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Summary

The Swedish Nuclear Fuel and Waste Management Company (SKB) has conducted site investigations at two different locations, the Forsmark and Laxemar areas, with the objective of siting a final repository for spent nuclear fuel. An important component of the site characterisation work is geologic mapping (surface mapping and logging of cored boreholes), which forms an important part of the preliminary evaluation of the rock mass down to a depth of about 1,000 m at these sites. During site investigations, approximately 200,000 individual fractures have been identified, logged and characterised in drill cores. These data sets have been registered in the Sicada database for further use (e.g. in geological modelling).

This study reports the findings from the examination of a group of fractures lacking visible mineralization, i.e. fractures classified as non-mineralised in Sicada, in drill cores from the Forsmark and Laxemar site investigation. Non-mineralised fractures may have formed recently, and hence their presence may have implications on site suitability for a deep repository since it could imply that fracturing is an ongoing process in rocks which are considered typical of the Scandinavian shield.

This study was initiated to: 1) quantify the number of fractures logged as non-mineralised; 2) carry out a detailed investigation of a selection of the non-mineralised fractures; and 3) outline possible processes forming these fractures.

The first phase of the study was a database extraction and statistical analysis. This was followed by a detailed investigation of a subset of these fractures. Non-mineralised fractures interpreted as flowing (PFL) fractures were considered a particularly important subset in this study. With the exception of a few non-mineralised PFL-fractures, this study only concerns non-mineralised fractures located outside deterministic deformation zones.

From the database extraction a total of 3.7% of all logged fractures from drill cores are classified as non-mineralised in Sicada. The non-mineralised fractures in Sicada occur at all depths from surface down to below repository depth and appear in all fracture domains. Their distribution of non-mineralised fractures with depth, if normalised to available borehole meters, is more or less constant with depth at Laxemar but decreases significantly with depth at Forsmark. From the database analysis we identified that a significant proportion of the non-mineralised fractures were logged as sealed fractures. Since it is a geologically impossible for a non-mineralised fracture to be sealed the meaning of these logging results have been clarified in this study.

Two subsets including a total of ~200 of these fractures were investigated in detail at both sites. The detailed investigation included a visual inspection of the fracture surfaces and drill core material was sampled for further detailed mineralogical analysis. The inspection revealed that most of these fractures were actually coated by minerals or that they were erroneously logged as fractures. However, many of these coatings were identified only by the use of SEM-EDS. Nevertheless, we confirmed that five of fractures subjected to detailed investigations were non-mineralised; all these fractures were identified in cores from Forsmark. Groundwater flow was detected in three of these fractures; all of them are sub-horizontal to gently dipping and occur at a depth > –250 m.a.s.l.

Processes that may have contributed to the origin of these fractures are: 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) Sheet jointing; and 6) Opening of fractures/micro-fractures and/or channelled flow. We conclude that processes #2 mechanical flushing and/or chemical dissolution of fracture coating are the least likely processes and #6 opening of fractures/micro-fractures and/or channelled flow to be the most likely process. Sheeting may also explain the existence of some of the non-mineralised fractures. Nevertheless, it is possible that a combination of the suggested processes are responsible for the formation of these fractures. It was not possible to draw any conclusions in terms of age of these fractures, because there were no fracture minerals to analyse. We cannot exclude that these fractures were opened up and became water conductive during the Quaternary glaciations or during the post-glacial Holocene period. However, based on the knowledge of fracture generations in Forsmark from previous studies, we suggest that fluid flow in these fractures is not older than Late Palaeozoic.

The effects these fractures might have on the long-term safety for the repository are difficult to ascertain given that the mechanism by which they form is not well understood. Understanding the origin and development of these fractures may enhance our ability to forecast the long-term evolution of the Forsmark and Laxemar sites. A multidisciplinary study involving a larger number of these non-mineralised fractures is suggested to achieve this objective.

Contents

1 Introduction and aim

The Swedish Nuclear Fuel and Waste Management Company (SKB) have undertaken site investigations with the objective of finding a suitable location in the Swedish Precambrian basement at approximately 500 m depth for a final repository for spent nuclear fuel. The investigated sites are Forsmark in northern Uppland and Oskarshamn (Laxemar) in eastern Småland (Figure 1-1). In order to make a preliminary evaluation of the rock mass down to a depth of about 1,000 m at these sites, SKB carried out a drilling program using surface-based core-drilled boreholes. Original data from the site investigations are stored in the Sicada database. Only data in SKB's databases are accepted for further interpretation and modelling. Consequently, as data used in modelling work is ordered and extracted from the Sicada database prior to modelling, it is vital to the outcome of such analysis that the data registered in the database is valid and up to date.

Detailed studies of the drill cores from both sites have been carried out as part of the site investigation programmes. Logging and mapping of fractures and the identification of fracture fillings is a standard part of the borehole logging procedure and have been performed routinely on all drill cores from the site investigation by on-site geologists. The logging of cored boreholes are carried out according to the SKB Boremap method, which utilises the simultaneous study of drill core material and BIPS-images. Information about rock characteristics and fracture properties are provided from the core logging. The BIPS-image enables the study of fractures and their characteristics along the borehole. Strike and dip of planar structures such as fractures, foliations and rock contacts are calculated and documented with the Boremap method. Thin section analysis and chemical analyses are used to determine type of fracture minerals and rock types. Indirect methods such as geophysical borehole logging, radar and seismics have been used to aid the determination of rock types, mineral alteration, fracture orientation and extent.

Approximately 200,000 individual fractures have been identified, logged and characterised in drill cores from the two sites. Fracture identities and characteristics have been entered into the Sicada database. These data sets have been used in the geological modelling work and have served as basis for further and more detailed studies, e.g. fracture mineralogy studies /Sandström et al. 2008a, Drake and Tullborg 2009/. Among these 200,000 fractures, a group of non-mineralised fractures exist in the Sicada database, i.e. they are classified as having no mineral coating or filling. Superficial fractures lacking filling (open and not filled) have been reported in e.g. /Carlsson 1979, Leijon 2005/ from the Forsmark site where they are referred to as glacial fractures. The fractures classified as non-mineralised in the Sicada database have been addressed during the site descriptive modelling at both sites /Stephens et al. 2007, Wahlgren et al. 2008/, where several hypotheses for their existence were outlined:

- The fractures were induced during drilling, and were incorrectly interpreted during the drill core logging and entered into the Sicada database as natural fractures.
- The coating or filling of the fractures is too thin for identification and has therefore been entered as "no mineral" in the Sicada database.
- The coatings and fillings of the fractures have been flushed/washed away during drilling.
- The fractures are geologically young (i.e. newly formed), and therefore contains no coating or filling.

Considering the possibility that these fractures formed recently and the many uncertainties associated with their true existence, further work was requested in e.g. /Stephens et al. 2007/ and /Wahlgren et al. 2008/. If the fractures without filling in Sicada are recently formed, and if such fractures are located at repository depth, they might have a yet non-quantified impact on long-term safety of the site.

1.1 Objectives and scope

The general objective of this report was to describe the results of the investigation of fractures classified as non-mineralised in Sicada. Such fractures exist at Forsmark and at Laxemar. The main aims of the investigation of these fractures were to:

- Quantify the number of non-mineralised fractures (i.e. fractures lacking mineral coating) in Sicada (table: p_fract_core_eshi).
- Closely examine a selection of fractures recorded as non-mineralised in Sicada.
- Outline possible reasons for the existence of non-mineralised fractures.

The work has involved extraction of fracture data from Sicada and subsequent statistical analysis. Since several thousand fractures are classified as non-mineralised in Sicada, it was not a practical possibility to include all these in this study, we examined one fracture sub-set from each site. We investigated a sample of 204 of these fractures in detail (see Sections 1.1 and 2.4). Rock mechanical differences between Forsmark and Laxemar and kinematic analysis of fracture surfaces is not discussed in this report.

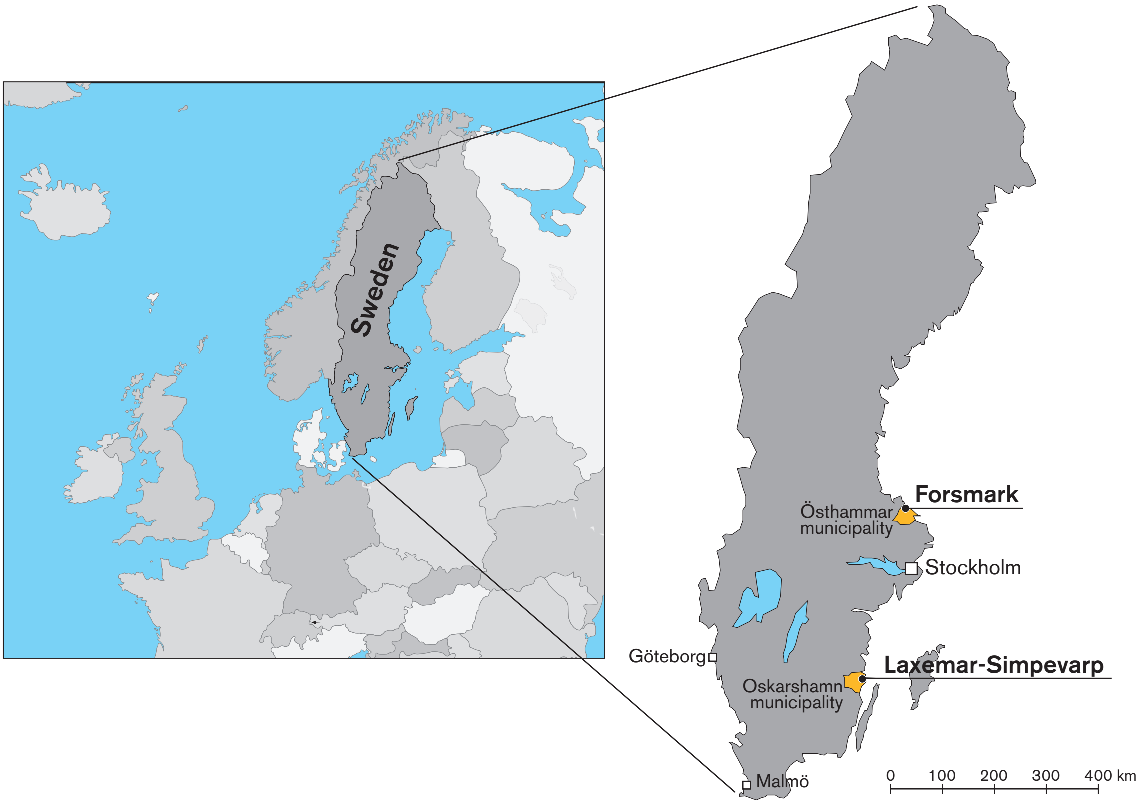


Figure 1-1. Map of Sweden showing the location of the Forsmark and Laxemar sites.

2 Nomenclature and definitions

Table 2-1 provides definitions of technical terms used in this report.

Table 2-1. Definitions of terms occurring in this report.

Term	Definition	Reference
Adjusted secup	Refers to the adjusted borehole length. The BIPS-image provides a borehole length. However, this length deviates from the true borehole length which is why adjustments are made on the basis of reference marks cut into the borehole wall after drilling (normally every 50 meter).	
BIPS	Borehole Image Processing System, which is a high resolution, side viewing, colour borehole TV system. The BIPS-image enables the study of fractures and their characteristics along the borehole.	/Gustafsson and Gustafsson 2009/.
Boremap	A software and method used for logging of cored boreholes.	/Döse et al. 2009/.
Non-mineralised fracture	A fracture either lacking entries in the Min1–Min4 columns or for which X5 or X7 codes have been registered in either an Min1–Min4 field or in the comment field in Sicada table p_fract_core_eshi.	This report.
PFL-fracture	A flowing fracture as determined by the Posiva Flow Log method. Detectable groundwater flow is on the order of ≥10^{-9} m^2s^{-1}. The PFL-f measurements (f=fracture) are based on ~1 week pumping where the entire borehole acts as a line sink. This method is designed to detect individual fracture flows along the borehole with a high spatial resolution (0.1 m). A flow anomaly as identified by the Posiva Flow Log method can consist of either a single fracture or a fracture- or crush zone, and is often referred to as a PFL anomaly. In this report we refer to them as PFL-fractures.	/Follin et al. 2007/.
Best choice PFL fracture	If an open, partly open fracture or crush zone is within ± 0.5 m of a PFL-anomaly, it is assumed that it can correspond to the PFL-anomaly. If one or several fractures (or crush zones) are documented as possible flowing features, the Best choice PFL-fracture denotes the most likely fracture/crush zone among the features denoted as PFL anomaly.	/Follin et al. 2007/.
Min1–Min4	The columns in Boremap used for mineral identification during the core logging, where Min1 denotes the most commonly existing mineral on the fracture surface and Min4 the least. Min1–Min4 forms part of the Sicada table p_fract_core_eshi.	According to the Boremap nomenclature.
X5 and X7 codes	Codes used during the core logging when fractures appear fresh and no minerals can be detected. The codes are entered in the Min1–Min4 columns or in the comment field. X7 has been utilised in Laxemar and X5 in Forsmark. However, these codes have been used with varying frequency especially during the early stages of the site investigations. The use of these codes has not been consistent between the Forsmark and Laxemar sites. During the early stages of the site investigations the Min1–Min4 fields were more frequently left with no entered information rather than using the appropriate X-code.	According to the Boremap nomenclature.
Rock domain	Refers to a rock volume in which rock units that show specifically similar composition, grain size, degree of bedrock homogeneity, and degree and style of ductile deformation have been combined.	Based on Section 2.4 in /Stephens et al. 2007/.
Deformation zone	Refers to an essentially 2-dimensional structure in which strain has been localized.	/Munier et al. 2003/.
Fracture domain	A fracture domain is a rock volume outside deformation zones in which rock units show similar fracture frequency characteristics.	Definition based on Section 2 in /Munier et al. 2003/. See /Olofsson et al. 2007/ for application at Forsmark.
Degree of openness (open/partly open/sealed)	All fractures with apertures > 0 mm area registered as open or partly open and all fractures with aperture = 0 are registered as sealed in the Sicada database. Two types of fractures are registered in Boremap, broken and unbroken fractures depending on whether the core is split through the core axis or not. Normally, unbroken fractures have apertures = 0 and broken fractures aperture > 0 mm. However, unbroken fractures with voids, for example have fractures > 0 mm. Broken fractures considered artificial have aperture = 0.	According to the Boremap nomenclature.

3 Available data and methodology

In order to carry out a methodical investigation of the non-mineralised fractures, the following sources of information were explored:

- Available SKB-reports, peer-reviewed scientific papers and books.
- Sicada data:
  - p_fract_core_eshi (data extraction date: 2009-01-09). This table contains information about single fractures in a drill core including information about rock type, domains, deformation zones, fracture minerals, degree of alteration and fracture orientation. A preliminary extraction of p_fract_core_eshi was also made on 2008-08-24 to get an overview of the amount of non-mineralised fractures.
  - pfl_anom_fract_id (data extraction date: 2009-05-06). This tables gives information about the recorded PFL anomalies in a borehole vs. fracture id:s from the Boremap logging. Due to the fact that all PFL-fracture IDs were not registered in Sicada when the project was initiated a preliminary extraction of pfl_anom_fract_id, using available PFL-fracture IDs had to be done (2008-08-24) in order to appraise the number of non-mineralised PFL-fractures.
  - pfl_inferr_anom (data extraction date: 2009-05-06). This table contains information about the inferred PFL anomalies and transmissivity values for these anomalies. Due to the fact that all PFL-fracture IDs were not registered in Sicada when this study started, we had to make a preliminary extraction of available pfl_inferr_anom (2008-08-24) to be able to get an overview of the number of non-mineralised flowing fractures (i.e. non-mineralised fractures with a detected transmissivitiy).
- Drill cores from Laxemar and Forsmark.
- Boremap/BIPS images.

During the logging of fracture mineral fillings, the identified minerals are entered in the Min1–Min4 columns in Boremap using assigned minerals codes according to the Boremap mineral list. Min1 represents the most abundant mineral and Min4 the least abundant mineral that is present. The Min1–Min 4 columns work in such way that it is not possible to enter the same mineral twice, however, it is possible to accidently leave one or several columns blank. In the case where properties and/or minerals are not represented in the mineral and property lists X-codes are used. After completed core logging, all data is entered in the p_fract_core_eshi data table. The table is then registered in the Sicada database. Note that, since the entering of data in Boremap is made manually it is always a risk that the identified minerals are accidently omitted from Boremap during logging, and consequently, no minerals would be registered in the p_fract_core_eshi table.

The investigation programme involved the following parts:

A) **Database extraction and statistical analysis.** Data from the following deliveries: Sicada/p_fract_core_eshi as of 2009-01-09 and Sicada/pfl_anom_fract_id 2009-05-06, were used to perform the statistical evolution of fracture distributions (i.e. abundance distribution, orientation distribution, spatial distribution). Statistical extraction and analyses were conducted by Raymond Munier and Lillemor Claesson Liljedahl, SKB.

B) **Investigation of fractures in drill cores.** The investigation of drill cores and check of logging records were conducted by: Michael Stephens (SGU) Carl-Henric Wahlgren (SGU), Allan Stråhle (Geosigma), Eva-Lena Tullborg (Terralogica), Björn Sandström (WSP Sverige AB), Henrik Drake (Isochron GeoConsulting), Assen Simeonov, Isabelle Olofsson, Thomas Kisiel, Raymond Munier and Lillemor Claesson Liljedahl (SKB).

C) **Sampling of drill cores and subsequent mineralogical and geochemical analyses.** Conducted by Björn Sandström (WSP Sverige AB), Henrik Drake (Isochron GeoConsulting) and Eva-Lena Tullborg (Terralogica).

3.1 Database extraction and statistical analysis

The main objectives of the data extraction and statistical analyses were: (1) to quantify the number of non-mineralised fractures recorded in Sicada at both sites, and (2) to provide a basis for selecting samples for detailed examinations of fracture surfaces. The extraction also enabled data comparison between the two sites. As different parameters are linked to the fracture data in the p_fract_core_eshi-table (e.g. fracture_domain, deformation_zone, confidence, fract_interpret, fract_logged and fract_alteration, orientiation etc.), various data subsets were analysed (see Section 4.1). Statistica 8 software was used for the database extraction and analyses.

3.2 Inspection of non-mineralised fractures in drill cores

In order to confirm or disprove the existence of non-mineralised fractures in our data set, we visually inspected selected subsets of the drill core fractures (see Sections 5.1 and 5.2).

The fracture inspections were carried out according to the following practice:

1. Identification of the fracture in Boremap/BIPS, where depth and fracture characteristics were noted.
2. Identification of the same fracture in the drill core.
3. The drill core and fracture were visually inspected. The aim of the inspection was to identify the presence of visible fracture filling on the fracture surface. Fracture appearance, signs of disturbances that can be related to drilling, the appearance of the fracture in BIPS in relation to the appearance in the core, missing material etc. were also noted. The results from the fracture inspection were entered in an Excel sheet (see Appendices 3 and 4).
4. Cross checking of the logging result entered in Sicada (i.e. the Min1–Min4 or X-coding information) and the data registered in Boremap/BIPS.
5. Fractures that lacked signs of mineral coating or where the type of mineral could not be identified were considered to require further analyses (i.e. optical microscopy and SEM-EDS), and were marked out for sampling.
6. Photo documentation of the core/fracture using a digital camera.

3.3 Mineral identification

Simple items were used to facilitate the inspection of the fractures: hand lens, paintbrush and tap water, rock hardness tool/scratcher, diluted hydrochloric acid (HCl), pen, folding rule and a digital camera.

In cases where fracture minerals could not be detected and/or in cases where fracture minerals were detected but not identified, fracture surfaces were (a) sampled for preparation of thin sections, and (b) prepared for further analyses using a binocular microscope, a polarizing transmissive microscope, and a scanning electron microscope equipped with an energy dispersive spectrometer (SEM-EDS).

3.4 Inconsistencies

Fracture ID:s
The inspection of non-mineralised fractures in this study had to be carried out using preliminary featureID:s from available data sources (i.e. not all featureID:s were available in Sicada when the study was carried out). This means that new featureID:s might have been registered in Sicada after the completion of this study.

X-coded minerals
The initial database extractions only targeted non-mineralised fractures with no entries in Min1–Min4 columns. However, after consulting the mineralogists we decided also to include the X-codes in the database extraction. Consequently, the X5/X7-coded fractures were included after the initial subset selection.

MWD/DMS
The measurement while drilling data (MWD/DMS), which contains information about drilling parameters (temperature, torque, drilling water pressure etc.) has not been accessible for all the boreholes utilised in this study. Due to the lack of a comparable data set, it has not been a possibility to compare the occurrence of non-mineralised fractures with the different drilling parameters in the MWD data files.

4 Database extraction and statistical analysis

Approximately 200,000 fractures (86,268 in Forsmark and 108,263 in Laxemar) have been logged and mapped during the site investigations (Table 4-1). A portion of these fractures were logged as non-mineralised. In this section, we present the results of the database extraction and statistical analysis of the fracture data.

4.1 Results from database extraction and statistical analysis

A desktop database extraction (Sicada_p_fract_core_eshi, 2009-01-09) was performed to: (1) get an overview of how many non-mineralised fractures exist in Sicada, and (2) analyse the data set to possibly identify clarifying patterns. An additional aim with the extraction was to select one fracture subset from each site, such that detailed inspection of these fractures was achievable.

Total number of non-mineralised fractures in Sicada

The result of the extraction shows that 3.7% (7,117 fractures) of the logged fractures at both sites are classified as non-mineralised in the Sicada database (Table 4-1). Of these fractures, 68% occur at Forsmark and 32% at Laxemar (Table 4-1). Fractures X-coded as non-mineralised constitutes ~19% of the non-mineralised fractures in Forsmark (Table 4-2) and ~92% in Laxemar (Table 4-3). We interpret the disparity in x-coded proportion of non-mineralised fractures in Laxemar and Forsmark, respectively, to be an artefact of different interpretations of the logging methodology (see Section 6).

Table 4-1. Total occurrence of non-mineralised fractures at Forsmark and Laxemar. Non-mineralised fractures refer to fractures where Min1, Min2, Min3 and Min4 have no registered entries or where the X5 or X7 codes have been used in the table p_fract_core_eshi. X-codes are used during the core logging when properties or minerals are not represented in the available mineral list.

	All logged fractures	Non-mineralised fractures	% non-mineralised fractures/ all logged fractures
Forsmark	86,268	4,872	5.6
Laxemar	108,263	2,245	2.1
Total	194,531	7,117	3.7

Table 4-2. Total occurrence of non-mineralised fractures at Forsmark. X5 denotes fractures that appear fresh and where no minerals can be detected.

Category	Number non-mineralised fractures	% of non-mineralised fractures
X5	904	18.5
No Min1–Min4	3,968	81.5
Total	4,872	100

Table 4-3. Total occurrence of non-mineralised fractures at Laxemar. X7 denotes fractures that appear fresh and where no minerals can be detected.

Category	Number non-mineralised fractures	% of non-mineralised fractures
X7	2,058	91.7
No Min1–Min4	187	8.3
Total	2,245	100

The X-coding has been used throughout site investigations at both sites. The reason for the disparity between the sites concerning the use of X-coding may be related to the slightly different approaches, on how to enter non-mineralised fractures into Boremap, between the core logging crews, e.g. /Glamheden and Curtis 2006/. At Forsmark, most crews have left the columns Min1–Min4 blank, whereas some have used the X5-code for describing fractures without fracture minerals. At Laxemar, the X7-code was used by most logging crews.

Number of non-mineralised fractures visible in BIPS

Fractures visible in BIPS represent observable discontinuities in the borehole wall, and their existence should be unaffected by drilling activities, drill core handling or mapping activities /Munier and Stigsson 2007/. We have no doubt that these fractures actually exist in situ and include only those fractures that are visible in BIPS in the remaining analyses presented in this report. A total of 60% of all non-mineralised fractures are visible in BIPS (Table 4-4). A total of 3.1% of all logged fractures at both sites are non-mineralised (Table 4-5), with 4.8% of the logged fractures at Forsmark being non-mineralised, and 1.5% at Laxemar (Table 4-5).

Table 4-4. Breakdown of the non-mineralised fractures (no entries in Min1–Min4 including the X5- and X7-coded fractures) visible and not visible in BIPS at Laxemar and Forsmark.

Category	Count	% of non-mineralised fractures
Fractures not visible in BIPS	2,723	38.3
Fractures visible in BIPS	4,300	60.4
Fractures where no BIPS-logging have been made	94	1.3
Total	7,117	

Table 4-5. Non-mineralised fractures in relation to all logged fractures visible in BIPS divided by site.

	All logged fractures visible in BIPS	Non-mineralised fractures visible in BIPS	Percent
Forsmark	68,023	3,284	4.8
Laxemar	69,792	1,016	1.5
Total	137,815	4,300	3.1

Non-mineralised fractures outside deformation zones

With the exception of a few non-mineralised PFL-fractures, this study focuses on non-mineralised fractures located outside deformation zones. The reason for excluding fractures in deformation zones (or fractures affected by deformation zones) is related to the complex nature of deformation zones. Excluding non-mineralised fractures located within deformation zones decreases the total amount of non-mineralised fractures from 3.1% to 2.9% (from 4,300 to 2,625 fractures), Table 4-6.

Tables 4-7 and 4-8 list the total occurrence of non-mineralised fractures outside deformation zones per borehole occurrence in Forsmark and Laxemar, respectively.

Table 4-6. Total occurrence of non-mineralised fractures visible in BIPS located outside deformation zones in Forsmark and Laxemar.

	All logged fractures	Non-mineralised fractures outside deformation zones	% non-mineralised fractures
Forsmark	41,119	1,844	4.6
Laxemar	50,296	781	1.6
Total	91,415	2,625	2.9

Table 4-7. Total occurrence of non-mineralised fractures visible in BIPS and located outside deformation zones at Forsmark, divided by borehole.

Borehole	Count	Percent
KFM01A	109	5.9
KFM01B	51	2.8
KFM01C	6	0.3
KFM01D	68	3.7
KFM02A	65	3.5
KFM02B	225	12.2
KFM03A	86	4.7
KFM04A	114	6.2
KFM05A	91	4.9
KFM06A	110	6.0
KFM06B	18	1.0
KFM06C	99	5.4
KFM07A	18	1.0
KFM07B	13	0.7
KFM07C	6	0.3
KFM08A	50	2.7
KFM08B	65	3.5
KFM08C	37	2.0
KFM08D	126	6.8
KFM09A	79	4.3
KFM09B	1	0.1
KFM10A	82	4.4
KFM11A	196	10.6
KFM12A	118	6.4
KFM90B	2	0.1
KFM90D	1	0.1
KFM90E	6	0.3
KFM90F	2	0.1
Total	1,844	100.0

Table 4-8. Total occurrence of non-mineralised fractures visible in BIPS and located outside deformation zones at Laxemar, divided by borehole.

Borehole	Count	Percent
KLX02	101	12.9
KLX03	45	5.8
KLX04	56	7.2
KLX05	40	5.1
KLX06	59	7.6
KLX07A	46	5.9
KLX07B	4	0.5
KLX08	39	5.0
KLX09	16	2.0
KLX09B	4	0.5
KLX09C	12	1.5
KLX09D	4	0.5
KLX09E	7	0.9
KLX09F	1	0.1
KLX09G	1	0.1
KLX10	16	2.0
KLX10B	3	0.4
KLX10C	1	0.1
KLX11A	12	1.5
KLX11B	8	1.0
KLX11C	2	0.3
KLX11D	11	1.4
KLX11F	2	0.3
KLX12A	8	1.0
KLX13A	41	5.2
KLX14A	13	1.7
KLX15A	10	1.3
KLX16A	20	2.6
KLX17A	36	4.6
KLX18A	30	3.8
KLX19A	24	3.1
KLX20A	4	0.5
KLX21B	17	2.2
KLX22A	12	1.5
KLX22B	16	2.0
KIX23A	2	0.3
KIX23B	3	0.4
KLX24A	7	0.9
KLX26A	8	1.0
KLX26B	11	1.4
KLX27A	23	2.9
KLX28A	3	0.4
KLX29A	3	0.4
Total	781	100.0

Spatial distribution of non-mineralised fractures outside deformation zones

The locations of non-mineralised fractures bear on repository safety. Tables 4-9 and 4-10 give an overview of non-mineralised fractures in terms of fracture domain occurrence. Domains FFM01, FFM02 and FFM03 host most of these fractures at Forsmark, and domains FSM_W, FSM_EW007 the majority of these fractures at Laxemar. However, the proportion of non-mineralised fractures relative to the total amount of fractures per fracture domain at Forsmark is greatest in domains FFM03, FFM04 and FFM02 (Table 4-9) The distribution between non-mineralised fracture occurrence per fracture domains is more evenly distributed in Laxemar (Table 4-10).

