P-07-29

Oskarshamn site investigation

Detailed outcrop mapping in trenches

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March 2007

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Keywords: Outcrop, Fracture, Lithology, Trench, Scanline.

Abstract

SKB performs site investigations in Forsmark and Oskarshamn for location of a deep repository for spent nuclear fuel. This document reports the data gained during detailed fracture and bedrock mapping on a number of outcrops in dug out trenches in the Laxemar subarea, of the site investigation in Oskarshamn.

The aim of the activity is to collect fracture data for discrete fracture network modelling and other statistical analyses. Focus is the intensity and orientation variation over space, in and around minor deformation zones. For this purpose, the mapped distance is decisive, thus the detailed mapping was restricted to all fractures that had any part within a one metre wide strip following the centreline of each trench.

The fracture trace location and form was surveyed with a total station. Fracture dip and other geologic characteristics that need direct observation were mapped in the field. Other special characteristics were calculated in the post process, such as; fracture termination, relation to lithology, host rock and alteration etc, were described. All fractures with a trace length longer than 1 metre were mapped.

The trenches were photographed from above in their full extent.

The combined outcrops contained 2,215 fractures, close to all of them longer than 1 metre. The total length of the mapped strips was approximately 580 metres, giving an area of a good 580 m^2. This gives a mean of approximately 3.8 fractures per m^2

A detailed mapping of outcrop lithology was conducted according to SKB MD 132.001.

Sammanfattning

SKB utför platsundersökningar i Forsmark och Oskarshamn för att finna en plats att djupförvara använt kärnbränsle. Följande rapport beskriver en detaljkartering av sprickor och bergarter av delvis sammanhängande längre avrymda hällar i Laxemarsområdet norr om Oskarshamn.

Ändamålet med insamlande av sprickdata är att samla data för diskret sprickmodellering och statistisk sprickanalys. Fokus ligger på variationer i orientering och intensitet i och omkring mindre deformationszoner (MDZ). För detta ändamål är den karterade längden avgörande. Hällarna i detta projekt kan därför beskrivas som långsmala diken, och detaljerad kartering har endast utförts till fullo inom ett en meter brett band längs med centrumlinjen på dessa.

Sprickornas läge och form har mätts in med total station. Sprickplanets stupning (dip) och vissa geologiska data som måste bedömas på plats har noterats i fält. Andra geologiska karakteristika har dock beräknats utifrån insamlade data i efterhand, såsom; sprickspårs avslut, bergartsrelation, moderbergart med flera. Nedre trunkeringsgräns för kartering av sprickor var 1 meter.

Hällarna har fotograferats uppifrån i hela sin utsträckning.

På hällarna karterades sammanlagt 2 215 sprickor längre än en meter (med ett fåtal undantag). Sammanlagda längden av de karterade banden på alla hällar var 580 meter. Detta innebär att den i detalj karterade arean var drygt 580 m^2. Sprickfrekvensen uppgår sålunda till cirka 3,8 sprickor per m^2.

En detaljerad bergartskartering har även utförts på hällarna. Denna är utförd i enlighet med SKB MD 132.001.

Contents

1 Introduction

SKB performs site investigations in Forsmark and Oskarshamn for location of a deep repository for spent nuclear fuel. This document reports the data gained during detailed fracture and bedrock mapping of a number of trenches (long outcrops) at the Laxemar area in Oskarshamn. The trenches, ASM000114–ASM000123, were mapped in September 2006.

The detailed fracture mapping and bedrock mapping was conducted according to the method description SKB MD 132.003e, SKB MD 132.001, and the activity plan AP PS 400-06-099, which as well contains a number of simplifying exceptions from the method descriptions.

The locations of the investigated trenches can be seen in Figure 1-1. The trenches have been exposed and cleaned from the soil cover prior to mapping. The total mapped length of the trenches is 580 metres, and a total of 2,215 fractures where mapped.

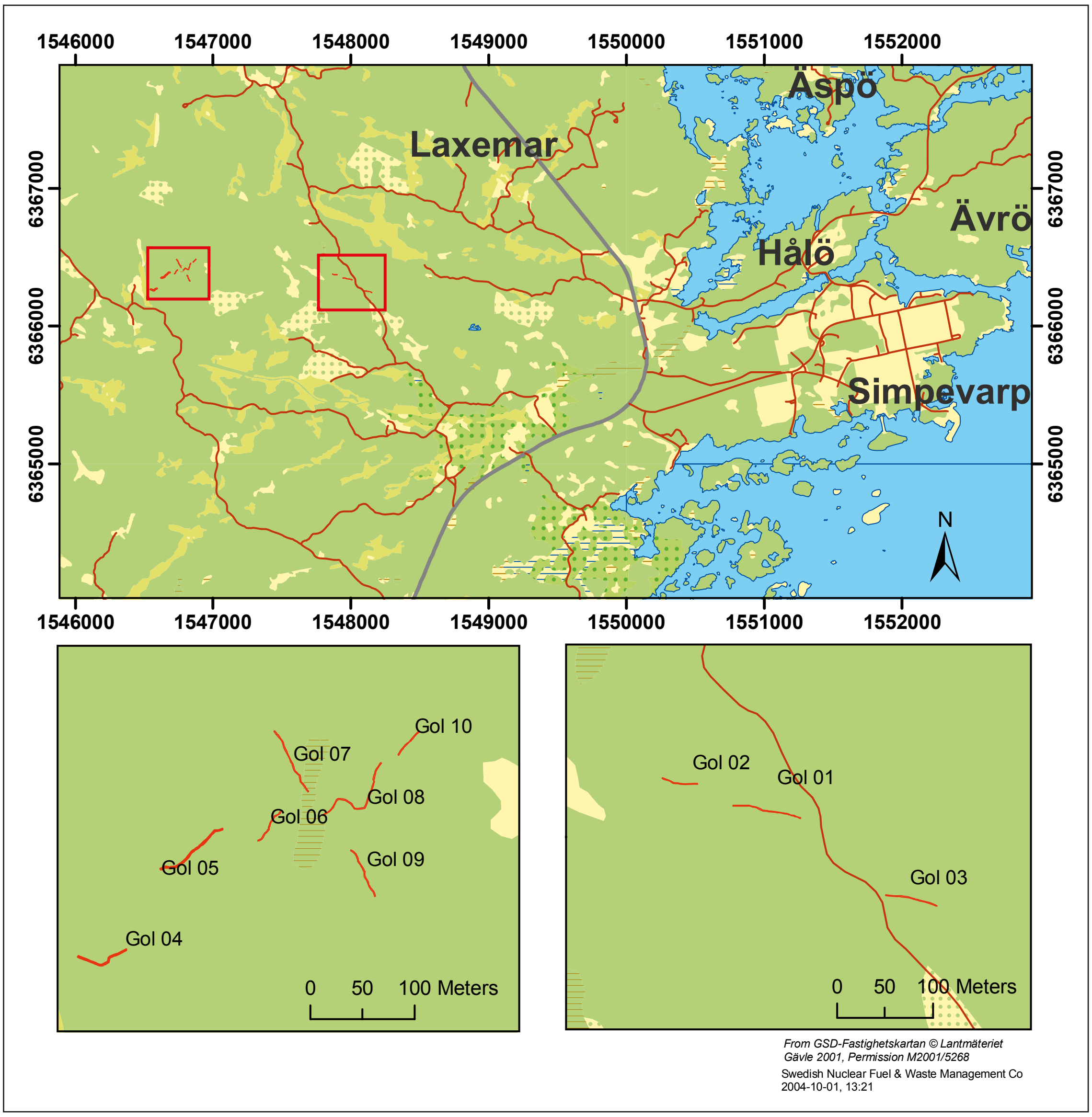


Figure 1-1. *Location of the trenches.*

In Table 1-1, SKB's internal controlling documents for performing this activity are listed.

Table 1-1. Controlling documents for the performance of the activity.

Activity plan	**Number**	**Version**
Kartering av längre diken	AP PS 400-06-099	1.0
Method descriptions	**Number**	**Version**
Detailed fracture mapping of rock outcrops	SKB MD 132.003e	2.0
Metod för berggrundskartering	SKB MD 132.001	1.0

2 Objective and scope

The aim of the activity was to collect fractures and lithology data for discrete fracture network modelling and other statistical analyses.

In the mapping of trenches focus was set on collecting information with a considerable extension length. Efforts as well as simplifications in method were made in order to map the longest distance possible in a set amount of time. The expected outcome was to obtain data that can be indicative of the spatial variation in fracture intensity and spacing. This is especially interesting when the behaviour of fracture intensity and orientation within and around minor deformation zones are studied.

The area mapping is expected to indicate the geometric properties for open and sealed fractures in the trace length interval between 1 metre to approximately 10 metres at the sites. The variability and properties of the fractures may also depend on type of bedrock and its structures which are also studied.

3 Equipment

3.1 Description of equipment

The fracture trace geometry and contacts between rock types were measured with a Geodimeter 640S Total Station. In theory, the survey instrument gives an error of the position (x, y and z) of less than 3 mm. However, this accuracy is based on the assumption that the measuring lath is held in a perfectly vertical position. Since this is not always possible to achieve in typical field conditions the error of each measured point is slightly larger. Each measurement is therefore estimated to be performed with an x, y accuracy better than 2 cm. The elevation error is estimated to be less than 0.5 cm.

The fracture dip was measured with a Silva Clinomaster with an error of maximum 20 degrees for sub planar, undulating or badly exposed fracture planes, or less than 10 degrees for sub vertical, sufficiently exposed fractures (these errors are due to uncertainties and variations of dip, while the instrument is indexed at 1 degree intervals).

The digital photographs in the geo-referenced series (cf Section 4.3.2) were captured with a Nikon D200 with a 27 mm lens, giving a theoretical resolution of 1.3 mm/pixel although the practical resolution is more like 3–4 mm/pixel. The camera is also equipped with remote release and laser sight. The camera is mounted on a light portable rig that gives a camera height of 3 metres. This height gives image coverage of about 3×2 metres depending on ground geometry.

General equipment for geologic interpretation; hammer, pocket lens, hydrochloric acid etc.

4 Execution

4.1 General

Outcrop mapping of fractures was completely performed in an approximately one metre wide strip, positioned along the centre of the trenches. Each fracture that had any part within this strip was mapped in its complete extent on the outcrop.

The fracture mapping was performed using a slim version of the protocols presented in the method description SKB MD 132.003e. To gain time in the field, only dip and prioritised geologic fracture parameters were mapped. While fracture orientation, trace length, relation to lithology, rock type termination and fracture host rock were computed after the field trip, based on the geodetic data from bedrock and fracture survey. Aperture, unevenness, lineation and mineral thickness were not mapped in this session. Waviness was marked if the fracture was clearly undulating or stepped, otherwise the field was left blank. Truncation limit for minimum fracture trace length was increased from 0.5 metre, as stated in the MD, to approximately 1 metre.

No scanline mapping was performed.

The bedrock mapping was carried out according to method description for bedrock mapping, SKB MD 132.001. The width of the exposed outcrops along the profiles varies between approximately 1 and 4 metres and the length of the profiles are between 30 and 98 metres. The entire cleared area was mapped in all the trenches. The bedrock profiles were mapped in detail with respect to major rock types, subordinate rock types, contact relations, alterations and deformational structures.

The trenches were also photographed in their full extent, and the photographs were georeferenced.

4.2 Preparations

The survey instrument was positioned outside each trench and was calibrated against three fix points located around the outcrop at the onset and the end of each field session. The instrument was also recalibrated to reflect temperature changes during the day. The coordinates of the fix points (listed in Appendix 1) were delivered by SKB prior to the mapping. The survey results were exported from the instrument and converted to RT90 each day after the field work, when a quality check of the days work was performed as well.

4.3 Execution of work

4.3.1 Field work

Site establishment involved the following activities:

1. On the first field day a start meeting was held. The general approach, a time plan etc, were set up together with the SKB activity leader.
2. An approximately 1 metre broad strip along the centre of each trench was marked up with nails and white plastic string. The strip marked the area that would be completely mapped.
3. The survey instrument was calibrated against known and appointed fix points in the vicinity to the outcrop.
4. The borders of the strip were surveyed with the total station.

The methodology of the lithologic mapping follows the SKB controlling document SKB MD 132.001. Specifically the work was carried out as follows:

1. The lithologic boundaries of the outcrop were identified and marked with yellow crayons.
2. A detailed 1:50 sketch of the whole trench, extending outside the 1 metre strip, was drawn. If possible to measure, strike and dip of observed dykes were also noted on the sketch
3. The lithologic boundaries within the 1 metre strip were registered with the survey instrument. In order save time, the number of points along a contact between rock types were restricted. The centimetre accuracy of rock types at the surface was not prioritised. Dykes less than 3 cm in width were registered as a line by the Geodimeter and enclaves less than 5 cm were registered as points. If higher resolution is needed later on there is extensive photographic documentation of all the trenches available.
4. The survey data were extracted and digitally conversed to RT90-RHB70 coordinates.

The methodology for mapping fractures follows the method presented in the SKB MD 132.003e (SKB internal controlling document) with the exceptions mentioned above. The work process was conducted as follows:

1. Each fracture trace was marked with a metal marker at its start (A) and end (B) points on the outcrop to keep track of measured fractures. The direction from start to end was defined according to the right hand rule. The used truncation length for mapping fracture traces was generally 1 metre. At some distances shorter fractures were mapped, since some trenches at parts were barely 1 metre wide (any fracture perpendicular to the trench would thus be excluded if it did not cross the whole trench).
2. Each fracture form was surveyed. The minimum amount of nodes on a trace is 2 points, but more are needed as the complexity of the trace increases. Complex fracture traces will always be simplified by the fact that the trace is represented by a number of straight lines. The aim was to keep this error within 2 cm.
3. At the end of each day the data was extracted from the survey instrument. The measurements of the day where opened in a CAD software. The reasonability of the traces was checked.
4. Each fracture was mapped with respect to the given geological parameters outlined in SKB MD 132.003e.
5. The outcrop was cleared from markers, nails and plastic string.

The photographic series of geo-referenced images along the trenches were captured as follows:

1. Each trench was photographed from above with a camera mounted on a portable rig that gives a camera height of 3 metres. This height gives image coverage of about 3×2 metres depending on ground geometry. Photographs were taken along the trenches with an image overlap of approximately 30%. Each outcrop was photographed twice, once in each direction to ensure a complete coverage of the area and to minimize the effect of sloping ground.
2. The images were evaluated and sorted into series that ensures the best coverage for the selected outcrop. Corrections to brightness and contrast are applied if needed. Any unsatisfying sequences were photographed once again.

4.3.2 Post processing

Off field activities conducted:

1. Geo-referencing – i.e. insertion of the photographs in the geodetic system – of the above mentioned photographic series was carried out with the software 'Global mapper 8'. Since the images were not orthogonally rectified, the images are slightly distorted, especially close to the edges. The distortion was higher for images where the ground geometry was more complex.

2. Construction of ArcMap shape files of fracture traces, lithologic features, outcrop grid and boundary. The shape files describing the lithologic data are assembled from the geo-referenced digital photos, the sketches and the survey data files together. The outer boundaries of the cleared rock surfaces were estimated from the geo-referenced photographs and the survey data. Fractures coded as: “Termination not visible” were supposed to be extending out under the soil cover, and the registered end point thus represents the edge of the cleared area.
3. Calculation of fracture strike, trace lengths, distance A to B and the dip of sub planar fractures. Fractures shorter than 1 metre were not removed from the dataset.
4. Spatial calculation of fracture host rock, relation to lithology and rock type termination, from the fracture survey and the lithology survey data.
5. Quality control of the survey data with respect to reasonability and permitted codes.
6. Report production.

