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Oskarshamn site investigation

Scan line fracture mapping

Subarea Laxemar and passage for tunnel

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October 2004

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Abstract

As part of the mapping of the bedrock geology in the candidate area in Oskarshamn, subarea Laxemar, a scan-line mapping of fractures is performed on selected outcrops. The purpose of this is to get a picture of the spatial variation of fracture frequency and fracture orientation, in the area and in relation to separate rock types. All fractures with a trace length of 1 m or more have been mapped along tape measures in orthogonal lines. A total length of 10 m in both north-south and east-west directions was mapped on each outcrop.

The activity in the Laxemar area comprises 24 localities, with a total line length of 480 m. 894 fractures have been mapped and the mean fracture frequency is 1.86 fracture per metre for the outcrops. The variation is large, however, and varies from 0.65 to 3.05 fractures per metre. Also the orientation varies considerably in the area, though many of the individual outcrops show distinctive sets of fractures.

Sammanfattning

I samband med den geologiska berggrundskarteringen av kanditatområdet i Oskarshamn, delområde Laxemar, genomförs en linjekartering av sprickor på ett antal utvalda hällar. Avsikten med detta är att få en uppfattning om den regionala variationen av sprickriktningar och sprickfrekvens i området, samt i olika bergartsled.

Samtliga sprickor med en spårlängd större eller lika med 1 meter på hällytan har karterats utmed linjer som markerats med måttband. Linjerna är totalt 10 meter långa i vardera nord-sydlig riktning och ost-västlig riktning på respektive häll.

Karteringsinsatsen inom delområdet Laxemar omfattar 24 separata lokaler, totalt 480 meters längd. 894 sprickor har kartlagts och medelvärdet för sprickfrekvensen på hällarna är 1.86 sprickor per meter. Variationen är stor, från 0.65 till 3.05 sprickor per meter, mellan de olika hällarna. De flesta sprickriktningar finns representerade i området, men med ganska stor variation mellan hällar över området.

Contents

1 Introduction

This document reports the results gained by the “Linjekartering delområde Laxemar och korridoren för tunnelpassagen”, which is one of the activities performed within the site investigation at Oskarshamn, subarea Laxemar. The work was carried out in accordance with activity plan AP PS 400-04-059 and SKB MD 132.003 (both internal controlling documents). In Table 1-1 controlling documents for performing this activity are listed.

During the site investigation at Forsmark and Oskarshamn the mapping of the surface bedrock geology has been carried out by the geological survey of Sweden. This mapping focus on the lithology and the ductile deformation the rock has suffered from. As part of the field mapping also the brittle deformation of the rock is documented. This sub-activity has been fulfilled by the present activity. A similar procedure was conducted for the Simpevarp subarea. The fieldwork was conducted during weeks 34 and 35, 2004.

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

Activity plan	**Number**	**Version**
Linjekartering delområde Laxemar och korridoren för tunnelpassagen	AP PS 400-04-059	1.0
Method description	**Number**	**Version**
Metodbeskrivning för detaljerad sprickundersökningar på berghällar	SKB MD 132.003	1.0

Table 1-2. Data references.

Subactivity	Database	Identity number
Scan line mapping of fractures	SICADA	Field note Simpevarp 514