Table 4-9. Proportion of non-mineralised fractures outside deformation zones and visible in BIPS relative to the total number of fractures in Forsmark sorted by fracture domain. Missing denotes fractures that have not been assigned a fracture domain in p_fract_core_eshi.

Fracture domains Forsmark	Total number of fractures visible in BIPS and located outside DZ	Non-mineralised fractures visible in BIPS and located outside DZ	% non-mineralised fractures per fracture domain
FFM01	10,691	462	4.3
FFM02	3,300	259	7.8
FFM03	2,397	219	9.1
FFM04	1,230	100	8.1
FFM05	2,000	58	2.9
FFM06	1,768	70	4.0
No fracture domain assigned in p_fract_core_eshi	19,733	676	3.4
Total	41,119	1,844	4.5

Table 4-10. Proportion of non-mineralised fractures relative to the total number of fractures outside deformation zones and visible in BIPS at Laxemar, sorted by fracture domain. Missing denotes fractures that have not been assigned a fracture domain in p_fract_core_eshi.

Fracture domains Laxemar	Total number of fractures visible in BIPS and located outside DZ	Non-mineralised fractures visible in BIPS and located outside DZ	% non-mineralised fractures per fracture domain
FSM_W	13,534	209	1.5
FSM_EW007	10,207	191	1.9
FSM_NE005	7,374	97	1.3
FSM_C	8,579	92	1.1
FSM_N	5,731	87	1.5
FSM_S	1,863	25	1.3
No fracture domain assigned in p_fract_core_eshi	3,008	80	2.7
Total	50,296	781	1.6

Depth occurrence of non-mineralised fractures outside deformation zones

In Tables 4-11 and 4-12 the distribution of non-mineralised fractures versus depth intervals are presented. The majority of these fractures occur down to 400 meters depth in Forsmark (Table 4-11). However, it is worth noting that ~20% of these fractures occur at depths corresponding to repository depth (–400 to –600 m.a.s.l.). The majority of non-mineralised fractures at Laxemar occur down to –600 m.a.s.l. (Table 4-12). In terms of depth, it is important to consider that the available drill core meters is unevenly distributed between fracture domains and to some extent overrepresented in the uppermost 600 meters. In addition, fracture intensity varies differently with depth in Laxemar and Forsmark respectively. When normalising the occurrence of non-mineralised fractures to total fracture intensity (Figure 4-1), to overcome intensity bias, a significant difference between Forsmark and Laxemar appears. The number of non-mineralised fractures is more or less constant with depth at Laxemar whereas the relative abundance of these fractures decreases with depth at Forsmark.

Table 4-11. Total number of non-mineralised fractures outside deformation zones and visible in BIPS at Forsmark, sorted by 200-meter depth intervals. Total length of drill core refers to the cumulative length of drill core within the designated depth interval for all boreholes at Forsmark.

Elevation (m.a.s.l)	Amount non-mineralised fractures	% distribution of non-mineralised fractures	Total length of drill core (m)
0 to –200	713	38.7	4,178
–200 to –400	603	32.7	4,841
–400 to –600	362	19.6	3,980
–600 to –800	153	8.3	2,720
–800 to –1,000	13	0.7	655
Total	1,844	100	16,374

Table 4-12. Total number of non-mineralised fractures outside deformation zones (DZ) and visible in BIPS at Laxemar, sorted by 200-meter depth intervals. Total length of drill core refers to the cumulative length of drill core within the designated depth interval for all boreholes at Laxemar.

Elevation (m.a.s.l)	Number non-mineralised fractures	% distribution of non-mineralised fractures	Total length of drill core (m)
200 to 0	66	8.5	549
0 to –200	250	32	4,968
–200 to –400	203	26	4,313
–400 to –600	143	18.3	3,813
–600 to –800	85	10.9	2,447
–800 to –1,000	34	4.4	970
Total	781	100	17,060

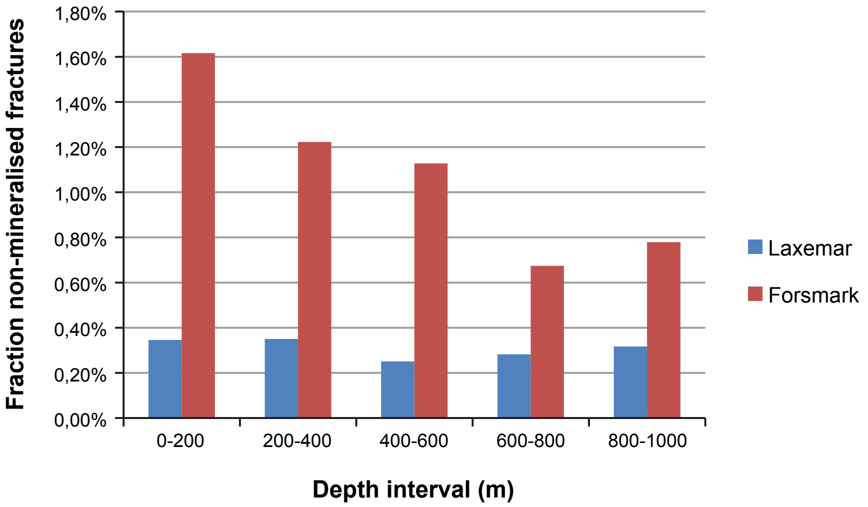


Figure 4-1. *Non-mineralised fracture frequency normalised against total fracture intensity (P10) in 200 meter depth intervals. Depth is vertical depth. This graph concerns fractures interpreted as open, partly open and sealed. Boreholes extend to depths greater than 1,000 meters at Laxemar, but data from them have been excluded from this graph because non-mineralised fractures are not registered in Sicada at depths below 1,000 meters depth.*

Degree of fracture openness

Fractures with aperture > 0 mm are registered as *open* or *partly open* whereas fractures with aperture = 0 are registered as *sealed* during core mapping/logging. Most non-mineralised fractures at Forsmark are interpreted as sealed (Table 4-13), whereas most non-mineralised fractures at Laxemar are interpreted as open (Table 4-14). However, when looking at the percentage of non-mineralised fractures, the majority of these fractures are *partly open* in both Forsmark and Laxemar. By definition, a sealed fracture should constitute a discontinuity that has been healed by growth of secondary minerals. Thus, the existence of sealed non-mineralised fractures in Sicada is impossible from a geological point of view. Given that such fractures are nevertheless registered in Sicada, these were included in this study, to understand the intended meaning of this classification and to detect eventual logging mistakes. Two of these fractures were, additionally, subject to physical inspection and re-interpretation during which mistakes were indeed detected (see Section 5.1.1).

Table 4-13. Non-mineralised fractures at Forsmark classified according to degree of openness.

Degree of openness	Total number of fractures	Number of non-mineralised fractures	% non-mineralised fractures of all fractures
Open	10,264	697	6.8
Partly open	704	109	15.5
Sealed	30,151	1,038	3.4
Total	41,119	1,844	

Table 4-14. Non-mineralised fractures at Laxemar classified according to degree of openness.

Degree of openness	Total number of fractures	Number of non-mineralised fractures	% non-mineralised fractures of all fractures
Open	13,590	402	3.0
Partly open	118	9	7.6
Sealed	36,587	370	1.0
Missing	1	0	0
Total	50,296	781	

Non-mineralised PFL-fractures

Hydraulically conductive fractures play a key role in hydrogeological systems and are an important consider in developing hydrogeological model e.g. /Follin 2008/. Flowing features (flow anomalies) are identified using the Posiva Flow Log/Difference Flow (PFL) method. The correlation analyses of PFL-fracture transmissivities and logged fractures were performed on computers using available PFL-fracture data files, Boremap interpretation files, and BIPS images e.g. /Teurneau et al. 2008/. No physical inspection of the cores is done by the hydrologist during the interpretive work of the PFL data. Given the role the hydraulically active fractures play, non-mineralised fractures interpreted as PFL-fractures were considered a particularly important subset in this study. However, the PFL-fracture data is not part of the p_fract_core_eshi table, where fracture characteristics are stored. Thus it is not possible to directly extract the flowing fractures classified as non-mineralised. The data from the core logging table (p_fract_core_eshi) was combined with the hydraulic property data tables (i.e. pfl_anom_fract_id and p_inferr_anom), and by utilising the unique fracture id (feature_id) as the common denominator, we were able to extract the non-mineralised flowing fractures from Sicada.

A total of 119 PFL-fractures are classified as non-mineralised for Forsmark and 80 for Laxemar (Table 4-15). Most of these are X-coded at Laxemar, whereas most are non X-coded PFL-fractures at Forsmark.

Table 4-15. Number of non-mineralised fractures visible in BIPS and interpreted as PFL-fractures from Forsmark and Laxemar. Note that the non-mineralised PFL-fractures also include fractures within deformation zones (DZ).

	All non-mineralised PFL-fractures visible in BIPS (including no Min1–Min 4 and X5/X7-coded fractures)	Number of non-mineralised PFL-fractures outside DZ
Forsmark	119	61
Laxemar	80	63
Total	199	124

Orientation of non-mineralised fractures

To analyse fracture orientation, it is important to acknowledge the orientation bias (e.g. /Terzaghi, 1965, Davy et al. 2006/), which stems from the intersection probability between a fracture and the borehole. In Sicada the angle between the fracture trace and the borehole axis (column alpha in table p_fract_core_eshi) is registered, and can be used directly for bias corrections according to /Terzaghi 1965/ without additional knowledge of borehole orientation. Though the method of /Davy et al. 2006/ also takes the fracture size distribution into consideration the method of Terzaghi is generally considered adequate for the purpose of this analysis.

All contoured stereonets in this report have been contoured according to /Kamb 1959/ using contour intervals of 2 σ (st. dev.) in SpheriStat3 /Pangea Scientific 2010/.

At Forsmark

Figure 4-2 (A1 to A6) shows the orientation of poles to logged fractures visible in BIPS at Forsmark. Figure A1 shows the orientation of poles to all logged fractures and A2 the orientation of poles to all non-mineralised fractures at Forsmark. The fracture orientations are not uniformly distributed, but clustered around particular orientations. A1 shows steep fractures of nearly every strike, with the most common strike being NE and a sub-horizontal to horizontal fracture set. Most of the non-mineralised fractures (A2) are horizontal to sub-horizontal, but a less prominent set of steeply dipping fractures striking WNW also exist. Figure A3 shows the orientation of all PFL-fractures and A4 the orientation of all non-mineralised PFL-fractures. Most of the PFL-fractures (both mineralised and non-mineralised) are horizontal to sub-horizontal, however some dip steeply and strike NE and WNW. Figures A5 and A6 shows the orientations of non-mineralised fractures divided in open (A5) and sealed (A6); sub-horizontal to horizontal fracture sets occur as well as steeply dipping fractures that strike NW and NE.

Note that the subset of fractures shown in A2 in Figure 2-2 have over-representative intensities of the NW striking set as compared to A1. The reason for this is not obvious to us, but we note that it roughly coincides with the direction of σ1.

At Laxemar

Figure 4-2 (B1 to B6) shows the orientation of poles to logged fractures visible in BIPS at Laxemar. Figure B1 shows the orientation of all logged fractures at Laxemar. The fracture orientations are not uniformly distributed, but clustered. B1 shows steep fractures of nearly every strike, with the most common strike being N and E and a sub-horizontal to horizontal fracture sets. B2 shows the orientation of poles to non-mineralised fractures visible in BIPS. Steeply dipping fractures striking WNW and NNE and sub-horizontal fractures are dominant. Figure B3 shows the orientation of poles to all PFL-fractures (i.e. flowing fractures) and B4 the orientation of poles to all non-mineralised PFL-fractures. Most of the PFL-fractures (B3) are sub-horizontal to horizontal, however some dip steeply and strike WNW. The dominating fracture orientations for non-mineralised PFL-fractures (B4) is WNW. Figures B5 and B6 show the orientations of non-mineralised fractures that are open (B5) and that are sealed (B6). The dominant fracture orientations for the open fractures (B5) are WNW and N, however, a horizontal to sub-horizontal set also occurs.

Similar to Forsmark, the subset of fractures shown in B2 have over-representative intensities of the NW striking set as compared to B1. Also at Laxemar, this direction coincides with σ1.

Differences in fracture orientations between Forsmark and Laxemar

The dominant sets of steeply dipping fracture sets at Forsmark strike NE, NW, and WNW whereas the dominant sets at Laxemar strike N-S and E-W. Both Forsmark and Laxemar display prominent horizontal to sub-horizontal fracture orientations. (Figure 4-2: A1 and B1). The non-mineralised fractures at Forsmark are dominantly sub-horizontal to gently dipping whereas in Laxemar they are steep and strike mostly NW-SE and NE-SW (e.g. A2 and B2). Figures A3 and B3 shows the orientations of the poles to PFL-fractures. Both sites display a sub-horizontal to gently dipping set, and vertical sets. The dominant non-mineralised PFL-fracture orientation in Laxemar is vertical and strikes WNW.). The non-mineralised PFL-fractures at Forsmark (A4) are dominantly horizontal to sub-horizontal. Vertical fractures that strike WNW occur at both Forsmark and Laxemar but are more pronounced at Laxemar (cf. A4 and B4). Most of the open non-mineralised fractures at Forsmark are horizontal to sub-horizontal (A5), whereas the dominant sets at Laxemar are nearly vertical (B5). The sealed non-mineralised fractures are dominantly sub-horizontal to horizontal at Forsmark (A6) and steeply dipping at Laxemar (B6).

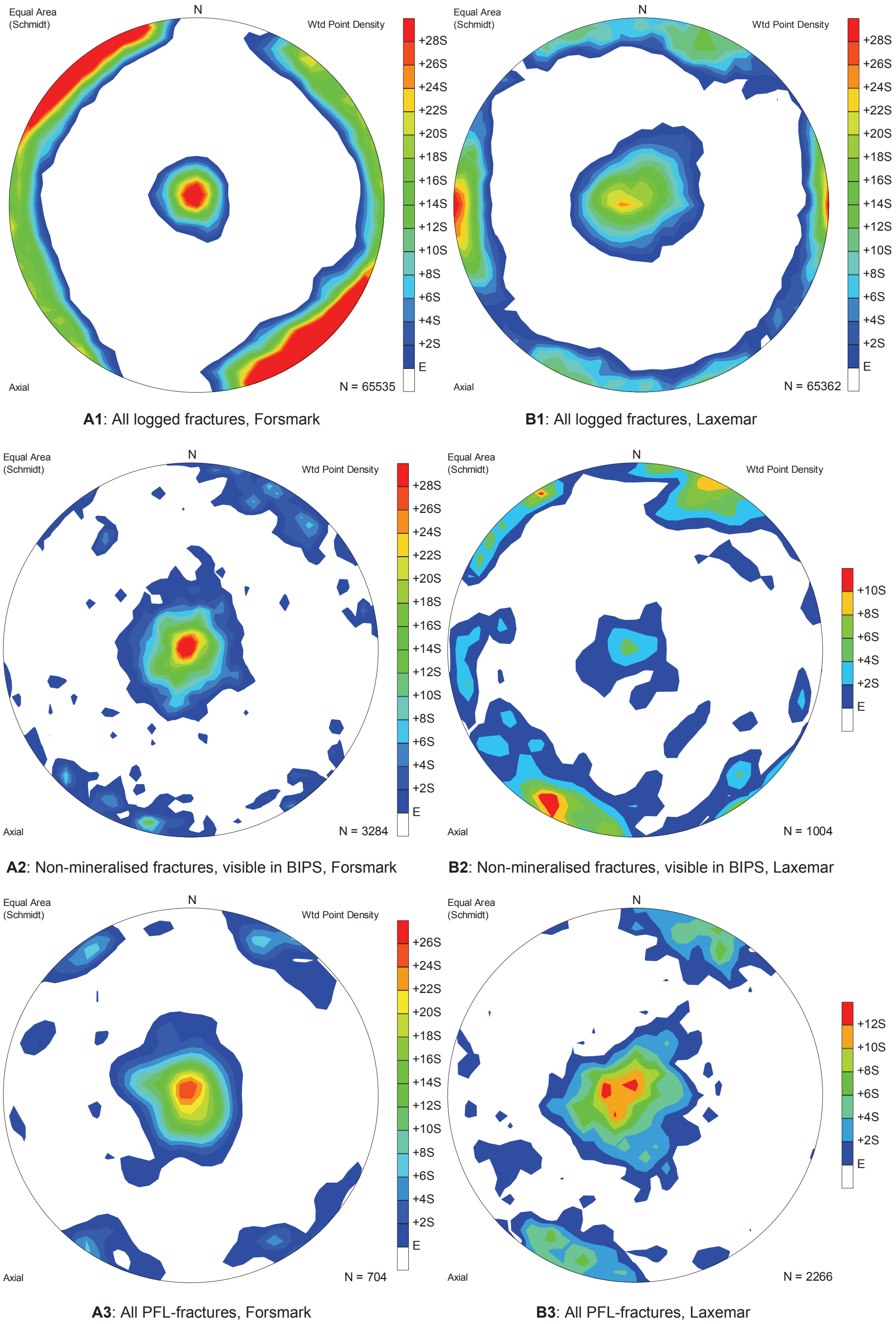


Figure 4-2. *Pole plots (equal-area, lower hemisphere) for fractures at Forsmark and Laxemar. A Terzaghi correction has been applied to all sets (with a maximum correction value of 10). Note that all plots only display fractures recorded as visible in BIPS. Plots A1–A4 and B1–B4 include fractures interpreted as open, partly open and sealed. A5–A6 and B5–B6 plots the open/partly open and sealed fractures separately. A1: All logged fractures at Forsmark (N=65535). B1: All logged fractures at Laxemar (N=65362). A2: All non-mineralised fractures at Forsmark (N=3284). B2: All non-mineralised fractures at Laxemar (N=1004). A3: All fractures interpreted as PFL-fractures at Forsmark (N=704). B3: All fractures interpreted as PFL-fractures at Laxemar (N=2266). A4: All non-mineralised PFL-fractures at Forsmark (N=119). B4: All non-mineralised PFL-fractures at Laxemar (N=88). A5: All non-mineralised fractures interpreted as open at Forsmark (N=806). B5: All non-mineralised fractures interpreted as open at Laxemar (N=407). A6: All non-mineralised fractures interpreted as sealed at Forsmark (N=1038). B6: All non-mineralised fractures interpreted as sealed at Laxemar (N=366). Note: The number of fractures in these plots vary from the number of fractures listed in Tables 4-9 and 4-10. The reason for this is that some of the logged fractures lack information about orientation. All stereonets (SpheriStat3) have been contoured according to /Kamb 1959/ using contour intervals of 2 σ.*

Summary of database extraction

Roughly 200,000 fractures have been logged at both sites. Of these 56% occur at Laxemar and 44% at Forsmark. The first step of the database extraction involved identification of all fractures classified as non-mineralised in Sicada. This extraction showed that a total of 7,117 fractures, i.e. 3.7% of all logged fractures, at both sites are classified as non-mineralised in Sicada. Nearly three times as many of the non-mineralised fractures occur at Forsmark compared to Laxemar. X-coded fractures dominates the population of non-mineralised fractures at Laxemar, but represents only 20% of the same population at Forsmark. Roughly 60% of the non-mineralised fractures are visible in BIPS, and by eliminating fractures not visible in BIPS from further analysis, we obtained a total of 3.1% non-mineralised fractures. By excluding fractures located within deformation zones the number of non-mineralised fractures was further decreased from 4,300 to 2,625, equivalent to 2.9% of all logged fractures.

The spatial distribution of non-mineralised fractures show that they occur in all fracture domains at both sites. Non-mineralised fractures are evenly distributed within fracture domains at Laxemar but unevenly distributed within fracture domains at Forsmark. ~20% of these fractures occurs at depths equivalent to repository depth at both sites. However, a significant difference in depth occurrence was noted when non-mineralised fractures was normalised to available borehole meters. The depth occurrence of these fractures is more or less constant at Laxemar whereas it significantly decreases with depth at Forsmark.

When looking at fracture aperture we noted that most non-mineralised fractures are classified as sealed. However, when looking at the total distribution of non-mineralised fractures, most are interpreted as partly open/open. Sealed non-mineralised fractures should not exist in Sicada, and in order to be able to identify possible database inconsistencies and to understand the meaning of these fractures we included a number of them in the continued work. Flowing fractures play a key role in the overall hydrogeological system, and the extraction revealed that a total of 4.6% of the non-mineralised fractures are PFL-fractures. Most of these are X-coded at Laxemar but not at Forsmark. Since it was not a realistic possibility to inspect all fractures classified as non-mineralised in Sicada, we had to narrow down the selection to obtain a resourceful subset of these fractures could be investigated in detail (see Section 5).

5 Selection of subset for physical inspection

One subset from each site (Table 5-1) consisting of fractures registered as non-mineralised in Sicada was selected for detailed inspection using the procedure described above. The main aim of the subset selection was to obtain a set of fractures so that we could get an overview of these fractures, and in detail look at their characteristics and confirm if their fracture surfaces were coated by minerals or not. Figures 5-1 and 5-2 illustrate the workflow used to extract the fracture subsets that were selected for detailed inspection. Instead of a completely random fracture selection from Sicada, the fractures selected for physical inspection forming the subsets satisfied the following conditions:

- The fracture was classified as non-mineralised in Sicada (i.e. the Min1–Min4 record has no registered entries for it or X5 or X7 codes have been used in table: p_fract_core_eshi).
- The fracture was visible in BIPS.
- The fracture occurred outside deformation zones[1].

The selected subsets included fractures from various depths and fracture domains and included most of the non-mineralised PFL-fractures outside deformation zones but also a number of PFL-fractures within deformation zones. The selected subsets included a total of 204 fractures from both sites (Table 5-1), with 99 fractures from Forsmark and 105 fractures from Laxemar.

Table 5-1. Subsets of non-mineralised fractures selected for further inspection.

Site	Number of fractures selected for inspection	Fractures with no registry in Min1–Min4	X-coded fractures*	Non-mineralised PFL-fractures	Number of physically inspected fractures	Sampled fractures
Forsmark	99	78	21	66	88	38
Laxemar	105	65	40	49	73	20
Total	204	143	61	115	161	58

*Mineral codes X7 and X5 were used during logging if a fracture appeared fresh and if no fracture minerals were detected.

[1] Non-mineralised PFL-fractures were prioritized due to the key role of flowing fractures in the overall hydrogeological system.

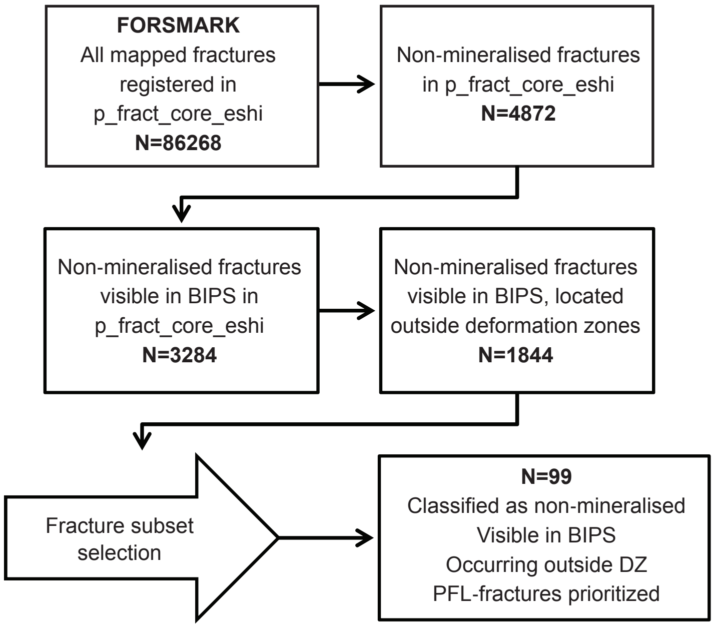


Figure 5-1. *Flow chart illustrating the extraction steps from database extraction to subset selection of non-mineralised fractures at Forsmark. First step involved the extraction of all fractures classified as non-mineralised in table p_fract_core_eshi at Forsmark. In the second step we removed all non-mineralised fractures that are not visible in BIPS. Third step involved removal of all fractures located within deformation zones. Final step involved the selection of the fracture subset. A total of 99 fractures were selected for inspection at Forsmark. These fractures occur at all depths, are visible in BIPS, located outside deformation zone and contain most of the non-mineralised fractures interpreted as PFL-fractures.*

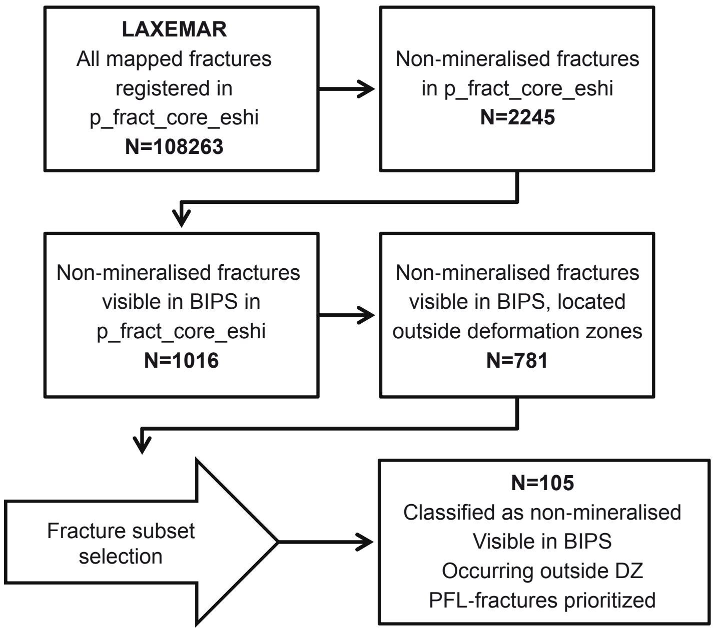


Figure 5-2. *Flow chart illustrating the extraction steps from database extraction to subset selection of non-mineralised fractures at Laxemar. First step involved the extraction of all fractures classified as non-mineralised in table p_fract_core_eshi at Laxemar. In the second step we removed all non-mineralised fractures that are not visible in BIPS. Third step involved removal of all fractures located within deformation zones. Final step involved the selection of the fracture subset. A total of 105 fractures were selected for inspection at Laxemar. These fractures occur at all depths, are visible in BIPS, located outside deformation zone and contain most of the non-mineralised fractures interpreted as PFL-fractures.*

5.1 Characteristics of the non-mineralised fracture subset at Forsmark

The selected fracture subset at Forsmark consists of 99 fractures classified as non-mineralised in Sicada. This subset includes fractures visible in BIPS from different depths and rock domains. Except for a few extracted PFL-fractures, all these fractures are located outside deformation zones. Sixty-six of the fractures are PFL-fractures (3 occurring outside deformation zones). Table 5-2 lists the boreholes that encountered the fractures. Figure 5-3 shows the locations of the boreholes.

Table 5-2. Drill cores from Forsmark inspected during the investigation of non-mineralised fractures. The locations of the boreholes are shown in Figure 5-3.

