3

MODELLING PROCEDURE

At the surface, corresponds to the low magnetic lineament MFM0036. Modelled to base of model volume using an assumed dip of 90 degrees based on a comparison with high confidence, vertical and steeply dipping zones with WNW and NW strike.



NW	ZFMNW0036	Version number	8	Total object CL	14

OBJECT CONFIDENCE ESTIMATE

Category	Object CL	Comment
INTERPRETATION		
Data source	1	MFM0036 merged
Results of interpretation	3	High confidence in lineament MFM0036.
INFORMATION DENSITY		
Number of observation points	1	1
Distribution of observation points	1	Single observation point in the form of a lineament.
INTERPOLATION		
Geometry	1	Geometry supported by surface geophysical data.
Geological indicators	1	Indirect support by geophysical data.
EXTRAPOLATION		
Dip direction	3	Extrapolated to the base of the model volume. Strike length of the modelled zone > 2000 m.
Strike direction	3	Conceptual understanding of the site and that the entire modelled zone is supported by the lineament.

FRACTURE CHARACTER

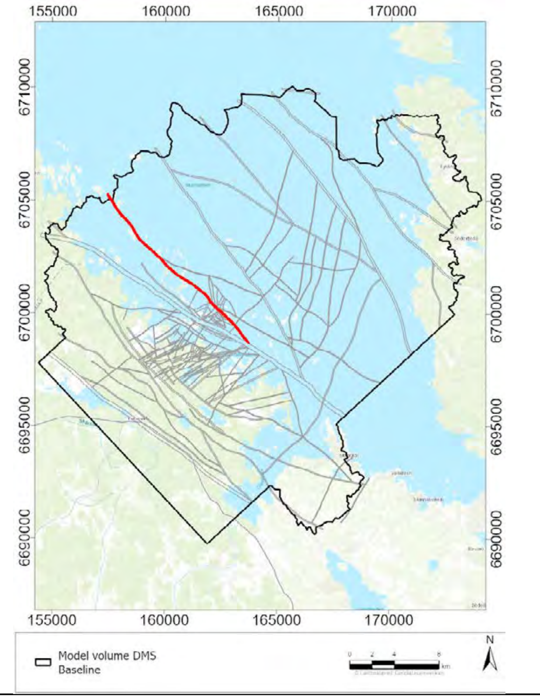
No data available

INDIVIDUAL INTERCEPTS

No data available

NW	ZFMNW0805A	Version number	12	Total object CL	22

GEOLOGICAL CHARACTER		Property CL
Deformation style:	Brittle-Ductile	3
Deformation description:	No data available.	
Alteration:		3
- First order:	Oxidation	
- Second order:	Quartz dissolution	
- Third order:	Not observed	
Fracture orientation and type:	Steeply dipping fractures dominate in the NW-SE orientation and with ENE-WSW orientation as well as gently dipping fractures..	2
Fracture comment:	No data available.	
Fracture fill mineralogy:	Calcite, chlorite, hematite/adularia, clay minerals, laumontite, quartz, epidote.	
OBJECT GEOMETRY		
Strike/dip:	316°/82°	
Length:	11612 m	
Mean thickness:	60 m (50 - 200 m)	
Max depth:	-2100 m	
Geometrical constraints:	ZFMWNW0001, Topo 40m grid Max error 20m, 1 Surface Planar Cut(s).	



BASIS FOR MODELLING

Zone based on surface lineaments, seismic data and borehole observations.

Outcrops:	-
Boreholes:	

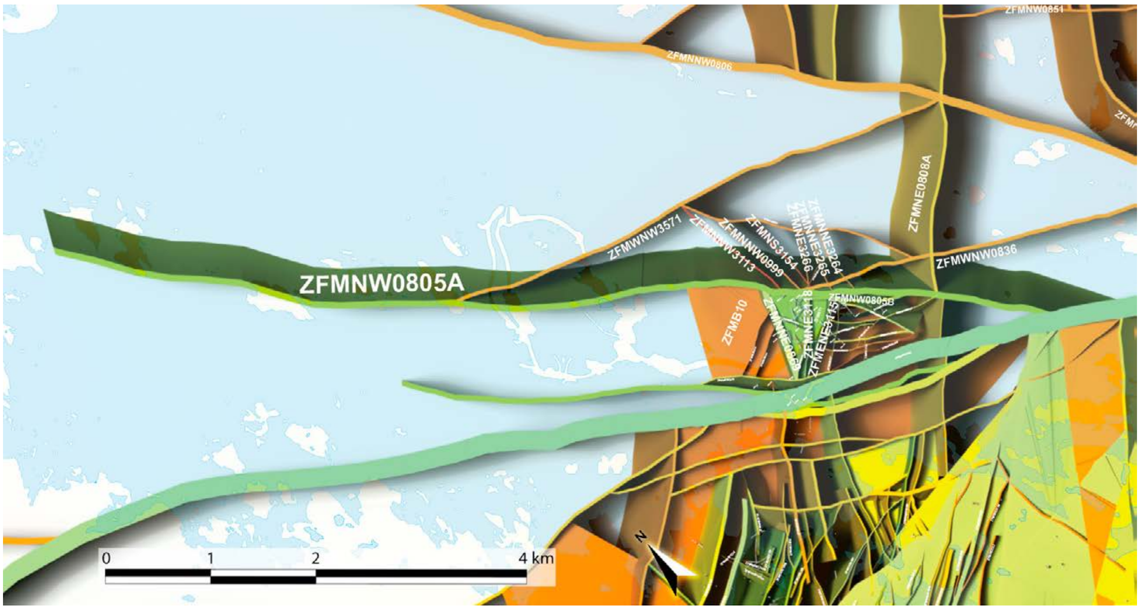
Borehole	PDZ	Target intercept		Geometric intercept		Comment
		Sec_up [m]	Sec_low [m]	Sec_up [m]	Sec_low [m]	
KFR08	DZ2	41.00	104.40	40.74	101.44	
KFR101	DZ5	242.00	341.76	234.01	338.45	
KFR11	DZ1	41.45	95.65	32.64	98.07	
KFR23		-	-	10.46	11.29	No SHI available.
KFR24		-	-	49.05	156.98	No SHI available.
KFR25		-	-	50.74	196.50	No SHI available.
KFR56		-	-	57.16	81.72	No SHI available.
KFR7A	DZ1	43.00	74.45	43.88	74.67	Subdivision of DZ1 between ZFMNW0805A and ZFMNW0805B.

Tunnels:	-	
Lineament and/or seismic indications:	MFM0805 merged.	2

MODELLING PROCEDURE

At the surface, corresponds to the low magnetic lineament MFM0805. Modelled to the base of the model volume using dip that has been inferred from data along near-surface boreholes, with target intercepts in KFR7A, KFR08, KFR101 and KFR11. Adopted in structural model for SFR (Axelsson and Hansen 1997, Holmén and Stigsson 2001).

NW	ZFMNW0805A	Version number	12	Total object CL	22

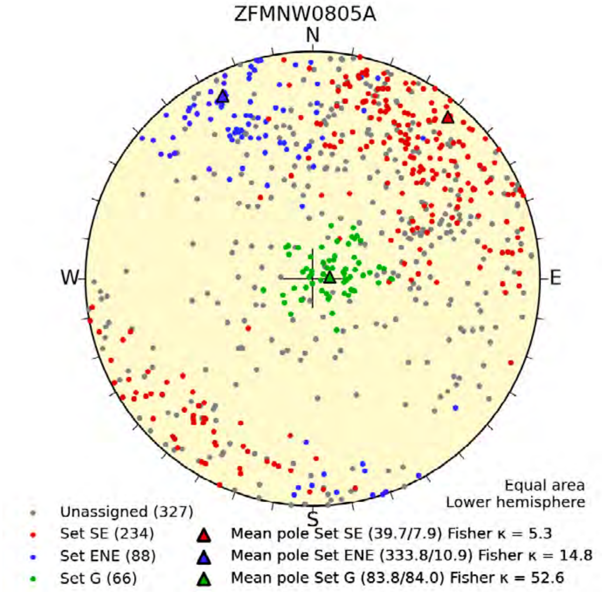
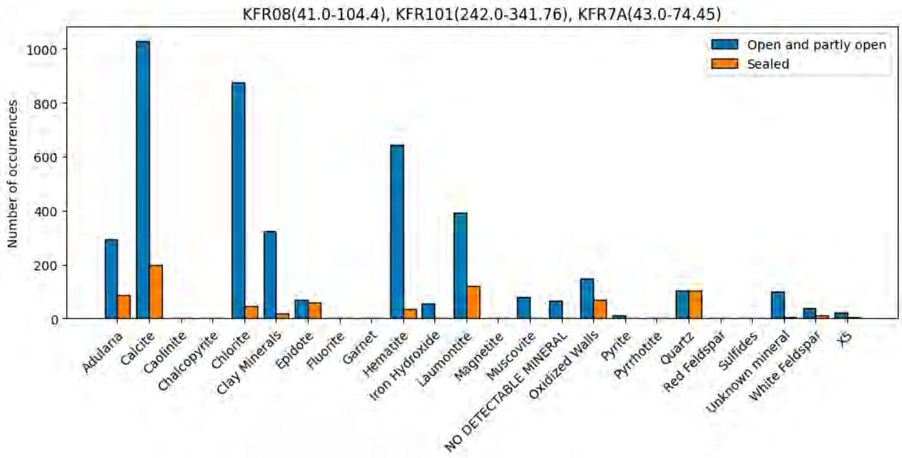


OBJECT CONFIDENCE ESTIMATE

Category	Object CL	Comment
INTERPRETATION		
Data source	2	MFM0805 merged, KFR7, KFR08, KFR11, KFR23, KFR24, KFR25, KFR56, KFR101.
Results of interpretation	3	High confidence observations in multiple boreholes.
INFORMATION DENSITY		
Number of observation points	3	>4
Distribution of observation points	2	Observation points cover <600 m of the zone which is modelled along strike for c. 10000 m. Obs. points considered as a cluster and the lineament as an outlier.
INTERPOLATION		
Geometry	3	Zone intercepted with multiple drill holes and described by SHI in at least three drill cores with high confidence.
Geological indicators	3	Interpolation supported by key geological parameters, foremost fracture orientation pattern.
EXTRAPOLATION		
Dip direction	3	Extrapolated to the base of the model volume. Strike length of the modelled zone > 2000 m.
Strike direction	3	Conceptual understanding of the site and that the entire modelled zone is supported by the lineament.

NW	ZFMNW0805A	Version number	12	Total object CL	22

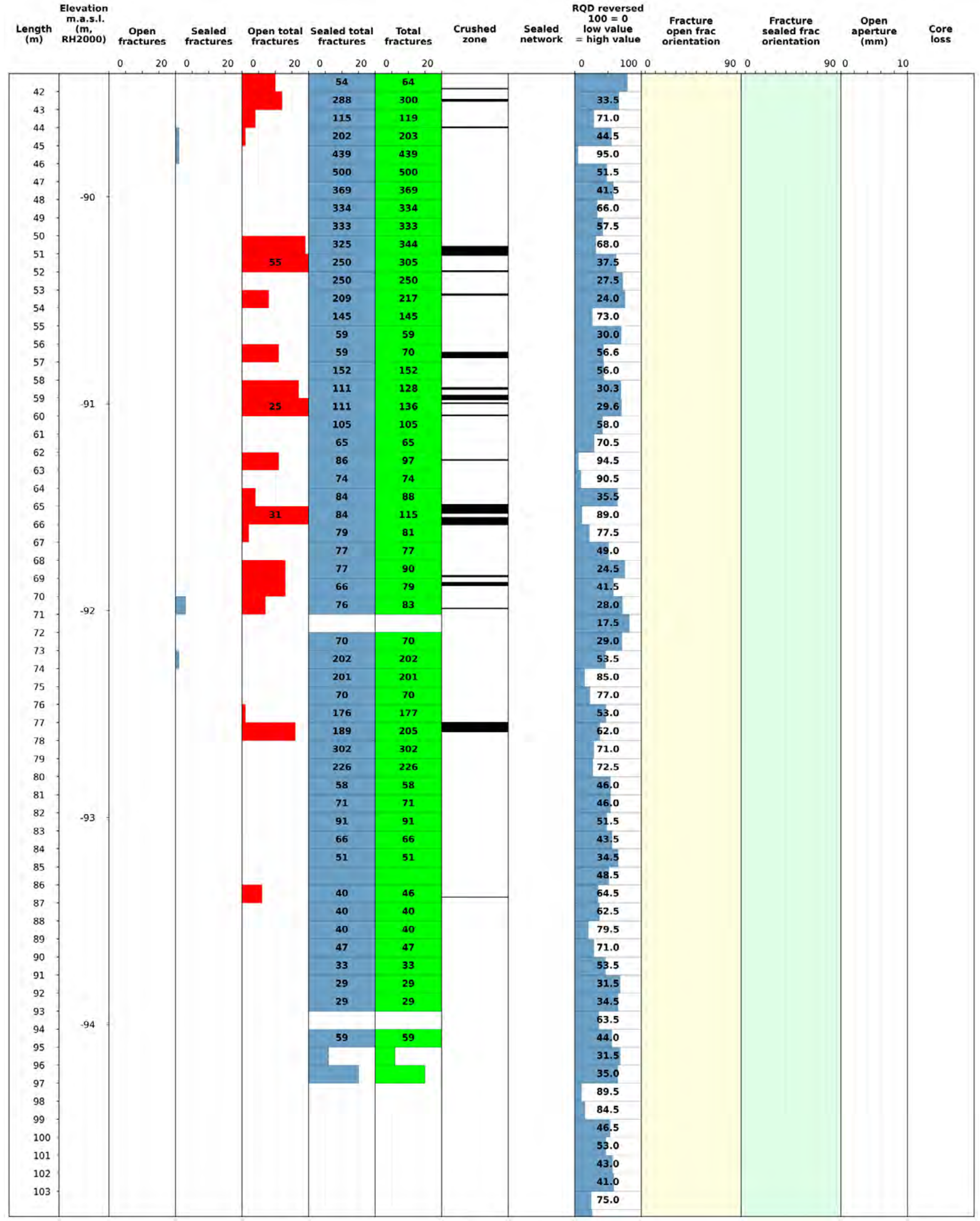
FRACTURE CHARACTER

Orientation: (strike/dip right-hand-rule)	Set SE: 129.7°/82.1° Set ENE: 63.8°/79.1° Set G: 173.8°/6.0°	
Frequency:	Boreholes: KFR101, KFR25, KFR56, KFR7A, KFR11, KFR23, KFR24, KFR08	
RQD:	min:17, max:100, mean:74	
Fracture fill mineralogy:		

FRACTURE TYPE	TERZAGHI-WEIGHED P10
Open and partly open	4.4 m-1
Sealed	1.0 m-1
Sealed network	6.3 % of DZ intercept
Crush	6.3 % of DZ intercept

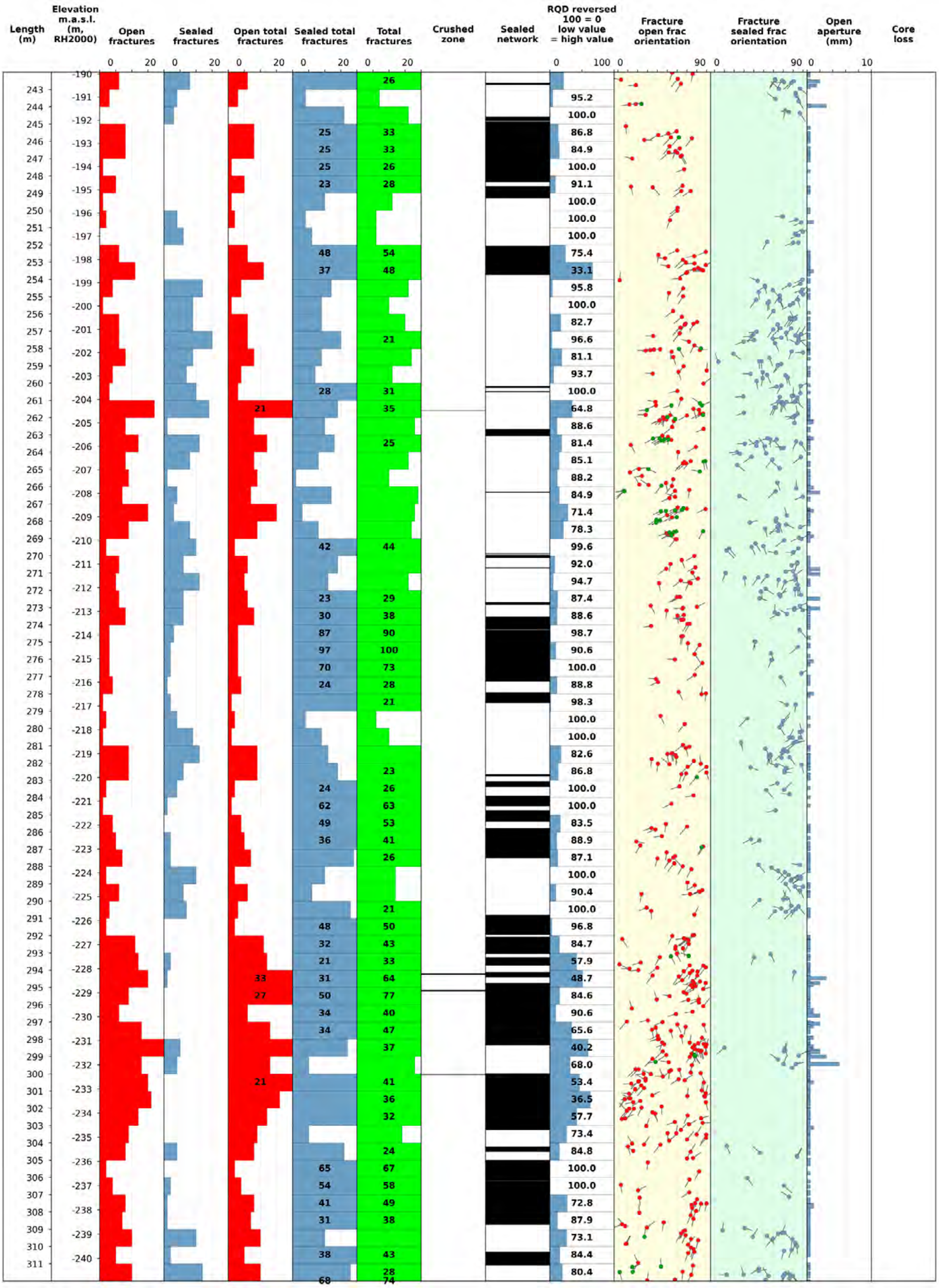
NW	ZFMNW0805A	Version number	12	Total object CL	22
INDIVIDUAL INTERCEPTS					

KFR08 DZ2 (41.0-104.4 m)

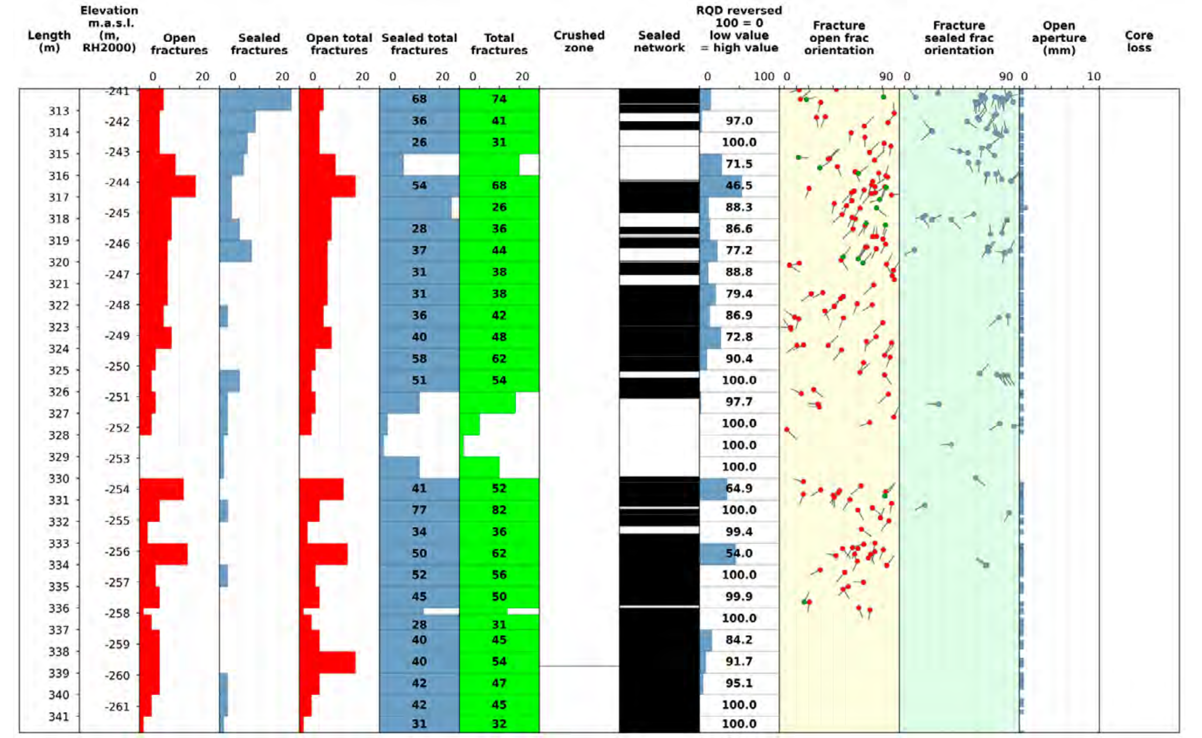


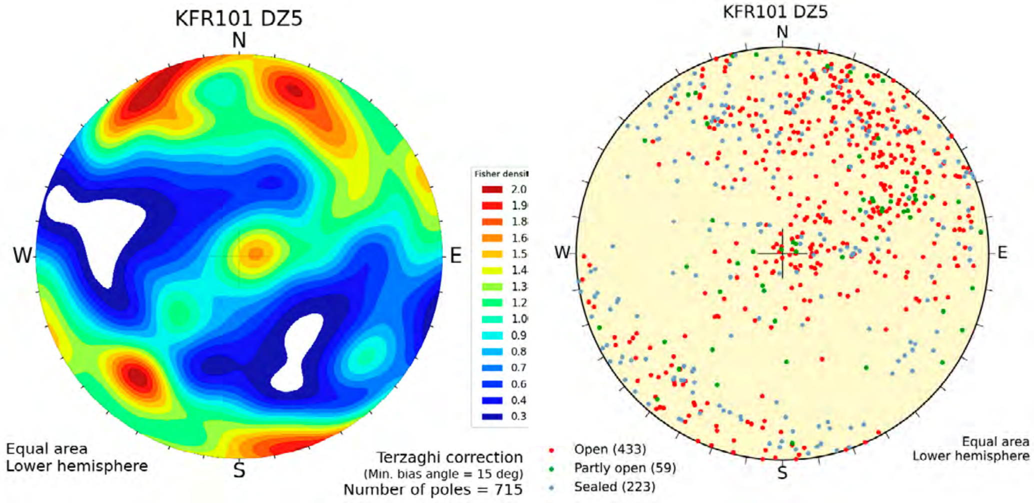
NW	ZFMNW0805A	Version number	12	Total object CL	22

KFR101 DZ5 (242.0-341.76 m)



NW	ZFMNW0805A	Version number	12	Total object CL	22





NW	ZFMNW0805A	Version number	12	Total object CL	22

KFR11 DZ1 (41.45-95.65 m)

No data available

KFR23 (10.46-11.29 m)

No data available

KFR24 (49.05-156.98 m)

No data available

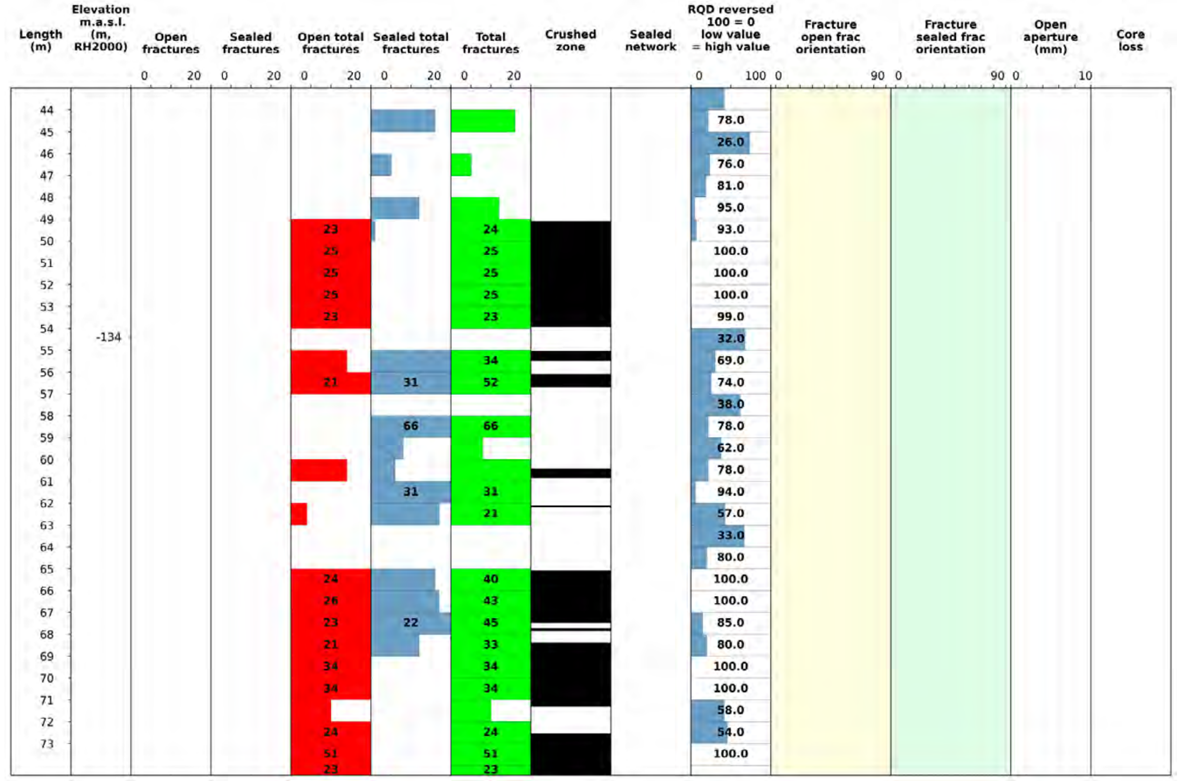
KFR25 (50.74-196.5 m)

No data available

KFR56 (57.16-81.72 m)

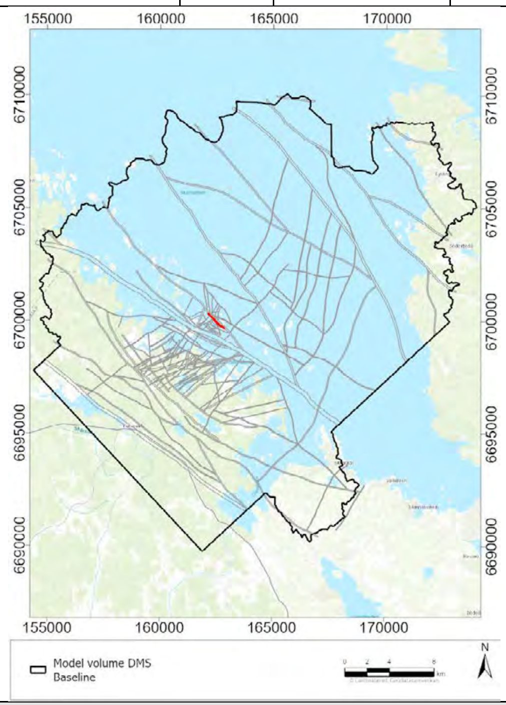
No data available

KFR7A DZ1 (43.0-74.45 m)



NW	ZFMNW0805B	Version number	4	Total object CL	22

GEOLOGICAL CHARACTER		Property CL
Deformation style:	Brittle-Ductile	3
Deformation description:	No data available.	
Alteration:		3
- First order:	Oxidation	
- Second order:	Chloritization	
- Third order:	Not observed	
Fracture orientation and type:	Steeply dipping fractures with WNW-ESE strike and gently dipping fractures are present.	2
Fracture comment:	No data available.	
Fracture fill mineralogy:	Calcite, chlorite, clay minerals, hematite/adularia, pyrite, quartz, epidote, laumontite.	



OBJECT GEOMETRY

Strike/dip:	317°/75°
Length:	1183 m
Mean thickness:	30 m (5 - 30 m)
Max depth:	-1071 m
Geometrical constraints:	ZFMNW0805A, Topo 40m grid Max error 20m.

BASIS FOR MODELLING

Zone based on surface lineaments, tunnel and borehole observations.

Outcrops: -

Boreholes:

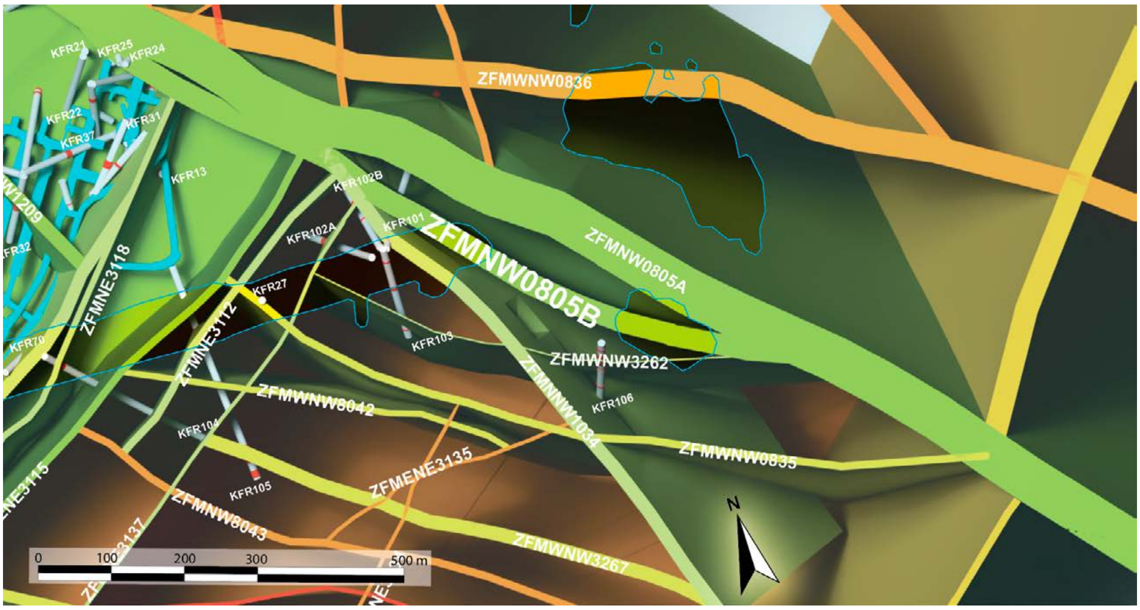
Borehole	PDZ	Target intercept		Geometric intercept		Comment
		Sec_up [m]	Sec_low [m]	Sec_up [m]	Sec_low [m]	
KFR08	DZ1	3.00	19.00	2.61	32.44	
KFR101	DZ2	97.00	116.00	80.24	131.56	
KFR11		-	-	0.00	18.71	Judging from the photographs of the drill cores there is no obvious indication of a zone with the dignity of ZFMNW0805B along the geometric intercept. The only conspicuous feature is an approximately 2 dm long, intensely fractured interval with moderate oxidation/laumontization at 16 m length. No target intercept is defined.
KFR24		-	-	8.12	40.88	No SHI available.
KFR25		-	-	9.38	50.61	No SHI available.
KFR38	DZ1	153.60	181.65	106.40	185.40	
KFR56		-	-	3.55	44.68	No SHI available.
KFR7A	DZ1	3.50	43.00	11.25	43.20	Subdivision of DZ1 between ZFMNW0805A and ZFMNW0805B.

Tunnels:	BT target intercept1+182 - 1+185 m, geometric intercept 1+178 - 1+193 m. 1B geometric intercept 0+023 - 0+044 m.	
Lineament and/or seismic indications:	MFM0805G1, MSFR08104, MSFR08098.	1

MODELLING PROCEDURE

At the surface, corresponds to the low magnetic lineament MFM0805. Modelled to the base of the model volume using dip that has been inferred from data along near-surface tunnels and boreholes (KFR08, KFR101, KFR38, KFR7A) and the BT and 1B tunnels in SFR. Adopted in structural model for SFR (Axelsson and Hansen 1997, Holmén and Stigsson 2001).

NW	ZFMNW0805B	Version number	4	Total object CL	22



OBJECT CONFIDENCE ESTIMATE

Category	Object CL	Comment
INTERPRETATION		
Data source	3	MFM0805G1, KFR08, KFR7A, KFR24, KFR25, KFR56, KFR101, BT and 1B.
Results of interpretation	3	High confidence observations in KFR07A, KFR101 and SFR tunnels.
INFORMATION DENSITY		
Number of observation points	3	>4
Distribution of observation points	2	Cluster of borehole intersections and a lineament as an outlier.
INTERPOLATION		
Geometry	3	Modelled as a splay to ZFMNW0805A.
Geological indicators	3	Interpolation supported by key geological parameters, foremost fracture orientation pattern and tunnel observations.
EXTRAPOLATION		
Dip direction	2	Extrapolation in dip direction supported by subsurface obs. point. Strike length of the modelled zone < 2000 m.
Strike direction	3	Conceptual understanding of the site and that the entire modelled zone is supported by the lineament. Splay to ZFMNW0805A supported mainly by sub-surface obs. point KFR101 and BT in SFR facility. Truncated against ZFMNW0805A which is a high conf. Zone.

FRACTURE CHARACTER

Orientation: (strike/dip right-hand-rule)	Set SE: 133.1°/85.8° Set G: 247.9°/6.1°	

<table>
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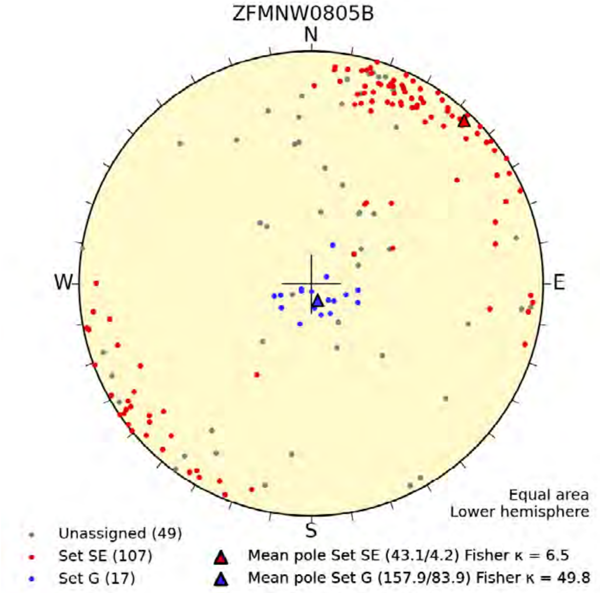
<tr><td>Frequency:</td><td>Boreholes: KFR101, KFR25, KFR56, KFR7A, KFR11, KFR38, KFR24, KFR08
<table><tr><td>FRACTURE TYPE</td><td>TERZAGHI-WEIGHED P10</td></tr><tr><td>Open and partly open</td><td>6.3 m-1</td></tr><tr><td>Sealed</td><td>1.5 m-1</td></tr><tr><td>Sealed network</td><td>5.7 % of DZ intercept</td></tr><tr><td>Crush</td><td>0.9 % of DZ intercept</td></tr></table></td><td colspan="4">
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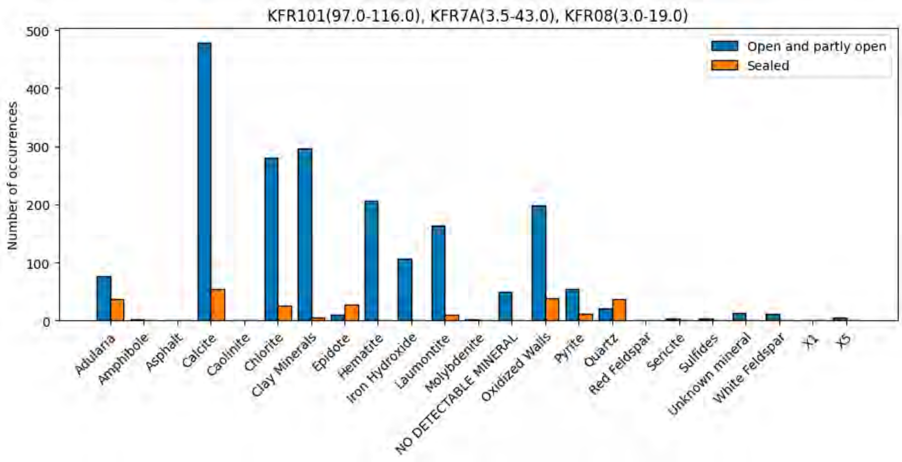
<tr><td>Fracture fill mineralogy:</td><td colspan="5">
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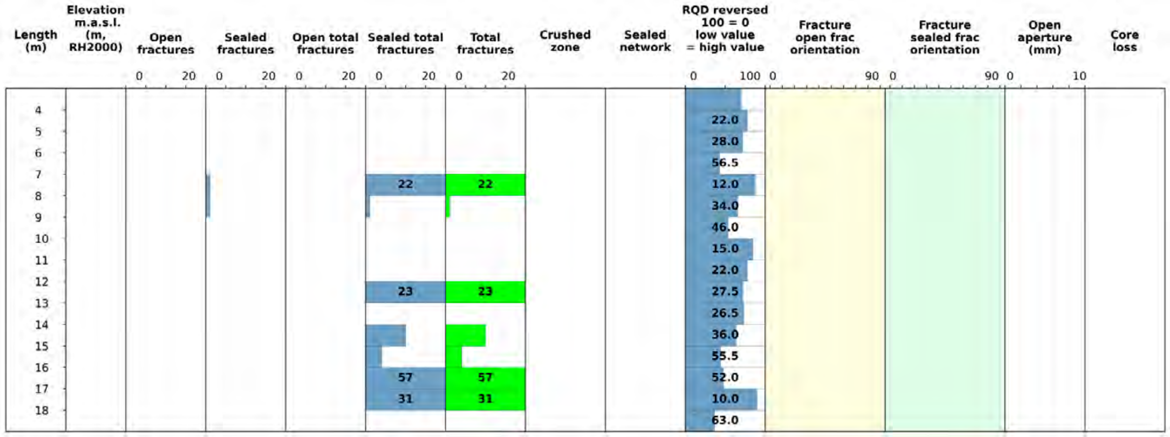
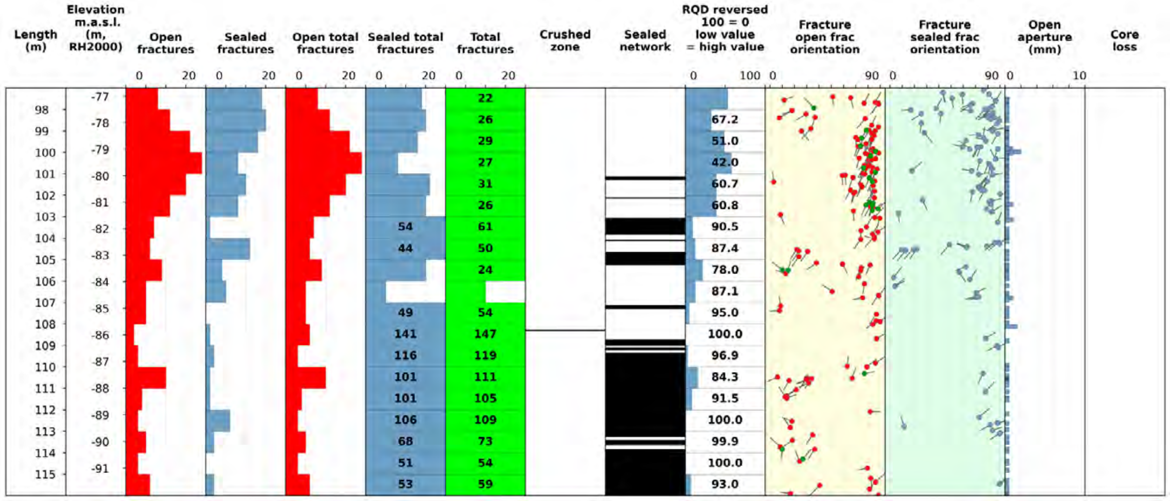
NW	ZFMNW0805B	Version number	4	Total object CL	22

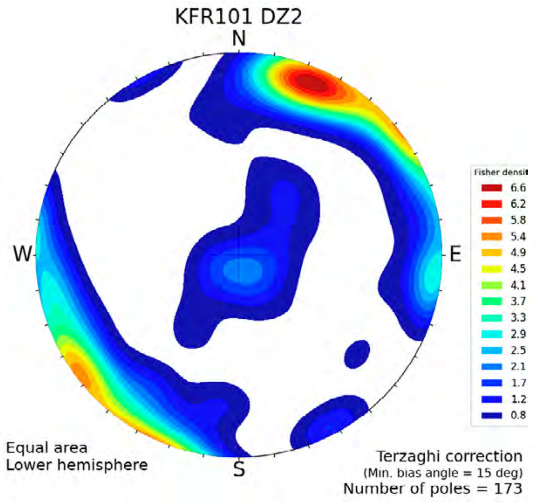
INDIVIDUAL INTERCEPTS

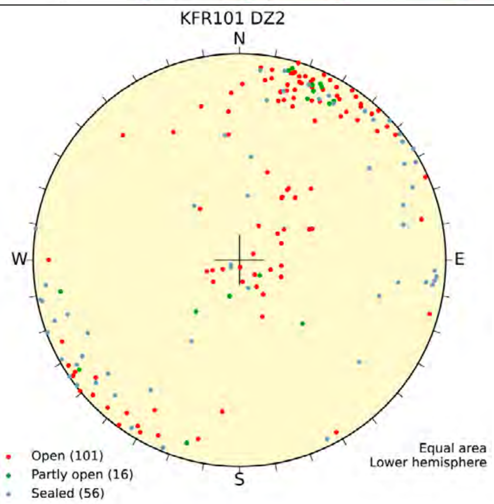
KFR08 DZ1 (3.0-19.0 m)



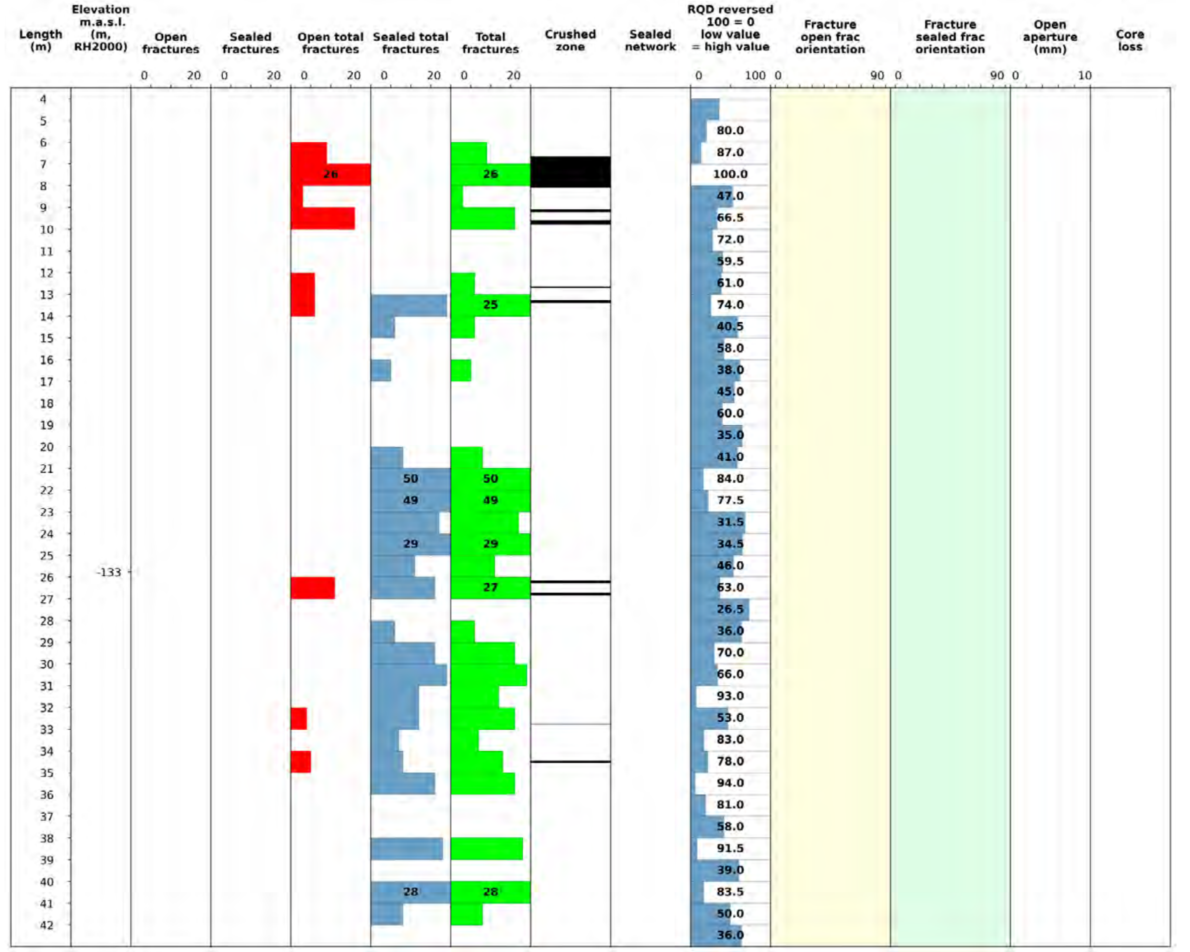
KFR101 DZ2 (97.0-116.0 m)





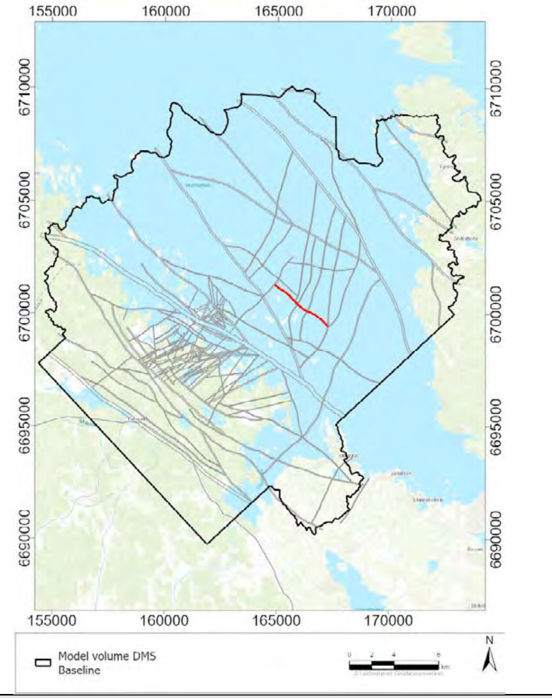


NW	ZFMNW0805B	Version number	4	Total object CL	22
KFR11 (0.0-18.71 m)					
No data available					
KFR24 (8.12-40.88 m)					
No data available					
KFR25 (9.38-50.61 m)					
No data available					
KFR38 DZ1 (153.6-181.65 m)					
No data available					
KFR56 (3.55-44.68 m)					
No data available					
KFR7A DZ1 (3.5-43.0 m)					



NW	ZFMNW0851		Version number	3	Total object CL	11

GEOLOGICAL CHARACTER		Property CL
Deformation style:	Brittle-Ductile	3
Deformation description:	No data available.	
Alteration:		2
- First order:	Oxidation	
- Second order:	Not observed	
- Third order:	Not observed	
Fracture orientation and type:	No data available.	
Fracture comment:	No data available.	
Fracture fill mineralogy:	No data available.	

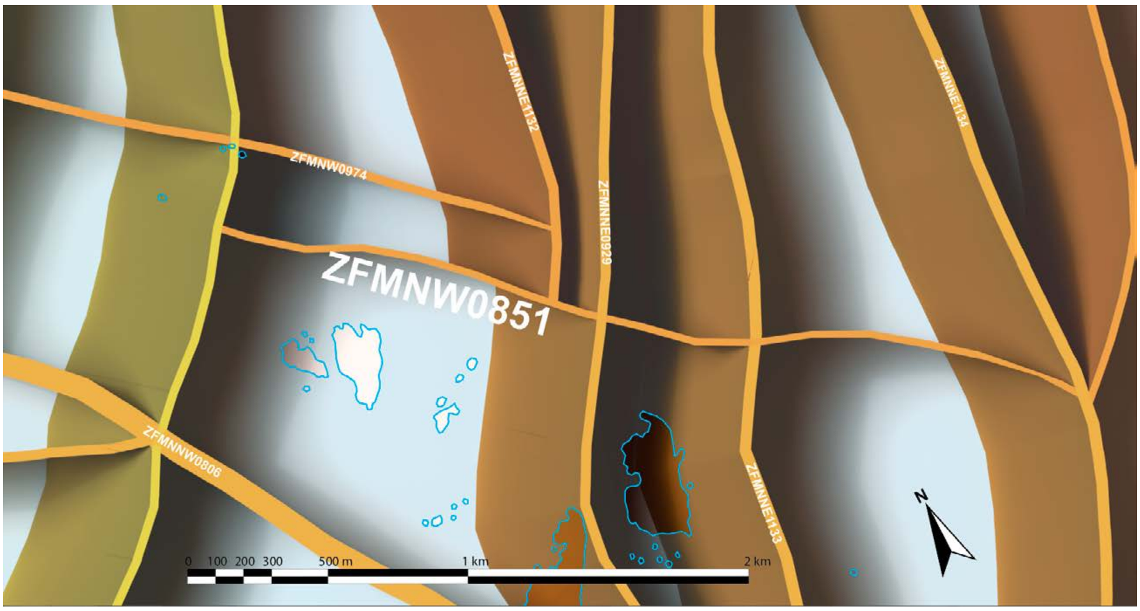


OBJECT GEOMETRY	
Strike/dip:	127°/90°
Length:	3076 m
Mean thickness:	25 m (15 - 64 m)
Max depth:	-2100 m
Geometrical constraints:	ZFMNE0808A, ZFMNNE1134, Topo 40m grid Max error 20m.

BASIS FOR MODELLING		
Zone based on surface lineaments.		
Outcrops:	-	
Boreholes: -		
Tunnels:	-	
Lineament and/or seismic indications:	MFM0851.	2

MODELLING PROCEDURE

At the surface, corresponds to the low magnetic lineament MFM0851. Modelled to the base of the model volume using an assumed vertical dip based on a comparison with high confidence, vertical and steeply dipping zones with WNW and NW strike.



NW	ZFMNW0851	Version number	3	Total object CL	11

OBJECT CONFIDENCE ESTIMATE

Category	Object CL	Comment
INTERPRETATION		
Data source	1	MFM0851.
Results of interpretation	2	Low confidence in lineament MFM0851.
INFORMATION DENSITY		
Number of observation points	1	1
Distribution of observation points	1	Single observation point in the form of a lineament.
INTERPOLATION		
Geometry	1	Geometry supported by surface geophysical data.
Geological indicators	1	Indirect support by geophysical data.
EXTRAPOLATION		
Dip direction	1	No subsurface obs. point, supported only by surface data. High uncertainty in dip-direction. Strike length of the modelled zone < 2000 m.
Strike direction	3	Conceptual understanding of the site and that the entire regional modelled zone is supported by the lineament.

FRACTURE CHARACTER

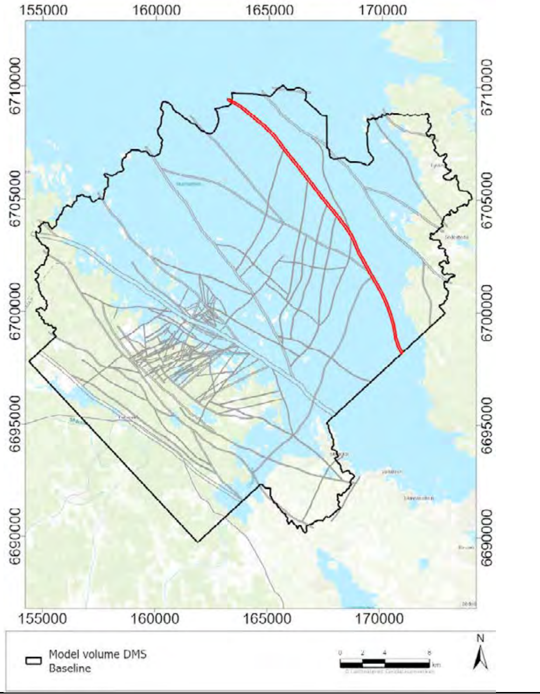
No data available

INDIVIDUAL INTERCEPTS

No data available

NW	ZFMNW0854		Version number	5	Total object CL	11

GEOLOGICAL CHARACTER		Property CL
Deformation style:	Brittle-Ductile	3
Deformation description:	No data available.	
Alteration:		2
- First order:	Oxidation	
- Second order:	Not observed	
- Third order:	Not observed	
Fracture orientation and type:	No data available.	
Fracture comment:	No data available.	
Fracture fill mineralogy:	No data available.	



OBJECT GEOMETRY	
Strike/dip:	142°/90°
Length:	29569 m
Mean thickness:	95 m (50 - 200 m)
Max depth:	-2100 m
Geometrical constraints:	Topo 40m grid Max error 20m, 2 Surface Planar Cut(s).

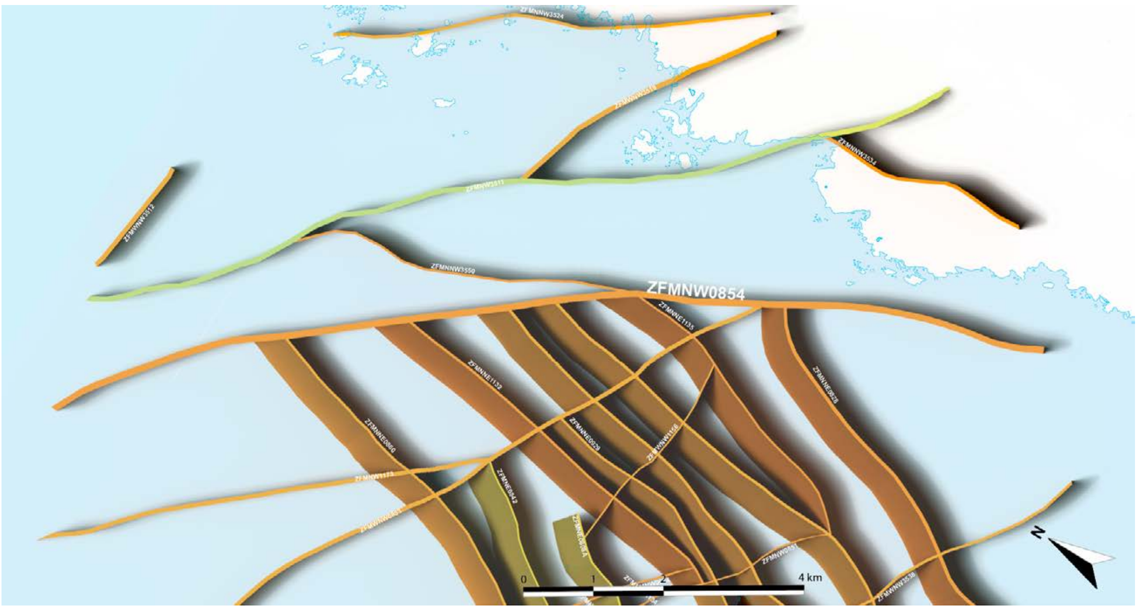
BASIS FOR MODELLING

Zone based on surface lineaments.

Outcrops:	-	
Boreholes: -		
Tunnels:	-	
Lineament and/or seismic indications:	MFM0854 merged.	1

MODELLING PROCEDURE

At the surface, corresponds to the low magnetic lineament MFM0854. Modelled to the base of the model volume using an assumed dip of 90 degrees based on a comparison with high confidence, vertical and steeply dipping zones with WNW and NW strike.



NW	ZFMNW0854	Version number	5	Total object CL	11

OBJECT CONFIDENCE ESTIMATE

Category	Object CL	Comment
INTERPRETATION		
Data source	1	MFM0854 merged.
Results of interpretation	2	Medium confidence in lineament MFM0854.
INFORMATION DENSITY		
Number of observation points	1	1
Distribution of observation points	1	Single observation point in the form of a lineament.
INTERPOLATION		
Geometry	1	Geometry supported by surface geophysical data.
Geological indicators	1	Indirect support by geophysical data.
EXTRAPOLATION		
Dip direction	1	No subsurface obs. point, supported only by surface data. High uncertainty in dip-direction. Strike length of the modelled zone < 2000 m.
Strike direction	3	Conceptual understanding of the site and that the entire regional modelled zone is supported by the lineament.

FRACTURE CHARACTER

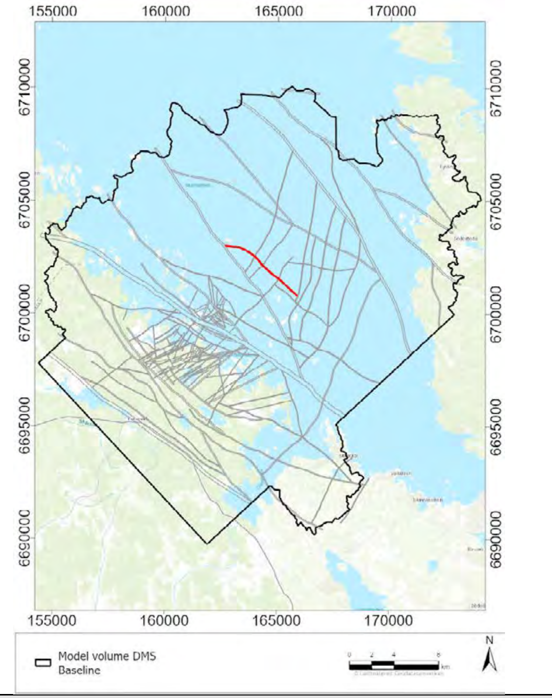
No data available

INDIVIDUAL INTERCEPTS

No data available

NW	ZFMNW0974		Version number	3	Total object CL	11

GEOLOGICAL CHARACTER		Property CL
Deformation style:	Brittle-Ductile	1
Deformation description:	No data available.	
Alteration:		2
- First order:	Oxidation	
- Second order:	Not observed	
- Third order:	Not observed	
Fracture orientation and type:	No data available.	
Fracture comment:	No data available.	
Fracture fill mineralogy:	No data available.	

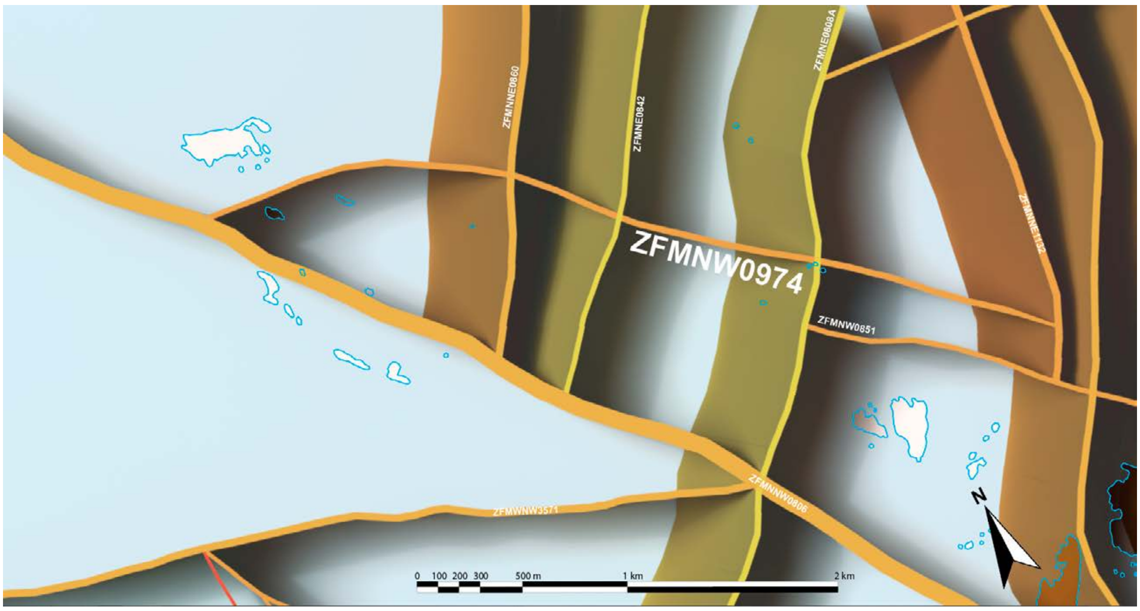


OBJECT GEOMETRY	
Strike/dip:	127°/90°
Length:	4096 m
Mean thickness:	30 m (15 - 64 m)
Max depth:	-2100 m
Geometrical constraints:	ZFMNNW0806, ZFMNNE1132, Topo 40m grid Max error 20m.

BASIS FOR MODELLING		
Zone based on surface lineaments.		
Outcrops:	-	
Boreholes: -		
Tunnels:	-	
Lineament and/or seismic indications:	MFM0974.	2

MODELLING PROCEDURE

At the surface, corresponds to the low magnetic lineament MFM0974. Modelled to the base of the model volume using an assumed dip of 90 degrees based on a comparison with high confidence, vertical and steeply dipping zones with WNW and NW strike.



NW	ZFMNW0974	Version number	3	Total object CL	11

OBJECT CONFIDENCE ESTIMATE

Category	Object CL	Comment
INTERPRETATION		
Data source	1	MFM0974 merged.
Results of interpretation	2	Medium confidence in lineament MFM0974.
INFORMATION DENSITY		
Number of observation points	1	1
Distribution of observation points	1	Single observation point in the form of a lineament.
INTERPOLATION		
Geometry	1	Geometry supported by surface geophysical data.
Geological indicators	1	Indirect support by geophysical data.
EXTRAPOLATION		
Dip direction	1	No subsurface obs. point, supported only by surface data. High uncertainty in dip-direction. Strike length of the modelled zone < 2000 m.
Strike direction	3	Conceptual understanding of the site and that the entire regional modelled zone is supported by the lineament.