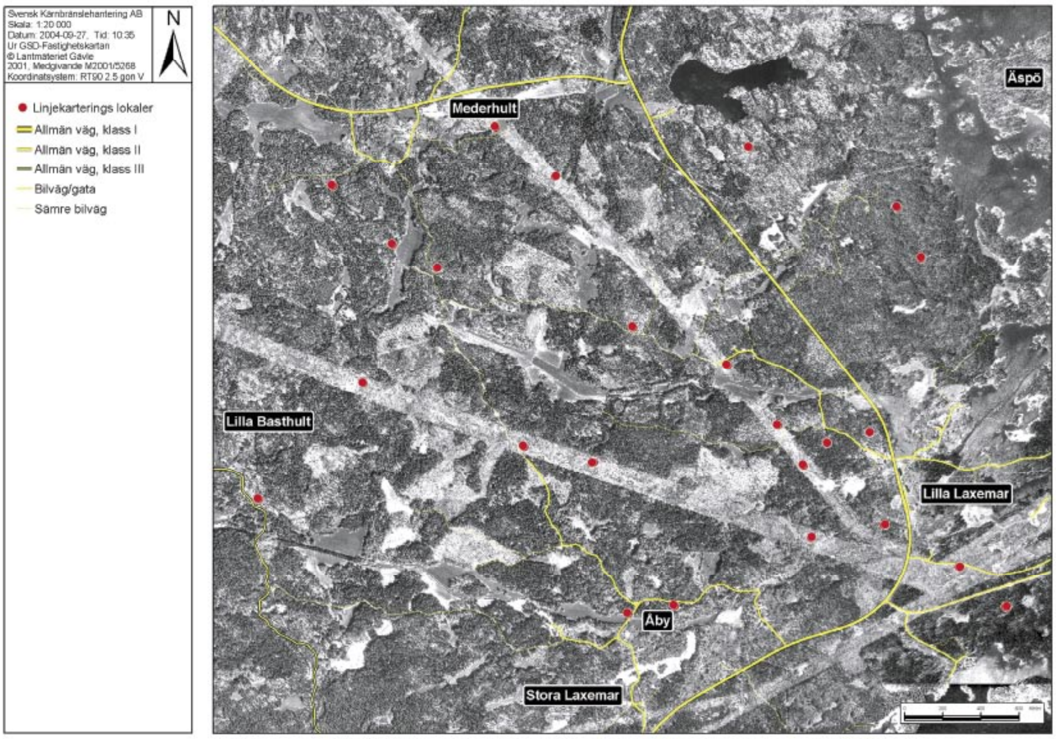

Figure 1-1. *Map showing the localities for scan line mapping of fractures in the present activity.*

2 Objective and scope

As a part of the bedrock mapping of subarea Laxemar, twenty-four outcrops were selected for fracture mapping. The locations of these, shown in Figure 1-1, were chosen to cover the candidate area spatially and geologically. The mapping was conducted along two or several orthogonal scan lines on each outcrop. The scan lines have a N-S and E-W direction with a total length of ten metres in each direction.

The mapping procedure is somewhat simplified compared to the Scan line mapping of fractures, described in the methodology description (MD 132.003, detaljerad sprickundersökning på berghällar, SKB internal controlling document).

A lower cut off was set to 100 cm. An upper truncation is ruled by the size of the uncovered trenched, 2 m wide and up to 10 m long

The intention of the mapping is to get a better view of the spatial distribution of fracture sets, fracture orientation and fracture intensity. The activity complements the bedrock mapping of outcrops and aims to collect data to be used as a basis for forthcoming analysis and modelling of fractures within the regional modelling area.

3 Equipment

Description of equipment/interpretation tools.

The equipment used during this activity was:

- GPS instrument Garmin® "Etrex Venture"
- Silva Compass
- Tape measure
- Observation protocols
- Magnification lens
- Knife
- Brush
- Shovel
- Spade
- Digital Camera

The coordinates (RT90) given from the GPS at a fix point close to the Site investigation office was documented regularly in order to avoid larger day-to-day differences in the measure.

In 2004 the magnetic declination in the area was c 3.5° (www.sgu.se, Geological Survey of Sweden).

4 Execution

4.1 General

The outcrops were generally covered with moss, lichen and partly also soil. Moss and soil, including roots etc, was uncovered as far as needed to complete the mapping, using brushes and shovels. However, the lichen was generally not possible to remove with the tools used. After conducted mapping the moss etc was put back on the outcrop. The scan lines were located on parts of outcrops where minimal uncover of soil etc was needed.

The following information are documented at the 24 outcrops:

- ID-code, line (LSM-number).
- ID-code, outcrop (PSM-number).
- Date.
- Coordinates for the start and end points of the lines
- Line trend.
- Line length.
- Position of crossing line.
- Number of fractures measured along the line.
- Fracture ID-numbers.
- Position of the fractures along the line, measured in metre with two decimals, from south to north (line trend 360°) and west to east (line trend 90°), respectively.
- Strike and dip of the fractures.
- Number of visible fracture endings (0, 1 or 2).
- Where relevant, descriptive information in free text format, including fracture filling if identified.

4.2 Preparations

The selection of outcrops where made by the staff at SGU (geological survey of Sweden) who completed the field mapping of the rock geology at outcrops in the summer 2004, together with the SKB staff of this activity at the site.