Details for activity point 3

On open fracture planes the circumference of the visible surface were mapped in the field (see SKB MD 132.003e). The calculation of ‘trace length’ and ‘distance A → B’ is demonstrated by fracture 33 from ASM000114 (Figure 4-1a), which is a typical ‘circular trace’. The fracture is registered with 8 nodes. The raw trace length is 9.98 metres, and the raw distance A → B is 0.67 metres. This is obviously not describing the fracture correctly, thus special treatment is applied, in order to be able to compare with fractures with a linear trace. The lengths between all nodes are analyzed (Figure 4-1b) in order to find the longest distance between any two nodes. These nodes (Figure 4-1c, node 1 and 4) are reassigned as A and B. Distance A → B = 4.46 metres (Figure 4-1d, pink line). The trace length is calculated (Figure 4-1d, blue line) as being the shorter way along the circumference between A and B.

An additional parameter ‘Calculated dip’ was calculated for these fractures, requiring at least 3 nodes forming a considerable area.

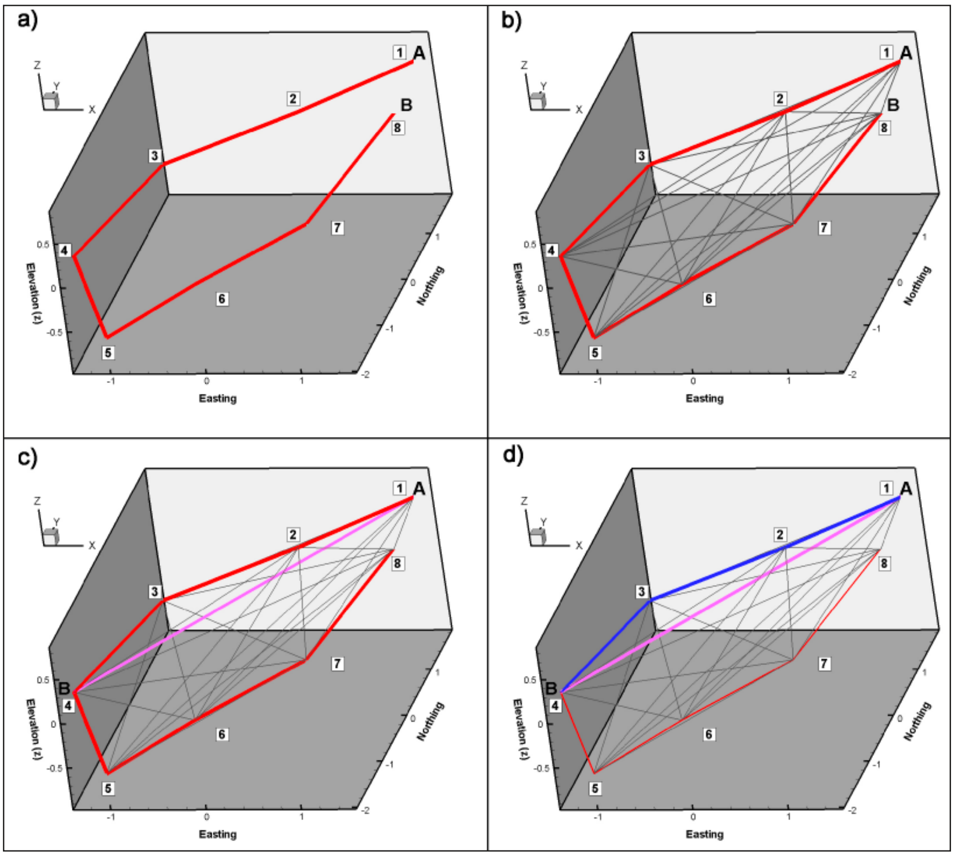


Figure 4-1. *Illustrations of the calculations done on circular traces.*

4.4 Data handling and deliveries

A complete registry of the delivered documents are given in Tables 4-1, 4-2 and 4-3.

Table 4-1. Field notes.

Description	Name	Format
Field mapping protocols	Blanket sprickkartering	Hard copy
Daily log of activities	Aktivitetsdagbok V2.0.1	Hard copy
SHM protocol	SHM protokoll	Hard copy

Table 4-2. Primary data. For each of the trenches ASM000114 to ASM000123 the following files are produced.

Folders	Files	Description	Gis format
Bedrock_GIS	ASMxxx_bedrock.shp	Bedrock lithology.	Polygon
	ASMxxx_StructOrient.shp	Structure orientation in bedrock.	Point
Fractures_GIS	ASMxxx_Fractures.shp	Fracture traces. Contains all fractures having any part within the mapped area.	Line
	ASMxxx_movement.shp	Fractures along which movement has occurred.	Line
Site_GIS	ASMxxx_strip.shp	The strip established on the outcrop.	Line
Each shape file is a combination of several files, such as a database file, different binary files, sometimes a layout (lyr) file and an xls-metadata file.			
CAD	ASMxxx_strip.dgn	The grid established on the outcrop.	
	ASMxxx_fractures.dgn	The mapped fracture traces from the outcrop in CAD format.	
	ASMxxx_water.dgn	Water obstructing the observation on the outcrop.	
Pictures	jpg-files as listed in: ASM000114-000123_Phototext.doc AFMxxx_"name"_NN.jpg (NN =initials of photografer)		
Geo-referenced images	ASMxxx_Klar	Geo-referenced photoseries.	
(2 separate DVDs)	ASMxxx_Originalbilder	Original pictures.	
SICADA	EG165 - ASMxxx_ Area_surveying.xls	Coordinates of the centred strip along the trench outcrops in a SICADA template.	
	GE076 - ASMxxx_ Fractures.xls	Parameters of the mapped fractures on the outcrop. Contains each fracture that has any part within the centre strip and is longer than 1 metre, or probably longer than 1 metre.	

Table 4-3. Other documents.

Description	File name
Report	Report - Detailed outcrop mapping in trenches.doc
File list	Table 4-3
QA-protocol	Granskningsintyg_ASM000114-000123.pdf
QA-protocol	Granskning_mätfiler_061002 (hard copy & pdf)
QA-protocol	Appendix 2. Screenspots_missade sprickor

5 Results

5.1 Detailed fracture mapping

The results of the outcrop mapping include data tables, CAD files and ArcMap shape files of:

- Outcrop lithology and shape.
- Area fracture mapping.

The mapped geological parameters on each fracture trace were recorded using the codes in MD 132.003e, according to a specified system that is appropriate for retrieving from SICADA, the SKB data base for the site investigations.

All outcrops are presented graphically in Appendix 3. The geo-referenced photographic series are partly presented in Appendix 4.

5.2 Detailed bedrock mapping

General rock description

ASM000114–ASM000116

Five rock types are present in the three profiles located in the central part of the Laxemar area – Ävrö granite, fine grained diorite to gabbro, fine-grained granite, granite dykes and pegmatite.

The dominant rock type is well-preserved, more or less isotropic, microcline porphyritic "Ävrö granite" with relatively low quartz content and a quartz monzodioritic composition. The rock groundmass is medium-grained and greyish red. The microcline phenocrysts are generally, 1–2 cm in size and dark red to purple. Characteristic for the Ävrö granite is also the locally frequent presence of dark grey, slightly elongated, fine-grained enclaves of fine-grained diorite to gabbro, generally 5–10 cm in size. The dominating elongation direction is east-west to westnorthwest-eastsoutheast. The presence of enclaves is most frequent in the profiles ASM000114 and ASM000115 where the enclaves constitute approximately 0.5–1% of the Ävrö granite outcrop surface (Appendix 3).

Table 5-1. Properties of the 10 trenches.

ID	Golder ID	Length (m)	Main orientation	Nr of fractures	Fractures/metre
ASM000114	Gol 01	72.6	EW	249	3.4
ASM000115	Gol 02	38.2	EW	180	4.7
ASM000116	Gol 03	55.0	EW	204	3.7
ASM000117	Gol 04	53.4	NE/NW	188	3.5
ASM000118	Gol 05	74.6	NE	192	2.6
ASM000119	Gol 06	37.3	NE	101	2.7
ASM000120	Gol 07	68.6	NW	255	3.7
ASM000121	Gol 08	98.3	NE/NW	450	4.6
ASM000122	Gol 09	51.2	NW	236	4.6
ASM000123	Gol 10	30.2	NE	160	5.3

The Ävrö granite is cut by dykes of fine-grained granite. The width of the dykes varies between 1 and 5 cm and the strike is dominantly northeast-southwest with a vertical or steep dip towards northwest. However, a moderately dipping dyke of fine-grained granite is noted in the easternmost part of profile ASM000114 (Appendix 3). The dykes are generally straight and the contacts between the dykes and the host rock are sharp.

Granite is only noted in two 2 cm wide dykes in profile ASM000115. The dykes are vertically dipping and strike towards northnorthwest and northeast.

Pegmatite is only noted in the easternmost profile, ASM000115, where the Ävrö granite is cut by two 5–7 cm wide, vertically dipping dykes with a northeast strike.

ASM000116–ASM000123

Four rock types are present in the profiles close to Lilla Basthult, in the western part of the Laxemar area – quartz monzodiorite, fine-grained granite, pegmatite and fine-grained diorite to gabbro.

The quartz monzodiorite is the predominant rock type in all profiles. It is grey, medium-grained, isotropic and equigranular. Typical for the quartz monzodiorite is a relatively high content, c. 5–10%, of dark green hornblende in the ground mass.

Fine-grained granite occurs generally as straight or gently curved dykes. The contacts between the dykes and the host rock are sharp. The dykes vary from 1 cm to c. 20 cm in width. The strike and dip of the dykes vary, but northwest and northeast striking dykes are dominating. Locally, eastwest trending dykes are also relatively common.

The dip of the dykes varies from approximately vertical to relatively gentle (c. 6–40°). The gentle dipping dykes are generally exposed as a thin cover on exposed rock surfaces and large irregular shaped areas of fine-grained granite are therefore occasionally common. Consequently the gently dipping dykes occupy a larger area on the detailed bedrock map compared to the steeper dykes. This must be taken into account if the detailed bedrock maps are used for volume or areal distribution calculations of the different rock types.

Pegmatite occurs generally as thin, crosscutting dykes (c. 2–10 cm). The presence of pegmatite is less abundant compared to the presence of dykes of fine-grained granite. The pegmatite dykes are generally northeast to eastwest trending and relatively steeply dipping. However, gently dipping pegmatite dykes are frequently occurring in profile ASM000123. Furthermore, east-west trending pegmatite dykes are also common. Similarly as for the fine-grained granite, the gently dipping appearance of the pegmatite dykes must be taken in to account, when calculating the volumetric proportions of the different rock types. Crosscutting relationships between fine-grained granite dykes and pegmatite dykes indicates that the pegmatite is younger.

Fine-grained diorite to gabbro is subordinate in the quartz monzodiorite. However, in profile ASM000117, several 0.2–1 metre large bodies of fine-grained diorite to gabbro occur along with fine-grained granite (Appendix 3). The mingling of fine-grained granite and fine-grained diorite to gabbro indicate that they constitute composite intrusions as previously has been noted in the Laxemar subarea /1/.

References

/1/ **Wahlgren C-H, Bergman T, Persson Nilsson K, Eliasson T, Ahl M, Ekström M, 2005.** Oskarshamn site investigation. Bedrock map of Laxemar subarea and surroundings. Description of rock types, modal and geochemical analyses, including the core boreholes KLX03, KSH03A and KAV01. SKB P-05-180, Svensk Kärnbränslehantering AB.

Appendix 1

Fix points on and around the trenches

	Northing	Easting	Elevation
KLX 11A			
1101	6366266.542	1546552.291	24.885
1102	6366256.773	1546571.313	23.822
1103	6366273.452	1546591.575	22.796
1104	6366341.808	1546626.099	26.008
1105	6366367.723	1546635.210	25.292
1106	6366369.938	1546660.687	22.299
1107	6366389.270	1546685.677	22.851
1108	6366377.724	1546722.358	21.893
1109	6366390.895	1546731.117	20.421
1110	6366405.023	1546740.427	21.248
KLX 18A			
1801	6366240.600	1548134.376	20.326
1802	6366264.369	1548137.989	20.414
1803	6366249.760	1548111.426	20.584
1804	6366332.151	1548007.353	20.231
1805	6366353.523	1547973.364	21.322
1806	6366348.572	1547939.936	19.139
1807	6366372.037	1547899.175	19.537
1808	6366369.383	1547885.108	18.897
1809	6366377.704	1547867.984	19.110
KLX 24A			
2401	6366325.502	1546830.756	21.984
2402	6366349.399	1546823.866	22.225
2403	6366367.682	1546812.570	20.776
2404	6366406.903	1546788.316	20.190
2405	6366420.230	1546798.134	19.795
2406	6366409.670	1546824.303	20.733
2407	6366429.037	1546831.314	21.583
2408	6366447.851	1546828.394	23.037
2409	6366466.834	1546857.930	19.780
2410	6366477.761	1546869.850	18.287
2411	6366432.639	1546763.050	21.705
2412	6366451.249	1546753.470	21.334
2413	6366476.552	1546740.959	23.225

Appendix 2

Quality control of mapping coverage. A comparison between photos and field observations.

The photographic documentation of the trenches, enables a check of to what extent the aim of mapping all fractures was fulfilled. A visual comparison between the photos and the digital traces was carried out. Eight fractures were identified, that seemed to have been missed during the field mapping of the 10 outcrops. A few of the fractures are obvious misses, while others could be misses. For example it can be argued on some occasions, that what looks like one long continuous fracture on the photos, in the field, due to variations in dip, was considered to be two or more fractures, each shorter than a meter. An example of this is shown in the last of the following pictures.

It should also be mentioned that on several occasions in the geo-referenced photo series, some fractures are displayed twice. This is inevitable since the assembling of the photo series could not be perfectly stitched, especially on the topographically uneven outcrops. Furthermore the same fracture can have quite different appearance in the different pictures due to the difference in angle of exposure, light etc.

The conclusion of the check is that only a few fractures have been missed during the field work (8 or less fractures missed and 2,215 mapped). This will have little or no effect on the overall quality of the survey.

Below are some pictures of the missed fractures. There are also some pictures of what could appear to be misses, when looking only at the picture information.

Table A2-1. Observations during control of unidentified fractures.

Dike	Control	Fracture	Observation	Comment
ASM000114	LB	174	Figure A2-1.	
ASM000115	LB	11		Bad overlap of photos gives an false image that it is two fractures.
ASM000116	LB		Figure A2-2.	
ASM000117	LB		Figure A2-3.	
ASM000118	LB		Figure A2-4 and A2-5.	
ASM000119	LB		Figure A2-6.	
ASM000120	LB	253	Area that crosses itself.	More than one fracture that are visible on the photos are probably less than one metre long, even if they look longer. Some other fractures have probably been considered to consist of several fractures with lengths under a metre.
ASM000121	LB	689	Figure A2-7.	Some fractures under a meter long seems to end in the vegetation and perhaps should have been included, but they were probably considered to be to short.
ASM000122	LB	–	Figure A2-8.	No larger missed fractures were found. In some parts it looks like fractures have been missed but all of those have been considered to short, even if they are in a fracture system. It is easier to get an understanding of this in the field than from the photos.
ASM000123	LB	1,085–1,086	Figure A2-9.	