FRACTURE CHARACTER

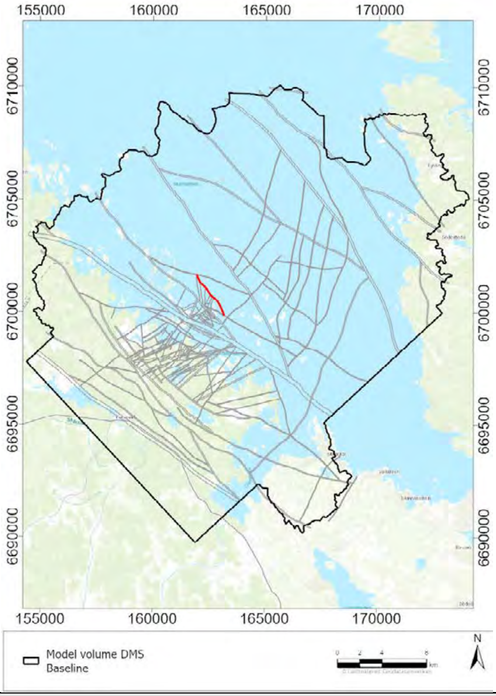
No data available

INDIVIDUAL INTERCEPTS

No data available

NW	ZFMNW0997	Version number	6	Total object CL	11

GEOLOGICAL CHARACTER		Property CL
Deformation style:	No data available	
Deformation description:	No data available. Zone based on lineament maps in the catchment area and bathymetry.	
Alteration:		
- First order:	Not observed	
- Second order:	Not observed	
- Third order:	Not observed	
Fracture orientation and type:	No data available.	
Fracture comment:	No data available.	
Fracture fill mineralogy:	No data available.	

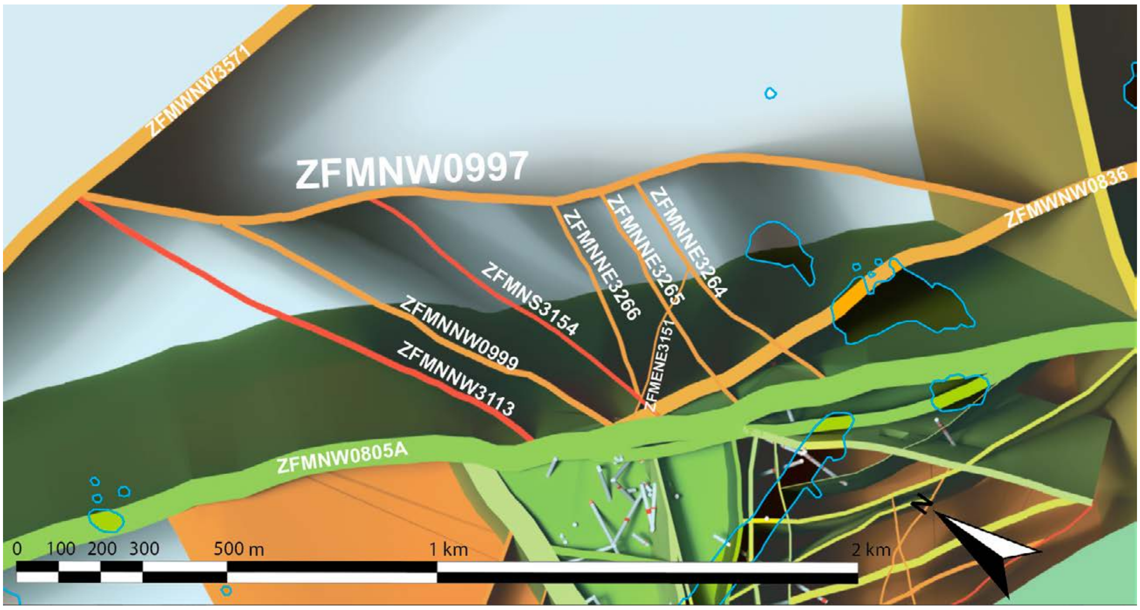


OBJECT GEOMETRY	
Strike/dip:	143°/90°
Length:	2240 m
Mean thickness:	20 m (3 - 50 m)
Max depth:	-2100 m
Geometrical constraints:	Topo 40m grid Max error 20m, ZFMWNW3571, ZFMWNW0836, ZFMNW0805A.

BASIS FOR MODELLING		
Zone based on surface lineaments.		
Outcrops:	-	
Boreholes: -		
Tunnels:	-	
Lineament and/or seismic indications:	XFM0997A0, MFM3550, MFM3557.	2

MODELLING PROCEDURE

-



NW	ZFMNW0997	Version number	6	Total object CL	11

OBJECT CONFIDENCE ESTIMATE

Category	Object CL	Comment
INTERPRETATION		
Data source	1	XFM0997A0, MFM3550.
Results of interpretation	2	Medium confidence in lineament XFM0997A0 and MFM3557.
INFORMATION DENSITY		
Number of observation points	1	2
Distribution of observation points	1	Single observation point in the form of a lineament.
INTERPOLATION		
Geometry	1	Geometry supported by surface geophysical data.
Geological indicators	1	Indirect support by geophysical data.
EXTRAPOLATION		
Dip direction	1	No subsurface obs. point, supported only by surface data. High uncertainty in dip-direction. Strike length of the modelled zone < 2000 m.
Strike direction	3	Conceptual understanding of the site and that the entire regional modelled zone is supported by the lineament.

FRACTURE CHARACTER

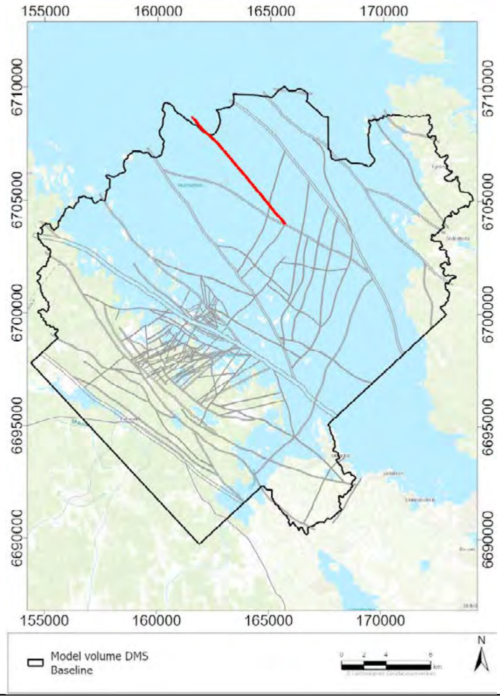
No data available

INDIVIDUAL INTERCEPTS

No data available

NW	ZFMNW1173		Version number	6	Total object CL	13

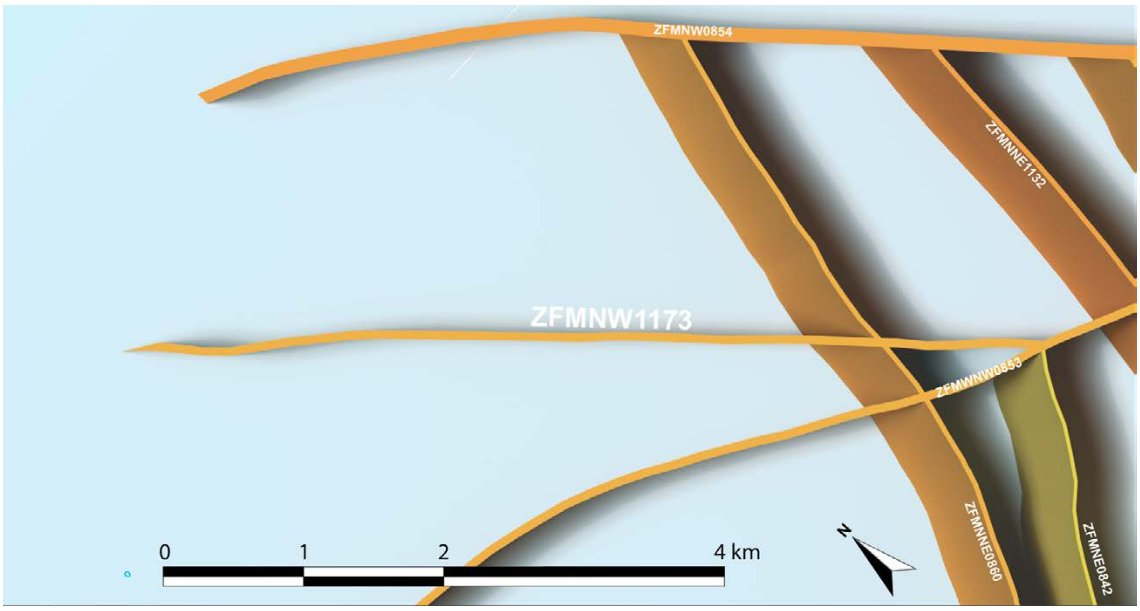
GEOLOGICAL CHARACTER		Property CL
Deformation style:	Brittle-Ductile	1
Deformation description:	No data available.	
Alteration:		2
- First order:	Oxidation	
- Second order:	Not observed	
- Third order:	Not observed	
Fracture orientation and type:	No data available.	
Fracture comment:	No data available.	
Fracture fill mineralogy:	No data available.	
OBJECT GEOMETRY		
Strike/dip:	139°/90°	
Length:	14000 m	
Mean thickness:	60 m (50 - 200 m)	
Max depth:	-2100 m	
Geometrical constraints:	ZFMWNW0853, Topo 40m grid Max error 20m, 1 Surface Planar Cut(s).	



BASIS FOR MODELLING		
Zone based on surface lineaments.		
Outcrops:	-	
Boreholes: -		
Tunnels:	-	
Lineament and/or seismic indications:	MFM1173 merged.	2

MODELLING PROCEDURE

At the surface, corresponds to the low magnetic lineament MFM1173. Modelled to the base of the model volume using an assumed dip of 90 degrees based on a comparison with high confidence, vertical and steeply dipping zones with WNW and NW strike.



NW	ZFMNW1173	Version number	6	Total object CL	13

OBJECT CONFIDENCE ESTIMATE

Category	Object CL	Comment
INTERPRETATION		
Data source	1	MFM1173 merged.
Results of interpretation	2	Medium confidence in lineament MFM1173.
INFORMATION DENSITY		
Number of observation points	1	1
Distribution of observation points	1	Single observation point in the form of a lineament.
INTERPOLATION		
Geometry	1	Geometry supported by surface geophysical data.
Geological indicators	1	Indirect support by geophysical data.
EXTRAPOLATION		
Dip direction	3	Extrapolated to the base of the model volume. Strike length of the modelled zone > 2000 m.
Strike direction	3	Conceptual understanding of the site and that the entire regional modelled zone is supported by the lineament.

FRACTURE CHARACTER

No data available

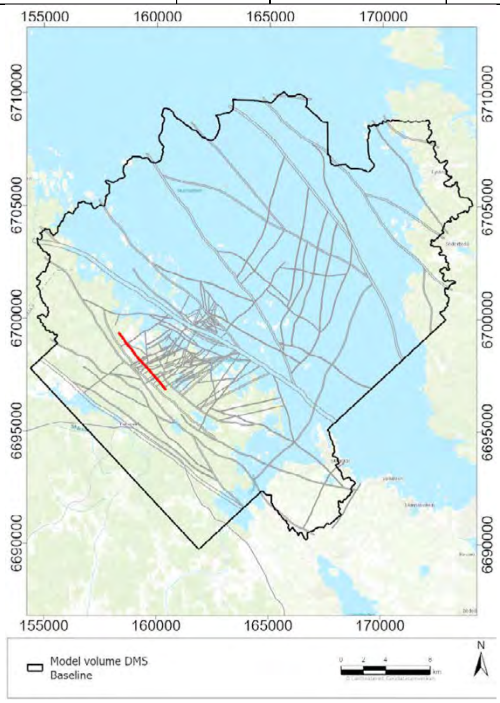
INDIVIDUAL INTERCEPTS

No data available

NW	ZFMNW1200		Version number	5	Total object CL	23

GEOLOGICAL CHARACTER		Property CL
Deformation style:	Brittle-Ductile	3
Deformation description:	Surface geology shows two different episodes of displacement along fault with NW-SE strike. Sinistral strike-slip displacement dominates. Oblique-slip shear with dextral normal displacement is also present in KFM09A (DZ4 and DZ5). Kinematic consistent with the surface data. Sinistral strike-slip faults with steep NW-SE strike dominate and dextral strike-slip along a fault with WSW strike is also present. Inferred conjugate set. One steeply dipping fault with a SE strike shows oblique slip with a strong dextral strike-slip component and subordinate normal displacement. One steeply dipping fault with a NE strike shows reverse dip-slip displacement.	
Alteration:		3
- First order:	Oxidation	
- Second order:	Not observed	
- Third order:	Not observed	
Fracture orientation and type:	Fractures that strike SE and dip steeply to the SW dominates. Gently dipping fractures as well as steeply dipping fractures with NE strike are also present. Sealed fractures dominate followed by open and partly open fractures. Quantitative estimate and span include sealed fracture networks.	2
Fracture comment:	No data available.	
Fracture fill mineralogy:	Chlorite, calcite, laumontite, prehnite, hematite/adularia, quartz and clay minerals.	

OBJECT GEOMETRY	
Strike/dip:	140°/85°
Length:	3280 m
Mean thickness:	46 m (15 - 64 m)
Max depth:	-2100 m
Geometrical constraints:	Topo 40m grid Max error 20m, 1 UNIVERSE Planar Cut(s).



NW	ZFMNW1200	Version number	5	Total object CL	23

BASIS FOR MODELLING

Zone based on surface lineaments, outcrop and borehole observations.

Outcrops: PFM007096, PFM001257

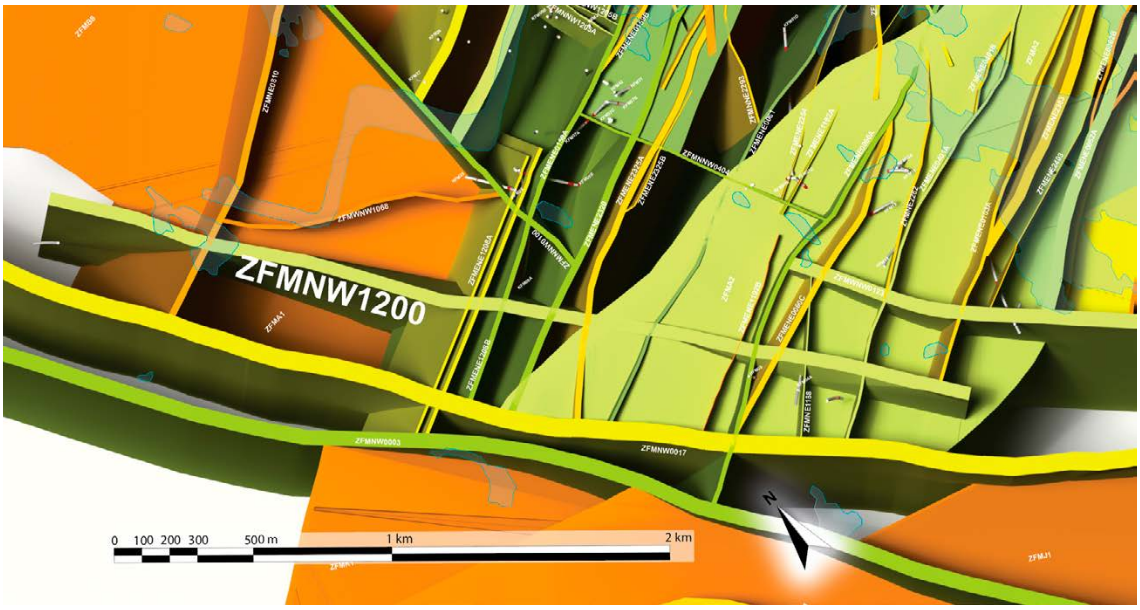
Boreholes:

Borehole	PDZ	Target intercept		Geometric intercept		Comment
		Sec_up [m]	Sec_low [m]	Sec_up [m]	Sec_low [m]	
KFM04A	DZ1	110.00	176.00	110.56	170.74	110-169 m added (cf. Table 3-2 in Stephens et al. 2007).
KFM09A	DZ4	723.00	754.00	723.10	793.22	Fractured rock between 754 and 770 m inferred to be affected by DZ (cf. Table 3-2 in Stephens et al. 2007).
KFM09A	DZ5	770.00	790.00	723.10	793.22	

Tunnels:	-	
Lineament and/or seismic indications:	MFM1200.	1

MODELLING PROCEDURE

At the surface, corresponds to the low magnetic lineament MFM1200. Zone extended to the northwest, where it corresponds to the linked lineament with NW trend, XFM0789A0, as well as the brittle deformation zone recognised at the surface observation point PFM007096. Modelled to the base of the model volume using dip estimated by connecting lineament MFM1200 at the surface with the borehole intersections 110-176 m in KFM04A (DZ1 and extension in interval 110-169 m), 723-754 m (DZ4) in KFM09A and 770-790 m (DZ5) in KFM09A. Borehole interval 754-770 m in KFM09A also inferred to be affected by this zone. Deformation zone plane passes through fixed points 159 m in KFM04A and 731 m in KFM09A. Decreased radar penetration also along the borehole interval 731-754 m in KFM09A.

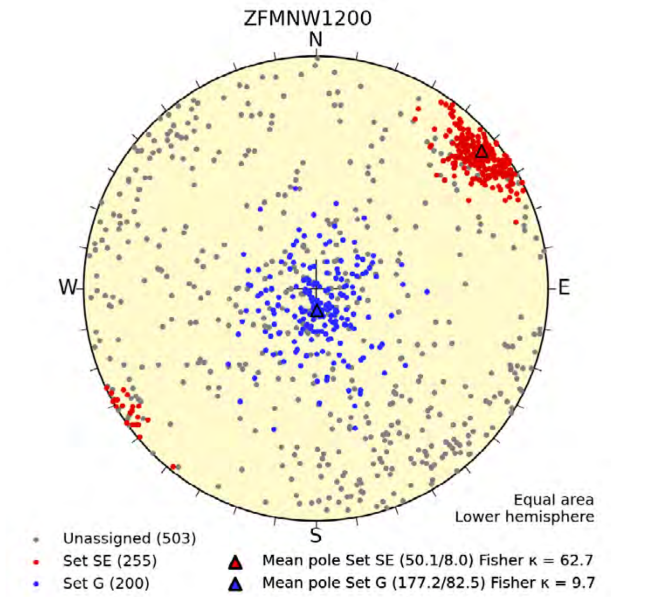


NW	ZFMNW1200	Version number	5	Total object CL	23

OBJECT CONFIDENCE ESTIMATE

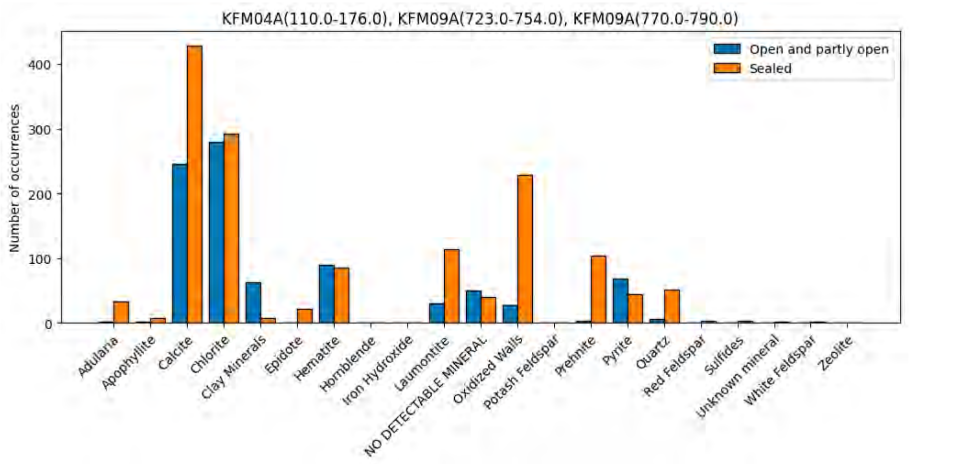
Category	Object CL	Comment
INTERPRETATION		
Data source	3	MFM1200, KFM04A, KFM09A, PFM007096, PFM001257.
Results of interpretation	3	High confidence observation in KFM09A.
INFORMATION DENSITY		
Number of observation points	3	>4
Distribution of observation points	2	Two sub-surface observation point and the lineament as an outlier.
INTERPOLATION		
Geometry	3	In addition to outcrops/field localities, one oriented radar reflector in KFM04A 169-176 m DZ1 provide support for current geometry and linking the zone to the surface lineament.
Geological indicators	3	Interpolation supported by key geological parameters, foremost fracture orientation pattern.
EXTRAPOLATION		
Dip direction	3	Extrapolated to the base of the model volume. Strike length of the modelled zone > 2000 m.
Strike direction	3	Supported by geological concept and partly by surface lineament. Modelled zone length > 2000 m.

FRACTURE CHARACTER

Orientation: (strike/dip right-hand-rule)	Set SE: 140.1°/82.0° Set G: 267.2°/7.5°	
Frequency:	Boreholes: KFM04A, KFM09A	
RQD:	min:56, max:100, mean:94	

FRACTURE TYPE	TERZAGHI-WEIGHED P10
Open and partly open	5.5 m-1
Sealed	17.0 m-1
Sealed network	6.4 % of DZ intercept
Crush	0.0 % of DZ intercept

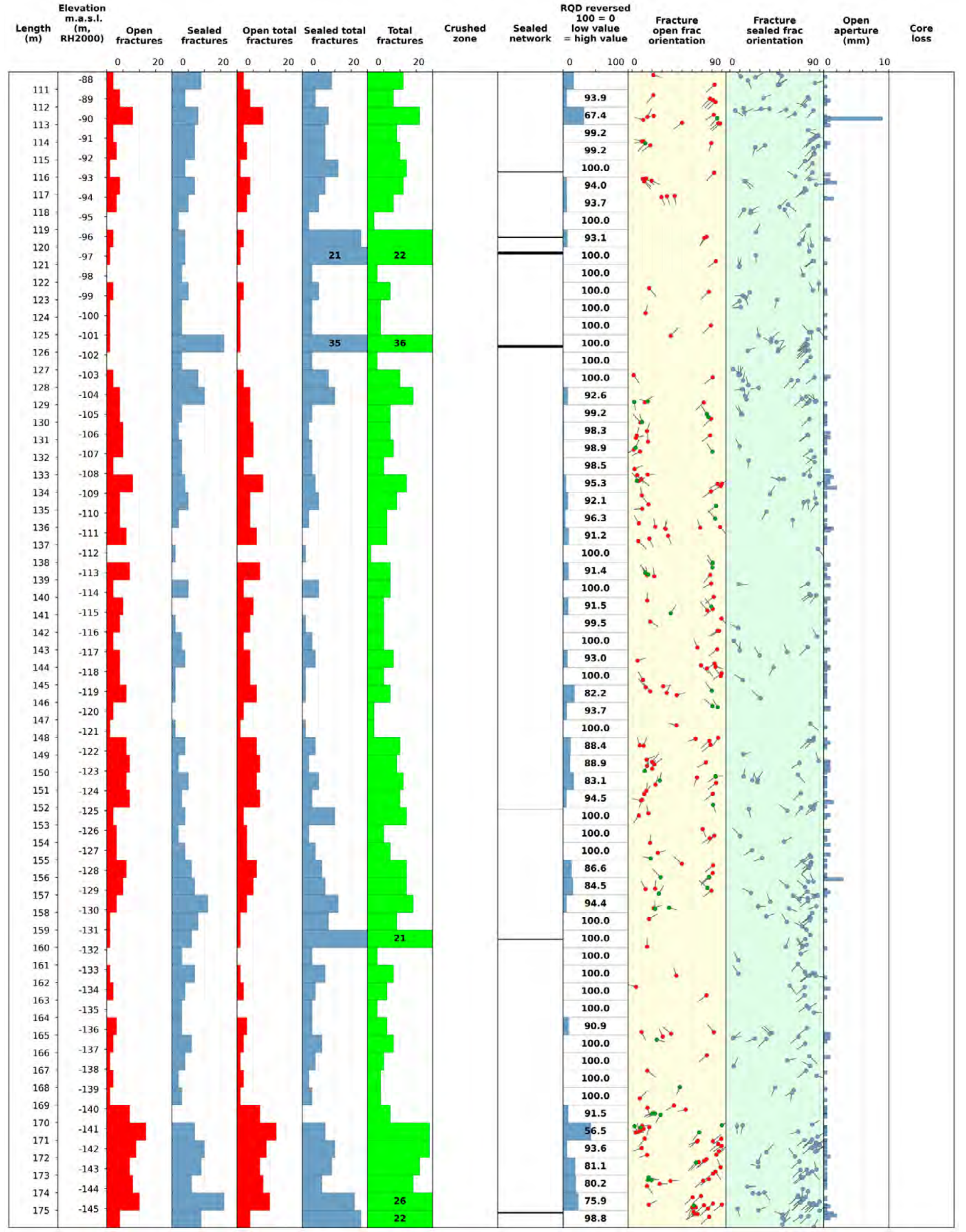
Fracture fill mineralogy:



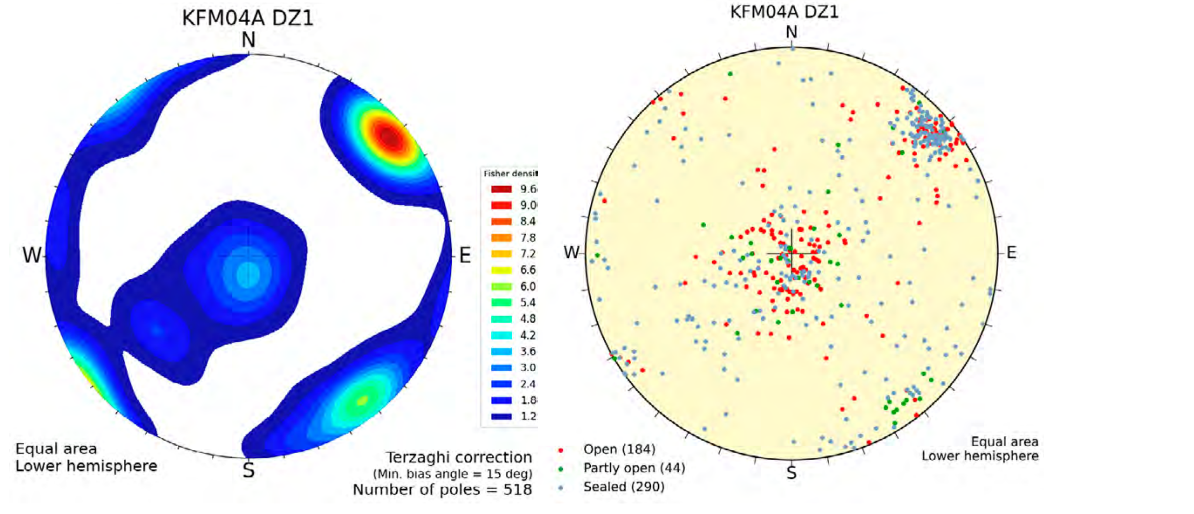
NW	ZFMNW1200	Version number	5	Total object CL	23

INDIVIDUAL INTERCEPTS

KFM04A DZ1 (110.0-176.0 m)

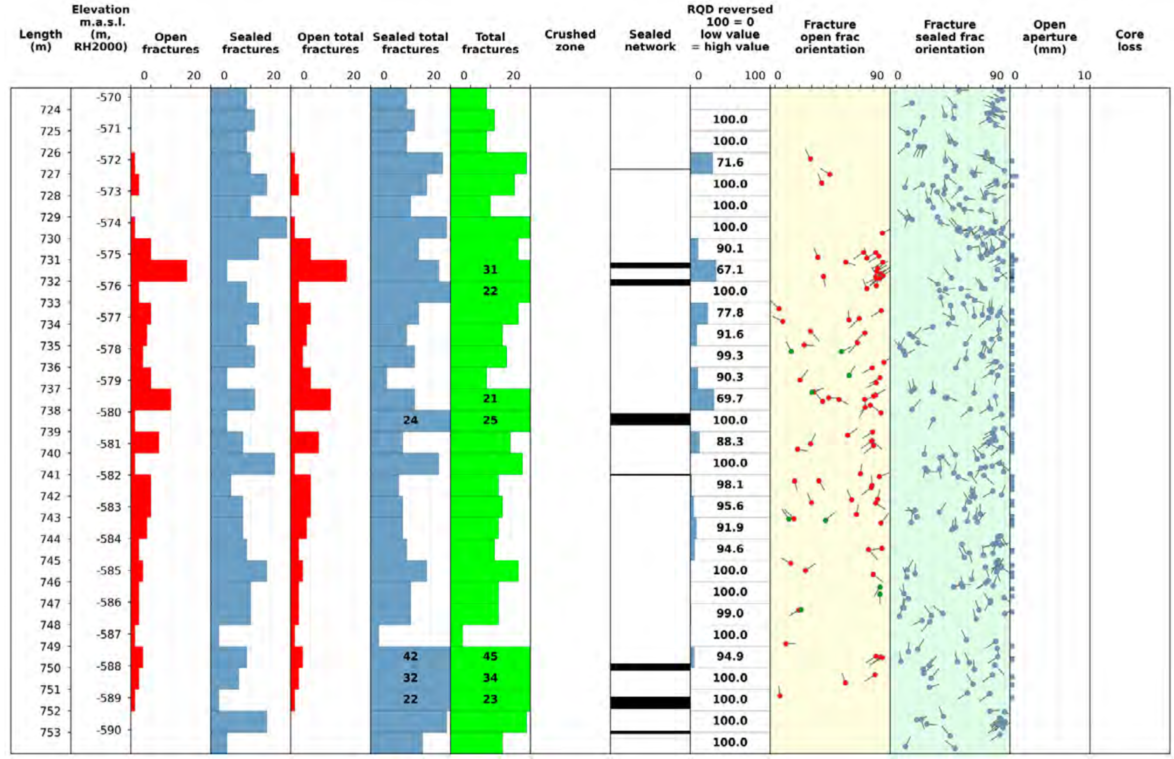


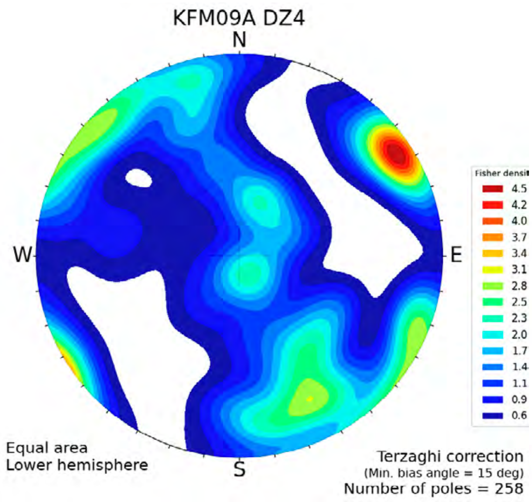
NW	ZFMNW1200	Version number	5	Total object CL	23

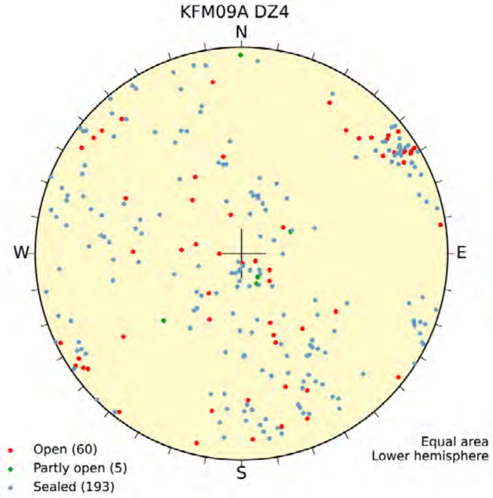


NW	ZFMNW1200	Version number	5	Total object CL	23

KFM09A DZ4 (723.0-754.0 m)

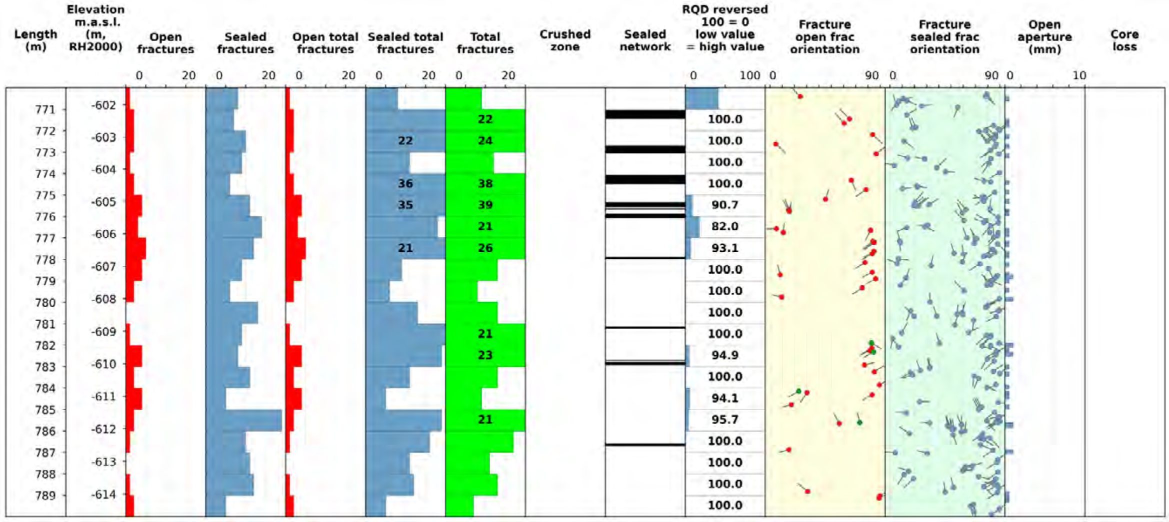


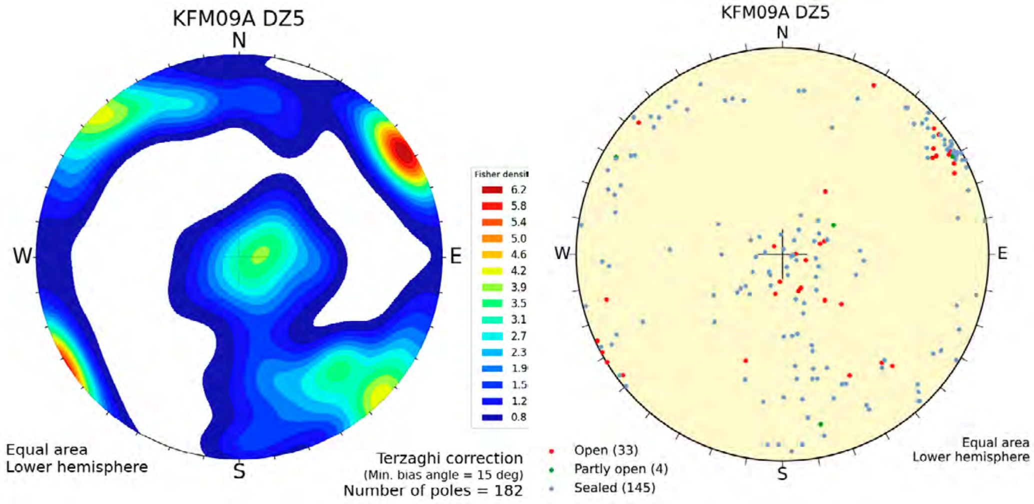


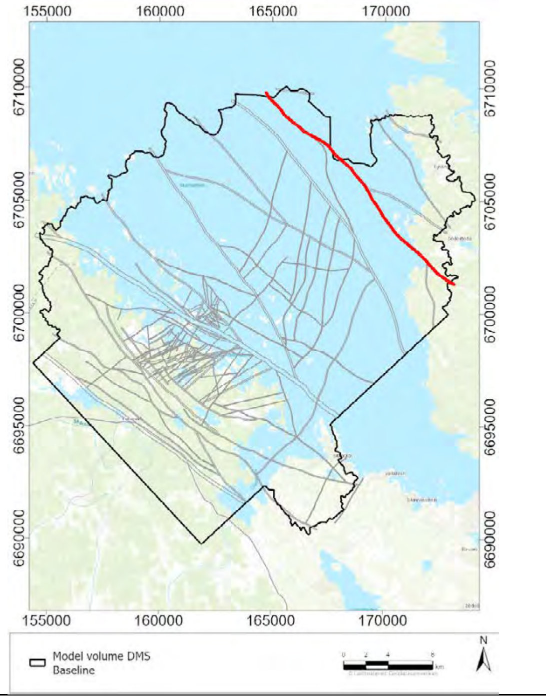


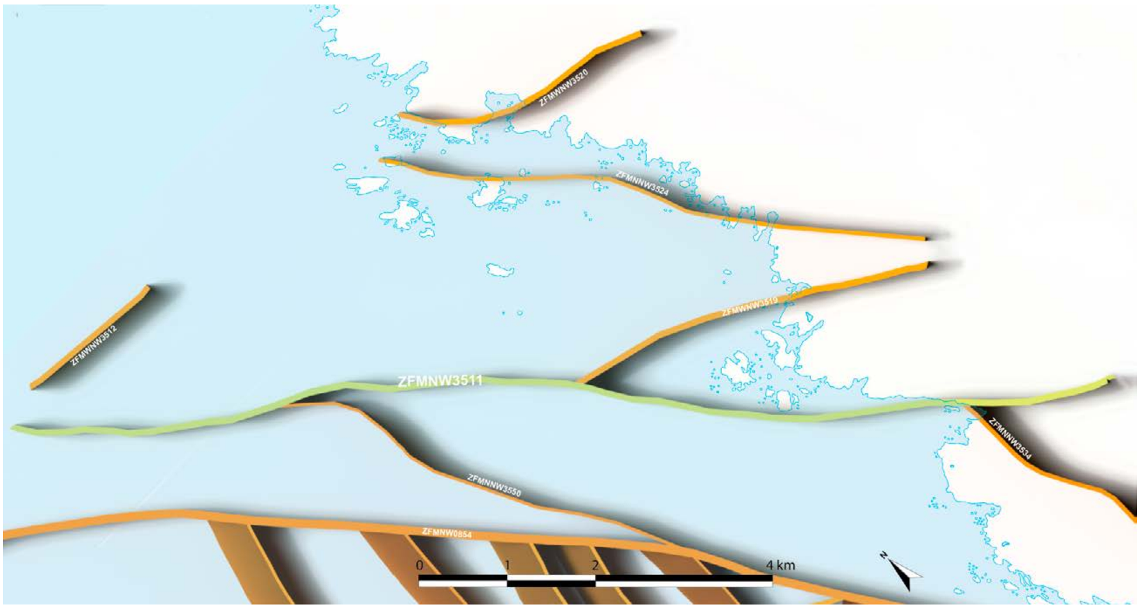
NW	ZFMNW1200	Version number	5	Total object CL	23

KFM09A DZ5 (770.0-790.0 m)





NW	ZFMNW3511		Version number	5	Total object CL	21
GEOLOGICAL CHARACTER		**Property CL**				
Deformation style:	Brittle-Ductile	3				
Deformation description:	No data available.					
Alteration:						
- First order:	Oxidation	1				
- Second order:	Quartz dissolution					
- Third order:	Not observed					
Fracture orientation and type:	Dominance of NW and NNW striking fracture set. Occurrence of sealed and open fractures. Sealed fracture networks are present.					
Fracture comment:	No data available.					
Fracture fill mineralogy:	Calcite, laumontite and adularia.					
OBJECT GEOMETRY						
Strike/dip:	129°/90°					
Length:	19814 m					
Mean thickness:	75 m (50 - 200 m)					
Max depth:	-2100 m					
Geometrical constraints:	ZFMWNW3512, Topo 40m grid Max error 20m, 2 Surface Planar Cut(s).					
BASIS FOR MODELLING						
Zone based on surface lineaments and outcrop observations.						
Outcrops:	ABR20002-1ABR20005, ABR20007, ABR20008, ABR200020,					
Boreholes: -						
Tunnels:	-					
Lineament and/or seismic indications:	MFM3511.					3
MODELLING PROCEDURE						
-						



NW	ZFMNW3511	Version number	5	Total object CL	21

OBJECT CONFIDENCE ESTIMATE

Category	Object CL	Comment
INTERPRETATION		
Data source	3	MFM3511, Field observations (ABR20002-ABR20005, ABR20007, ABR20008, ABR200020, ABR200021, ABR200034).
Results of interpretation	3	High confidence in outcrop observations (ABR20002-ABR20005, ABR20007, ABR20008, ABR200020, ABR200021, ABR200034).
INFORMATION DENSITY		
Number of observation points	3	>4
Distribution of observation points	2	A cluster of field observations (outcrops) and a surface lineament based on geophysics.
INTERPOLATION		
Geometry	2	No subsurface observation points, but still a supporting arrangement of outcrops and fracture orientations.
Geological indicators	2	Interpolation supported by data from outcrops.
EXTRAPOLATION		
Dip direction	3	Extrapolated to the base of the model volume. Strike length of the modelled zone > 2000 m.
Strike direction	3	Conceptual understanding of the site and that the entire regional modelled zone is supported by the lineament. Surface data supported by outcrop observations.

FRACTURE CHARACTER

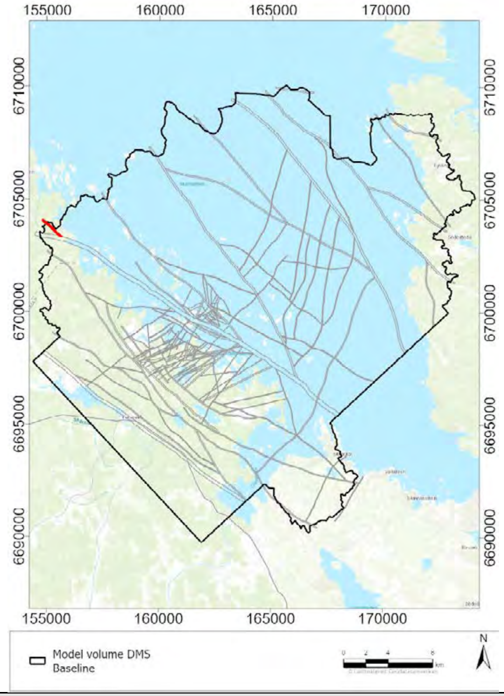
No data available

INDIVIDUAL INTERCEPTS

No data available

NW	ZFMNW3552	Version number	3	Total object CL	12

GEOLOGICAL CHARACTER		Property CL
Deformation style:	No data available	
Deformation description:	No data available. Zone based on lineament maps in the catchment area.	
Alteration:		
- First order:	Not observed	
- Second order:	Not observed	
- Third order:	Not observed	
Fracture orientation and type:	No data available.	
Fracture comment:	No data available.	
Fracture fill mineralogy:	No data available.	



OBJECT GEOMETRY	
Strike/dip:	131°/90°
Length:	13000 m
Mean thickness:	60 m (50 - 200 m)
Max depth:	-2100 m
Geometrical constraints:	Topo 40m grid Max error 20m, ZFMWNW0001, 1 Surface Planar Cut(s).

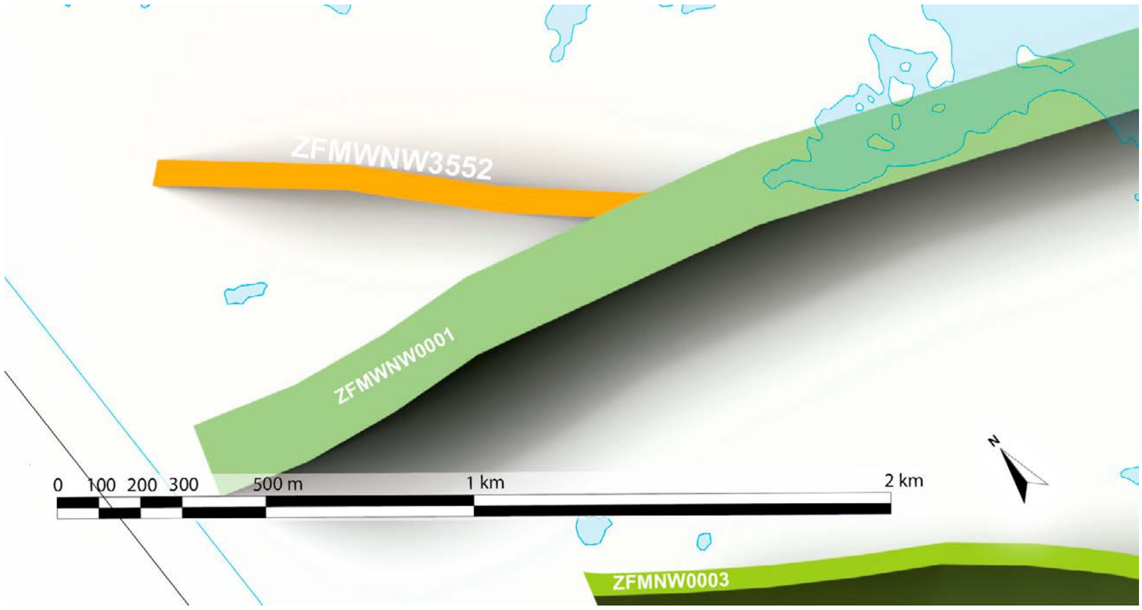
BASIS FOR MODELLING

Zone based on surface lineaments.

Outcrops:	-	
Boreholes: -		
Tunnels:	-	
Lineament and/or seismic indications:	MFM0803A merge.	3

MODELLING PROCEDURE

-



NW	ZFMNW3552	Version number	3	Total object CL	12

OBJECT CONFIDENCE ESTIMATE

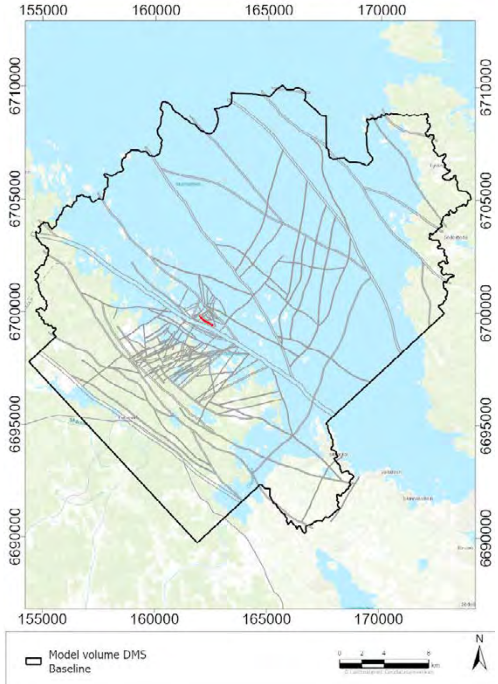
Category	Object CL	Comment
INTERPRETATION		
Data source	1	MFM0803a merged.
Results of interpretation	3	High confidence in lineament MFM0803a.
INFORMATION DENSITY		
Number of observation points	1	1
Distribution of observation points	1	Single observation point in the form of a lineament.
INTERPOLATION		
Geometry	1	Geometry supported by surface geophysical data.
Geological indicators	1	Indirect support by geophysical data.
EXTRAPOLATION		
Dip direction	1	Extrapolated to the base of the model volume. Strike length of the modelled zone > 2000 m.
Strike direction	3	Conceptual understanding of the site and that the entire regional modelled zone is supported by the lineament.

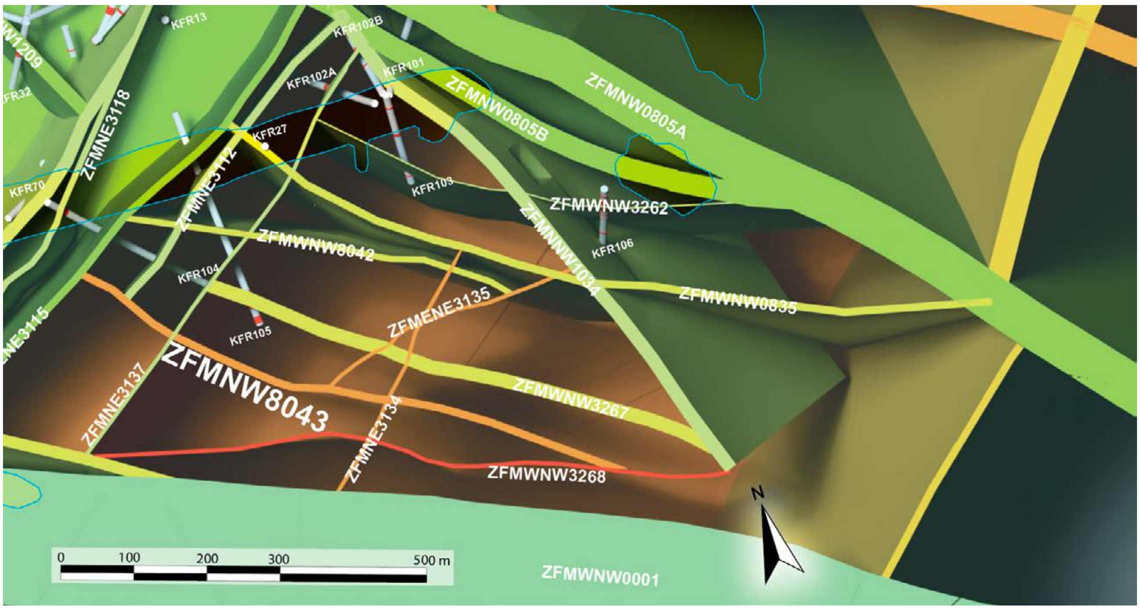
FRACTURE CHARACTER

No data available

INDIVIDUAL INTERCEPTS

No data available

NW	ZFMNW8043		Version number	5	Total object CL	10
GEOLOGICAL CHARACTER		**Property CL**				
Deformation style:	Brittle	2				
Deformation description:	No data available.					
Alteration:						
- First order:	Not observed					
- Second order:	Not observed					
- Third order:	Not observed					
Fracture orientation and type:	No data available.					
Fracture comment:	No data available.					
Fracture fill mineralogy:	No data available.					
OBJECT GEOMETRY						
Strike/dip:	126°/90°					
Length:	775 m					
Mean thickness:	10 m (2 - 36 m)					
Max depth:	-780 m					
Geometrical constraints:	ZFMWNW3268, ZFMENE3115, Topo 40m grid Max error 20m, 1 Surface Planar Cut(s).					
BASIS FOR MODELLING						
Zone based on surface lineaments.						
Outcrops:	-					
Boreholes: -						
Tunnels:	-					
Lineament and/or seismic indications:	MSFR10002.					1
MODELLING PROCEDURE						
The position of the zone at the ground surface is based on version 1.0 magnetic lineament MSFR10002 that replaces version 0.1 lineaments MSFR08043 and MSFR08045. The earlier number has been kept in the zone name to assist traceability between different model versions. The modelled dip and thickness are default values.						



NW	ZFMNW8043	Version number	5	Total object CL	10

OBJECT CONFIDENCE ESTIMATE

Category	Object CL	Comment
INTERPRETATION		
Data source	1	MSFR10002.
Results of interpretation	1	High confidence in lineament MSFR10002.
INFORMATION DENSITY		
Number of observation points	1	1
Distribution of observation points	1	Single observation point in the form of a lineament.
INTERPOLATION		
Geometry	1	Geometry supported by surface geophysical data.
Geological indicators	1	Indirect support by geophysical data.
EXTRAPOLATION		
Dip direction	1	No subsurface obs. point, supported only by surface data. High uncertainty in dip-direction. Strike length of the modelled zone < 2000 m.
Strike direction	3	Conceptual understanding of the site and that the entire regional modelled zone is supported by the lineament.

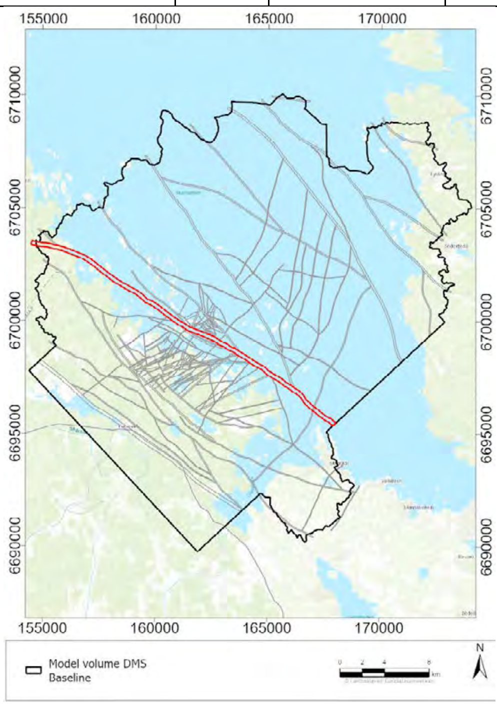
FRACTURE CHARACTER

No data available

INDIVIDUAL INTERCEPTS

No data available

WNW	ZFMWNW0001		Version number	5	Total object CL	24
GEOLOGICAL CHARACTER		Property CL				
Deformation style:	Brittle-Ductile	3				
Deformation description:	Steeply dipping faults with NW-SE or WNW-ESE strike shows dextral strike-slip, oblique-slip with a reverse dip-slip component, sinistral strike-slip or normal dip-slip displacement. Remainder faults exhibit strike-slip or oblique slip displacements. Steeply dipping faults with ENE-WSW or NE-SW strike shows strike-slip, oblique-slip with dominant strike- slip component in part dextral, oblique-slip with dominant reverse dip-slip component or normal dip-slip displacements. Steeply dipping faults with NNW strike shows sinistral strike-slip displacement. Gently dipping faults shows dextral strike- slip, oblique slip with dominant dextral strike-slip component or reverse dip-slip displacements. The larger part of the borehole interval 498-630 m in KFM11A (part of DZ1), which has been studied for the more detailed characterization and kinematics of zone ZFWNW0001, was classified as fault core; fault rocks (breccias and cataclasites) as well as crush zones were superimposed on rock affected by ductile deformation. Most fault slip data occur in the interval 510-540 m and close to the bottom of the studied interval at 625-629 m.					
Alteration:		3				
- First order:	Oxidation					
- Second order:	Sericitization					
- Third order:	Argillization					
Fracture orientation and type:	Steep sets with WNW-ESE to NW-SE and ENE strike are prominent. Fractures with other orientations, including gently dipping fractures, are also present. Dominance of sealed fractures. Quantitative estimate and span include sealed fracture networks and crush zones.	3				
Fracture comment:	No data available.					
Fracture fill mineralogy:	Chlorite, calcite, laumontite, hematite/adularia, clay minerals, quartz, epidote.					
OBJECT GEOMETRY						
Strike/dip:	119°/90°					
Length:	35551 m					
Mean thickness:	181 m (50 - 200 m)					
Max depth:	-2100 m					
Geometrical constraints:	Topo 40m grid Max error 20m, 3 Surface Planar Cut(s).					



WNW	ZFMWNW0001	Version number	5	Total object CL	24

BASIS FOR MODELLING

Zone based on surface lineaments, tunnel and borehole observations.

Outcrops: -

Boreholes:

Borehole	PDZ	Target intercept		Geometric intercept		Comment
		Sec_up [m]	Sec_low [m]	Sec_up [m]	Sec_low [m]	
HFM34	DZ1	37.00	192.00	17.78	200.74	
HFM34	DZ2	37.00	192.00	17.78	200.74	
HFM34	DZ3	37.00	192.00	17.78	200.74	
HFM35	DZ1	24.00	33.00	8.13	41.38	DZ1 also lies within ZFMNW0002.
HFM35	DZ2	47.20	52.50	8.13	41.38	DZ2 also lies within ZFMNW0002.
HFR105	DZ1	21.12	31.00	14.12	77.41	
HFR105	DZ2	88.00	92.00	14.12	77.41	
KFM11A	DZ1	498.00	824.00	490.67	826.73	Geometrical split of DZ1 between ZFMWNW0001, ZFMWNW0813 and ZFMWNW3259.
KFR01	DZ1	0.00	62.30	0.00	62.29	
KFR61	DZ1	1.40	70.90	2.29	70.90	
KFR62	DZ1	45.64	82.80	4.65	82.80	
KFR64	DZ1	12.79	54.17	2.73	54.17	
KFR65	DZ1	17.63	39.68	1.77	39.68	
KFR66	DZ1	14.99	29.17	3.13	29.17	
KFR67	DZ1	13.74	48.95	4.12	48.95	
KFR71	DZ1	65.67	69.50	0.00	120.90	
KFR71	DZ2	72.14	120.90	0.00	120.90	
KFR84		-	-	0.00	29.50	No SHI available.
KFR85		-	-	0.00	12.20	No SHI available.
KFR86		-	-	0.00	14.70	No SHI available.

Tunnels:	DT target intercept 0+212 - 0+295 m, geometric intercept 0+155 - 0+362 m. BT target intercept 0+189 - 0+283 m, geometric intercept 0+140 - 0+345 m.	
Lineament and/or seismic indications:	MFM0803A merge, MFM3506.	3

MODELLING PROCEDURE

At the surface, corresponds to the low magnetic lineaments MFM0803 and MFM0803G0. Zone ZFMWNW0001 forms the main structural component in a system of sub-parallel deformation zones with WNW-ESE or NW-SE strike and vertical or steep dip in the central part of the model volume. Modelling procedure and properties inherited from updated geological model for SFR presented in Appendix 11 in Curtis et al. (2011). The zone intersects the SFR DT tunnel (tDZ7 0+212, tDZ8 0+243, tDZ9 0+255, tDZ10 0+257, tDZ12 0+259, tDZ13 0+260, tDZ14 0+258–0+271, tDZ15 0+275, tDZ16 0+278–0+295 and tDZ17 0+291) and BT tunnel (tDZ7 0+189, tDZ8 0+220, tDZ9 0+228, tDZ10 0+229, tDZ11 0+231, tDZ12 0+234, tDZ13 0+238, tDZ14 0+238–0+249, tDZ15 0+248, tDZ16 0+267–0+283, tDZ17 0+268 and tDZ18 0+280), borehole KFM11A along interval 498-824 m (part of DZ1) and several older cored and percussion boreholes at SFR.

WNW	**ZFMWNW0001**	Version number	**5**	Total object CL	**24**

OBJECT CONFIDENCE ESTIMATE

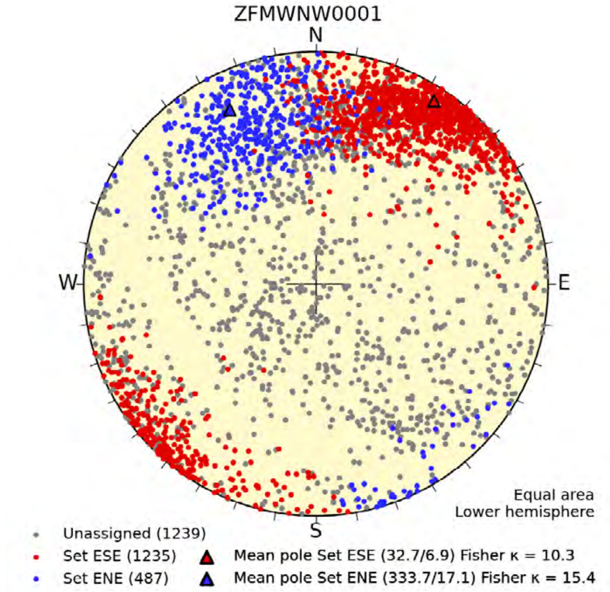
Category	Object CL	Comment
INTERPRETATION		
Data source	3	MFM0803a merged, HFM34, HFM35, HFR105, KFM11, KFR01, KFR61, KFR62, KFR64, KFR65, KFR66, KFR67, KFR71, KFR84, KFR86, SFR DT and BT tunnels and older SFR boreholes along these tunnels.
Results of interpretation	3	High confidence observations in multiple boreholes and SFR tunnels.
INFORMATION DENSITY		
Number of observation points	3	>4
Distribution of observation points	3	Multiple subsurface observations points suggesting one strong alternative.
INTERPOLATION		
Geometry	3	Geometry supported by multiple subsurface obs. points. One strong interpolation alternative.
Geological indicators	3	Interpolation supported by key geological parameters within the range of the obs. points.
EXTRAPOLATION		
Dip direction	3	Extrapolated to the base of the model volume. Strike length of the modelled zone > 2000 m. Dip based on data from intersections along tunnels 1-2, 3 and SFR, and boreholes along tunnels.
Strike direction	3	Conceptual understanding of the site and that the entire regional modelled zone is supported by the lineament.