The maps used during the fieldwork were provided by SKB.

The protocols used in the field was made and protected with plastic covers by SwedPower prior to the fieldwork.

The equipment used to uncover and restore the outcrops was provided by SKB.

4.3 Execution of fieldwork

Two persons fulfilled the fieldwork; one writing the protocols while the other one mapped and measured the fractures.

1 m was uncovered on each side of the line and a tape measure was lined up along the centre of the uncovered outcrop. As a first step all fractures to be measured was marked (strike and endings) with white chalk. Then each fracture was measured and scrutinised for fracture infillings and aperture.

Fractures that did not cross the scan line were ignored. Fractures that crossed more than one scan line in an outcrop were measured in both scan lines, and this was also noted in the comment field. Parallel fractures closer than c 2 cm apart were considered as one fracture. Fractures that seem to end, but then continues along its course after a short brake (shorter than c 5 cm) were considered as one and the same fracture. Fractures with en echelon course was regarded as one fracture if their individual orientation was equal or less than a few degrees (< 5) and if the were closer than c 2 cm apart. Otherwise they were regarded separate fractures. The orientation of a fracture has been measured as close to the tape measure as possible.

The mapped fractures where generally open or slightly eroded at the surface. Even when present, infillings was normally very difficult to identify, because of weathering and/or lichen cover, and hence most fractures have no comment regarding fracture mineralogy or other infilling.

4.4 Data handling/post processing

At the office after each field session, the protocols were digitised, i.e. the hand written protocols were transformed to a Microsoft Excel® file.

The data were plotted and analysed using statistical functions in Excel and a program for stereographic projection (Geoplot). Fractures dipping 45° or more were plotted in rose diagrams.

- Briefly describe the various steps of the data handling process, from data acquisition (raw data files) to primary data files.

4.5 Analyses and interpretations

- Give a brief description of the method of analysis and the underlying theories, with references to the literature and which predictions that are made.
- Describe how the interpretation tool is validated.
- Generally, interpretation should only include data from this specific activity and not data from other activities. Also, no interpretation should be done that expresses influence on the deep repository.

4.6 Nonconformities

The methodology used here is a simplified version of the scan-line method described in MD 132.003 (SKB internal controlling document).

The outcrops were photographed only after they had been uncovered, i.e. they were not documented prior to this work.

5 Results

In total 894 fractures have been measured. The mean value for fracture frequency in the 24 outcrops is 1.86. It varies from a minimum of 0.65 to a maximum of 2.8 fractures per metre between the outcrops. A majority of the measured fractures are steeply dipping, although there probably is a bias related to the dominance of horizontal outcrops. Figure 5-1 has inset rose diagrams showing fracture frequency in different directions for each outcrop. Only fractures steeper than 45° have been plotted in the stereograms, which make up c 95% of the fractures (Figure 5-2).

It should be kept in mind when analysing the results that these outcrops represent elevated areas in the terrain that exhibit less altered and fractured rock than what may be found in topographically lower areas.