Investigation Site	Borehole	Borehole length (m)	Inclination (°)	Bearing (°)
Forsmark	KFM01A	1,001.5	85	318
Forsmark	KFM01B	500.5	79	268
Forsmark	KFM01D	800.2	55	35
Forsmark	KFM02A	1,002.4	85	276
Forsmark	KFM02B	573.9	80	313
Forsmark	KFM03A	1,001.2	86	272
Forsmark	KFM04A	1,001.4	60	45
Forsmark	KFM05A	1,002.7	60	81
Forsmark	KFM06A	1,000.6	60	301
Forsmark	KFM06B	100.3	84	297
Forsmark	KFM06C	1,000.9	60	26
Forsmark	KFM07A	1,002.1	59	262
Forsmark	KFM07B	298.9	54	134
Forsmark	KFM08A	1,001.2	61	321
Forsmark	KFM08C	951.1	61	36
Forsmark	KFM08D	942.3	55	100
Forsmark	KFM09A	799.7	60	200
Forsmark	KFM10A	500.2	50	10
Forsmark	KFM11A	851.2	61	40

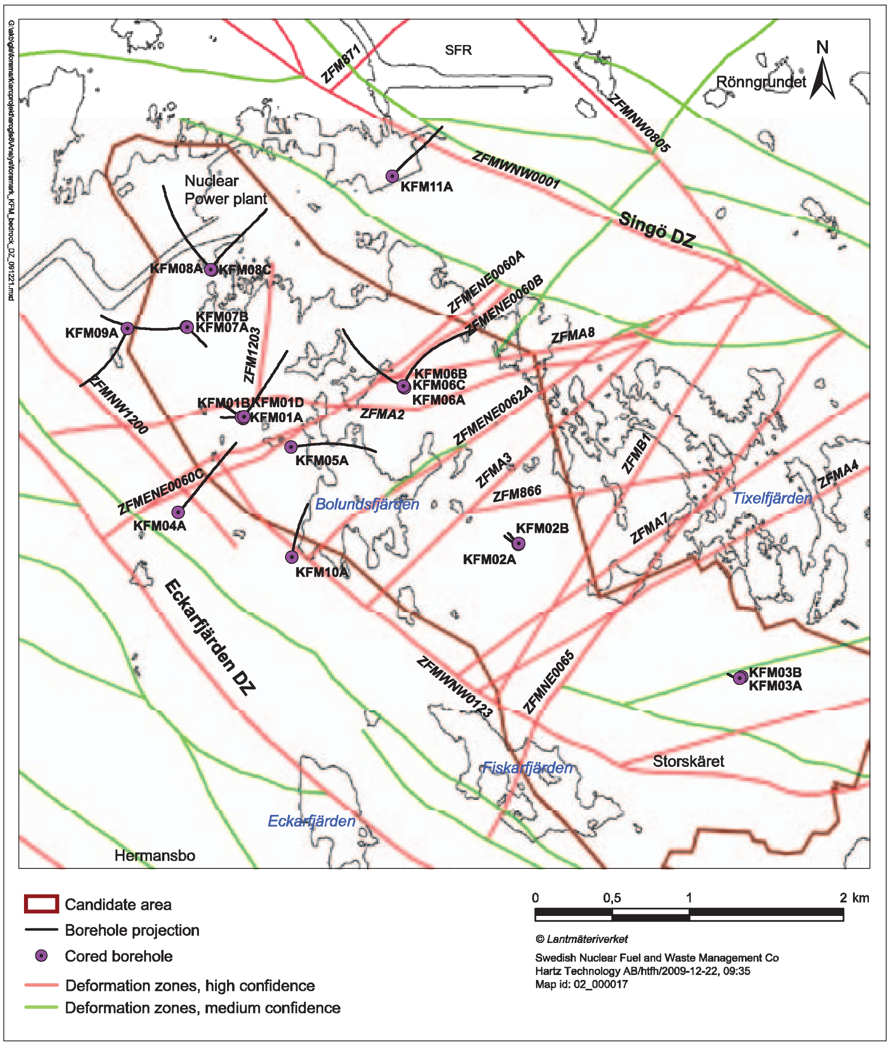


Figure 5-3. *Map of the Forsmark area showing the surface projections of the investigated drill cores.*

Forsmark non-mineralised fractures

The selected subset of fractures was inspected in the Forsmark core shed in November 2008 and April, 2009. We could inspect only 88 out of the 99 selected fractures because some core was missing. Appendix 3 presents the list of the inspected fractures and the inspection chart.

After the inspection, the features were categorised into eight groups based on our interpretation of what the features represent (Table 5-3). Many of the fractures have common traits.

Table 5-3. Grouping criteria for the inspected non-mineralised fractures in Forsmark. A total of 88 fractures were inspected. N denotes the number of fractures belonging to one group. The percentage denotes the portion of the sampled subset in each group.

Group	Grouping criteria	Relative % distribution	N
1	Partly missing core material, which made logging difficult.	11	10
2	Drilling induced fracture (damage caused by rotation, which in turn has removed core material). Induced fractures should not be visible in BIPS, which implies that these fractures are likely erroneously recorded in Boremap.	8	7
3	Fracture probably induced by core disking	10	9
4	Indications of coating – but so thin that it is close to impossible to detect macroscopically.	16	14
5	Correctly logged non-mineralised fracture– no coating detectable by visual inspection.	30	26
6	Erroneously logged non-mineralised fracture – noticeable coating exists.	7	6
7	Uncertain if fracture is natural– feature is barely visible in BIPS even though it is registered in Boremap/Sicada.	16	14
8	The feature either does not exist in the core or could not be located in the core.	2	2
Total		100	88

Group 1 includes fractures where either part of the fracture surface, the entire fracture, or part of the core is missing (Figure 5-4). Handling of the core might have caused the loss of material, but more likely the material sections were lost during to drilling (e.g. material was destroyed when two adjacent core sections were rotated towards in the core barrel). However, even if parts or all of Group 1 fractures was missing they were visible in BIPS.

***Figure 5-4.** Photo of core KFM06A (fracture ID 60D642D98A327BFD). This fracture is a typical Group 1 fracture: it is clearly visible in BIPS, and the missing material in the core coincides with drilling disturbances. The diameter of the drill cores is 50 mm.*

Group 2 includes fractures (Figure 5-5) that clearly bear signs of drilling (e.g. the fracture existed close to core polishing marks or in the vicinity of core uptake, which is seen as a brownish circular mark on the core.

Figure 5-5. *Photo of core KFM02A (fracture ID E8D242D98A31E7B6). This fracture is a typical Group 2 fracture, as it is coincides with or is affected by drilling disturbances. In this example the fracture coincides with a change in lithology at the uptake of the drill core. The diameter of the drill cores is 50 mm.*

Group 3 includes fractures coinciding with signs of core disking (e.g. saddle-shaped fracture surfaces) and lack of evidence of a fracture in the BIPS image (Figure 5-6). These fractures were likely misinterpreted during core logging and have been erroneously registered as visible in BIPS and as true fractures in Sicada.

Figure 5-6. *Photo of core KFM10A (fracture ID 25D046D98A15B32C). These fractures are typical Group 3 fractures and display strong indications of core disking. The core disking appear to coincide with nearby bands of micro-fractures. The diameter of the drill cores is 50 mm.*

Group 4 represents erroneously logged fractures, for they most likely are mineral coated (Figure 5-7). However, the coating was too thin to allow for mineral identification by the unaided eye.

Figure 5-7. *Photo of core KFM06C (fracture ID 7C9642D9881B5146). This fracture is a typical Group 4 fracture, with indications of mineral coating but the coating is too thin to distinguish the minerals forming the coating with the unaided eye. This fracture was sampled for further mineralogical analyses. The diameter of the drill cores is 50 mm.*

Group 5 represents non-mineralised fractures, where no mineral coating could be observed (Figures 5-8 and 5-9). We consider these fractures to have been correctly logged.

Figure 5-8. *Photo of core KFM06A (fracture ID 945642D98A3485D4). This fracture is a typical Group 5 fracture, with no indications of mineral coating (i.e. a non-mineralised fracture by definition). This is a PFL-f fracture which was sampled for further mineralogical analyses. No signs of mineral coating were detected using SEM-EDS. Figure 5-9 shows the BIPS image of the same fracture. The diameter of the drill cores is 50 mm.*

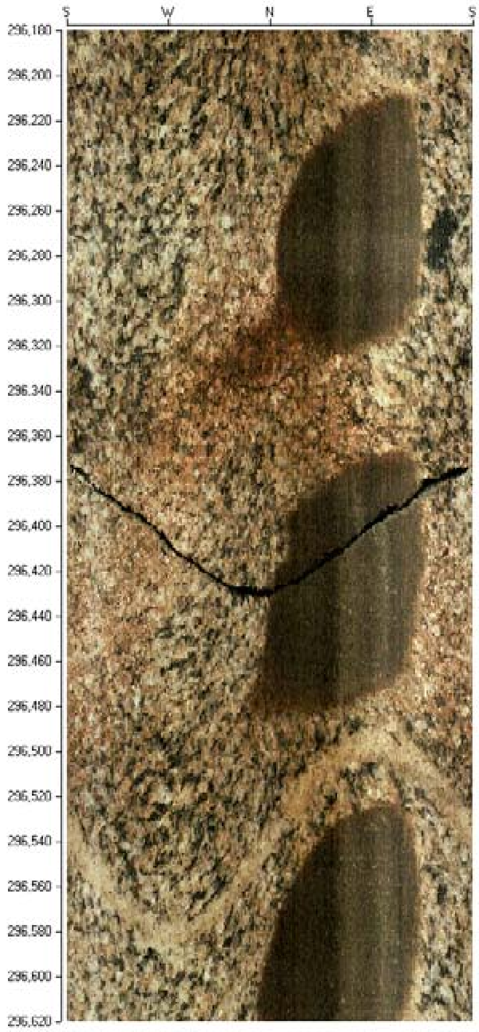


Figure 5-9. BIPS image of core KFM06A (fracture ID 945642D98A3485D4), with a distinct visible fracture. This fracture is a typical non-mineralised fracture, and is furthermore a PFL fracture.

Group 6 include fractures with mineral coating that were readily visible to the unaided eye (Figure 5-10). We consider these to have been erroneously logged.

Figure 5-10. Photo of core KFM10A (fracture ID BF5046D98A11738D). This fracture is a typical Group 6 fracture, with clear indications of mineral coating. This fracture was sampled for further mineralogical analyses. The diameter of the drill cores is 50 mm.

Group 7 denotes fractures that were very difficult or impossible, to detect in the BIPS image (Figure 5-11). We consider these to have been erroneously registered in Sicada. These fractures might reflect core breakage from the core handling (Figure 5-12).

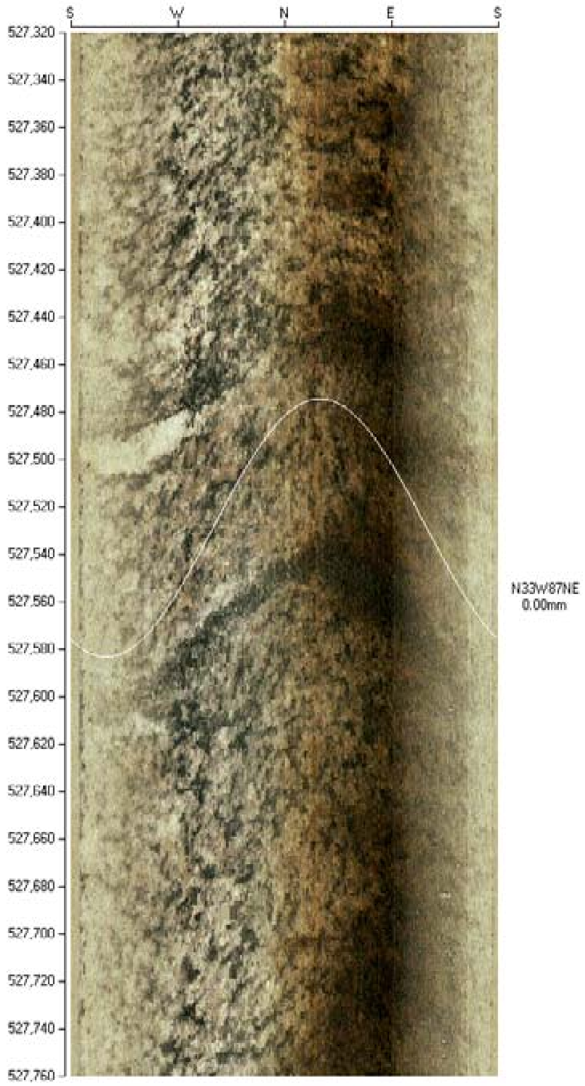


Figure 5-11. *BIPS image of core KFM01D (fracture ID 521142D98F180CA9). This BIPS image shows no clear signs of a fracture.*

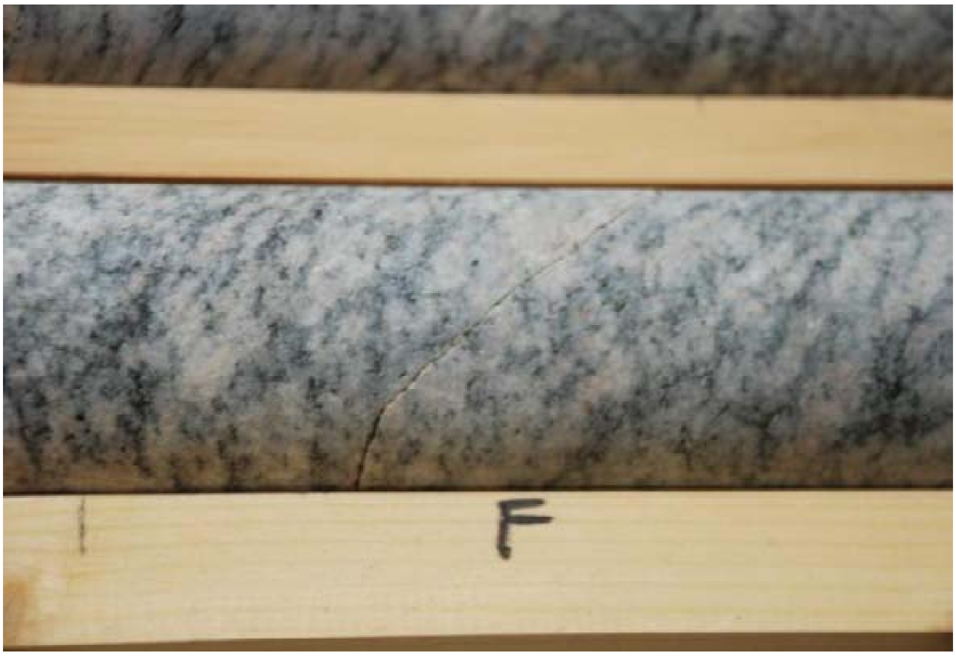


Figure 5-12. Photo of core KFM01D (fracture ID 521142D98F180CA9). F indicates that this break occurred during handling of the core. This fracture is a typical Group 7 fracture; it is not visible in BIPS (see Figure 5-11), and was erroneously logged as an in situ fracture. The diameter of the drill cores is 50 mm.

Group 8 corresponds to features that could not be located in the core (Figure 5-13). The reason for the unfeasibility to identify the fracture was related to complex fracturing (a crush zone) where the part of the core where the fracture was supposed to occur was heavily fractured.

Figure 5-13. Photo of core KFM08C (fracture ID 849842D988280291). White rectangle frames a crush zone. Some of the fracture surfaces in this section are coated by minerals whereas some are not. Difficult to identify the specific fracture among the number of fractures. It cannot be excluded that some of these are drilling induced fractures. The diameter of the drill cores is 50 mm.

Summary

Figure 5-14 shows the distribution by percentage of each identified group of fractures at Forsmark. Most of the inspected fractures lacked clear signs of mineral coating, implying that they were correctly logged as non-mineralised fractures (group 5). About 16% of the fractures had faint mineral coatings (group 4). Only 7% of the fractures had clear signs of mineral coating, and were thus erroneously logged (group 6). However, considering that the fractures belonging to group 7 are likely misinterpreted and not true fractures, these were also probably erroneously logged. Fractures lacking signs of mineral coating or where the fracture coating was too thin for visual identification of fracture mineral were sampled for further mineralogical analyses (Table 5-4).

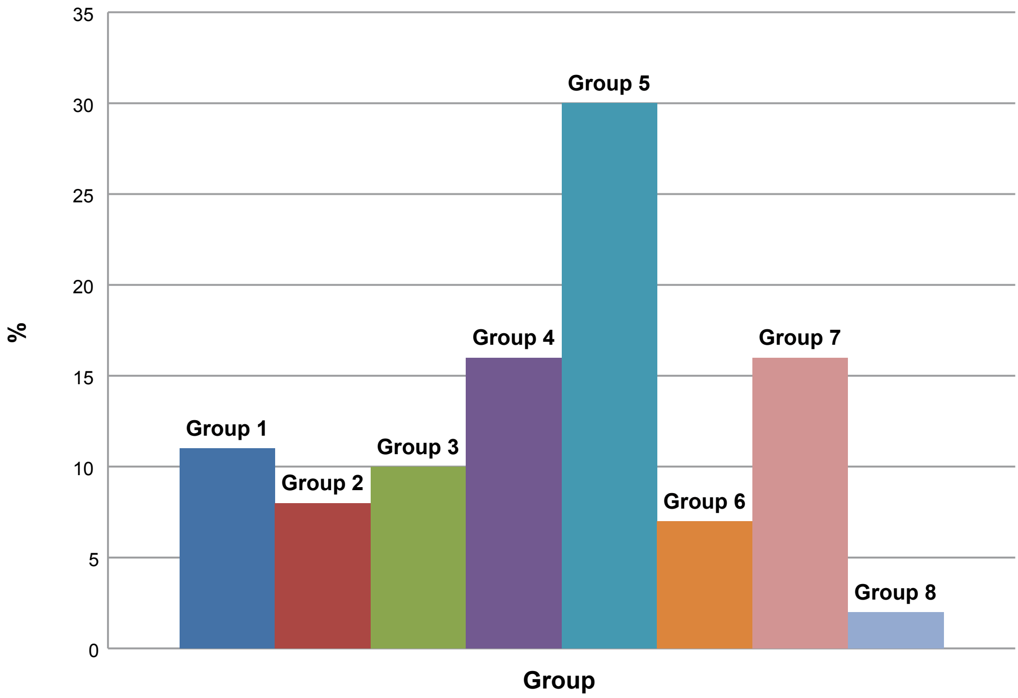


Figure 5-14. *Percentage of the different groups identified during the inspection of non-mineralised fractures in Forsmark. Group 1: missing fracture surface/core material; Group 2: signs of drilling; Group 3: core disking; Group 4: signs of mineral coating; Group 5: correctly logged non-mineralised fracture (i.e. no macroscopic signs of coating); Group 6: clearly visible coating (i.e. erroneously logged non-mineralised fracture); Group 7: difficult to detect a fracture in the core; and Group 8:difficult to locate the correct fracture in the core.*

5.1.1 Mineralogical and geochemical analyses of the Forsmark fractures

Thirty-five fractures lacking clear indications of mineral coating or type of coating were sampled for further mineralogical/geochemical analyses. The aim of the detailed mineralogical analysis was to see if the fracture surfaces had mineral coatings. The detailed results of the mineralogical/geochemical analyses are presented in Appendix 1. The surfaces of these 35 fractures, from groups 1 to 5 (Table 5-4), were sampled and subsequently analysed by optical microscopy and SEM-EDS. In all but six samples, fracture mineral coatings were detected.

Table 5-4. Compilation of results from investigation of sampled fractures. One additional sample was taken during the inspection of the fractures KFM02B (429.603 m) to investigate a yellowish colouring of the core. This extra sample does not form a non-mineralised fracture. Note that two of the sampled 35 fractures are interpreted as "sealed" in p_fract_core_eshi.

Borehole	Length (m)	Fracture interpretation	Detected fracture minerals	No detected fracture minerals	Comment
KFM01A	316.726	Open	X		Sub-parallel to micro-fractures.
KFM01B	208.093	Open	X		Sub-parallel to micro-fractures.
KFM01D	91.669	Open	X		
KFM02A	129.707	Open	X		
KFM02A	411.321	Open	X		
KFM02A	416.498	Open	X		
KFM04A	178.913	Open	X		Sub-parallel to micro-fractures.
KFM05A	166.372	Open		X	Sub-parallel to micro-fractures with calcite, quartz and adularia.
KFM05A	167.142	Open		X	Sub-parallel to micro-fractures with clay minerals (corrensite).
KFM05A	203.509	Sealed		X	Sub-parallel to micro-fractures with calcite and pyrite.
KFM06A	109.262	Open	X		Sub-parallel to micro-fractures.
KFM06A	297.253	Open		X	
KFM06C	619.565	Sealed	X		
KFM06C	744.804	Open	X		Sub-parallel to micro-fractures with no mineral.
KFM08A	111.198	Open	X		Sub-parallel to micro-fractures.
KFM10A	332.834	Open		X	Sub-parallel to micro-fractures with no mineral.
KFM10A	334.43	Open		X	Sub-parallel to micro-fractures with no mineral.
KFM11A	395.37	Open	X		Sub-parallel to micro-fractures with laumontite.
KFM01A	955.507	Open	X		
KFM02B	330.696	Open	X		Sub-parallel to micro-fractures with pyrite.
KFM02B	413.066	Open	X		Sub-parallel to micro-fractures with no detected mineral.
KFM02B	423.349	Open	X		Sub-parallel to micro-fractures with no detected mineral.
KFM02B	426.132	Open	X		Numerous micro-fractures with no detected minerals.
KFM02B	426.354	Open	X		Sub-parallel to micro-fractures with no detected mineral.
KFM02B	429.508	Open	X		Sub-parallel to micro-fractures with adularia.
KFM02B	429.603	Open	X		Extra sample, yellow coating from drilling/logging.
KFM02B	436.367	Open	X		Sub-parallel to micro-fractures with corrensite and allanite.
KFM02B	497.092	Open	X		Sub-parallel to fracture sealed with prehnite and adularia.
KFM03A	515.936	Open	X		Sub-parallel to fracture with calcite, allanite, adularia, corrensite.
KFM03A	846.040	Open	X		
KFM08D	109.218	Open	X		Sub-parallel to micro-fractures with wall rock fragments.
KFM08D	147.957	Open	X		Sub-parallel to micro-fractures with no detected mineral.
KFM10A	103.241	Open	X		Sub-parallel to micro-fractures with no detected mineral.
KFM10A	328.076	Open	X		Sub-parallel to micro-fractures with no detected mineral.
KFM10A	328.723	Open	X		

Confirmed non-mineralised fractures

Six of the sampled and analysed fractures have been confirmed as non-mineralised fractures. Detailed information of these fractures is shown in Table 5-5. One of these fractures (KFM05A FeatureID 555542D98A1319B6) was interpreted as sealed and visible in BIPS during the original drill core logging. However, our detailed inspection indicates that this should not have been recorded as visible in BIPS. This fracture is likely a break of the core, which probably occurred during core handling. Thus, this fracture is excluded from further discussion in this report. Consequently, five non-mineralised fractures have been verified in this study. All these fractures are interpreted as PFL-fractures. However, during the fracture inspection the following observations were made concerning two fractures in core KFM05A:

1) The fracture with featureID 735545D98A12893B at 166.37 meters depth (adjusted secup) in KFM05A has a neighbouring fracture located 5.4 cm up hole (featureID 621542D98A128905), that appears to be a more likely PFL-fracture candidate as this fracture had clear signs of mineral coating. This other fracture is also classified as non-mineralised in Sicada but is coated by minerals when inspecting the core.
2) The fracture with featureID 6B9542D98A128C3A at 167.142 meters depth (adjusted secup) in KFM05A has a neighbouring fracture located 3.8 cm above up hole (featureID 00D542D98A128C14), that bears clear a mineral coating. This other fracture is also classified as non-mineralised in Sicada.

Based on the above observations we suggest that the two confirmed non-mineralised fractures in KFM05A are not to be considered as non-mineralised PFL-fractures, but rather only non-mineralised fractures. Consequently, a total of five non-mineralised fractures were confirmed in this study. Three of these non-mineralised fractures are classified as PFL-fractures (Table 4-15).

Table 5-5. Confirmed non-mineralised fractures. * denotes "Best choice PFL-fracture". Idcode = borehole ID; Adjusted secup = adjusted borehole length; Elevation adjusted secup = vertical depth; Fract_mapped = fracture logged as broken or unbroken, Fract_interpret = fracture interpreted originally being open, sealed or partly open; Roughness = fracture roughness as planar, undulating or stepped, Fract_alteration = fracture alteration as fresh, slightly/moderately altered etc; Strike = fracture strike measured clockwise from north (right hand rule); Dip = fracture dip from horizontal plane (0–90 deg, 90 = vertical); Fracture domain = see R-07-15 for definition; featureID = 20 character ID code for individual fractures.

Idcode	Adjusted secup (m)	Elevation adjusted secup (m)	Fract mapped	Fract_ interpret	Roughness	Fract alteration	Strike (°)	Dip (°)	Fracture domain	FeatureID	PFL-fracture	Comment
KFM06A	297.253	–252.487	Broken	Open	Planar	Fresh	146	6	FFM01	945642D98A3485D4	*	
KFM10A	332.834	–235.478	Broken	Open	Undulating	Fresh	212	12	FFM03	F21046D98A1514B5	*	
KFM10A	334.43	–236.522	Broken	Open	Undulating	Fresh	178	118	FFM03	BAD046D98A151AEC	*	
KFM05A	166.372	–138.664	Broken	Open	Planar	Slightly altered	132	13	FFM02	735542D98A12893B	*	Alternative PFL-fracture exist 5.4 cm above this fracture.
KFM05A	167.142	–139.328	Broken	Open	Stepped	Slightly altered	108	17	FFM02	6B9542D98A128C3A	*	Alternative PFL-fracture exist 3.8 cm above this fracture.
KFM05A	203.509	–170.639	Broken	Sealed	Planar	Fresh	157	45	FFM02	555542D98A1319B6		Originally erroneously logged and not a true non-mineralised fracture. Removed from further discussions.

5.1.2 Characteristics of the non-mineralised fractures

The identified minerals on fractures surfaces classified as non-mineralised in Sicada occur as small crystals on the fracture surface and are very difficult to distinguish macroscopically (Figures 5-15 and 5-16). The fracture minerals identified include; hydroxyapophyllite, corrensite, quartz, calcite, barite and pyrite (see Appendix 1). This mineral paragenesis is diagnostic for the Palaeozoic fracture mineral generation 3 at Forsmark (Table 5-6) /Sandström et al. 2008a, 2009/, although hydroxyapophyllite previously only has been identified in a few fractures /Sandström et al. 2004/.

The confirmed non-mineralised fractures are sub-horizontal to horizontal (Figure 2-19) and were encountered at depths ranging from –138 to –252 m.a.s.l. A conspicuous feature is that most of the investigated fractures classified as non-mineralised in Sicada are sub-parallel to nearby fractures (Table 5-4 and Figure 5-16). The wall rock adjacent to the five fractures where no fracture minerals were detected is fresh and do not show any signs of alteration. All but one of the five confirmed non-mineralised fractures are sub-parallel to bands of micro-fractures adjacent to the non-mineralised fractures (Table 5-4). These bands of micro-fractures are found close to the non-mineralised fractures (less than a centimetre to a few centimetres away). Some of the micro-fractures are sealed with e.g. clay minerals whereas others are without fracture minerals. The latter indicates that the micro-fractures are open (or at least partly open), but their size is very small and they are often not connected all the way through the drill core, leaving the drill core unbroken. Identical bands of micro-fractures are also found adjacent to the majority of the sampled fractures where fracture minerals were detected during the detailed analysis (Table 5-4).

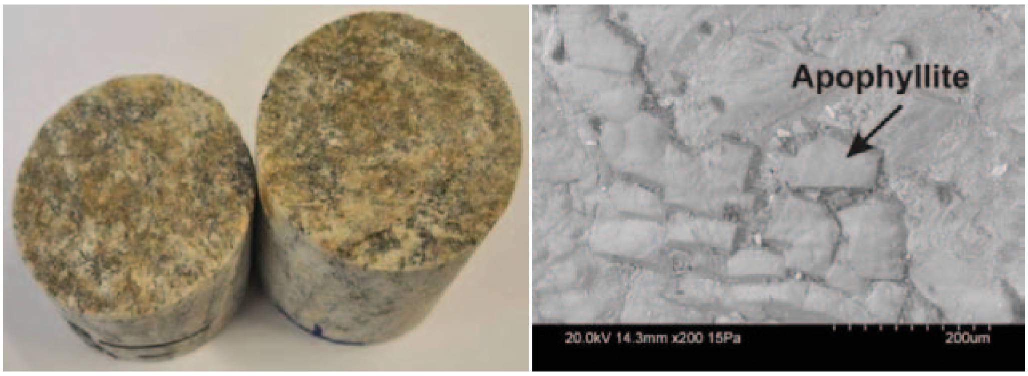


Figure 5-15. Open fracture with small crystals of hydroxyapophyllite. The diameter of the dill core is c. 5 cm. The right figure is an electron image, sample KFM01B 208.093 m. The diameter of the drill cores is 50 mm.

Figure 5-16. Left figure shows an open fracture with no detected fracture mineral (sample KFM05A 166.372 m). Right figure is an open fracture (non-mineralised in Sicada) on which hydroxyapophyllite was identified (sample KFM08A 111.198 m). Observe the similar appearance of the bands of micro-fractures parallel to the open fracture surfaces (see arrows). The diameter of the drill cores is 50 mm.

Table 5-6. Sequence of fracture mineral generations at Forsmark (1=oldest, 4=youngest). Table compiled from /Sandström et al. 2004, 2008a, 2009/.

Generation and fracture minerals	Main related event and age
1) Epidote, quartz, chlorite.	1.8–1.1 Ga (possibly waning stage of Svecokarelian orogeny, 1.8–1.7 Ga)
2) Adularia, albite, prehnite, laumontite, calcite, hematite, chlorite/corrensite.	Sveconorwegian orogeny, 1.1–1.0 Ga
3) Quartz, calcite, pyrite, asphaltite, adularia, galena, fluorite, corrensite, sphalerite, barite, chalcopyrite, analcime, hydroxyapophyllite.	Caledonian orogeny, 260–277 Ma
4) Clay minerals, calcite, pyrite, Fe-oxyhydroxide.	< 277 Ma to possibly recent

Orientation of confirmed non-mineralised fractures

Figure 5-17 shows the orientation of the poles to the five confirmed non-mineralised fractures. All five fractures are horizontal to sub-horizontal.