WNW	ZFMWNW0001	Version number	5	Total object CL	24

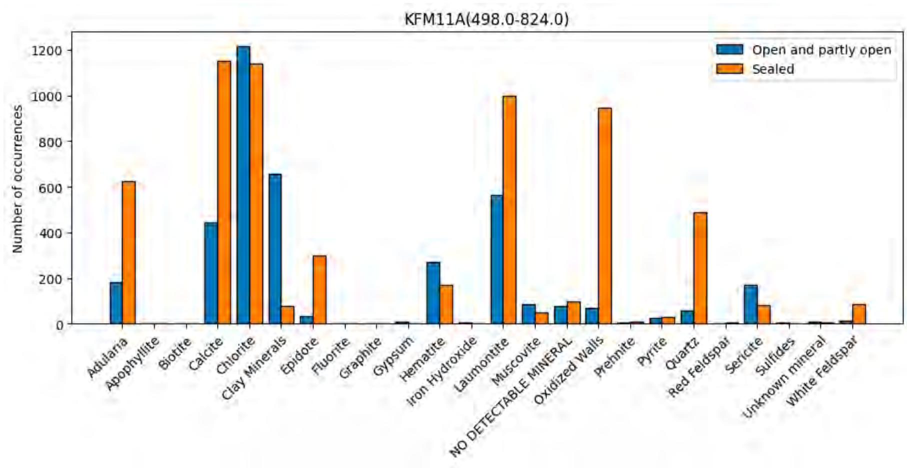
FRACTURE CHARACTER

Orientation: (strike/dip right-hand-rule)	Set ESE: 122.7°/83.1° Set ENE: 63.7°/72.9°
Frequency:	Boreholes: KFR67, KFR62, KFM11A, KFR61, KFR64, KFR65, KFR71, KFR85, KFR01, KFR84, KFR66, KFR86

FRACTURE TYPE	TERZAGHI-WEIGHED P10
Open and partly open	0.7 m-1
Sealed	1.7 m-1
Sealed network	2.2 % of DZ intercept
Crush	0.2 % of DZ intercept



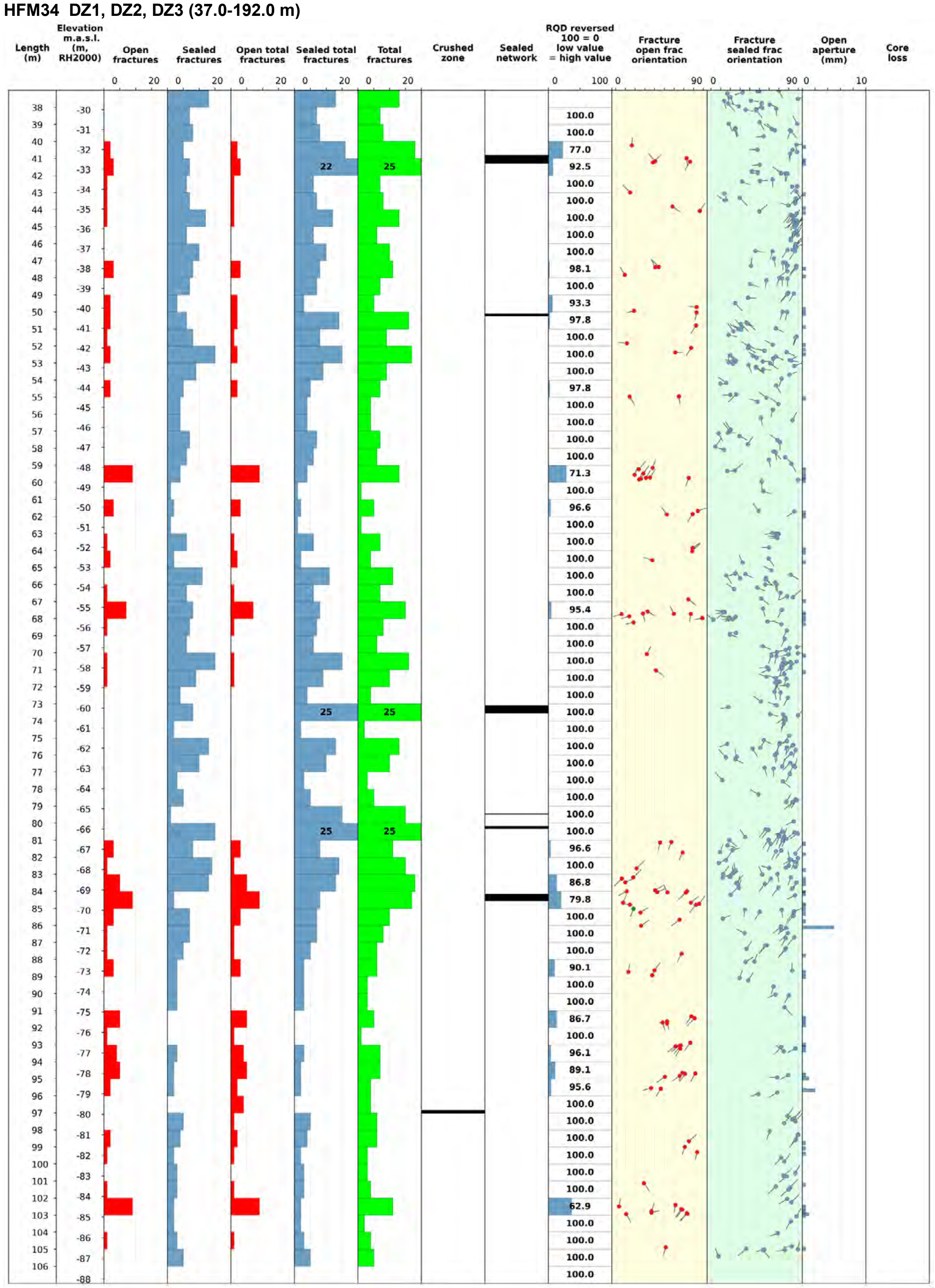
RQD:	min:28, max:100, mean:90
Fracture fill mineralogy:	



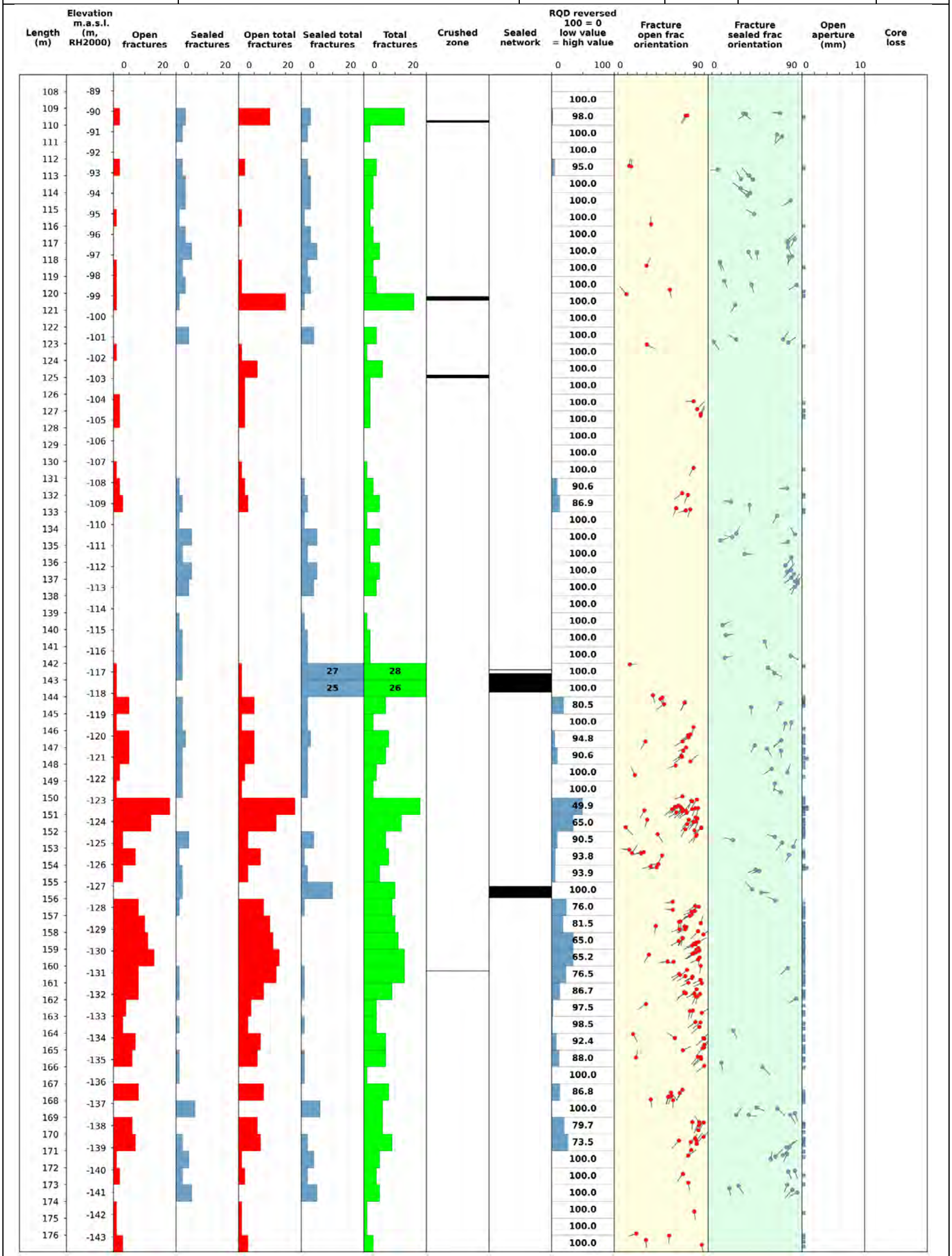
WNW	ZFMWNW0001	Version number	5	Total object CL	24

INDIVIDUAL INTERCEPTS

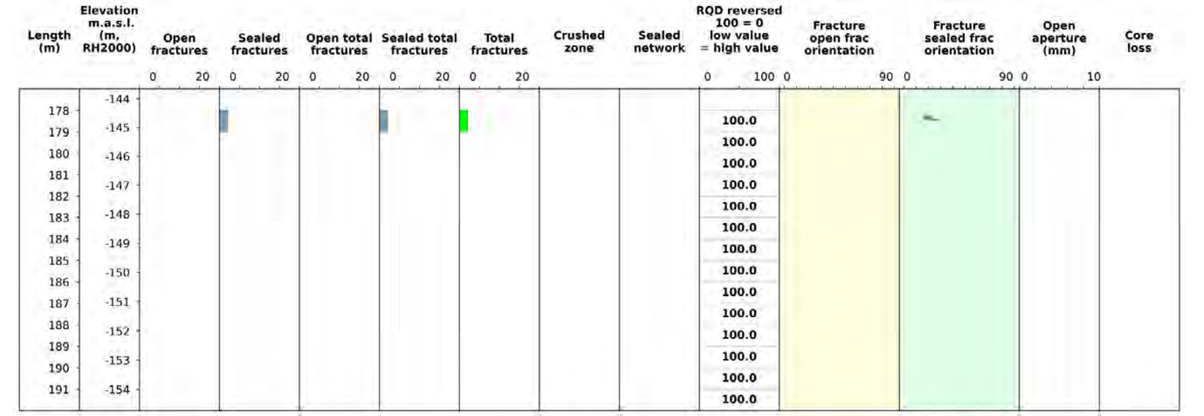
HFM34 DZ1, DZ2, DZ3 (37.0-192.0 m)



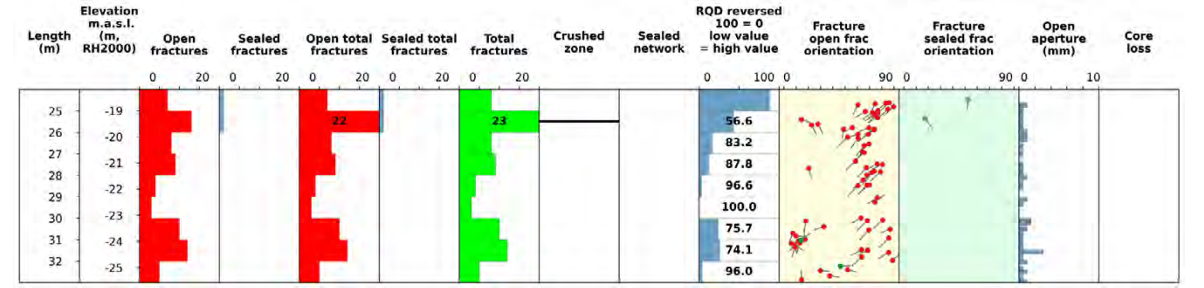
WNW	ZFMWNW0001	Version number	5	Total object CL	24



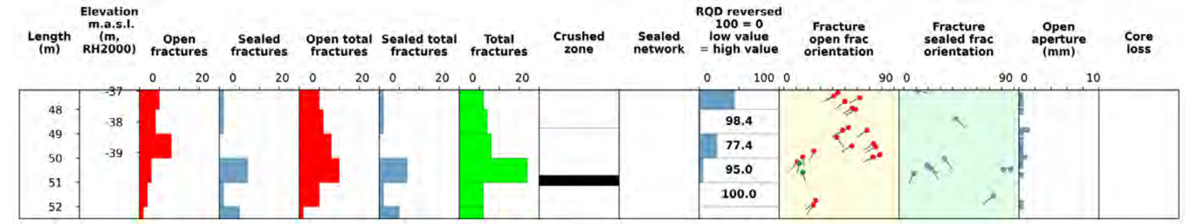
WNW	ZFMWNW0001	Version number	5	Total object CL	24



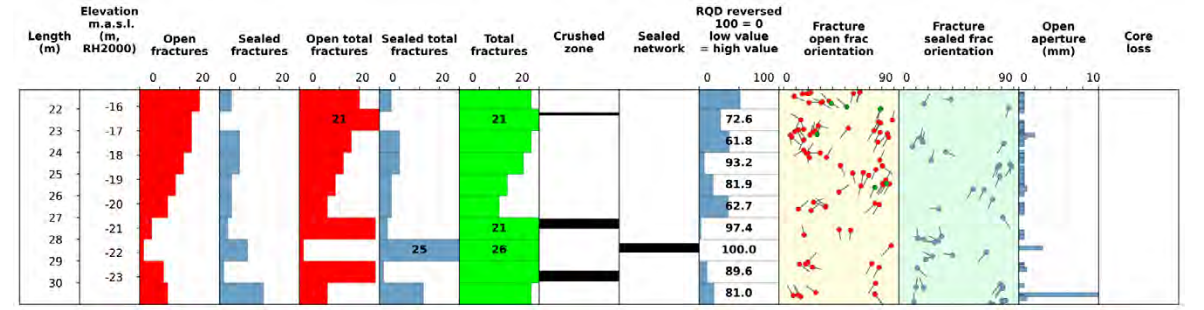
HFM35 DZ1 (24.0-33.0 m)



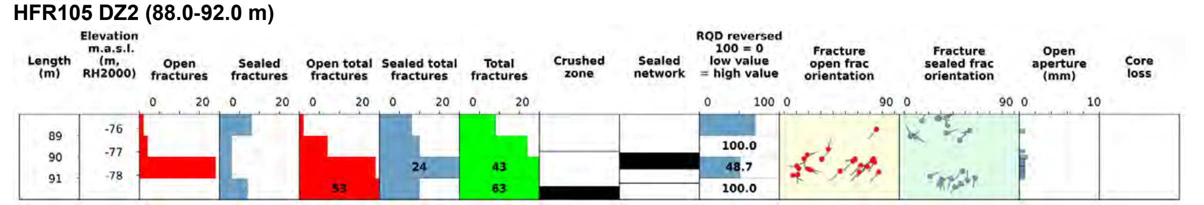
HFM35 DZ2 (47.2-52.5 m)



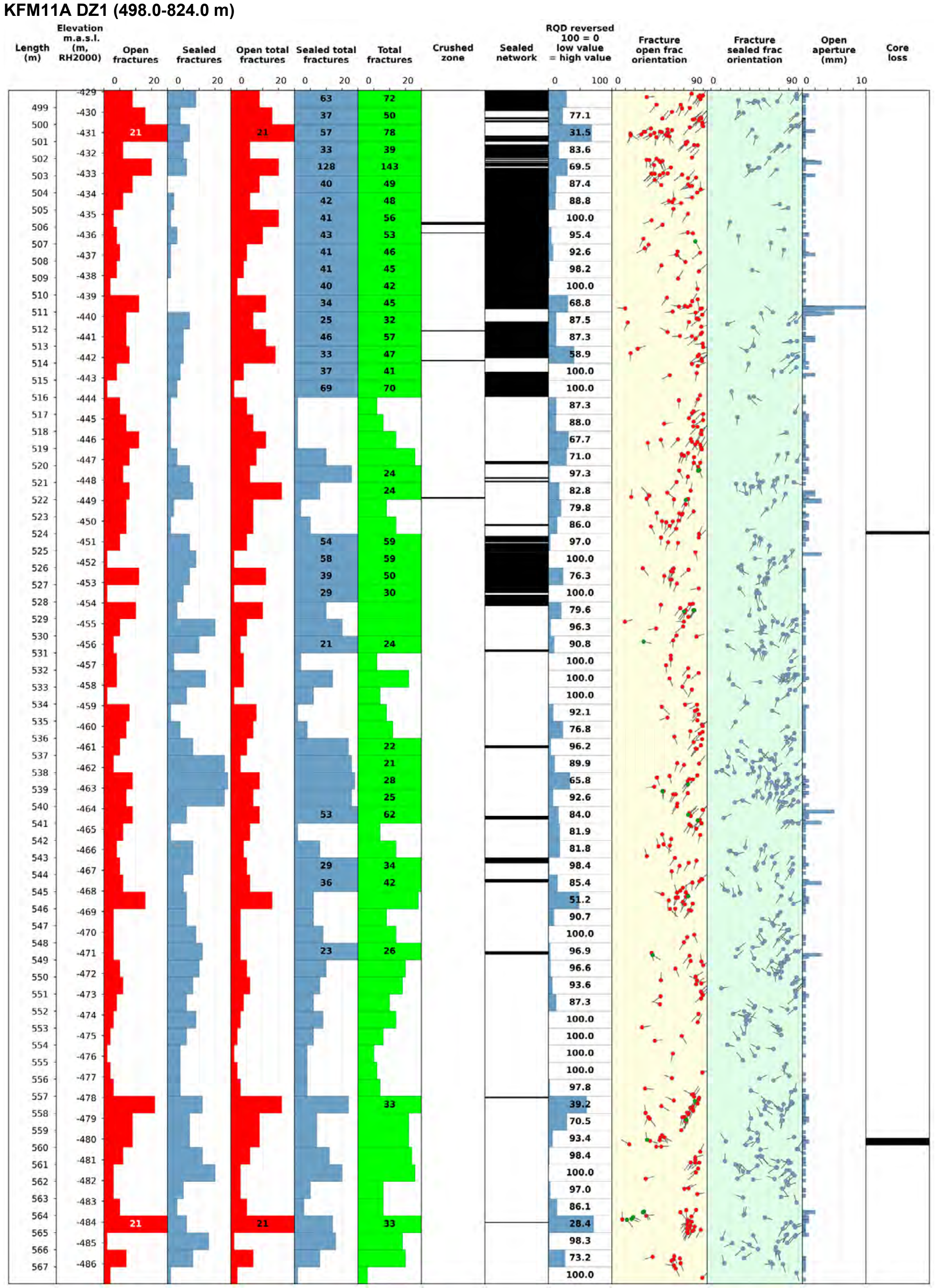
HFR105 DZ1 (21.12-31.0 m)



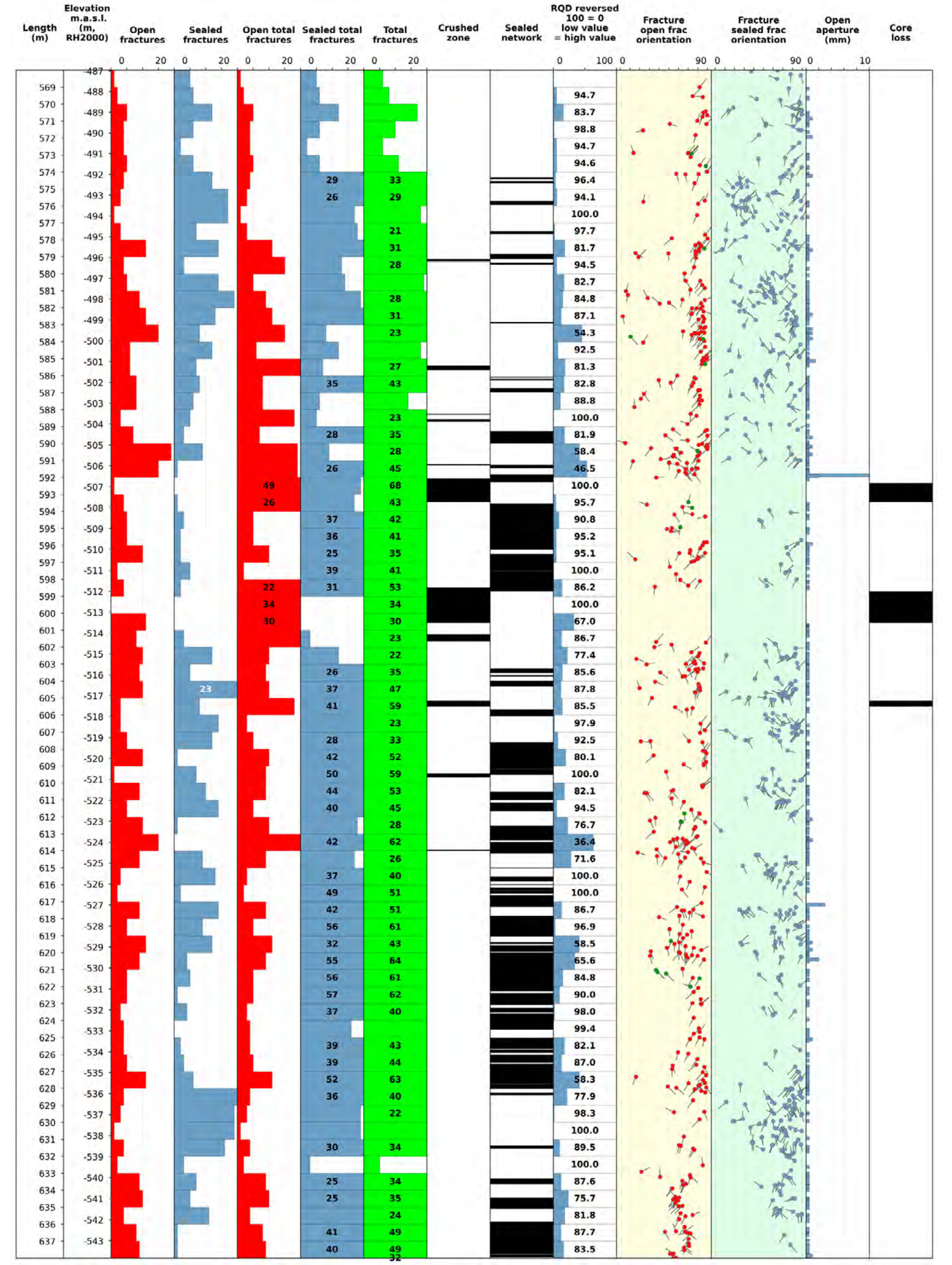
HFR105 DZ2 (88.0-92.0 m)



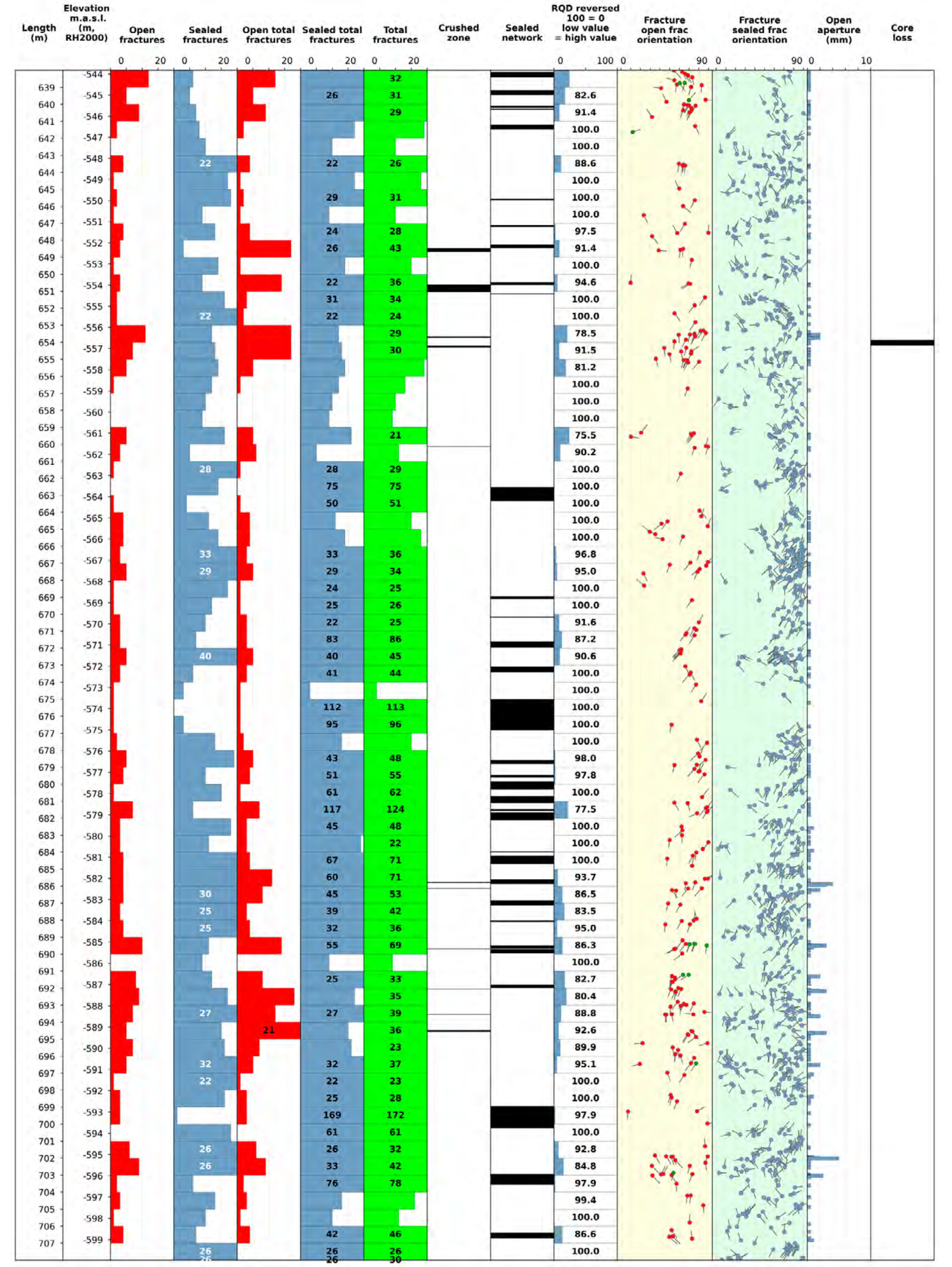
WNW	ZFMWNW0001	Version number	5	Total object CL	24

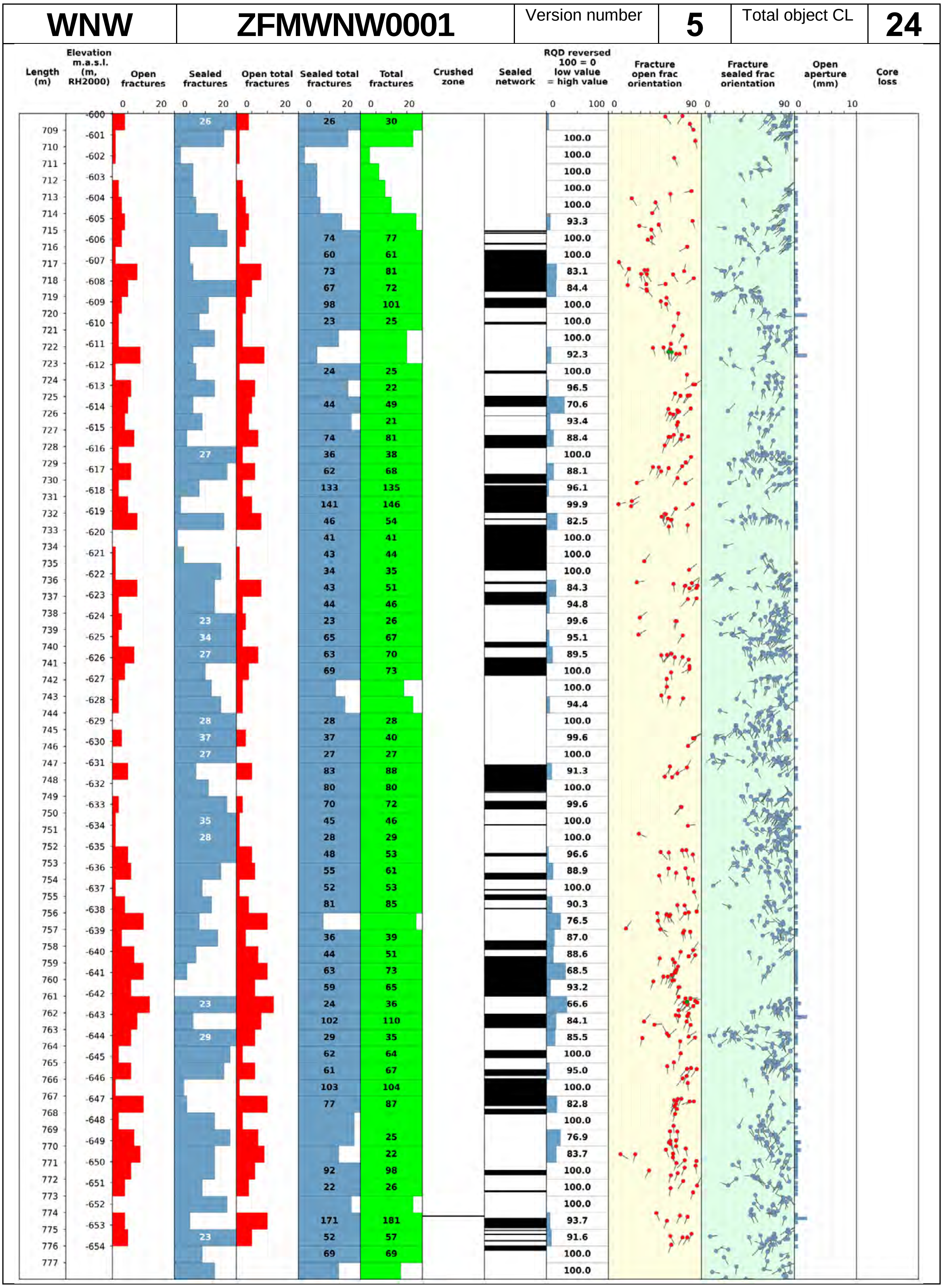


WNW	ZFMWNW0001	Version number	5	Total object CL	24

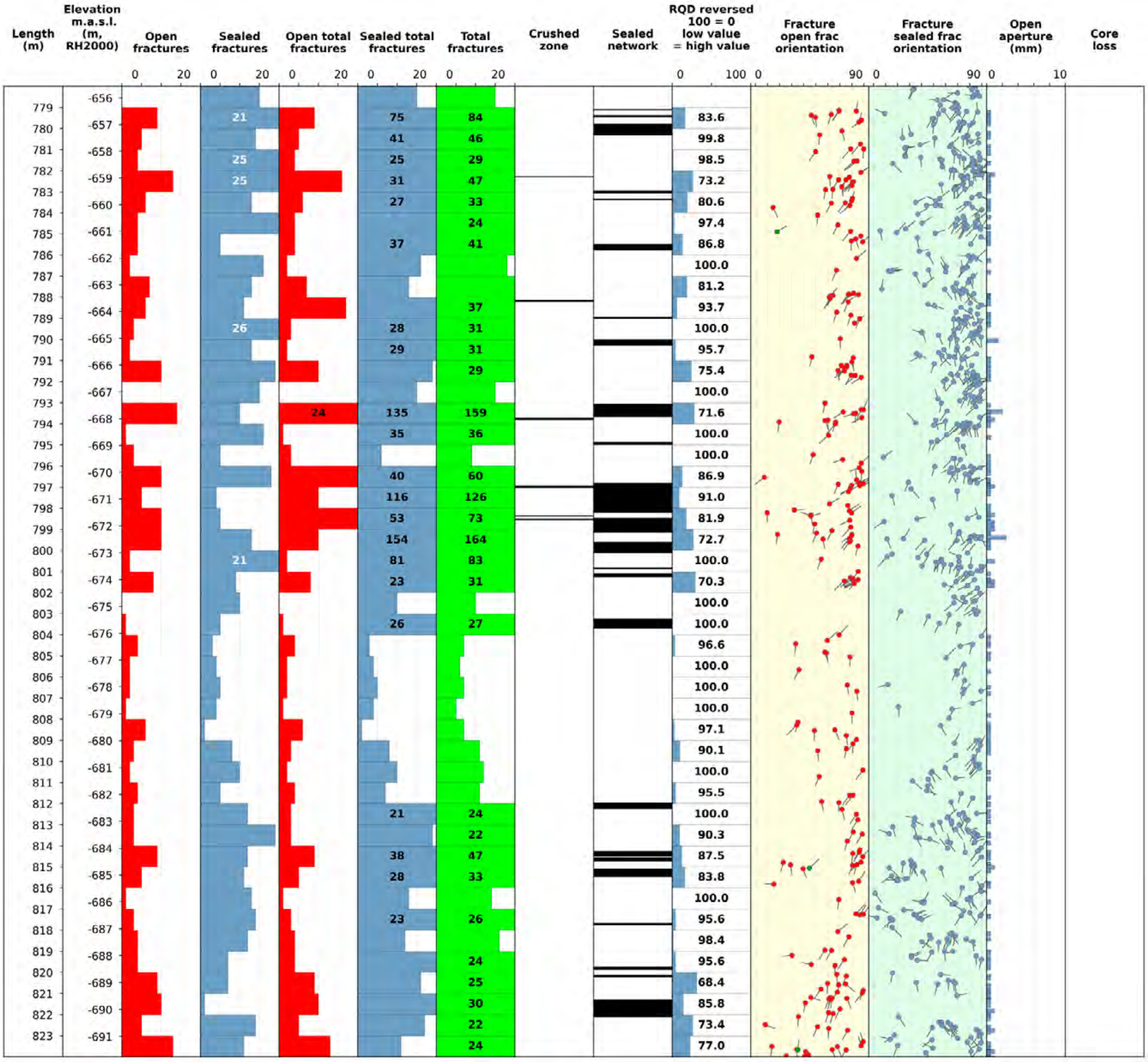


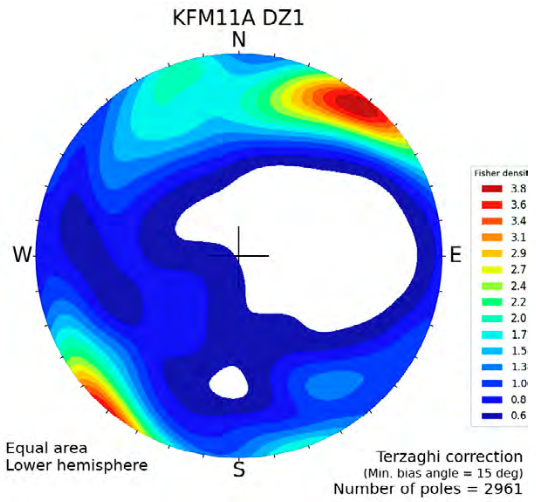
WNW	ZFMWNW0001	Version number	5	Total object CL	24

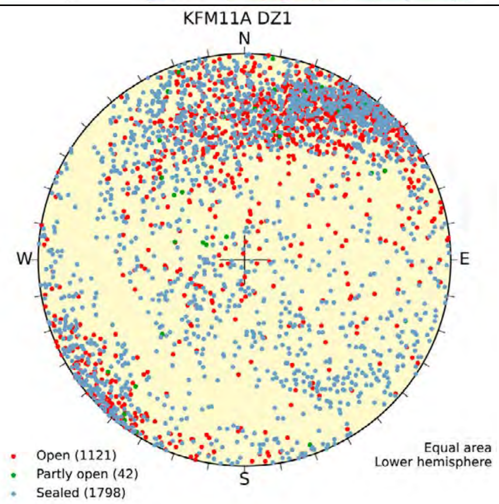



WNW
ZFMWNW0001
Version number
5
Total object CL
24
Length (m)
Elevation m.a.s.l. (m, RH2000)
Open fractures
Sealed fractures
Open total fractures
Sealed total fractures
Total fractures
Crushed zone
Sealed network
RQD reversed 100 = 0 low value = high value
Fracture open frac orientation
Fracture sealed frac orientation
Open aperture (mm)
Core loss

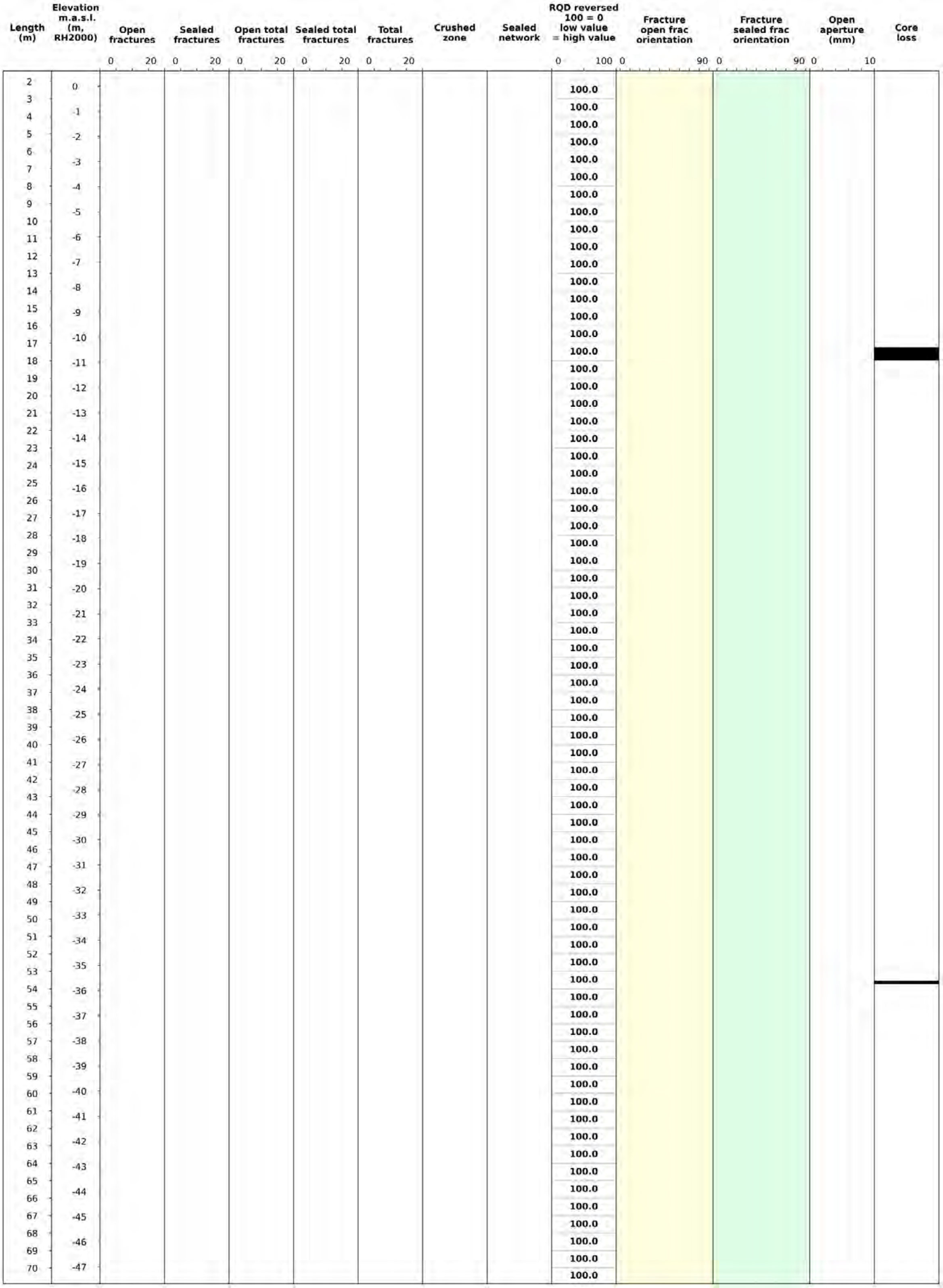
WNW	ZFMWNW0001	Version number	5	Total object CL	24





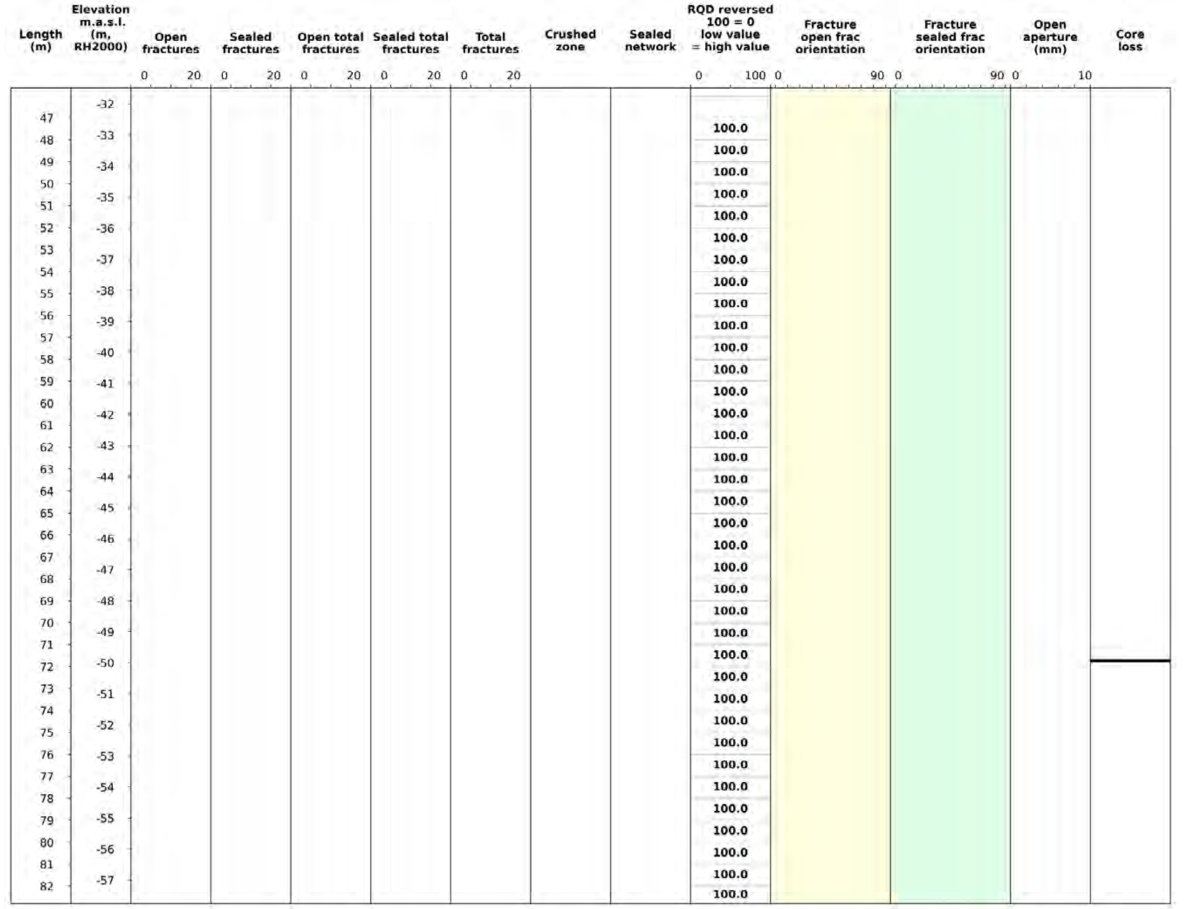


WNW	ZFMWNW0001	Version number	5	Total object CL	24
KFR01 DZ1 (0.0-62.3 m)					
No data available					
KFR61 DZ1 (1.4-70.9 m)					



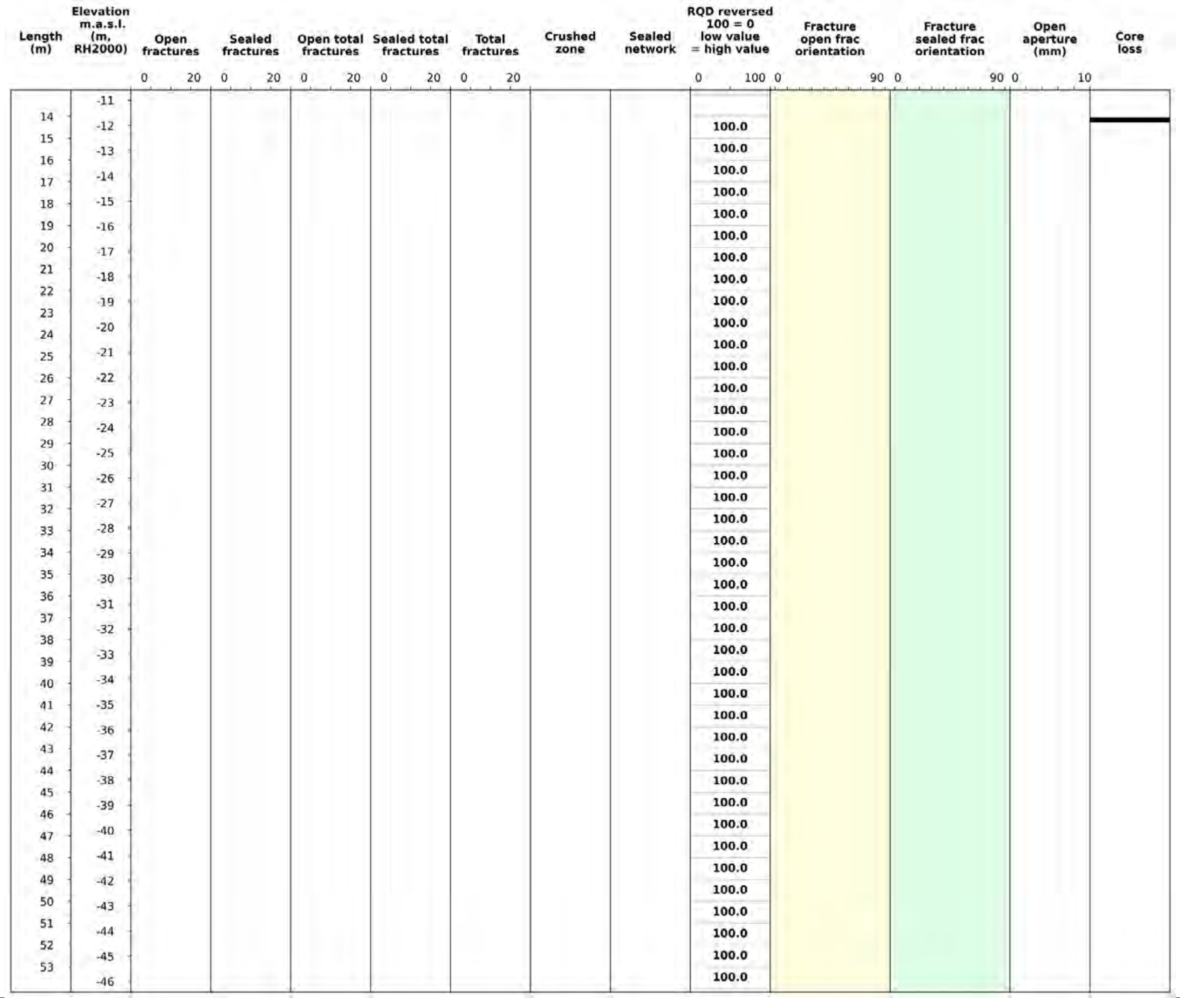
WNW	ZFMWNW0001	Version number	5	Total object CL	24

KFR62 DZ1 (45.64-82.8 m)



WNW	ZFMWNW0001	Version number	5	Total object CL	24

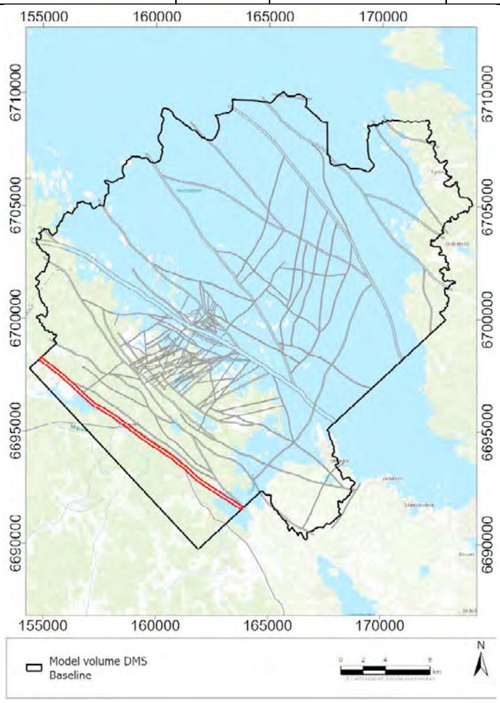
KFR64 DZ1 (12.79-54.17 m)



KFR65 DZ1 (17.63-39.68 m)	
No data available	
KFR66 DZ1 (14.99-29.17 m)	
No data available	
KFR67 DZ1 (13.74-48.95 m)	
No data available	
KFR71 DZ1 (65.67-69.5 m)	
No data available	
KFR71 DZ2 (72.14-120.9 m)	
No data available	
KFR84 (0.0-29.5 m)	
No data available	
KFR85 (0.0-12.2 m)	
No data available	
KFR86 (0.0-14.7 m)	
No data available	

WNW	ZFMWNW0004		Version number	7	Total object CL	24

GEOLOGICAL CHARACTER		Property CL
Deformation style:	Brittle-Ductile	3
Deformation description:	Steeply dipping faults with NW-SE or WNW-ESE strike shows strike-slip with sinistral or dextral displacement. Oblique-slip including dominant sinistral or dextral strike-slip component, dextral strike-slip, sinistral strike-slip, reverse dip-slip or normal dip-slip displacement. Steeply dipping faults with ENE-WSW or NE-SW strike shows sinistral strike-slip or uncertain sense of shear. Steeply dipping faults with NNE-SSW strike shows reverse dip-slip or oblique slip displacement with dominant strike-slip component. Gently dipping faults shows reverse dip-slip, oblique-slip with dominant strike-slip component or strike-slip with dextral or sinistral displacement. Several intervals of fault core identified composed of cataclasite (see photograph below), ultra-cataclasite, fault breccia, sealed fracture networks including epidote-sealed networks, and crush zones (see photograph below). The interval between 312 and 338 m is most conspicuous. Vuggy rock with dissolution of quartz is also present along borehole interval 230–240 m.	
Alteration:		3
- First order:	Oxidation	
- Second order:	Quartz dissolution	
- Third order:	Not observed	
Fracture orientation and type:	Steeply dipping fractures with NW-SE strike and dip predominantly to the southwest and more gently dipping fractures dipping to the south-east are prominent. Fractures with other orientations (e.g. steep ENE-WSW) are also present.	2
Fracture comment:	No data available.	
Fracture fill mineralogy:	Chlorite, calcite, laumontite, hematite/adularia, quartz, clay minerals, epidote, prehnite and pyrite. Note locally some asphaltite.	
OBJECT GEOMETRY		
Strike/dip:	122°/90°	
Length:	70000 m	
Mean thickness:	143 m (50 - 200 m)	
Max depth:	-2100 m	
Geometrical constraints:	Topo 40m grid Max error 20m, 2 Surface Planar Cut(s).	



WNW	ZFMWNW0004	Version number	7	Total object CL	24

BASIS FOR MODELLING

Zone based on surface lineaments and borehole observations.

Outcrops: -

Boreholes:

Borehole	PDZ	Target intercept		Geometric intercept		Comment
		Sec_up [m]	Sec_low [m]	Sec_up [m]	Sec_low [m]	
HFM37	DZ1	15.00	191.46	0.00	191.75	
HFM37	DZ2	15.00	191.46	0.00	191.75	
HFM37	DZ3	15.00	191.46	0.00	191.75	
KFM12A	DZ1	125.00	402.00	122.79	400.63	
KFM12A	DZ2	125.00	402.00	122.79	400.63	

Tunnels:	-	
Lineament and/or seismic indications:	MFM0014.	3

MODELLING PROCEDURE

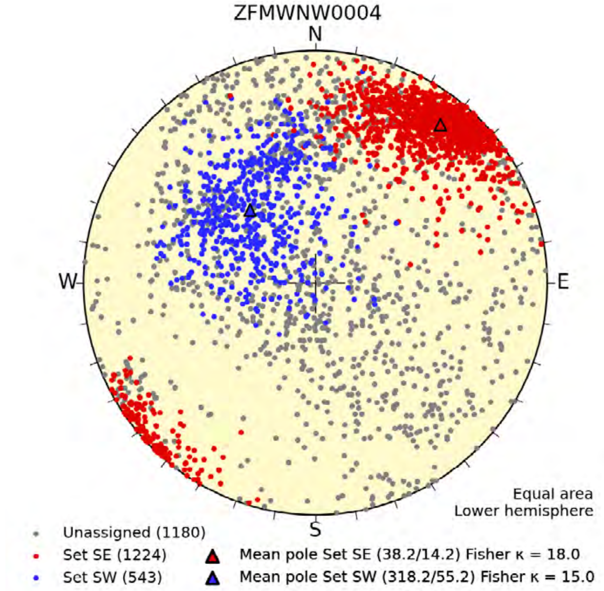
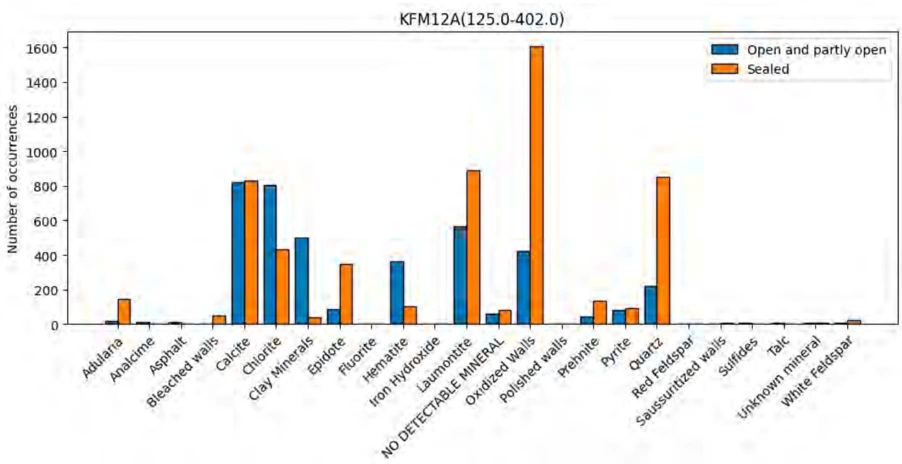
At the surface, corresponds to the low magnetic lineament MFM0014. Modelled to the base of the model volume using an assumed dip of 90 degrees by comparison with ZFMWNW0001. Intersects KFM12 at 125-402 m (DZ1 and 2) as well as the whole HFM37 (DZ1-3).

OBJECT CONFIDENCE ESTIMATE

Category	Object CL	Comment
INTERPRETATION		
Data source	3	MFM0014a, HFM37, KFM12A.
Results of interpretation	3	High confidence observations in KFM12A.
INFORMATION DENSITY		
Number of observation points	3	3
Distribution of observation points	3	Considering the two boreholes as a cluster and the lineament as an outlier.
INTERPOLATION		
Geometry	3	One strong alternative based on available sub-surface observation points.
Geological indicators	3	Interpolation supported by key geological parameters.
EXTRAPOLATION		
Dip direction	3	Extrapolated to the base of the model volume. Strike length of the modelled zone > 2000 m.
Strike direction	3	Conceptual understanding of the site and that the entire regional modelled zone is supported by the lineament.