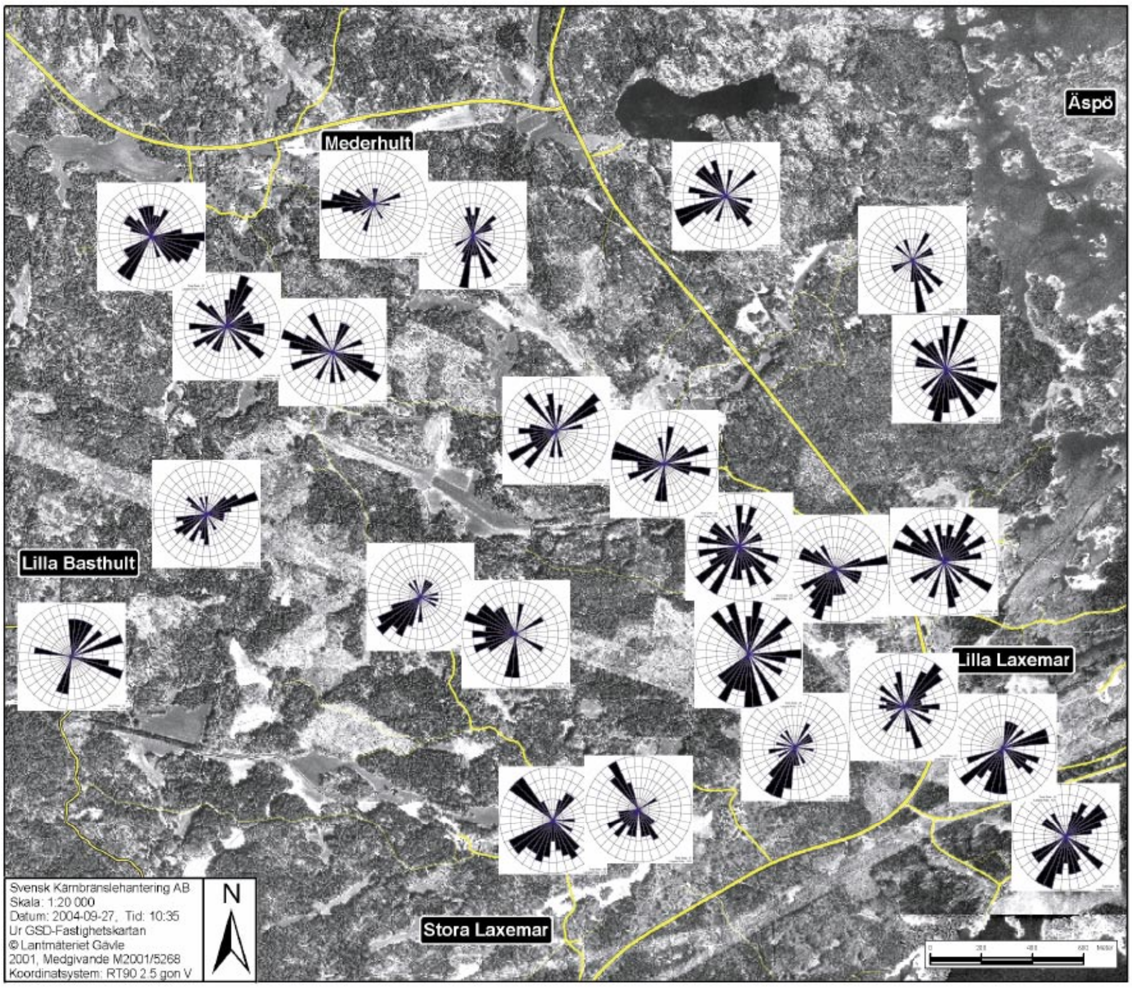

Figure 5-1. *Rose diagrams showing the strike of steep (≥ 45°) fractures at each outcrop. Note that the location of each stereogram is only approximately located, for space reason, and that the amount of fractures represented by the radius of each stereogram varies.*

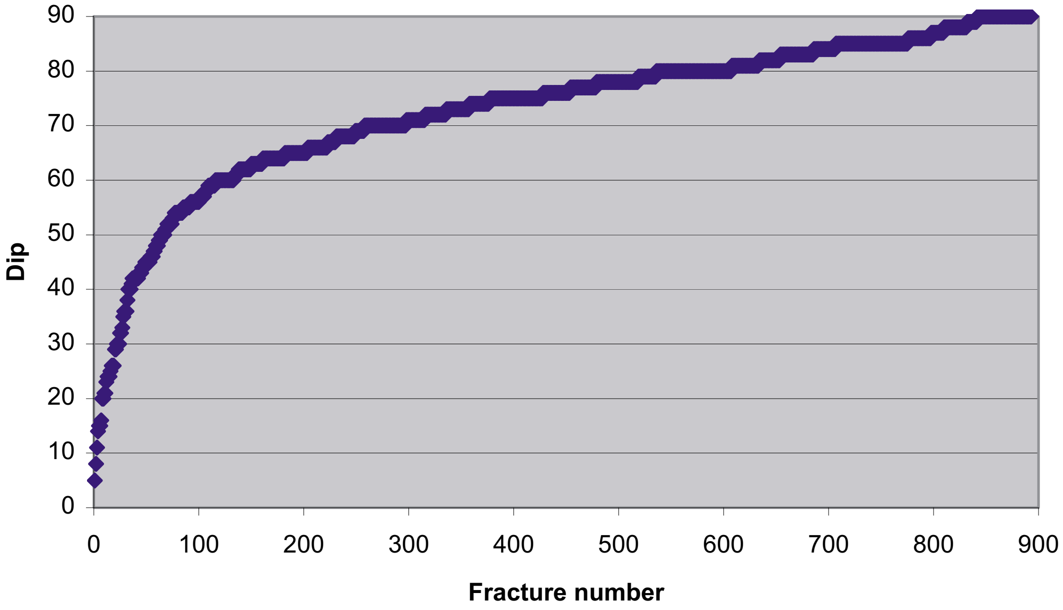

Figure 5-2. Diagram showing the dip of the mapped fractures.