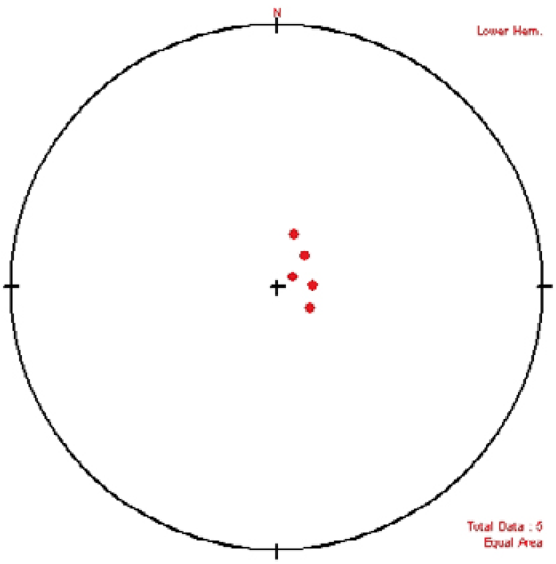


***Figure 5-17.** Pole-plot (equal-area, lower hemisphere) of poles to the five confirmed non-mineralised fractures. The non-mineralised fractures occur at depths ranging from –138 to –252 m.a.s.l.*

5.2 Characteristics of the non-mineralised fracture subset at Laxemar

The selected fracture subset at Laxemar consists of 105 fractures classified as non-mineralised in Sicada. This subset includes fractures visible in BIPS from different depths and different rock domains. Forty-nine of these are PFL-fractures. With the exception of seven fractures (three of which are PFL-fractures) all are located outside deformation zones. Table 5-7 lists the individual boreholes hosting the fractures comprising the selected subset. The locations of the boreholes are illustrated in Figure 5-18.

Table 5-7. Drill cores from Laxemar inspected during the investigation of non-mineralised fractures. The locations of the boreholes are shown in Figure 5-18.

Investigation Site	Borehole	Borehole length (m)	Inclination (°)	Bearing (°)
Laxemar	KLX02	1,700.5	–85	357
Laxemar	KLX04	993.5	–85	0
Laxemar	KLX05	1,000.2	–65	190
Laxemar	KLX07A	844.7	–60	174
Laxemar	KLX07B	200.1	–85	174
Laxemar	KLX08	1,000.4	–60	199
Laxemar	KLX09	880.4	–85	267
Laxemar	KLX10	1,001.2	–85	251
Laxemar	KLX11D	120.4	–59	269
Laxemar	KLX13A	595.9	–82	225
Laxemar	KLX16A	433.6	–65	294
Laxemar	KLX17A	701.1	–61	11
Laxemar	KLX18A	611.3	–82	271
Laxemar	KLX19A	800.1	–58	197
Laxemar	KLX20A	457.9	–50	271
Laxemar	KLX21B	858.8	–71	225
Laxemar	KLX22A	100.5	–60	179
Laxemar	KLX26A	101.1	–61	94

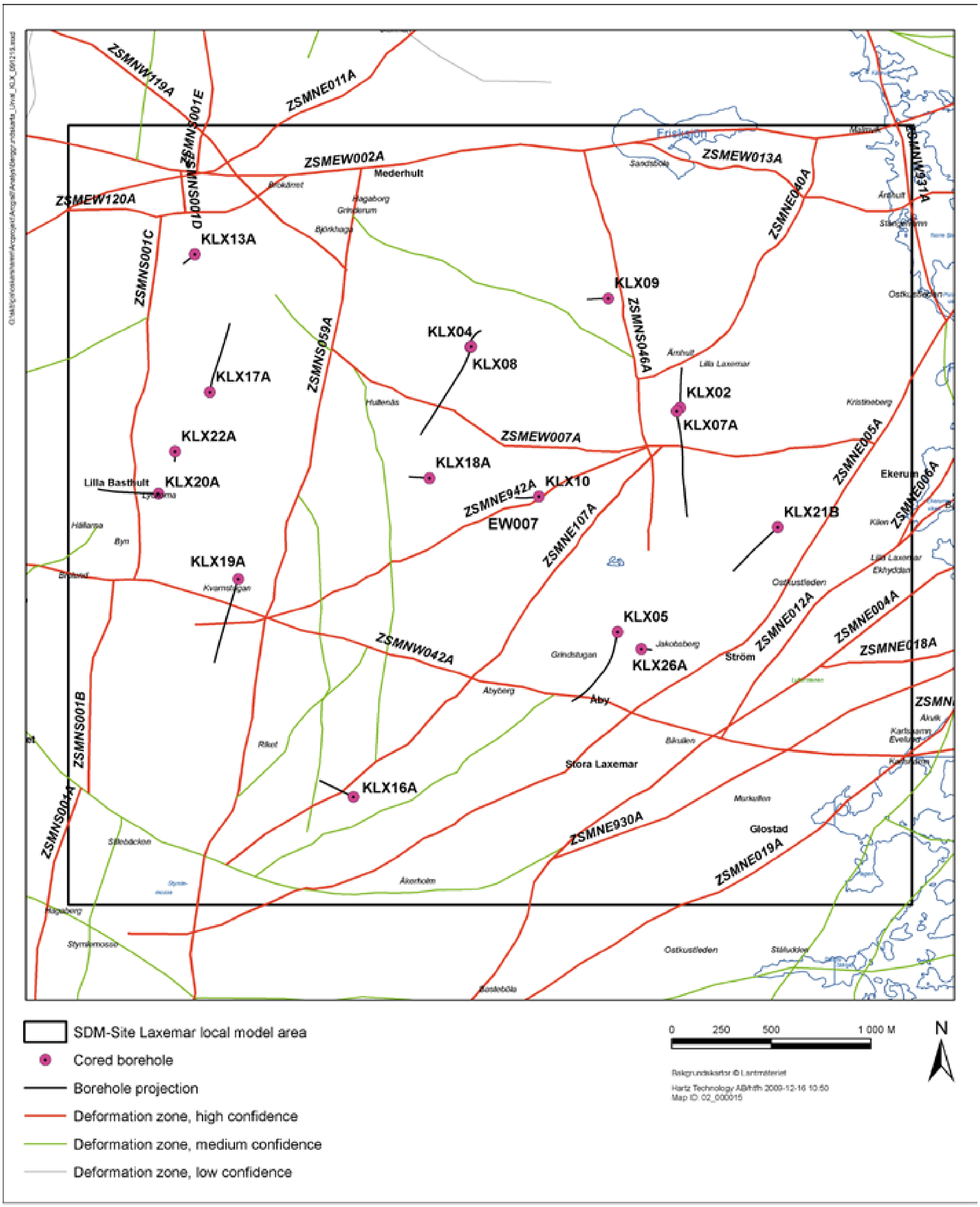


Figure 5-18. *Map of the Laxemar area showing the surface projections of the investigated drill cores.*

Laxemar non-mineralised fractures

The selected fracture subset was inspected in the Oskarshamn core shed in March, 2009. During the inspection of the subset, the fractures were categorised into eight groups (Table 5-8). Due to missing core material we were only able to inspect 73 out of these 105 fractures. Most of the core missing from KLX17A was used in sampling for pore water analysis. Many of the fractures displayed features from several groups. However, they are grouped according to the most dominant feature. The list with all inspected fractures and the inspection chart is presented in Appendix 4.

Table 5-8. Grouping criteria for the inspected non-mineralised fractures at Laxemar. A total of 73 fractures were inspected. N denotes the number of fractures belonging to one group. Percentage denotes the portion of the sampled subset. The same grouping criteria were used for the inspection at Laxemar as at Forsmark.

Group	Grouping criteria	Relative % distribution	N
1	Partly missing core material, which made the logging difficult due to lack of fracture material.	0	0
2	Drilling induced fracture (damage caused by rotation, which in turn has removed core material).	6	4
3	Fracture probably induced by core disking.	0	0
4	Indications of coating – but so thin that it is close to impossible to detect macroscopically.	19	14
5	Correctly logged non-mineralised fracture– no coating detectable by visual inspection.	11	8
6	Erroneously logged non-mineralised fracture – noticeable coating exist.	53	39
7	Uncertain if it is a natural fracture – barely visible in BIPS even though a registry exists in Boremap/Sicada. Probably an over interpreted fracture (i.e. no real fracture).	1	1
8	No fracture exist in the core or impossible to locate the correct fracture in the core.	10	7
Total		100	73

Note that no fractures belonging to groups 1 and 3 were observed during the inspection of the Laxemar cores. In general, the cores displayed very few signs of drilling disturbances and no core disking fractures were observed.

Group 2 includes fractures in a section of the core that is clearly affected by drilling disturbances (e.g. the logged fracture location was close to core polishing marks or in the vicinity of core uptake, which is seen as a brownish circular mark on the core) (Figure 5-19).

Figure 5-19. *Photo of core KLX26A (fracture ID:s C0964B8B0A1080C3; 20964B8B0A1080F4; 40964B8B0A1081A9). This photo shows several fractures typical of Group 2 fractures, where core/fracture and/or material is missing due to drilling disturbances. The diameter of the drill cores is 50 mm.*

Group 4 represents erroneously logged fractures, for they most likely are mineral coated (Figure 5-20). However, the coating was in most instances too thin to allow for mineral identification by the unaided eye.

Figure 5-20. *Photo of KLX08A (fracture ID: 4CD8438B2B149FB3) showing a Group 4 fracture with indications of mineral coating. The diameter of the drill cores is 50 mm.*

Group 5 represents non-mineralised fractures, where no mineral coating could be observed (Figure 5-21). We consider these fractures to have been correctly logged.

Figure 5-21. *Photo of KLX05 (fracture ID: 6B95438B2B12310C) showing a Group 5 fracture with no signs of mineral coating (i.e. a non-mineralised fracture). The diameter of the drill cores is 50 mm.*

Group 6 fractures displayed clear signs of visible mineral coating, and had consequently been erroneously logged (Figure 5-22).

Figure 5-22. *Photo of KLX17A (fracture ID: 3497478B0A21F03D) showing a typical Group 6 fracture with clear signs of mineral coating (in this case chlorite, calcite and pyrite). The diameter of the drill cores is 50 mm.*

Group 7 denotes fractures that were very difficult or impossible, to detect in the BIPS image and are most likely not true fractures (Figure 5-23). We consider these fractures to be erroneously registered in Sicada.

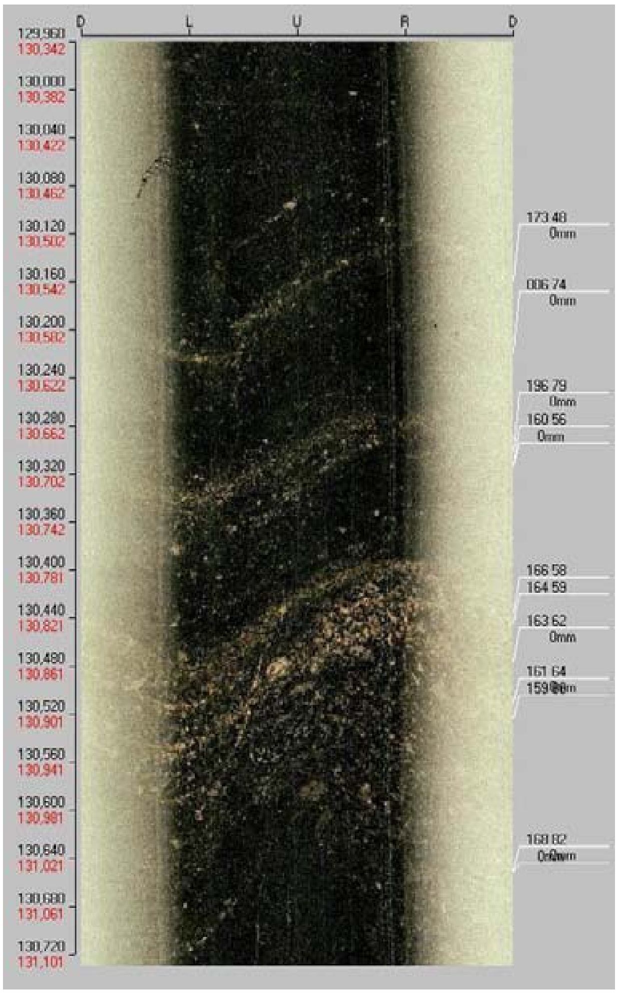


Figure 5-23. BIPS image of the part of KLX17A where a fracture has been logged (fracture ID: A997478B0A21FE38). However, it was impossible to locate this fracture both in the BIPS and in the core, i.e. this is most likely a misinterpreted fracture.

Group 8 includes sections with features that could not be located in the core (Figure 5-24).

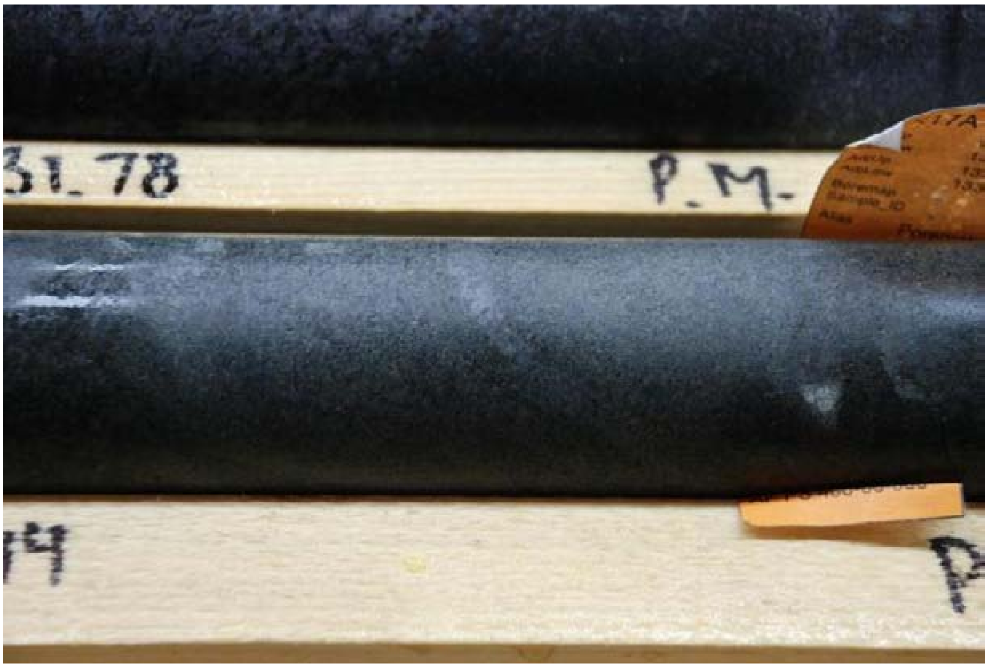


Figure 5-24. *Photo of KLX17A (fracture ID: 3417478B0A220456) showing a Group 8 fracture, i.e. a part of the core where it is impossible to locate any fracture. The diameter of the drill cores is 50 mm.*

Summary

Figure 5-25 shows the percentage of each identified group during the inspection of the fractures at Laxemar. Most (53%) of the inspected fractures had clear signs of mineral coating, implying that they were originally erroneously logged (group 6). An additional 19% of the fractures had faint indications of mineral coating (group 4). Only 11% of the fractures lacked signs of mineral coating, and were thus originally correctly logged (group 5). Fractures lacking signs of mineral coating or type of coating were sampled for further mineralogical analyses (Table 5-9).

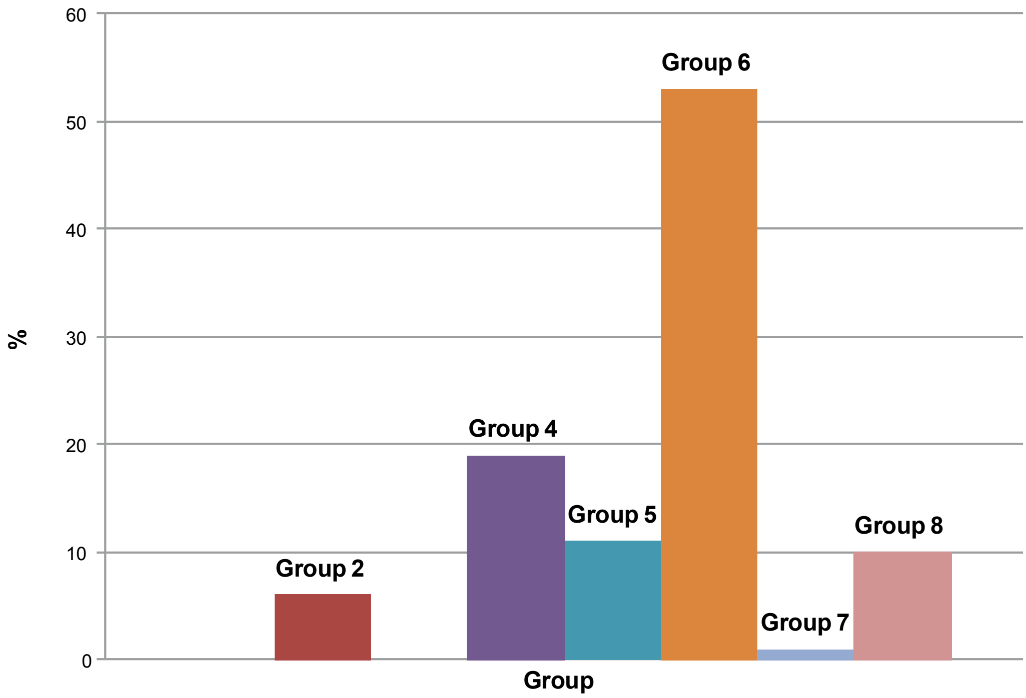


Figure 5-25. *Percentage of the different groups identified during the inspection of non-mineralised fractures in Laxemar. No fractures were assigned to group 1 and 3. Group 1: missing fracture surface/core material; Group 2: signs of drilling; Group 3: core disking; Group 4: signs of mineral coating; Group 5: correctly logged non-mineralised fracture (i.e. no macroscopic signs of coating); Group 6: clearly visible coating (i.e. erroneously logged non-mineralised fracture); Group 7: difficult to detect a fracture in the core; and Group 8:difficult to locate the correct fracture in the core.*

5.2.1 Results and interpretations from mineralogical and geochemical analyses of the Laxemar fractures

Twenty fractures lacking clear indications of coating or type of coating were sampled for further mineralogical and geochemical analyses. The detailed results of these analyses are presented in Appendix 2. The surfaces of these 20 fractures belong to groups 4 to 6 (Table 5-9), and were analysed by optical microscopy and SEM-EDS. Fracture minerals were detected in all samples.

Table 5-9. Compilation of results from investigation of sampled fractures. For details, see Appendix 2.

Borehole	Length (m) (ADJUSTED-SECUP)	Fracture interpretation	Detected fracture minerals	No fracture minerals detected	Comment
KLX02	241.504	Open	X		Sub-parallel to micro-fractures.
KLX05	143.527	Open	X		
KLX06	271.515	Open	X		Sub-parallel to micro fractures.
KLX06	296.037	Open	X		Sub-parallel to micro-fractures.
KLX06	561.074	Open	X		
KLX07A	341.026	Open	X		Sub-parallel to micro-fractures.
KLX07A	396.319	Open	X		Sub-parallel to micro-fractures.
KLX08	303.912	Open	X		
KLX08	361.701	Open	X		Sub-parallel to micro-fractures.
KLX08	491.453	Open	X		
KLX10	284.245	Open	X		Sub-parallel to micro-fractures.
KLX13A	465.239	Open	X		
KLX13A	470.658	Open	X		
KLX18A	309.503	Open	X		Sub-parallel to micro-fractures.
KLX18A	382.470	Open	X		Sub-parallel to micro-fractures.
KLX18A	421.006	Open	X		Sub-parallel to micro-fractures.
KLX18A	468.079	Open	X		Sub-parallel to micro-fractures.
KLX18A	554.815	Open	X		
KLX19A	684.759	Open	X		
KLX19A	733.604	Open	X		Sub-parallel to micro-fractures.

The identified minerals occur as small crystals on the fracture surface and are very difficult to distinguish macroscopically (Figure 5-26). However, when the surfaces were examined with SEM-EDS, minerals could in most cases readily be identified (e.g. Figure 5-27). The fracture minerals identified include; quartz, calcite, barite, pyrite, adularia, REE-carbonate, illite and harmotome.

The appearance of the fractures, i.e. their degree of weathering and wall rock alteration, and in most cases the fracture mineral assemblage, suggests that the fractures are not formed during the low-temperature conditions of the Quaternary. Several earlier studies in the area have resulted in a detailed understanding of the characteristics of the different fracture mineral generations in the area, and their relative ages /Drake and Tullborg 2009/. For some generations absolute ages are available as well. The fracture mineral generations (simplified) and their ages are listed below (Table 5-10).

Figure 5-26. *Photo of KLX18A (fracture ID: 8098478B0A171FDD) showing a fracture with no visible mineral coating (i.e. a group 5 fracture). Pyrite crystals were observed when the surface was examined using SEM-EDS, see Figure 5-27.*

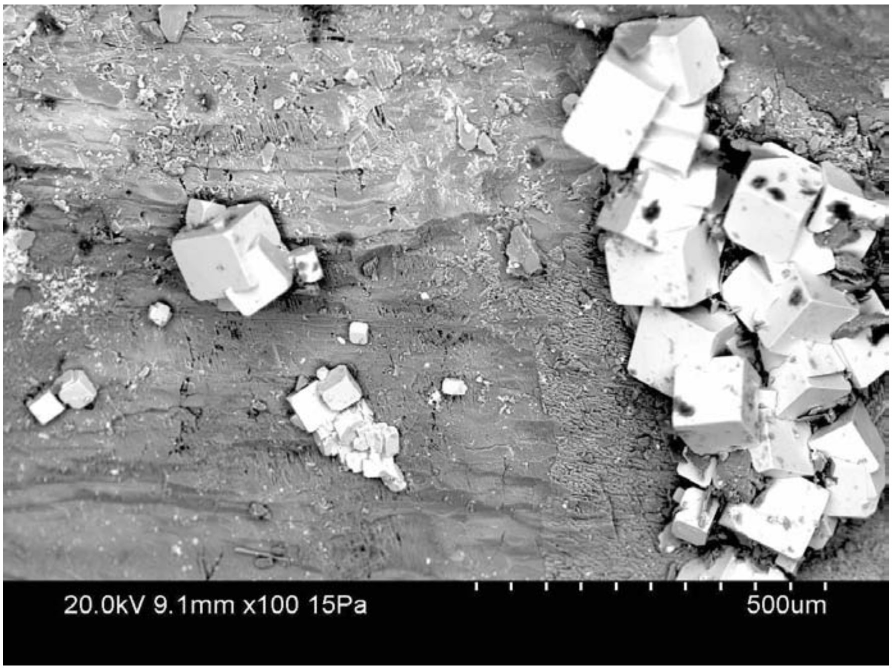


Figure 5-27. Back-scattered SEM-image of pyrite (bright, cubic crystals) from KLX18A.

Table 5-10. Sequence of fracture filling generations (1=oldest, 6= youngest). Table from /Drake et al. 2009/.

Generation and dominating fracture minerals	Main related event and/or age
1) Mylonite; quartz, epidote, muscovite, chlorite, albite ± K-feldspar, albite.	Waning stages of the Svecokarelian orogeny (> 1,750 Ma).
2a) Cataclasite; epidote, quartz, chlorite ± K-feldspar, albite.	Probably 1,750–1,620 Ma.
2b) Cataclasite; K-feldspar, chlorite, quartz, hematite, albite ± illite.	Probably 1,750–1,620 Ma.
3a) Quartz, epidote, chlorite, calcite, pyrite, fluorite, muscovite ± K-feldspar, hornblende.	Intrusion of Götemar and Uthammar granites, related to the 1.47–1.44 Ga Danapolonian orogeny.
3b) Prehnite ± calcite, fluorite.	
3c) Calcite, laumontite, adularia, chlorite, quartz, illite, hematite.	
4) Calcite, adularia, laumontite, chlorite, quartz, illite, hematite ± albite, apatite.	Sveconorwegian orogeny (1.1–0.9 Ga).
Cambrian sandstone (near surface).	Early Cambrian extension.
5) Calcite, adularia, chlorite, hematite, fluorite, quartz, pyrite, barite, gypsum, clay minerals, apophyllite, harmotome, REE-carbonate (probably bastnäsite), ± galena, chalcopyrite, laumontite, sphalerite, analcime.	Caledonian orogeny at 440–400 Ma.
6) Calcite, pyrite, clay minerals, goethite (near surface).	Possibly Quaternary.

Most of the minerals identified on the fracture surfaces, originally logged as non-mineralised, belong to fracture mineral generation 5 at the Laxemar site /Drake et al. 2009/ and are therefore assumed to be Palaeozoic (440–400 Ma). Some minerals of Proterozoic generation 3 have also been identified (cf. Table 5-10). In a few samples, single minerals, e.g. pyrite, has been identified, and since pyrite is found in several generations it cannot be used as an individual age indicator. However, in these cases the weathering of wall rock suggests that the fractures were not formed during the low-temperature conditions of the Quaternary, although the pyrite crystals may have been formed during the Quaternary. The fractures with generation 3 minerals show intense red-staining alteration, i.e. mm to dm wide fracture-adjacent hydrothermal alteration of primary biotite, plagioclase and magnetite to chlorite, hematite-stained (red) secondary feldspars and hematite, respectively /Drake and Tullborg 2009/, and these fractures are sometimes reactivated and coated with younger minerals. Fractures younger then Generation

3 do not show this intense hydrothermal alteration. Instead they show more discrete alteration of e.g. biotite, magnetite and plagioclase, commonly close to the fracture rim, and a characteristic feature is also sub-parallel fractures, which in some cases are filled with Generation 5 minerals. Although, no dating has been performed, the characteristics of most of the inspected fractures and fracture minerals indicate formation several hundred million years ago or earlier, based on the extensive earlier fracture mineralogical studies conducted in the area (cf. /Drake and Tullborg 2009, Drake et al. 2009/).

5.3 Summary of results

Table 5-11 lists and compare the results of the physical inspection of fractures classified as non-mineralised at Laxemar and Forsmark. We note that the amount of fractures classified as non-mineralised in Sicada is considerably higher at Forsmark than at Laxemar. One aim of the physical inspection of the selected fracture subset was to check the core logging results registered in Sicada. The physical inspection undertaken in this study indicates that the portion of originally correctly logged non-mineralised fractures (i.e. the fractures are lacking signs of mineral coating upon visual inspection) is considerably higher in Forsmark than in Laxemar. In total, five non-mineralised fractures were confirmed in this study. All of these fractures were confirmed in drill cores from Forsmark. The confirmed non-mineralised fractures represent 14.3% of the sampled fractures and 5.7% of the inspected fractures at Forsmark.

Table 5-11. Compilation of number of fractures in p_fract_core_eshi and the results of the inspection of non-mineralised fractures. Note: This table only concerns fractures visible in BIPS. N = Amount of fractures.

	Forsmark (N)	Forsmark % % of total amount of fractures visible in BIPS N = 68023)	Forsmark % % of all non-mineralised fracturesvisible in BIPS (N=3284)	Forsmark % of non-mineralised fractures in relation to inspected fractures (N=88)	Laxemar (N)	Laxemar % % of total amount of fractures visible in BIPS (N=1016)	Laxemar % % of all non-mineralised fractures visible in BIPS (N=69792)	Laxemar % of non-mineralised fractures in relation to inspected fractures (N=73)
Non-mineralised fractures in p_fract_core_eshi, visible in BIPS	3,284	4.8	100		1,016	1.5	100	
Selected non-mineralised fractures for inspection	99	0.15	3.0		105	0.15	10.3	
Inspected non-mineralised fractures	88	0.13	2.7	100	73	0.10	7.2	100
Originally correctly logged non-mineralised fractures (group 5), out of the inspected fractures	26			29.5	8			11
Erroneously logged non-mineralised fractures (group 6) , out of the inspected fractures	6			6.8	39			53.4
Sampled fractures, out of the inspected fractures	35			39.8	20			27.3
Confirmed non-mineralised fractures during inspection and detailed analyses, out of the sampled/inspected fractures	5			14.3				0
Number of confirmed non-mineralised PFL-fracture, out of the sampled/inspected fractures	3			8.6				0

Spatial distribution of the non-mineralised fractures at Forsmark

Figure 5-28 is a 3D-view of the main fracture domains (FFM01 and FFM06) at Forsmark and includes a cross section plane cutting through the main domains in Forsmark. The cross section plane is used for the 2D illustrations in Figure 5-29 to Figure 5-32, and is an attempt to show the spatial occurrence and distribution of non-mineralised fractures. From Figures 5-29 and 5-30 we conclude that fractures denoted as non-mineralised occur from the surface down below repository level in FFM01 and FFM06. Figure 5-31 illustrates the locations of the inspected non-mineralised fractures and Figure 5-32 the locations of the five confirmed non-mineralised fractures. All five non-mineralised fractures occur above the level of the repository depth.