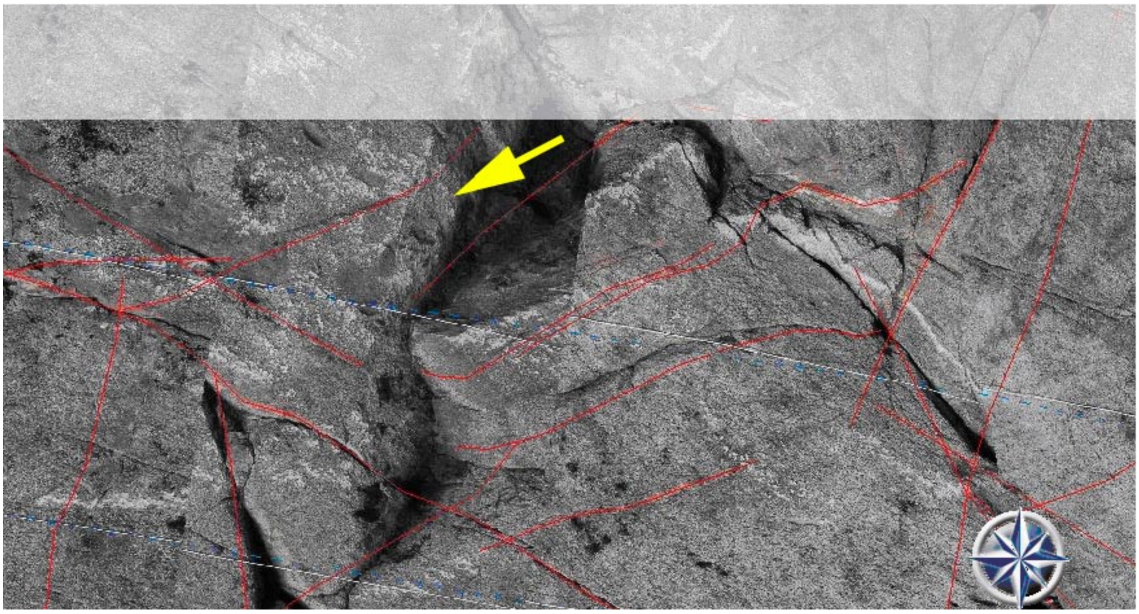


Figure A2-1. *ASM000114. Picture from the western part of the trench. Partly open fracture, perpendicular to the trench orientation, was missed during field work.*

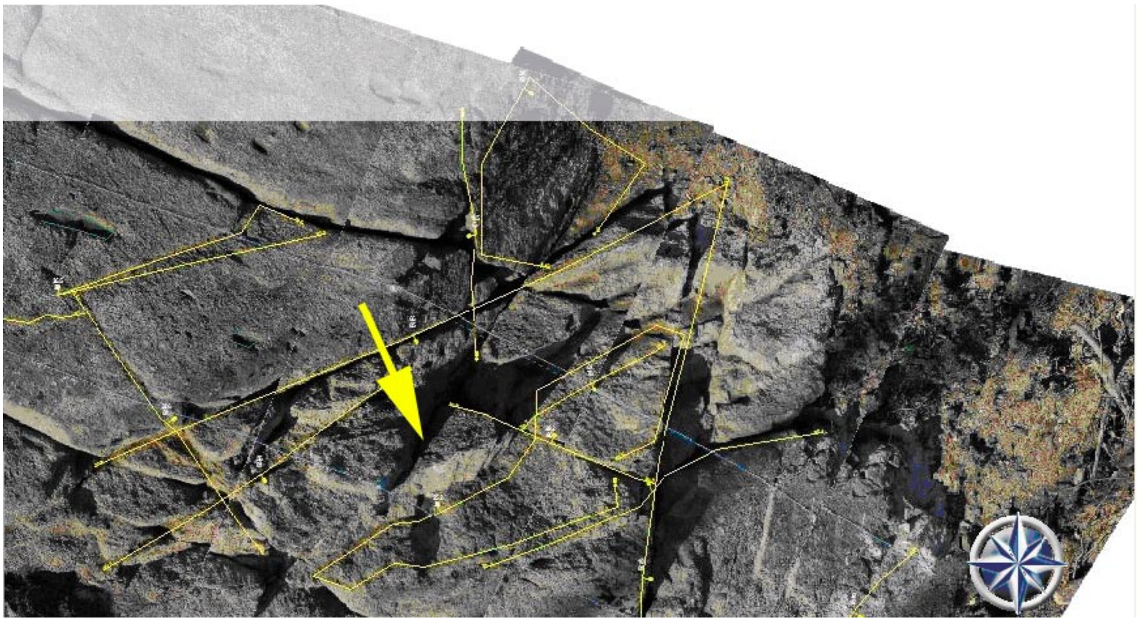


Figure A2-2. *ASM000116. Picture from the eastern part of the trench. Missed fracture perpendicular to the trench orientation.*

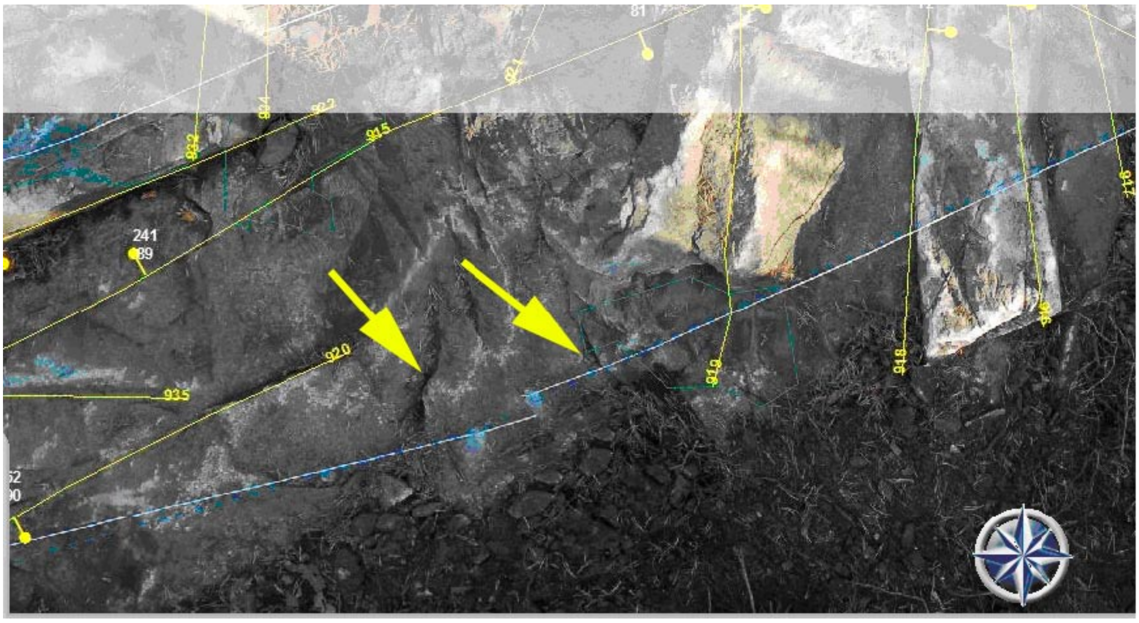


Figure A2-3. *ASM000117. Picture from the eastern part of the trench. Two fractures that are shorter than a meter, but extends into the vegetation. Could maybe have been included.*

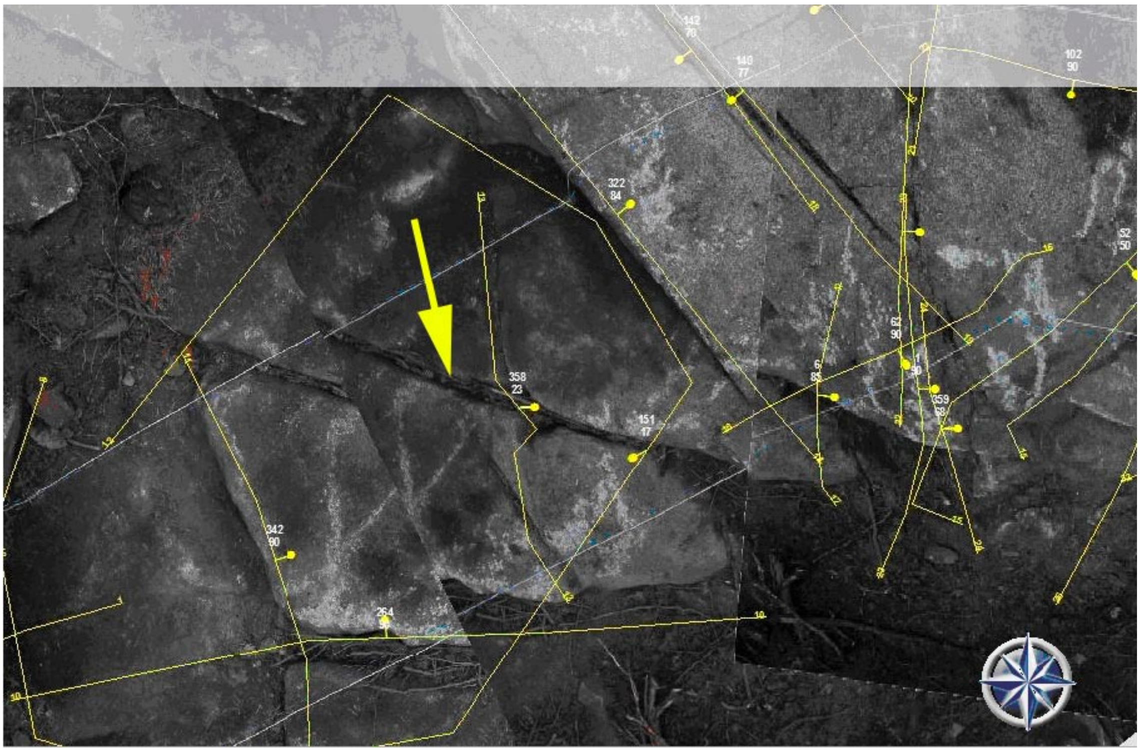


Figure A2-4. *ASM000118. Picture from the western part of the trench. Large open fracture that was missed in the field.*

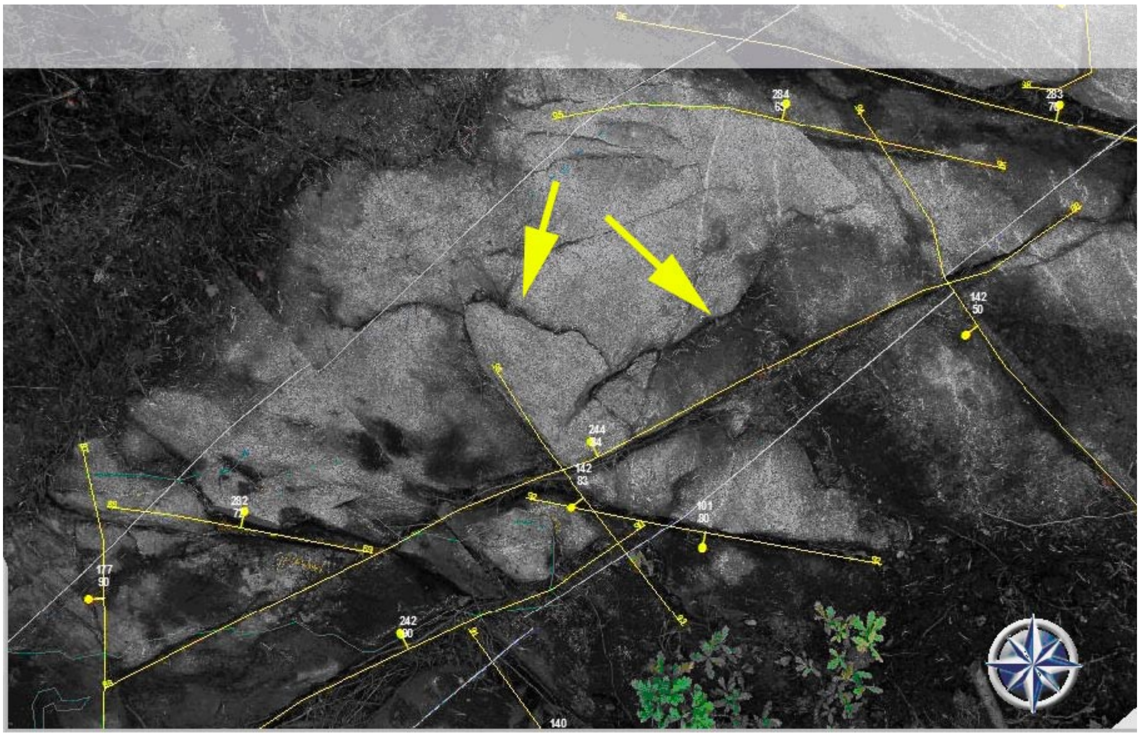


Figure A2-5. *ASM000118. Picture with two unmarked fractures. One is undulating towards northwest; the other is perpendicular to it. The fractures were regarded as several shorter fractures during field work.*

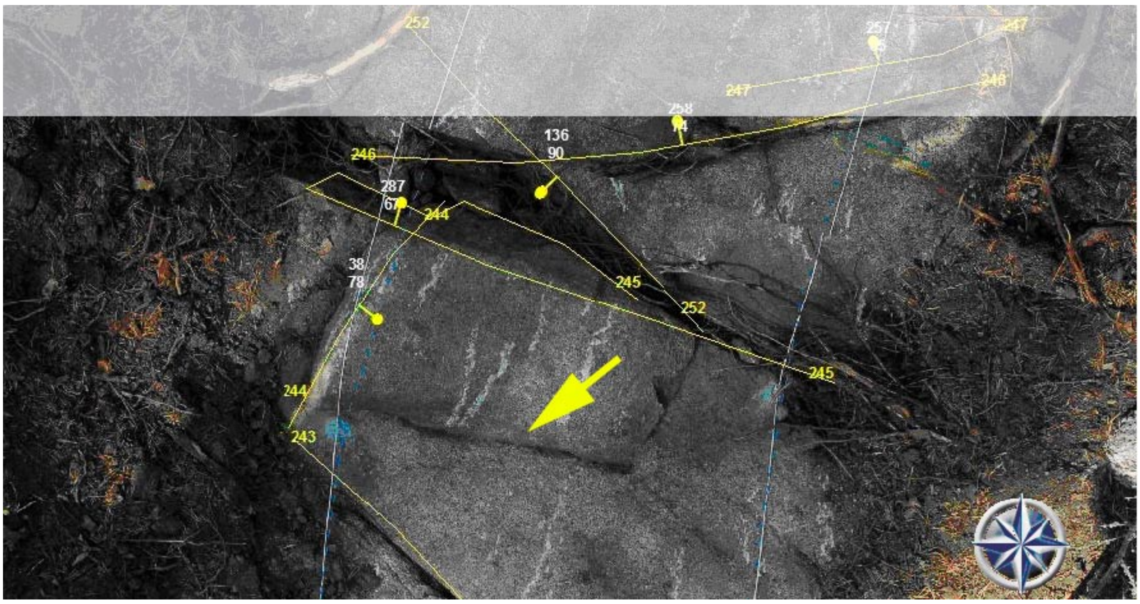


Figure A2-6. *ASM000119. Picture from the central part of the trench. Possibly a fracture, there is no visible trace, but a clear depression in the rock surface. The fracture may be extending into the vegetation.*