Figure 5-3 show the distribution of fracture frequency in the 24 outcrops. By the frequency in this case is meant the average number of mapped fractures each metre along the scan line. The outcrop fracture data is separated into 0.5 fracture/m large boxes, i.e. there is 1 outcrop having between 0.5 and 1 fractures per metre, 7 between 1 and 1.5, etc (see Appendix for complete data table). A statistical overview of the fracture intensity in these outcrops is also shown in Table 5-1.

Figure 5-3. Diagram that illustrates the average number of mapped fracture per metre at the outcrops.

Table 5-1. Fracture frequency (fractures/m) on outcrops.

Mean	1.8625
Standard Error	0.124537
Median	1.725
Mode	1.15
Standard Deviation	0.610105
Sample Variance	0.372228
Kurtosis	–0.38734
Skewness	0.286792
Range	2.4
Minimum	0.65
Maximum	3.05
Sum	44.7
Count	24
Confidence level (95%)	0.2576244

Table 5-2. Fracture frequency (fractures/m) from the 64 lines.

Value	Line direction 360°	Line direction 90°
Mean	1.833333	1.96129
Standard Error	0.133475	0.149528
Median	1.9	1.8
Mode	2	1.8
Standard Deviation	0.766757	0.832537
Sample Variance	0.587917	0.693118
Kurtosis	–0.58971	0.033437
Skewness	0.014201	0.466733
Range	2.9	3.5
Minimum	0.3	0.5
Maximum	3.2	4
Sum	60.5	60.8
Count	33	31
Confidence Level(95.0%)	0.27188	0.305377

Original results are stored in the primary database (SICADA). Only data from SICADA should be used for further interpretation (modelling). Reference to the data can be found in Table 1-2.

Nineteen (19) of the twenty-four (24) outcrops are located in the same rock type, the so-called Ävrö granite. Two (2) is located in the "dioritoid" and one (1) in each of "diorite to gabbro", "granite, medium to coarse-grained" and "quartz monzodiorite". This is probably not enough data to make any conclusive statement regarding differences in fracture characteristics between different rock types. The outcrop in the quartz-monzodiorite has an average of 0.65 fractures/metre, the granite (medium to fine grained) outcrop has 1.85, the diorite to gabbro outcrop has 1.7 and finally the dioritoid outcrops has an average of 2.4 fractures/metre.

The fracture frequency found from the similar activity in the Simpevarp subarea /1/ was c 1.9, i.e. slightly higher than in the Laxemar subarea.

There is a large scatter of the orientation of fractures in the investigated outcrops (Figure 5-4). Comparing with a similar investigation in the Simpevarp subarea further to the east /1/, the orientation of fractures at Laxemar appear to be more scattered considering the whole dataset, whereas at Simpevarp a few more distinctive sets could be recognised on a regional scale. Looking at outcrop scale in both areas, however, a few distinctive sets generally dominates on all outcrops.