WNW	ZFMWNW0004	Version number	7	Total object CL	24

FRACTURE CHARACTER

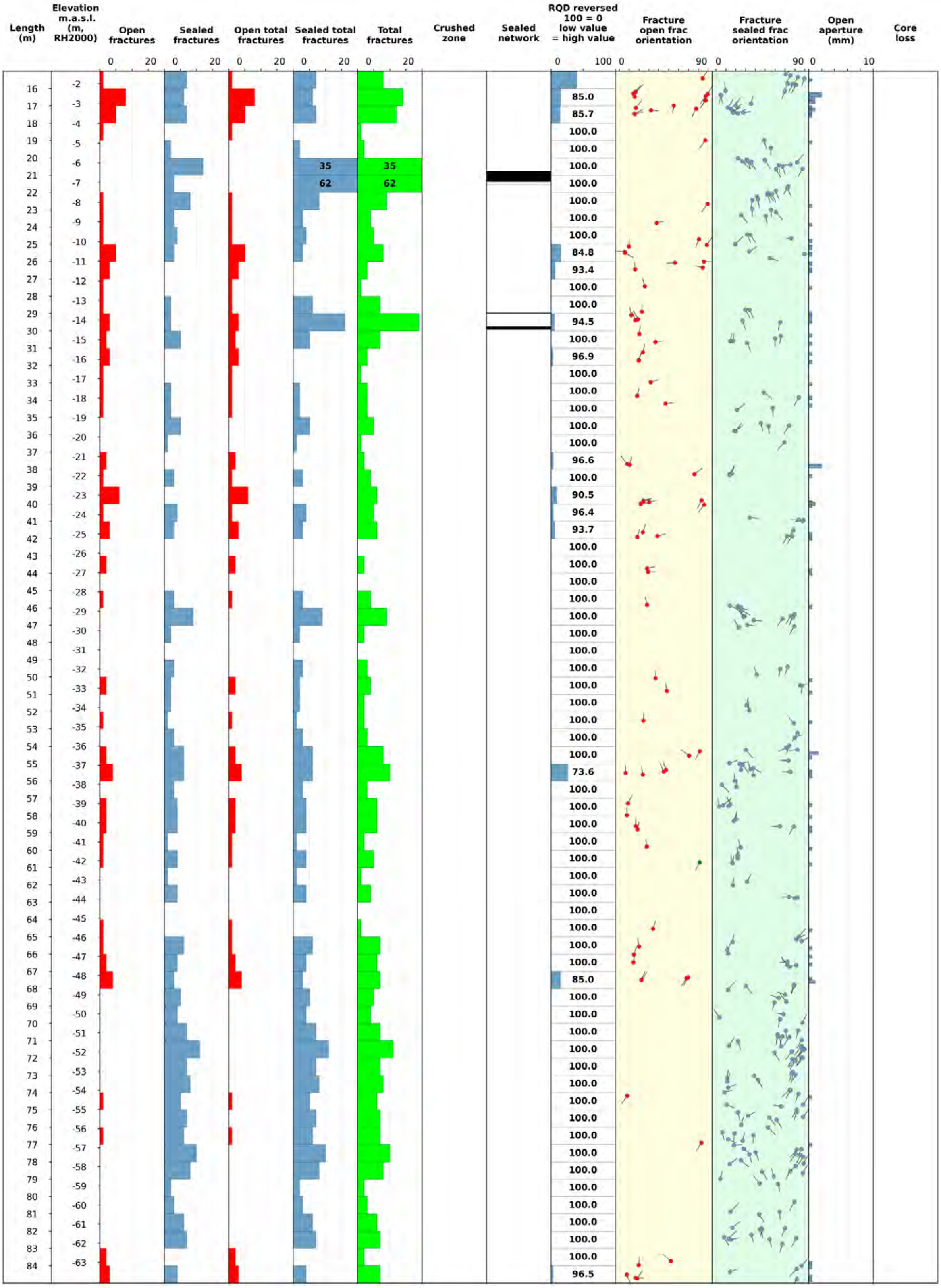
Orientation: (strike/dip right-hand-rule)	Set SE: 128.2°/75.8° Set SW: 48.2°/34.8°	
Frequency:	Boreholes: KFM12A	
RQD:	min:14, max:100, mean:89	
Fracture fill mineralogy:		

FRACTURE TYPE	TERZAGHI-WEIGHED P10
Open and partly open	8.8 m-1
Sealed	20.0 m-1
Sealed network	52.9 % of DZ intercept
Crush	0.4 % of DZ intercept

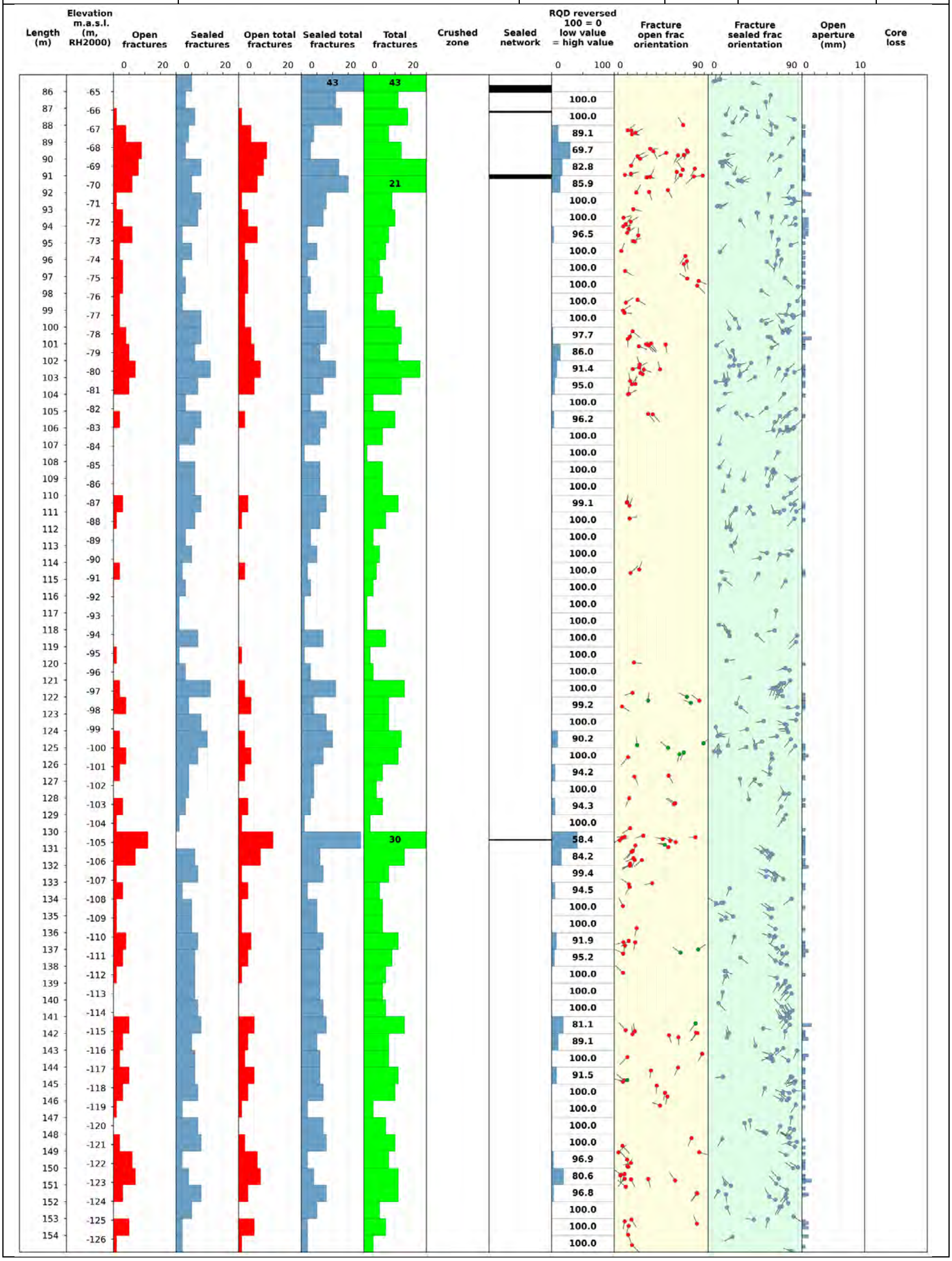
WNW	ZFMWNW0004	Version number	7	Total object CL	24

INDIVIDUAL INTERCEPTS

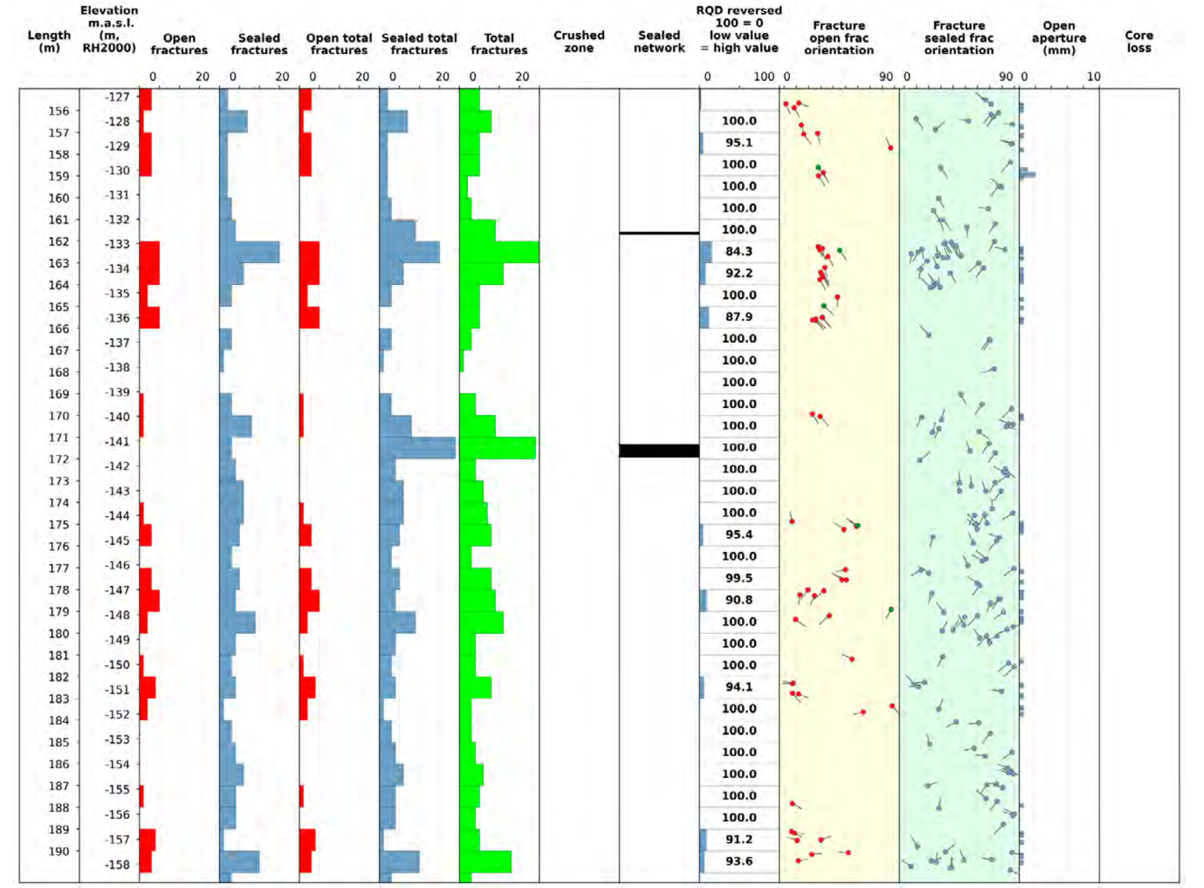
HFM37 DZ1, DZ2, DZ3 (15.0-191.46 m)



WNW	ZFMWNW0004	Version number	7	Total object CL	24

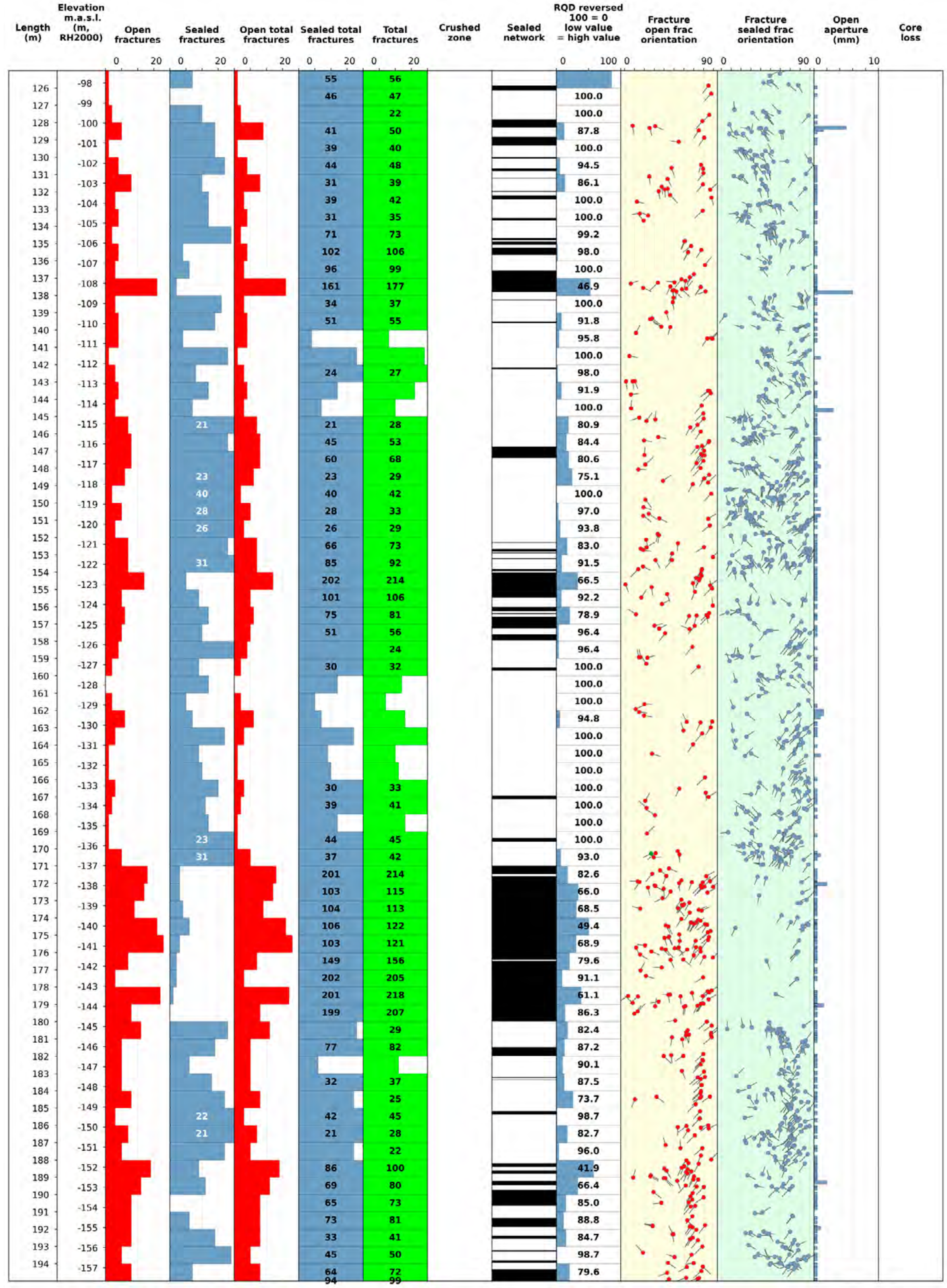


WNW	ZFMWNW0004	Version number	7	Total object CL	24

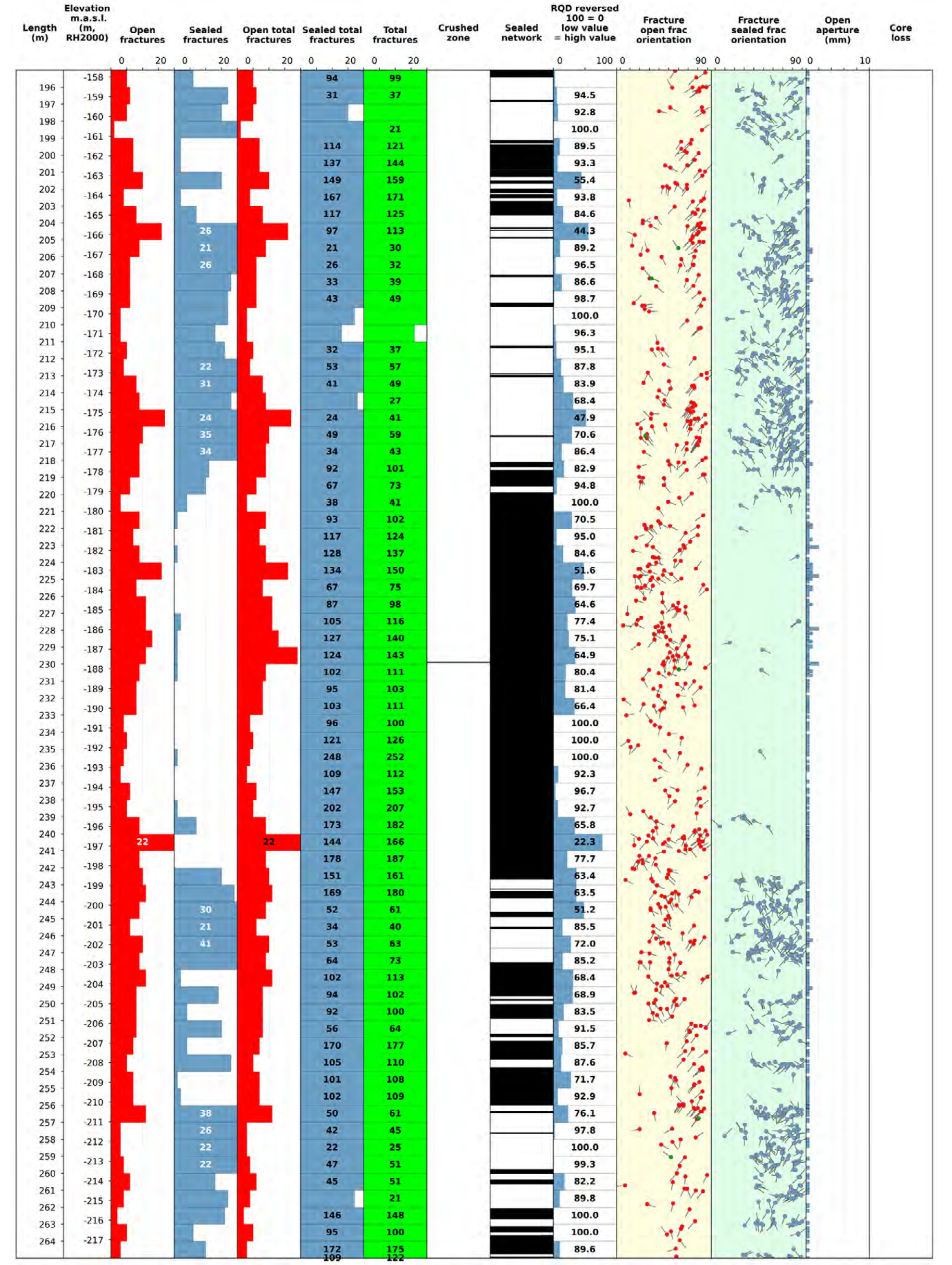


WNW	ZFMWNW0004	Version number	7	Total object CL	24

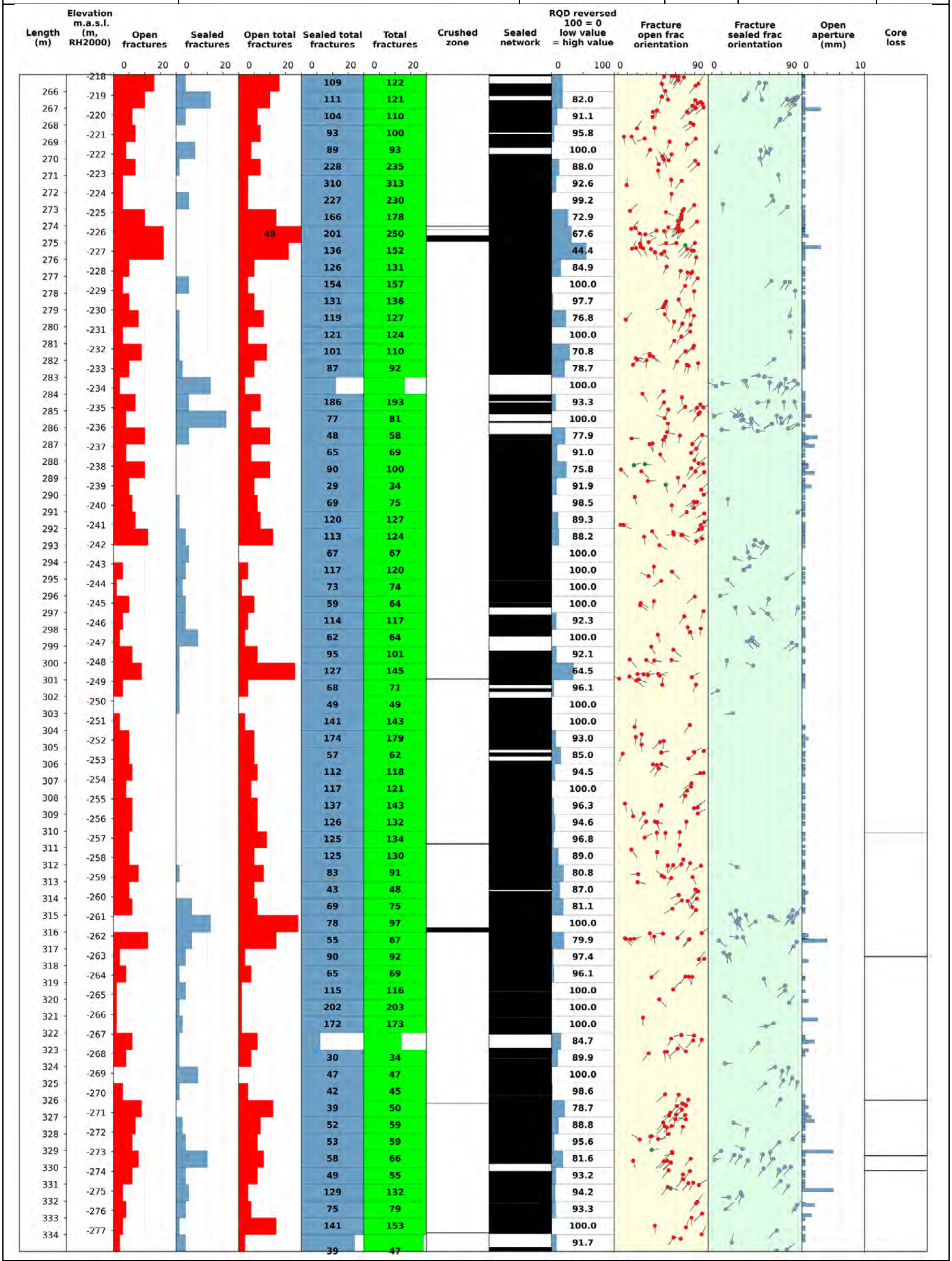
KFM12A DZ1, DZ2 (125.0-402.0 m)



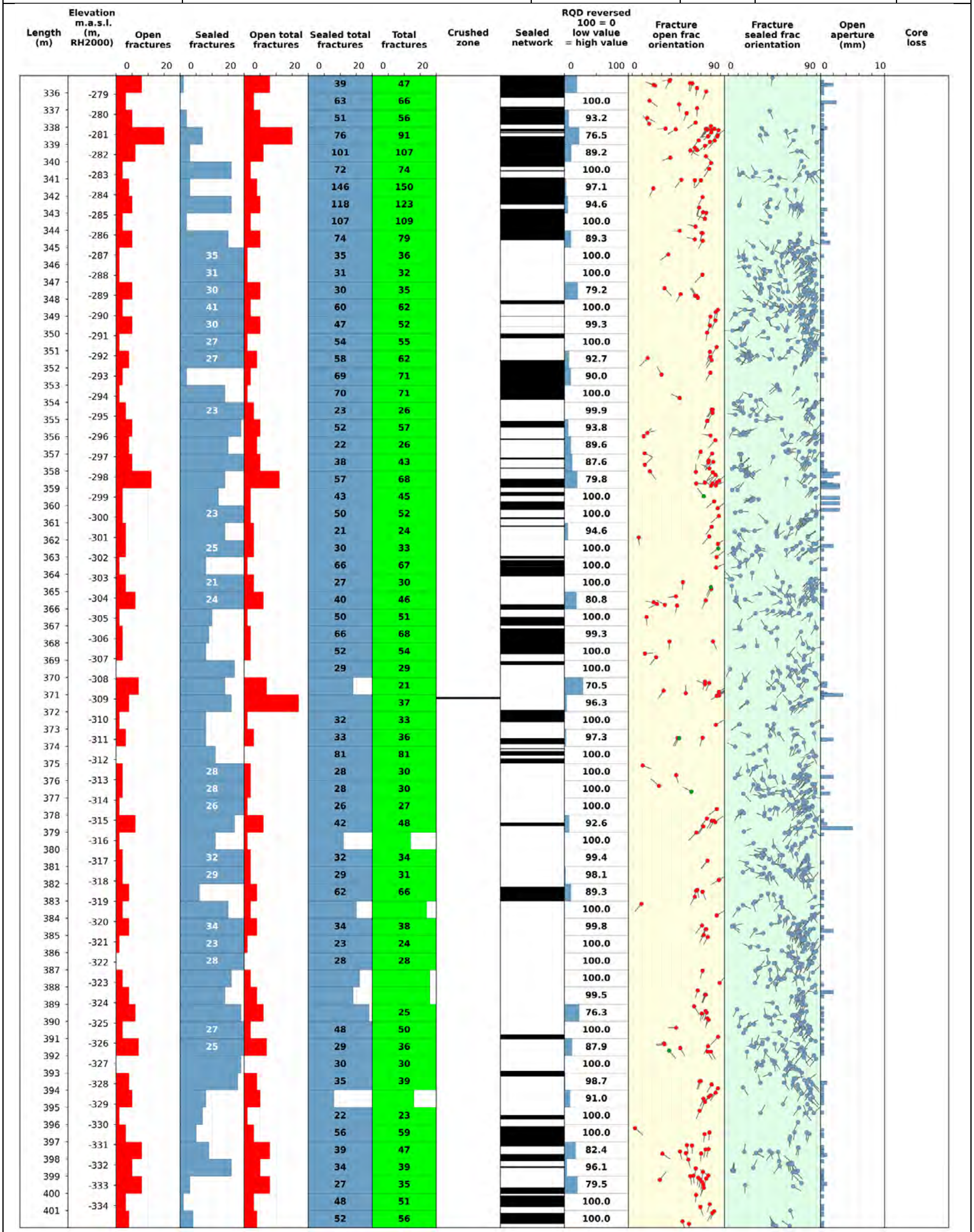
WNW	ZFMWNW0004	Version number	7	Total object CL	24



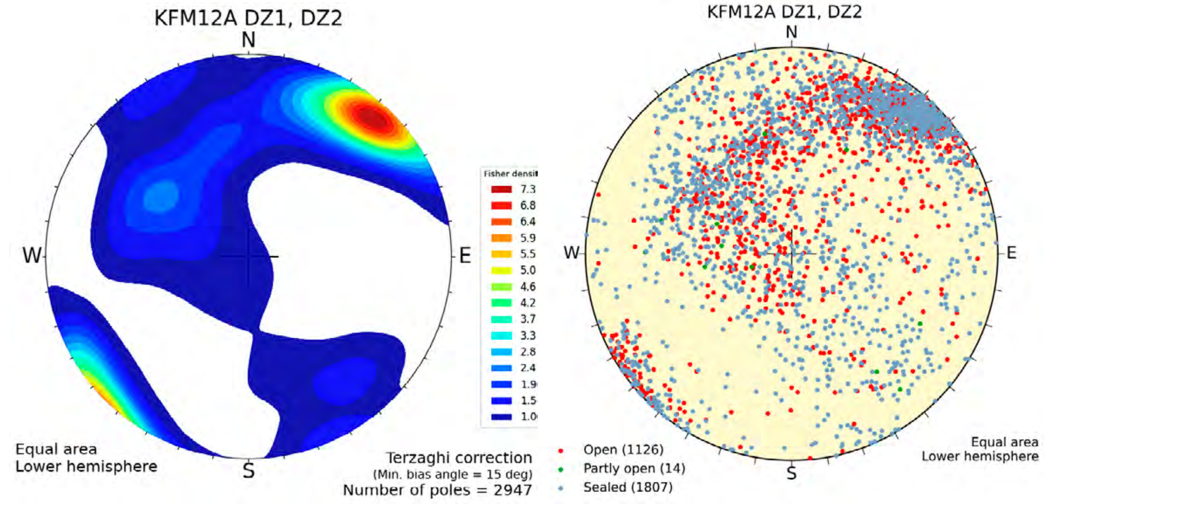
WNW	ZFMWNW0004	Version number	7	Total object CL	24



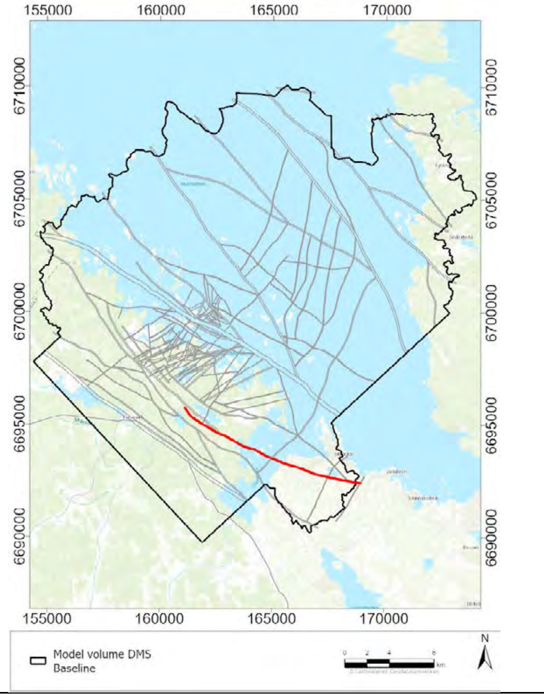
WNW	ZFMWNW0004	Version number	7	Total object CL	24



WNW	ZFMWNW0004	Version number	7	Total object CL	24



WNW	ZFMWNW0019	Version number	9	Total object CL	13
GEOLOGICAL CHARACTER		**Property CL**			
Deformation style:	Brittle-Ductile	1			
Deformation description:	No data available.				
Alteration:		1			
- First order:	Oxidation				
- Second order:	Not observed				
- Third order:	Not observed				
Fracture orientation and type:	No data available.				
Fracture comment:	No data available.				
Fracture fill mineralogy:	No data available.				
OBJECT GEOMETRY					
Strike/dip:	114°/85°				
Length:	8695 m				
Mean thickness:	45 m (15 - 64 m)				
Max depth:	-2100 m				
Geometrical constraints:	Topo 40m grid Max error 20m, 1 Surface Planar Cut(s), 1 UNIVERSE Planar Cut(s).				



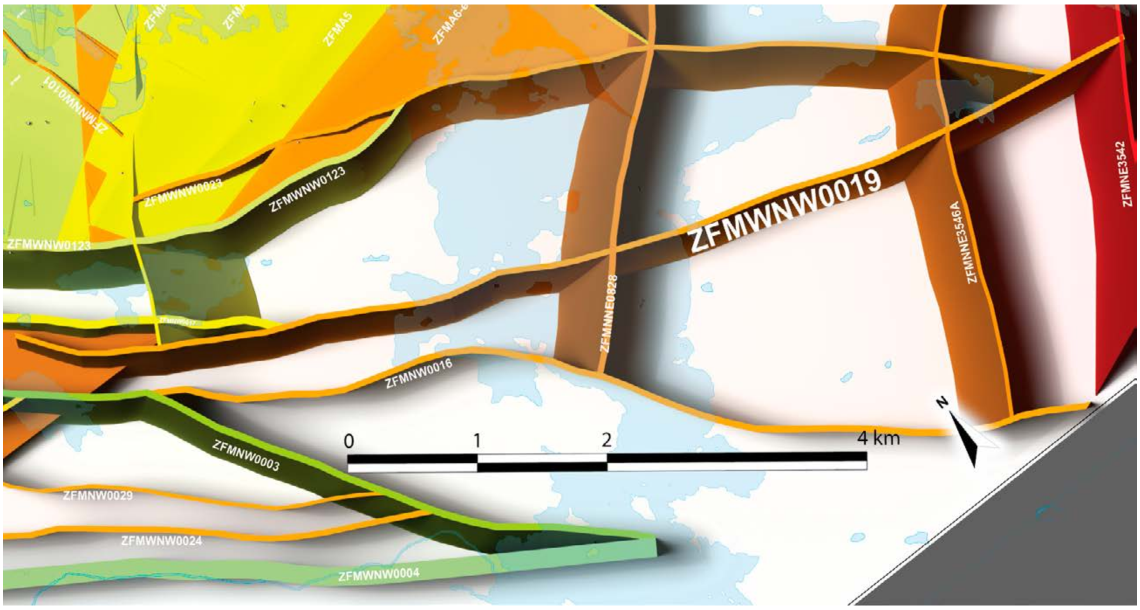
BASIS FOR MODELLING

Zone based on surface lineaments.

Outcrops:	-
Boreholes: -	
Tunnels:	-
Lineament and/or seismic indications:	MFM0019 merged. — 2

MODELLING PROCEDURE

At the surface, corresponds to the low magnetic lineament MFM0019. Modelled to the base of the model volume using an assumed dip of 85 degrees to the southwest based on a comparison with high confidence zone ZFMNW0017.



WNW	ZFMWNW0019	Version number	9	Total object CL	13

OBJECT CONFIDENCE ESTIMATE

Category	Object CL	Comment
INTERPRETATION		
Data source	1	MFM0019.
Results of interpretation	2	Medium confidence in lineament MFM0019.
INFORMATION DENSITY		
Number of observation points	1	1
Distribution of observation points	1	Single observation point in the form of a lineament.
INTERPOLATION		
Geometry	1	Geometry supported by surface geophysical data.
Geological indicators	1	Indirect support by geophysical data.
EXTRAPOLATION		
Dip direction	3	Extrapolated to the base of the model volume. Strike length of the modelled zone > 2000 m.
Strike direction	3	Conceptual understanding of the site and that the entire regional modelled zone is supported by the lineament.

FRACTURE CHARACTER

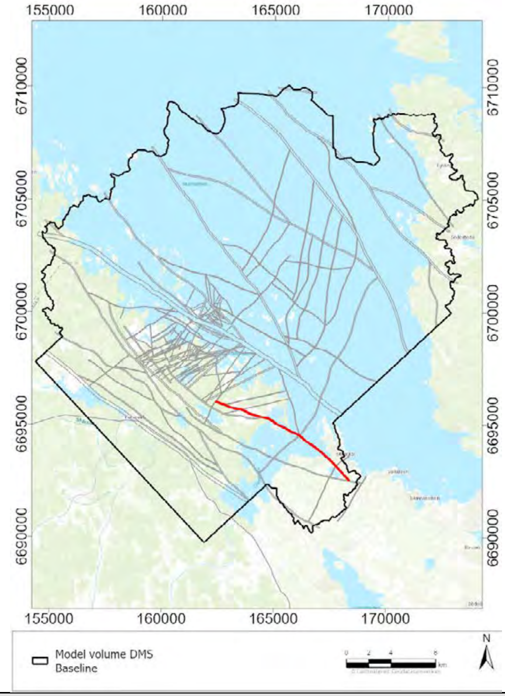
No data available

INDIVIDUAL INTERCEPTS

No data available

WNW	ZFMWNW0023	Version number	8	Total object CL	13

GEOLOGICAL CHARACTER		Property CL
Deformation style:	Brittle-Ductile	1
Deformation description:	No data available.	
Alteration:		2
- First order:	Oxidation	
- Second order:	Not observed	
- Third order:	Not observed	
Fracture orientation and type:	No data available.	
Fracture comment:	No data available.	
Fracture fill mineralogy:	No data available.	



OBJECT GEOMETRY	
Strike/dip:	119°/82°
Length:	7093 m
Mean thickness:	40 m (15 - 64 m)
Max depth:	-2100 m
Geometrical constraints:	Topo 40m grid Max error 20m, ZFMNE0065, ZFMWNW0019, 1 Surface Planar Cut(s).

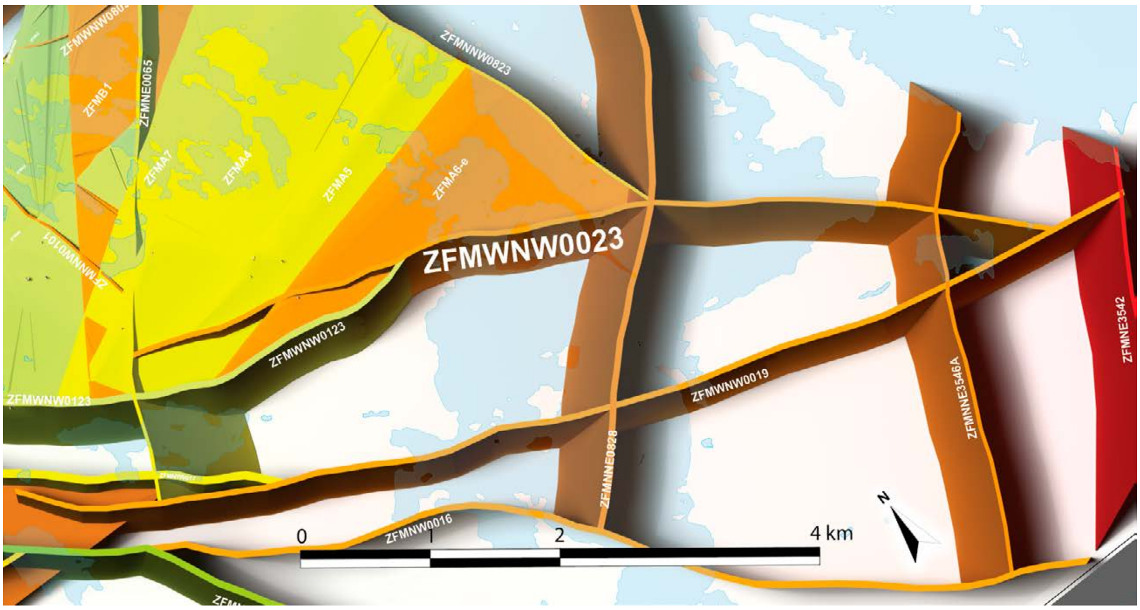
BASIS FOR MODELLING

Zone based on surface lineaments.

Outcrops:	-	
Boreholes: -		
Tunnels:	-	
Lineament and/or seismic indications:	MFM0023 merged.	2

MODELLING PROCEDURE

At the surface, corresponds to the low magnetic lineament MFM0023. Modelled to the base of the model volume using an assumed dip of 82 degrees to the southwest based on a comparison with high confidence zone ZFMWNW0123.



WNW	ZFMWNW0023	Version number	8	Total object CL	13

OBJECT CONFIDENCE ESTIMATE

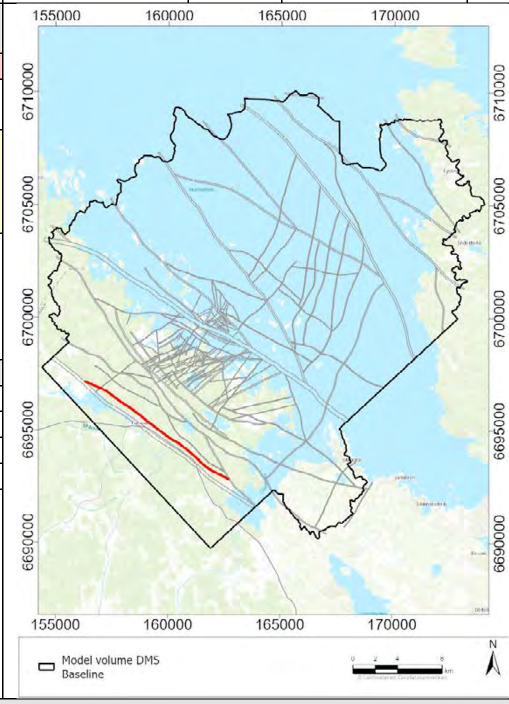
Category	Object CL	Comment
INTERPRETATION		
Data source	1	MFM0023.
Results of interpretation	2	Medium confidence in lineament MFM0023.
INFORMATION DENSITY		
Number of observation points	1	1
Distribution of observation points	1	Single observation point in the form of a lineament.
INTERPOLATION		
Geometry	1	Geometry supported by surface geophysical data.
Geological indicators	1	Indirect support by geophysical data.
EXTRAPOLATION		
Dip direction	3	Extrapolated to the base of the model volume. Strike length of the modelled zone > 2000 m.
Strike direction	3	Conceptual understanding of the site and that the entire regional modelled zone is supported by the lineament.

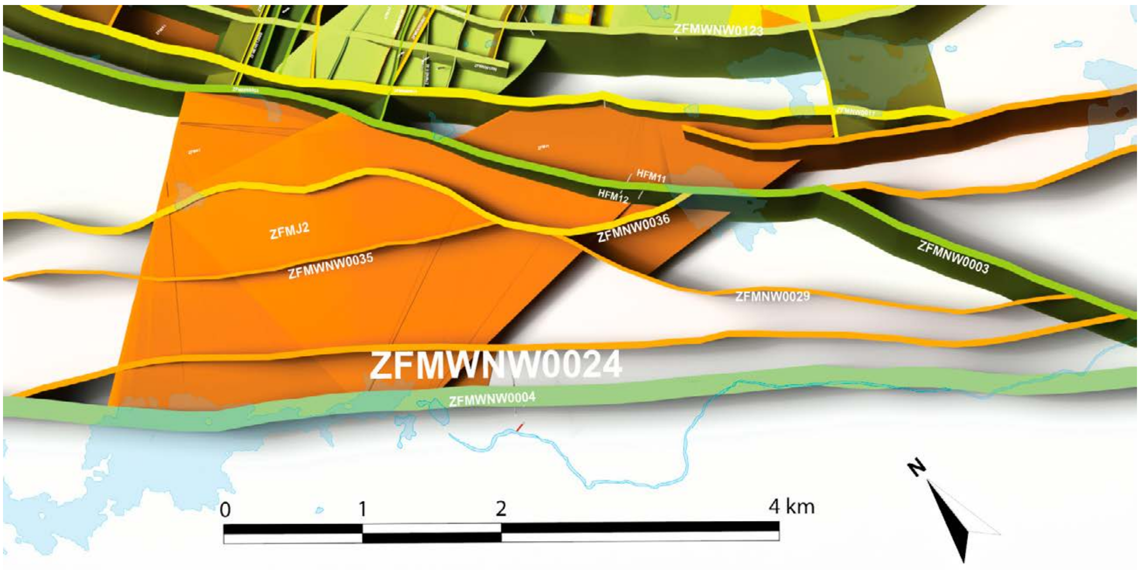
FRACTURE CHARACTER

No data available

INDIVIDUAL INTERCEPTS

No data available

WNW	ZFMWNW0024	Version number	3	Total object CL	12
GEOLOGICAL CHARACTER		**Property CL**			
Deformation style:	Brittle-Ductile	1			
Deformation description:	No data available.				
Alteration:		2			
- First order:	Oxidation				
- Second order:	Not observed				
- Third order:	Not observed				
Fracture orientation and type:	No data available.				
Fracture comment:	No data available.				
Fracture fill mineralogy:	No data available.				
OBJECT GEOMETRY					
Strike/dip:	125°/90°				
Length:	7980 m				
Mean thickness:	45 m (15 - 64 m)				
Max depth:	-2100 m				
Geometrical constraints:	ZFMWNW0004, ZFMNW0003, Topo 40m grid Max error 20m.				
BASIS FOR MODELLING					
Zone based on surface lineaments.					
Outcrops:	-				
Boreholes: -					
Tunnels:	-				
Lineament and/or seismic indications:	MFM0023 merged.				1
MODELLING PROCEDURE					
At the surface, corresponds to the low magnetic lineament MFM0024. Modelled to the base of the model volume using an assumed dip of 90 degrees degrees based on a comparison with high confidence, vertical and steeply dipping zones with WNW and NW strike.					



WNW	ZFMWNW0024	Version number	3	Total object CL	12

OBJECT CONFIDENCE ESTIMATE

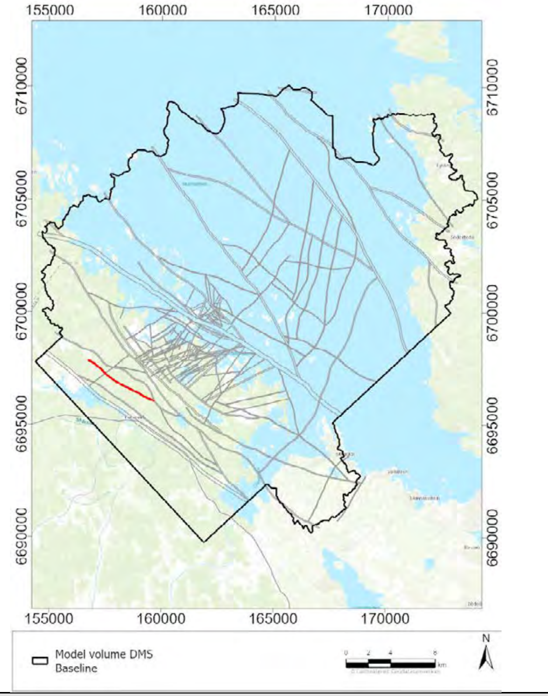
Category	Object CL	Comment
INTERPRETATION		
Data source	1	MFM0024.
Results of interpretation	1	Low confidence in lineament MFM0024.
INFORMATION DENSITY		
Number of observation points	1	1
Distribution of observation points	1	Single observation point in the form of a lineament.
INTERPOLATION		
Geometry	1	Geometry supported by surface geophysical data.
Geological indicators	1	Indirect support by geophysical data.
EXTRAPOLATION		
Dip direction	3	Extrapolated to the base of the model volume. Strike length of the modelled zone > 2000 m.
Strike direction	3	Conceptual understanding of the site and that the entire regional modelled zone is supported by the lineament.

FRACTURE CHARACTER

No data available

INDIVIDUAL INTERCEPTS

No data available

WNW	ZFMWNW0035		Version number	4	Total object CL	12
GEOLOGICAL CHARACTER		**Property CL**				
Deformation style:	Brittle-Ductile	1				
Deformation description:	No data available.					
Alteration:						
- First order:	Oxidation	2				
- Second order:	Not observed					
- Third order:	Not observed					
Fracture orientation and type:	No data available.					
Fracture comment:	No data available.					
Fracture fill mineralogy:	No data available.					
OBJECT GEOMETRY						
Strike/dip:	122°/90°					
Length:	3506 m					
Mean thickness:	25 m (15 - 64 m)					
Max depth:	-2100 m					
Geometrical constraints:	ZFMNW0036, Topo 40m grid Max error 20m, 1 UNIVERSE Planar Cut(s).					

BASIS FOR MODELLING		
Zone based on surface lineaments.		
Outcrops:	-	
Boreholes: -		
Tunnels:	-	
Lineament and/or seismic indications:	MFM0023 merged.	1

MODELLING PROCEDURE

At the surface, corresponds to the low magnetic lineament MFM0035. Modelled to the base of the model volume using an assumed dip of 90 degrees based on a comparison with high confidence, vertical and steeply dipping zones with WNW and NW strike.

WNW	ZFMWNW0035	Version number	4	Total object CL	12

OBJECT CONFIDENCE ESTIMATE

Category	Object CL	Comment
INTERPRETATION		
Data source	1	MFM0035.
Results of interpretation	1	Low confidence in lineament MFM0035.
INFORMATION DENSITY		
Number of observation points	1	1
Distribution of observation points	1	Single observation point in the form of a lineament.
INTERPOLATION		
Geometry	1	Geometry supported by surface geophysical data.
Geological indicators	1	Indirect support by geophysical data.
EXTRAPOLATION		
Dip direction	3	Extrapolated to the base of the model volume. Strike length of the modelled zone > 2000 m.
Strike direction	3	Conceptual understanding of the site and that the entire regional modelled zone is supported by the lineament.

FRACTURE CHARACTER

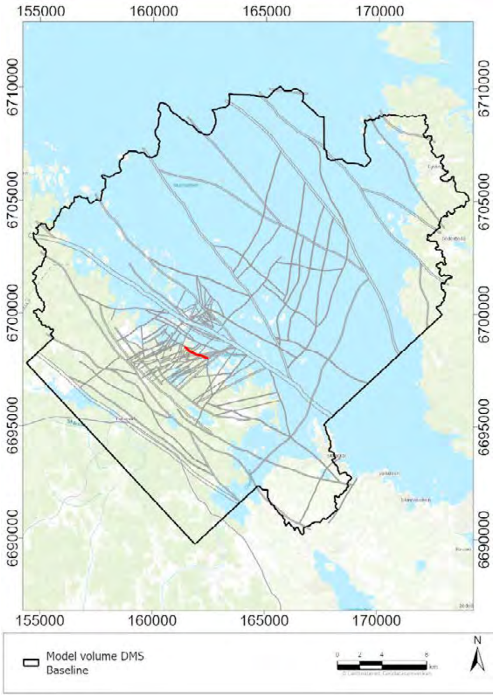
No data available

INDIVIDUAL INTERCEPTS

No data available

WNW	ZFMWNW0044	Version number	5	Total object CL	14

GEOLOGICAL CHARACTER		Property CL
Deformation style:	Brittle	3
Deformation description:	Steep faults with N, SSW or NNE strike show strike-slip displacement, one of which is sinistral. A moderately S-dipping fault shows dip-slip displacement.	
Alteration:		3
- First order:	Oxidation	
- Second order:	Not observed	
- Third order:	Not observed	
Fracture orientation and type:	Fractures that strike ESE to SE and dip steeply to the SSW to SW as well as sub-vertical fractures that strike NNE-SSW form conspicuous fracture sets. Dominance of sealed followed by open and partly open fractures. Quantitative estimate and span include sealed fracture networks and crush zones.	2
Fracture comment:	No data available.	
Fracture fill mineralogy:	Chlorite, calcite, hematite/adularia, quartz, clay minerals, epidote.	



OBJECT GEOMETRY	
Strike/dip:	115°/77°
Length:	1178 m
Mean thickness:	40 m (3 - 50 m)
Max depth:	-1200 m
Geometrical constraints:	ZFMWNW2225, ZFMENE0062A, Topo 40m grid Max error 20m, 1 Surface Planar Cut(s).

BASIS FOR MODELLING

Zone based on surface lineaments and borehole observations.

Outcrops:	-

Boreholes:

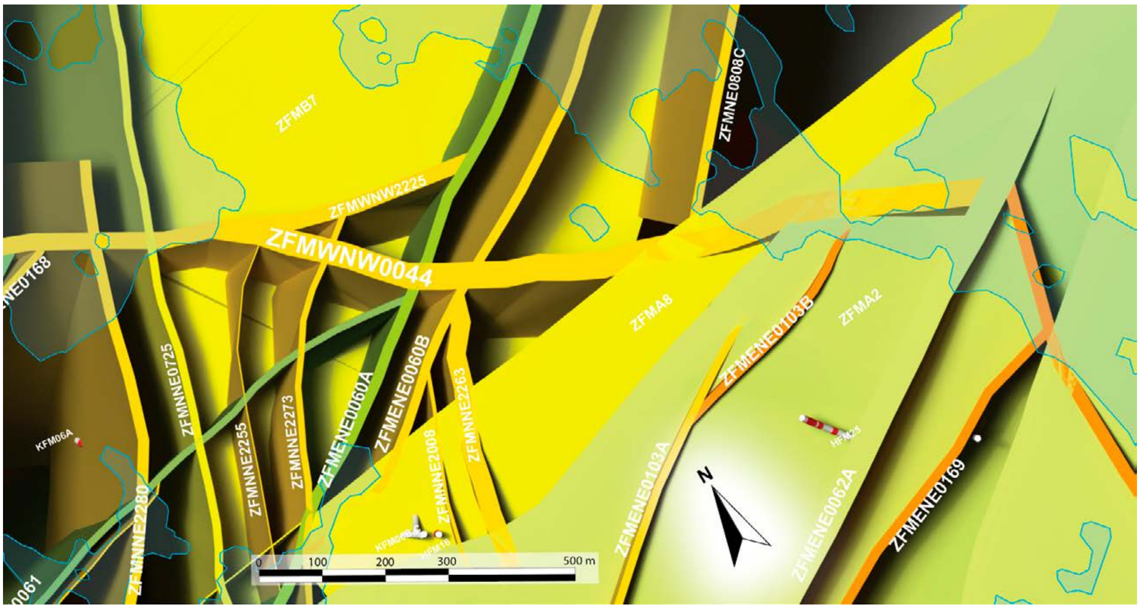
Borehole	PDZ	Target intercept		Geometric intercept		Comment
		Sec_up [m]	Sec_low [m]	Sec_up [m]	Sec_low [m]	
KFM06C	DZ4	502.00	555.00	502.39	554.68	

Tunnels:	-	
Lineament and/or seismic indications:	MFM0044, MFM0044G0.	2

MODELLING PROCEDURE

At the surface, corresponds to the low magnetic lineament MFM0044 and its continuation to the north-west along the south-eastern part of the low magnetic lineament MFM0044G0. The north-western part of lineament MFM0044G0 is judged to belong to the north-westerly continuation of lineament MFM2225G and has been used in the modelling of zone ZFMWNW2225. On the basis of this revised interpretation, there is a discrepancy between the original lineament interpretation and the geometric model for zone ZFMWNW0044. Modelled down to 850 m depth, using the dip estimated by connecting the lineament segments with the borehole intersection 502-555 m in KFM06C (DZ4). Deformation zone plane placed at fixed point 536 m where both a crush zone and a sealed fracture network are present. Decreased radar penetration also along the borehole interval 532-540 m. Inferred to be a minor zone.

WNW	ZFMWNW0044	Version number	5	Total object CL	14



OBJECT CONFIDENCE ESTIMATE

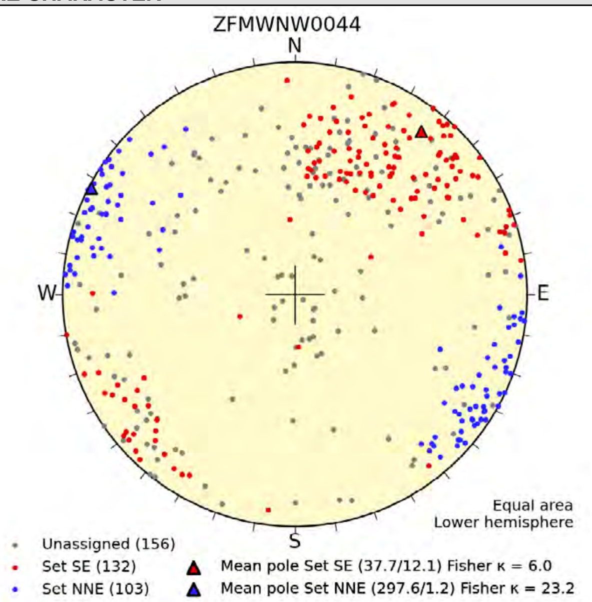
Category	**Object CL**	**Comment**
INTERPRETATION		
Data source	2	MFM0044G, MFM0044G0, KFM06C.
Results of interpretation	3	High confidence observations in KFM06C.
INFORMATION DENSITY		
Number of observation points	2	2
Distribution of observation points	1	Single observation point at depth and surface lineaments.
INTERPOLATION		
Geometry	1	Geometry supported by a lineament and a single intercept.
Geological indicators	1	Indirect support by geophysical data.
EXTRAPOLATION		
Dip direction	2	Extrapolation in dip direction supported by subsurface obs. point. Strike length of the modelled zone < 2000 m.
Strike direction	2	Conceptual understanding of the site and that the entire regional modelled zone is supported by the lineament.

FRACTURE CHARACTER

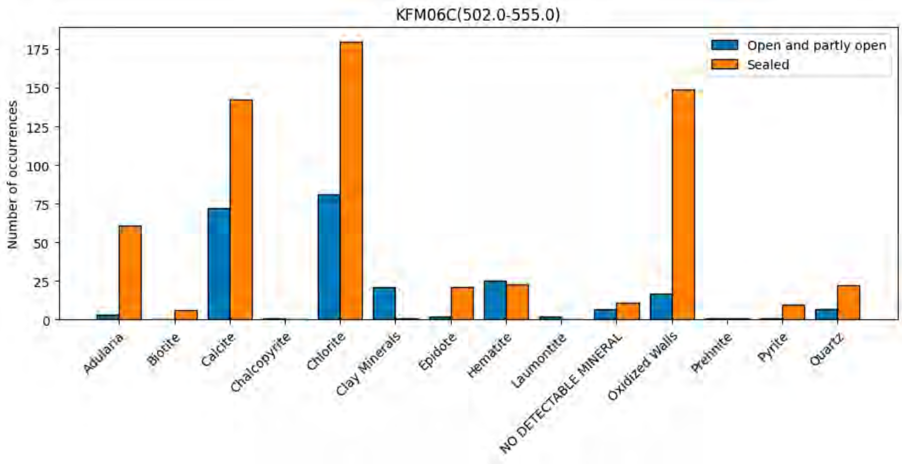
Orientation: (strike/dip right-hand-rule): Set SE: 127.7°/77.9°; Set NNE: 27.6°/88.8°

Frequency: Boreholes: KFM06C

FRACTURE TYPE	TERZAGHI-WEIGHED P10
Open and partly open	3.2 m-1
Sealed	14.8 m-1
Sealed network	11.8 % of DZ intercept
Crush	1.0 % of DZ intercept



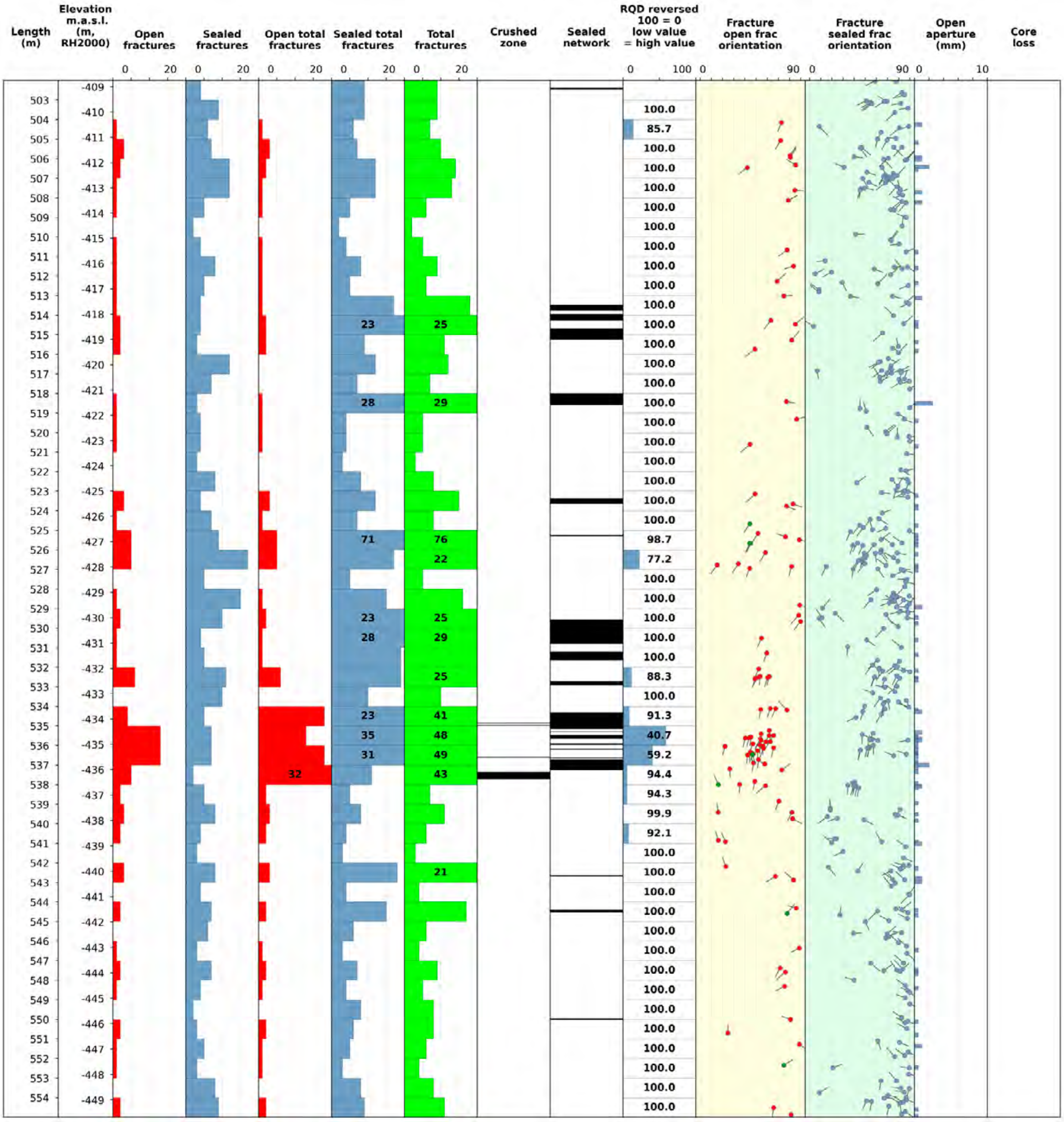
RQD: min:41, max:100, mean:97

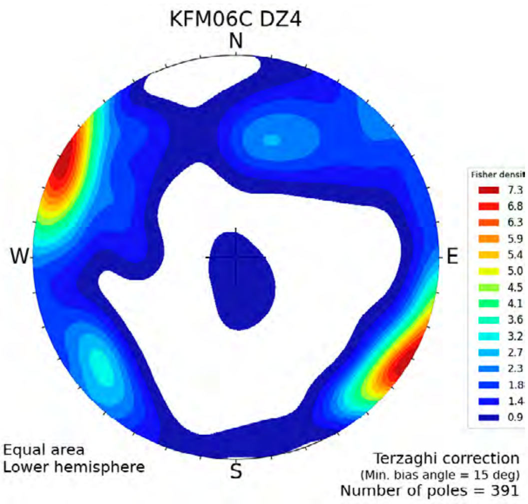
WNW	ZFMWNW0044	Version number	5	Total object CL	14
Fracture fill mineralogy:					

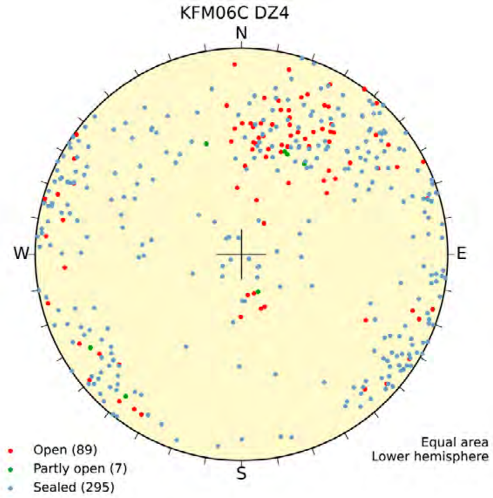
WNW	ZFMWNW0044	Version number	5	Total object CL	14

INDIVIDUAL INTERCEPTS

KFM06C DZ4 (502.0-555.0 m)

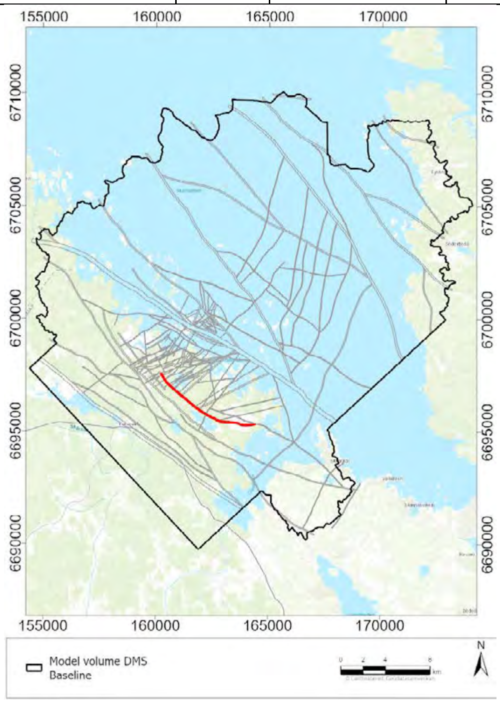






WNW	ZFMWNW0123	Version number	7	Total object CL	20

GEOLOGICAL CHARACTER		Property CL
Deformation style:	Brittle-Ductile	3
Deformation description:	Steep faults with SE, ESE and WNW strike show strike-slip displacement, eight of which have distinctive sinistral strike-slip displacement. One steeply fracture with SSE strike also shows strike-slip displacement. Two gently dipping faults show dip-slip displacement, one of which with reverse dip-slip.	
Alteration:		3
- First order:	Oxidation	
- Second order:	Epidotization	
- Third order:	Quartz dissolution	
Fracture orientation and type:	Fractures that strike SE and dip steeply to the SW dominates. Gently dipping fractures and steeply dipping fractures that strike NE are also conspicuous along DZ1 in KFM10A. Open fractures that both dip steeply to the SW and are gently dipping are prominent along DZ1 in KFM10A. Crush zones also present. Dominance of sealed fractures along DZ5 in KFM04A. Quantitative estimate and span include sealed fracture networks and crush zones.	2
Fracture comment:	No data available.	
Fracture fill mineralogy:	Calcite, hematite/adularia, chlorite, clay minerals, quartz, prehnite, epidote.	



OBJECT GEOMETRY	
Strike/dip:	119°/82°
Length:	5078 m
Mean thickness:	52 m (15 - 64 m)
Max depth:	-2100 m
Geometrical constraints:	ZFMENE0060A, Topo 40m grid Max error 20m, ZFMWNW0023, 1 Surface Planar Cut(s).

BASIS FOR MODELLING

Zone based on surface lineaments and borehole observations.

Outcrops: -

Boreholes:

Borehole	PDZ	Target intercept		Geometric intercept		Comment
		Sec_up [m]	Sec_low [m]	Sec_up [m]	Sec_low [m]	
HFM24	DZ1	18.00	32.00	12.48	111.89	
HFM24	DZ2	42.00	63.00	12.48	111.89	
HFM24	DZ3	67.00	103.00	12.48	111.89	
HFM29	DZ1	19.00	25.00	32.00	120.38	
HFM29	DZ2	62.00	81.00	32.00	120.38	
HFM29	DZ3	146.00	150.00	32.00	120.38	
KFM04A	DZ5	654.00	661.00	622.02	688.39	
KFM10A	DZ1	62.85	145.00	62.84	144.42	

Tunnels:	-	
Lineament and/or seismic indications:	MFM0123.	3

WNW	ZFMWNW0123	Version number	7	Total object CL	20

MODELLING PROCEDURE

At the surface, corresponds to the low magnetic lineament MFM0123. Modelled to base of the model volume using the dip estimated by connecting lineament MFM0123 with the borehole intersections 63-145 m in KFM10A (DZ1), 18-32 m, 42-63 m and 67-103 m in HFM24 (DZ1, DZ2 and DZ3), 19-25 m, 62-81 m and 146-150 m in FM29 (DZ1, DZ2 and DZ3), and 654-661 m in KFM04A (DZ5). Deformation zone plane passes through fixed points 108 m in KFM10A, 69 m in HFM29 and 655 m in KFM04A. Decreased radar penetration along the borehole interval 85-120 m in KFM10A.

OBJECT CONFIDENCE ESTIMATE

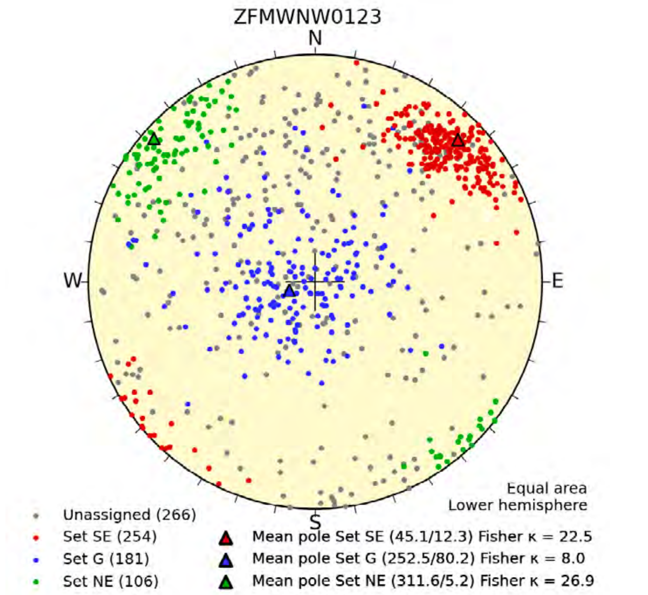
Category	Object CL	Comment
INTERPRETATION		
Data source	2	MFM0123G0, HFM24, HFM29, KFM04A, KFM10A.
Results of interpretation	3	High confidence observations in KFM10A.
INFORMATION DENSITY		
Number of observation points	3	>4
Distribution of observation points	2	Cluster of borehole intersections and a lineament as an outlier.
INTERPOLATION		
Geometry	3	Geometry supported by information from multiple drill hole (SHI), strong support for one alternative.
Geological indicators	2	Some discrepancies in the geological data.
EXTRAPOLATION		
Dip direction	3	Extrapolated to the base of the model volume. Strike length of the modelled zone > 2000 m.
Strike direction	2	Conceptual understanding of the site and that the entire regional modelled zone is supported by the lineament.