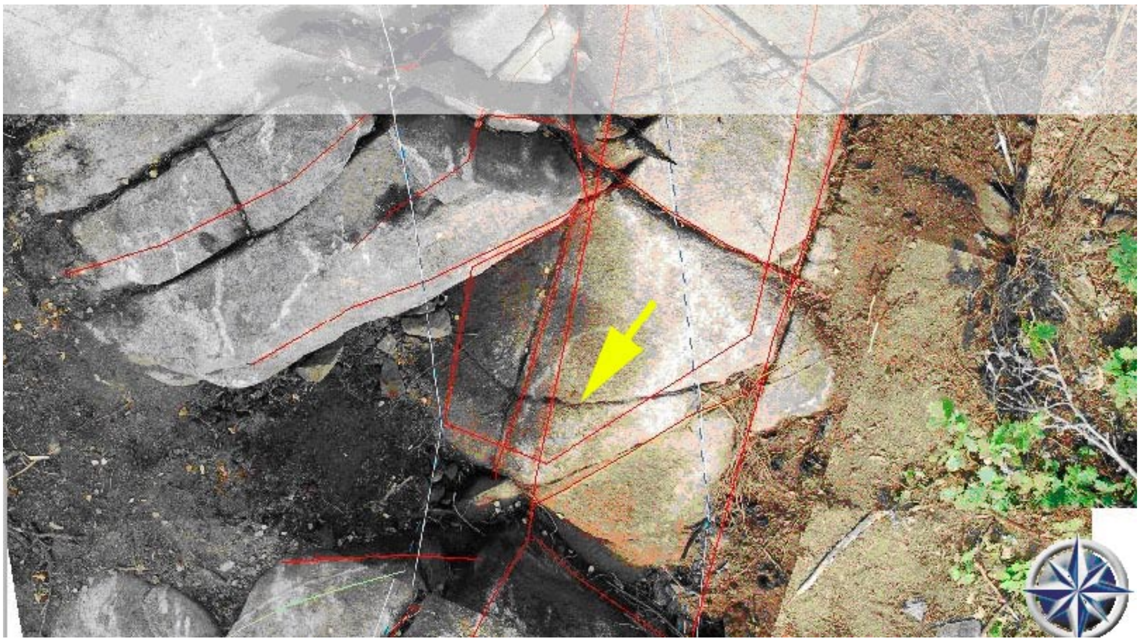


Figure A2-7. *ASM000121. Picture taken about 20 m from the northern part of the trench. This is probably a missed fracture with a relatively low dip. May be the polygon indicated (sub horizontal fractures are deceptive in 2D).*

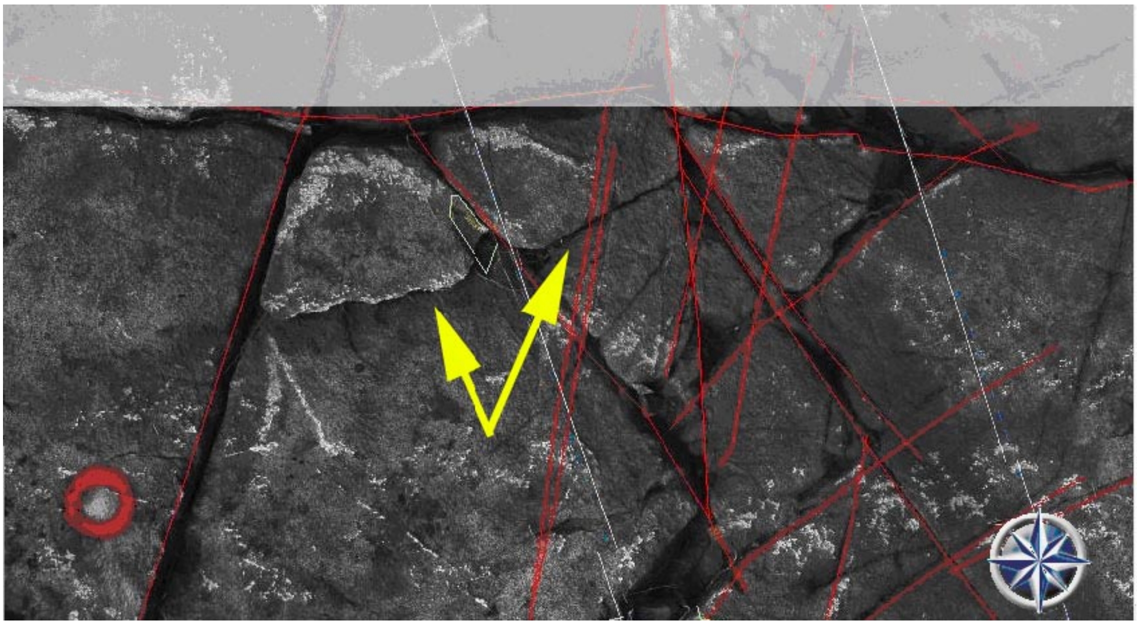


Figure A2-8. *ASM000122. Picture from the southern part of the trench. This is a typical case where the fracture appears to be missed during field work. For this particular fracture, field notes confirm that the segments are dipping in different directions, thus it is regarded as a set of individual fractures all less than 1 meter long.*

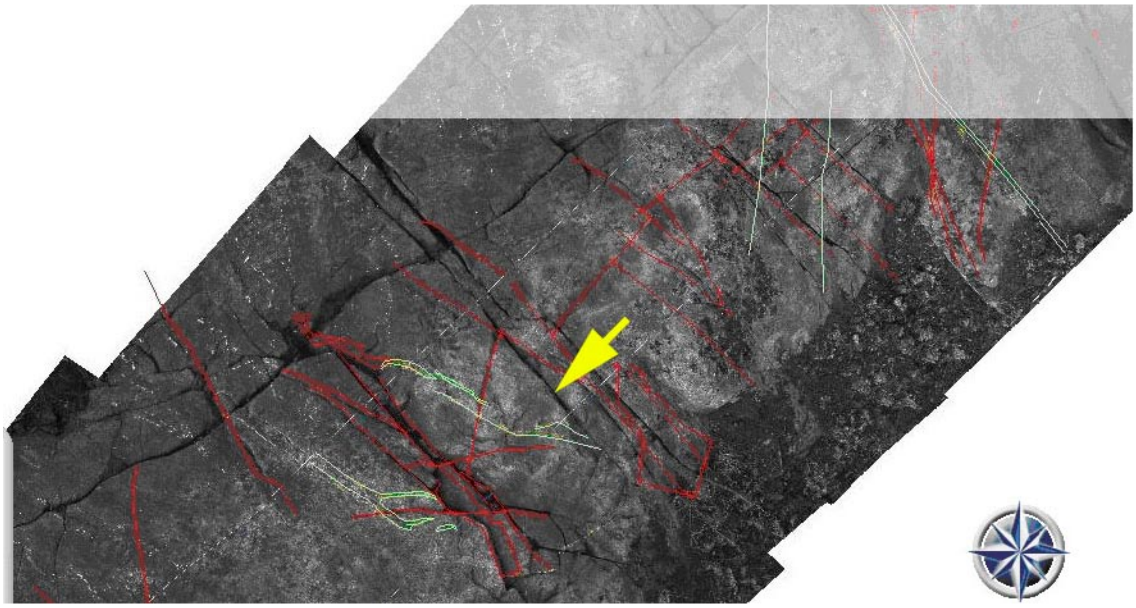


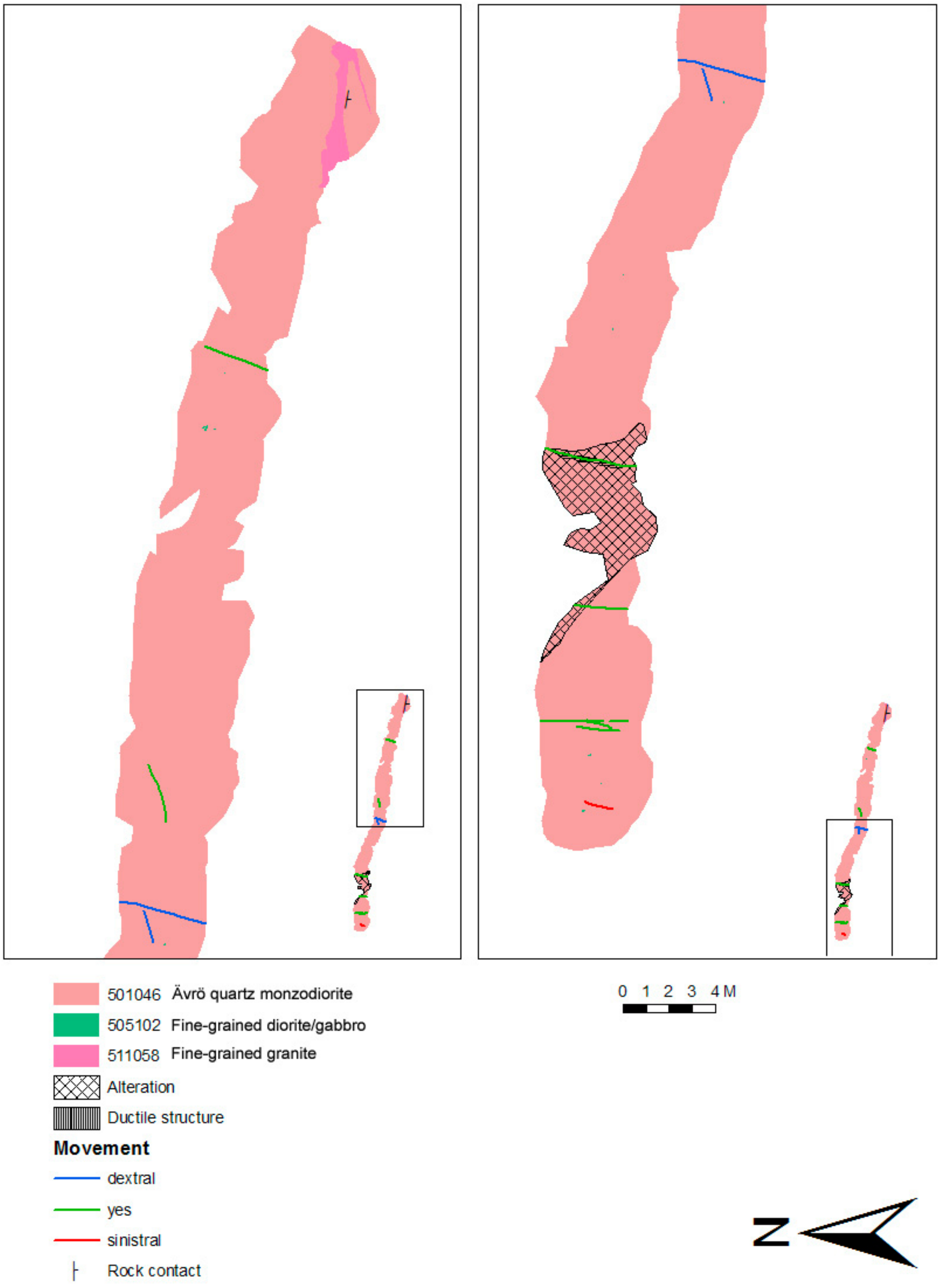
Figure A2-9. *ASM000123. Picture from the middle part of the trench. Larger fracture perpendicular to the trench that has been missed during field work. On the photo it looks like there are two fractures that have been missed. This is an effect of the picture overlaps mentioned in the text.*