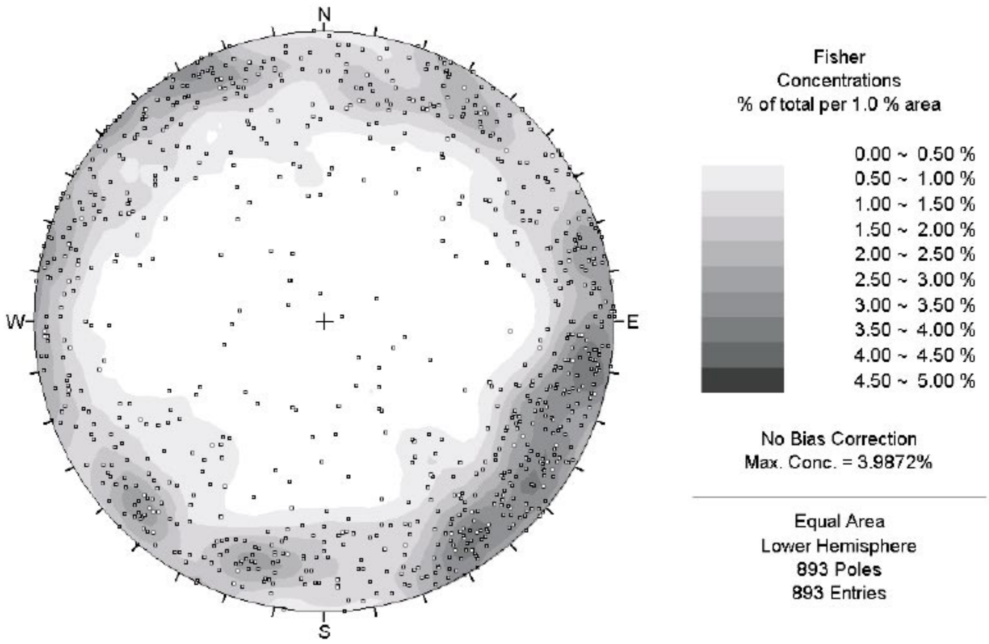

Figure 5-4. *Stereograms showing the orientation of all measured fractures.*

References

/1/ **Wahlgren C-H, Ahl M, Sandahl K-A, Berglund J, Peterson J, Ekström M, Persson P-O, 2003**. Oskarshamn site investigation. Bedrock mapping 2003 – Simpevarp subarea. Outcrop data, fracture data, modal and geochemical classification of rock types, bedrock map, radiometric dating. SKB P-03-73, Svensk Kärnbränslehantering AB.