WNW	ZFMWNW0123	Version number	7	Total object CL	20

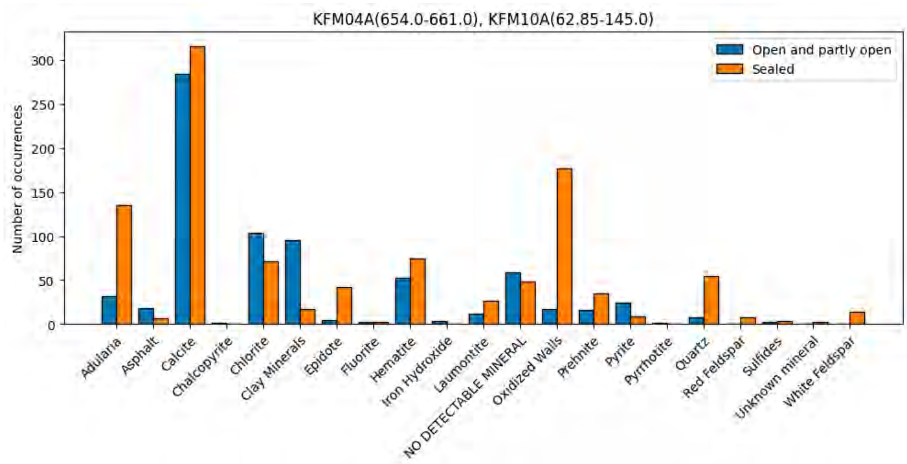
FRACTURE CHARACTER

Orientation: (strike/dip right-hand-rule)	Set SE: 135.1°/77.7° Set G: 342.5°/9.8° Set NE: 41.6°/84.8°
Frequency:	Boreholes: KFM10A, KFM04A

FRACTURE TYPE	TERZAGHI-WEIGHED P10
Open and partly open	5.7 m-1
Sealed	13.7 m-1
Sealed network	3.4 % of DZ intercept
Crush	0.2 % of DZ intercept



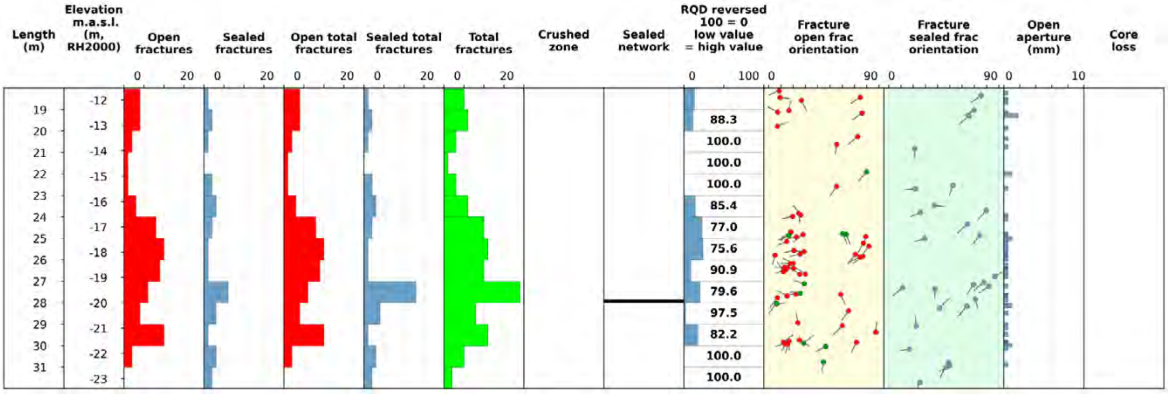
RQD:	min:6, max:100, mean:90
Fracture fill mineralogy:	



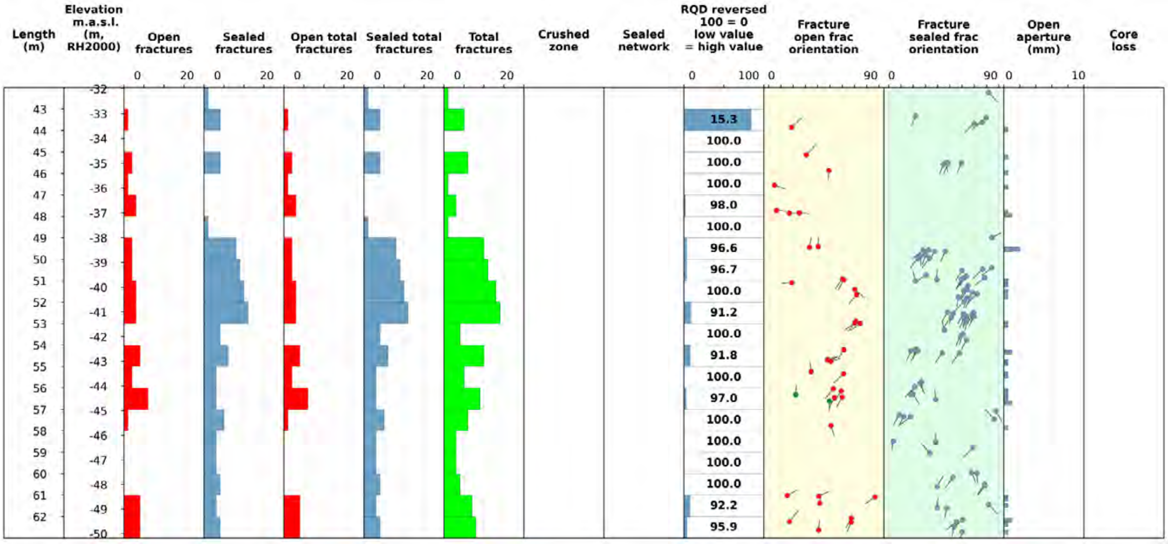
WNW	ZFMWNW0123	Version number	7	Total object CL	20

INDIVIDUAL INTERCEPTS

HFM24 DZ1 (18.0-32.0 m)

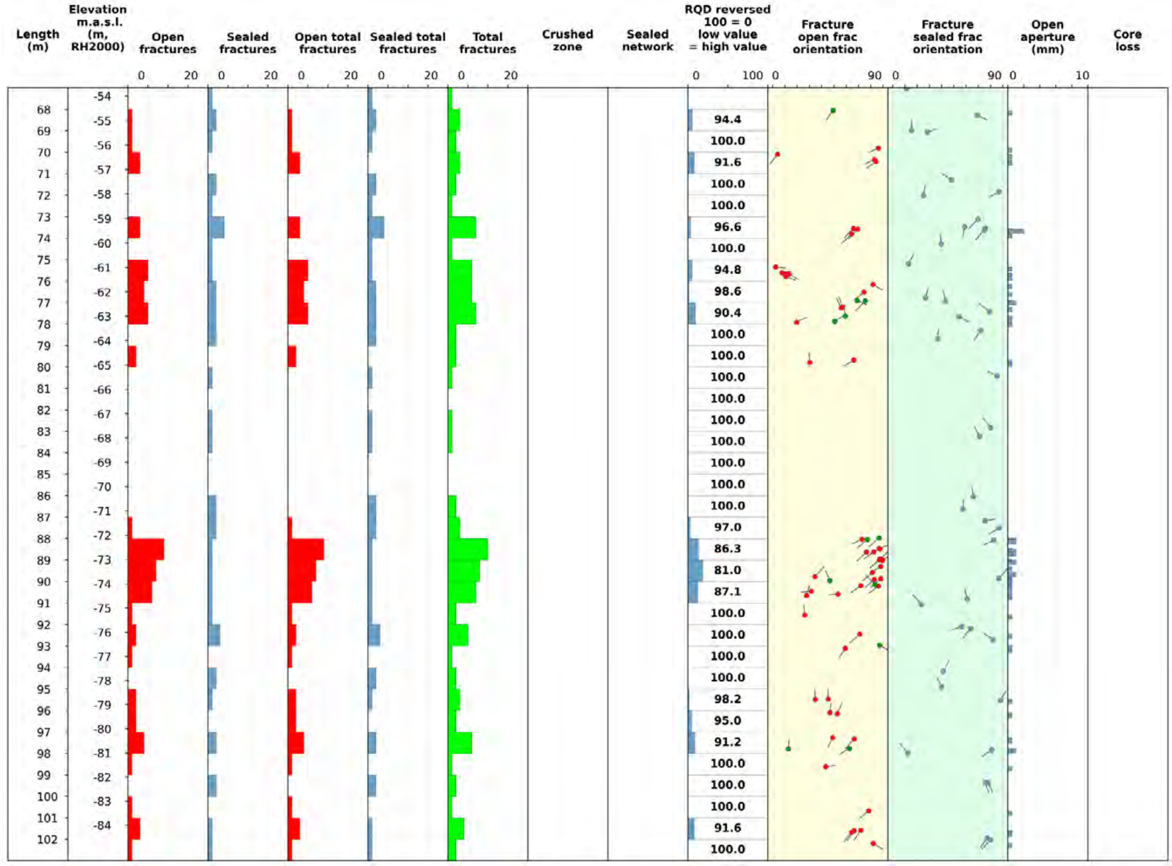


HFM24 DZ2 (42.0-63.0 m)

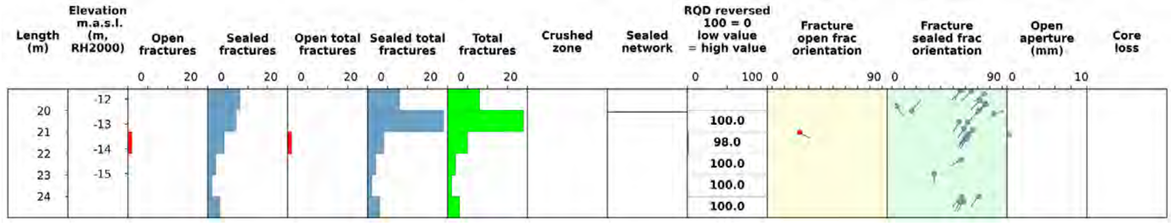


WNW	ZFMWNW0123	Version number	7	Total object CL	20

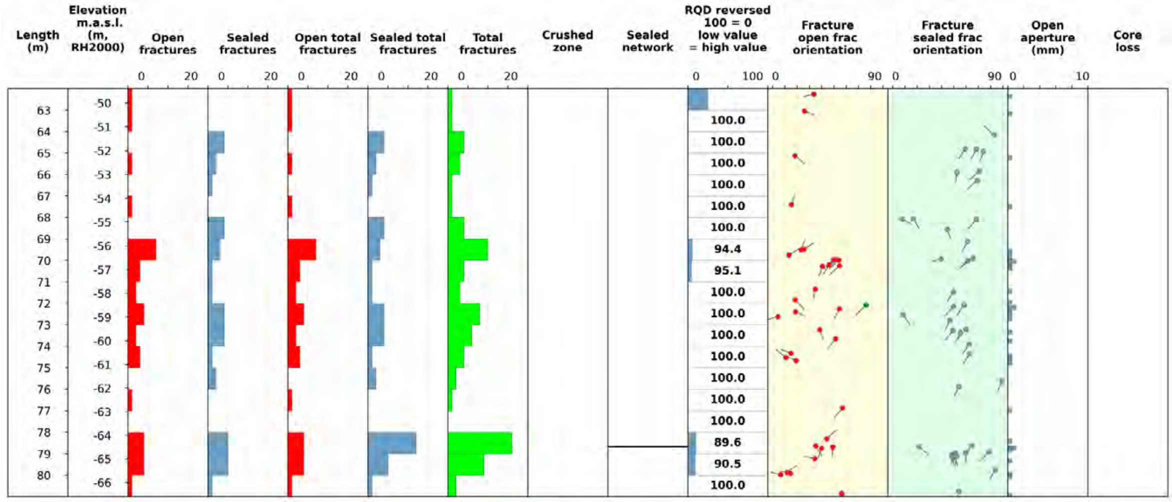
HFM24 DZ3 (67.0-103.0 m)



HFM29 DZ1 (19.0-25.0 m)

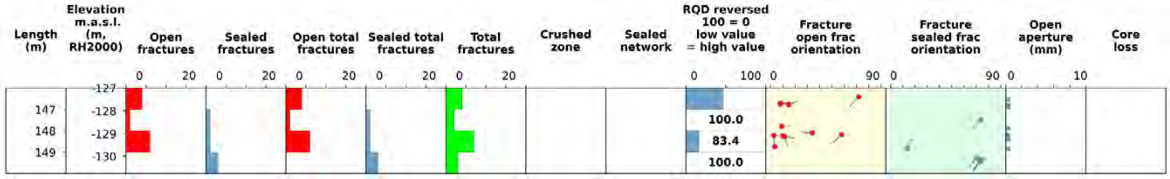


HFM29 DZ2 (62.0-81.0 m)

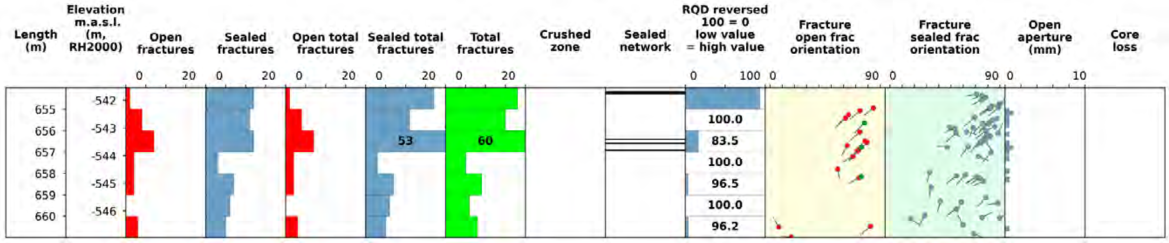


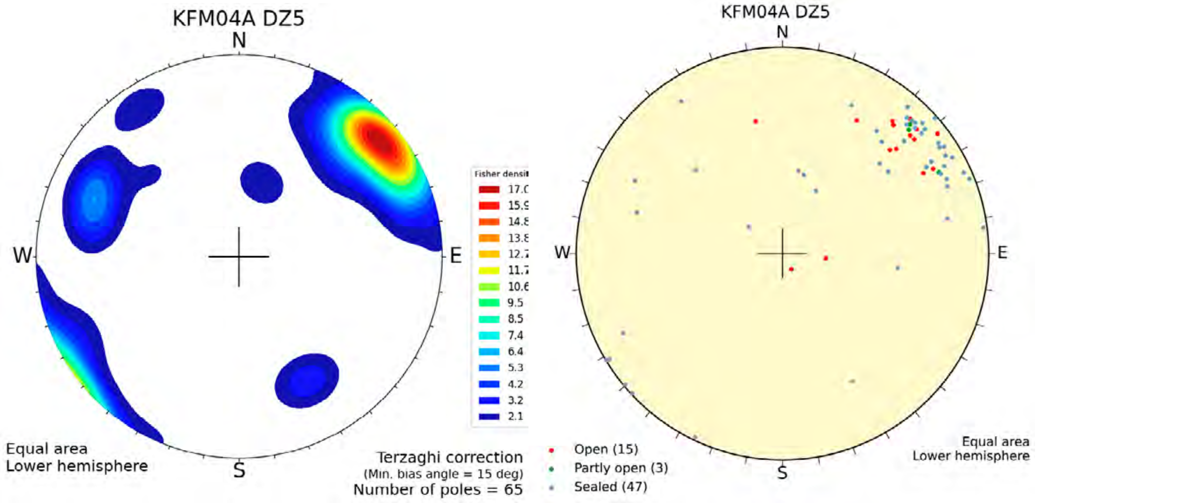
WNW	ZFMWNW0123	Version number	7	Total object CL	20

HFM29 DZ3 (146.0-150.0 m)



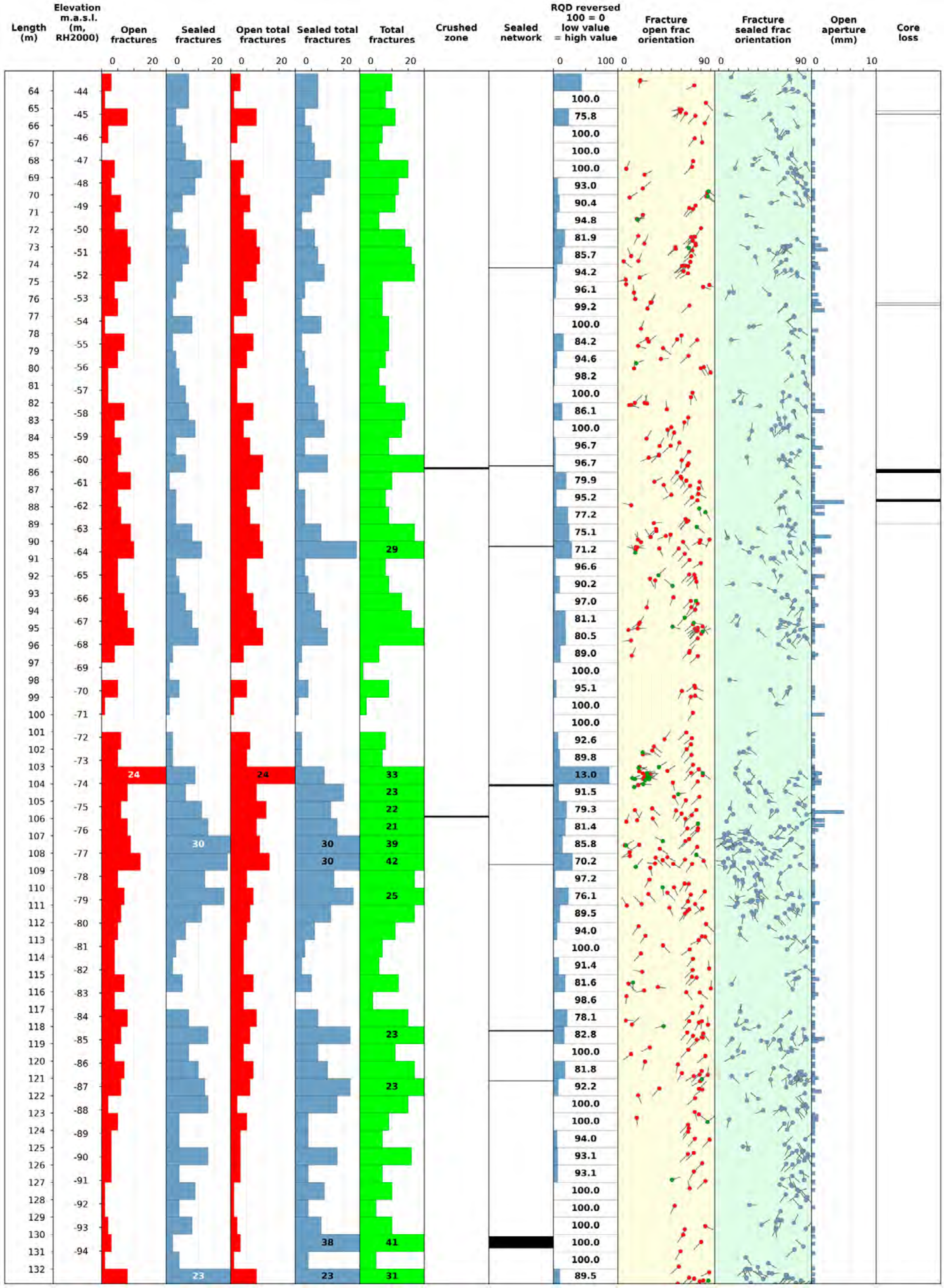
KFM04A DZ5 (654.0-661.0 m)



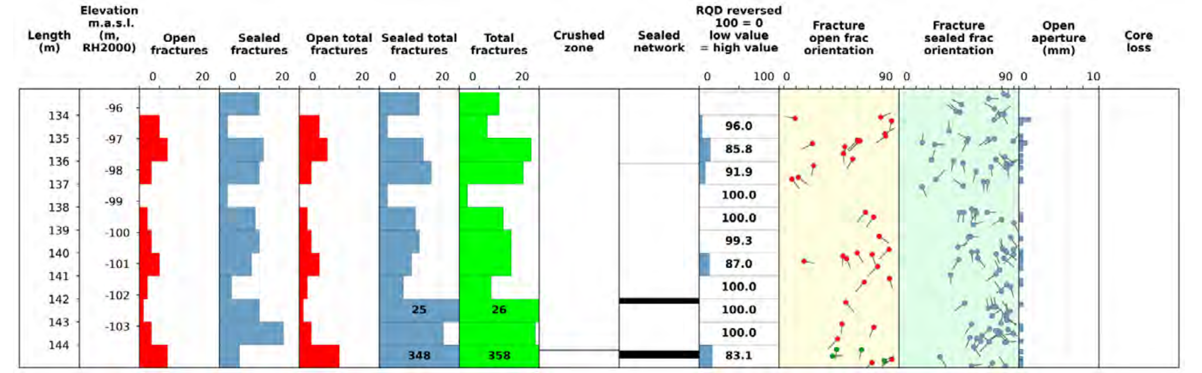


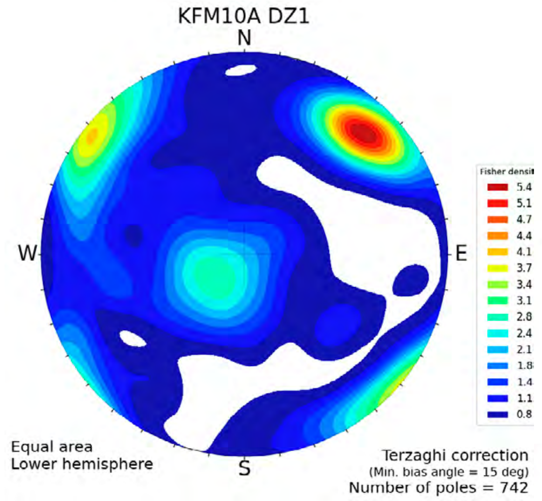
WNW	ZFMWNW0123	Version number	7	Total object CL	20

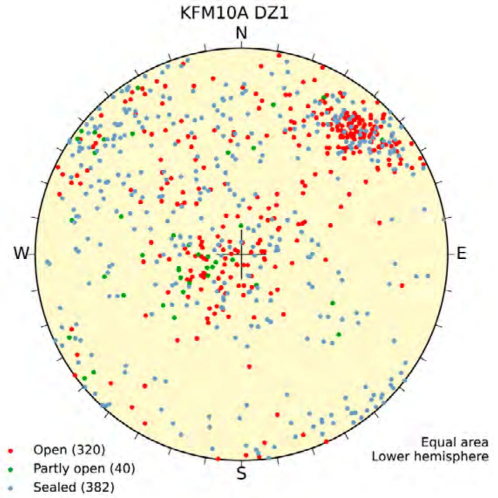
KFM10A DZ1 (62.85-145.0 m)



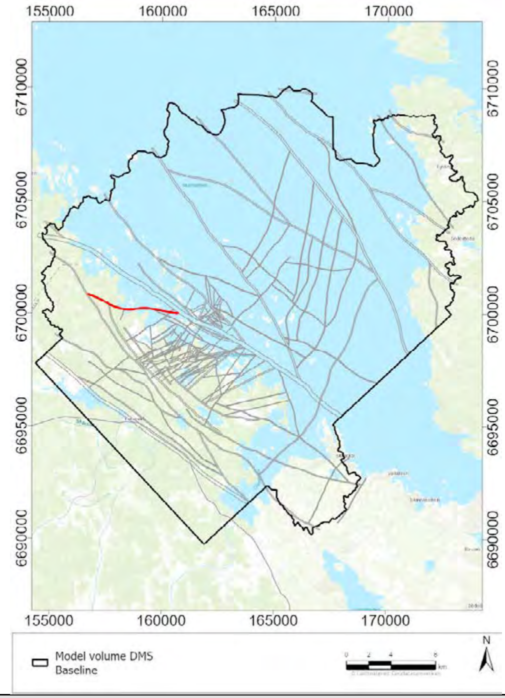
WNW	ZFMWNW0123	Version number	7	Total object CL	20







WNW	ZFMWNW0137		Version number	5	Total object CL	14
GEOLOGICAL CHARACTER		**Property CL**				
Deformation style:	Brittle-Ductile	1				
Deformation description:	No data available.					
Alteration:		2				
- First order:	Oxidation					
- Second order:	Not observed					
- Third order:	Not observed					
Fracture orientation and type:	No data available.					
Fracture comment:	No data available.					
Fracture fill mineralogy:	No data available.					
OBJECT GEOMETRY						
Strike/dip:	100°/90°					
Length:	4373 m					
Mean thickness:	30 m (15 - 64 m)					
Max depth:	-2100 m					
Geometrical constraints:	ZFMWNW0001, Topo 40m grid Max error 20m, ZFMNW0003.					



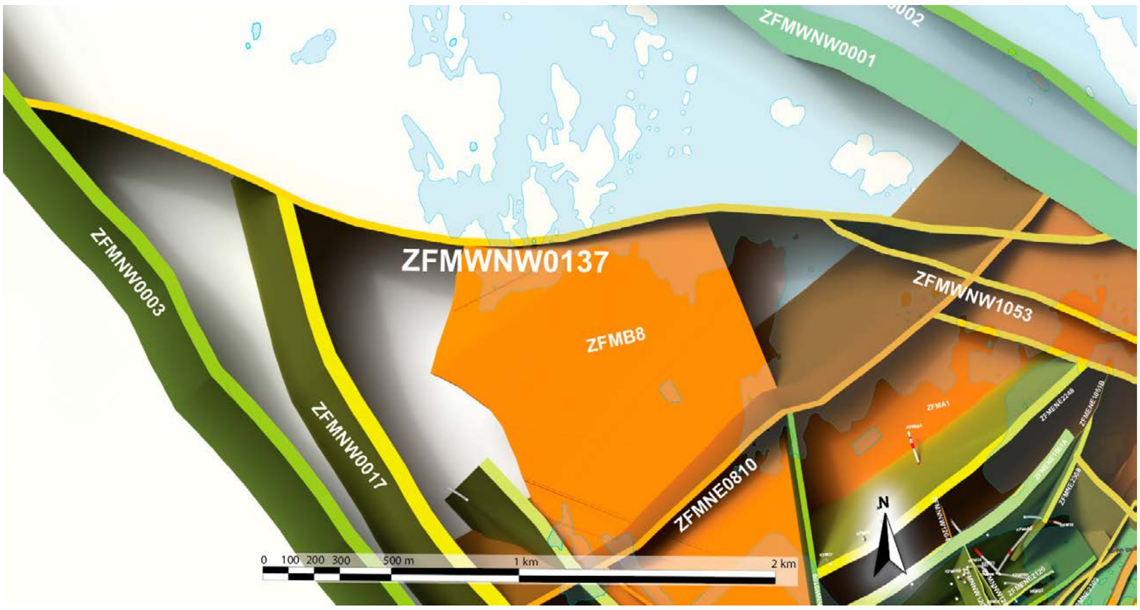
BASIS FOR MODELLING

Zone based on surface lineaments.

Outcrops:	-	
Boreholes: -		
Tunnels:	-	
Lineament and/or seismic indications:	MFM0137 merged.	3

MODELLING PROCEDURE

At the surface, corresponds to the low magnetic lineament MFM0137A0. Modelled to the base of the model volume using an assumed dip of 90 degrees based on comparison with high confidence, vertical and steeply dipping zones.



WNW	ZFMWNW0137	Version number	5	Total object CL	14

OBJECT CONFIDENCE ESTIMATE

Category	Object CL	Comment
INTERPRETATION		
Data source	1	MFM0137.
Results of interpretation	3	High confidence in lineament MFM0137.
INFORMATION DENSITY		
Number of observation points	1	1
Distribution of observation points	1	Single observation point in the form of a lineament.
INTERPOLATION		
Geometry	1	Geometry supported by surface geophysical data.
Geological indicators	1	Indirect support by geophysical data.
EXTRAPOLATION		
Dip direction	3	Extrapolated to the base of the model volume. Strike length of the modelled zone > 2000 m.
Strike direction	3	Conceptual understanding of the site and that the entire regional modelled zone is supported by the lineament.

FRACTURE CHARACTER

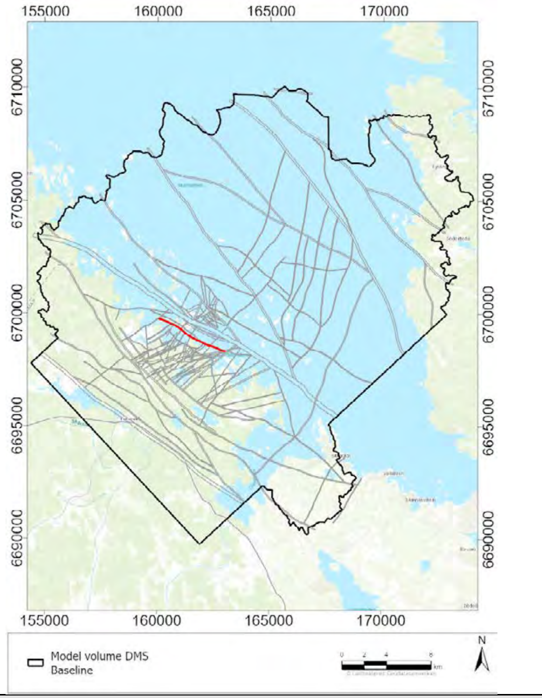
No data available

INDIVIDUAL INTERCEPTS

No data available

WNW	ZFMWNW0809A	Version number	3	Total object CL	14

GEOLOGICAL CHARACTER		Property CL
Deformation style:	Brittle	1
Deformation description:	No data available.	
Alteration:		2
- First order:	Oxidation	
- Second order:	Not observed	
- Third order:	Not observed	
Fracture orientation and type:	No data available.	
Fracture comment:	No data available.	
Fracture fill mineralogy:	No data available.	
OBJECT GEOMETRY		
Strike/dip:	118°/90°	
Length:	3349 m	
Mean thickness:	25 m (15 - 64 m)	
Max depth:	-2100 m	
Geometrical constraints:	ZFMNE0810, ZFMENE0062A, Topo 40m grid Max error 20m.	



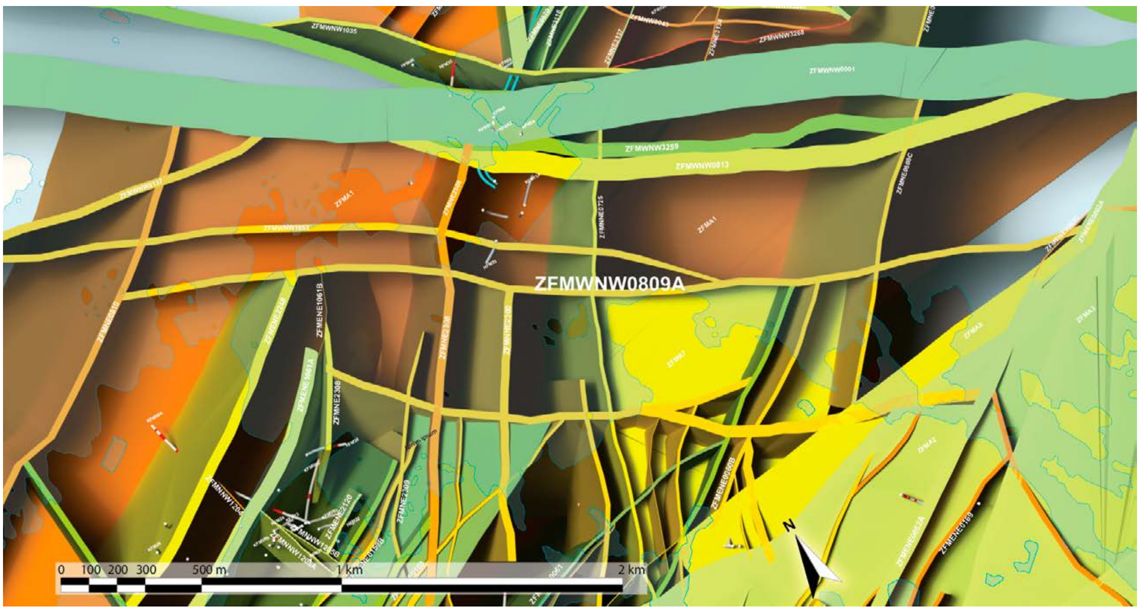
BASIS FOR MODELLING

Zone based on surface lineaments. Zone ZFMWNW0809 consists of two segments, ZFMWNW0809A and ZFMWNW0809B, judged to constitute elements of one and the same structure.

Outcrops:	-	
Boreholes: -		
Tunnels:	-	
Lineament and/or seismic indications:	MFM0809, MFM0809G.	3

MODELLING PROCEDURE

Zone ZFMWNW0809 consists of two segments, the most prominent of which is denoted ZFMWNW0809A. These two segments are judged to constitute elements of one and the same structure. At the surface, zone ZFMWNW0809A corresponds to the low magnetic lineaments MFM0809 and MFM0809G. Lineament MFM0809 is inferred to continue east of zone ZFMENE0062A as far as ZFMWNW0001, with a slightly different trend, and is inferred to be the surface expression of zone ZFMWNW0809B. Both segments modelled to base of the model volume using an assumed dip of 90 degrees, based on a comparison with high confidence, vertical and steeply dipping zones with WNW and NW strike.



WNW	ZFMWNW0809A	Version number	3	Total object CL	14

OBJECT CONFIDENCE ESTIMATE

Category	Object CL	Comment
INTERPRETATION		
Data source	1	MFM2215G.
Results of interpretation	3	High confidence in lineament MFM2215G.
INFORMATION DENSITY		
Number of observation points	1	1
Distribution of observation points	1	Single observation point in the form of a lineament.
INTERPOLATION		
Geometry	1	Geometry supported by surface geophysical data.
Geological indicators	1	Indirect support by geophysical data.
EXTRAPOLATION		
Dip direction	3	Extrapolated to the base of the model volume. Strike length of the modelled zone > 2000 m.
Strike direction	3	Conceptual understanding of the site and that the entire regional modelled zone is supported by the lineament.

FRACTURE CHARACTER

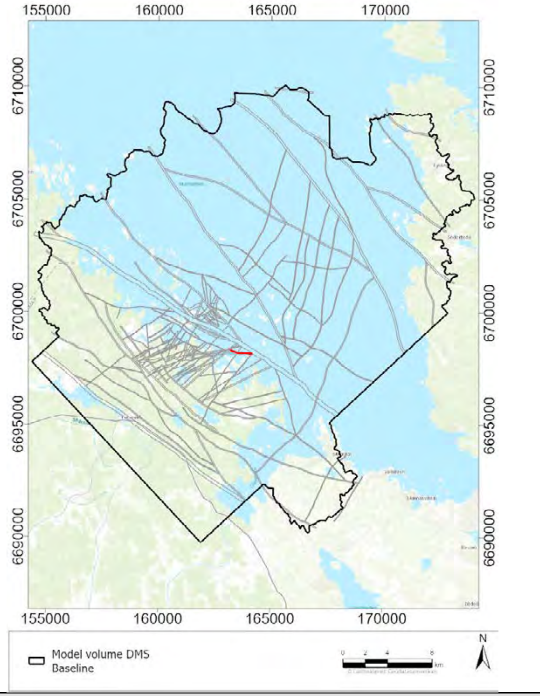
No data available

INDIVIDUAL INTERCEPTS

No data available

WNW	ZFMWNW0809B		Version number	3	Total object CL	13

GEOLOGICAL CHARACTER		Property CL
Deformation style:	Brittle	1
Deformation description:	No data available.	
Alteration:		2
- First order:	Oxidation	
- Second order:	Not observed	
- Third order:	Not observed	
Fracture orientation and type:	No data available.	
Fracture comment:	No data available.	
Fracture fill mineralogy:	No data available.	



OBJECT GEOMETRY	
Strike/dip:	111°/90°
Length:	1254 m
Mean thickness:	15 m (3 - 50 m)
Max depth:	-2100 m
Geometrical constraints:	ZFMENE0062A, ZFMWNW0001, Topo 40m grid Max error 20m.

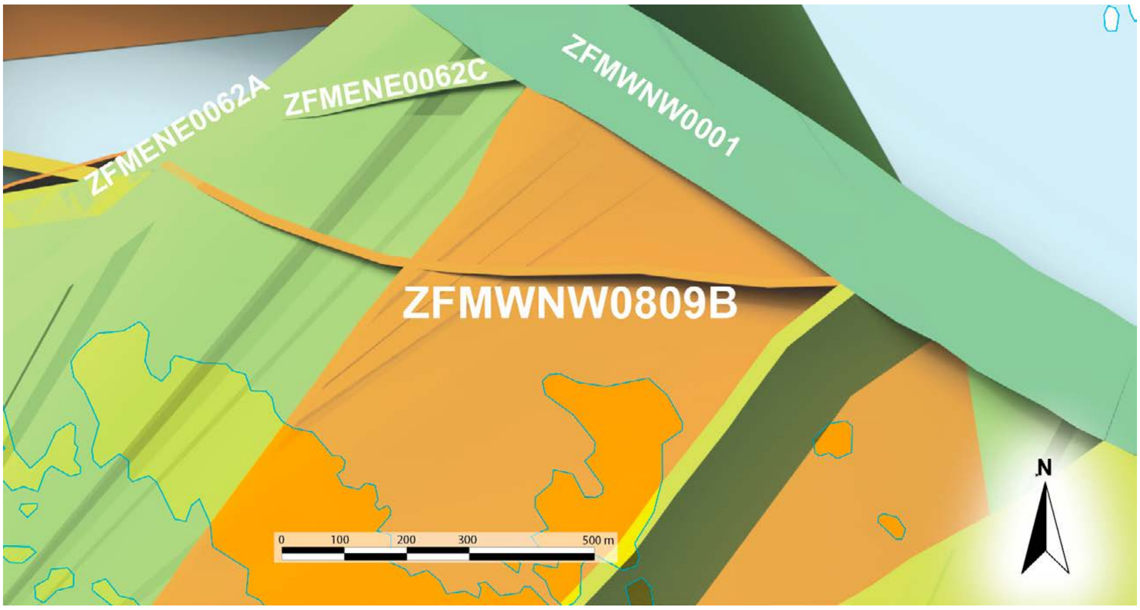
BASIS FOR MODELLING

Zone based on surface lineaments. Zone ZFMWNW0809 consists of two segments, ZFMWNW0809A and ZFMWNW0809B, judged to constitute elements of one and the same structure.

Outcrops:	-	
Boreholes: -		
Tunnels:	-	
Lineament and/or seismic indications:	MFM1056.	2

MODELLING PROCEDURE

Zone ZFMWNW0809 consists of two segments, the most prominent of which is denoted ZFMWNW0809A. These two segments are judged to constitute elements of one and the same structure. At the surface, zone ZFMWNW0809A corresponds to the low magnetic lineaments MFM0809 and MFM0809G. Lineament MFM0809 is inferred to continue east of zone ZFMENE0062A as far as ZFMWNW0001, with a slightly different trend, and is inferred to be the surface expression of zone ZFMWNW0809B. Both segments modelled to base of the model volume using an assumed dip of 90 degrees, based on a comparison with high confidence, vertical and steeply dipping zones with WNW and NW strike.



WNW	ZFMWNW0809B	Version number	3	Total object CL	13

OBJECT CONFIDENCE ESTIMATE

Category	Object CL	Comment
INTERPRETATION		
Data source	1	MFM1056G.
Results of interpretation	2	Medium confidence in lineament MFM1056G.
INFORMATION DENSITY		
Number of observation points	1	1
Distribution of observation points	1	Single observation point in the form of a lineament.
INTERPOLATION		
Geometry	1	Geometry supported by surface geophysical data.
Geological indicators	1	Indirect support by geophysical data.
EXTRAPOLATION		
Dip direction	3	Extrapolated to the base of the model volume. Strike length of the modelled zone > 2000 m.
Strike direction	3	Conceptual understanding of the site and that the entire regional modelled zone is supported by the lineament.

FRACTURE CHARACTER

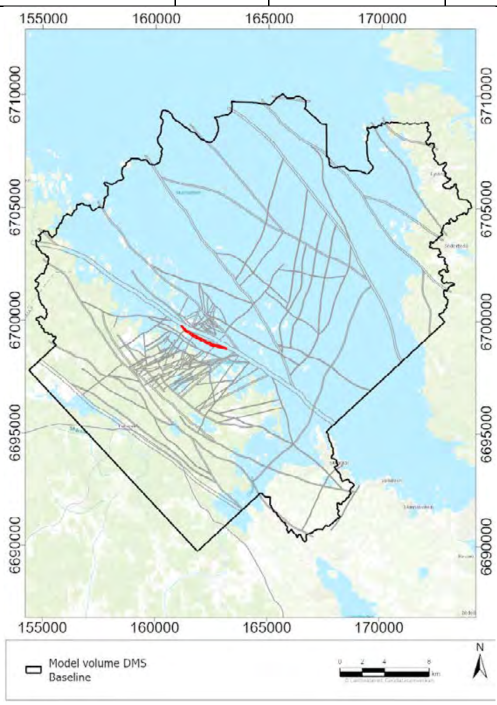
No data available

INDIVIDUAL INTERCEPTS

No data available

WNW	ZFMWNW0813	Version number	3	Total object CL	20

GEOLOGICAL CHARACTER		Property CL
Deformation style:	Brittle-Ductile	3
Deformation description:	No data available.	
Alteration:		3
- First order:	Oxidation	
- Second order:	Chloritization	
- Third order:	Sericitization	
Fracture orientation and type:	Steep sets with WNW-ESE and SSE strike as well as a set consisting of gently dipping fractures are prominent. Fractures with other orientations are also present. Dominance of sealed fractures. Quantitative estimate and span include several sealed fracture networks and some crush zones.	2
Fracture comment:	No data available.	
Fracture fill mineralogy:	Chlorite, calcite, hematite/adularia, epidote, quartz, laumontite and clay minerals.	



OBJECT GEOMETRY	
Strike/dip:	117°/90°
Length:	2788 m
Mean thickness:	76 m (40 - 76 m)
Max depth:	-2100 m
Geometrical constraints:	ZFMWNW0001, Topo 40m grid Max error 20m.

BASIS FOR MODELLING

Zone based on surface lineaments, tunnel and borehole observations.

Outcrops:	-

Boreholes:

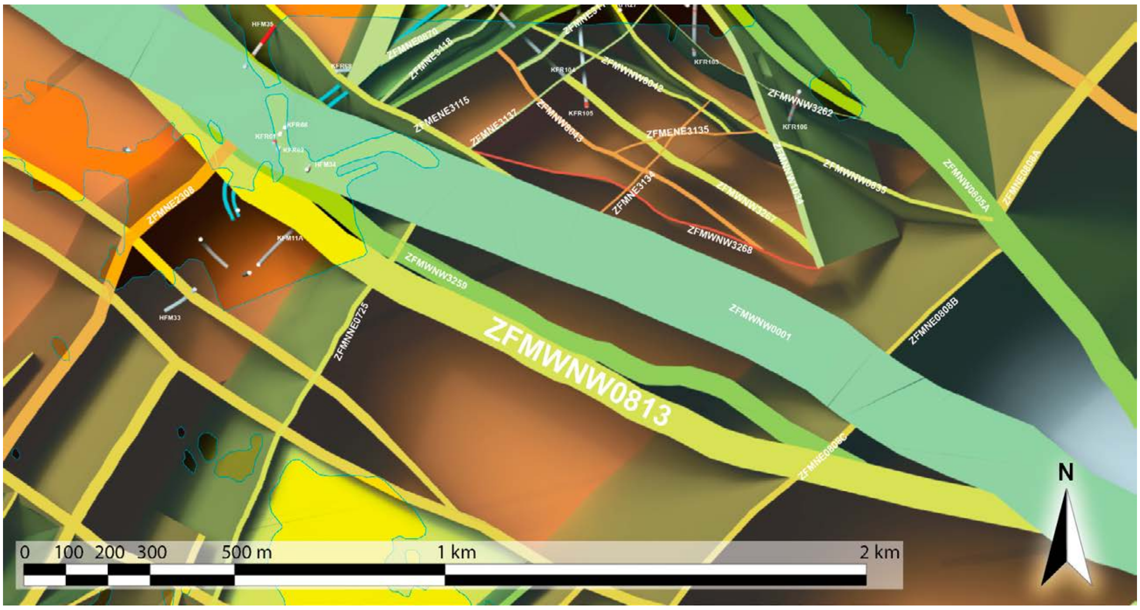
Borehole	PDZ	Target intercept		Geometric intercept		Comment
		Sec_up [m]	Sec_low [m]	Sec_up [m]	Sec_low [m]	
KFM11A	DZ1	245.00	400.00	244.48	391.14	Geometrical split of DZ1 between ZFMWNW0001, ZFMWNW0813 and ZFMWNW3259.

Tunnels:	DT target intercept 0+065 - 0+128 m, geometric intercept 0+062 - 0+138 m. BT target intercept 0+042 - 0+082 m, geometric intercept 0+042 – 0+082 m.	
Lineament and/or seismic indications:	MFM0813G.	2

MODELLING PROCEDURE

At the surface, corresponds to the low magnetic lineament MFM081301 . Modelled to a depth of 1600 m using an assumed dip of 90 degrees based on a comparison with high confidence, vertical and steeply dipping zones with WNW and NW strike. The original lineament and zone trace diverge in the area of the tunnel, with the zone extended to cross the SFR construction and operation tunnels before terminating at ZFMWNW0001. The modification was based on the existence of deformation seen in the upper level of KFM11A DZ1 and significant deformation seen in the BT and DT detailed tunnel mapping results. Forward modelling of magnetic data along profiles 24, 25 and 26 (see Appendix 6, Curtis et al. 2011) supports a vertical to steep dip to the south-west.

WNW	ZFMWNW0813	Version number	3	Total object CL	20

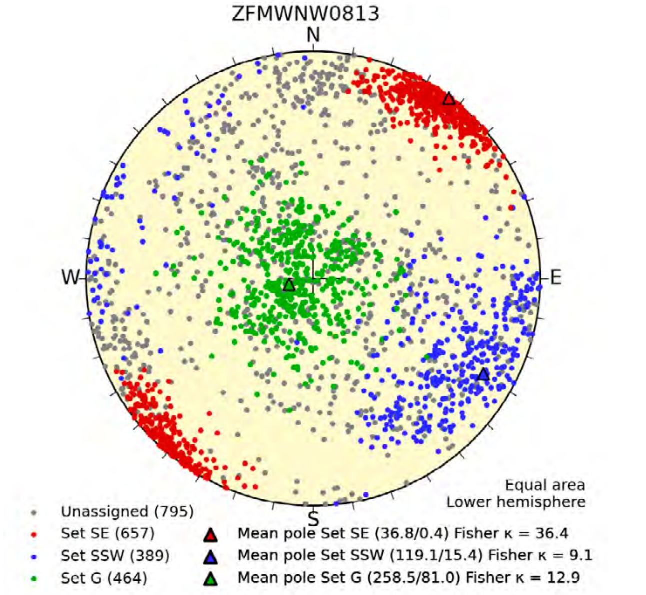
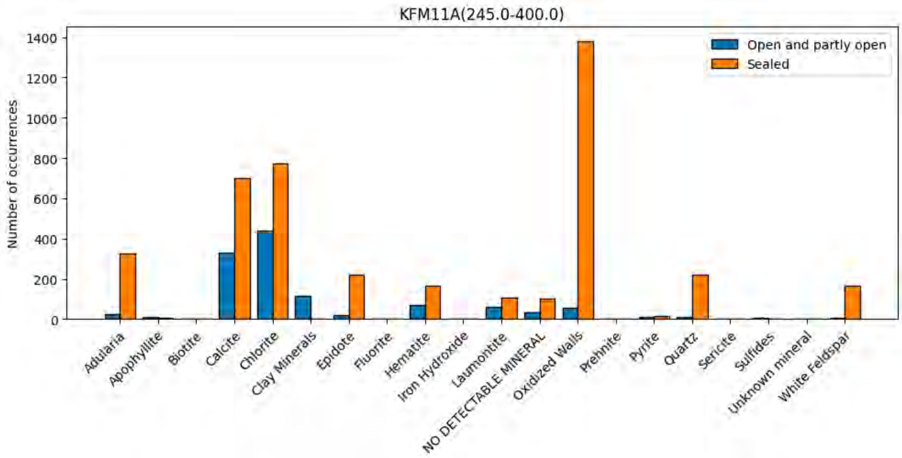


OBJECT CONFIDENCE ESTIMATE

Category	Object CL	Comment
INTERPRETATION		
Data source	3	MFM0813G, KFM11A and shotcrete indications in the DT tunnel and tDZ3, 4 and 5 in BT tunnel.
Results of interpretation	3	High confidence observation in KFM11A.
INFORMATION DENSITY		
Number of observation points	2	2
Distribution of observation points	2	Indications from tunnels and a single observation at depth from a borehole intercept and lineament as an outlier.
INTERPOLATION		
Geometry	2	Geometry supported by a lineament, tunnel indications and a single intercept.
Geological indicators	2	Single observation from a borehole and indications from tunnel mapping with support from surface geophysical data.
EXTRAPOLATION		
Dip direction	3	Extrapolated to the base of the model volume. Strike length of the modelled zone > 2000 m.
Strike direction	3	Conceptual understanding of the site and that the entire regional modelled zone is supported by the lineament.

WNW	ZFMWNW0813	Version number	3	Total object CL	20

FRACTURE CHARACTER

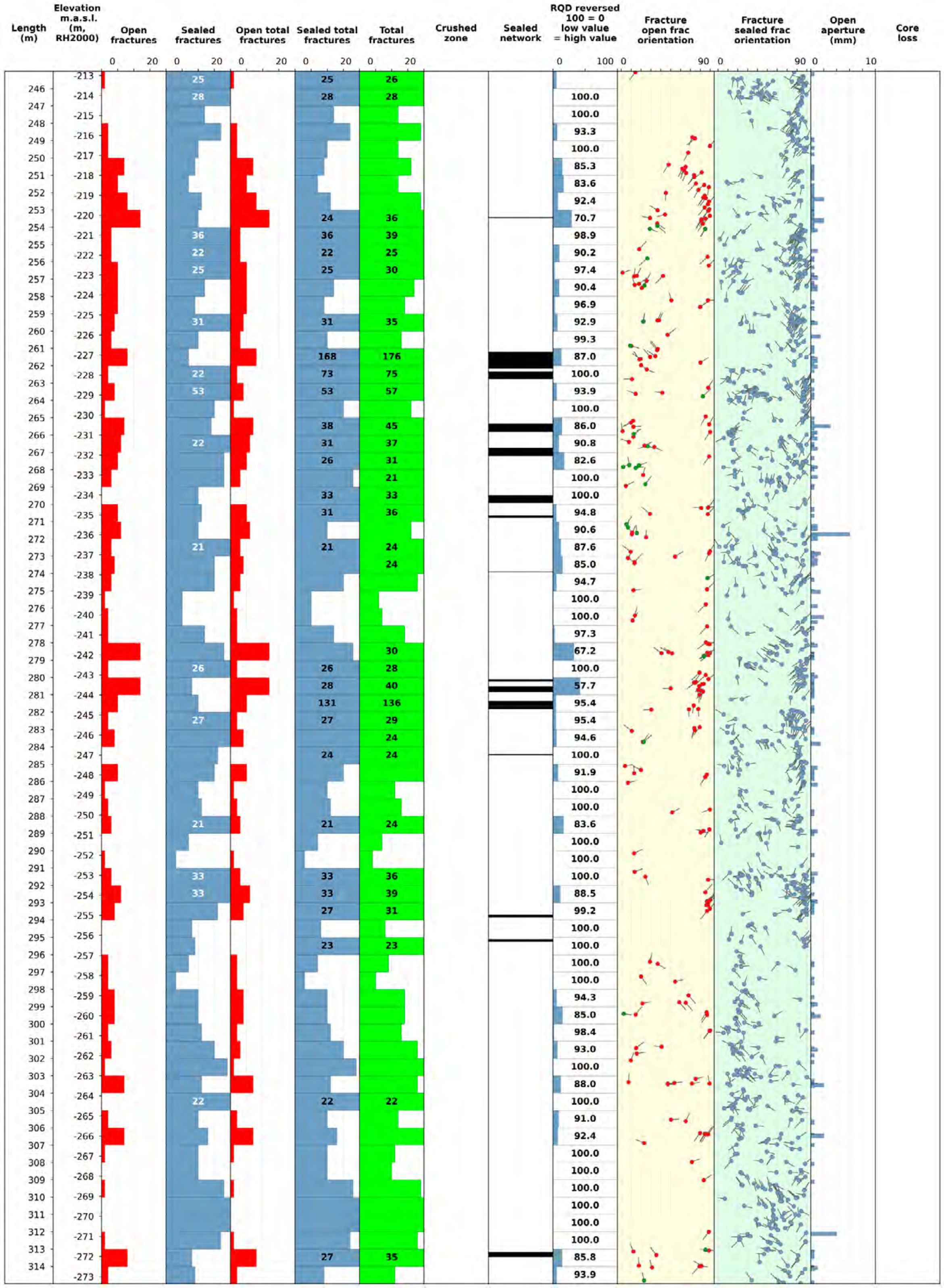
Orientation: (strike/dip right-hand-rule)	Set SE: 126.8°/89.6° Set SSW: 209.1°/74.6° Set G: 348.5°/9.0°	
Frequency:	Boreholes: KFM11A	
RQD:	min:58, max:100, mean:94	
Fracture fill mineralogy:		

FRACTURE TYPE	TERZAGHI-WEIGHED P10
Open and partly open	7.1 m-1
Sealed	32.1 m-1
Sealed network	9.0 % of DZ intercept
Crush	0.6 % of DZ intercept

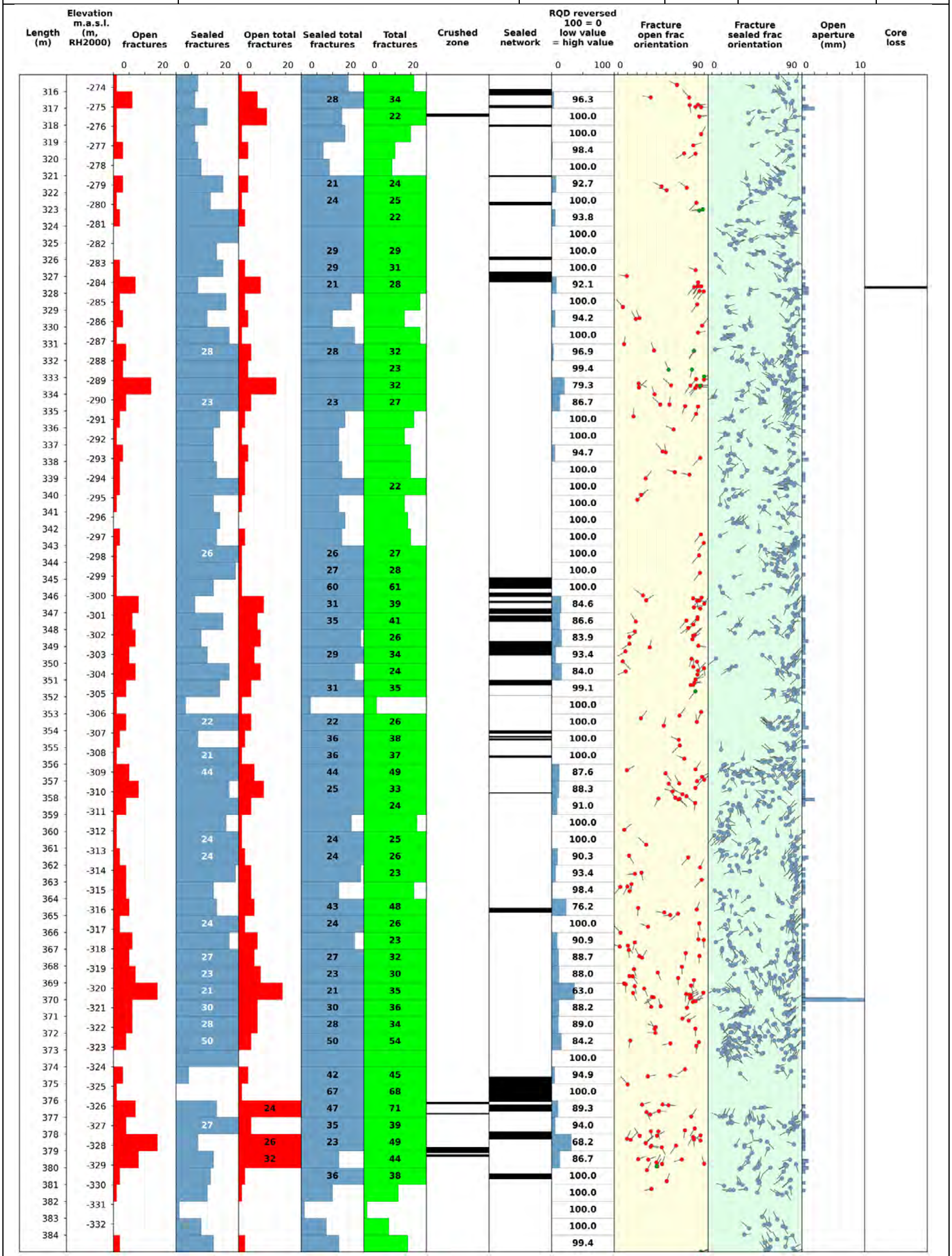
WNW	ZFMWNW0813	Version number	3	Total object CL	20

INDIVIDUAL INTERCEPTS

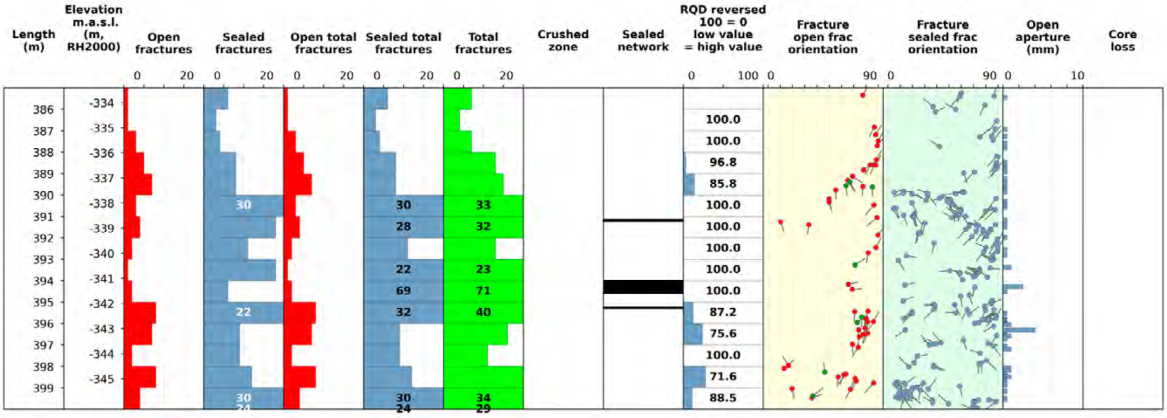
KFM11A DZ1 (245.0-400.0 m)

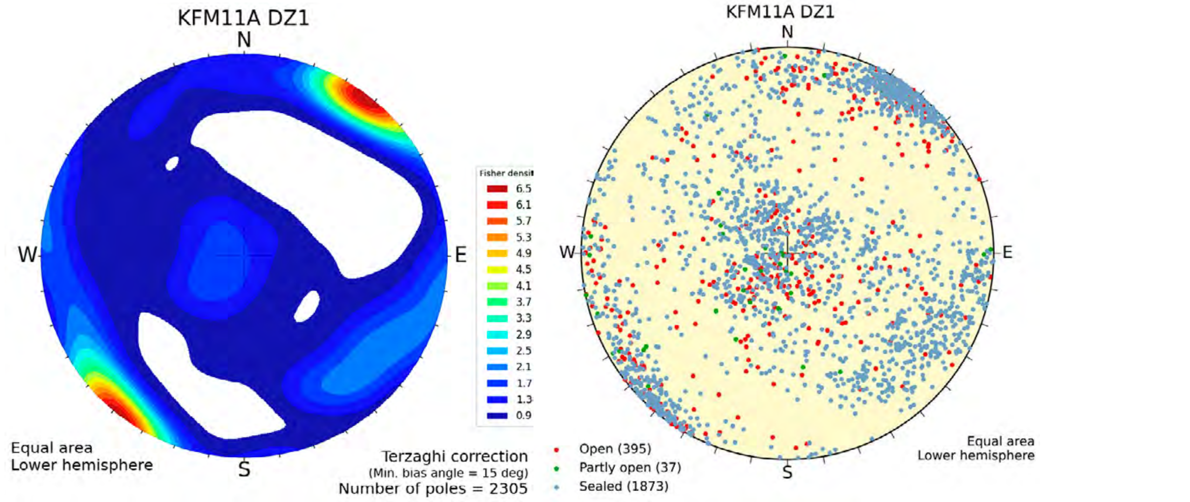


WNW	ZFMWNW0813	Version number	3	Total object CL	20



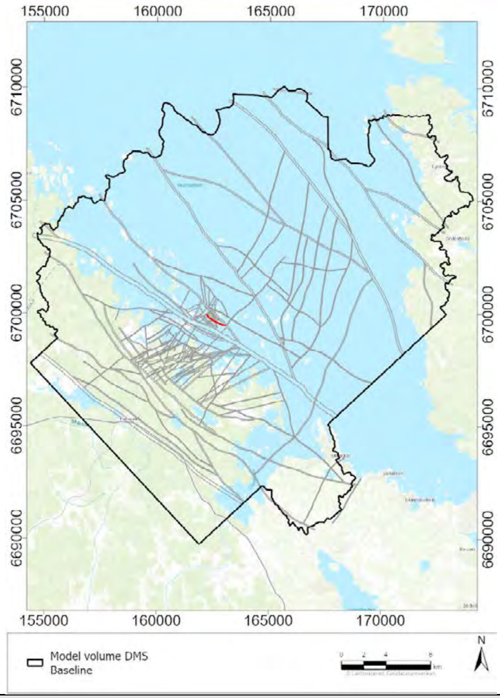
WNW	ZFMWNW0813	Version number	3	Total object CL	20





WNW	ZFMWNW0835		Version number	8	Total object CL	16

GEOLOGICAL CHARACTER		Property CL
Deformation style:	Brittle-Ductile	1
Deformation description:	No data available.	
Alteration:		2
- First order:	Oxidation	
- Second order:	Not observed	
- Third order:	Not observed	
Fracture orientation and type:	No data available.	
Fracture comment:	No data available.	
Fracture fill mineralogy:	No data available.	