Appendix 3

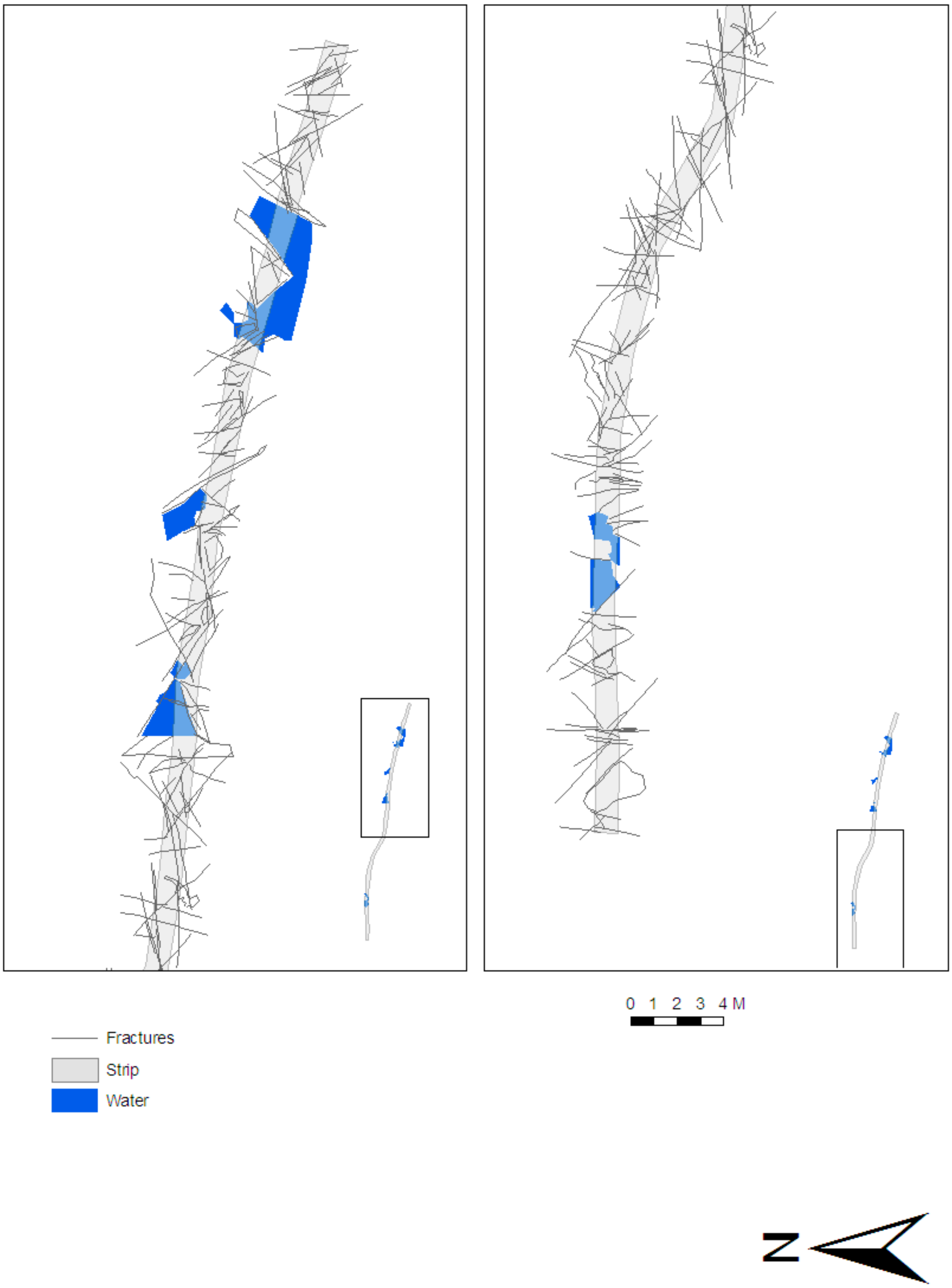
GIS illustrations of the ten trenches

Gathered spatial data of the 10 trenches

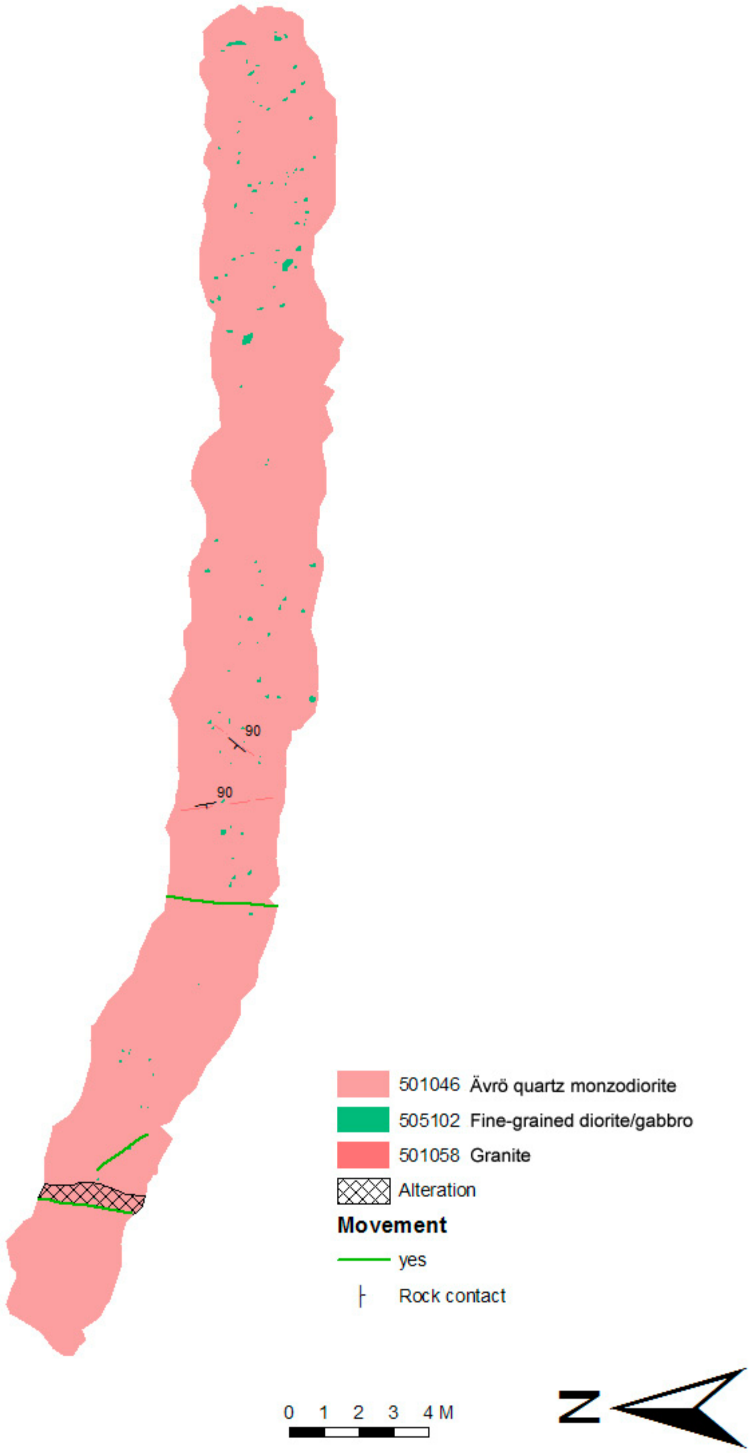
ASM000114


501046 Ävrö quartz monzodiorite
505102 Fine-grained diorite/gabbro
511058 Fine-grained granite
Alteration
Ductile structure
Movement
dextral
yes
sinistral
Rock contact
0 1 2 3 4 M
N

ASM000114- Mapped fractures

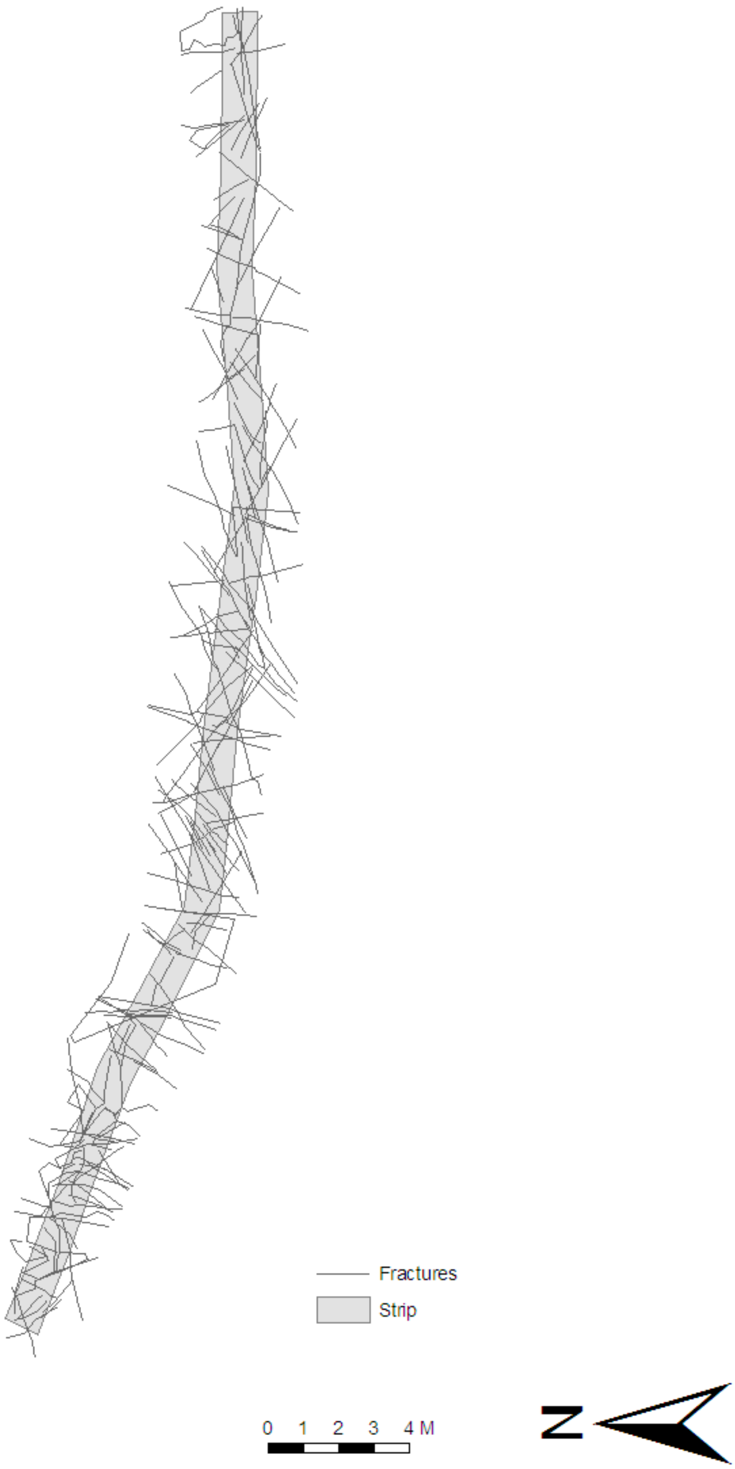


ASM000115

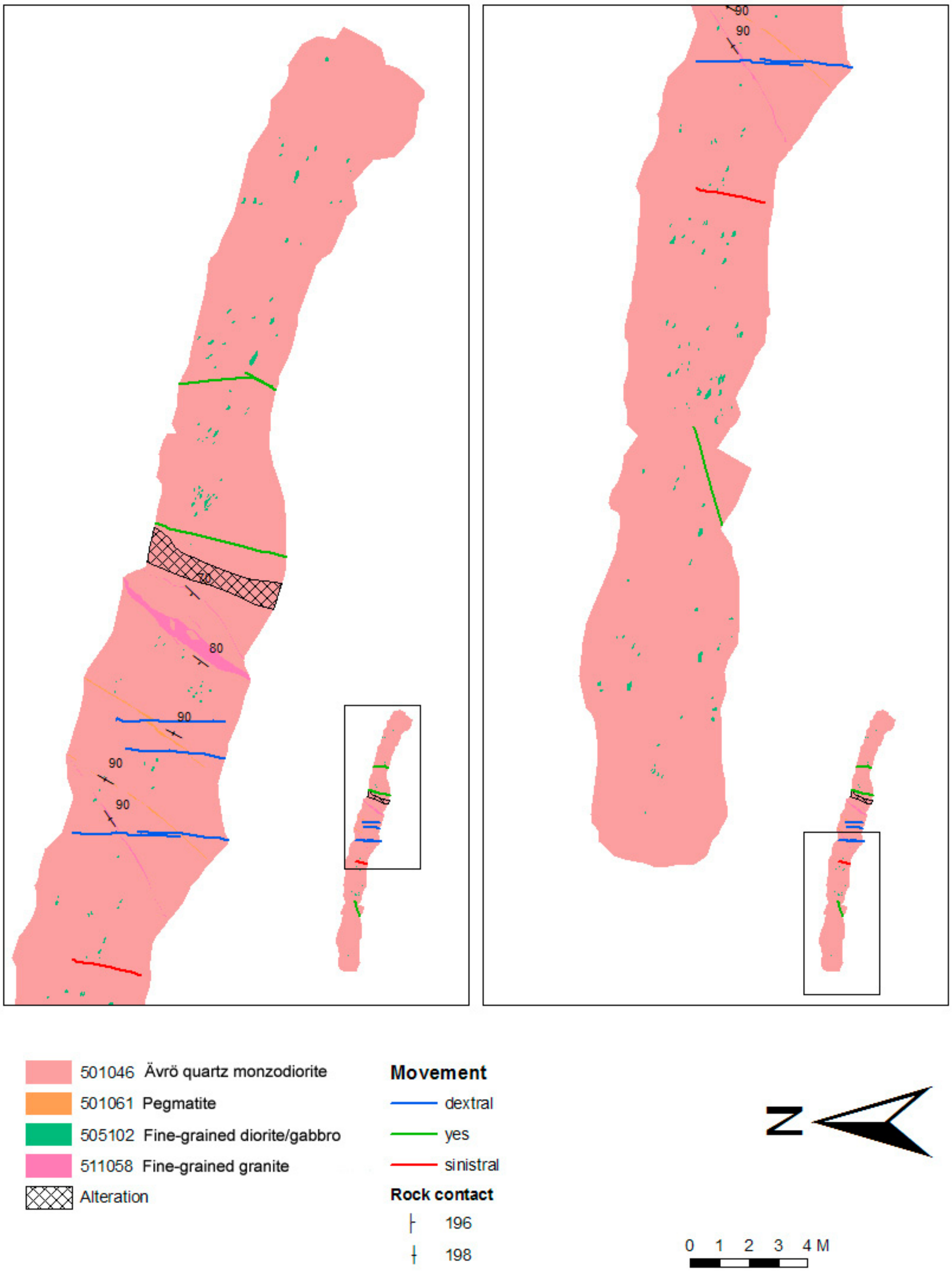


90
90
501046 Ävrö quartz monzodiorite
505102 Fine-grained diorite/gabbro
501058 Granite
Alteration
Movement
yes
Rock contact
0 1 2 3 4 M
N