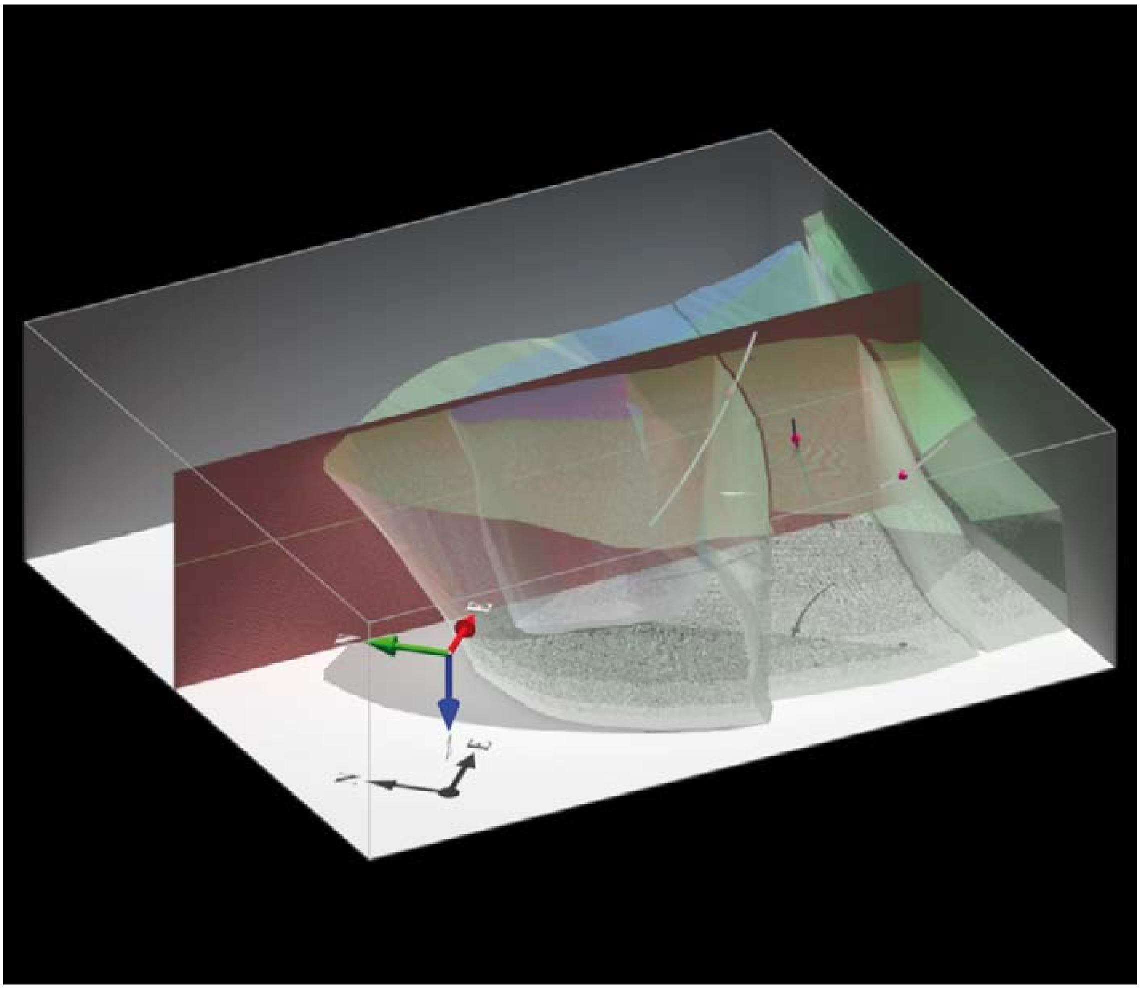


Figure 5-28. *3D-view of the main fracture domains (FFM01 in green and FFM06 in blue) in Forsmark including an inserted cross section plane (in red). The cross section (with dimensions 1,200×3,800 m and strike 315°) through the domains is shown in 2D in Figure 2-31 to 2-34. Note that deformation zones are omitted from the figure. The repository level (–470 meters) is indicated by a green line projected on the cross section plane. The locations of the five confirmed non-mineralised fractures are illustrated as red spheres. Two of the confirmed non-mineralised fractures occur very close to each other. For this reason only three red spheres are visible in the figure.*

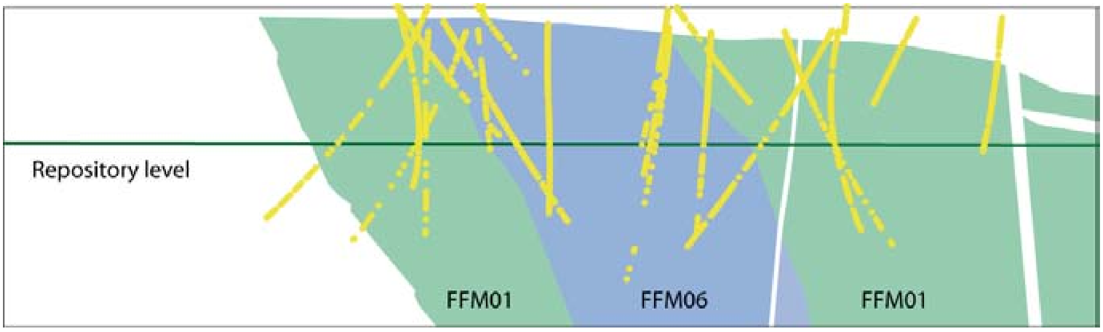


Figure 5-29. *Cross section through the fracture domains in Figure 5-28 showing the borehole intersections of all non-mineralised fractures (yellow dots) at Forsmark.*

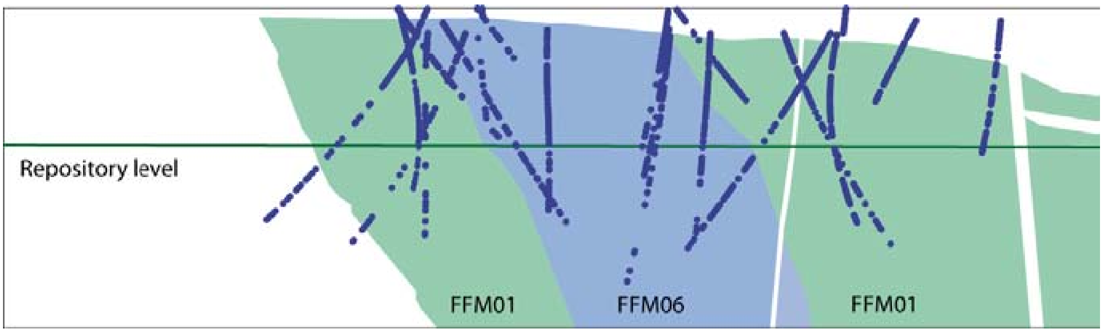


Figure 5-30. *Cross section through the fracture domains in Figure 5-28 showing the borehole intersections of all non-mineralised fractures visible in BIPS (blue dots) at Forsmark.*

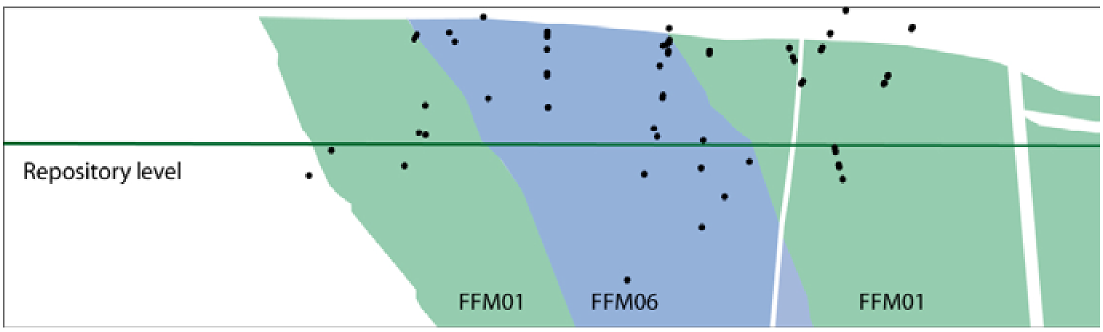


Figure 5-31. *Cross section through the fracture domains in Figure 5-28 showing the borehole intersections of the inspected non-mineralised fractures (black dots) at Forsmark.*

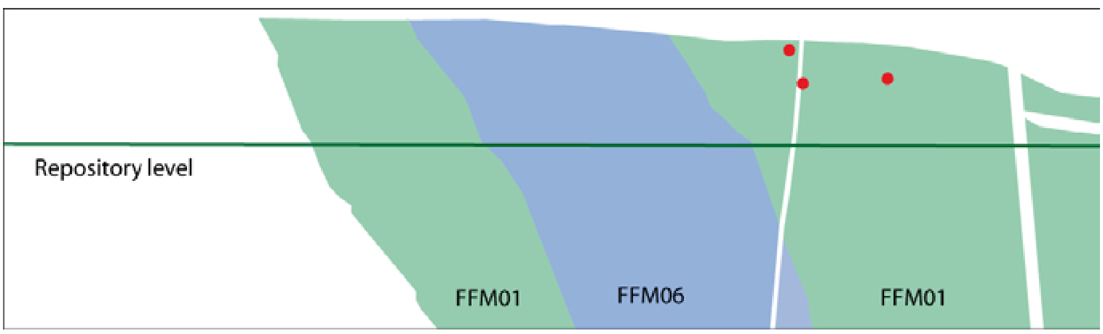


Figure 5-32. *Cross section through the fracture domains in Figure 5-28 showing the borehole intersections of the five confirmed non-mineralised fractures (red dots) at Forsmark. Note, two of the confirmed non-mineralised fractures occur very close to each other, which is why it appears as if only three non-mineralised fractures were confirmed.*

6 Discussion

After inspection of the selected non-mineralised fracture subsets at Forsmark and Laxemar we conclude that fractures lacking mineral coating were only detected in the drill cores from Forsmark. We stress that the inspected fracture subset (204 fractures from both sites combined) only constitutes 4.7% of the total number of non-mineralised fractures visible in BIPS, registered in Sicada. Furthermore, due to missing core material it was only possible to inspect 161 out of these 204 fractures, which means that a total of 3.7% of all fractures classified as non-mineralised in Sicada was investigated in detail within this study. The selected subsets included only fractures visible in BIPS and most of the non-mineralised PFL-fractures. The correlation analyses of PFL-fracture transmissivities and logged fractures are made on a computer and no physical inspection of the cores are made by the hydrogeologist who analyze the flow data in the boreholes. This introduces some degree of uncertainty as fractures close to a fracture assigned as a PFL-fracture (i.e. within 5 cm on each side of the fracture in question) might be a more likely PFL-fracture from a geological point of view. All five confirmed non-mineralised fractures were classified as PFL-fractures in Sicada. However, upon the inspection of these fractures we concluded that two of these fractures were likely erroneously classified as PFL-fractures, which reduces the number of confirmed non-mineralised PFL-fractures to three. These PFL-fractures occur in the midst of other PFL-fractures with otherwise similar geometrical and hydraulic properties.

6.1 Possible explanations to the existence of non-mineralised fractures in Sicada

Given that there are no instantly recognizable geologic, hydrogeologic or drilling related reasons explaining the existence of these fractures, we can only speculate about the causes of these observations. One of the outcomes of this study is that not all data registered in Sicada mirrors fact. A significant portion of the investigated fractures turned out to be mineral coated. Since three of the five confirmed non-mineralised fractures are classified as PFL-fractures, it is important to discuss what processes have the potential of forming non-mineralised transmissive fractures. In view of the fact that non-mineralised fractures were only identified at Forsmark, the discussion about the possible origin and age of these fractures is restricted to Forsmark. The following causes, involving a mix of mechanisms such as geometry, fracture age and mechanics, are judged relevant and evaluated:

1. Fractures induced during 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 (tip).
5. Sheet jointing.
6. Recent opening of fractures/micro-fractures and/or channelled flow (somewhat related to #1).

1. Fractures induced during drilling and subsequent handling of the core

The drill fluid and heat from the coring process can impose additional stresses on the rock during drilling. One scenario is that the non-mineralised fractures were induced during the drilling process. In general, during drilling and coring of a borehole, three types of drilling-induced fractures may form /Zoback 2007/:

1. **Core disking**, results in stress-induced fractures perpendicular to the core axis. These fractures only form in the drill core and do not occur in the wall of the borehole. These have been observed at a few locations at Forsmark and Laxemar (Figure 6-1) /Stephens et al. 2007, Wahlgren et al. 2008/. Core disking fractures are indicative of elevated stress magnitudes and since the fractures form normal to the core axis, their orientation changes as the boreholes direction changes.

2. **Tensile fractures**, which occur parallel or sub-parallel to the borehole axis. These fractures form in the wall of the borehole and not in the drill core. Tensile fractures occur when the borehole fluid pressure exceeds the sum of the tensile strength of the rock and the minimum tangential stresses on the boundary of the borehole. Hence tensile fracture is normally observed in very deep boreholes or when the fluid pressure is elevated such as in hydraulic fracturing /Doe et al. 2006/. Hydraulic fracturing at Forsmark /Klee and Rummel 2004/ required fluid pressures between 13 and 30 MPa to fracture the borehole wall at vertical depths between 247 and 487 m, respectively. These values significantly exceed the fluid pressure that is typically used during drilling operations at these depth (e.g. 500 m×9.81 kN/m^3=4.9 MPa).
3. **Borehole breakout**, i.e. spalling of the borehole wall. This results in a small v-shaped notch in the wall of the borehole that is parallel to the borehole axis. The shallow v-shaped notch is composed of thin slabs that follow the borehole axis. These have been observed at a few locations at Forsmark /Stephens et al. 2007, Wahlgren et al. 2008/. The orientation of the multiple fractures that form the v-shaped notch is not compatible with the orientation of the discrete open non-mineralised fractures observed at Forsmark.

Figure 6-1 illustrates the three types of fractures noted above that can be drill-induced or at least enhanced by the drilling-induced stresses. As seen in Figure 6-1, drilling-induced fracture patterns do not resemble the non-mineralised fractures detected at Forsmark. From the appearance of core disking fractures one might think that these fracture could propagate into the wall of the borehole. However, these core-disking fractures are caused by excessive compressive stress and these compressive stresses cause borehole breakouts on the wall of the borehole. Hence, core disking and borehole breakouts usually occur together, i.e. stress-induced disking of the core and stress-induced breakouts on the borehole wall. In conclusion, drilling induced stresses cannot be used to explain the occurrence of non-mineralised fractures observed both in the drill cores and in the wall of the boreholes at Forsmark.

The extent of fractures outside the borehole is, however, poorly known and a possible scenario is that a major transmissive fracture is present only a few centimetres into the borehole wall. During drilling, new pathways could open up for the water top flow between the borehole and transmissive fracture could be initiated, e.g. along a previously non-transmissive fracture. In this scenario, both the fracture and the measured PFL-anomaly are a drilling induced phenomena. Transmissivities of fractures intersecting boreholes can be disturbed during drilling – a phenomenon known as negative skin – such that artificially higher transmissivities are detected close to boreholes. This statement is supported by the observations made by Follin et al. 2007, which conclude that the connectivity of the near-field fracture system at Forsmark usually is improved by drilling. This observation might indicate that new flow pathways can be induced during drilling. In comparison, negative skin occurs to a higher extent at Forsmark than at Laxemar /Follin et al. 2007, Rhén et al. 2008/.

Core Fractures

Core Disking

Core disking fractures are normal to the core axis. In the figure below from Forsmark, the disking fractures intersect and interact with the naturally induced inclined fractures.

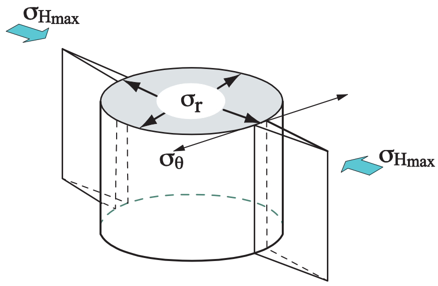
Core disking is caused by tensile stresses induced in the core stub close to the drill bit. The tensile stresses are induced by very high compressive stresses that get turned into tension by the geometry of the core stub. The stresses can be artificially induced during drilling by excessive heat from the drill bit.

Core disking and breakouts are commonly found together.

Borehole Wall Fractures

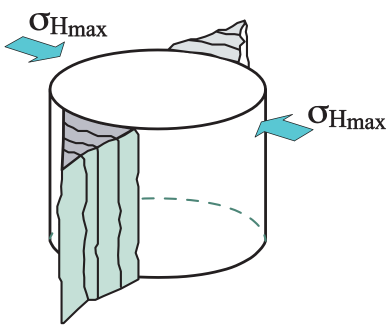
Tensile Fracture

(Hydraulically induced)



These fractures form when the stress applied to the borehole hole induces a tangential stress that exceeds the tensile strength of the rocks. These process can be caused by excessive fluid pressure, induced either during drilling or hydraulic fracturing.

Borehole Breakout



These fractures form when the stress applied to the borehole hole induces a tangential stress that exceeds the compressive (spalling) strength of the rocks. The stresses can be artificially induced during drilling by excessive heat from the drill bit.

Figure 6-1. *Types of fracture patterns that can be induced during drilling.*

2. Mechanical flushing and/or chemical dissolution of fracture coating

Another process put forward to describe the reason for the existence of non-mineralised fractures, e.g. /Stephens et al. 2007/, assumes that the non-mineralised fractures once carried fracture minerals but these were mechanically or chemically removed at a later stage. Mechanically flushing may e.g. be represented in near-surface fractures once filled with e.g. glacial sediments, that during some unknown conditions, were flushed and the fracture filling material was removed. However, at depth this is not a reasonable explanation since fractures that can be flushed with high enough flow in order to transport such material are usually large structures close to the surface (definitely upper 100 m) /Leijon 2005/. This is not in agreement with the typical characteristics of the non-mineralised fractures investigated in this study, i.e. discrete fractures with aperture less than a few mm. Furthermore, a completely fresh fracture surface is less probable if the fracture once was filled with sediments. At depth, unlithified fracture filling material may consist of fault gouge and clay minerals formed *in situ*. However, if this type of material would have been flushed out, the fracture surface would not be fresh and complete removal of the material is also not likely. No evidences of flushing of unlithified sediments in fractures below 100 m have been found and are not considered likely. As the non-mineralised fractures confirmed in this study are all located below 138 meters depth it is inferred that any mineral coatings in these fractures have not been removed by mechanical flushing.

The other possibility is that fracture minerals have been removed by chemical dissolution. In order for this to occur, fluids able to completely dissolve the fracture mineral while leaving the wall rock minerals totally unaffected must have circulated in the fracture. This is not probable. Dissolution of fracture minerals can usually be seen as dissolution textures in partially dissolved fracture minerals or as dissolution effects on rock minerals on the fracture surface (Figure 6-2). No signs of this can be seen on the sampled fracture surfaces. If aggressive fluids have circulated in the fracture and removed the fracture minerals, it is highly unlikely that the fracture surface would be left unaffected.

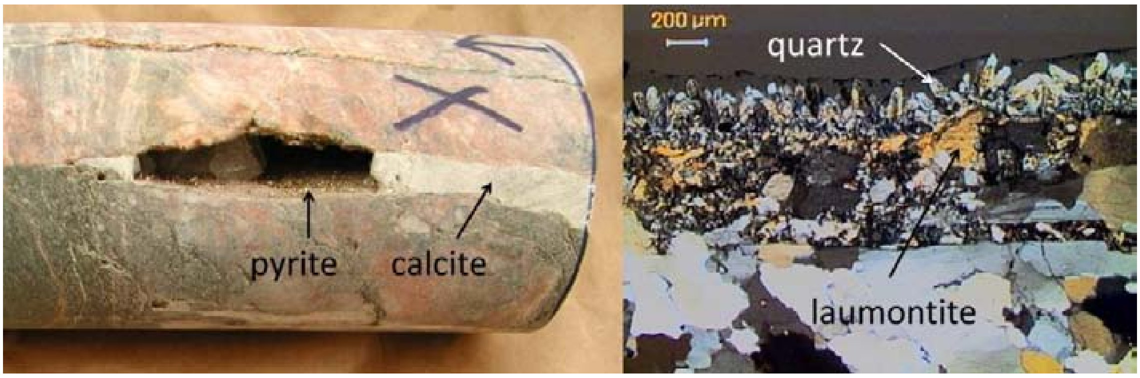


Figure 6-2. *In the photograph to the left, evidence of dissolution of fracture minerals can be seen as a cavity. In adjacent parts of the drill core, hydrothermal laumontite and calcite are still present. Following dissolution, younger fracture minerals such as Palaeozoic calcite and pyrite have precipitated in the cavity. In the photomicrograph from the same sample to the right, remnants of the partly dissolved laumontite can be seen. Quartz has later precipitated on the etched surface. Although this fracture has been exposed to dissolution under hydrothermal conditions, remnants of the older fracture minerals can still be found when the fracture is studied under the microscope. Sample KFM04A 306.40–306.55 m, modified after /Sandström and Tullborg 2005/.*

3. Fracturing by ice segregation

An additional scenario is that the non-mineralised fractures represent fractures that opened up during summer thawing and autumn freeze-back periods when permafrost was present in Forsmark. This processes is called ice segregation and is common in polar and alpine regions and often attributed to the volumetric expansion of trapped water in pores and cracks /Hall et al. 2002/. Ice segregation occur when permafrost is present and the unfrozen water migrates down into the underlying frozen ground, allowing the growth of ice-lens and formation of fractures parallel to cooling surfaces. However, this process is commonly reported to take place in freezing soils and wet porous rocks in the base of the active layer and beneath the top of the permafrost /Matsouka 2001, Murton et al. 2006/ and it is not likely that this process can account for the generation of open fractures at depths greater than 10 meters.

4. Non-mineralised fractures represent borehole intersection with fracture fronts

Fractures have a limited extent in three-dimensional space. It is possible that the non-mineralised fractures, regardless of genesis, represent the fronts (or tips) of larger fracture surfaces in which mineral precipitation may have been prevented by insignificant flow of saturated fluids along these peripheral parts of the fracture. Though an appealing hypothesis, it is contradicted by the fact that no non-mineralised fractures were confirmed at Laxemar.

5. Sheet jointing

Another alternative is that the confirmed non-mineralised fractures represent sheet jointing, e.g. /Martel 2006/, which is supported by the sub-horizontal orientation of the fractures. However, the prerequistes for sheet jointing below about 200 m do not prevail at Forsmark /Lönnqvist et al. 2010/. As three of the univocally confirmed non-mineralised (horizontal) fractures were identified at about –250 m.a.s.l. sheet jointing could explain some, but obviously not all, of the fractures unless, of course, sheeting can occur at greater depths than previously anticipated. The rate by which the relative intensity of non-mineralised fractures decreases with depth at Forsmark, and not at Laxemar, supports sheeting as a plausible process for their formation.

The lack of mineralisation suggests that the duration of fluid flow in these fractures has not been sufficient to allow for mineral precipitation. Accordingly, regardless of genesis, we cannot exclude that these fracture are geologically young (see Section 6.2)

6. Recent opening of fracture/micro-fractures and/or channelled flow

It is also possible that the confirmed non-mineralised fractures represent older fractures/micro-fractures that have been reactivated (opened) during denudation associated with erosion of sediments and/or glacial rebound. The strongest argument for this scenario is the conspicuous presence of partly open or sealed nearby fractures/micro-fractures parallel to the majority of the studied non-mineralised fractures (e.g. Figures 5-16 and 6-3). Moreover, as the confirmed non-mineralised fractures are sub-horizontal to gently dipping (Figure 5-17), this is in agreement with opening processes as proposed by e.g. /Martel 2006/. The mechanisms behind the formation of the parallel micro-fractures are beyond the scope of this report, however, micro-fractures are known to occur near sheet joints, e.g. /Holzhausen 1989/.

Another scenario relating to opening of the fractures/micro-fractures is that the fractures represent non-connected, partly sealed, parts of a fracture plane (Figure 6-4). Given that roughness and aperture of a fracture plane can vary, water flows preferentially through “channels” in the fracture plane. The more narrow parts of the fracture plane might be accessible to fluids only by diffusion. Thus, a fracture is seldom evenly coated and the coating appears patchy and the parts of the fracture plane where solute transport mainly is controlled by diffusion can be left non-mineralised. It is therefore possible that previously non-transmissive (i.e. non-connected) and non-mineralised parts of the fracture plane were intercepted and opened up during the drilling process. This would allow connection and enabled flow in the fracture, resulting in a non-mineralised PFL-fracture. However, given that the fracture part has not been open for a long time, fracture mineral precipitation has not occurred (Figure 6-4). We emphasize that the sampled fracture surfaces represents a very small area (diameter c. 5 cm) of the actual fracture plane. Therefore, if this process is feasible, it can be expected that some drill cores will intercept a non-mineralised part of the fracture plane.

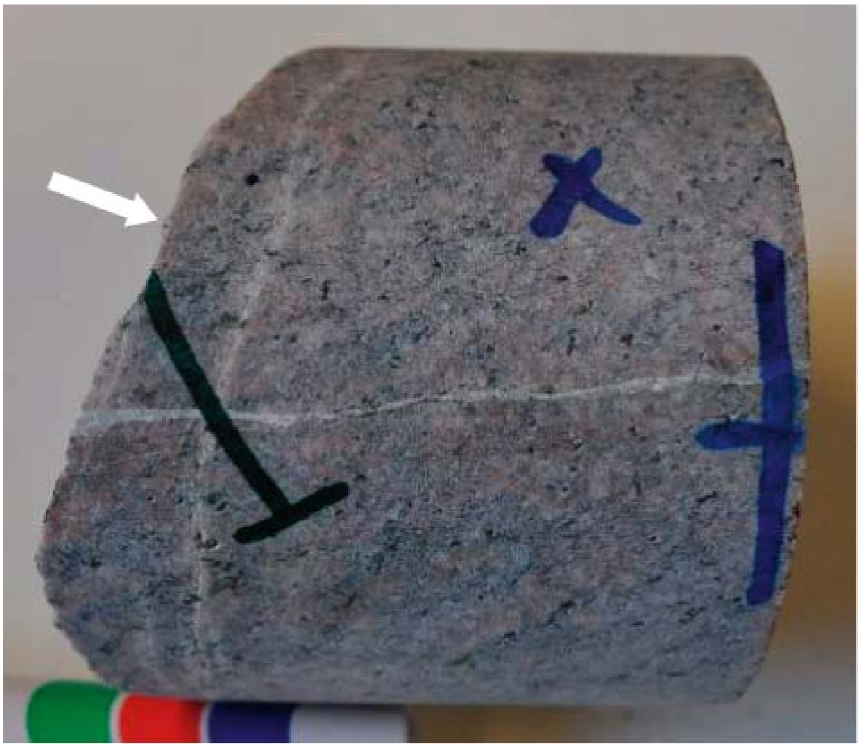


Figure 6-3. Photo of the identified non-mineralised fracture KFM05A 166.372 m, showing typical bands of micro-fractures occurring sub-parallel to the non-mineralised fracture (indicated by white arrow). The sub-parallel bands of micro-fractures contain fracture-sealing calcite, quartz and adularia. The diameter of the core is c. 5 cm.