OBJECT GEOMETRY	
Strike/dip:	120°/88°
Length:	1065 m
Mean thickness:	10 m (3 - 50 m)
Max depth:	-1050 m
Geometrical constraints:	Topo 40m grid Max error 20m, ZFMENE3115, 1 Surface Planar Cut(s).

BASIS FOR MODELLING

Zone based on surface lineaments and intersections with KFR121 and KFR27. Zone ZFMWNW0835 consists of two segments, ZFMWNW0835A and ZFMWNW0835B, judged to constitute elements of one and the same structure.

Outcrops: -

Boreholes:

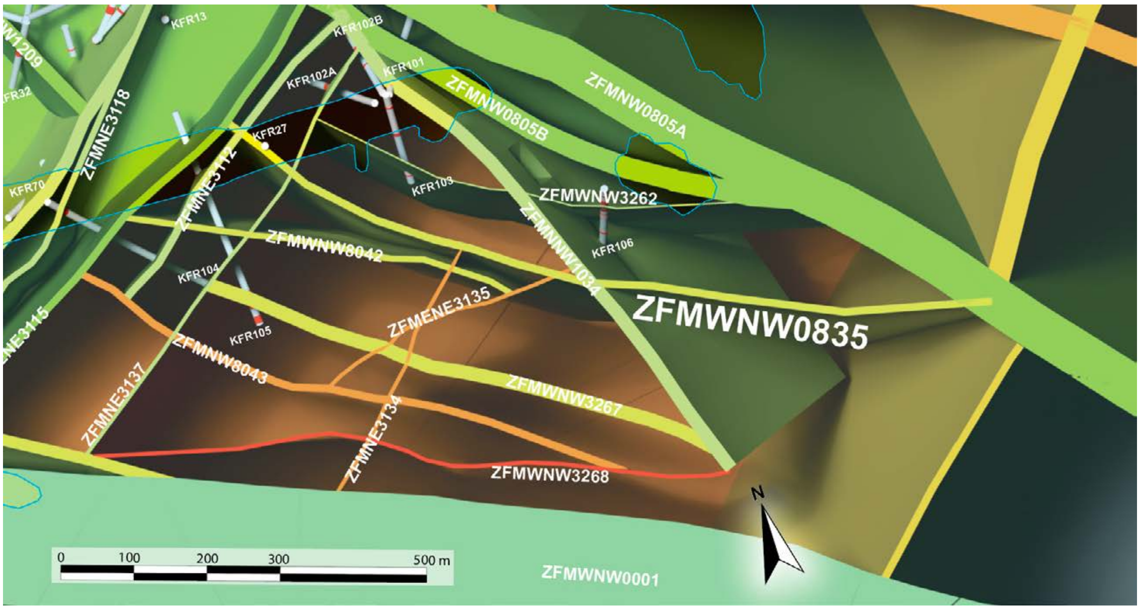
Borehole	PDZ	Target intercept		Geometric intercept		Comment
		Sec_up [m]	Sec_low [m]	Sec_up [m]	Sec_low [m]	
KFR121	DZ3	225.00	233.00	221.75	238.90	
KFR27		-	-	9.83	33.05	
KFR27	DZ2	323.00	469.00	300.87	476.53	
KFR27	DZ3	323.00	469.00	300.87	476.53	
KFR27	DZ4	323.00	469.00	300.87	476.53	

Tunnels:	-	
Lineament and/or seismic indications:	MSFR08107, MSFR08106.	2

MODELLING PROCEDURE

Zone ZFMWNW0835 consists of two segments, the most prominent of which is denoted ZFMWNW0835A. These two segments are judged to constitute elements of one and the same structure. At the surface, correspond to the low magnetic lineaments MFM0835A0 and MFM0835B0, respectively. Both segments modelled to base of the model volume using an assumed dip of 90 degrees, based on a comparison with high confidence, vertical and steeply dipping zones with WNW and NW strike supported by SHI in KFR121 and KFR27.

WNW	ZFMWNW0835	Version number	8	Total object CL	16



OBJECT CONFIDENCE ESTIMATE

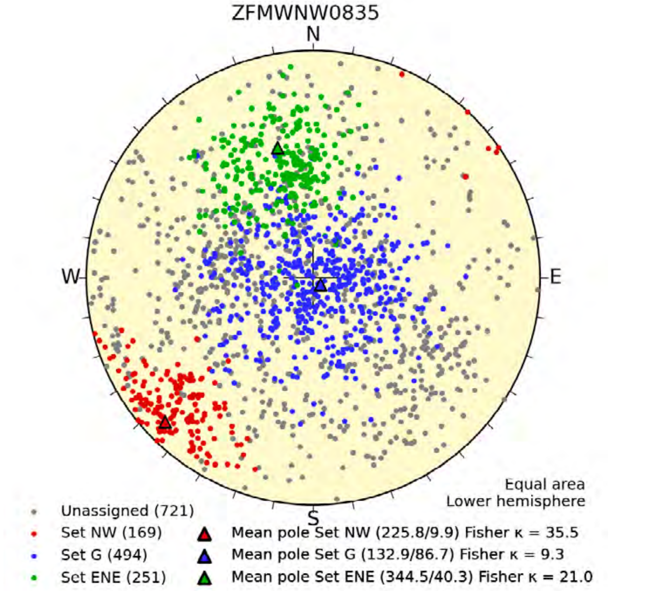
Category	Object CL	Comment
INTERPRETATION		
Data source	2	MFM0835BG (MSFR08107 and MSFR08106 (updated from lineament MFM0835BG in Forsmark stage 2.3)), KFR27, KFR121.
Results of interpretation	3	High confidence observation in KFR27.
INFORMATION DENSITY		
Number of observation points	2	3
Distribution of observation points	1	Horizontal distance c. 500 m between sub-surface obs. points.
INTERPOLATION		
Geometry	2	Geometry supported by two borehole intercepts and by a lineament.
Geological indicators	2	Some discrepancies in the geological data.
EXTRAPOLATION		
Dip direction	2	Extrapolation in dip direction supported by subsurface obs. point. Strike length of the modelled zone < 2000 m. Drill hole intercept provide confidence to interpolate to c. 470 m depth (zone radius >215m). Extrapolation beyond that point in SE direction based mainly on methodology proposed by Munier et al. 2003 (vertical extend correspond to surface trace length).
Strike direction	2	Supported by geological concept and partly by surface lineament.

WNW	ZFMWNW0835	Version number	8	Total object CL	16

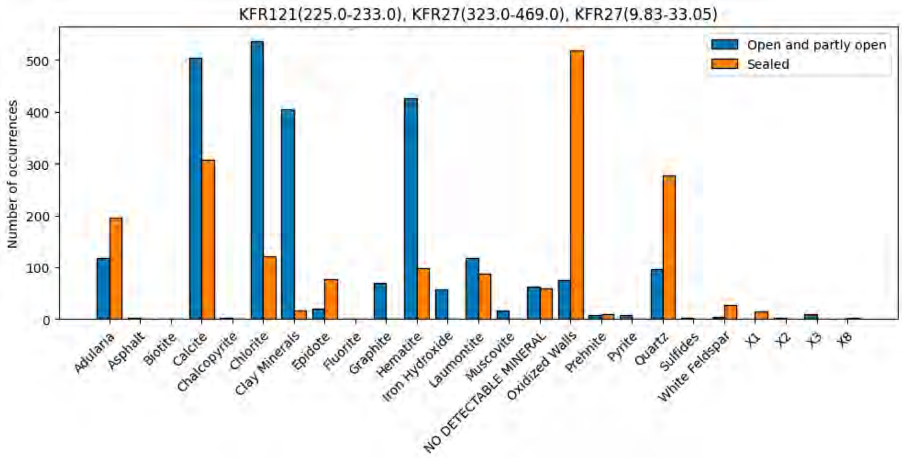
FRACTURE CHARACTER

Orientation: (strike/dip right-hand-rule)	Set NW: 315.8°/80.1° Set G: 222.9°/3.3° Set ENE: 74.5°/49.7°
Frequency:	Boreholes: KFR27, KFR121

FRACTURE TYPE	TERZAGHI-WEIGHED P10
Open and partly open	8.9 m-1
Sealed	10.6 m-1
Sealed network	29.4 % of DZ intercept
Crush	1.0 % of DZ intercept



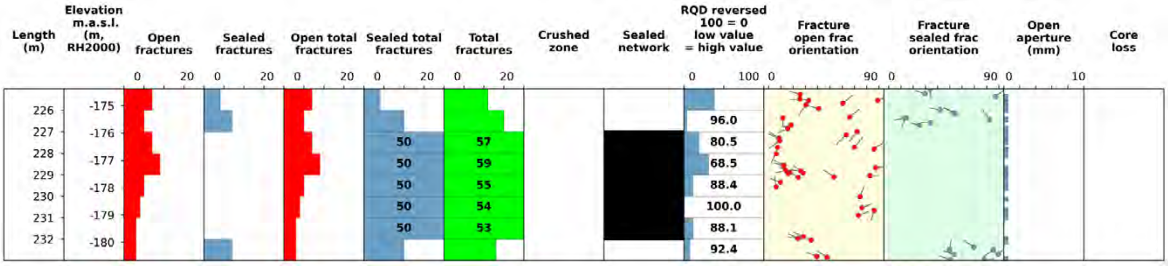
RQD:	min:7, max:100, mean:84
Fracture fill mineralogy:	

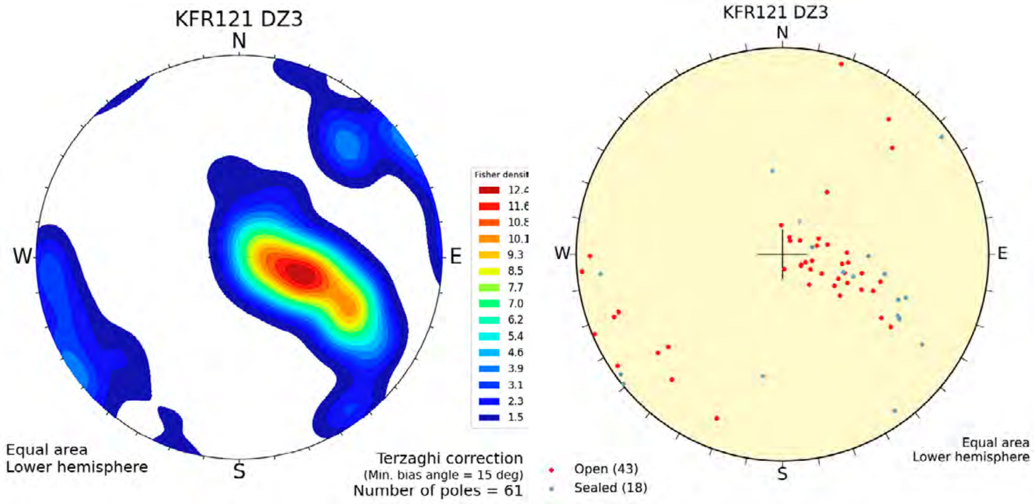


WNW	ZFMWNW0835	Version number	8	Total object CL	16

INDIVIDUAL INTERCEPTS

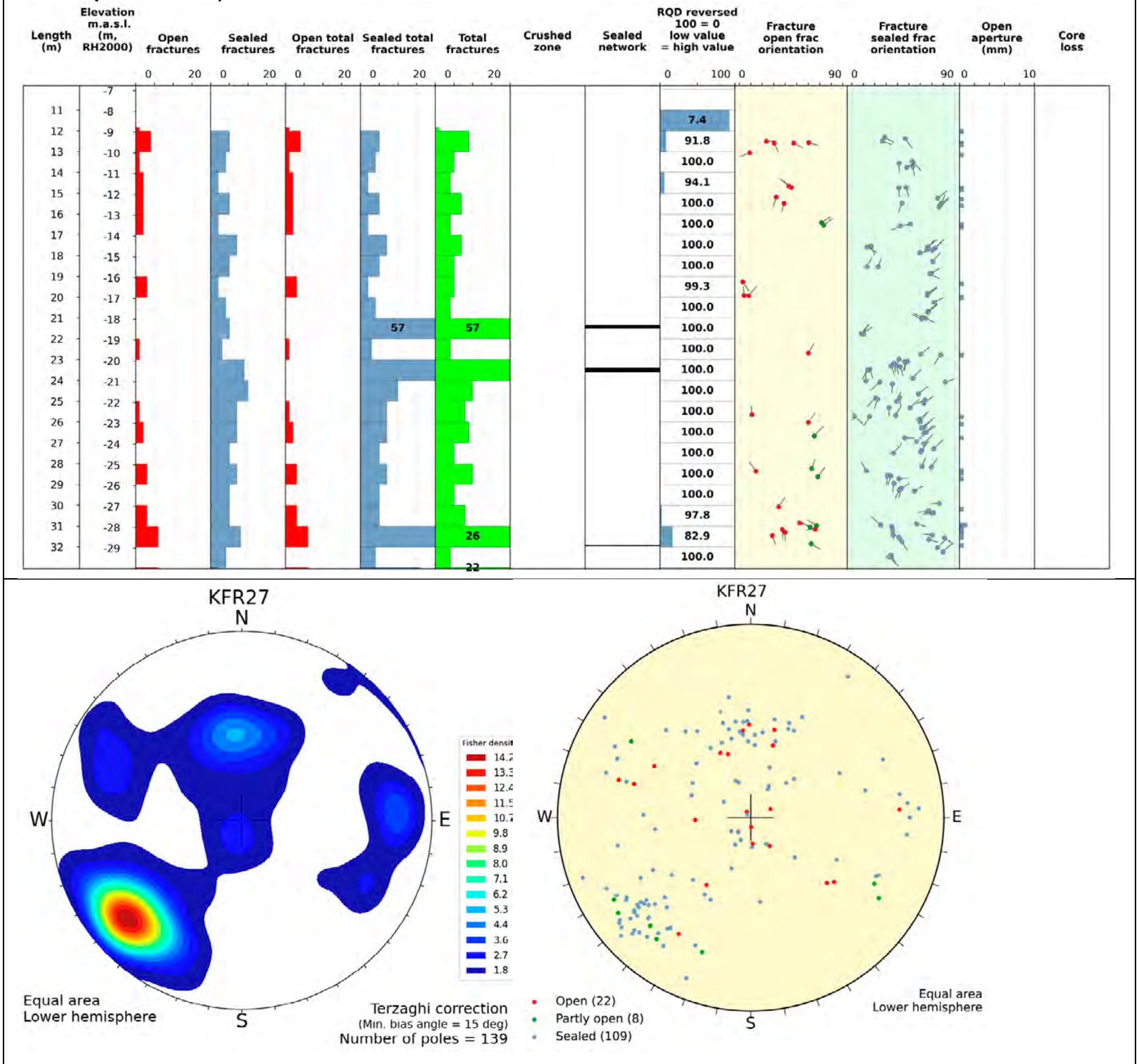
KFR121 DZ3 (225.0-233.0 m)





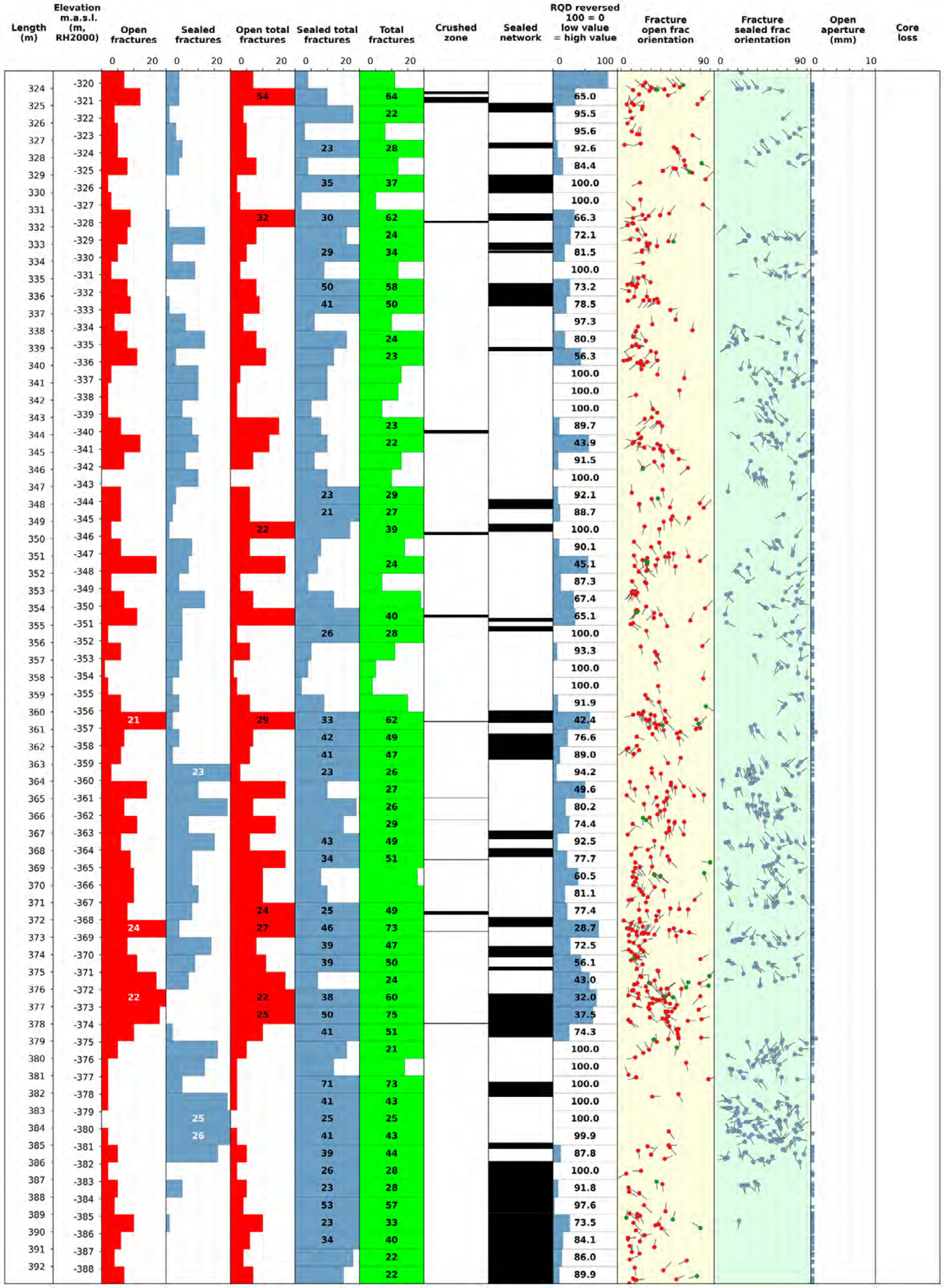
WNW	ZFMWNW0835	Version number	8	Total object CL	16

KFR27 (9.83-33.05 m)

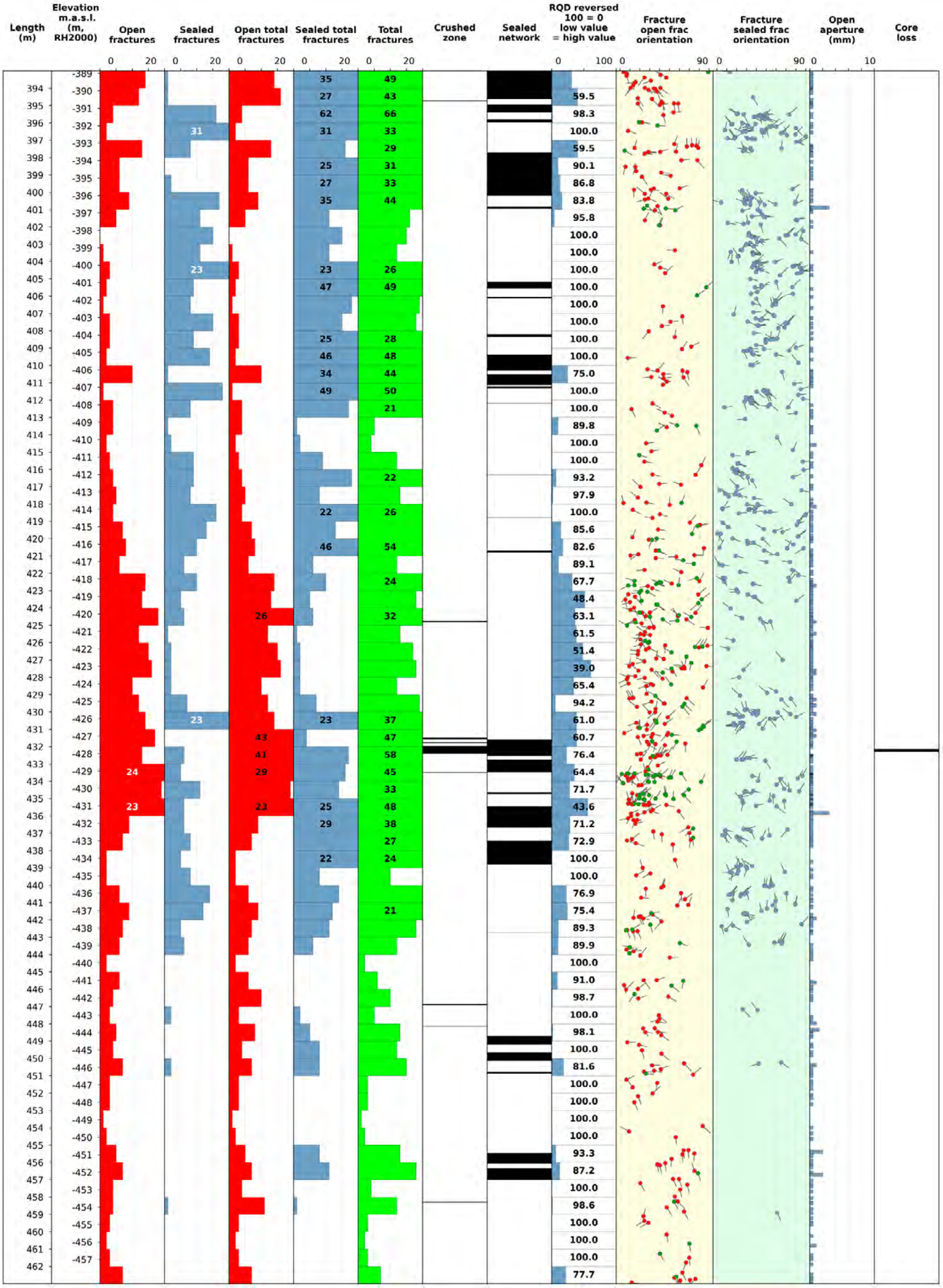


WNW	ZFMWNW0835	Version number	8	Total object CL	16

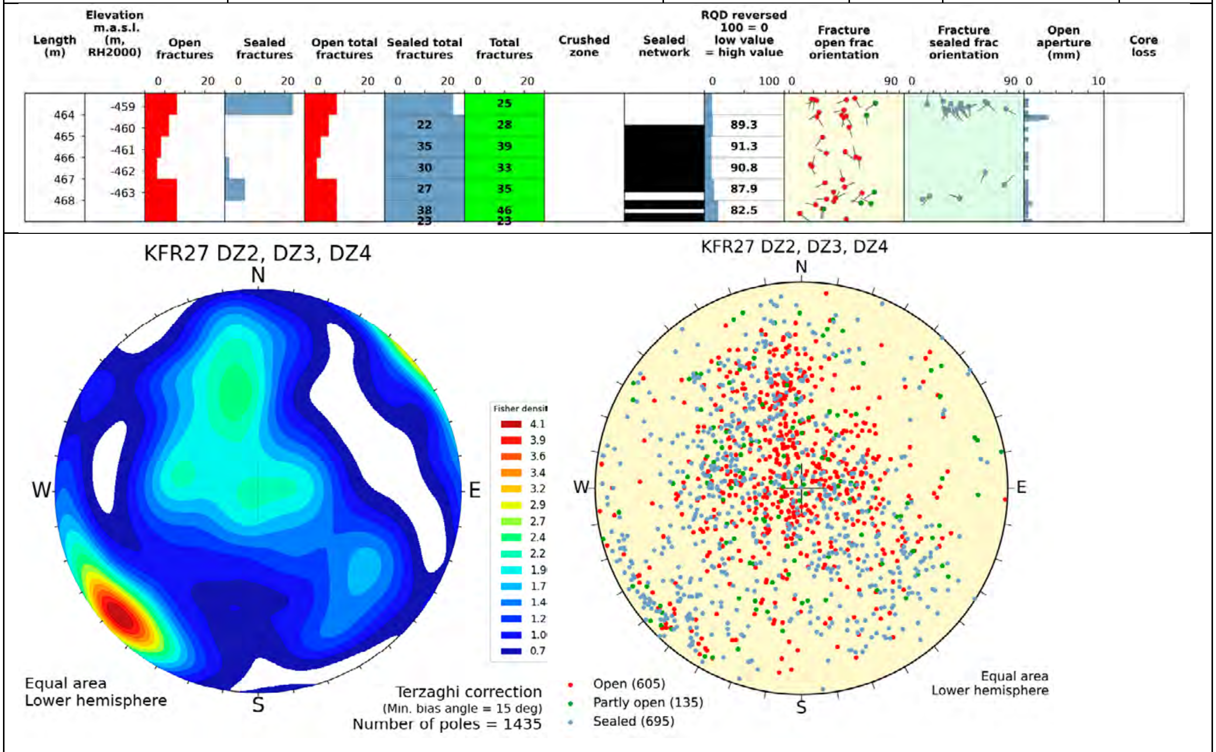
KFR27 DZ2, DZ3, DZ4 (323.0-469.0 m)



WNW	ZFMWNW0835	Version number	8	Total object CL	16



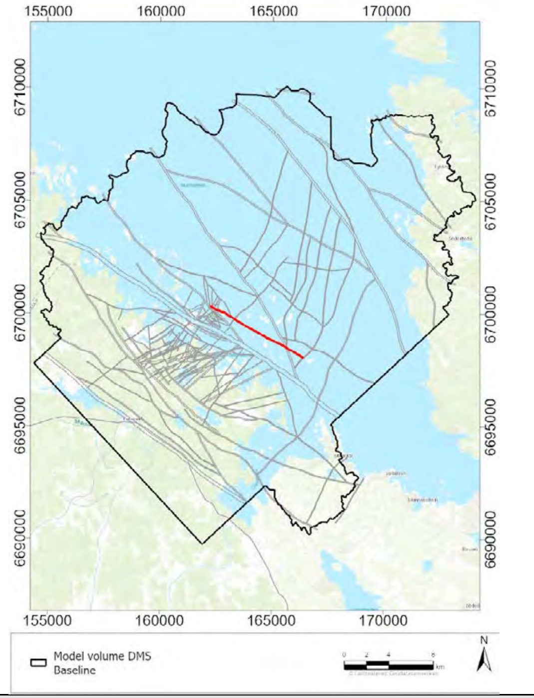
WNW	ZFMWNW0835	Version number	8	Total object CL	16



WNW	ZFMWNW0836		Version number	4	Total object CL	13

GEOLOGICAL CHARACTER		Property CL
Deformation style:	Brittle	1
Deformation description:	No data available.	
Alteration:		2
- First order:	Oxidation	
- Second order:	Not observed	
- Third order:	Not observed	
Fracture orientation and type:	No data available.	
Fracture comment:	No data available.	
Fracture fill mineralogy:	No data available.	

OBJECT GEOMETRY	
Strike/dip:	119°/90°
Length:	4866 m
Mean thickness:	35 m (15 - 64 m)
Max depth:	-2100 m
Geometrical constraints:	ZFMNW0805A, ZFMNNE1134, Topo 40m grid Max error 20m.



BASIS FOR MODELLING

Zone based on surface lineaments.

Outcrops:	-

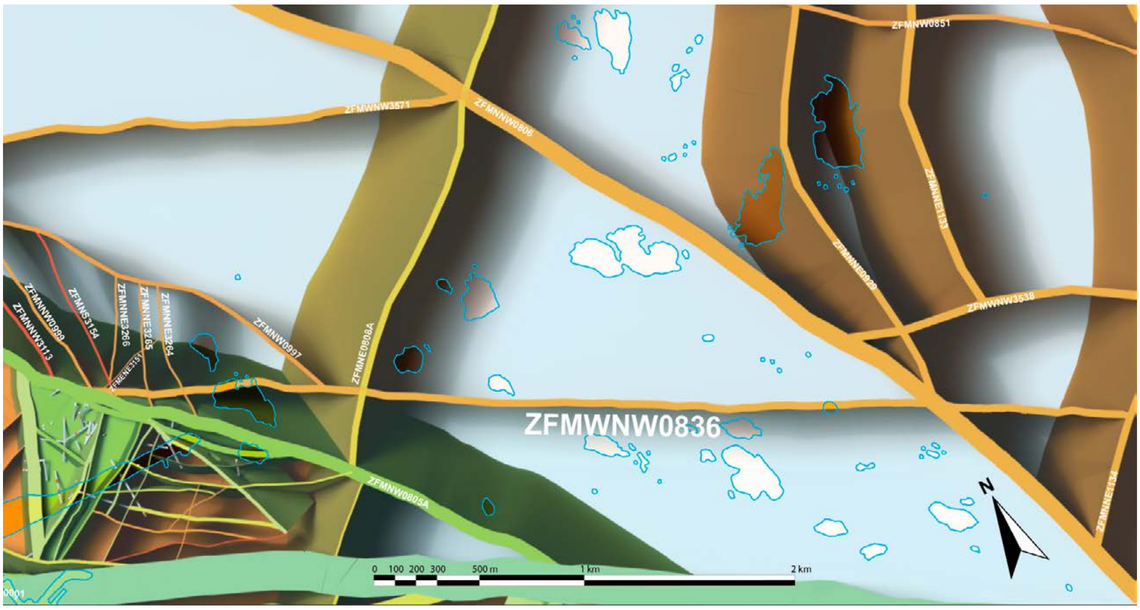
Boreholes:

Borehole	PDZ	Target intercept		Geometric intercept		Comment
		Sec_up [m]	Sec_low [m]	Sec_up [m]	Sec_low [m]	
KFR24		-	-	156.98	159.20	No SHI available.

Tunnels:	-	
Lineament and/or seismic indications:	MFM0836.	2

MODELLING PROCEDURE

At the surface, corresponds to the low magnetic lineament MFM0836. Modelled to base of the model volume using an assumed dip of 90 degrees based on a comparison with high confidence, vertical and steeply dipping zones with WNW and NW strike.



WNW	ZFMWNW0836	Version number	4	Total object CL	13

OBJECT CONFIDENCE ESTIMATE

Category	Object CL	Comment
INTERPRETATION		
Data source	1	MFM0836G, KFR24 (No SHI available).
Results of interpretation	2	Medium confidence in lineament MFM0836G.
INFORMATION DENSITY		
Number of observation points	1	2
Distribution of observation points	1	Single observation point in the form of a lineament.
INTERPOLATION		
Geometry	1	Geometry supported by surface geophysical data.
Geological indicators	1	Indirect support by geophysical data. (No SHI available for KFR24).
EXTRAPOLATION		
Dip direction	3	Extrapolated to the base of the model volume. Strike length of the modelled zone > 2000 m.
Strike direction	3	Conceptual understanding of the site and that the entire regional modelled zone is supported by the lineament.

FRACTURE CHARACTER

No data available

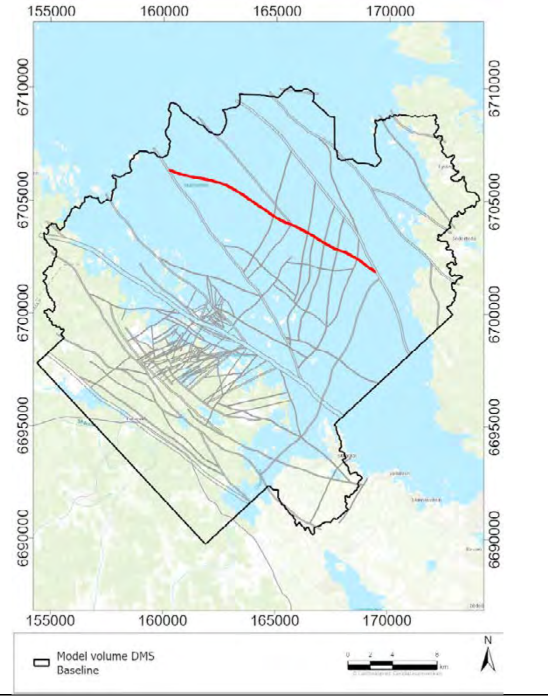
INDIVIDUAL INTERCEPTS

KFR24 (156.98-159.2 m)

No data available

WNW	ZFMWNW0853	Version number	5	Total object CL	13

GEOLOGICAL CHARACTER		Property CL
Deformation style:	Brittle-Ductile	1
Deformation description:	No data available.	
Alteration:		2
- First order:	Oxidation	
- Second order:	Not observed	
- Third order:	Not observed	
Fracture orientation and type:	No data available.	
Fracture comment:	No data available.	
Fracture fill mineralogy:	No data available.	



OBJECT GEOMETRY	
Strike/dip:	117°/90°
Length:	10543 m
Mean thickness:	60 m (50 - 200 m)
Max depth:	-2100 m
Geometrical constraints:	ZFMNW0854, Topo 40m grid Max error 20m, ZFMNNW0806.

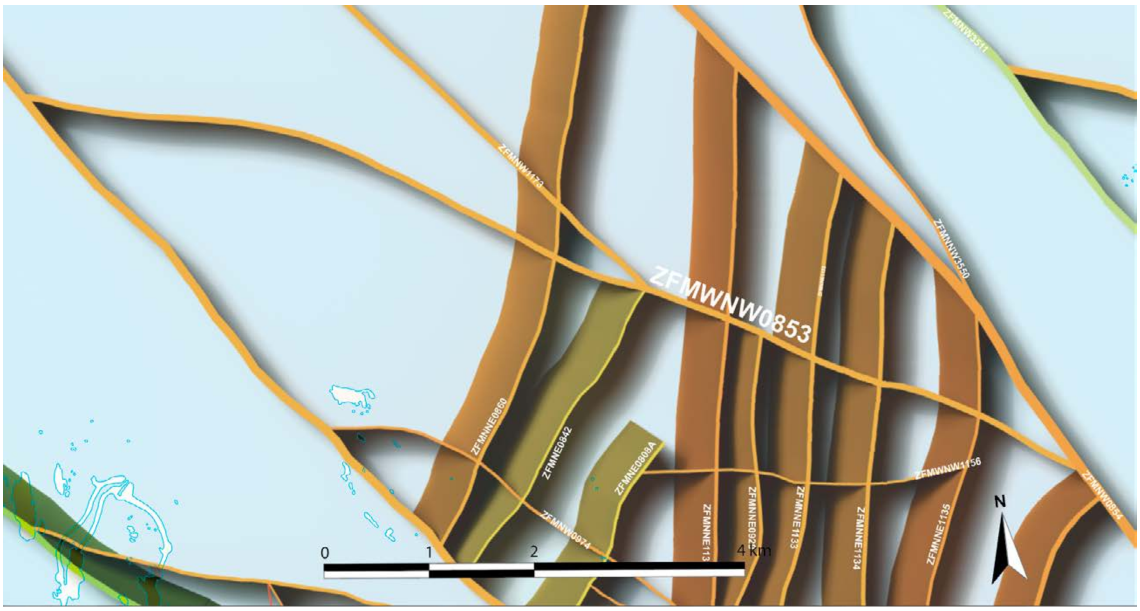
BASIS FOR MODELLING

Zone based on surface lineaments.

Outcrops:	-	
Boreholes: -		
Tunnels:	-	
Lineament and/or seismic indications:	MFM0853 merged.	2

MODELLING PROCEDURE

At the surface, corresponds to the low magnetic lineament MFM0853. Modelled to base of the model volume using an assumed dip of 90 degrees based on a comparison with high confidence, vertical and steeply dipping zones with WNW and NW strike.



WNW	ZFMWNW0853	Version number	5	Total object CL	13

OBJECT CONFIDENCE ESTIMATE

Category	Object CL	Comment
INTERPRETATION		
Data source	1	MFM0853.
Results of interpretation	2	Medium confidence in lineament MFM0853.
INFORMATION DENSITY		
Number of observation points	1	1
Distribution of observation points	1	Single observation point in the form of a lineament.
INTERPOLATION		
Geometry	1	Geometry supported by surface geophysical data.
Geological indicators	1	Indirect support by geophysical data.
EXTRAPOLATION		
Dip direction	3	Extrapolated to the base of the model volume. Strike length of the modelled zone > 2000 m.
Strike direction	3	Conceptual understanding of the site and that the entire regional modelled zone is supported by the lineament.

FRACTURE CHARACTER

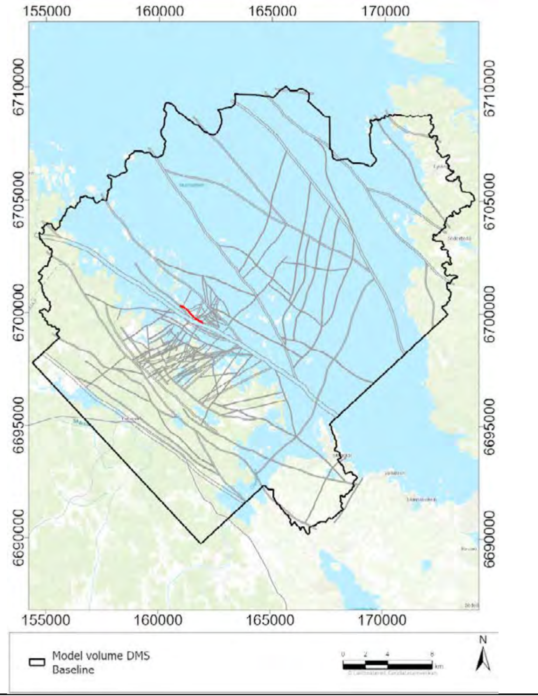
No data available

INDIVIDUAL INTERCEPTS

No data available

WNW	ZFMWNW1035	Version number	6	Total object CL	19

GEOLOGICAL CHARACTER		Property CL
Deformation style:	Brittle-Ductile	3
Deformation description:	No data available.	
Alteration:		3
- First order:	Oxidation	
- Second order:	Not observed	
- Third order:	Not observed	
Fracture orientation and type:	Steep fractures with WNW-ESE strike and gently dipping fractures are prominent. Steeply dipping fractures with a SE strike are also present.	
Fracture comment:	No data available.	
Fracture fill mineralogy:	No data available.	



OBJECT GEOMETRY	
Strike/dip:	124°/81°
Length:	2078 m
Mean thickness:	15 m (5 - 20 m)
Max depth:	-876 m
Geometrical constraints:	Topo 40m grid Max error 20m, ZFMWNW0001, ZFMNW0002.

BASIS FOR MODELLING

Zone based on surface lineaments, tunnel and borehole observations.

Outcrops: -

Boreholes:

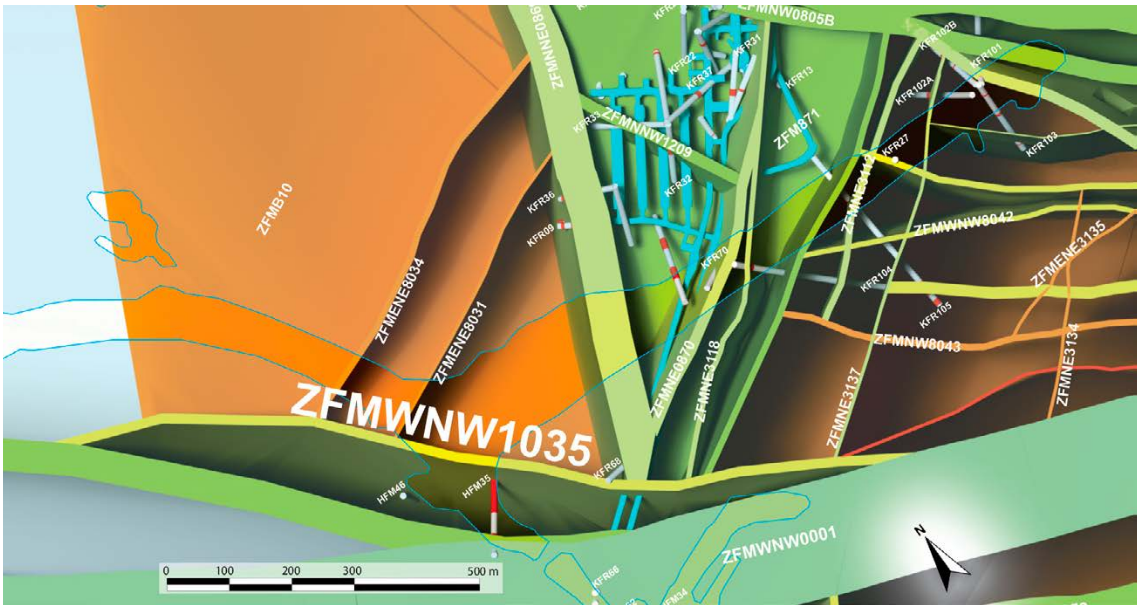
Borehole	PDZ	Target intercept		Geometric intercept		Comment
		Sec_up [m]	Sec_low [m]	Sec_up [m]	Sec_low [m]	
HFM35	DZ3	-	-	180.82	199.08	DZ3 in HFR105 rather than HFM35 DZ3 has been given a higher priority for defining the ZFMWNW1035 zone geometry. No specific target intercept is defined.
HFR105	DZ3	119.00	147.00	119.24	146.38	

Tunnels:	DT target intercept 0+420 - 0+433 m, geometric intercept 0+420 - 0+435 m. BT target intercept 0+398 - 0+416 m, geometric intercept 0+398 – 0+412 m.	
Lineament and/or seismic indications:	MFM1035G, MSFR08112, MSFR08110, MSFR08123.	2

MODELLING PROCEDURE

The surface position of ZFMNW1035 is based on the magnetic lineaments MFM1035G, MSFR08112, MSFR08110 and MSFR08123 (Isaksson et al. 2007, SFR model version 1.0) with some adjustments based on correlation with SFR tunnel mapping and borehole information. There are a number of structures mapped in the tunnels with strikes parallel to the trends of the lineaments and with a steep dip to the south-west with target intercept in the DT tunnel defined by tDZ2 and tDZ27 and in the BT tunnel at tDZ26 (see appendix 11, Curtis et al. 2011). A thickness of 15 m has been defined by the thickness of HFR105 DZ3, as well as to reflect the spread of the inferred related structures seen in the tunnel mapping. In a similar manner as other parallel oriented zones in the vicinity of SFR, tunnel mapping suggests that the zone consists of an associated group of subparallel smaller structures and the different zones together, in the area around SFR, define the complex Singö tectonic belt. The forward modelling of magnetic data along profile 1 (see Appendix 6, Curtis et al. 2011) data suggests a sub-vertical to steep dip to the north-east but the lateral continuity of the anomaly and, as a result, how representative it is for zone ZFMNW1035 are uncertain. Other modelled profiles (24, 25, 26 and 33) indicate a general steep dip to the southwest, as inferred by linking the lineaments to borehole and tunnel intersections in the modelling procedure.

WNW	ZFMWNW1035	Version number	6	Total object CL	19

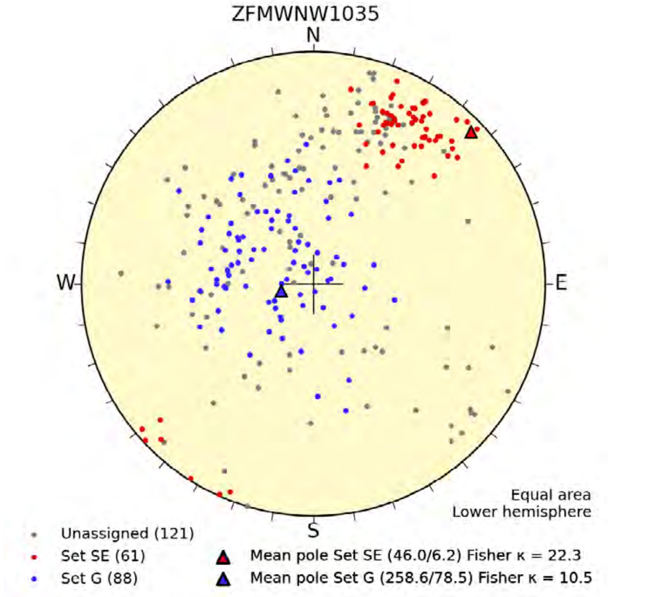


OBJECT CONFIDENCE ESTIMATE

Category	Object CL	Comment
INTERPRETATION		
Data source	3	MFM1035G (MFM1035G, MSFR08112, MSFR08110, MSFR08123), HFM35, HFR105, DT, BT.
Results of interpretation	3	High confidence observations in HFM35 and tunnels of the SFR facility.
INFORMATION DENSITY		
Number of observation points	3	>4
Distribution of observation points	2	Tunnel and a borehole intercept considered as a cluster with support from another borhole intecept and lineament gives a medium in this category. A group of clustered observation points and at least one or more outliers (Hermanson and Petersson 2022)
INTERPOLATION		
Geometry	2	Splay to Singö zone. Several sub-surface obs. points from drill holes and SFR tunnels in SE available. Combined and linked with surface lineament, perhaps one strong alternative for interpolation in SE, however, the distance to next sub-surface obs. point HFM35 in horizontal space is c. 450 m.
Geological indicators	2	Some discrepancies in the geological data.
EXTRAPOLATION		
Dip direction	2	Extrapolation in dip direction supported by subsurface obs. point. Strike length of the modelled zone < 2000 m. Zone exposed in several tunnels. Truncated against ZFMWNW0001.
Strike direction	2	Supported by geological concept and partly by surface lineament.

WNW	ZFMWNW1035	Version number	6	Total object CL	19

FRACTURE CHARACTER

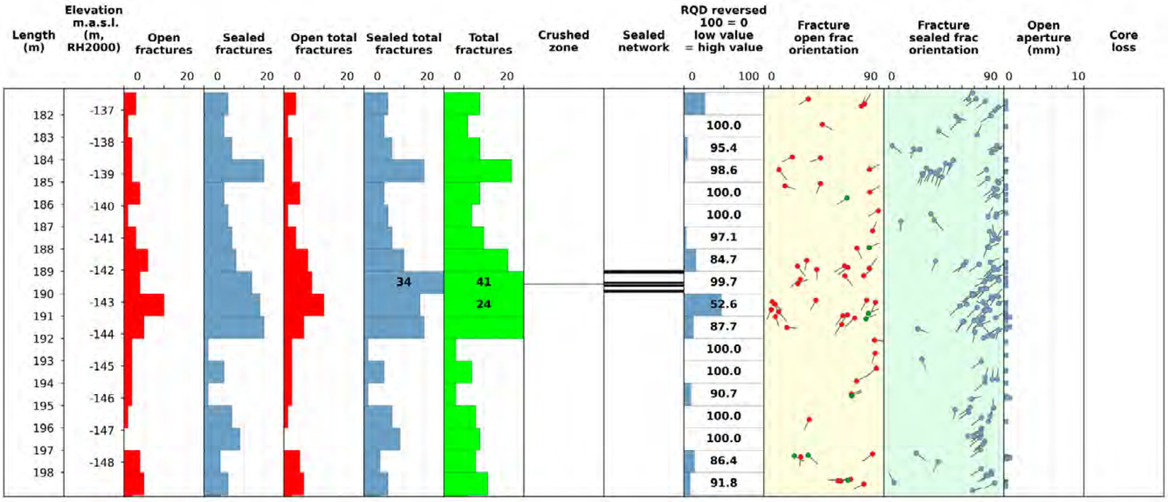
Orientation: (strike/dip right-hand-rule)	Set SE: 136.0°/83.8° Set G: 348.6°/11.5°	
Frequency:	Boreholes: -	
RQD:	--	
Fracture fill mineralogy:	No data available	

FRACTURE TYPE	TERZAGHI-WEIGHED P10
Open and partly open	0.0 m-1
Sealed	0.0 m-1
Sealed network	0.0 % of DZ intercept
Crush	0.0 % of DZ intercept

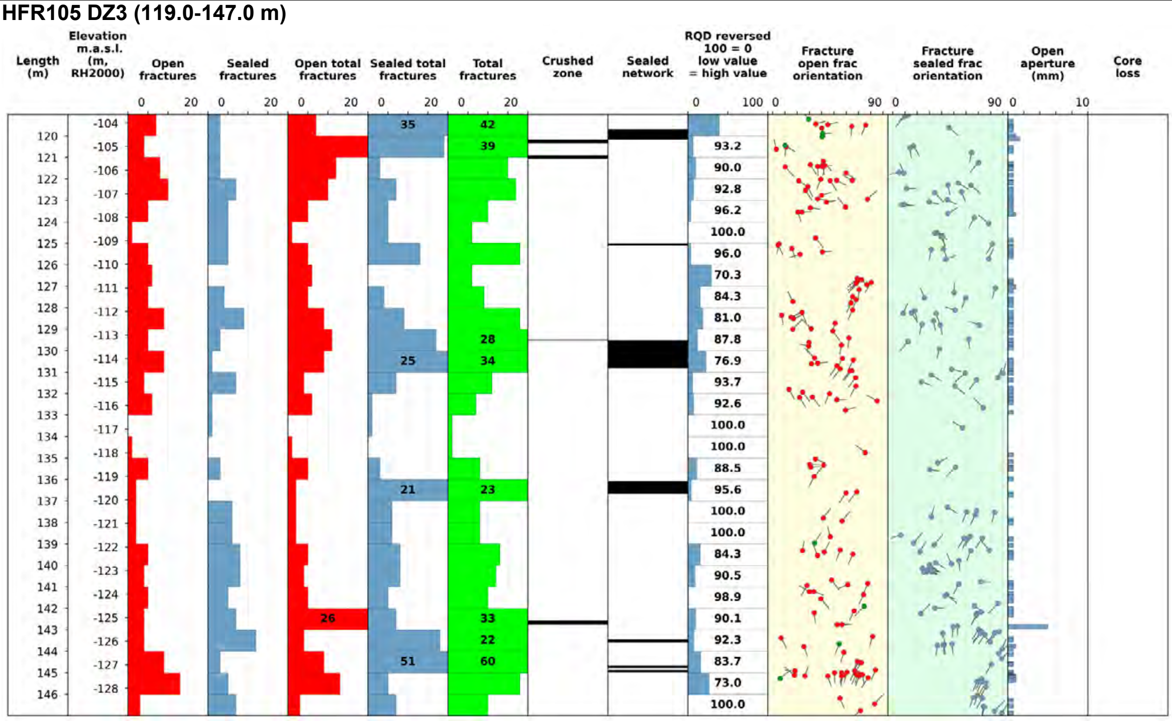
WNW	ZFMWNW1035	Version number	6	Total object CL	19

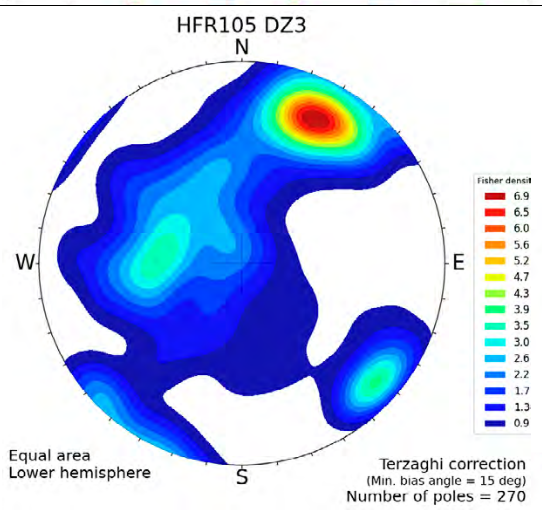
INDIVIDUAL INTERCEPTS

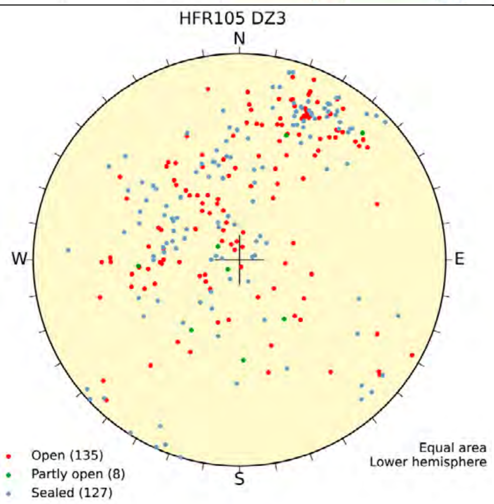
HFM35 DZ3 (180.82-199.08 m)



HFR105 DZ3 (119.0-147.0 m)

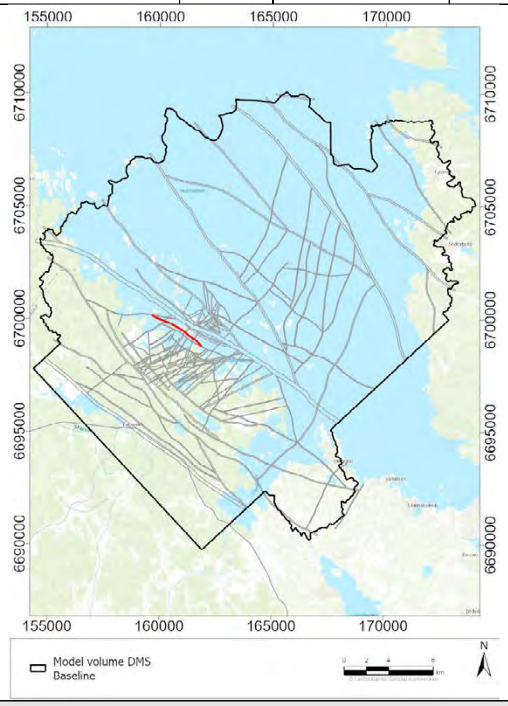






WNW	ZFMWNW1053		Version number	3	Total object CL	14

GEOLOGICAL CHARACTER		Property CL
Deformation style:	Brittle-Ductile	1
Deformation description:	No data available.	
Alteration:		2
- First order:	Oxidation	
- Second order:	Not observed	
- Third order:	Not observed	
Fracture orientation and type:	No data available.	
Fracture comment:	No data available.	
Fracture fill mineralogy:	No data available.	



OBJECT GEOMETRY	
Strike/dip:	121°/90°
Length:	2680 m
Mean thickness:	25 m (3 - 50 m)
Max depth:	-2100 m
Geometrical constraints:	Topo 40m grid Max error 20m, ZFMWNW0809A, ZFMWNW0137.

BASIS FOR MODELLING

Zone based on surface lineaments.

Outcrops: -

Boreholes:

Borehole	PDZ	Target intercept		Geometric intercept		Comment
		Sec_up [m]	Sec_low [m]	Sec_up [m]	Sec_low [m]	
HFM33		-	-	9.42	49.87	

Tunnels:	-	
Lineament and/or seismic indications:	MFM1094G.	3

MODELLING PROCEDURE

At the surface, corresponds to the low magnetic lineaments MFM1053, MFM1053G and MFM1094. Modelled to base of the model volume using an assumed dip of 90 degrees based on a comparison with high confidence, vertical and steeply dipping zones with WNW and NW strike.

WNW	ZFMWNW1053	Version number	3	Total object CL	14

OBJECT CONFIDENCE ESTIMATE

Category	Object CL	Comment
INTERPRETATION		
Data source	1	MFM1094G.
Results of interpretation	3	High confidence in lineament MFM1094G.
INFORMATION DENSITY		
Number of observation points	1	1
Distribution of observation points	1	Single observation point in the form of a lineament.
INTERPOLATION		
Geometry	1	Geometry supported by surface geophysical data.
Geological indicators	1	Indirect support by geophysical data.
EXTRAPOLATION		
Dip direction	3	Extrapolated to the base of the model volume. Strike length of the modelled zone > 2000 m.
Strike direction	3	Conceptual understanding of the site and that the entire regional modelled zone is supported by the lineament.

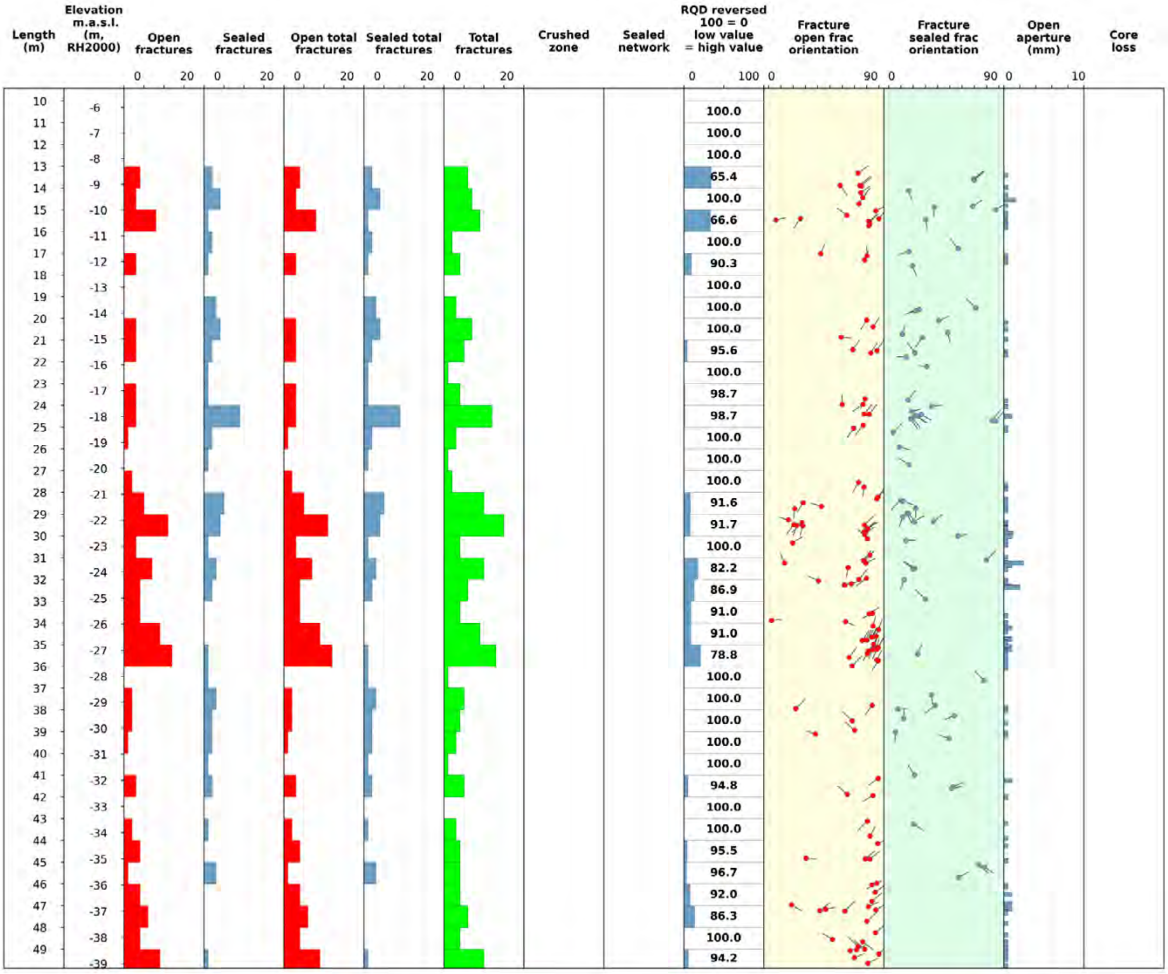
FRACTURE CHARACTER

No data available

WNW	ZFMWNW1053	Version number	3	Total object CL	14

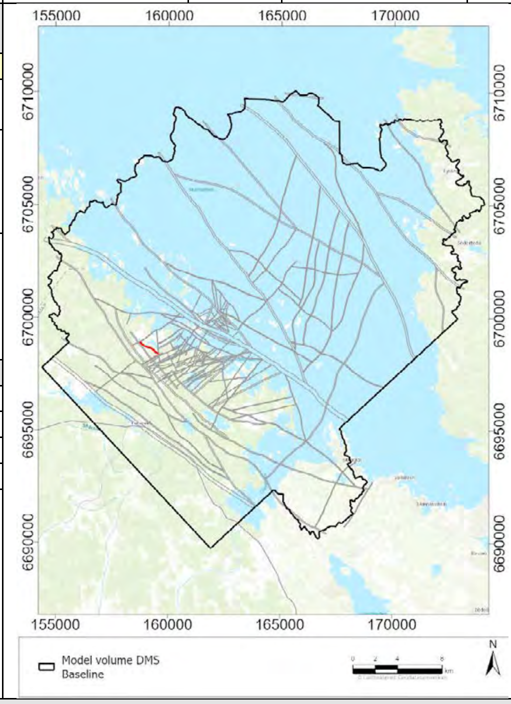
INDIVIDUAL INTERCEPTS

HFM33 (9.42-49.87 m)



WNW	ZFMWNW1068	Version number	5	Total object CL	11

GEOLOGICAL CHARACTER		Property CL
Deformation style:	Brittle	2
Deformation description:	No data available.	
Alteration:		
- First order:	Not observed	
- Second order:	Not observed	
- Third order:	Not observed	
Fracture orientation and type:	No data available.	
Fracture comment:	No data available.	
Fracture fill mineralogy:	No data available.	



OBJECT GEOMETRY	
Strike/dip:	121°/90°
Length:	1002 m
Mean thickness:	15 m (3 - 50 m)
Max depth:	-1000 m
Geometrical constraints:	ZFMNE0810, ZFMNNW0100, Topo 40m grid Max error 20m, 1 Surface Planar Cut(s).