ASM000115 - Mapped fractures



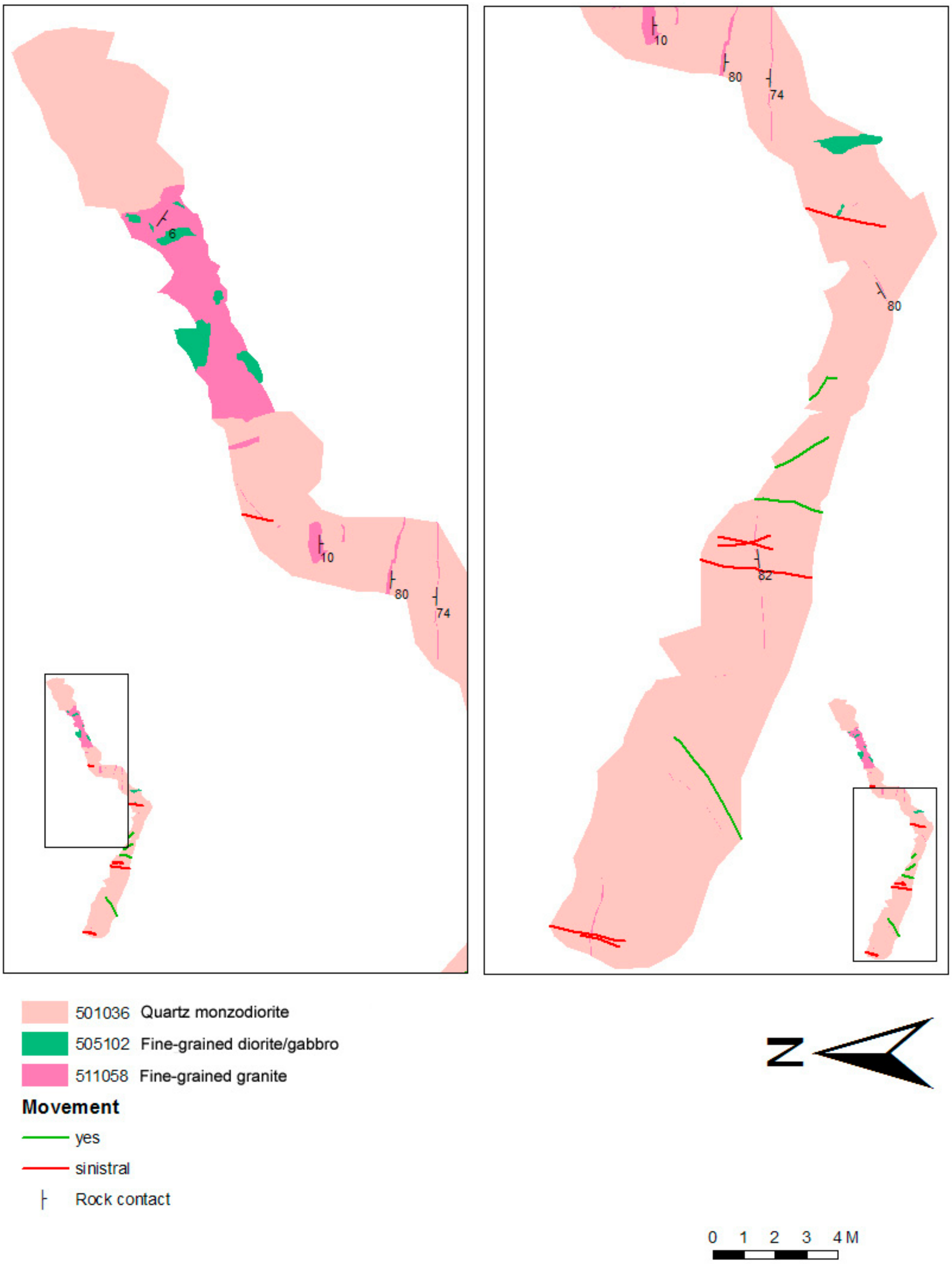
ASM000116



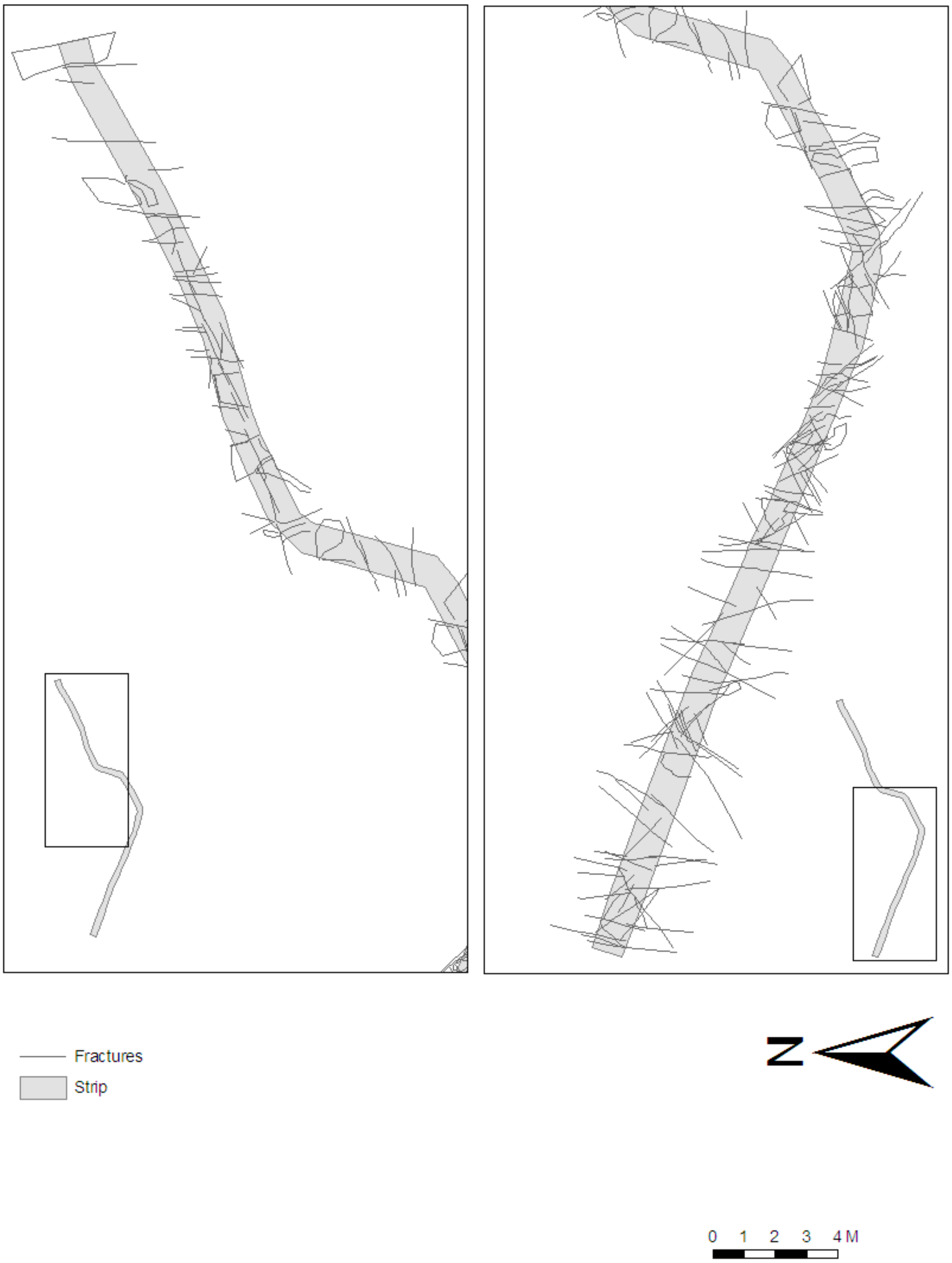
90
90
70
80
90
90
90
501046 Ävrö quartz monzodiorite
501061 Pegmatite
505102 Fine-grained diorite/gabbro
511058 Fine-grained granite
Alteration
Movement
dextral
yes
sinistral
Rock contact
196
198
N
0 1 2 3 4 M

ASM000116 - Mapped fractures

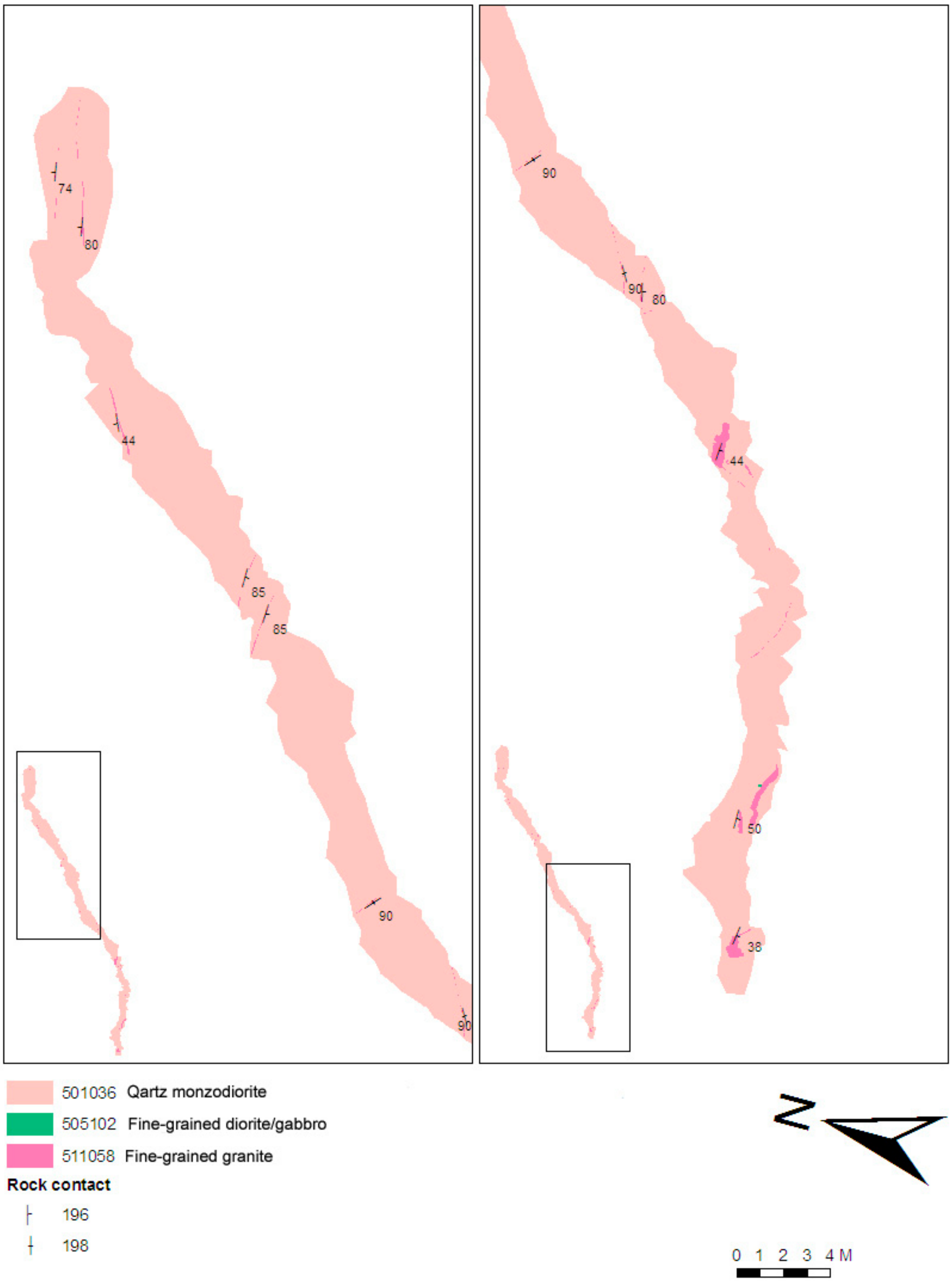
ASM000117


10
80
74
6
10
80
74
80
82
501036 Quartz monzodiorite
505102 Fine-grained diorite/gabbro
511058 Fine-grained granite
Movement
yes
sinistral
Rock contact
N
0 1 2 3 4 M

ASM000117 - Mapped fractures

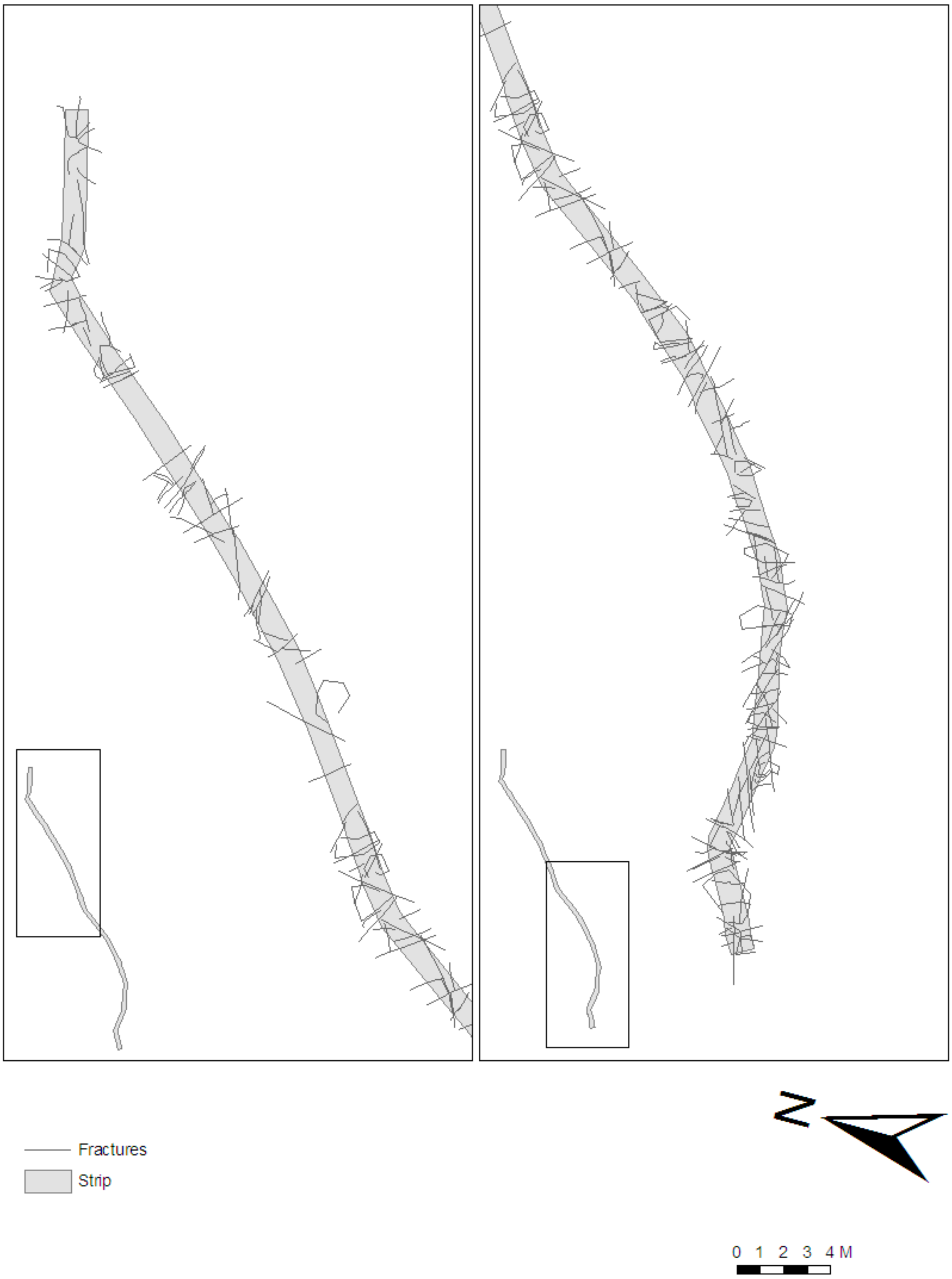


ASM000118

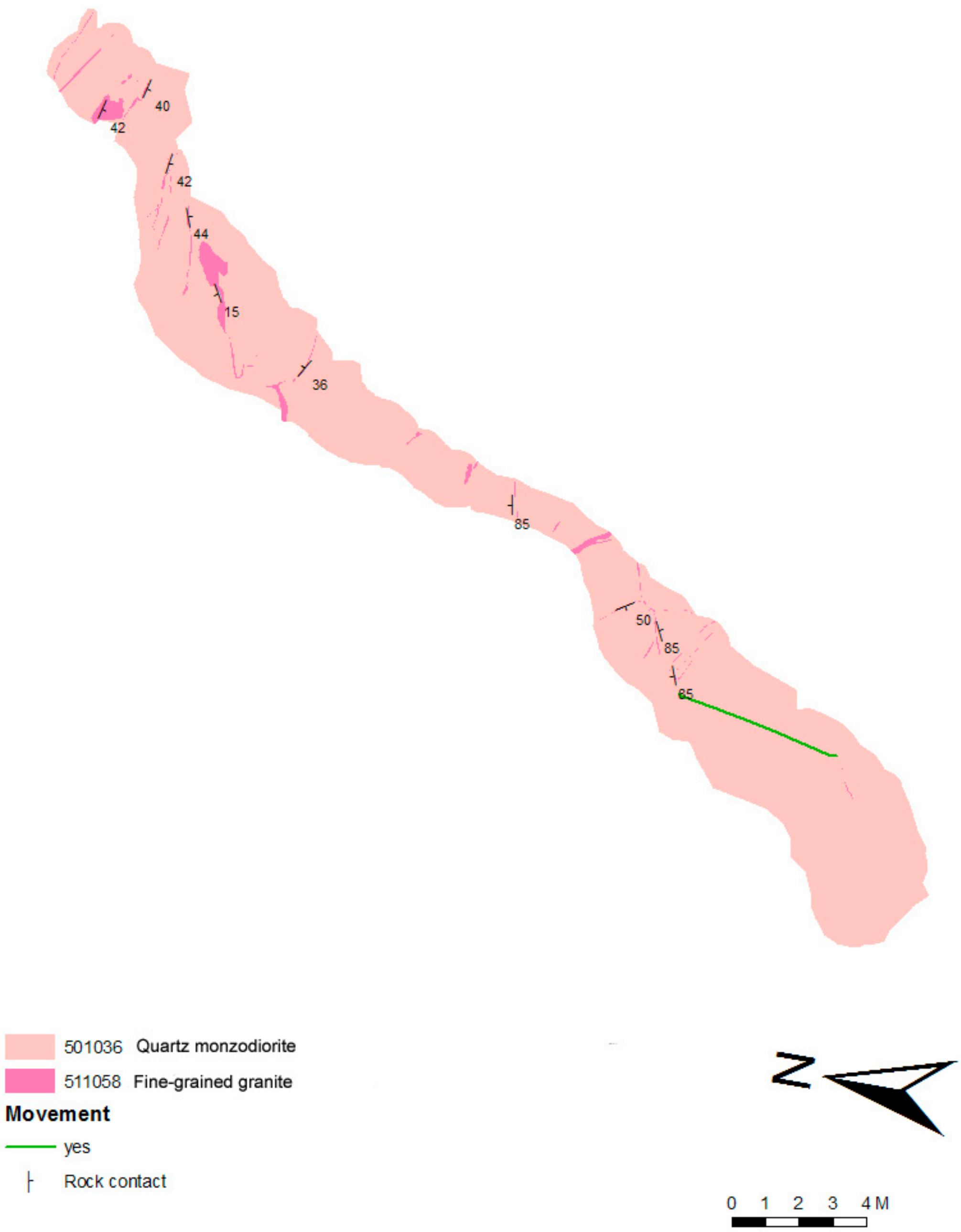


74
80
44
85
85
90
90
90
90
80
44
50
38
501036 Qartz monzodiorite
505102 Fine-grained diorite/gabbro
511058 Fine-grained granite
Rock contact
196
198
N
0 1 2 3 4 M