Appendix 1

Data compilation

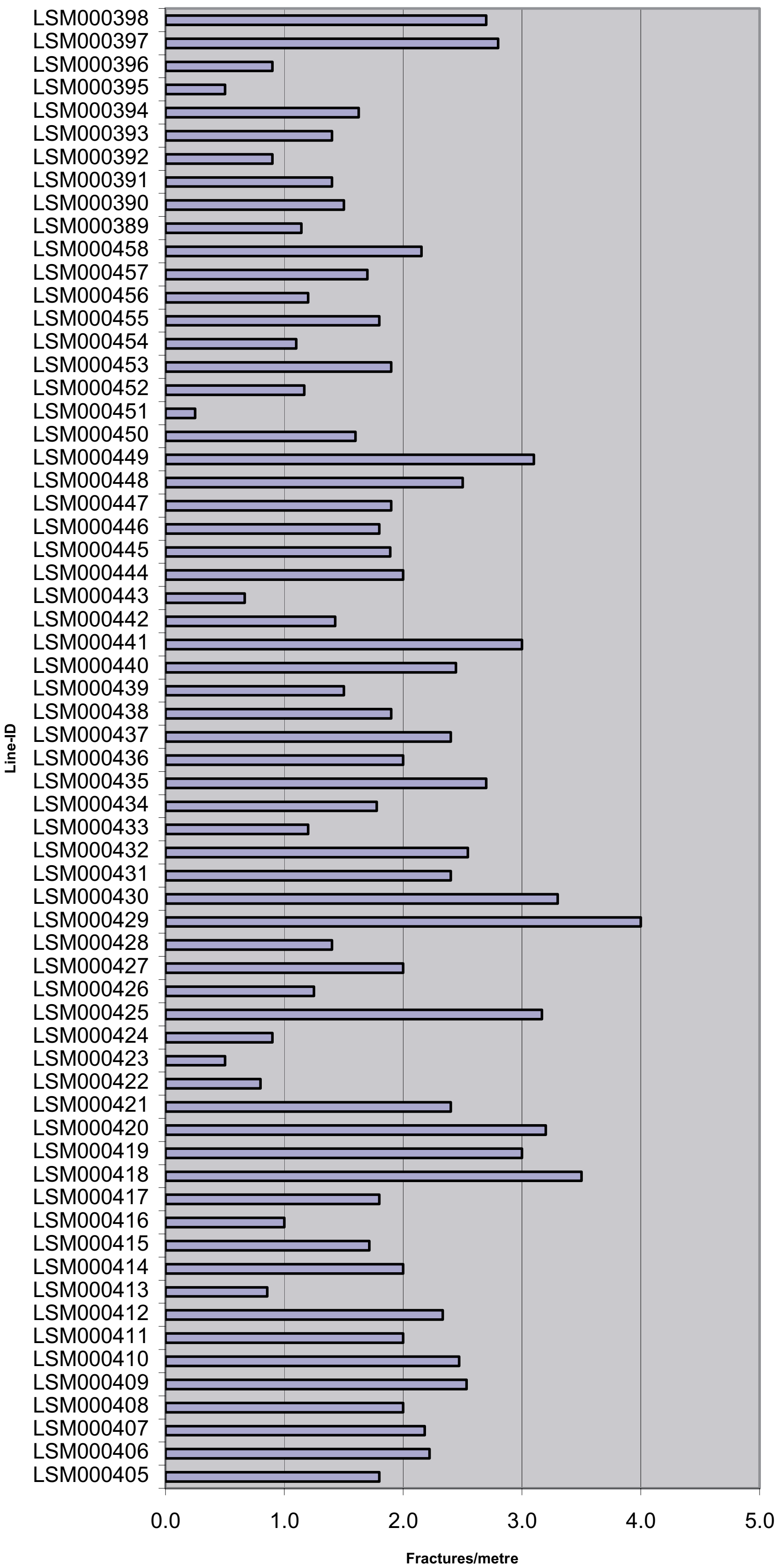

Table A-1. Data compilation.

Line ID-code	Line direction (deg)	Length of line (m)	No. of fractures	Frequency (m^{-1})
LSM000405	360	10	18	1.8
LSM000406	90	4.5	10	2.2
LSM000407	90	5.5	12	2.2
LSM000408	360	2.5	5	2.0
LSM000409	360	7.5	19	2.5
LSM000410	90	8.5	21	2.5
LSM000411	90	1.5	3	2.0
LSM000412	360	3	7	2.3
LSM000413	360	7	6	0.9
LSM000414	90	3	6	2.0
LSM000415	90	7	12	1.7
LSM000416	360	10	10	1.0
LSM000417	90	10	18	1.8
LSM000418	360	2	7	3.5
LSM000419	360	8	24	3.0
LSM000420	90	7.5	24	3.2
LSM000421	90	2.5	6	2.4
LSM000422	360	10	8	0.8
LSM000423	90	10	5	0.5
LSM000424	360	10	9	0.9
LSM000425	90	6	19	3.2
LSM000426	90	4	5	1.3
LSM000427	360	5.5	11	2.0
LSM000428	90	10	14	1.4
LSM000429	360	4.5	18	4.0
LSM000430	360	10	33	3.3
LSM000431	90	10	24	2.4
LSM000432	360	5.5	14	2.5
LSM000433	90	10	12	1.2
LSM000434	360	4.5	8	1.8
LSM000435	360	10	27	2.7
LSM000436	90	10	20	2.0
LSM000437	360	10	24	2.4
LSM000438	90	10	19	1.9
LSM000439	360	10	15	1.5
LSM000440	90	9	22	2.4
LSM000441	90	1	3	3.0
LSM000442	360	6.3	9	1.4
LSM000443	90	1.5	1	0.7
LSM000444	90	8.5	17	2.0
LSM000445	360	3.7	7	1.9
LSM000446	360	10	18	1.8
LSM000447	90	10	19	1.9
LSM000448	360	10	25	2.5

LSM000449	90	10	31	3.1
LSM000450	360	10	16	1.6
LSM000451	90	4	1	0.3
LSM000452	90	6	7	1.2
LSM000453	360	10	19	1.9
LSM000454	90	10	11	1.1
LSM000455	360	10	18	1.8
LSM000456	90	10	12	1.2
LSM000457	360	10	17	1.7
LSM000458	90	6.5	14	2.2
LSM000389	90	3.5	4	1.1
LSM000390	360	10	15	1.5
LSM000391	90	10	14	1.4
LSM000392	360	10	9	0.9
LSM000393	90	10	14	1.4
LSM000394	360	8	13	1.6
LSM000395	360	2	1	0.5
LSM000396	90	10	9	0.9
LSM000397	360	10	28	2.8
LSM000398	90	10	27	2.7