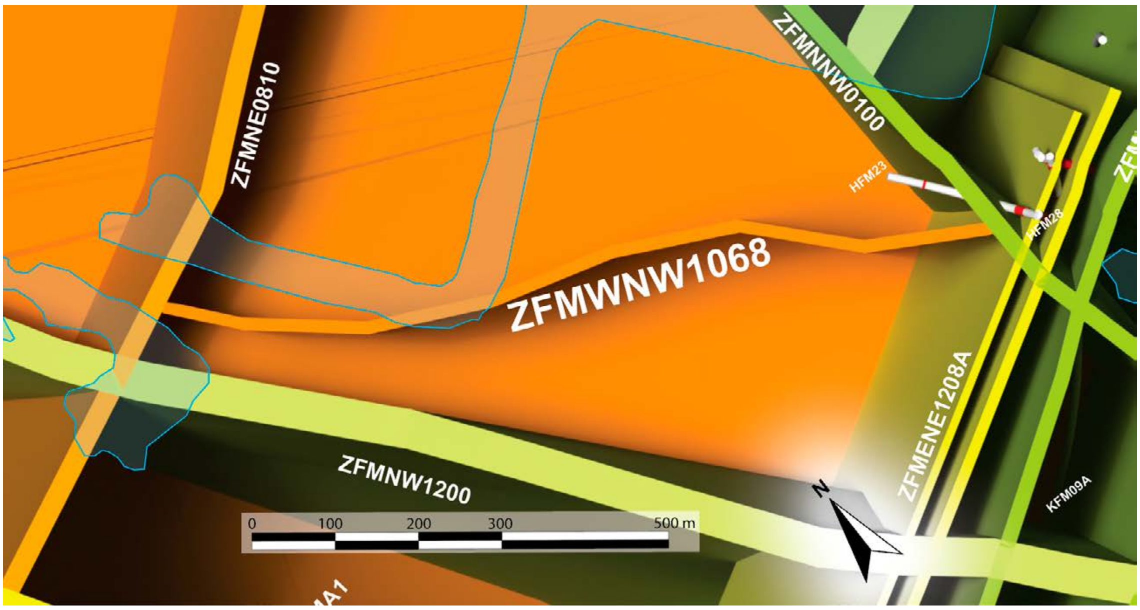
BASIS FOR MODELLING

Zone based on surface lineaments and seismic refraction data.

Outcrops:	-	
Boreholes: -		
Tunnels:	-	
Lineament and/or seismic indications:	MFM1068.	2

MODELLING PROCEDURE

At the surface, corresponds to the lineament MFM1068. This lineament is defined by a depression in the bedrock surface, the form of which has been recognised on the basis of an analysis of old refraction seismic data (Isaksson and Keisu, 2005). Possible correlation also with a low velocity seismic refraction anomaly (Isaksson and Keisu, 2005), RSLV02 in Figure 5-33 in SKB (2005). Modelled to a depth of 1000 m using an assumed dip of 90 degrees, based on a comparison with high confidence, vertical and steeply dipping zones with WNW and NW strike.



WNW	ZFMWNW1068	Version number	5	Total object CL	11

OBJECT CONFIDENCE ESTIMATE

Category	Object CL	Comment
INTERPRETATION		
Data source	1	MFM1068.
Results of interpretation	2	Medium confidence in lineament MFM1068.
INFORMATION DENSITY		
Number of observation points	1	1
Distribution of observation points	1	Single observation point in the form of a lineament.
INTERPOLATION		
Geometry	1	Geometry supported by surface geophysical data.
Geological indicators	1	Indirect support by geophysical data.
EXTRAPOLATION		
Dip direction	1	No subsurface obs. point, supported only by surface data. High uncertainty in dip-direction. Strike length of the modelled zone < 2000 m. Modelled to base of the model volume using an assumed dip of 90 degrees based on a comparison with high confidence, vertical and steeply dipping zones with WNW or NW strike (Stephens and Simeonov 2015).
Strike direction	3	Conceptual understanding of the site and that the entire regional modelled zone is supported by the lineament.

FRACTURE CHARACTER

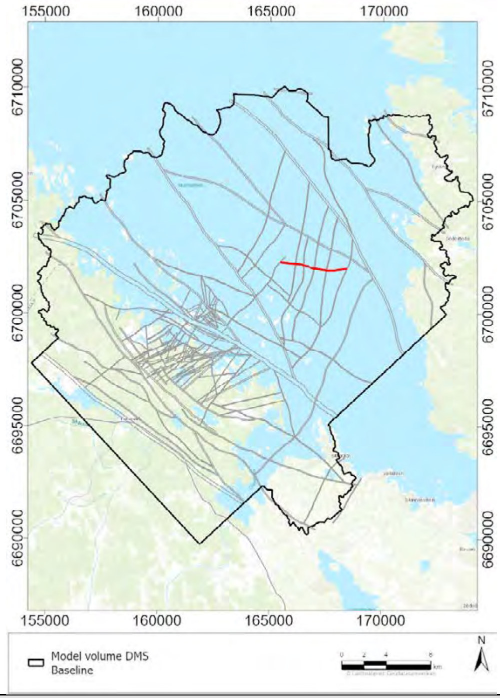
No data available

INDIVIDUAL INTERCEPTS

No data available

WNW	ZFMWNW1156		Version number	3	Total object CL	12

GEOLOGICAL CHARACTER		Property CL
Deformation style:	Brittle	1
Deformation description:	No data available.	
Alteration:		2
- First order:	Oxidation	
- Second order:	Not observed	
- Third order:	Not observed	
Fracture orientation and type:	No data available.	
Fracture comment:	No data available.	
Fracture fill mineralogy:	No data available.	



OBJECT GEOMETRY	
Strike/dip:	97°/90°
Length:	3021 m
Mean thickness:	25 m (15 - 64 m)
Max depth:	-2100 m
Geometrical constraints:	ZFMNE0808A, ZFMNE1135, Topo 40m grid Max error 20m.

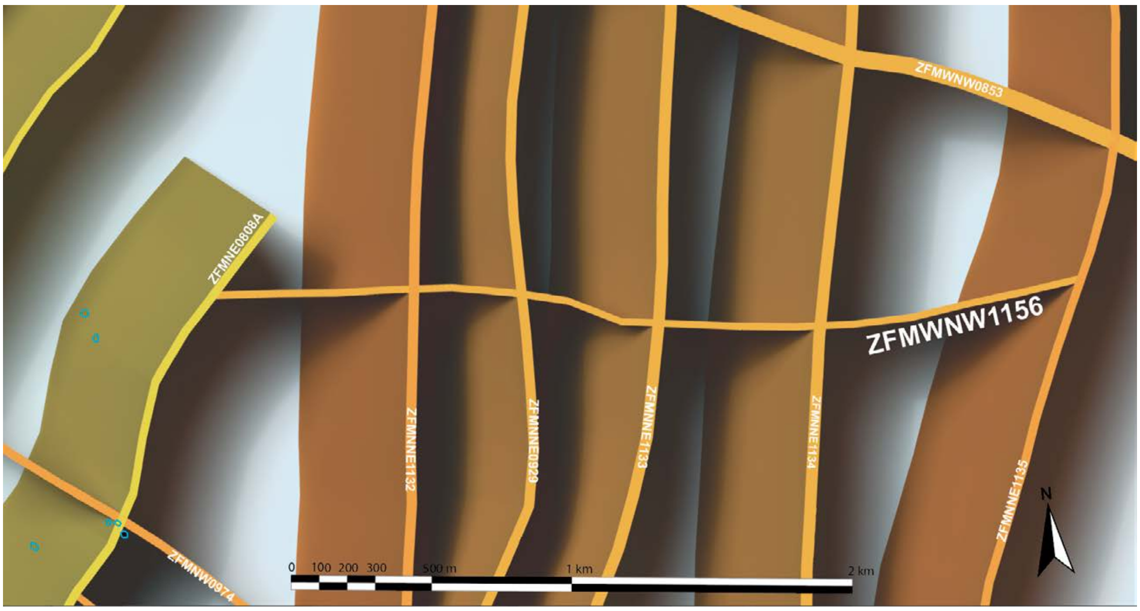
BASIS FOR MODELLING

Zone based on surface lineaments.

Outcrops:	-	
Boreholes: -		
Tunnels:	-	
Lineament and/or seismic indications:	MFM1156.	1

MODELLING PROCEDURE

At the surface, corresponds to the low magnetic lineament MFM1156. Modelled to base of the model volume using an assumed dip of 90 degrees, based on a comparison with high confidence, vertical and steeply dipping zones.



WNW	ZFMWNW1156	Version number	3	Total object CL	12

OBJECT CONFIDENCE ESTIMATE

Category	Object CL	Comment
INTERPRETATION		
Data source	1	MFM1156.
Results of interpretation	1	Low confidence in lineament MFM1156.
INFORMATION DENSITY		
Number of observation points	1	1
Distribution of observation points	1	Single observation point in the form of a lineament.
INTERPOLATION		
Geometry	1	Geometry supported by surface geophysical data.
Geological indicators	1	Indirect support by geophysical data.
EXTRAPOLATION		
Dip direction	3	Extrapolated to the base of the model volume. Strike length of the modelled zone > 2000 m.
Strike direction	3	Extrapolation in strike direction mainly based on the trend of linked surface lineament. Terminated against ZFMWNW1156 and ZFMNNE1135., Conceptual understanding of the site and that the entire regional modelled zone is supported by the lineament.

FRACTURE CHARACTER

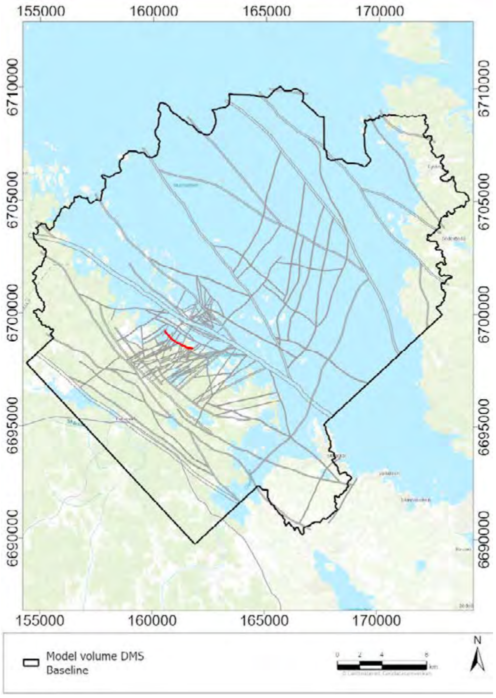
No data available

INDIVIDUAL INTERCEPTS

No data available

WNW	ZFMWNW2225	Version number	6	Total object CL	15

GEOLOGICAL CHARACTER		Property CL
Deformation style:	Brittle	3
Deformation description:	Vertical fault with WNW-ESE strike show sinistral strike-slip displacement. Gently S-dipping fault show dextral strike slip displacement.	
Alteration:		3
- First order:	Oxidation	
- Second order:	Not observed	
- Third order:	Not observed	
Fracture orientation and type:	Steeply dipping fractures that strike in NW and SE sectors dominates. Fractures with other orientations, including gently dipping fractures, are also present. Dominance of sealed fractures followed by open and partly open fractures. Quantitative estimate and span include sealed fracture networks.	2
Fracture comment:	No data available.	
Fracture fill mineralogy:	Chlorite, calcite, hematite/adularia, epidote, quartz, clay minerals.	



OBJECT GEOMETRY	
Strike/dip:	122°/78°
Length:	1531 m
Mean thickness:	26 m (3 - 50 m)
Max depth:	-1550 m
Geometrical constraints:	ZFMENE0060A, Topo 40m grid Max error 20m, 1 Surface Planar Cut(s).

BASIS FOR MODELLING

Zone based on surface lineaments and a borehole observation.

Outcrops:	-

Boreholes:

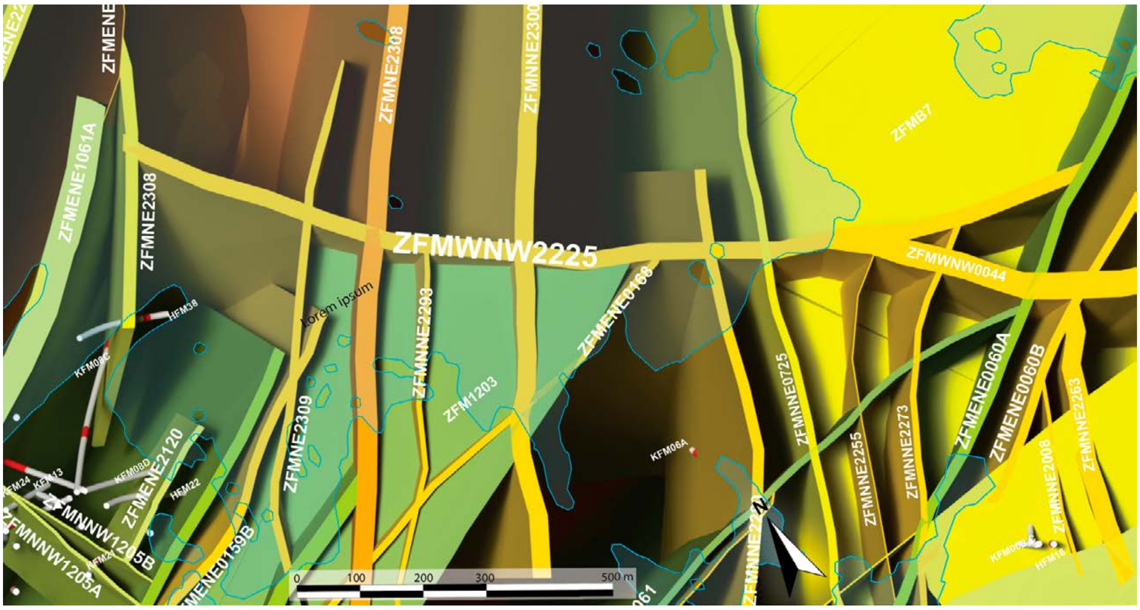
Borehole	PDZ	Target intercept		Geometric intercept		Comment
		Sec_up [m]	Sec_low [m]	Sec_up [m]	Sec_low [m]	
KFM08C	DZ3	673.00	705.00	673.22	705.32	

Tunnels:	-	
Lineament and/or seismic indications:	MFM2225G, MFM0044G0.	2

MODELLING PROCEDURE

At the surface, corresponds to the low magnetic lineament MFM2225G and the north-western part of the low magnetic lineament MFM0044G0, which have been combined. Modelled down to 1600 m depth using the dip estimated by connecting these lineament segments with the borehole intersection 673-705 m in KFM08C (DZ3). Deformation zone plane placed at fixed point 693 m where a sealed fracture network is present. Decreased radar penetration also along the borehole interval 692-696 m.

WNW	ZFMWNW2225	Version number	6	Total object CL	15



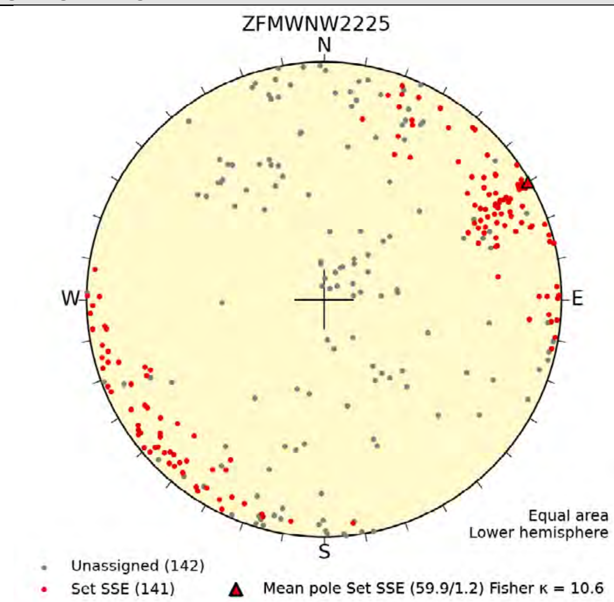
OBJECT CONFIDENCE ESTIMATE

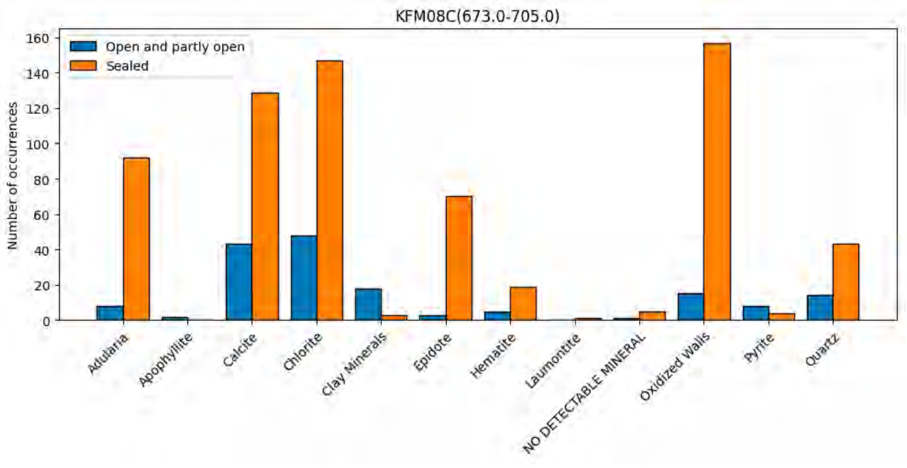
Category	Object CL	Comment
INTERPRETATION		
Data source	2	MFM2225G0, MFM2225G1, KFM08C.
Results of interpretation	3	High confidence observation in KFM08C.
INFORMATION DENSITY		
Number of observation points	2	2
Distribution of observation points	1	Single observation point at depth and surface lineaments.
INTERPOLATION		
Geometry	1	Geometry supported by surface geophysical data.
Geological indicators	1	Indirect support by geophysical data.
EXTRAPOLATION		
Dip direction	2	Extrapolation in dip direction supported by subsurface obs. point. Strike length of the modelled zone < 2000 m.
Strike direction	3	Conceptual understanding of the site and that the entire regional modelled zone is supported by the lineament. Extrapolation in strike direction mainly based on the trend of linked surface lineament. Terminated against ZFMENE0060A in SE and limited by ZFMNNE2312 and ZFMENE1061A in NW.

FRACTURE CHARACTER

Orientation: (strike/dip right-hand-rule)	Set SSE: 149.9°/88.8°
Frequency:	Boreholes: KFM08C

FRACTURE TYPE	TERZAGHI-WEIGHED P10
Open and partly open	4.1 m-1
Sealed	18.4 m-1
Sealed network	5.4 % of DZ intercept
Crush	0.0 % of DZ intercept

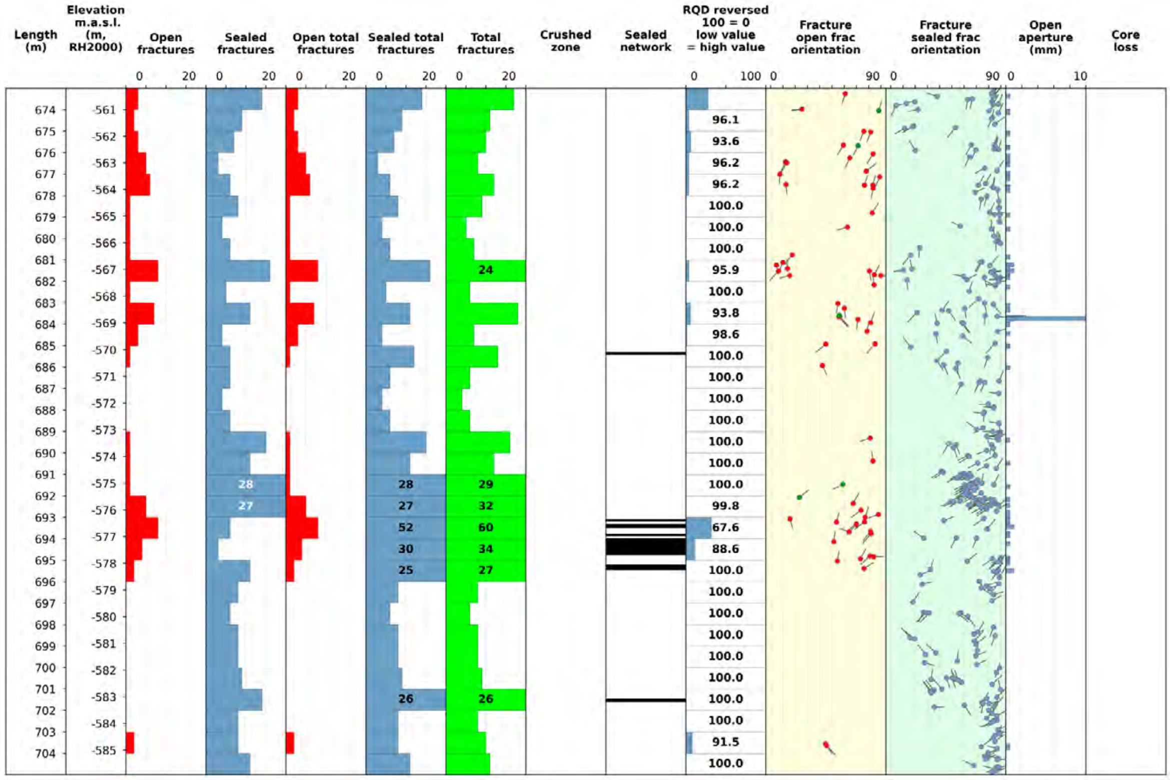


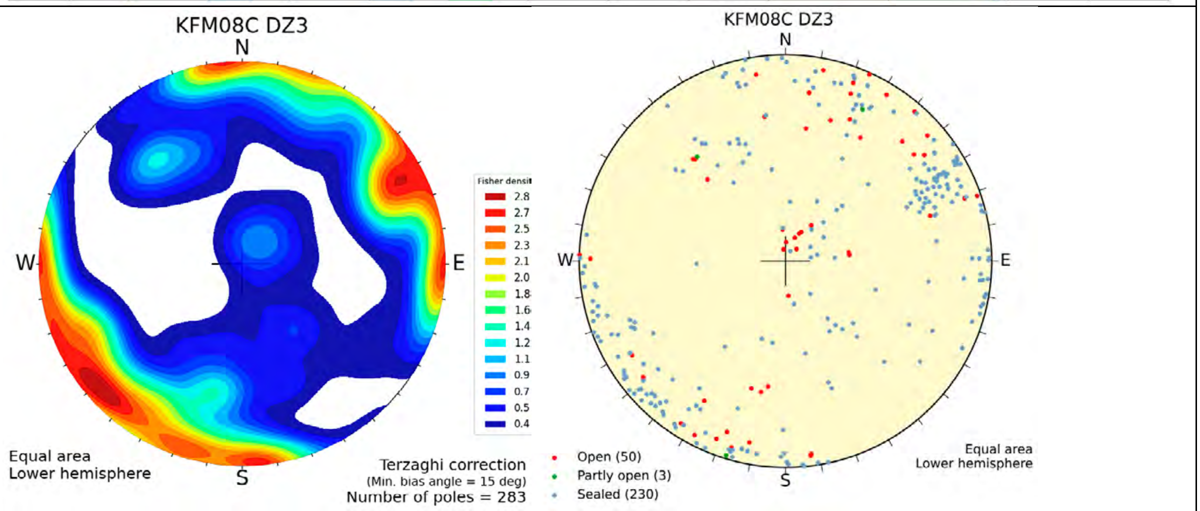
WNW	ZFMWNW2225	Version number	6	Total object CL	15
RQD:	min:68, max:100, mean:97				
Fracture fill mineralogy:					

WNW	ZFMWNW2225	Version number	6	Total object CL	15

INDIVIDUAL INTERCEPTS

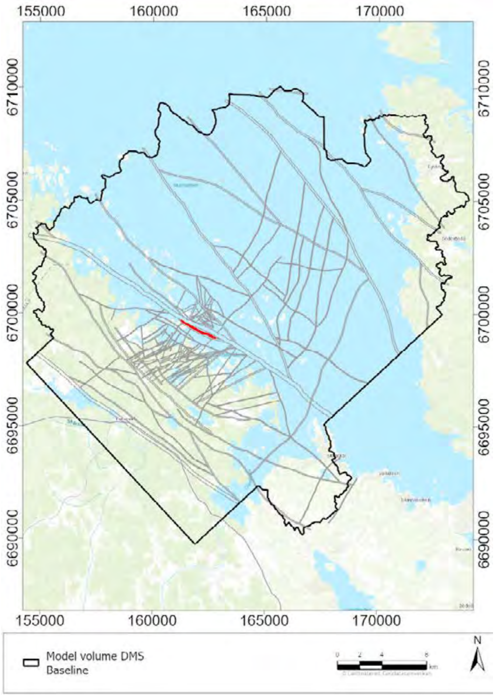
KFM08C DZ3 (673.0-705.0 m)





WNW	ZFMWNW3259	Version number	3	Total object CL	22

GEOLOGICAL CHARACTER		Property CL
Deformation style:	Brittle-Ductile	3
Deformation description:	No data available.	
Alteration:		3
- First order:	Oxidation	
- Second order:	Chloritization	
- Third order:	Sericitization	
Fracture orientation and type:	Steep sets with NW-SE and E strike as well as a set consisting of gently dipping fractures are prominent. Fractures with other orientations are also present. Dominance of sealed fractures. Quantitative estimate and span include several sealed fracture networks and some crush zones.	2
Fracture comment:	No data available.	
Fracture fill mineralogy:	Chlorite, calcite, hematite/adularia, epidote, quartz, laumontite and clay minerals.	



OBJECT GEOMETRY	
Strike/dip:	119°/90°
Length:	2173 m
Mean thickness:	50 m (20 - 60 m)
Max depth:	-2100 m
Geometrical constraints:	ZFMWNW0813, ZFMWNW0001, Topo 40m grid Max error 20m.

BASIS FOR MODELLING

Zone based on surface lineaments, tunnel and borehole observations.

Outcrops: -

Boreholes:

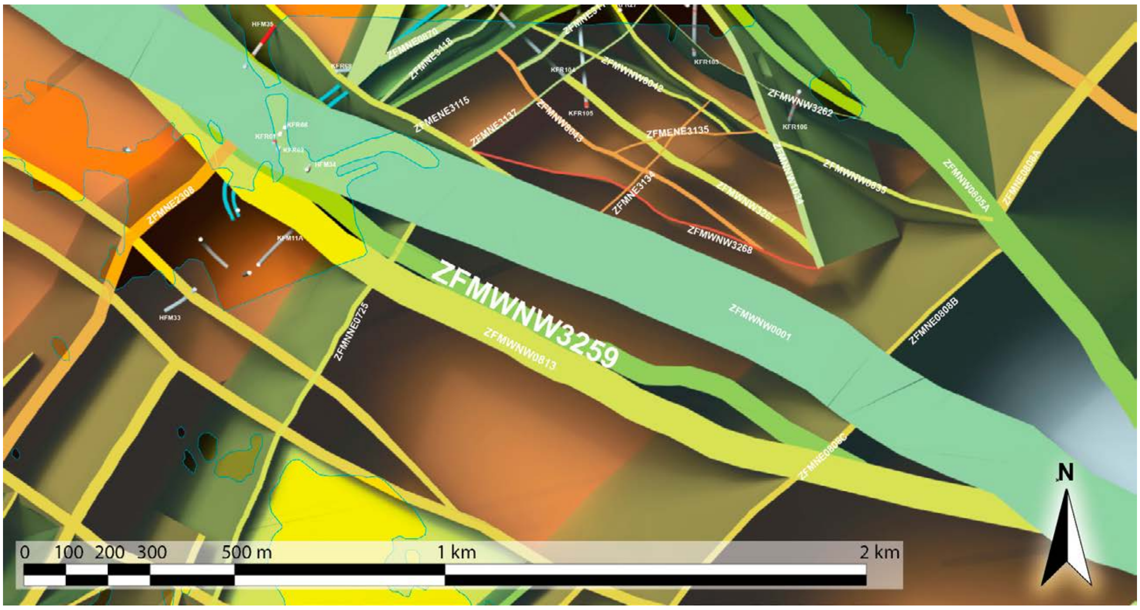
Borehole	PDZ	Target intercept		Geometric intercept		Comment
		Sec_up [m]	Sec_low [m]	Sec_up [m]	Sec_low [m]	
KFM11A	DZ1	400.00	498.00	401.73	490.67	Geometrical split of DZ1 between ZFMWNW0001, ZFMWNW0813 and ZFMWNW3259.

Tunnels:	DT target intercept 0+142 – 0+170 m, geometric intercept 0+128 – 0+180 m. BT target intercept 0+120 – 0+150 m, geometric intercept 0+108 – 0+158 m.	
Lineament and/or seismic indications:	MFM3259G.	1

MODELLING PROCEDURE

The position of the zone at the ground surface is based on magnetic lineament MFM3259G (Isaksson et al. 2007), with a slight lateral adjustment in position as it traverses KFM11A and a further extension to the north-west coupled to a re-linking of the connection with MFM0813G. MFM3259G is taken to be the equivalent of linking the series of much shorter SFR version 1.0 lineaments MSFR08073, MSFR08074 and MSFR08075 in SFR model version 1.0 and is considered to be a more suitable length of trace to use in the model area. Forward modelling of magnetic data along profiles 24, 25 and 26 (see Appendix 6, Curtis et al. 2011) suggests a vertical to steep dip to the south-west. Due to the uncertainty of the modelling result and probable local variations, a vertical dip, based on the tunnel and KFM11A data, has been retained in the model. The target intercept in the tunnels are mainly based on the shotcrete coverage marked in the tunnel mapping (Christiansson and Bolvede , 1987). No specific evidence is taken to define the boundaries of this zone in the tunnel but similar to in KFM11A there is clear evidence of deformation and the modelled zone represents a more general subdivision of deformation seen in the tunnel between this zone, ZFMWNW0813, ZFMWNW0001 and ZFMNW0002.

WNW	ZFMWNW3259	Version number	3	Total object CL	22



OBJECT CONFIDENCE ESTIMATE

Category	Object CL	Comment
INTERPRETATION		
Data source	3	MFM3259G, KFM11A, DT/BT.
Results of interpretation	3	High confidence observations in KFM11A and tunnels of the SFR facility.
INFORMATION DENSITY		
Number of observation points	3	4
Distribution of observation points	2	Supported by sub-surface information in tunnels of SFR facility and drill hole KFM11A.
INTERPOLATION		
Geometry	3	Geometry supported by drill hole and two tunnel observations.
Geological indicators	3	Supported by key geological parameters from two tunnel observations.
EXTRAPOLATION		
Dip direction	2	Extrapolation in dip direction supported by subsurface obs. point. Strike length of the modelled zone < 2000 m.
Strike direction	3	Conceptual understanding of the site and that the entire regional modelled zone is supported by the lineament.

FRACTURE CHARACTER

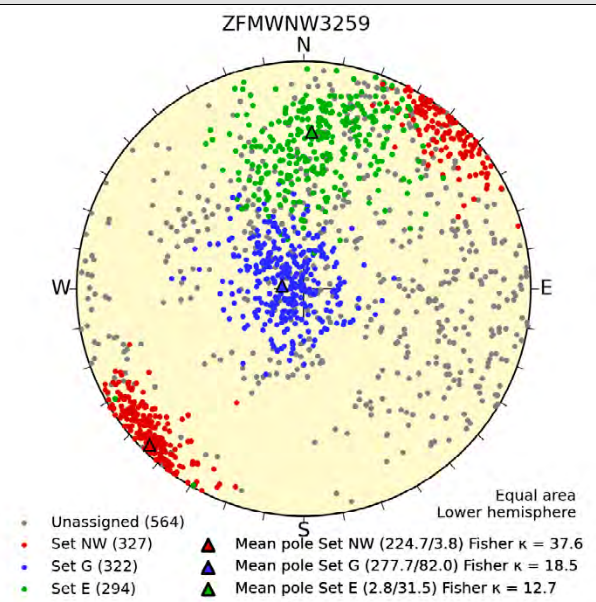
Orientation: (strike/dip right-hand-rule)

Set NW: 314.7°/86.2°
Set G: 7.7°/8.0°
Set E: 92.8°/58.5°

Frequency:

Boreholes: KFM11A

FRACTURE TYPE	TERZAGHI-WEIGHED P10
Open and partly open	7.5 m-1
Sealed	27.1 m-1
Sealed network	22.6 % of DZ intercept
Crush	0.3 % of DZ intercept



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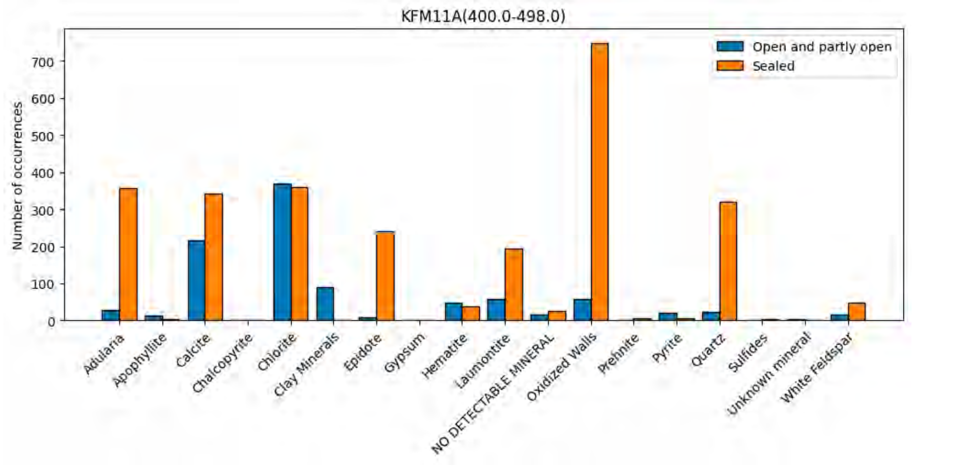
<tr><td>RQD:</td><td colspan="5">min:52, max:100, mean:91</td></tr>
<tr><td>Fracture fill mineralogy:</td><td colspan="5"></td></tr>
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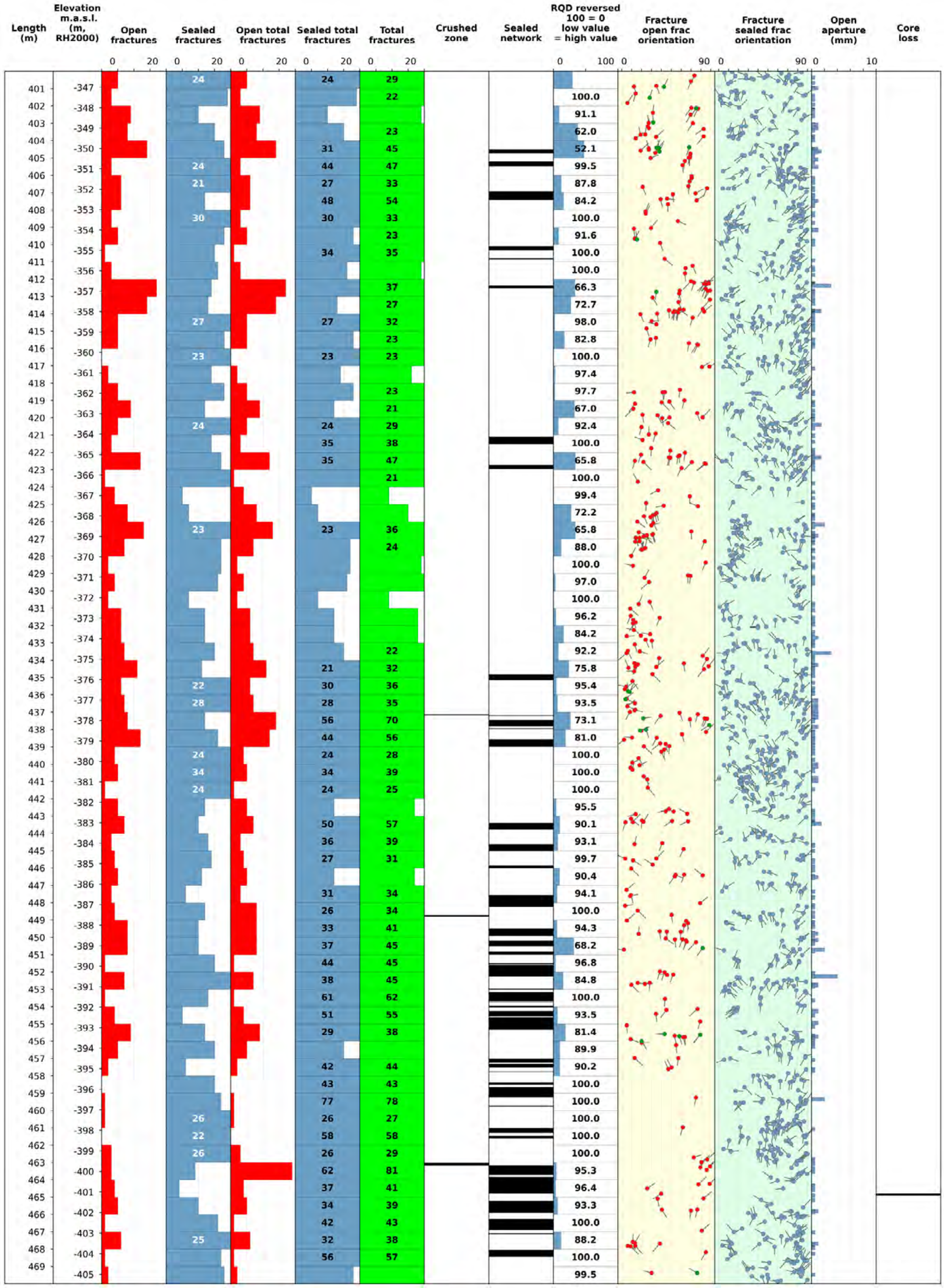
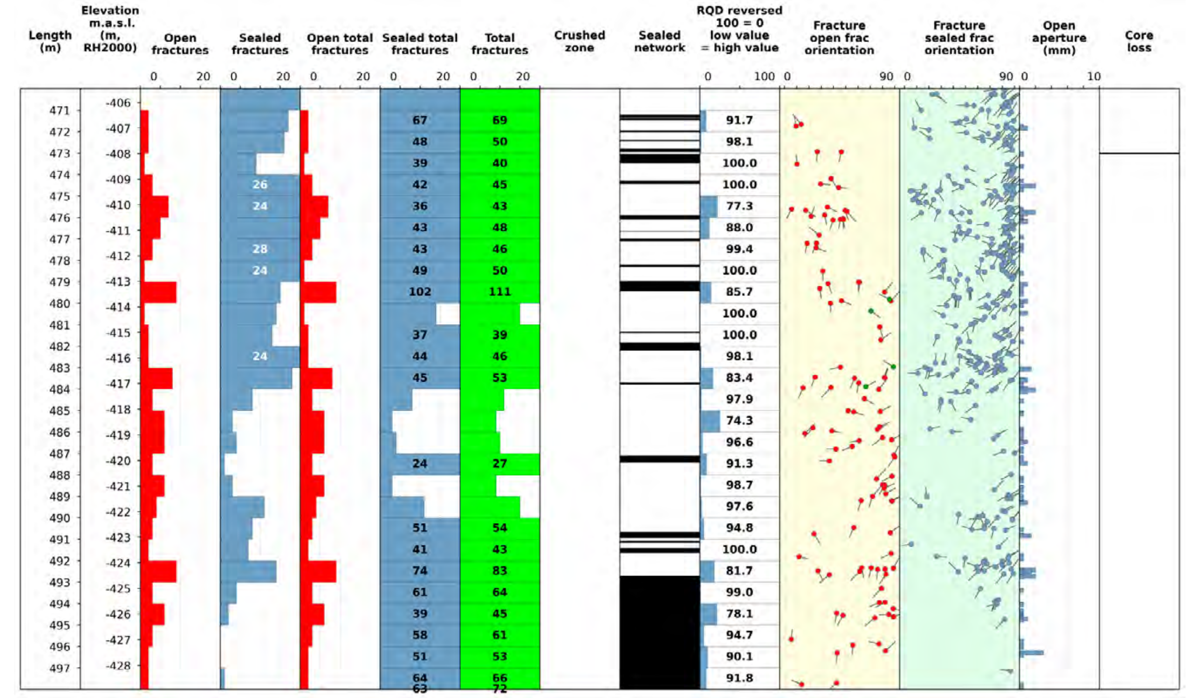
WNW	ZFMWNW3259	Version number	3	Total object CL	22

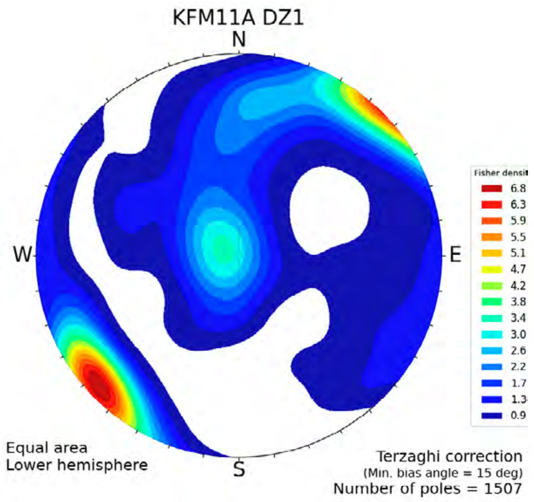
INDIVIDUAL INTERCEPTS

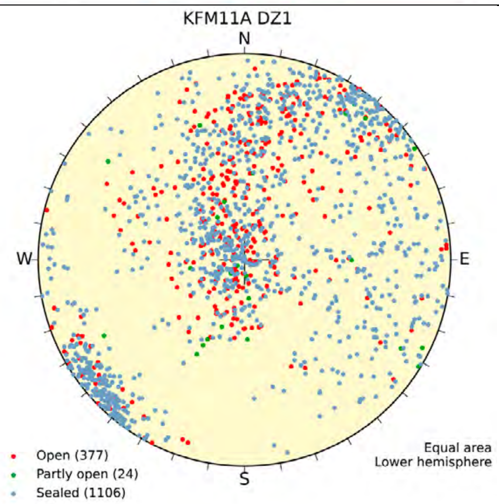
KFM11A DZ1 (400.0-498.0 m)



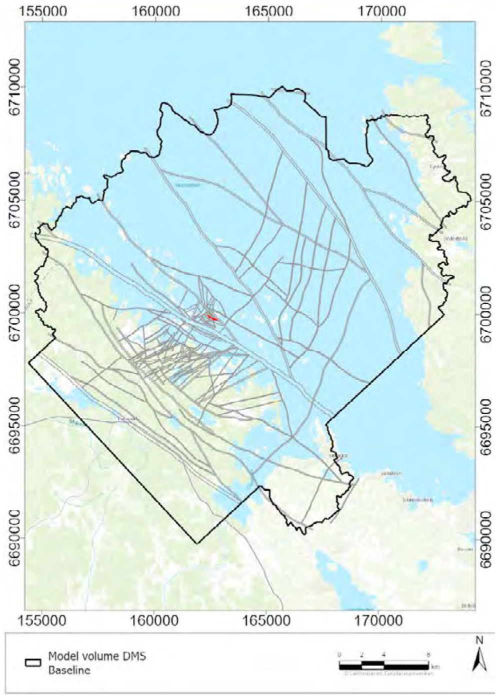
WNW	ZFMWNW3259	Version number	3	Total object CL	22







WNW	ZFMWNW3262	Version number	8	Total object CL	20



GEOLOGICAL CHARACTER		Property CL
Deformation style:	Brittle-Ductile	3
Deformation description:	No data available.	
Alteration:		3
- First order:	Oxidation	
- Second order:	Not observed	
- Third order:	Not observed	
Fracture orientation and type:	Fracture set with WNW strike dominating. Gently dipping fracture set also present.	
Fracture comment:	Fracture apertures generally between 0.5 and 1.5mm.	
Fracture fill mineralogy:	Calcite, chlorite are dominating open and sealed fractures. Laumontite in sealed and clay minerals in open fractures are conspicuous.	

OBJECT GEOMETRY	
Strike/dip:	118°/86°
Length:	618 m
Mean thickness:	2 m (2 - 36 m)
Max depth:	-610 m
Geometrical constraints:	ZFMNE3137, ZFMNW0805A, ZFMNW0805B, Topo 40m grid Max error 20m, 1 Surface Planar Cut(s).

BASIS FOR MODELLING

Zone based on surface lineaments and three borehole observations.

Outcrops: -

Boreholes:

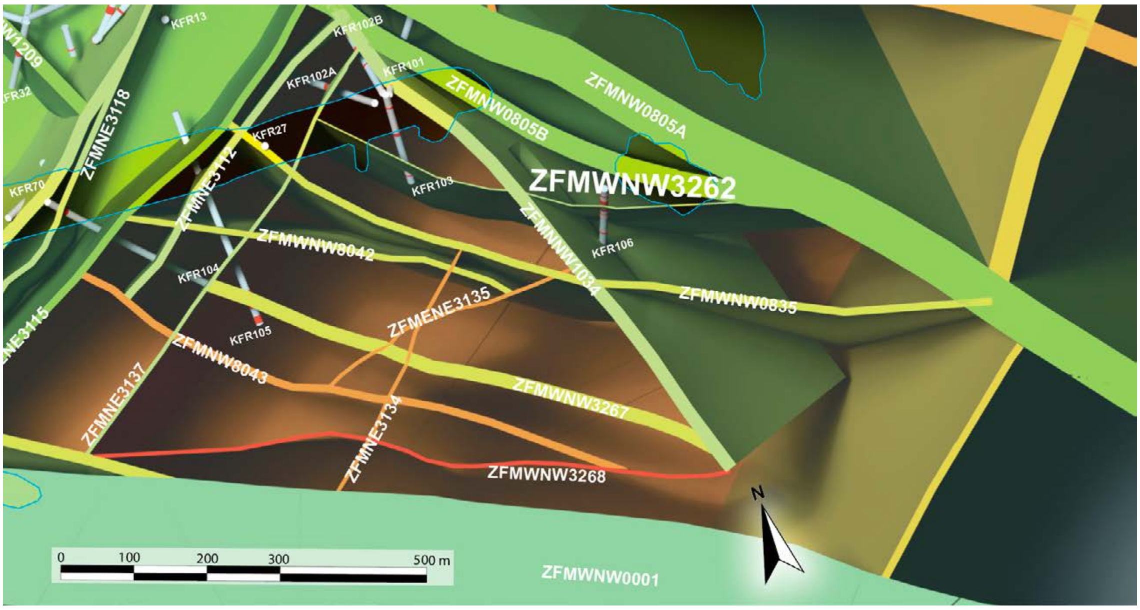
Borehole	PDZ	Target intercept		Geometric intercept		Comment
		Sec_up [m]	Sec_low [m]	Sec_up [m]	Sec_low [m]	
KFR103	DZ3	180.00	182.50	178.30	183.57	
KFR106	DZ3	67.00	73.00	66.95	75.17	
KFR121	DZ1	89.00	100.00	92.77	96.42	

Tunnels:	-	
Lineament and/or seismic indications:	MSFR08105.	1

MODELLING PROCEDURE

The position of the zone on the ground surface is based on magnetic lineament MSFR08105 in SFR model version 1.0, itself a modification of lineament MFM3262G from (Isaksson et al. 2007). The earlier number has been retained in the zone name to assist traceability. There has been an extension to the WNW, through an area where the magnetic field is disturbed, to allow termination at zone ZFMNE3137. Thickness is based on the SHI PDZ borehole intercepts. Forward modelling of magnetic data along profile 2 (Appendix 6, Curtis et al. 2011) indicates a very steep dip to the north-east whereas inversion modelling indicates a vertical to sub-vertical dip towards the south-west that corresponds to the modelled geometry.

WNW	ZFMWNW3262	Version number	8	Total object CL	20



OBJECT CONFIDENCE ESTIMATE

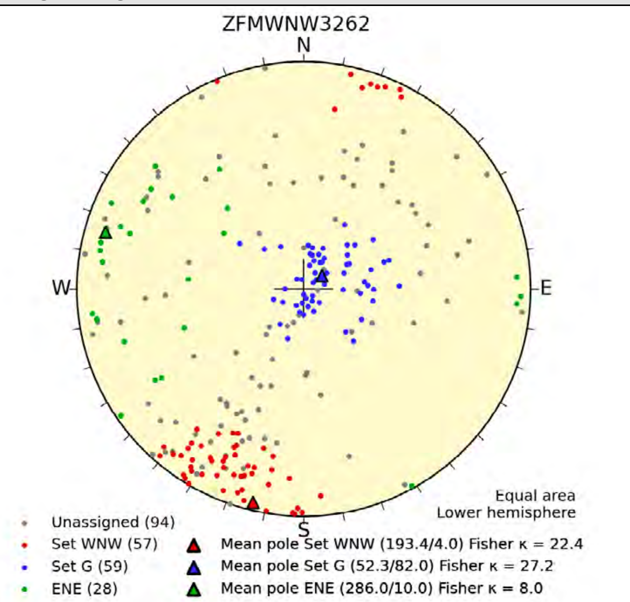
Category	Object CL	Comment
INTERPRETATION		
Data source	2	MSFR08105 (MFM3262G in RVS), KFR103, KFR106, KFR121.
Results of interpretation	3	High confidence observations in multiple boreholes.
INFORMATION DENSITY		
Number of observation points	3	4
Distribution of observation points	2	Lineament, three boreholes close to each other and one outlier.
INTERPOLATION		
Geometry	3	Three boreholes, somewhat spread out, and one lineament. Appears to truncate against ZFMNE3137, ZFMNW0805A and ZFMNW0805B.
Geological indicators	2	Interpolation supported by data from boreholes.
EXTRAPOLATION		
Dip direction	2	Extrapolation in dip direction supported by subsurface obs. point. Strike length of the modelled zone < 2000 m.
Strike direction	3	Conceptual understanding of the site and that the entire regional modelled zone is supported by the lineament.

FRACTURE CHARACTER

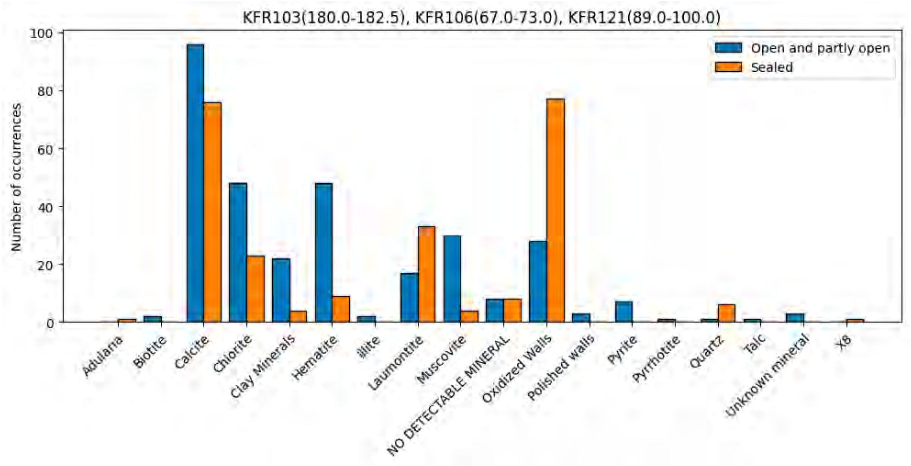
Orientation: (strike/dip right-hand-rule): Set WNW: 283.4°/86.0°; Set G: 142.3°/8.0°; ENE: 16.0°/80.0°

Frequency: Boreholes: KFR106, KFR103, KFR121

FRACTURE TYPE	TERZAGHI-WEIGHED P10
Open and partly open	14.1 m-1
Sealed	14.9 m-1
Sealed network	16.6 % of DZ intercept
Crush	2.2 % of DZ intercept



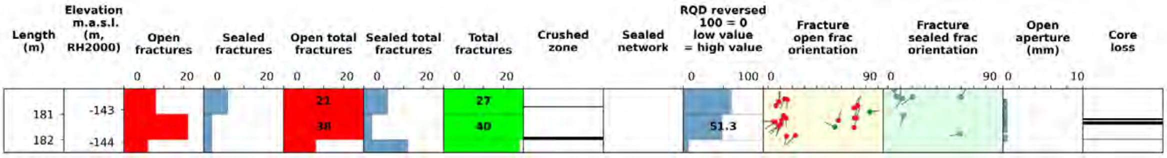
RQD: min:40, max:100, mean:81

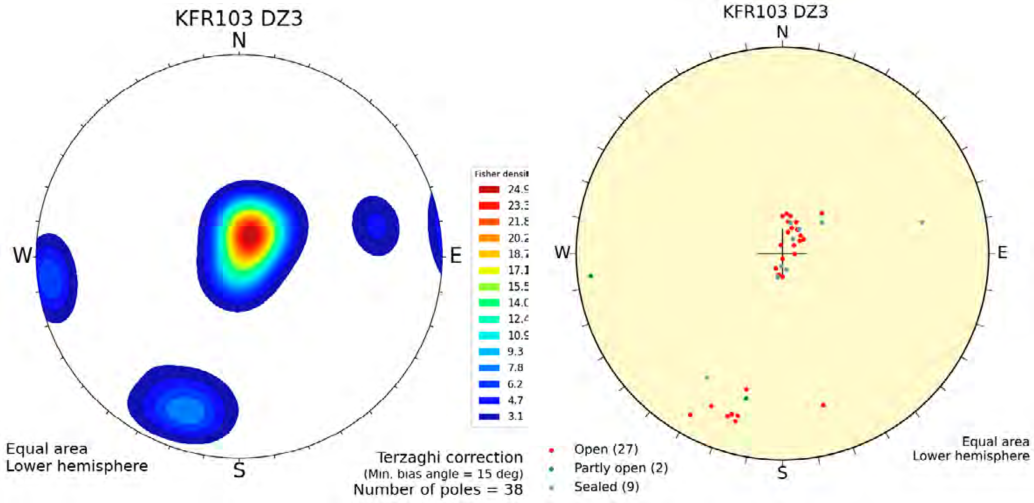
WNW	ZFMWNW3262	Version number	8	Total object CL	20
Fracture fill mineralogy:					

WNW	ZFMWNW3262	Version number	8	Total object CL	20

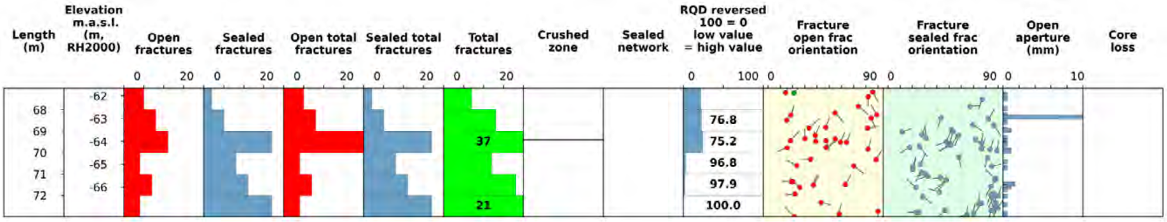
INDIVIDUAL INTERCEPTS

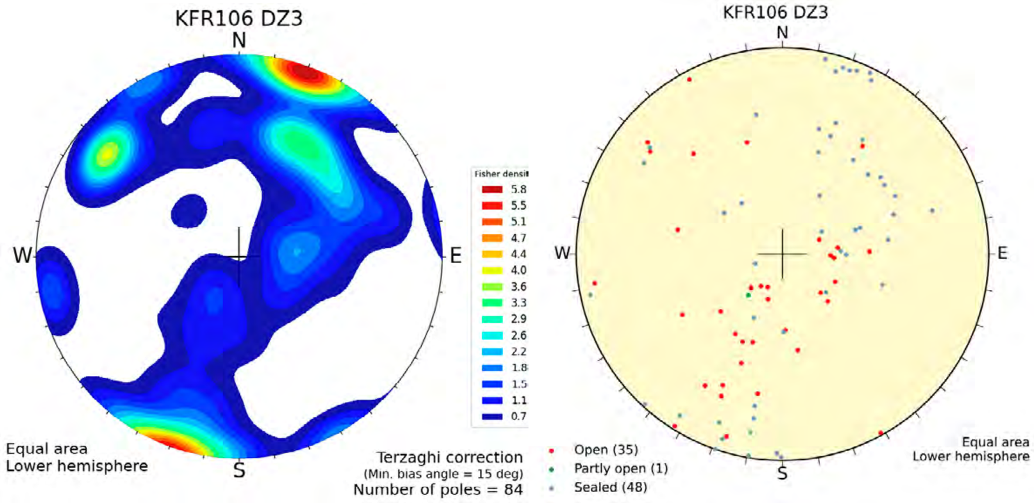
KFR103 DZ3 (180.0-182.5 m)





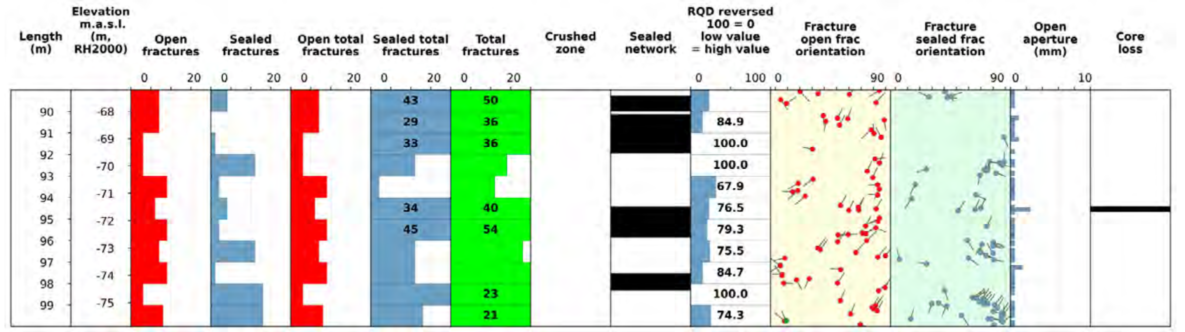
KFR106 DZ3 (67.0-73.0 m)

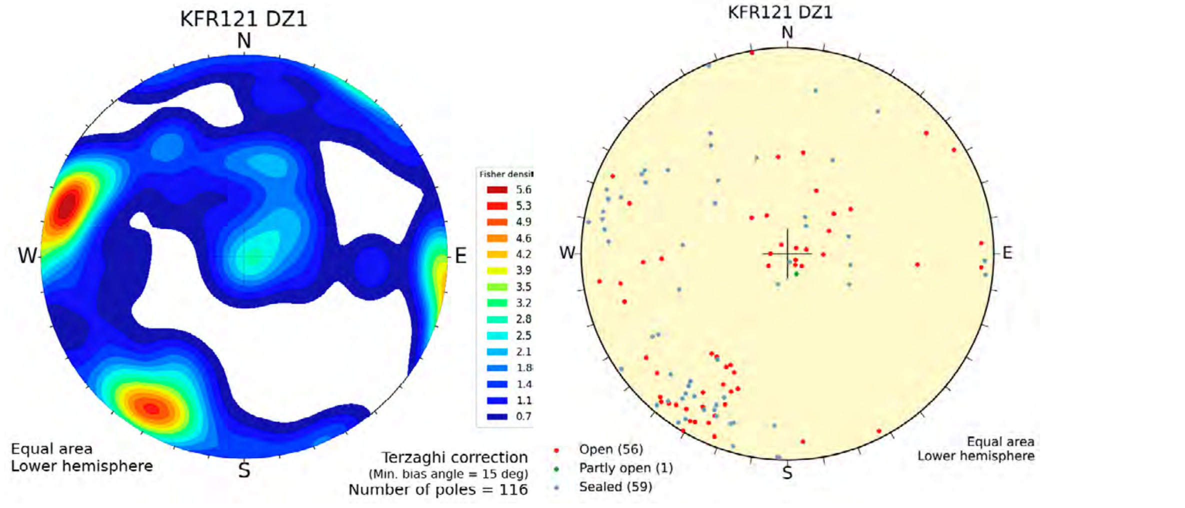




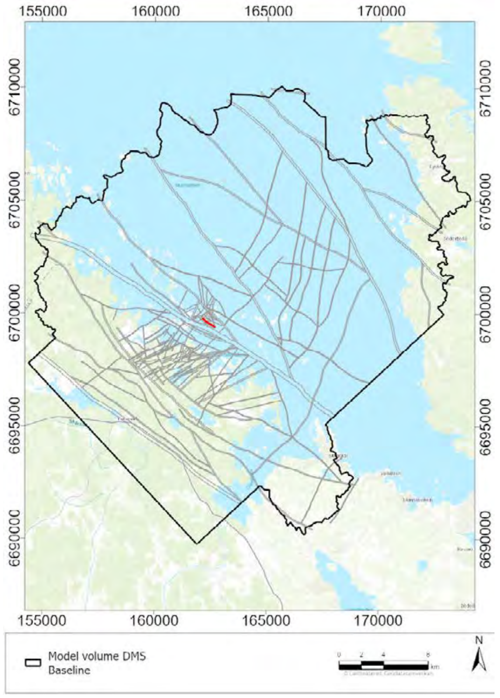
WNW	ZFMWNW3262	Version number	8	Total object CL	20

KFR121 DZ1 (89.0-100.0 m)





WNW	ZFMWNW3267	Version number	6	Total object CL	17



GEOLOGICAL CHARACTER		Property CL
Deformation style:	Brittle	3
Deformation description:	No data available.	
Alteration:		3
- First order:	Oxidation	
- Second order:	Argillization	
- Third order:	Lamontization	
Fracture orientation and type:	Steeply dipping ESE fracture sets are dominating followed by steeply dipping SSW sets. Dominance of sealed fractures. Open and partly open fractures are also present.	3
Fracture comment:	Fracture apertures up to 2 mm.	
Fracture fill mineralogy:	Calcite, chlorite and laumontite dominate.	

OBJECT GEOMETRY	
Strike/dip:	124°/90°
Length:	702 m
Mean thickness:	18 m (2 - 36 m)
Max depth:	-700 m
Geometrical constraints:	ZFMNE3137, ZFMNNW1034, Topo 40m grid Max error 20m, 1 Surface Planar Cut(s).

BASIS FOR MODELLING

Zone based on surface lineaments and borehole observations.