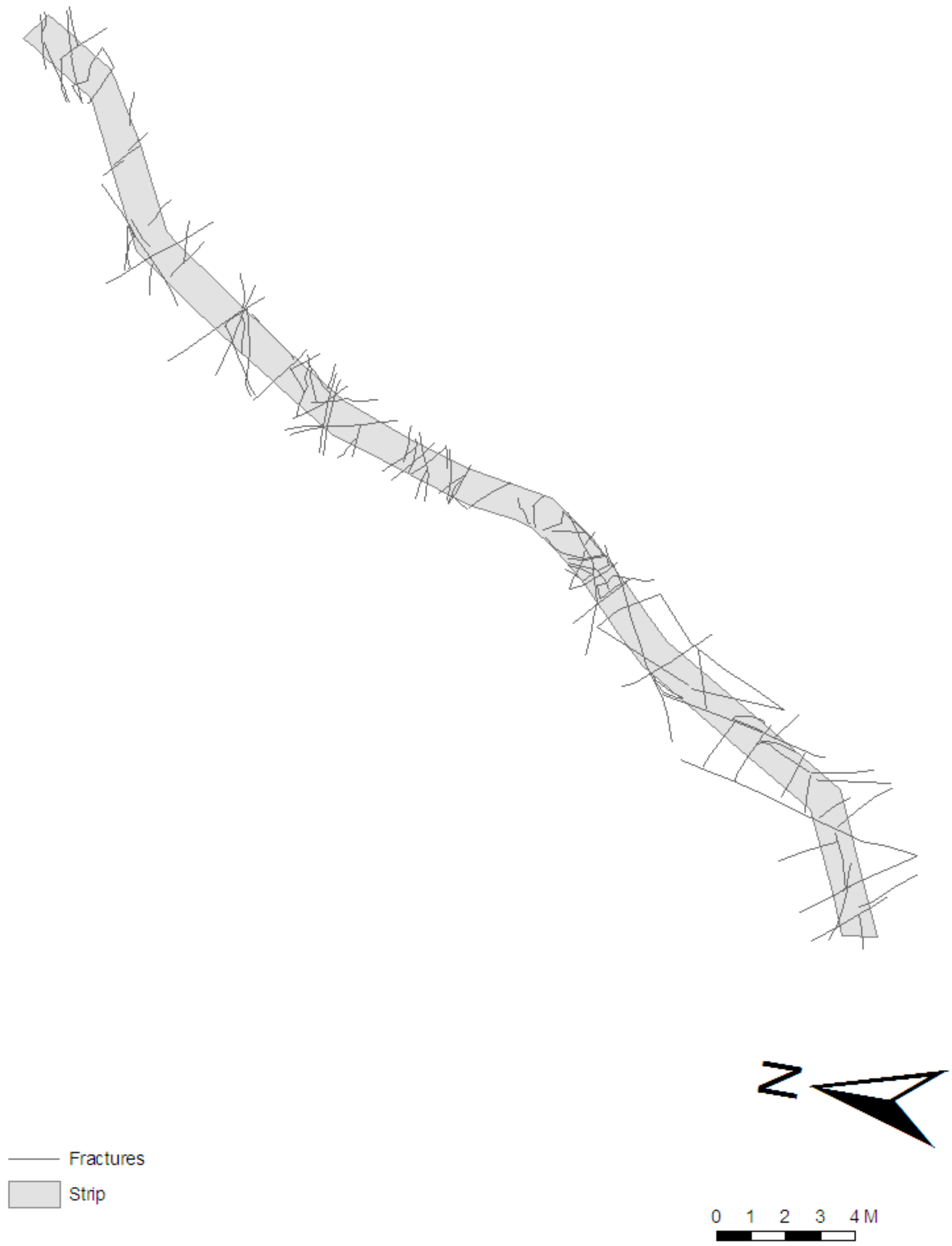
ASM000118



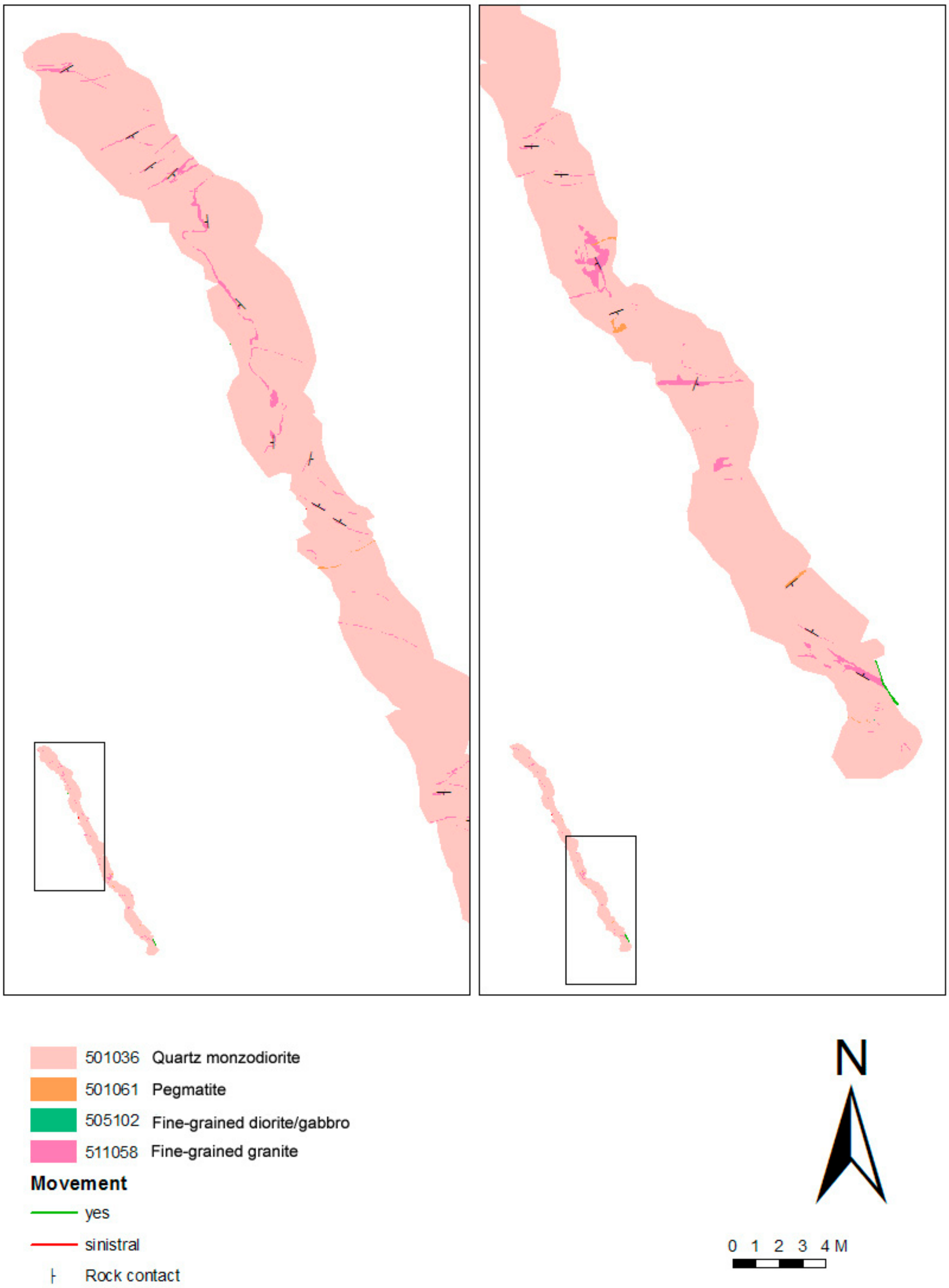
ASM000119


40
42
42
44
15
36
85
50
85
85
501036 Quartz monzodiorite
511058 Fine-grained granite
Movement
yes
Rock contact
N
0 1 2 3 4 M

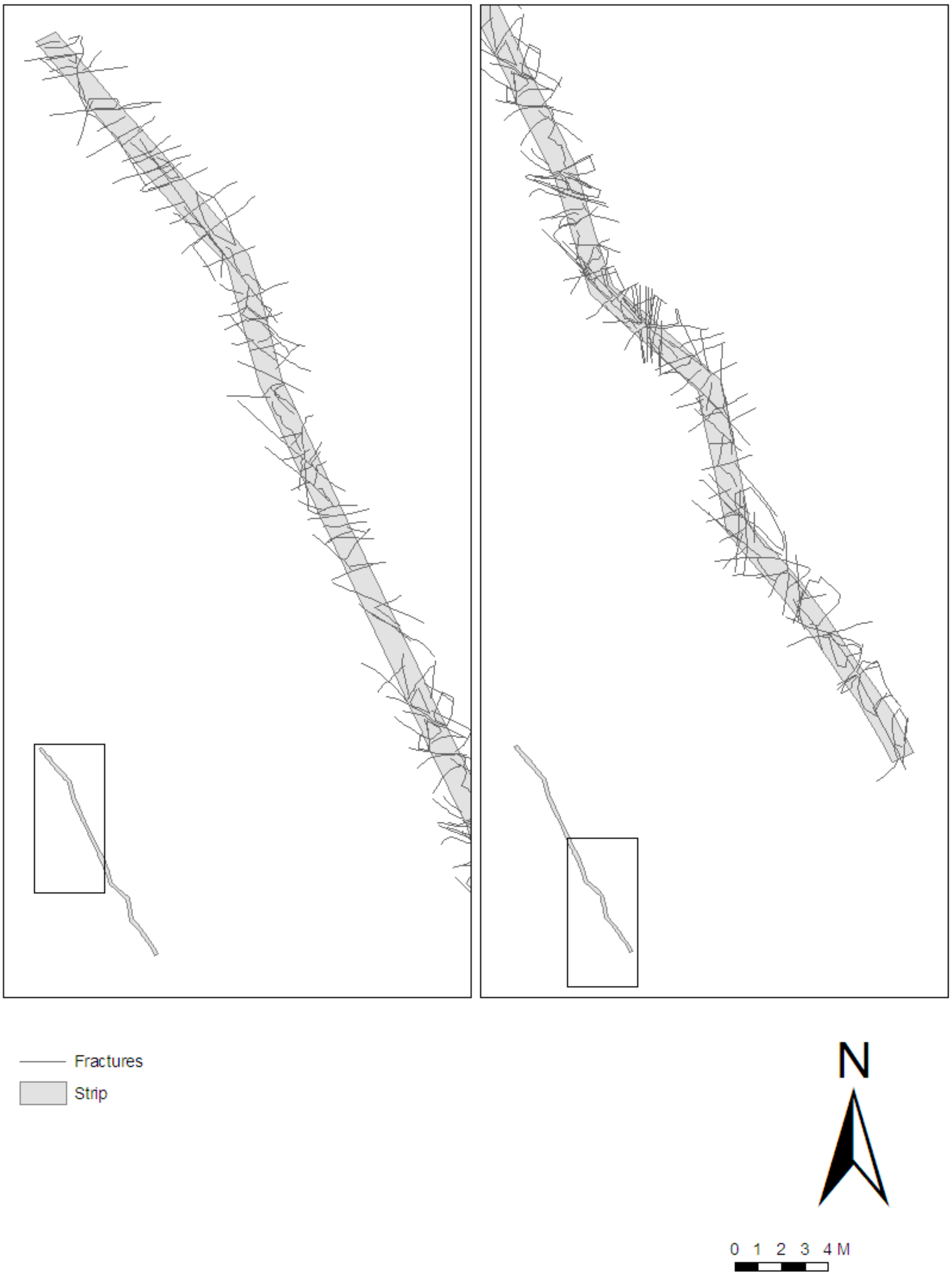
ASM000119 - Mapped fractures



ASM000120


501036 Quartz monzodiorite
501061 Pegmatite
505102 Fine-grained diorite/gabbro
511058 Fine-grained granite
Movement
yes
sinistral
Rock contact
N
0 1 2 3 4 M