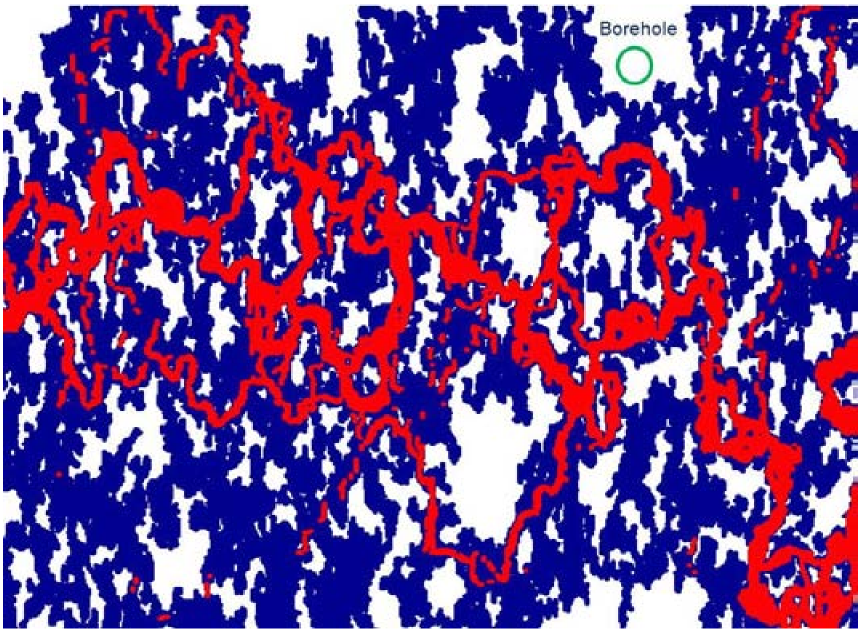


Figure 6-4. Channelled flow theory. The figure show flowing (red) and stagnant (blue) water and areas where the fracture surfaces are in contact, i.e. no water (white).The borehole (green circle) has intersected the fracture plane where the surfaces are in contract (non-mineralised). Figure modified from /SKB 2010/. One possible reason for the uneven mineral coating of the fracture plane is channelled flow, i.e. the circulating fluid has only accessed parts of the fracture plane (red and blue) due to e.g. aperture differences. In this scenario minerals have been precipitated on the parts of the fracture plane where fluids have been circulating. If a borehole penetrates a part of the fracture plane, which has not been accessed by circulating fluids (white), this part is consequently non-mineralised. However, it may, due to e.g. glacial unloading or core drilling activity, have been opened up and just recently been accessed by circulating fluids. Given that the fluid has circulated in the fracture for a relatively short time period, this part of the fracture surface is left non-mineralised but still transmissive.

6.2 Age of the non-mineralised fractures

The five confirmed non-mineralised fractures are all visible in BIPS. A fracture observed in the wall rock cannot have formed by fracturing along the bands of micro-fractures during core handling after drilling since such fractures, of course, would only be present in the drill core. Since no cross-cutting relations have been observed between non-mineralised fractures and fractures with parageneses of known ages, a maximum formation age of the non-mineralised fractures can only be constrained to when the bedrock started to respond to brittle deformation. At Forsmark, this occurred between 1.8 and 1.7 Ga, during cooling after the Svecokarelian metamorphism /Söderlund et al. 2009/.

Many of the fractures sampled for detailed mineralogical studies that appeared non-mineralised during visual inspection, were upon inspection by SEM-EDS found to contain mineral coatings e.g. hydroxyapophyllite and pyrite (e.g. Figure 5-15 and Appendices 1 and 3). In many of these fractures, only a few microscopic crystals were found on the sampled surface. Based on the similar characteristics, it is possible that the confirmed non-mineralised fractures represent parts of the same type of fractures (i.e. scarcely mineralised), only that no crystals were present on the small area intersected by the borehole. Hydroxyapophyllite was found during the site investigation, together with green adularia, calcite and corrensite /Sandström et al. 2004/, a paragenesis typical for the Palaeozoic generation 3 fracture minerals in Forsmark /Sandström et al. 2008a, Sandström et al. 2009/. Therefore, it seems possible that the confirmed non-mineralised fractures may have existed already during the Palaeozoic, but the non-mineralised PFL-fractures were not transmissive until during later episodes.

If the confirmed non-mineralised fractures represent older, reactivated fractures/micro-fractures, the age of when they became transmissive is likely also the age of when they were reactivated. When these fractures became transmissive cannot be determined by any radiometric method since no datable minerals are present in these fractures by definition. However, a maximum age can be postulated based on the knowledge of the geological evolution in the area:

- Hydrothermal alteration of the wall rock is a characteristic feature found adjacent to fractures which were subjected to fluid circulation prior to 1,000 Ma (Figure 6-5). This alteration was caused by chemical re-equilibrium processes under hydrothermal conditions at temperatures > 200°C /Sandström et al. 2010/. This type of alteration is not found adjacent to the non-mineralised fractures, indicating that no fluids circulated in these fracture prior to 1,000 Ma.
- The non-mineralised fractures probably did not conduct water during the Palaeozoic events of fluid migration in the Forsmark area, which caused abundant mineral precipitation within fractures /Sandström et al. 2009/. Therefore, a maximum age of 277 Ma (the age of the late stage of precipitation of generation 3 minerals (Table 5-6) for water flow in these fractures is postulated.

A more precise age determination of when these fractures became water conductive cannot be made and it cannot be excluded that the non-mineralised fractures were opened and became water conductive during the Quaternary glaciations or during the post-glacial Holocene period.

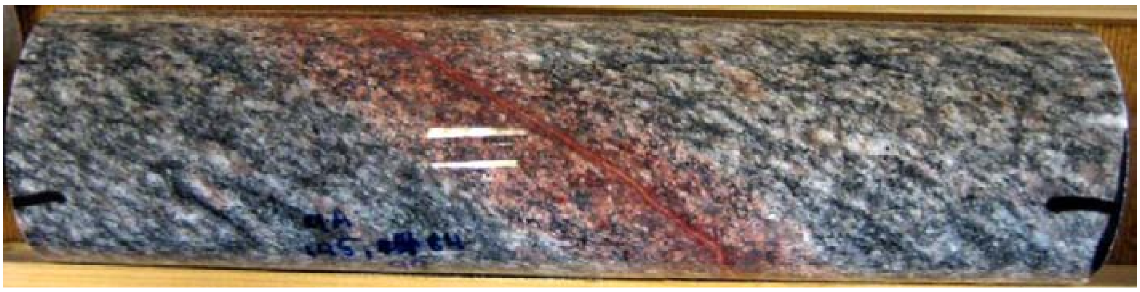


***Figure 6-5.** Red-stained hydrothermally altered wall rock adjacent to a fracture sealed with laumontite. Sample KFM09A 150.67 m, figure from /Sandström et al. 2008b/. The diameter of the dill core is c. 5 cm.*

6.3 Comments regarding the core logging procedures

Non-mineralised fractures were only confirmed in cores from Forsmark. The reason why such fractures have not been confirmed in Laxemar cores has not been discussed in detail in this report. However, the database extraction shows that the orientations of the non-mineralised fractures vary between the two sites, such that at Forsmark the majority of these fractures are sub-horizontal to horizontal whereas they are more vertical at Laxemar (Figure 4-2). Whether their existence can be related to differences in rock stresses or other site differences (e.g. geology) is beyond the scope of this report. Although the same quality standards and working methods for drill core logging have been applied at both sites, the clarity, consistency and traceability of the terminology between Boremap and Sicada have not been found to be completely straightforward /Glamheden and Curtis 2006/. The Boremap system of variables and parameters has been followed during drill core logging at both sites, but /Glamheden and Curtis 2006/ pointed out that the results from the core logging at the two sites display clear differences. Notably, a clear difference existed in how to interpret open vs. sealed fractures. A clear difference in judgement is also apparent concerning visibility of fractures in BIPS. We emphasise that the open versus sealed fracture classification is not a parameter measured by the geologists but is determined by the Boremap system based on a combination of parameters. Thus, the difference in the results is related to differences in more than one underlying parameter and is also related to site specific developed methodology /Glamheden and Curtis 2006/. The study by /Glamheden and Curtis 2006/ concluded that with regards to rock type, alteration and mineral identification, along with fracture frequency and fracture orientation, the logging appeared consistent.

Nevertheless, the database extraction in this study, demonstrate that the use of X-coding for "non-mineralised fractures (X5 and X7)" between the sites has been significantly different in terms of the number of X-coded fractures (Tables 4-2 and 4-3). The logging team at Laxemar appeared to utilized the X-coding for *non-mineralised fractures* notably more than the Forsmark team. As a consequence, the selected non-mineralised fracture subset for Laxemar contained a higher portion X-coded fractures than the Forsmark subset. In this study we observed that the proportion of originally incorrectly logged non-mineralised fractures differs significantly between the sites. At Laxemar 53% of the inspected fractures were incorrectly logged and only 7% at Forsmark (Tables 5-3 and 5-8), i.e. these fractures appeared to be mineral coated upon visual inspection. Conversely, the proportion of originally correctly logged non-mineralised fractures was much higher at Forsmark (30%) than at Laxemar (11%) (Tables 5-3 and 5-8), i.e. these fractures appeared to be non-mineralised upon visual inspection. It was also in Forsmark that non-mineralised fractures were confirmed. We stress that it was only possible to confirm the lack of mineral coating on these fracture surfaces after detailed inspection using microscopy and SEM. Furthermore, the database extraction, revealed that a portion of the fractures registered as non-mineralised in Sicada were logged as sealed. A portion of the sealed fractures was also recorded as unbroken in Sicada. Because a sealed non-mineralised fracture is a geologic impossibility, and because they are registered in Sicada, we included a few of these fractures in our study. Four fractures interpreted as sealed were included in the Forsmark fracture subset and two was sampled for detailed mineralogical analysis. All but one of these fractures was classified as a PFL-fracture in Sicada. Only one of these fractures was clearly visible in BIPS. However, this fracture was excluded from the confirmed non-mineralised fractures group as the fracture was barely visible in BIPS and we consider it likely to represent an induced fracture. From the inspection of these fractures, it was clear that these fractures were either erroneously logged by BIPS or they should have been logged as partly open instead of sealed.

6.3.1 Recommendations for future logging

Logging of cored boreholes is essential for understanding the sub-surface. During the site investigations the drill core logging followed the Boremap method, which is based on the simultaneous study of the drill core and the use of BIPS-images of the borehole wall. Chemical analysis of rock material and thin section investigations provided complimentary information to the Boremap logging. In order to be able to compare data from different boreholes and even different sites, geologists logging the core should follow the same routines and make as similar judgements and interpretations as possible. Given that geologic logging always will contain a certain amount of subjective interpretation, it is even more important that the methodology for logging routines is continuously updated, such that improvements of the methodology is incorporated. The results from this study accentuate that, despite formalised logging routines, subjective interpretations are integral to the process, and there will always be some interpretation differences and logging inconsistencies. Most of the fractures investigated in detail in this study did contain fracture mineral coating, in contrast to the logging record. We stress that the errors in Sicada are not by default the result of erroneous logging, but rather an artefact of the combination of; 1) the choices available in the Boremap software during the logging, and; 2) the macroscopic logging procedure, which is a product of visual acuity (i.e. the eye's ability to detect fine details). In order to develop the logging procedures for future core logging, and to make sure that a proper registration of non-mineralised fractures is made available, we propose the following for consideration in future borehole logging:

1. As it may be very difficult to distinguish the fracture minerals on the surface macroscopically, it is necessary to update Boremap such that a designated code for "no mineral detected" is available as a selection rather than having the possibility of leaving the field empty or adding "X5 or X7 (no mineral)".
2. The use of X-coding needs to be systematic and should only be used in the same way by all logging personnel, on all drill cores. When an X-code has been used to record an unidentified mineral, it is suggested that the X-code is immediately exchanged with the real mineral name in Sicada once it has been identified. It is important to exclude the possibility to use X-codes during fracture logging when it is impossible to see any mineral coating on the fracture surface. We consider it also helpful for the logging team if a warning message appear on the computer screen during logging when no mineral is entered in the Min1–Min4 columns, such that the logger has to press "OK" to approve the lack of minerals.
3. The terms "certain, possible and probable" in Boremap have different meanings for different variables. When a fracture has visible minerals "certain, possible and probable" refer to the degree of certainty with respect to the fracture being "open" or not. However, when a fracture has no visible minerals "certain, possible and probable" refers to the degree of certainty with respect to the existence of the fracture. This difference should be made clearer in Boremap and Sicada.
4. It should not be possible to register a fracture as sealed non-mineralised. The routines in Boremap needs to be updated so that this option is removed.
5. We suggest more frequent communication between the team interpreting the flow log data and the core logging team. Once the PFL-fractures have been identified by the analyst (i.e. hydrogeologist), we recommend that a joint physical inspection of the core and the PFL-fractures be made where both hydrologists and geologists participate. This will allow for correlation and communication where both hydrology and geology are represented and this will be an opportunity to verify and directly adjust the PFL-fracture interpretation, should that be needed.
6. For future logging activities (e.g. DETUM) it is critical to secure consistent logging routines, and provide control functions to make sure that logging is consistent over time and that new routines are implemented throughout the logging teams. If new or updated routines are introduced it is important to update and correct previous logging results, such that the tables in Sicada are up to date.

7 Conclusions

An inspection of the fracture database revealed that 4.8% of all fractures visible in BIPS at Forsmark and 1.5% at Laxemar are classified as non-mineralised in Sicada. In this study we inspected selected subsets of non-mineralised fractures at both sites, we could only confirm non-mineralised fractures in cores from Forsmark. A total of five out of the 88 investigated (5.7%) fractures were confirmed as non-mineralised; three of these are flowing (PFL) fractures. We conclude that many of the fractures registered as non-mineralised in Sicada were originally erroneously logged, i.e. upon inspection they were shown to contain minerals. We stress that on many of the fracture surfaces it was only possible to detect the mineral coating after analysis using scanning electron microscope. Moreover, on some of these fracture surfaces only a few microscopic crystals were detected, which explains why these fractures were logged as non-mineralised. Furthermore, the risk of accidently omitting information in a data table during logging is always a prevailing risk that is difficult to quantify.

We have confirmed that the slightly different approaches between the core logging crews, e.g. /Glamheden and Curtis 2006/, also have affected how non-mineralised fractures have been logged in Boremap. At Forsmark, most logging crews appears to have left the data fields Min1–Min4 blank, whereas only some crews have used the X5-code for describing fractures without fracture minerals. At Laxemar, blank codes were generally avoided. Instead the X7-code was used to represent non-mineralised fractures. In contrast to the logging record in Sicada, most of the fractures sampled for this study contained mineral coating. We therefore recommend an update of logging procedures according to the findings herein.

Normalizing the number of non-mineralised fractures to account for the bias stemming from varying intensities with depth, a significant difference between the sites appears. At Laxemar the fraction of non-mineralised fractures is more or less constant with depth, whereas at Forsmark the fraction clearly decreases with depth. Whether the non-mineralised fractures are overrepresented in the upper parts of the bedrock or underrepresented in the lower parts of the bedrock at Forsmark could unfortunately not be resolved within the framework of the analyses presented in this report. However, since the fraction at Laxemar is constant there should be a site specific explanation for the observations at Forsmark such as site specific geological processes, e.g. the sheeting at Forsmark, differences in rock stresses, or yet unresolved differences in drilling practices. The small differences in logging methodology between the sites cannot alone explain the differences observed.

In view of the fact that no definitive geologic, hydrogeologic or drilling related processes explaining the formation of these fractures have been revealed, we can only hypothesise over their formation and occurrence.

Of the six proposed explanations we find #2 *mechanical flushing and/or chemical dissolution theory* to be the least likely process forming of these fractures. Mechanical flushing is a process most likely to flush away fracture material close to the ground surface and chemical dissolution of fracture minerals would expectedly leave behind dissolution features on the fracture surface. Since the non-mineralised fractures occur between –138 to –252 m.a.s.l. and that no chemical dissolution features have been observed on the fracture surfaces, this theory can be ruled out.

We find the most likely process forming these fractures to be the #6 *opening of fractures/micro-fractures and/or channelled flow theory*, which postulates that old micro-fractures were reactivated and opened up and/or these fractures form parts of non-mineralised fracture surfaces that became transmissive during e.g. drilling. After these fractures were opened, the time period of fluid flow was not sufficient to allow for mineral precipitation. Given the sub-horizontal to gently-dipping orientation of the confirmed non-mineralised fractures, they may represent *sheet joints* (#5). Sheeting may also explain the existence of some of the micro-fractures, as these are known to occur close to sheet joints. However, sheeting is a near surface process and can therefore not explain the occurrence of the non-mineralised fractures or micro-fractures found at greater depth, with less than sheeting can develop deeper than previously anticipated.

It is also possible that these fractures have formed due to a combination of the suggested processes. Since we have no datable material for these fractures, we could not determine their age nor when these fractures became water conductive. Based on the appearance of the fractures and the wall rock adjacent to the fractures we postulate that fluid flow in these fractures occurred no earlier than Late Palaeozoic. We cannot exclude that these fractures are recent.

Only a portion of all non-mineralised fractures recorded in Sicada was inspected in this study, all occur above –250 meters. This makes it difficult to draw any conclusions for all fractures classified as non-mineralised in Sicada, but our study shows that the total number of truly non-mineralised fractures is small. If the subset inspected in this study is representative, we judge it not necessary to move ahead with a full-scale investigation where all non-mineralised fractures in Sicada are inspected. However, given that the formation process of these fracture remains unresolved, it is difficult to assess the impact of these findings on the interpreted geological evolution of the Forsmark Site as provided in /Stephens et al. 2007/. Consequently, in order to better understand the genesis, age and implications of these non-mineralised fractures, and the observation that they occur sub-parallel to micro-fractures, we recommend a more detailed, multidisciplinary, study of a larger subset of these fractures. We anticipate that detailed site investigations at relevant depth will provide data such that the findings presented herein can be more thoroughly addressed.

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Appendix 1

Investigation of fracture surfaces by optical microscopy and SEM-EDS, Forsmark

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Introduction and execution

This document presents the results from detailed investigations of fractures in drill cores from Forsmark, which are non-mineralised in the Sicada database. Investigation has been carried out on thin sections and surface samples with optical microscope and with a Hitachi S-3400N scanning electron microscope equipped with an INCADryCool energy dispersive X-ray spectrometer (SEM-EDS) at the Department of Earth Sciences, University of Gothenburg. The EDS-system was used to aid mineral identification.

30 µm polished thin sections were prepared by Minoprep AB with the sections cutting the fracture surface. Samples were examined by petrographic microscope and subsequently carbon-coated before mounted in the SEM-EDS. Fracture surface samples were prepared by rock saw and examined with binocular microscope before mounted in the SEM-EDS. Low vacuum conditions was used to avoid coating the surface samples.

Results and sample descriptions

Table A1-1. Compilation of results from investigation of fracture surfaces where Min1-Min3 were empty in p_fract_core.

Borehole	Length (m)		Fracture minerals detected	No fracture minerals detected	Comment
KFM01A	316.726	Open	X		
KFM01B	208.093	Open	X		
KFM01D	91.669	Open	X		
KFM02A	129.707	Open	X		
KFM02A	411.321	Open	X		
KFM02A	416.498	Open	X		
KFM04A	179.913	Open	X		
KFM05A	166.372	Open		X	Parallel to fracture/micro-fractures with calcite, quartz and adularia.
KFM05A	167.142	Open		X	Parallel to micro-fractures with clay minerals (corrensite).
KFM05A	203.509	Sealed		X	Parallel to micro-fractures with calcite and pyrite.
KFM06A	109.262	Open	X		
KFM06A	297.253	Open		X	
KFM06C	619.565	Sealed	X		
KFM06C	744.804	Open	X		Parallel to micro-fractures with no mineral.
KFM08A	111.198	Open	X		
KFM10A	332.834	Open		X	Parallel to micro-fractures with no mineral.
KFM10A	334.43	Open		X	Parallel to micro-fractures with no mineral.
KFM11A	395.37	Open	X		

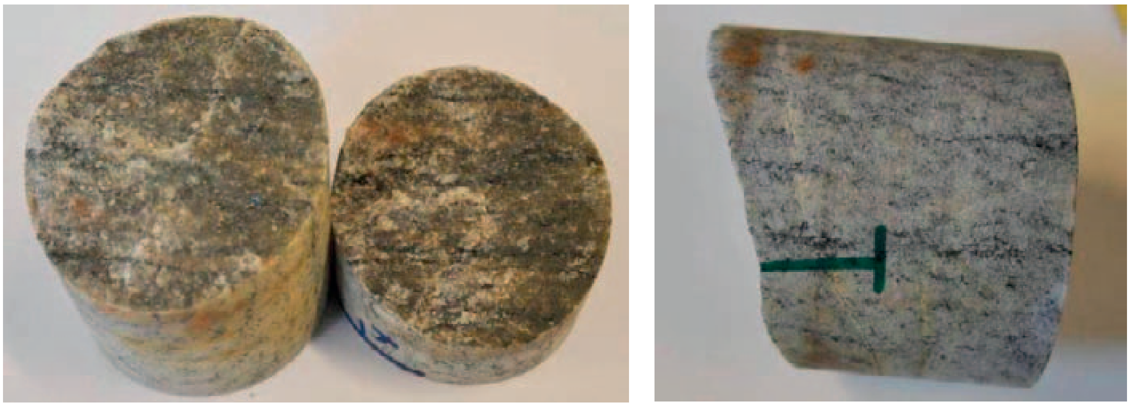
KFM01A 316.726 m

Open fracture

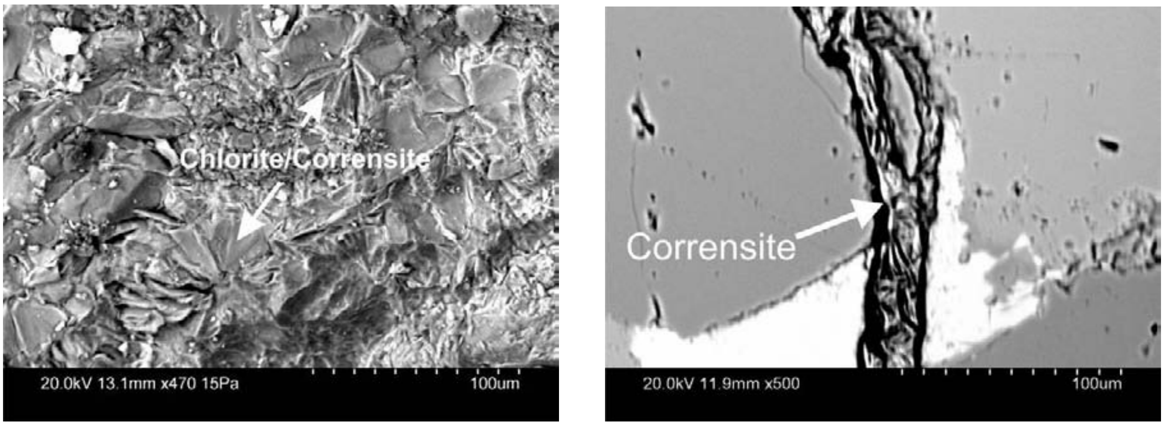
Fracture minerals: Chlorite/corrensite, Fe-oxide.

Wall rock: Unaltered biotite and plagioclase.

The open fracture is parallel with a micro-fracture with clay mineral (probably corrensite).



Photographs of drill core and fracture surface.



Back-scattered SEM-image of corrensite on fracture surface and in micro-fracture.

FM01B 208.093 m

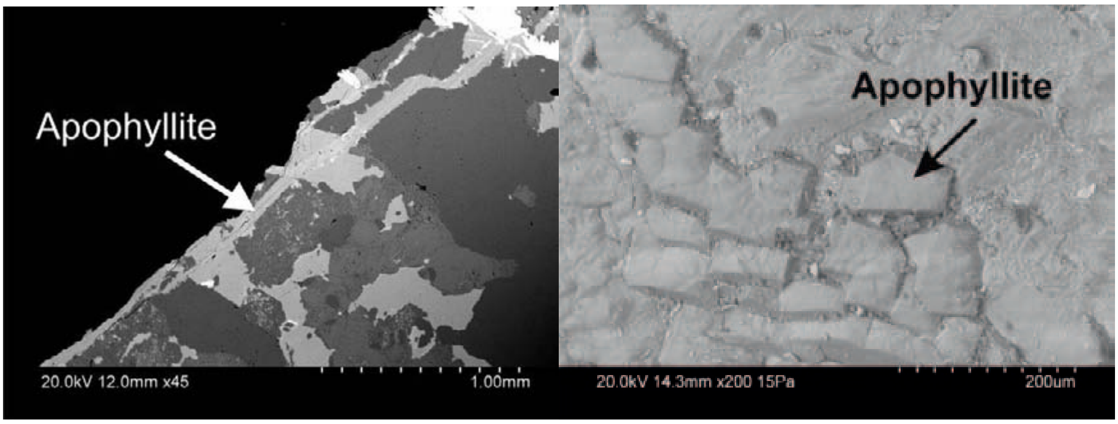
Open fracture

Fracture minerals: Hydroxyapophyllite, pyrite.

Wall rock: Saussuritised plagioclase but fresh unaltered biotite.

The fracture has been opened along a micro-fracture sealed with hydroxyapophyllite.

Photograph of drill core and fracture surface.



Back-scattered SEM-image of apophyllite on fracture surface and in micro- fracture.

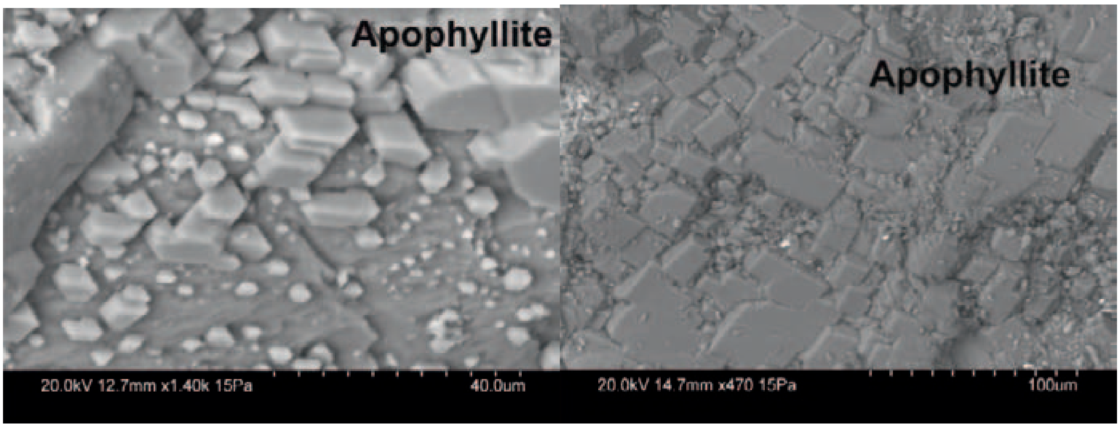
KFM01D 91.669 m

Open fracture

Fracture minerals: Hydroxyapophyllite, clay mineral (probably corrensite).

Wall rock: Fresh biotite and relatively unaltered plagioclase.

Photograph of drill core and fracture surface.



Back-scattered SEM-image of apophyllite on fracture surface.

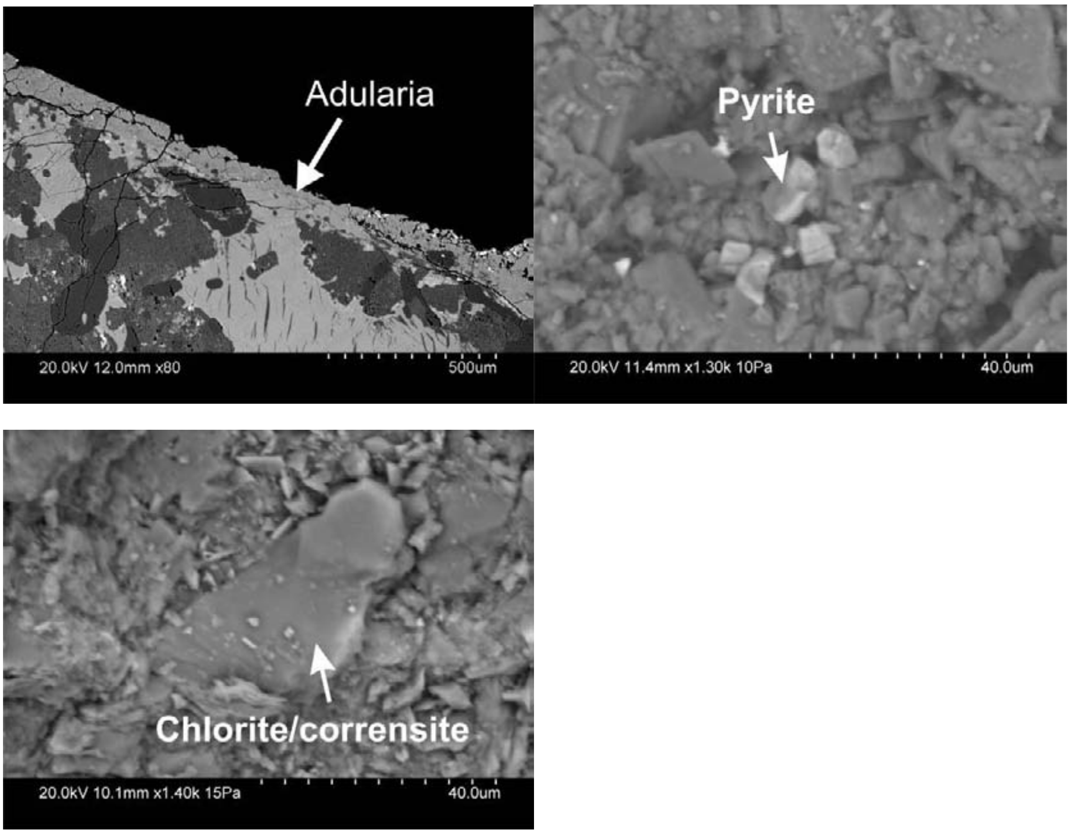
KFM02A 129.707 m

Open fracture

Fracture minerals: Adularia, chlorite/corrensite, pyrite.