Outcrops:	-

Boreholes:

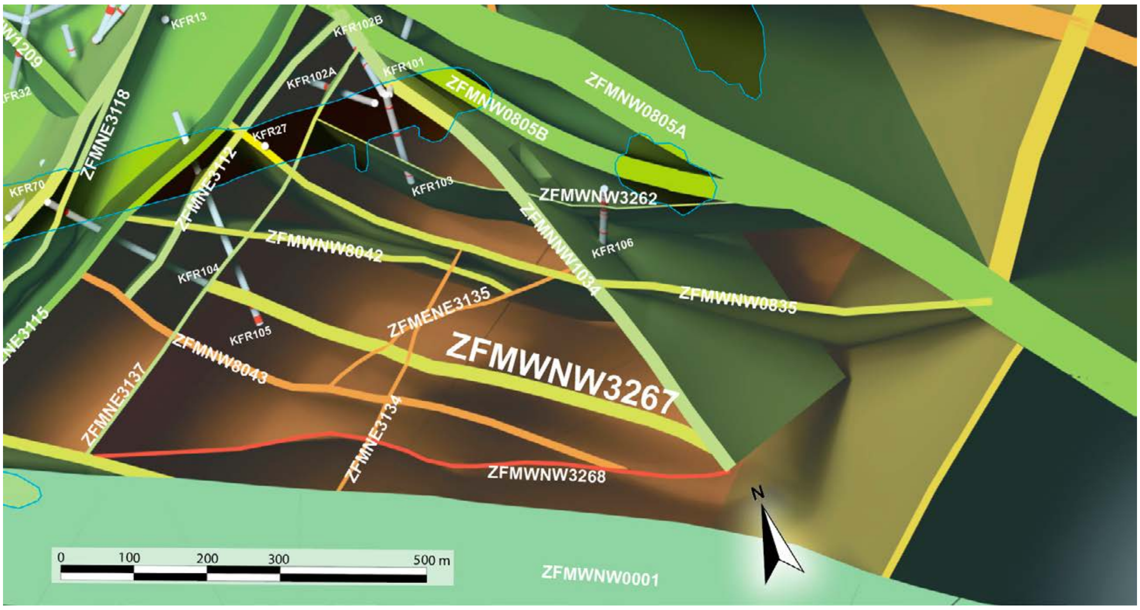
Borehole	PDZ	Target intercept		Geometric intercept		Comment
		Sec_up [m]	Sec_low [m]	Sec_up [m]	Sec_low [m]	
KFR104	DZ5	396.00	454.57	388.65	454.53	No geometrical Sec_up as the borehole not pentrates the modelled surfaces.
KFR104	DZ6	396.00	454.57	388.65	454.53	No geometrical Sec_up as the borehole not pentrates the modelled surfaces.
KFR105	DZ4	258.00	283.00	257.76	282.88	

Tunnels:	-	
Lineament and/or seismic indications:	MFM3267G.	1

MODELLING PROCEDURE

In the current SFR model version 1.0, this zone is based on a modification of the Forsmark stage 2.3 lineament MFM3267G (Isaksson et al. 2007). In the SFR model version 0.1 lineament interpretation, this lineament was replaced by MSFR08121 and MSFR08115. The dip of the zone is based on a link with the borehole interceptions in KFR104 and KFR105. The forward modelling of magnetic data along profile 1 (see Appendix 6 in Curtis et al. 2011) data suggests a sub-vertical to a very steep dip to the north-east, while profile 39 modelling suggests a vertical dip.

WNW	ZFMWNW3267	Version number	6	Total object CL	17



OBJECT CONFIDENCE ESTIMATE

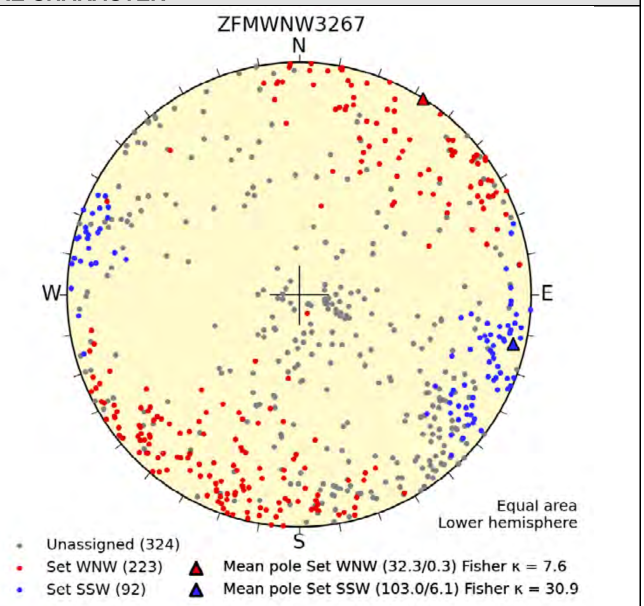
Category	Object CL	Comment
INTERPRETATION		
Data source	2	MFM3267G, KFR104, KFR105.
Results of interpretation	3	High confidence observations in multiple boreholes.
INFORMATION DENSITY		
Number of observation points	2	3
Distribution of observation points	2	Two subsurface observation points, evenly distributed, and one lineament.
INTERPOLATION		
Geometry	2	The lineament that this zone follows, deviates around the area where the zone is seen in the boreholes, i.e. it could follow either the lineament, or the boreholes.
Geological indicators	2	Interpolation supported by mineral fillings within fractures from boreholes.
EXTRAPOLATION		
Dip direction	2	Extrapolation in dip direction supported by subsurface obs. point. Strike length of the modelled zone < 2000 m.
Strike direction	2	Supported by geological concept and partly by surface lineament.

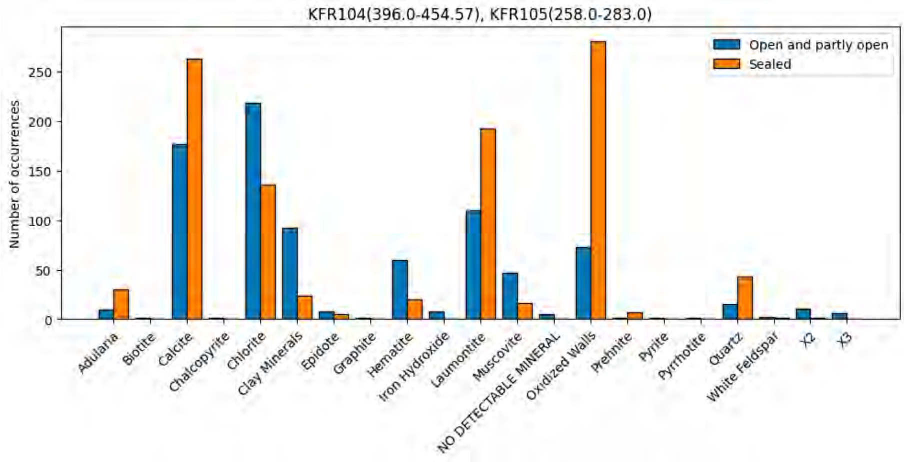
FRACTURE CHARACTER

Orientation: (strike/dip right-hand-rule): Set WNW: 122.3°/89.7°; Set SSW: 193.0°/83.9°

Frequency: Boreholes: KFR104, KFR105

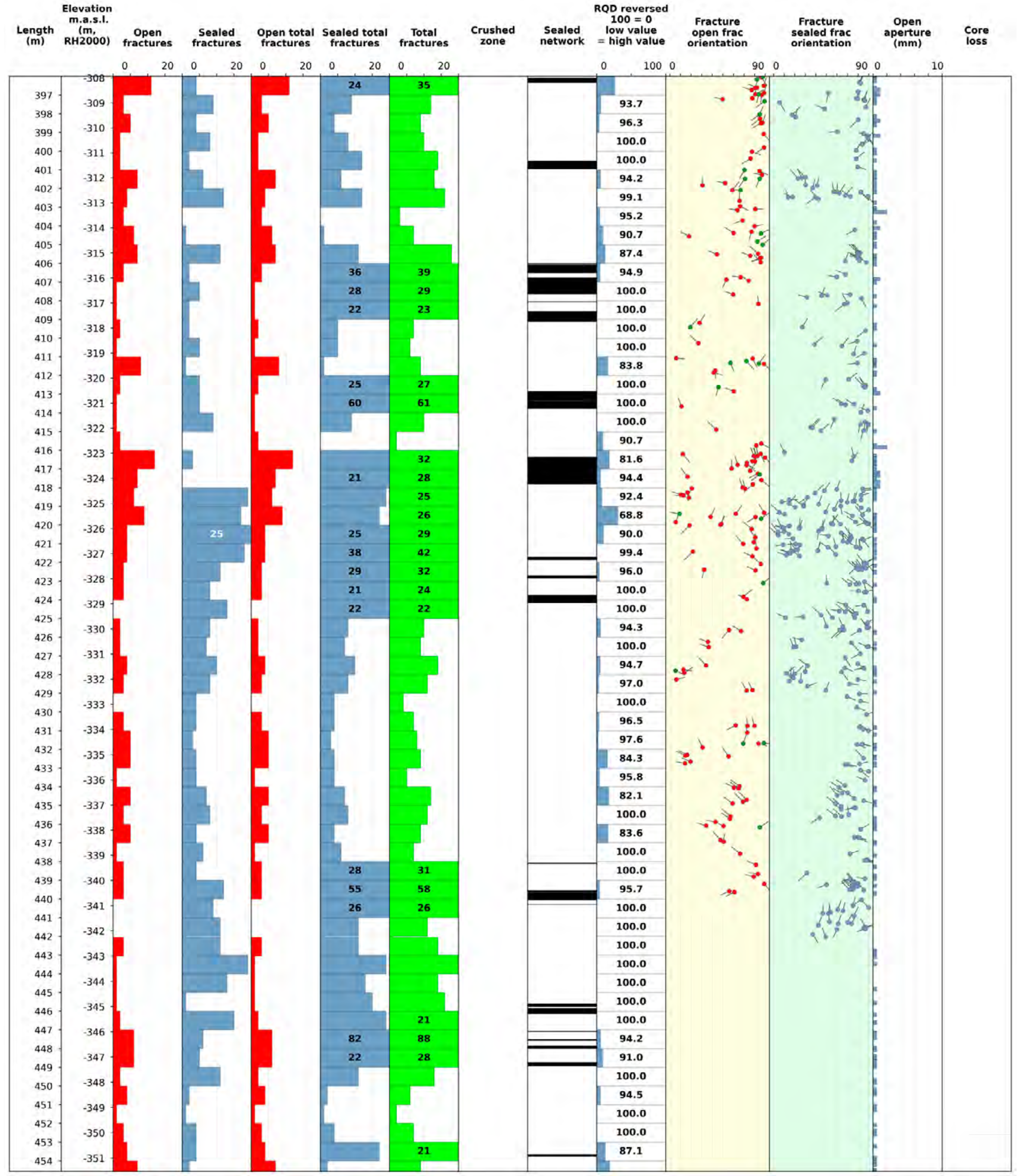
FRACTURE TYPE	TERZAGHI-WEIGHED P10
Open and partly open	8.1 m-1
Sealed	12.9 m-1
Sealed network	23.7 % of DZ intercept
Crush	0.1 % of DZ intercept



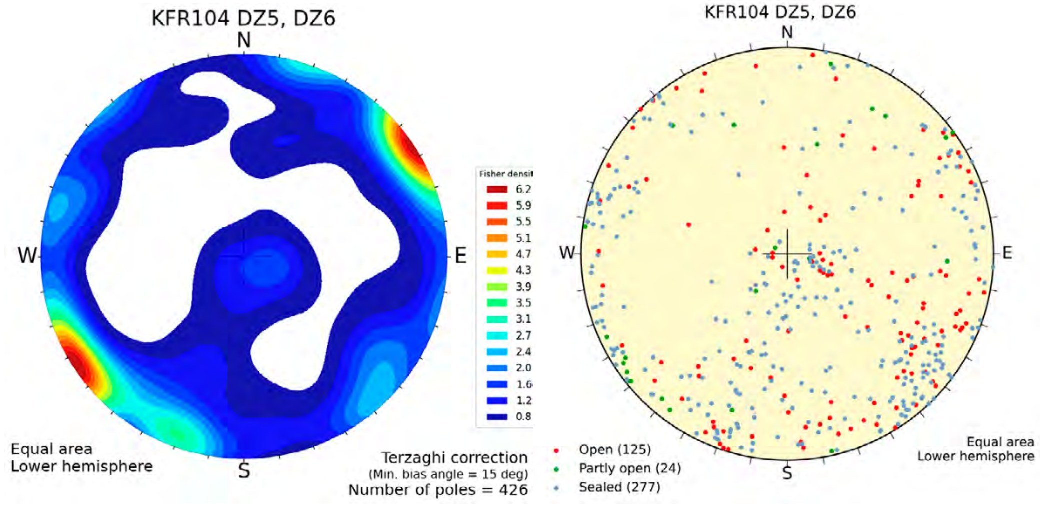
WNW	ZFMWNW3267	Version number	6	Total object CL	17
RQD:	min:60, max:100, mean:93				
Fracture fill mineralogy:					

WNW	ZFMWNW3267	Version number	6	Total object CL	17
INDIVIDUAL INTERCEPTS					

KFR104 DZ5, DZ6 (396.0-454.57 m)

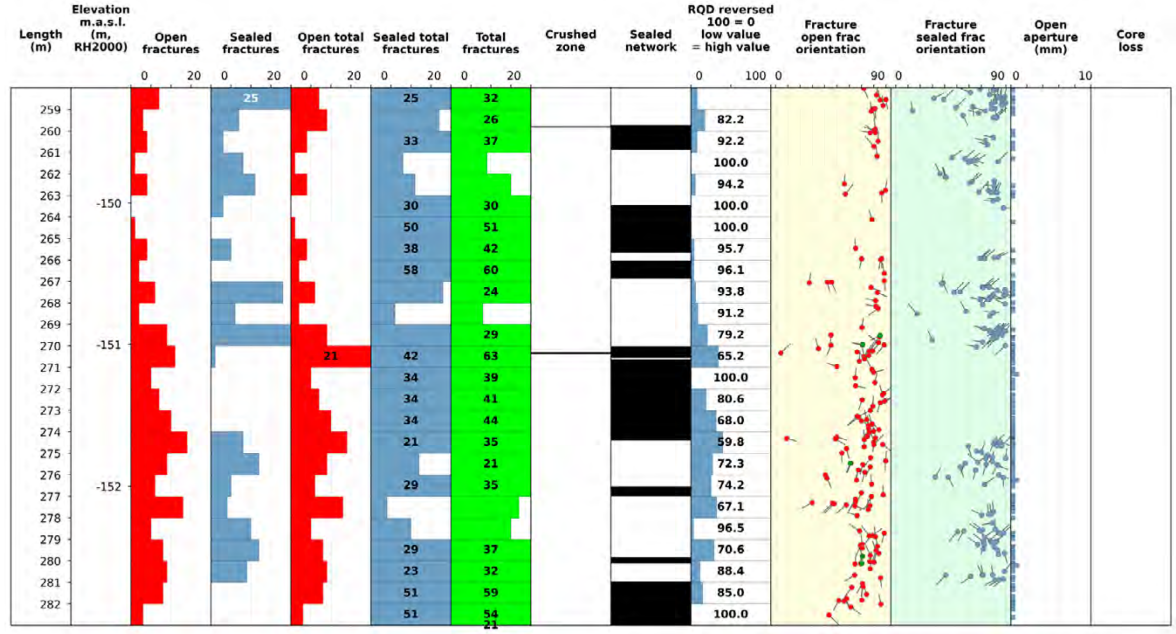


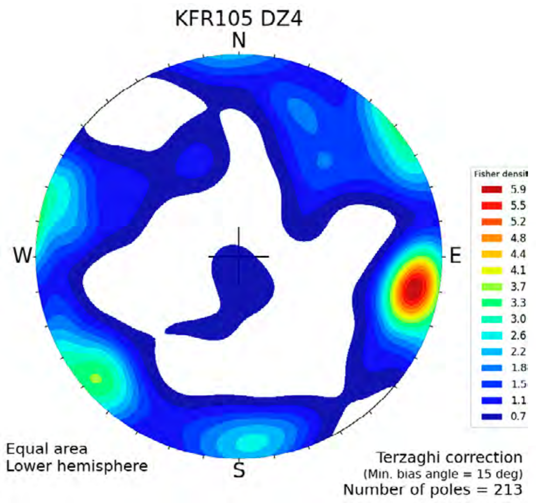
WNW	ZFMWNW3267	Version number	6	Total object CL	17

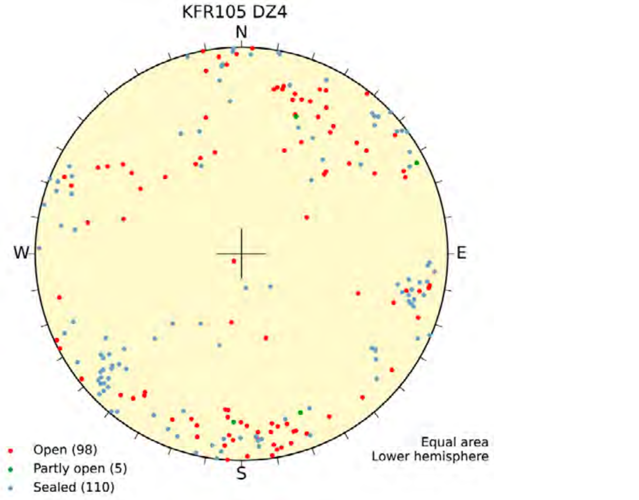


WNW	ZFMWNW3267	Version number	6	Total object CL	17

KFR105 DZ4 (258.0-283.0 m)

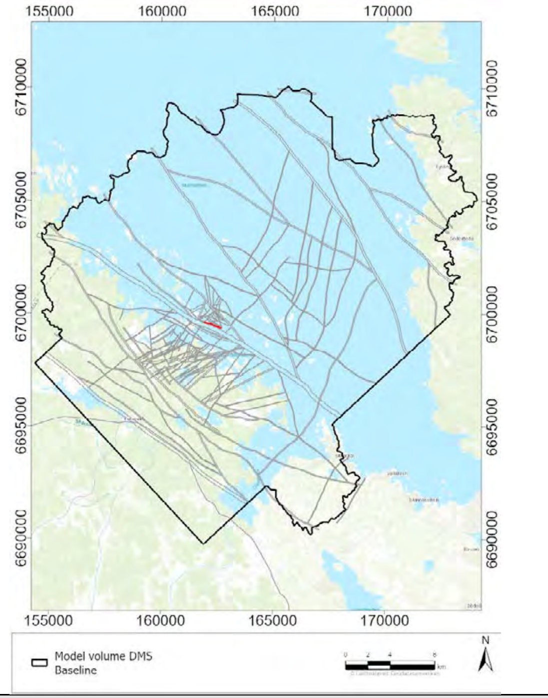






WNW	ZFMWNW3268	Version number	6	Total object CL	9

GEOLOGICAL CHARACTER		Property CL
Deformation style:	Brittle-Ductile	2
Deformation description:	No data available.	
Alteration:		
- First order:	Not observed	
- Second order:	Not observed	
- Third order:	Not observed	
Fracture orientation and type:	No data available.	
Fracture comment:	No data available.	
Fracture fill mineralogy:	No data available.	

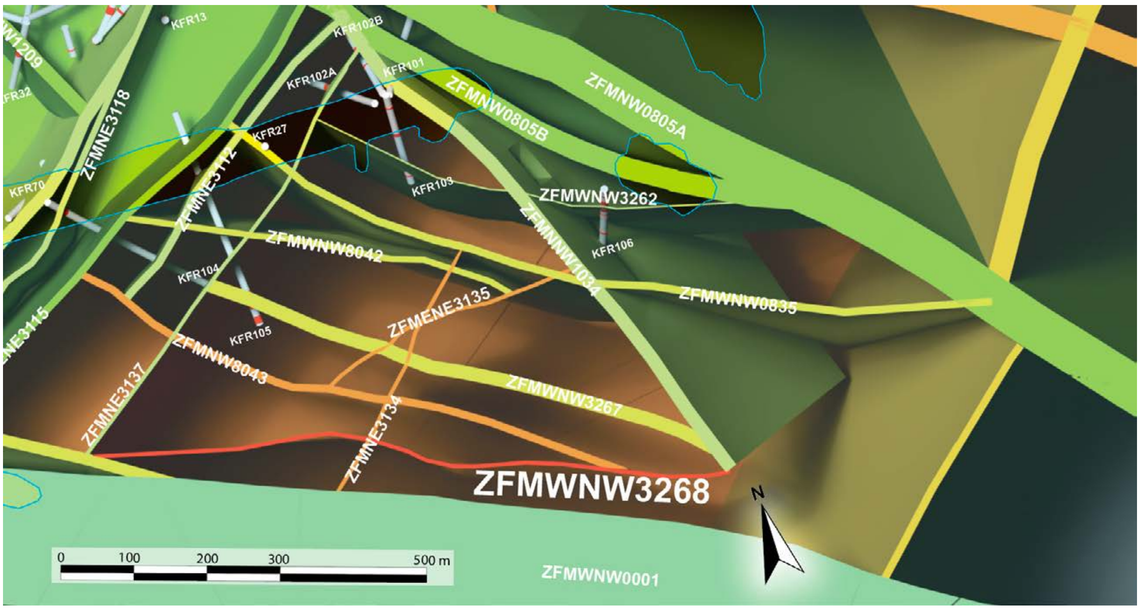


OBJECT GEOMETRY	
Strike/dip:	111°/90°
Length:	862 m
Mean thickness:	5 m (2 - 36 m)
Max depth:	-860 m
Geometrical constraints:	ZFMNE3137, ZFMWNW1035, Topo 40m grid Max error 20m, 1 Surface Planar Cut(s).

BASIS FOR MODELLING		
Zone based on surface lineaments.		
Outcrops:	-	
Boreholes: -		
Tunnels:	-	
Lineament and/or seismic indications:	MSFR80006.	1

MODELLING PROCEDURE

The position of the zone at the ground surface is based on magnetic lineament MSFR80006 (SFR model version 1.0), itself an update of lineament MFM3268G Isaksson et al. (2007), with a further extension to the WNW to allow termination at ZFMNE3137 and ZFMWNW1035. The vertical dip is a default value. The modelled thickness is a 1% default value based on the traceable zone length of 709 m. However, in the model the zone geometry has been extended to terminate at ZFMWNW1035 to ensure connectivity giving an rvs modelled length of 861 m.



WNW	ZFMWNW3268	Version number	6	Total object CL	9

OBJECT CONFIDENCE ESTIMATE

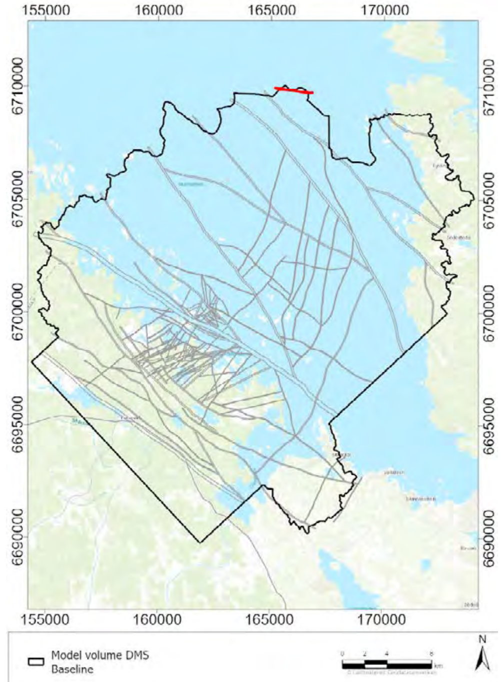
Category	Object CL	Comment
INTERPRETATION		
Data source	1	MSFR80006. Modified. Earlier represented by MFM3268G (Isaksson et al. 2007). Further extension to the WNW to allow termination at ZFMNE3137 and ZFMWNW1035.
Results of interpretation	1	Low confidence in lineament MFM3268G.
INFORMATION DENSITY		
Number of observation points	1	1
Distribution of observation points	1	Single observation point in the form of lineaments.
INTERPOLATION		
Geometry	1	Geometry supported by surface geophysical data.
Geological indicators	1	Indirect support by geophysical data.
EXTRAPOLATION		
Dip direction	1	No subsurface obs. point, supported only by surface data. High uncertainty in dip-direction. Strike length of the modelled zone < 2000 m.
Strike direction	2	Supported by geological concept and partly by surface lineament.

FRACTURE CHARACTER

No data available

INDIVIDUAL INTERCEPTS

No data available

WNW	ZFMWNW3512		Version number	4	Total object CL	13
GEOLOGICAL CHARACTER		**Property CL**				
Deformation style:	No data available					
Deformation description:	No data available. Zone based on lineament maps in the catchment area.					
Alteration:						
- First order:	Not observed					
- Second order:	Not observed					
- Third order:	Not observed					
Fracture orientation and type:	No data available.					
Fracture comment:	No data available.					
Fracture fill mineralogy:	No data available.					
OBJECT GEOMETRY						
Strike/dip:	96°/90°					
Length:	15262 m					
Mean thickness:	65 m (50 - 200 m)					
Max depth:	-2100 m					
Geometrical constraints:	Topo 40m grid Max error 20m, 2 Surface Planar Cut(s).					

BASIS FOR MODELLING		
Zone based on surface lineaments.		
Outcrops:	-	
Boreholes: -		
Tunnels:	-	
Lineament and/or seismic indications:	MFM3508, MFM3512.	3
MODELLING PROCEDURE		
-		

WNW	ZFMWNW3512	Version number	4	Total object CL	13

OBJECT CONFIDENCE ESTIMATE

Category	Object CL	Comment
INTERPRETATION		
Data source	1	MFM3508.
Results of interpretation	3	High confidence in lineament MFM3508.
INFORMATION DENSITY		
Number of observation points	1	1
Distribution of observation points	1	Single observation point in the form of a lineament.
INTERPOLATION		
Geometry	1	Geometry supported by surface geophysical data.
Geological indicators	1	Indirect support by geophysical data.
EXTRAPOLATION		
Dip direction	3	Extrapolated to the base of the model volume. Strike length of the modelled zone > 2000 m.
Strike direction	2	Supported by geological concept and partly by surface lineament.

FRACTURE CHARACTER

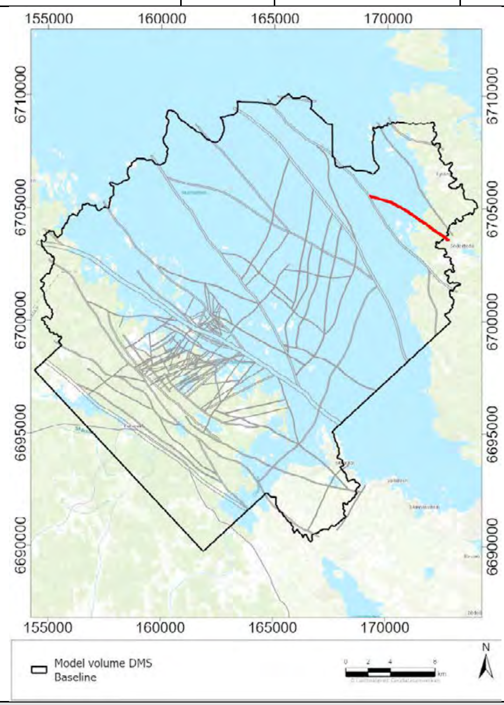
No data available

INDIVIDUAL INTERCEPTS

No data available

WNW	ZFMWNW3519	Version number	4	Total object CL	13

GEOLOGICAL CHARACTER		Property CL
Deformation style:	No data available	
Deformation description:	No data available. Zone based on lineament maps in the catchment area.	
Alteration:		
- First order:	Not observed	
- Second order:	Not observed	
- Third order:	Not observed	
Fracture orientation and type:	No data available.	
Fracture comment:	No data available.	
Fracture fill mineralogy:	No data available.	



OBJECT GEOMETRY	
Strike/dip:	121°/90°
Length:	16455 m
Mean thickness:	70 m (50 - 200 m)
Max depth:	-2100 m
Geometrical constraints:	ZFMNW3511, Topo 40m grid Max error 20m, 1 Surface Planar Cut(s).

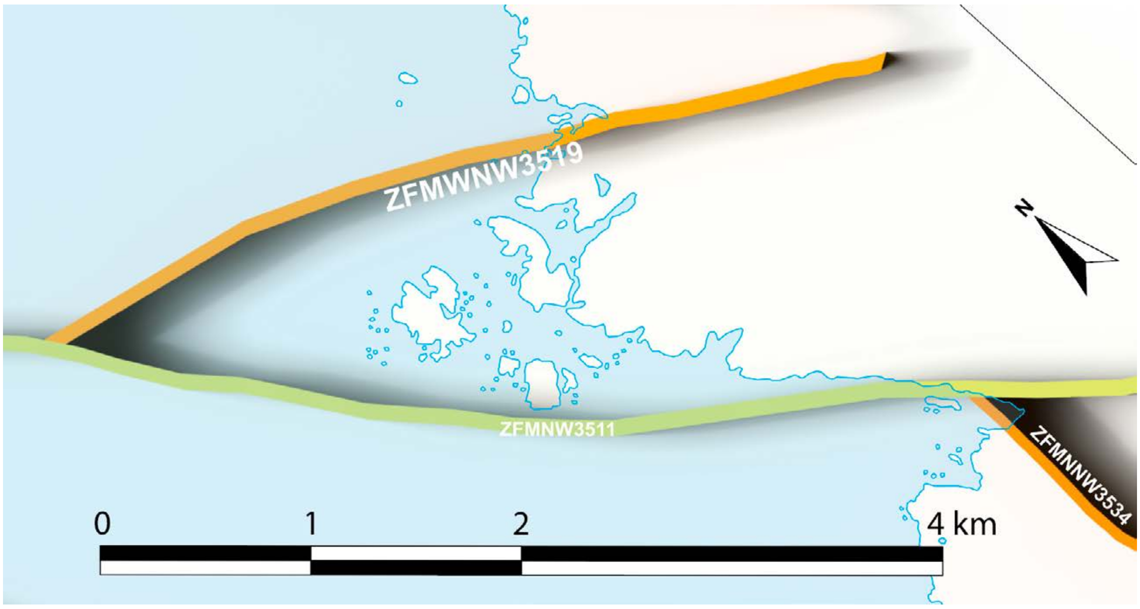
BASIS FOR MODELLING

Zone based on surface lineaments.

Outcrops:	-	
Boreholes: -		
Tunnels:	-	
Lineament and/or seismic indications:	MFM3519.	3

MODELLING PROCEDURE

-



WNW	ZFMWNW3519	Version number	4	Total object CL	13

OBJECT CONFIDENCE ESTIMATE

Category	Object CL	Comment
INTERPRETATION		
Data source	1	MFM3519.
Results of interpretation	3	High confidence in lineament MFM3519.
INFORMATION DENSITY		
Number of observation points	1	1
Distribution of observation points	1	Single observation point in the form of a lineament.
INTERPOLATION		
Geometry	1	Geometry supported by surface geophysical data.
Geological indicators	1	Indirect support by geophysical data.
EXTRAPOLATION		
Dip direction	3	Extrapolated to the base of the model volume. Strike length of the modelled zone > 2000 m.
Strike direction	2	Supported by geological concept and partly by surface lineament.

FRACTURE CHARACTER

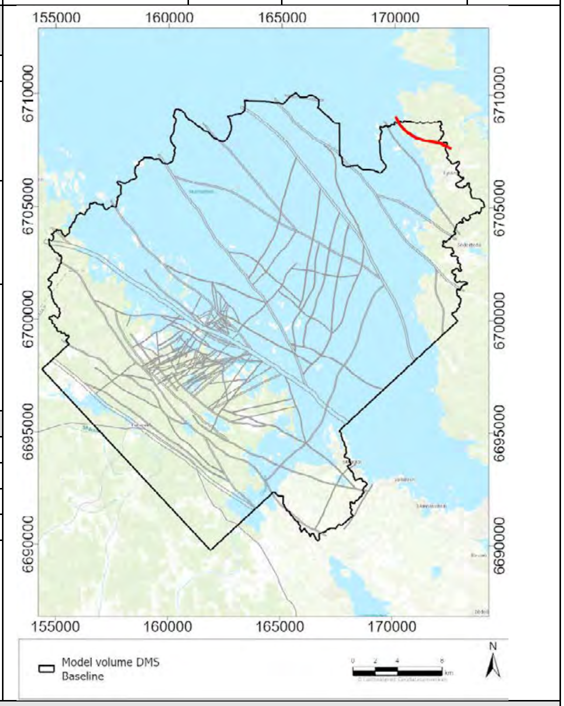
No data available

INDIVIDUAL INTERCEPTS

No data available

WNW	ZFMWNW3520	Version number	4	Total object CL	13

GEOLOGICAL CHARACTER		Property CL
Deformation style:	No data available	
Deformation description:	No data available. Zone based on lineament maps in the catchment area.	
Alteration:		
- First order:	Not observed	
- Second order:	Not observed	
- Third order:	Not observed	
Fracture orientation and type:	No data available.	
Fracture comment:	No data available.	
Fracture fill mineralogy:	No data available.	



OBJECT GEOMETRY	
Strike/dip:	121°/90°
Length:	14739 m
Mean thickness:	65 m (50 - 200 m)
Max depth:	-2100 m
Geometrical constraints:	Topo 40m grid Max error 20m, 2 Surface Planar Cut(s).

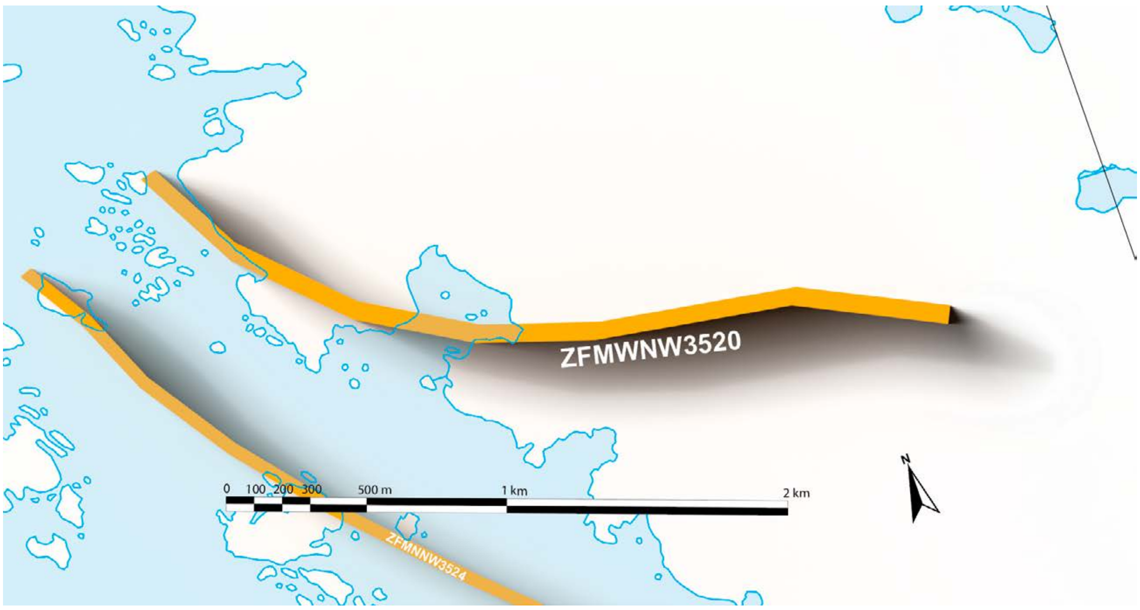
BASIS FOR MODELLING

Zone based on surface lineaments.

Outcrops:	-	
Boreholes: -		
Tunnels:	-	
Lineament and/or seismic indications:	MFM3520.	2

MODELLING PROCEDURE

-



WNW	ZFMWNW3520	Version number	4	Total object CL	13

OBJECT CONFIDENCE ESTIMATE

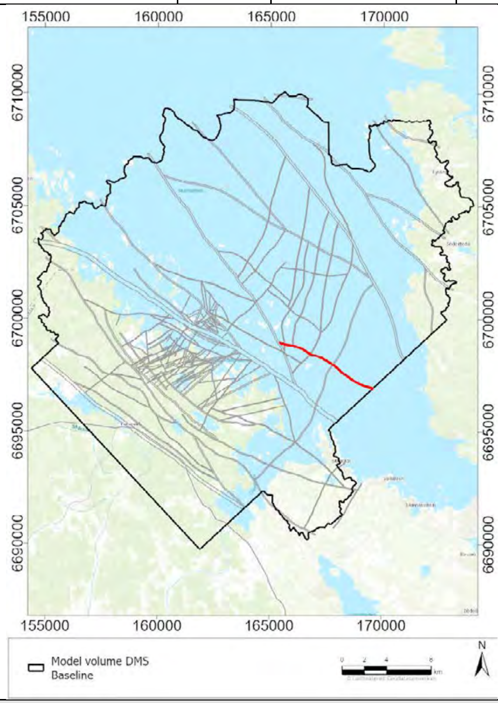
Category	Object CL	Comment
INTERPRETATION		
Data source	1	MFM3520.
Results of interpretation	2	Medium confidence in lineament MFM3520.
INFORMATION DENSITY		
Number of observation points	1	1
Distribution of observation points	1	Single observation point in the form of a lineament.
INTERPOLATION		
Geometry	1	Geometry supported by surface geophysical data.
Geological indicators	1	Indirect support by geophysical data.
EXTRAPOLATION		
Dip direction	3	Extrapolated to the base of the model volume. Strike length of the modelled zone > 2000 m.
Strike direction	3	Conceptual understanding of the site and that the entire regional modelled zone is supported by the lineament.

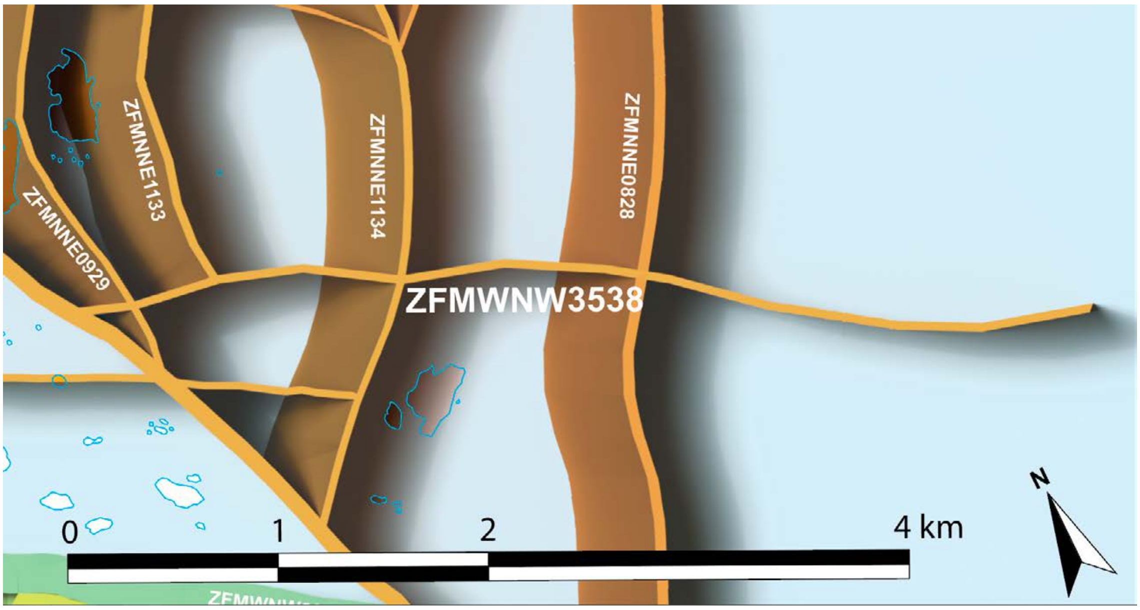
FRACTURE CHARACTER

No data available

INDIVIDUAL INTERCEPTS

No data available

WNW	ZFMWNW3538	Version number	4	Total object CL	13
GEOLOGICAL CHARACTER		**Property CL**			
Deformation style:	No data available				
Deformation description:	No data available. Zone based on lineament maps in the catchment area.				
Alteration:					
- First order:	Not observed				
- Second order:	Not observed				
- Third order:	Not observed				
Fracture orientation and type:	No data available.				
Fracture comment:	No data available.				
Fracture fill mineralogy:	No data available.				
OBJECT GEOMETRY					
Strike/dip:	114°/90°				
Length:	6587 m				
Mean thickness:	40 m (15 - 64 m)				
Max depth:	-2100 m				
Geometrical constraints:	Topo 40m grid Max error 20m, ZFMNNW0806, 1 Surface Planar Cut(s).				
BASIS FOR MODELLING					
Zone based on surface lineaments.					
Outcrops:	-				
Boreholes: -					
Tunnels:	-				
Lineament and/or seismic indications:	MFM3538.				2
MODELLING PROCEDURE					
-					



WNW	ZFMWNW3538	Version number	4	Total object CL	13

OBJECT CONFIDENCE ESTIMATE

Category	Object CL	Comment
INTERPRETATION		
Data source	1	MFM3538.
Results of interpretation	2	Medium confidence in lineament MFM3538.
INFORMATION DENSITY		
Number of observation points	1	1
Distribution of observation points	1	Single observation point in the form of a lineament.
INTERPOLATION		
Geometry	1	Geometry supported by surface geophysical data.
Geological indicators	1	Indirect support by geophysical data.
EXTRAPOLATION		
Dip direction	3	Extrapolated to the base of the model volume. Strike length of the modelled zone > 2000 m.
Strike direction	3	Conceptual understanding of the site and that the entire regional modelled zone is supported by the lineament.

FRACTURE CHARACTER

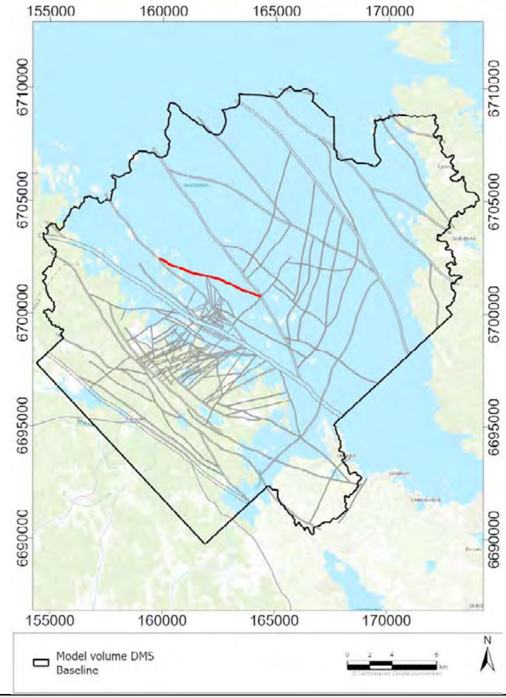
No data available

INDIVIDUAL INTERCEPTS

No data available

WNW	ZFMWNW3571	Version number	6	Total object CL	13

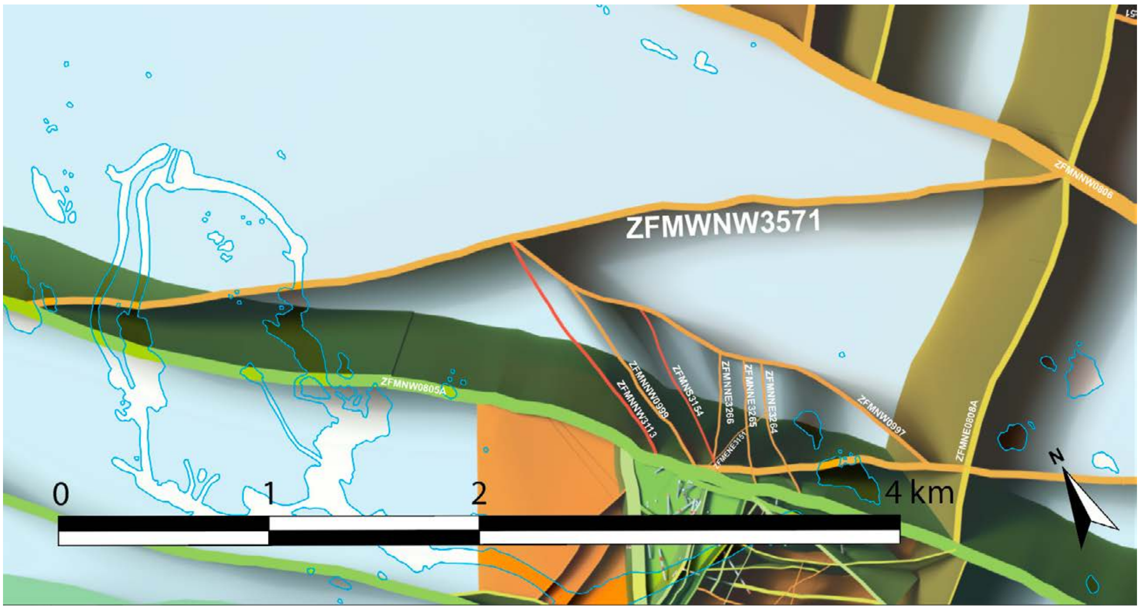
GEOLOGICAL CHARACTER		Property CL
Deformation style:	No data available	
Deformation description:	No data available. Zone based on lineament maps in the catchment area.	
Alteration:		
- First order:	Not observed	
- Second order:	Not observed	
- Third order:	Not observed	
Fracture orientation and type:	No data available.	
Fracture comment:	No data available.	
Fracture fill mineralogy:	No data available.	



OBJECT GEOMETRY	
Strike/dip:	109°/90°
Length:	4879 m
Mean thickness:	35 m (15 - 64 m)
Max depth:	-2100 m
Geometrical constraints:	Topo 40m grid Max error 20m, ZFMNE0808A, ZFMNW0805A, 1 UNIVERSE Planar Cut(s).

BASIS FOR MODELLING		
Zone based on surface lineaments.		
Outcrops:	-	
Boreholes: -		
Tunnels:	-	
Lineament and/or seismic indications:	MFM3571, MFM3551.	2

MODELLING PROCEDURE
-



WNW	ZFMWNW3571	Version number	6	Total object CL	13

OBJECT CONFIDENCE ESTIMATE

Category	Object CL	Comment
INTERPRETATION		
Data source	1	MFM3571, MFM3551, Northernmost part of MFM3551.
Results of interpretation	2	Medium confidence in lineament MFM3571 and MFM3551.
INFORMATION DENSITY		
Number of observation points	1	2
Distribution of observation points	1	Single observation point in the form of a lineament.
INTERPOLATION		
Geometry	1	Geometry supported by surface geophysical data.
Geological indicators	1	Indirect support by geophysical data.
EXTRAPOLATION		
Dip direction	3	Extrapolated to the base of the model volume. Strike length of the modelled zone > 2000 m.
Strike direction	3	Conceptual understanding of the site and that the entire regional modelled zone is supported by the lineament.

FRACTURE CHARACTER

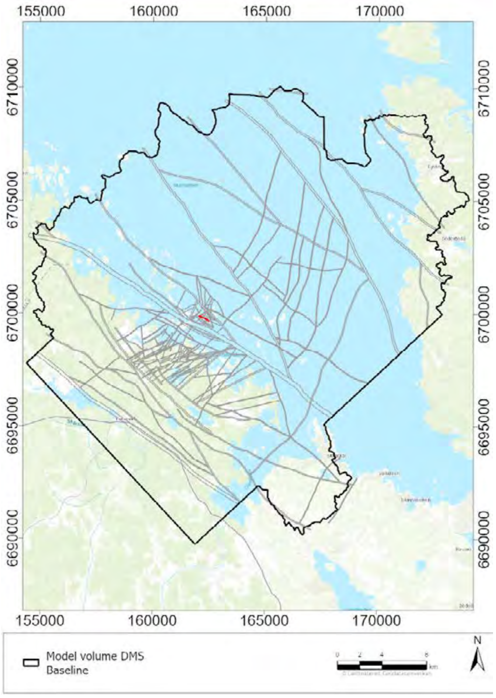
No data available

INDIVIDUAL INTERCEPTS

No data available

WNW	ZFMWNW8042	Version number	7	Total object CL	17

GEOLOGICAL CHARACTER		Property CL
Deformation style:	Brittle	3
Deformation description:	No data available.	
Alteration:		3
- First order:	Oxidation	
- Second order:	Chloritization	
- Third order:	Not observed	
Fracture orientation and type:	Steeply dipping WNW fracture set. Dominance of open fractures. Sealed fractures and sealed fracture networks are present.	
Fracture comment:	No data available.	
Fracture fill mineralogy:	Predominant fracture minerals in open fractures are chlorite, oxidized walls, laumontite, calcite and clay minerals and in sealed fractures laumontite, calcite.	



OBJECT GEOMETRY	
Strike/dip:	298°/88°
Length:	524 m
Mean thickness:	8 m (2 - 36 m)
Max depth:	-520 m
Geometrical constraints:	Topo 40m grid Max error 20m, ZFMENE3135, ZFMENE3115, ZFMWNW0835, 1 Surface Planar Cut(s).

BASIS FOR MODELLING

Zone based on surface lineaments and borehole observations.

Outcrops:	-

Boreholes:

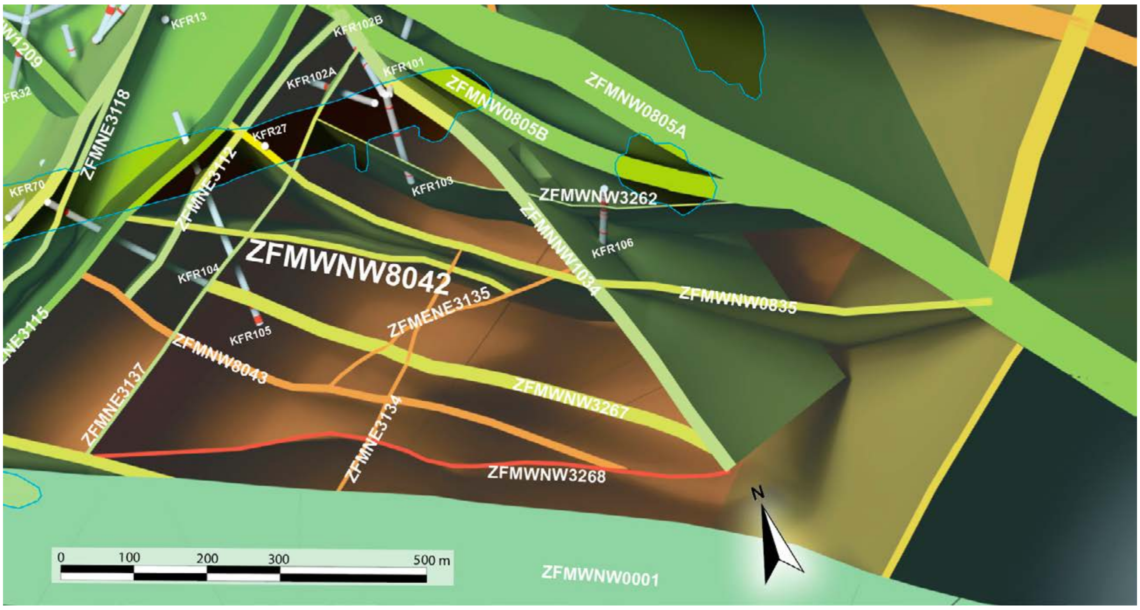
Borehole	PDZ	Target intercept		Geometric intercept		Comment
		Sec_up [m]	Sec_low [m]	Sec_up [m]	Sec_low [m]	
KFR105	DZ3	170.80	176.00	168.63	177.71	
KFR121	DZ4	289.80	303.00	290.74	302.88	

Tunnels:	-	
Lineament and/or seismic indications:	MSFR08042.	2

MODELLING PROCEDURE

The position of the zone at the ground surface is based on magnetic lineament MSFR08042 (SFR model version 1.0) with a further extension to the WNW to allow termination at ZFMENE3115. The zone thickness is based on the borehole intercepts of KFR105 and KFR121 and the dip is based on linking the lineament to the borehole intercepts. Forward modelling of magnetic data along profiles 12 and 44 supports the vertical dip and limited thickness of the zone, while inversion modelling suggests a very steep dip to the north-east (see Appendix 6 in Curtis et al. 2011).

WNW	ZFMWNW8042	Version number	7	Total object CL	17



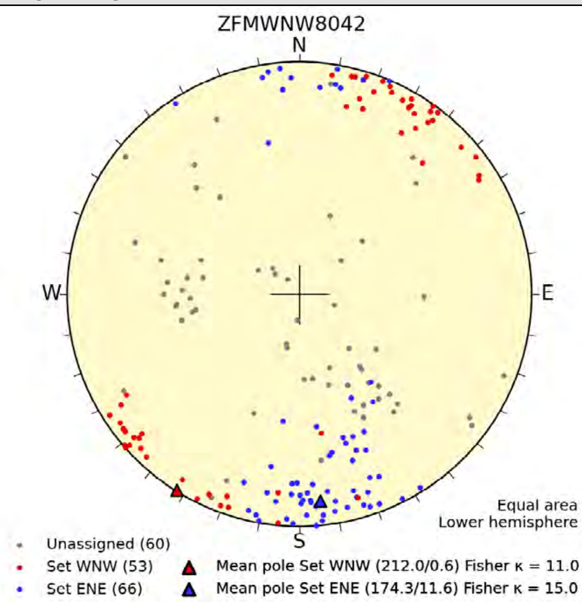
OBJECT CONFIDENCE ESTIMATE

Category	Object CL	Comment
INTERPRETATION		
Data source	2	MSFR08042, Inferred continuation to the WNW to allow termination at ZFMENE3115 and intersections in KFR121, KFR105.
Results of interpretation	3	High confidence observation in KFR121 and KFR105.
INFORMATION DENSITY		
Number of observation points	2	3
Distribution of observation points	2	Two subsurface observation points, evenly distributed.
INTERPOLATION		
Geometry	2	Geometry supported by two subsurface observation points and partly surface lineament.
Geological indicators	2	Some discrepancies in the geological data.
EXTRAPOLATION		
Dip direction	2	Extrapolation in dip direction supported by two subsurface obs. point. Strike length of the modelled zone < 2000 m.
Strike direction	2	Partly support by surface lineament. Supported by geological concept and subsurface observation points.

FRACTURE CHARACTER

Orientation: (strike/dip right-hand-rule)	Set WNW: 302.0°/89.4° Set ENE: 264.3°/78.4°
Frequency:	Boreholes: KFR105, KFR121

FRACTURE TYPE	TERZAGHI-WEIGHED P10
Open and partly open	11.0 m-1
Sealed	7.3 m-1
Sealed network	65.7 % of DZ intercept
Crush	1.1 % of DZ intercept



RQD:	min:29, max:100, mean:83

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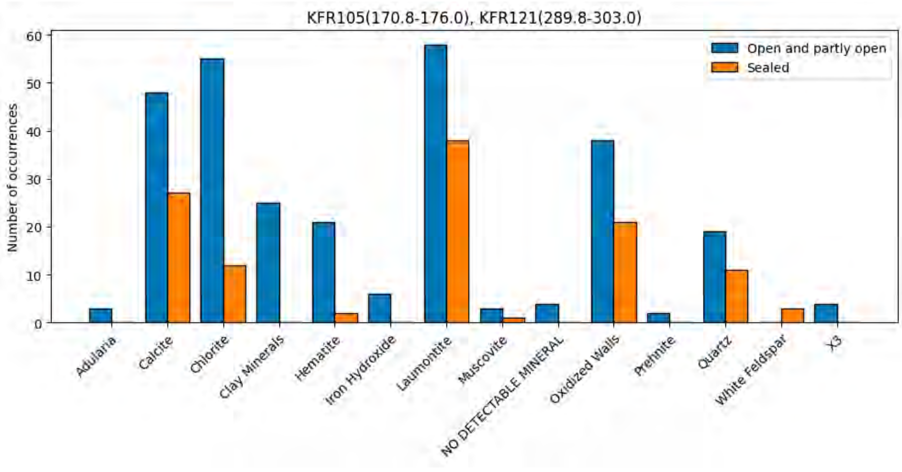
<tr><td>Fracture fill mineralogy:</td><td colspan="5"></td></tr>
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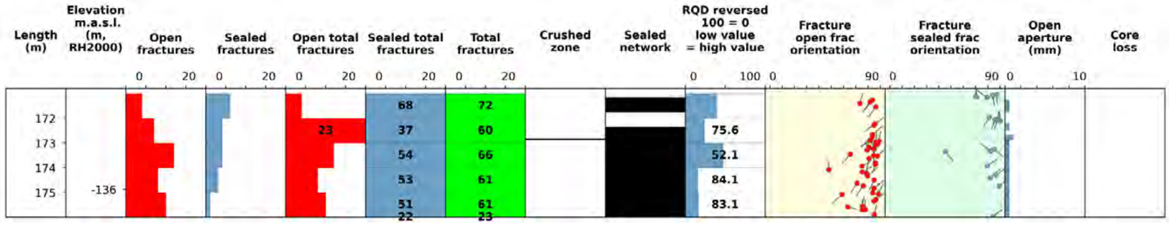
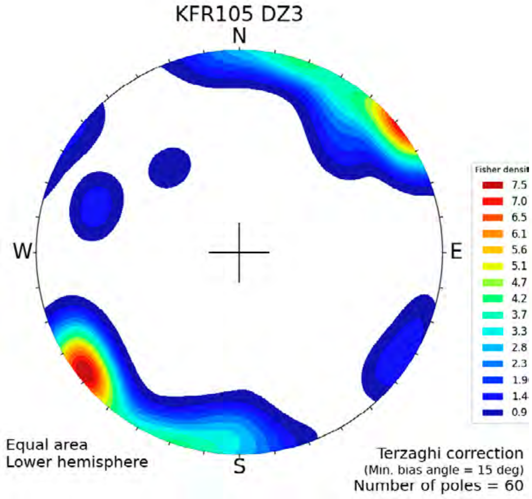
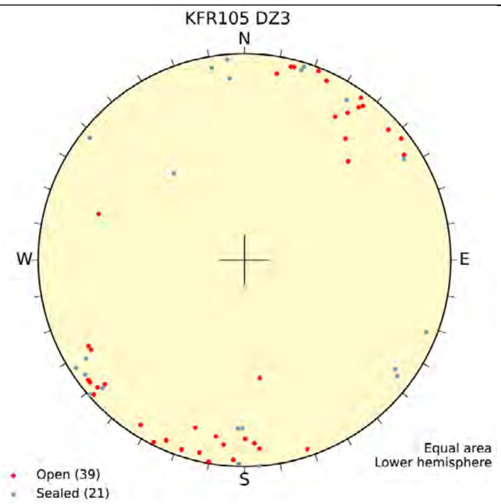
WNW	ZFMWNW8042	Version number	7	Total object CL	17

INDIVIDUAL INTERCEPTS

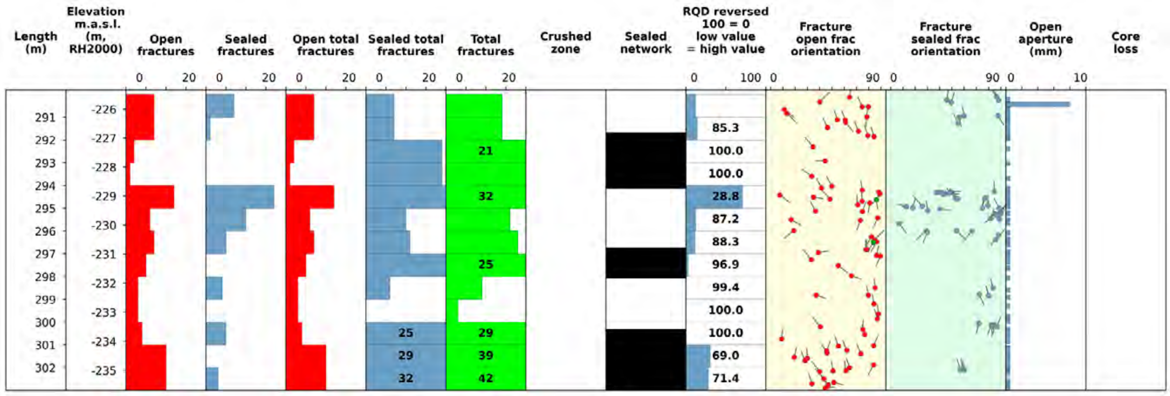
KFR105 DZ3 (170.8-176.0 m)

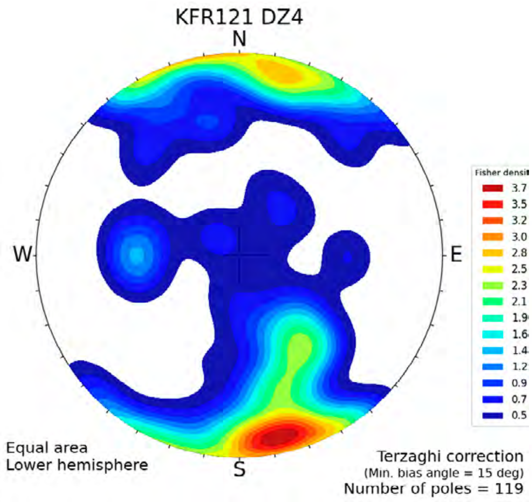


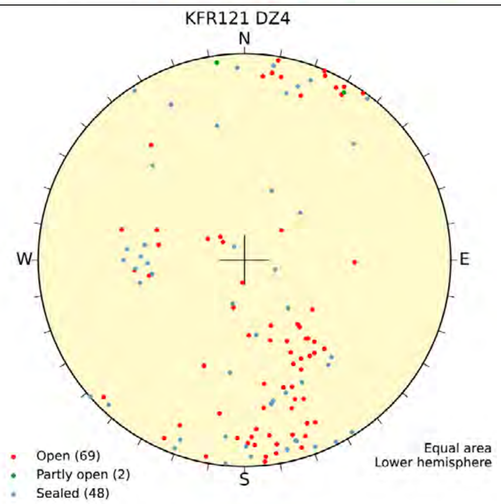




KFR121 DZ4 (289.8-303.0 m)







Arkitektkopia AB, Bromma, 2025

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