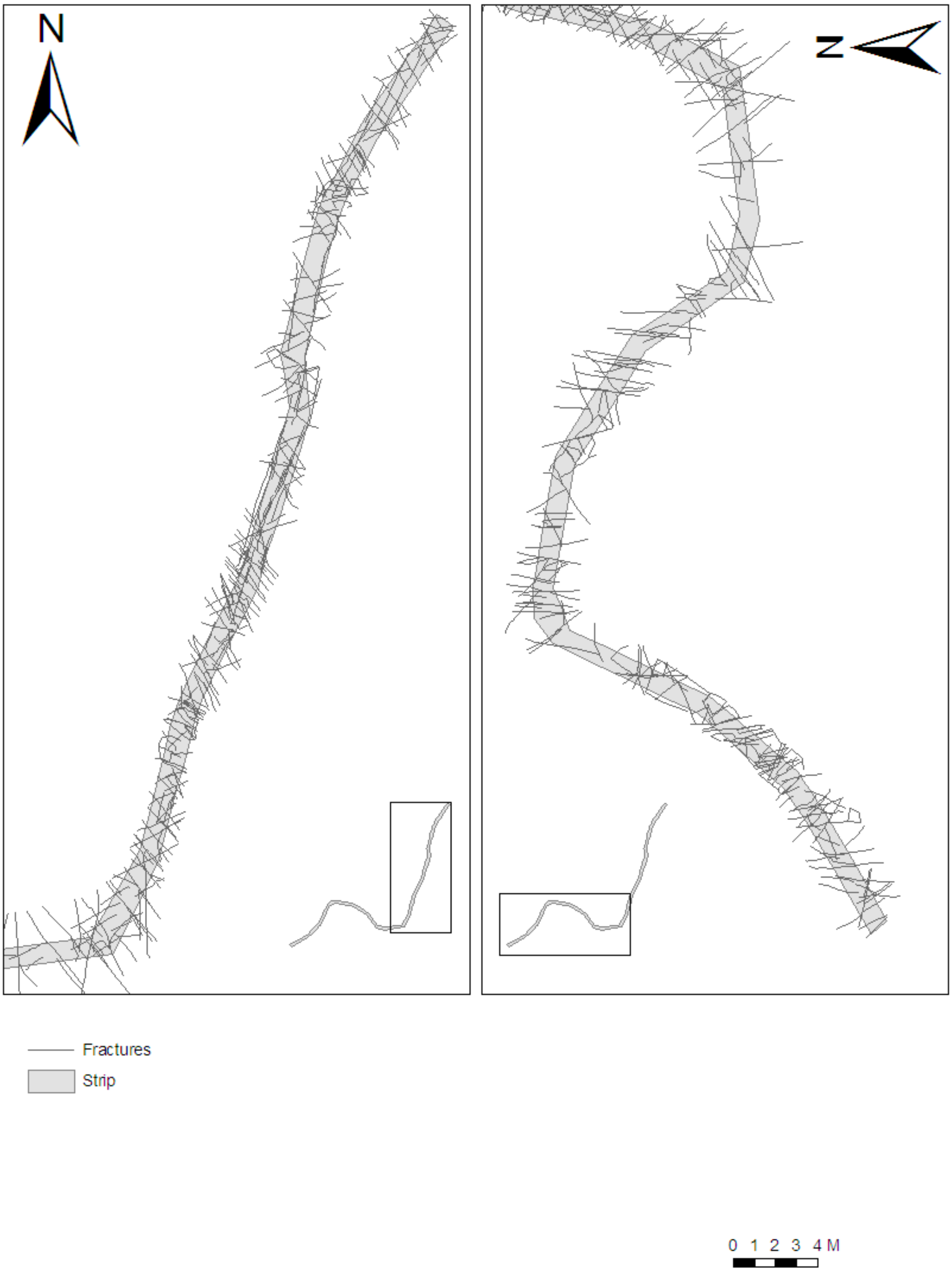
ASM000120 - Mapped fractures



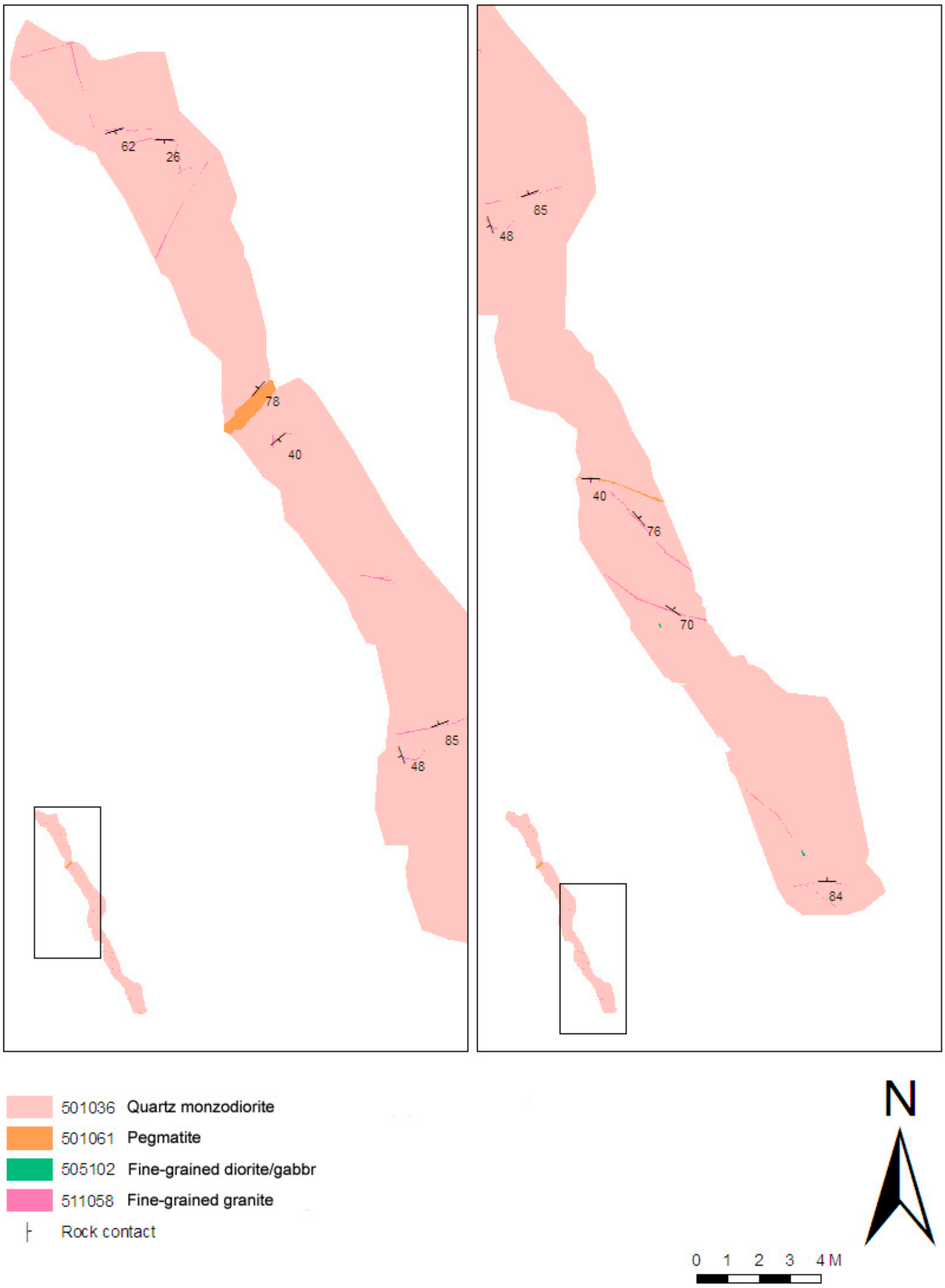
ASM000121


N
40
76
85
88
87
34
86
74
84
74
88
48
20
70
85
20
70
85
N
86
82
80
80
70
80
501036 Quartz monzodiorite
501061 Pegmatite
511058 Fine-grained granite
Movement
dextral
sinistral
Rock contact
0 1 2 3 4 M

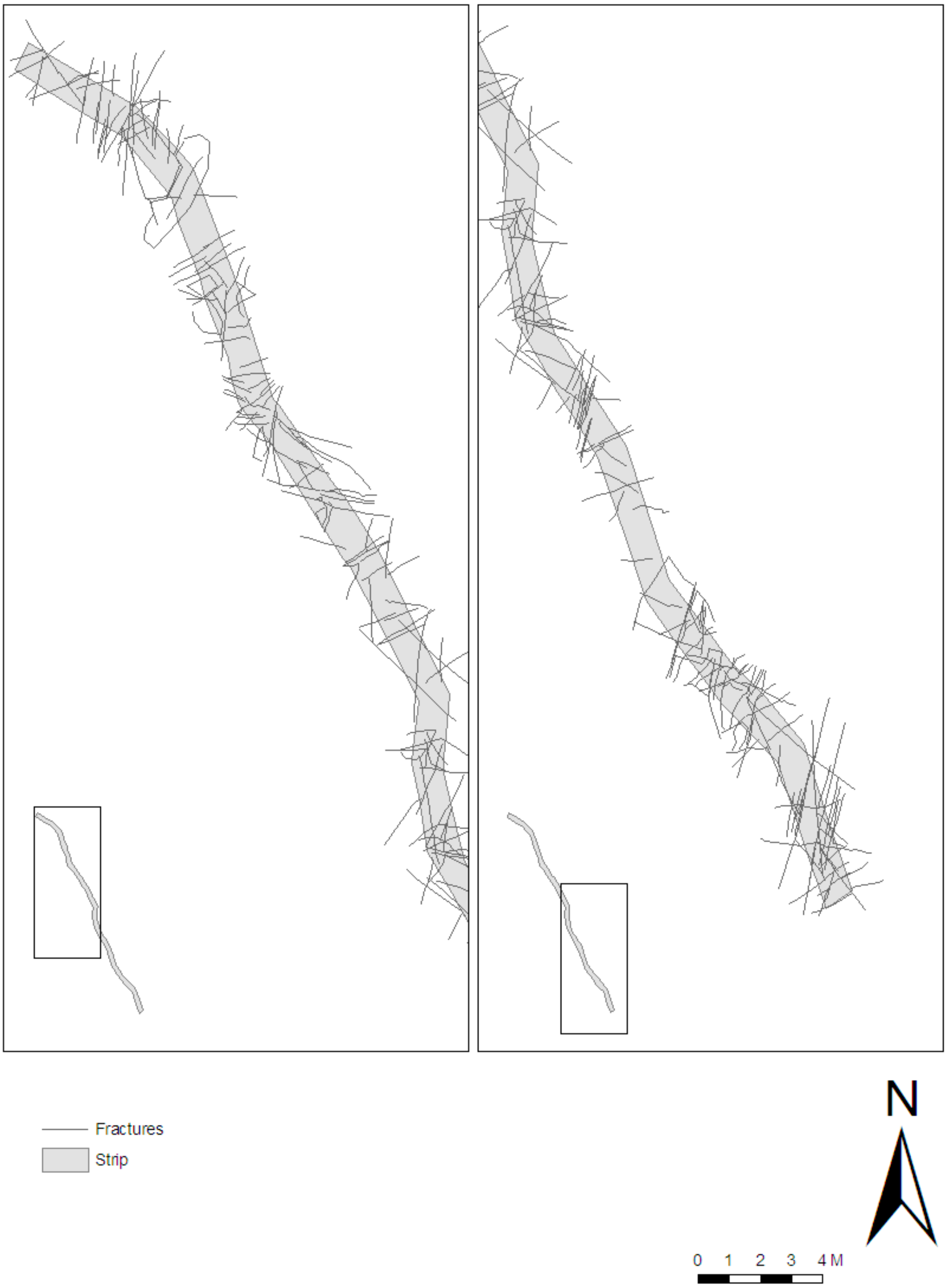
ASM000121 - Mapped fractures



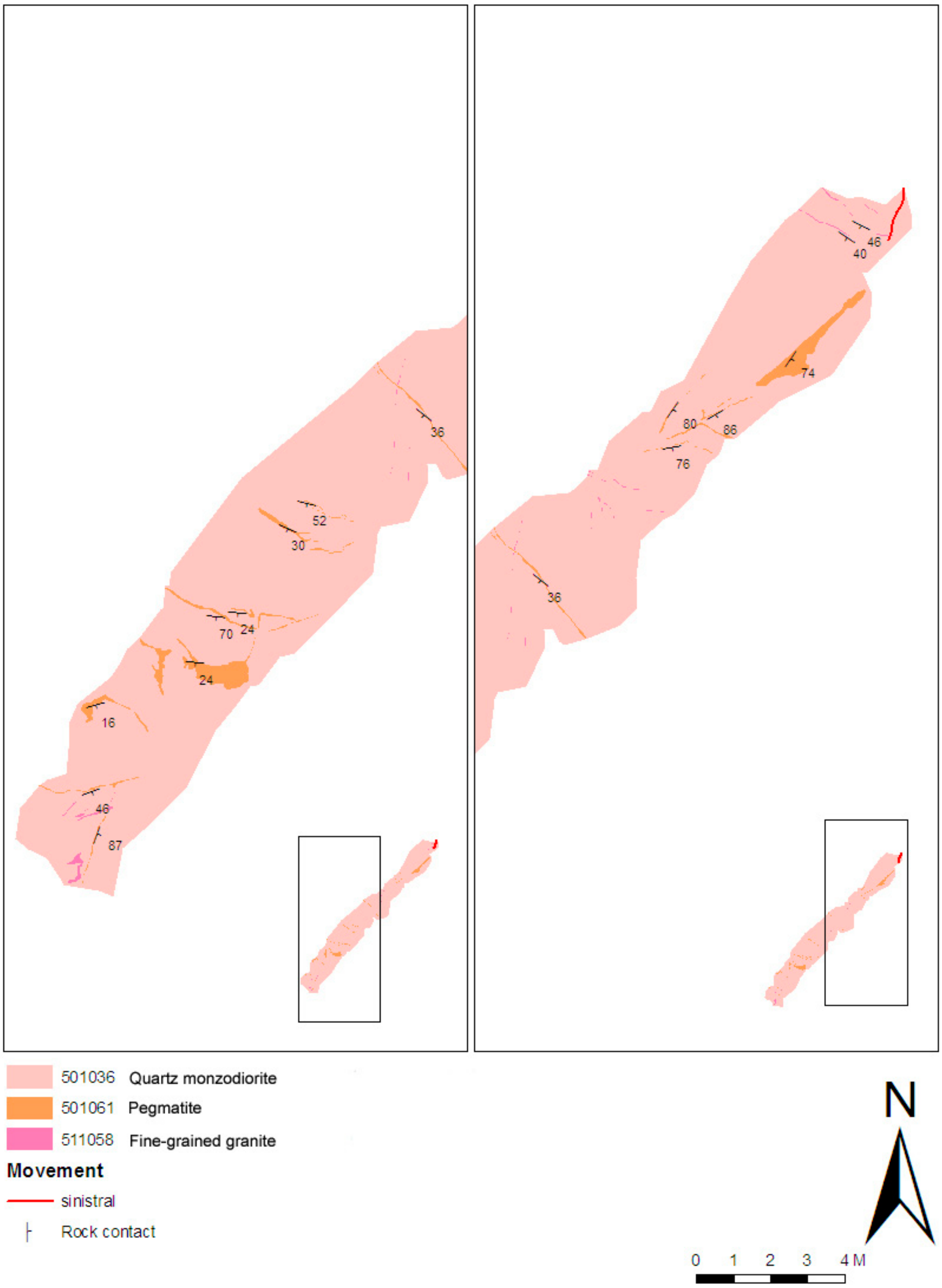
ASM000122


62
26
78
40
85
48
85
48
40
76
70
84
501036 Quartz monzodiorite
501061 Pegmatite
505102 Fine-grained diorite/gabbr
511058 Fine-grained granite
Rock contact
N
0 1 2 3 4 M

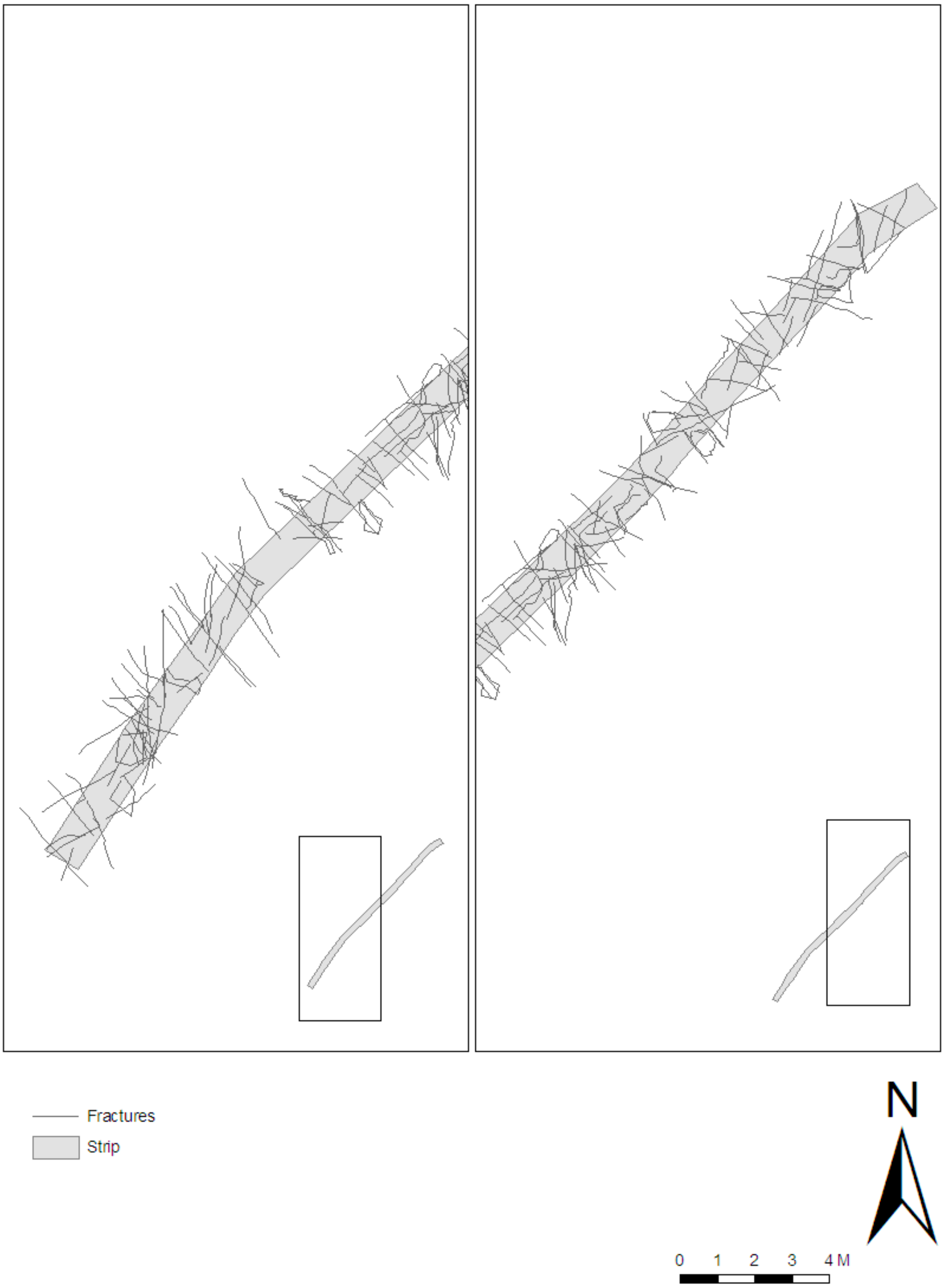
ASM000122 - Mapped fractures



ASM000123


36
52
30
70
24
24
16
46
87
46
40
74
80
86
76
36
501036 Quartz monzodiorite
501061 Pegmatite
511058 Fine-grained granite
Movement
sinistral
Rock contact
N
0 1 2 3 4 M

ASM000123 - Mapped fractures



Samples of the geo-rectified photographic series of the outcrops

Sample from the detailed photo study. Overview and extracts from trench ASM000122.