Wall rock alteration: Saussuritized plagioclase, unaltered biotite.

Photograph of drill core and fracture surface.

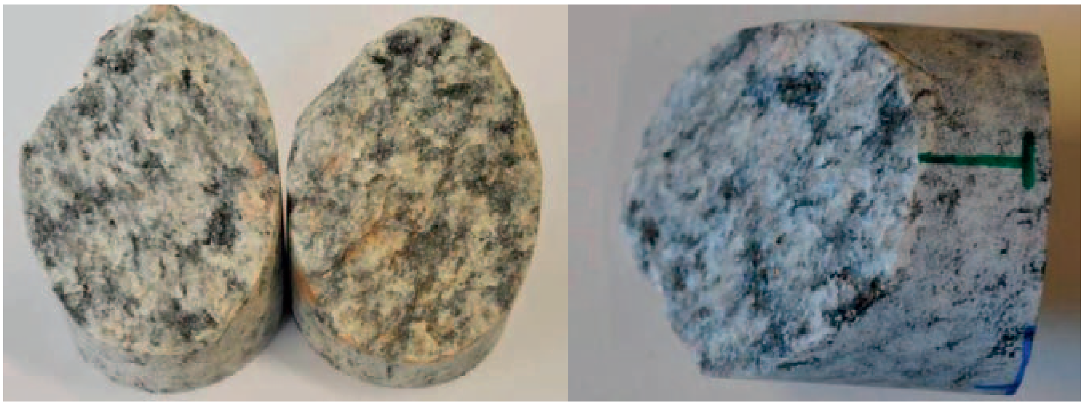


Back-scattered SEM-image of adularia, pyrite and chlorite/corrensite on fracture surface.

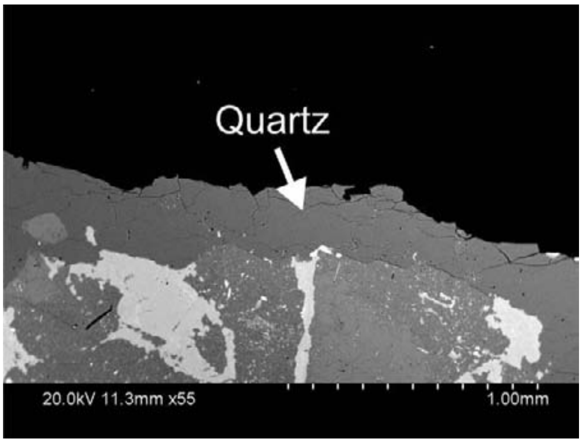
KFM02A 411.321 m

Open fracture

Fracture mineral:	Quartz.
Wall rock:	Unaltered biotite and plagioclase.



Photograph of drill core and fracture surface.



Back-scattered SEM-image of quartz on fracture surface

KFM02A 416.498 m

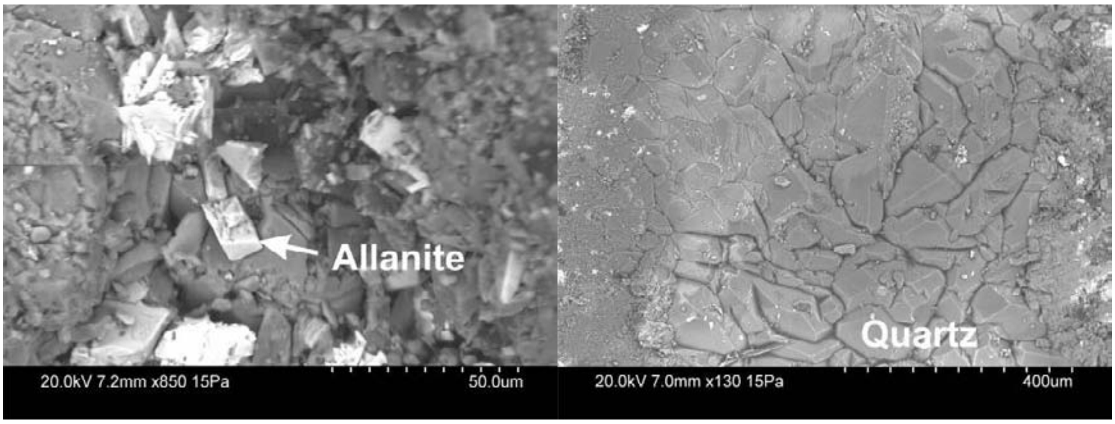
Open fracture

Fracture minerals: Quartz, clay mineral (probably corrensite), calcite, allanite.

Wall rock: Unaltered biotite, partial saussuritization of plagioclase.

The fracture has opened along a micro-fracture sealed with quartz, clay mineral (probably corrensite) and allanite.

Photograph of drill core and fracture surface.



Back-scattered SEM-image of quartz and allanite on fracture surface.

KFM04A 179.913 m

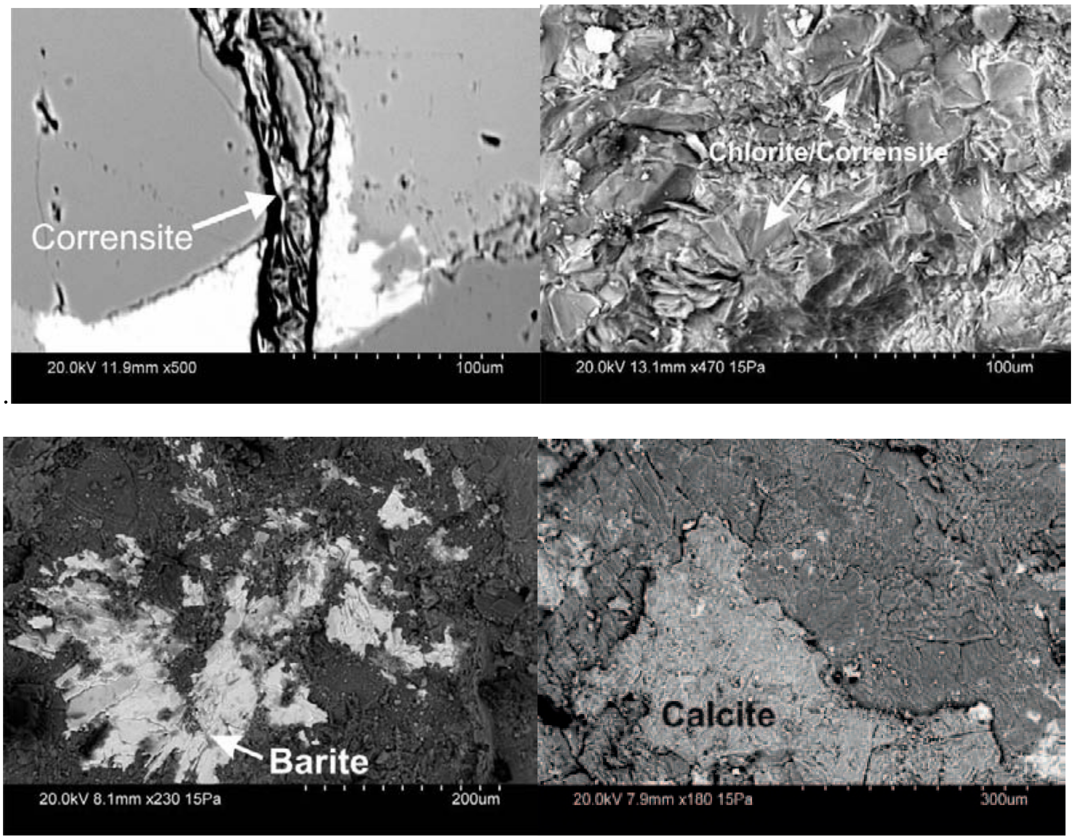
Open fracture

Fracture minerals: Calcite, clay mineral, barite, quartz.

Wall rock: Chloritised biotite, saussuritised plagioclase.

Fracture parallel to a micro-fracture sealed with clay mineral (probably corrensite).

Photographs of drill core and fracture surface.



Back-scattered SEM-image of corrensite on fracture surface.

KFM05A 166.372 m

Open fracture

Fracture minerals: No detected fracture mineral.

Wall rock: Chloritised biotite, saussuritised plagioclase.

Fracture parallel to micro-fractures sealed with calcite, quartz and adularia

Photographs of drill core and fracture surface.

KFM05A 167.142 m

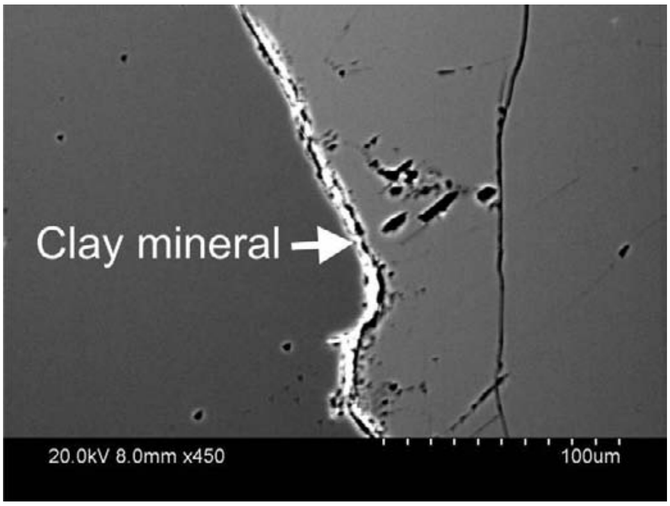
Open fracture

Fracture minerals: No detected mineral.

Wall rock: Unaltered biotite and plagioclase.

Fractures parallel to micro-fractures with clay mineral.

Photographs of drill core and fracture surface.



Back-scattered SEM-image of clay mineral on fracture surface.

KFM05A 203.509 m

Sealed fracture

Fracture minerals: No detected mineral.

Wall rock: Unaltered biotite and plagioclase.

Fracture parallel to bands of micro-fractures, sealed with calcite and pyrite.

Photographs of drill core and fracture surface.

KFM06A 109.262 m

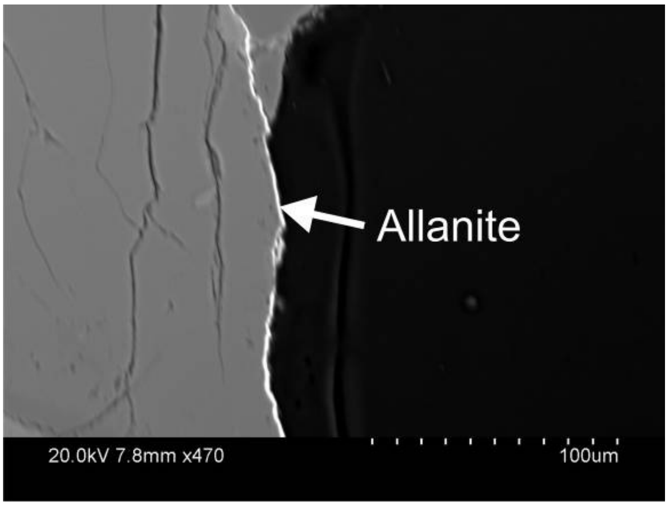
Open fracture

Fracture minerals: Allanite.

Wall rock: Unaltered biotite and plagioclase.

Fracture parallel to micro-fractures with pyrite and adularia.

Photographs of drill core and fracture surface.



Back-scattered SEM-image of allanite on fracture surface.

KFM06A 297.253 m

Open fracture cutting sealed prehnite-filled fracture

Fracture minerals: No detected minerals.

Wall rock: Chloritised biotite and saussuritised plagioclase.

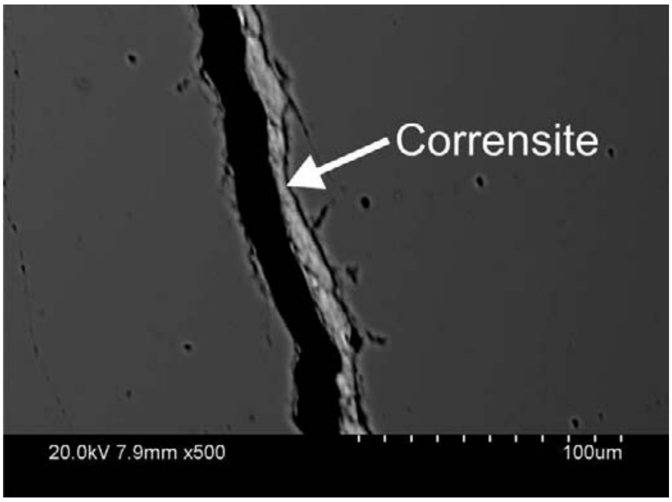
Photographs of drill core and fracture surface.

KFM06C 619.565 m

Sealed fracture

Fracture minerals:	Clay mineral (probably corrensite).
Wall rock:	Unaltered and partly saussuritised plagioclase.

Photographs of drill core and fracture surface.



Back-scattered SEM-image of corrensite in micro-fracture.

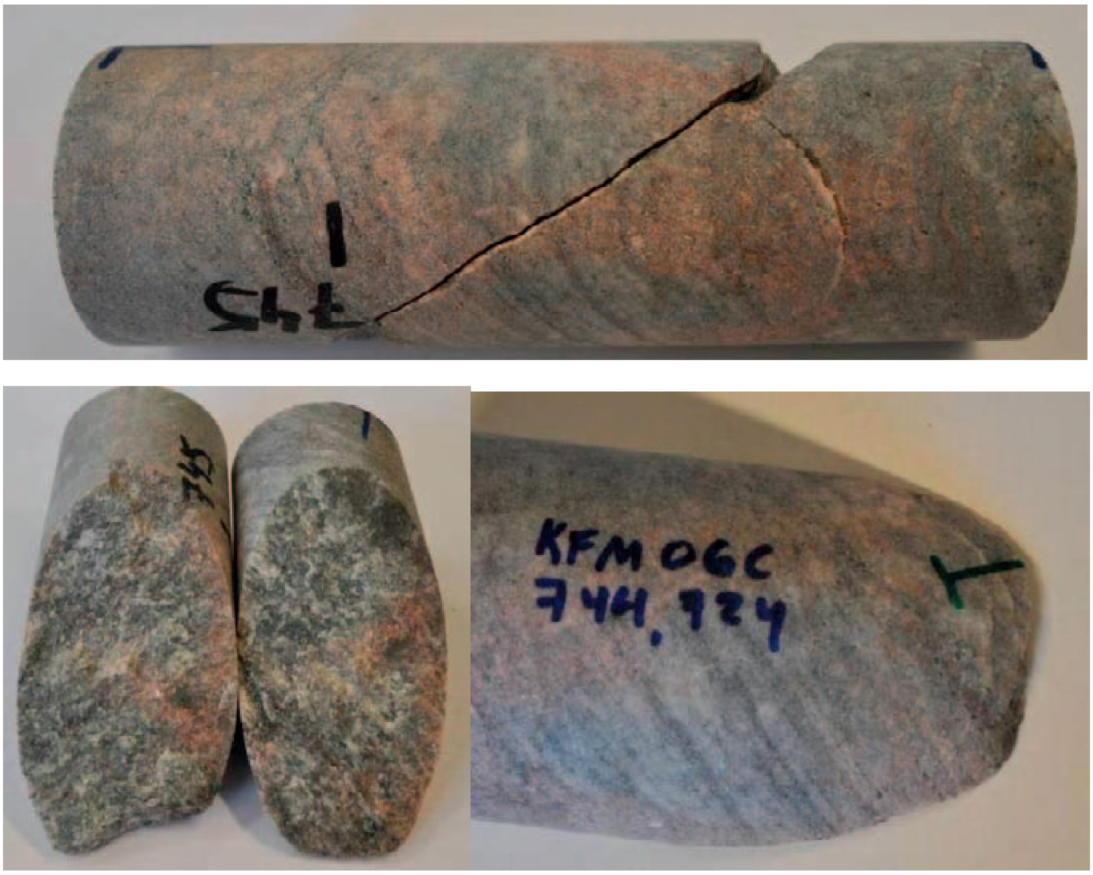
KFM06C 744.804 m

Open fracture

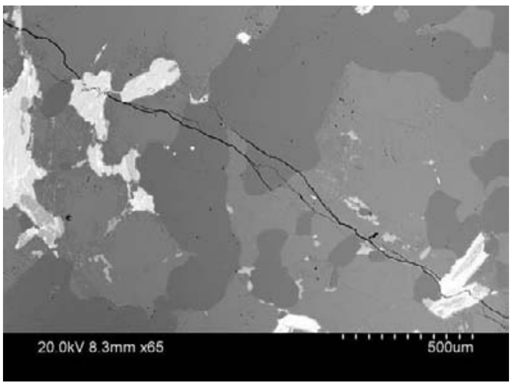
Fracture mineral: No detected mineral.

Wall rock: Unaltered biotite and plagioclase adjacent to the open fracture.

Fracture parallel to micro-fractures with no mineral.



Photographs of drill core and fracture surface.



Back-scattered SEM-image of micro-fracture.

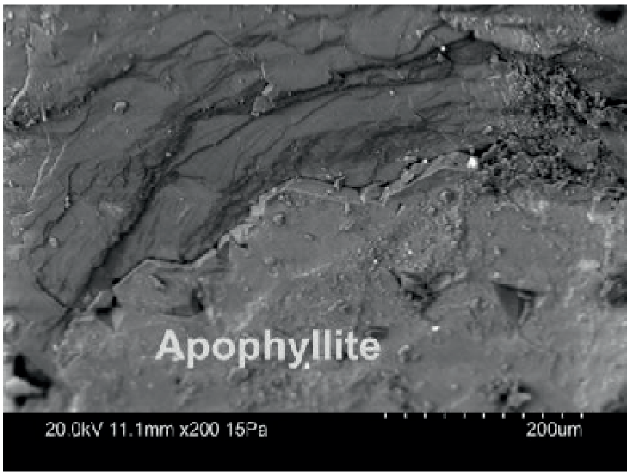
KFM08A 111.198 m

Open fracture

Fracture minerals: Hydroxyapophyllite.

Wall rock: Unaltered biotite and plagioclase.

Photographs of drill core and fracture surface.



Back-scattered SEM-image of apophyllite on fracture surface.

KFM10A 332.834 m

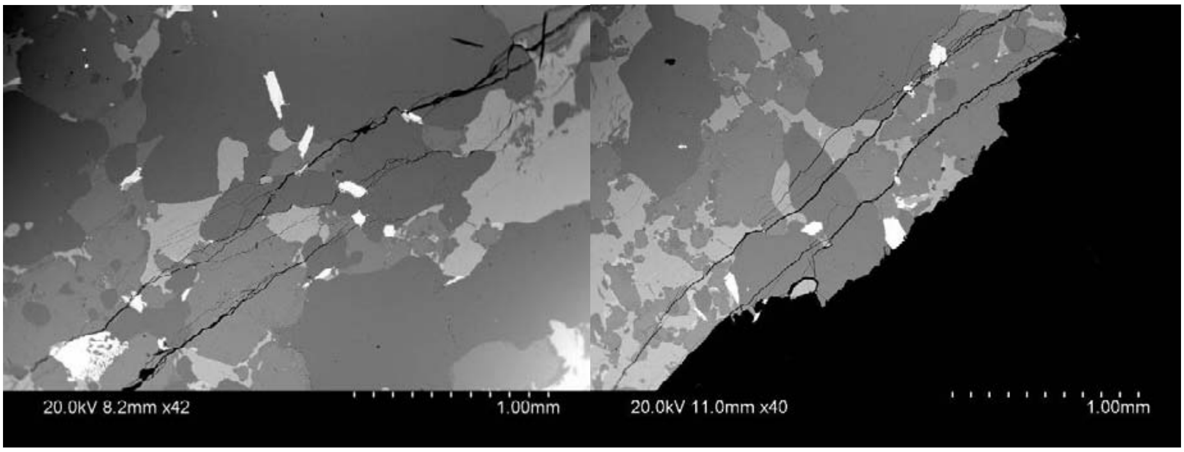
Open fracture

Fracture minerals: No detected mineral in the parallel micro-fracture.

Wall rock: Unaltered biotite and plagioclase.

Fracture parallel to micro-fractures with no mineral.

Photographs of drill core and fracture surface.



Back-scattered SEM-image of micro-fractures.

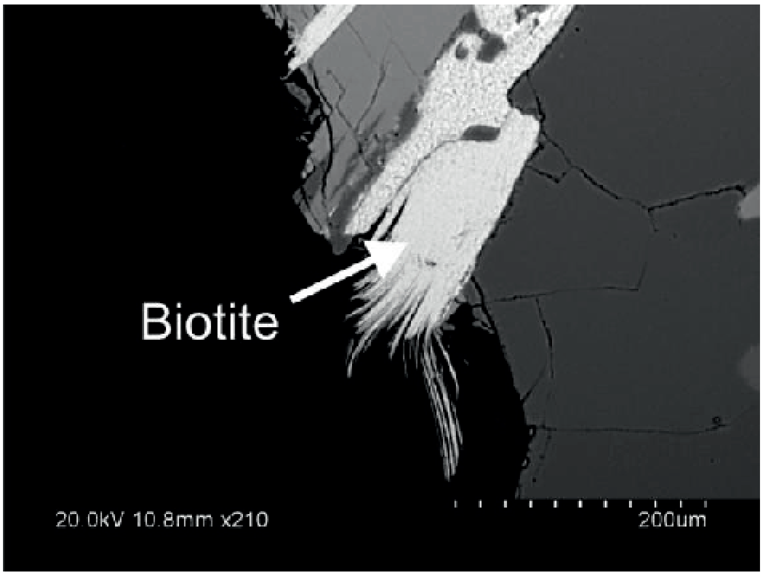
KFM10A 334.430 m

Open fracture

Fracture minerals: No detected mineral.

Wall rock: Unaltered biotite and plagioclase.

Photographs of drill core and fracture surface.



Back-scattered SEM-image of biotite in wall rock.

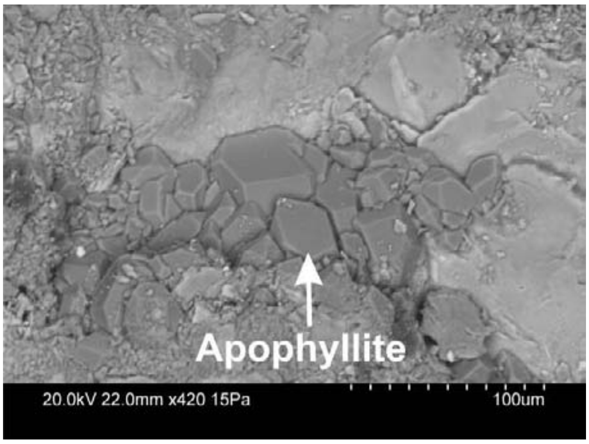
KFM11A 395.37 m

Open fracture

Fracture minerals:	Hydroxyapophyllite.
Wall rock:	Chloritised biotite and saussuritised plagioclase, mylonite texture.

The open fracture is parallel to a laumontite-sealed fracture.

Photographs of drill core and fracture surface.



Back-scattered SEM-image of apophyllite on fracture surface.

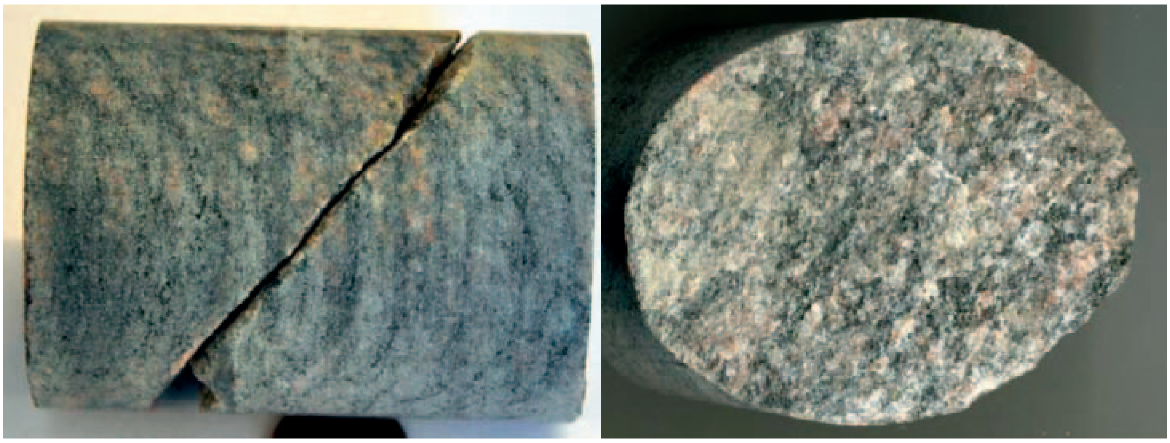
Table A1-2. Compilation of results from investigation of fracture surfaces mapped as “X5” in Boremap.

Borehole	Length (m)		Fracture minerals detected	No fracture minerals detected	Comment
KFM01A	955.507	Open	X		
KFM02B	330.696	Open	X		Parallel to micro-fractures with pyrite crystals.
KFM02B	413.066	Open	X		Parallel to micro-fractures with no detected mineral.
KFM02B	423.349	Open	X		Parallel to micro-fractures with no detected mineral.
KFM02B	426.132	Open	X		Numerous micro-fractures with no detected minerals.
KFM02B	426.354	Open	X		Parallel to micro-fractures with no detected mineral.
KFM02B	429.508	Open	X		Parallel to micro-fractures with adularia.
KFM02B	429.603	Open	X		Extra sample, yellow coating from drilling/mapping?
KFM02B	436.367	Open	X		Parallel to micro-fractures with corrensite and allanite.
KFM02B	497.092	Open	X		Parallel to fracture sealed with prehnite and adularia.
KFM02B	515.936	Open	X		Parallel to fracture with calcite, allanite, adularia, corrensite.
KFM03A	846.040	Open	X		
KFM08D	109.218	Open	X		Parallel to micro-fractures with wall rock fragments.
KFM08D	147.957	Open	X		Parallel to micro-fractures with no detected mineral.
KFM10A	103.241	Open	X		Parallel to micro-fractures with no detected mineral.
KFM10A	328.076	Open	X		Parallel to micro-fractures with no detected mineral.
KFM10A	328.723	Open	X		

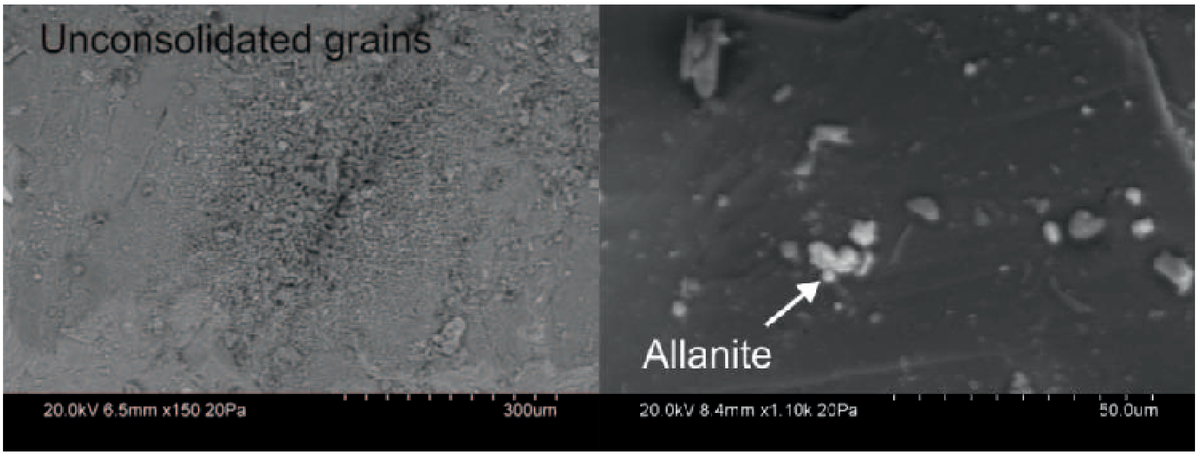
KFM01A 955.507 m

Open fracture

Fracture minerals:	Unconsolidated material consisting of grains of biotite, plagioclase, K-feldspar, quartz, chlorite. Small crystals of allanite.
Wall rock:	Unaltered, fresh biotite.



Photographs of drill core and fracture surface.



Back-scattered SEM-images of allanite on fracture surface.

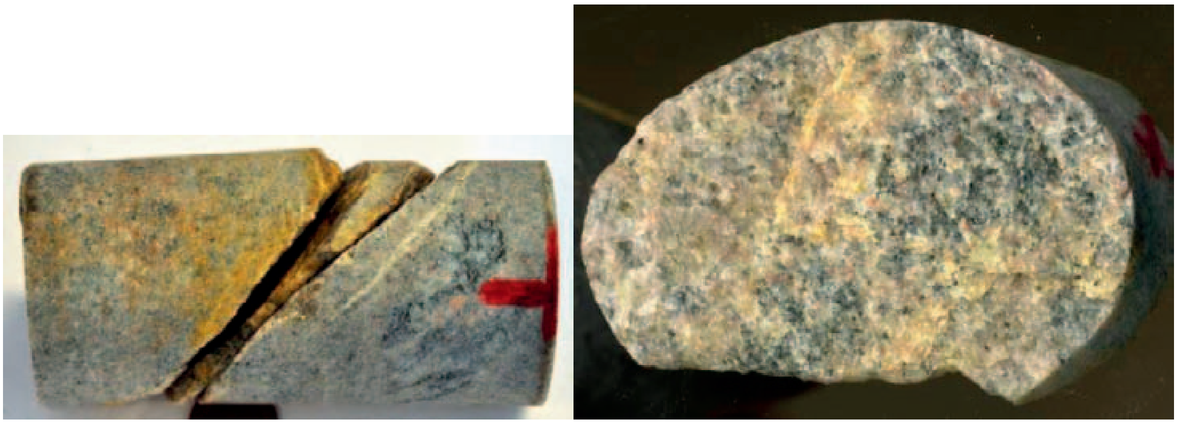
KFM02B 330.696 m

Open fracture

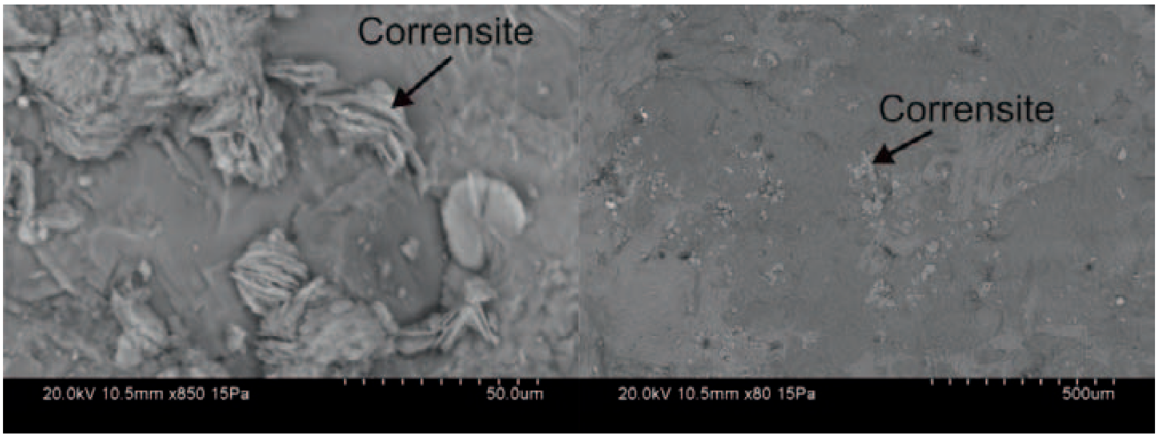
Fracture minerals: Corrensite, pyrite.

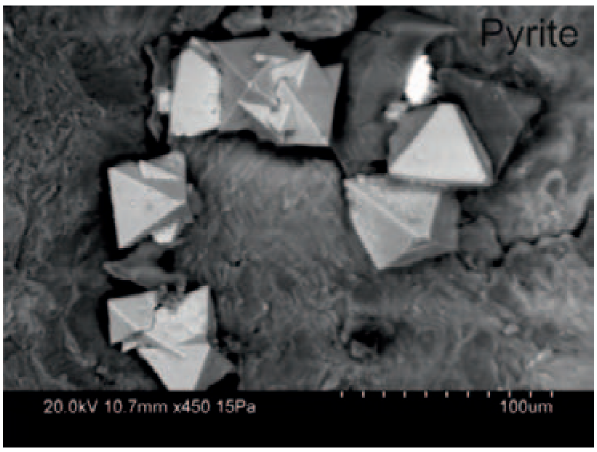
Wall rock: Unaltered, fresh biotite.

Parallel to micro-fractures with a few pyrite crystals.



Photographs of drill core and fracture surface.



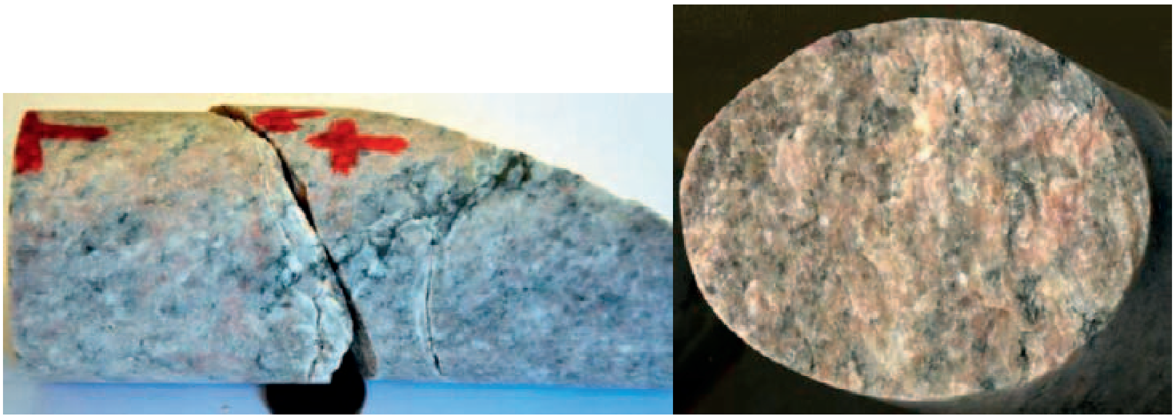


Back-scattered SEM-image of corrensite and pyrite on fracture surface.

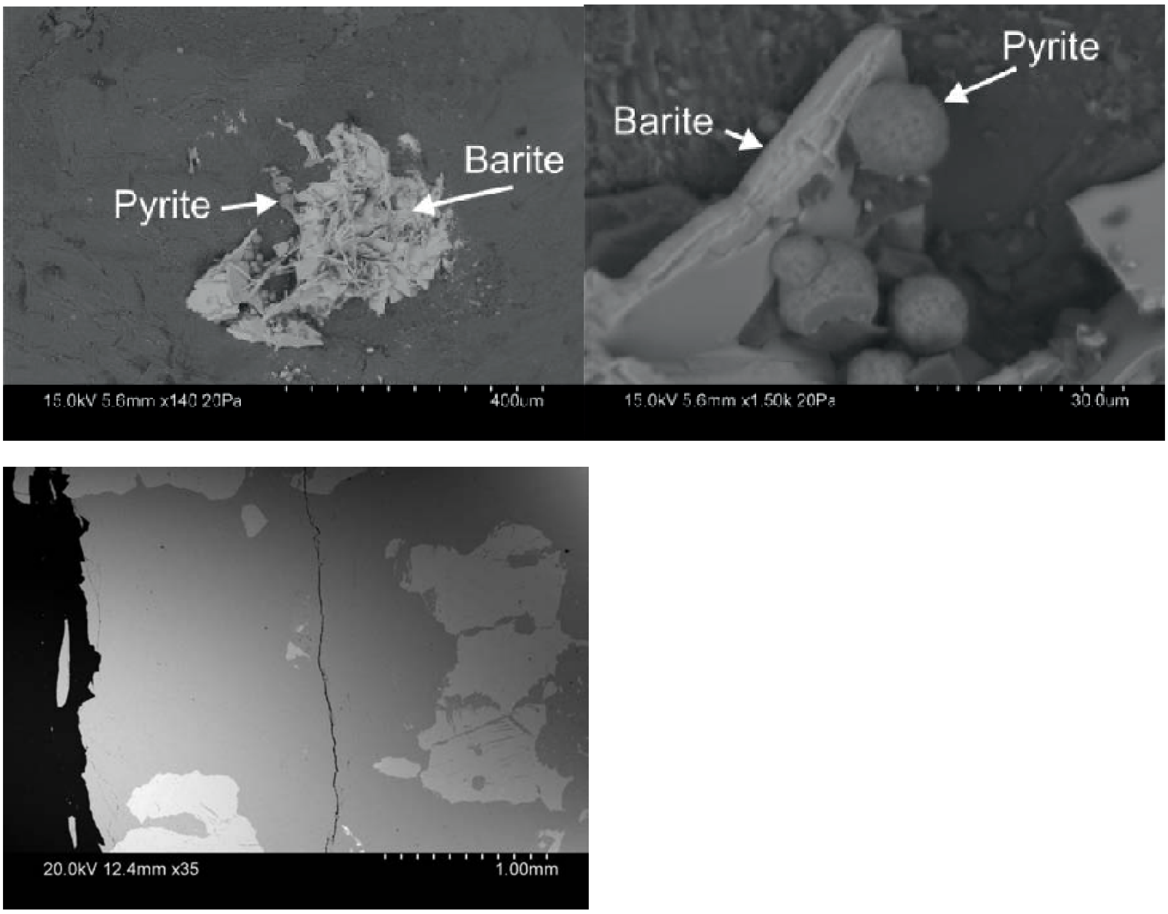
KFM02B 413.066 m

Open fracture

Fracture minerals:	Barite, pyrite.
Wall rock:	Altered, chloritised biotite.



Photographs of drill core and fracture surface.



Back-scattered SEM-image of pyrite and bariteon fracture surface.

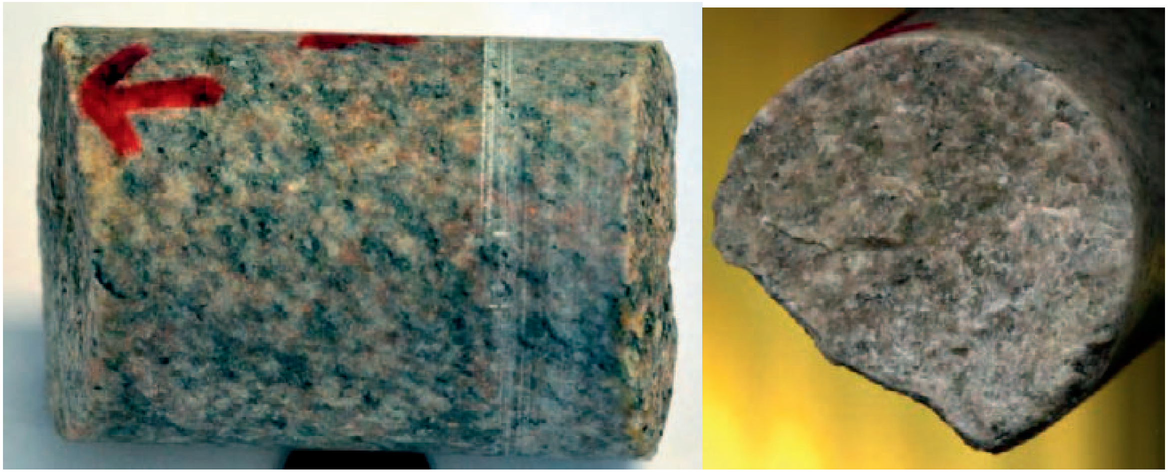
KFM02B 423.349 m

Open fracture

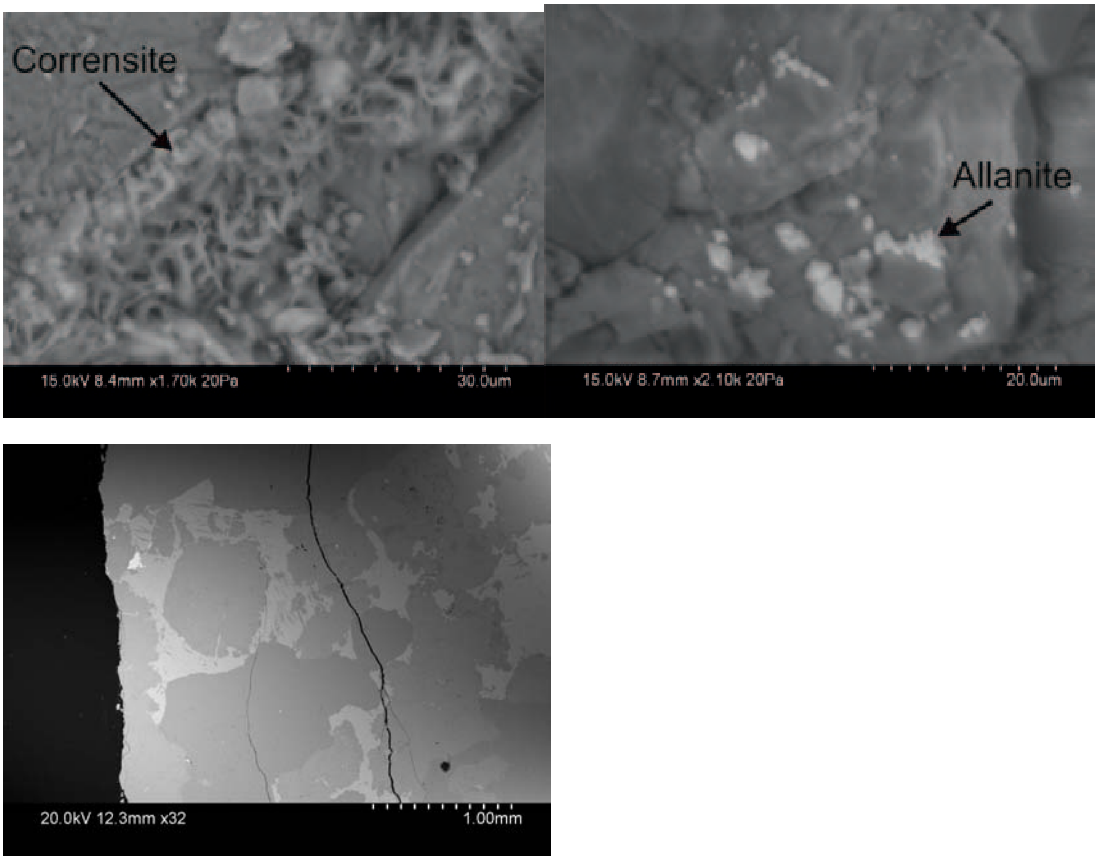
Fracture minerals: Corrensite, allanite.

Wall rock: Altered, chloritised biotite.

Parallel to micro-fractures with no detected mineral.



Photographs of drill core and fracture surface.



Back-scattered SEM-image of corrensite and allanite on fracture surface.

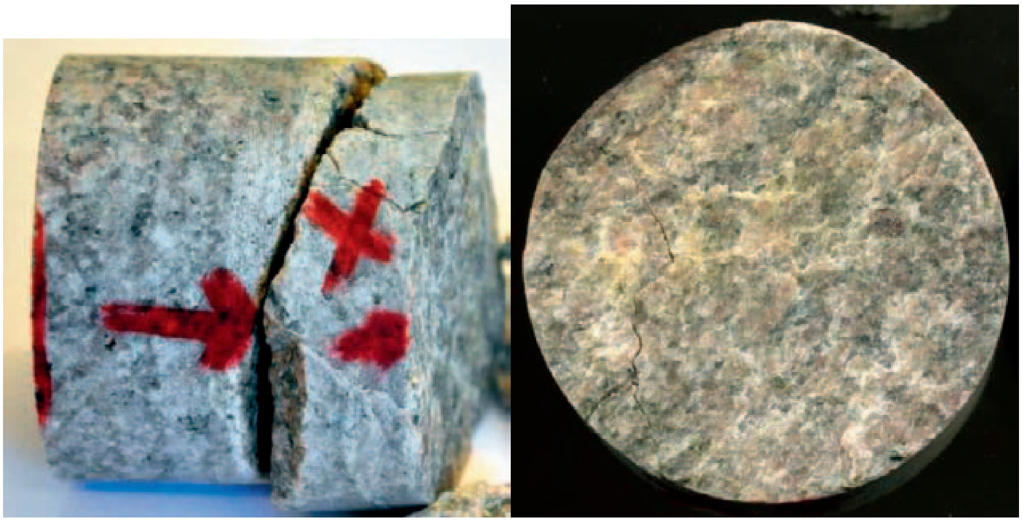
KFM02B 426.132 m

Open fracture

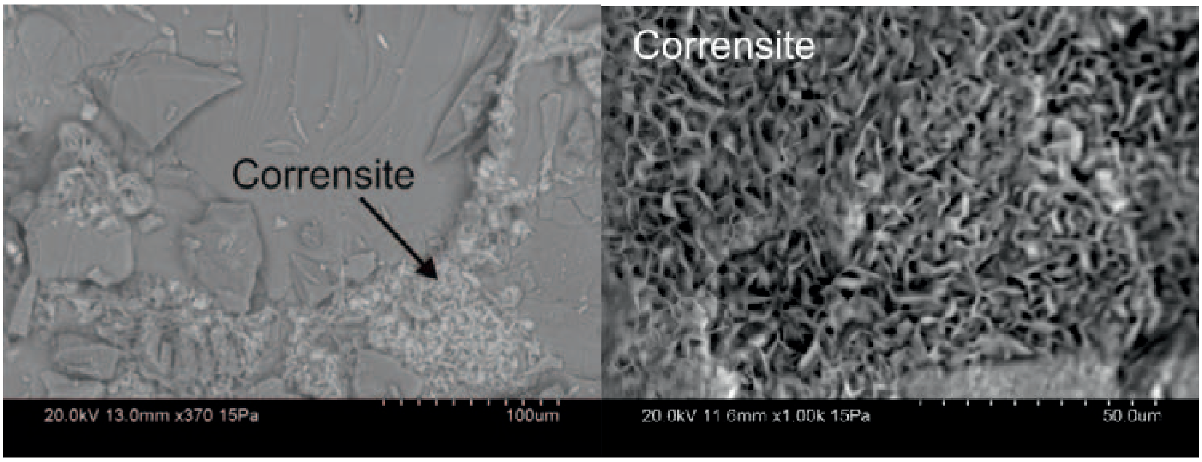
Fracture minerals: Corrensite.

Wall rock: Partly chloritised biotite.

Sample cut by numerous micro-fractures without detected minerals.



Photographs of drill core and fracture surface.



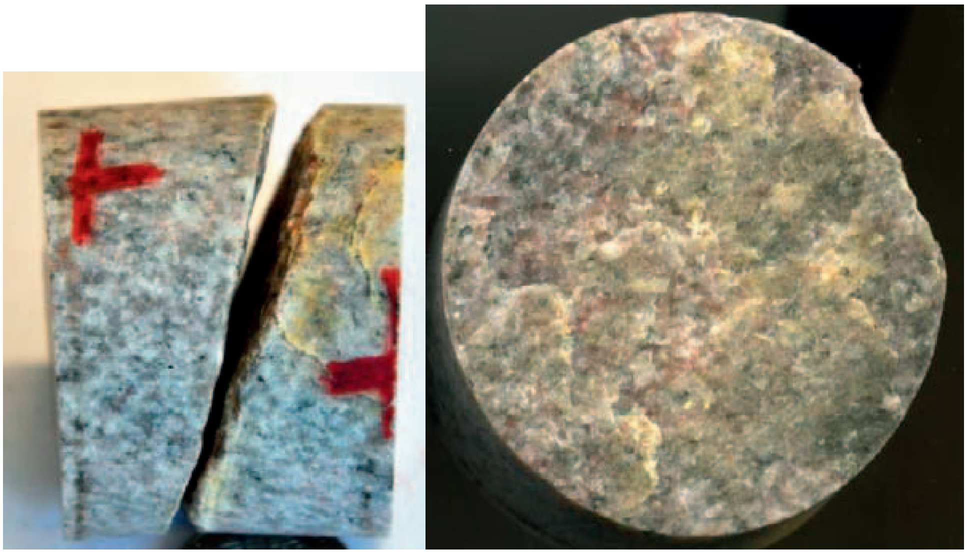
Back-scattered SEM-image of corrensite on fracture surface.

KFM02B 426.354 m

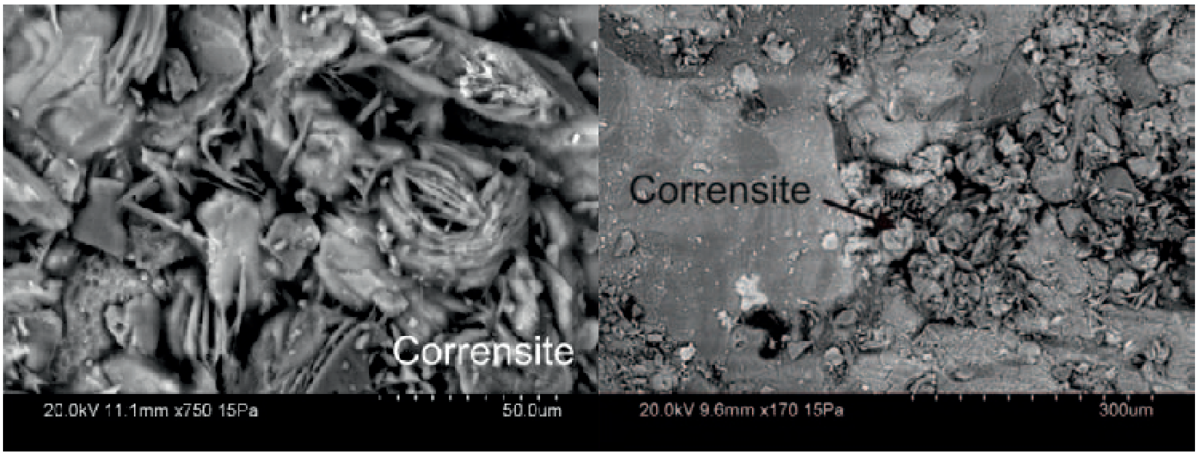
Open fracture

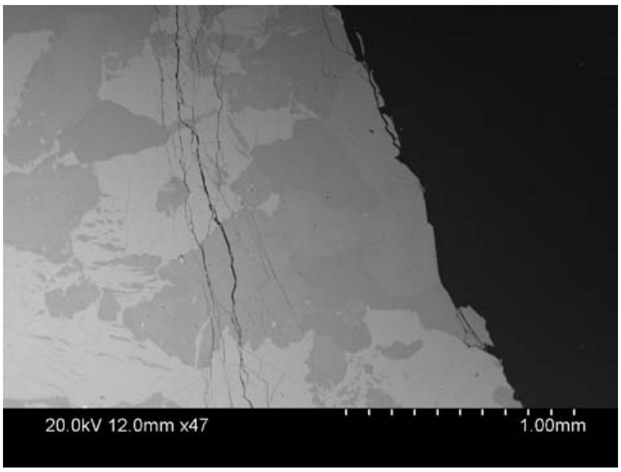
Fracture minerals:	Corrensite.
Wall rock:	Altered, chloritised biotite.

Parallel to micro-fractures with no detected mineral.



Photographs of drill core and fracture surface.





Back-scattered SEM-image of corrensite on fracture surface.

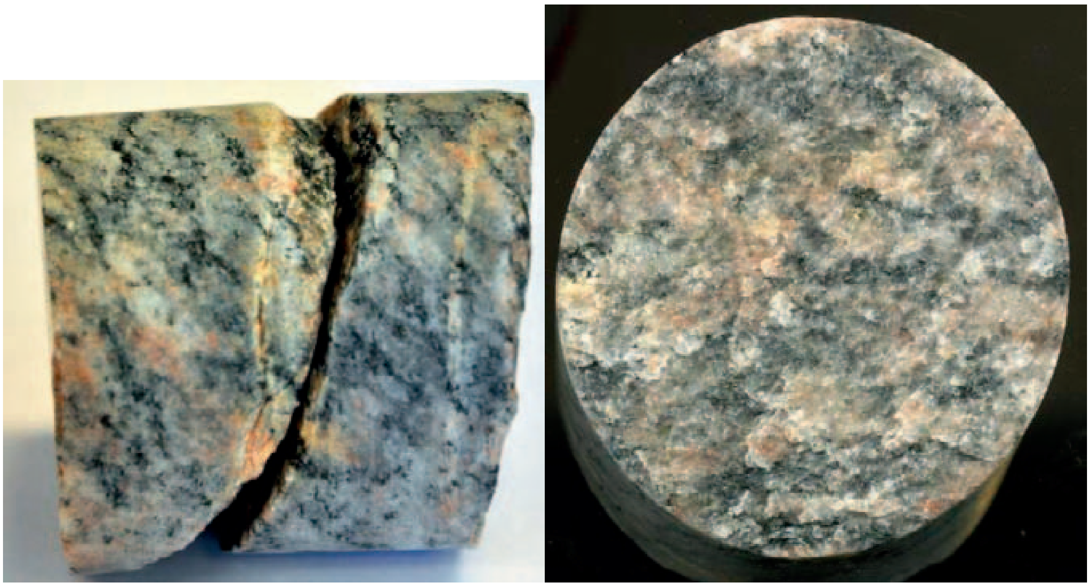
KFM02B 429.508 m

Open fracture

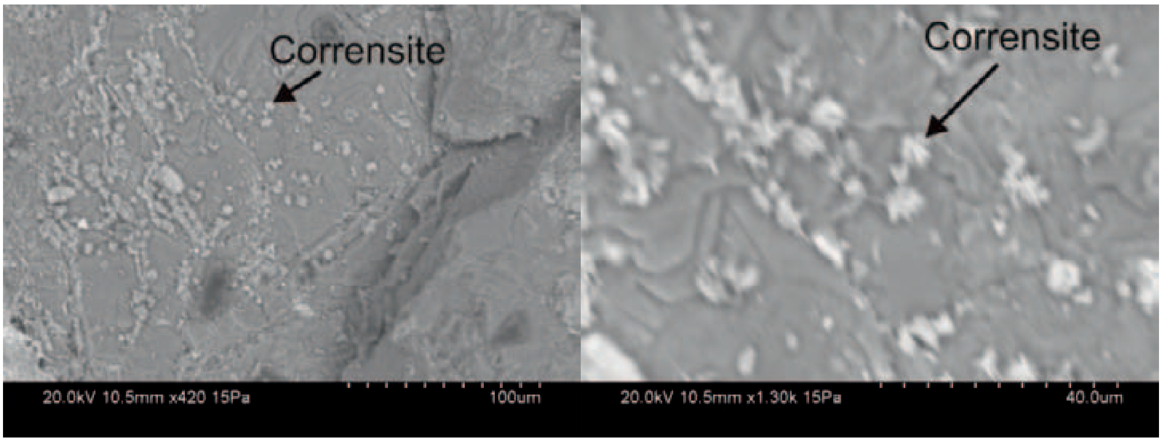
Fracture minerals: Corrensite.

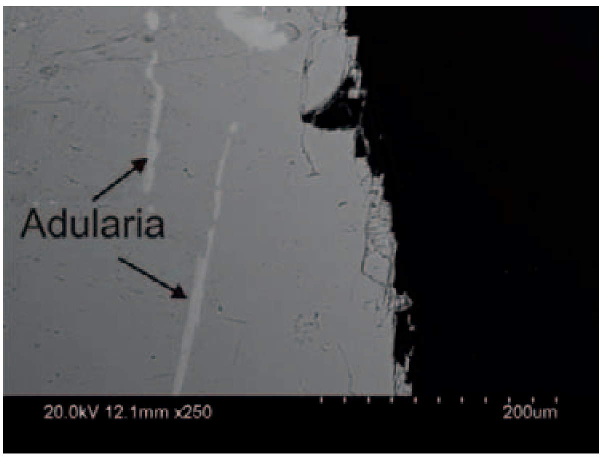
Wall rock: Unaltered, fresh biotite.

Sub-parallel to micro-fractures partly sealed with adularia.



Photographs of drill core and fracture surface.





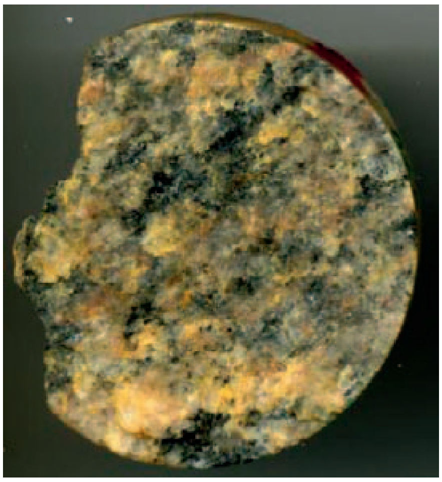
Back-scattered SEM-image of corrensite and adularia on fracture surface.

KFM02B 429.603 m

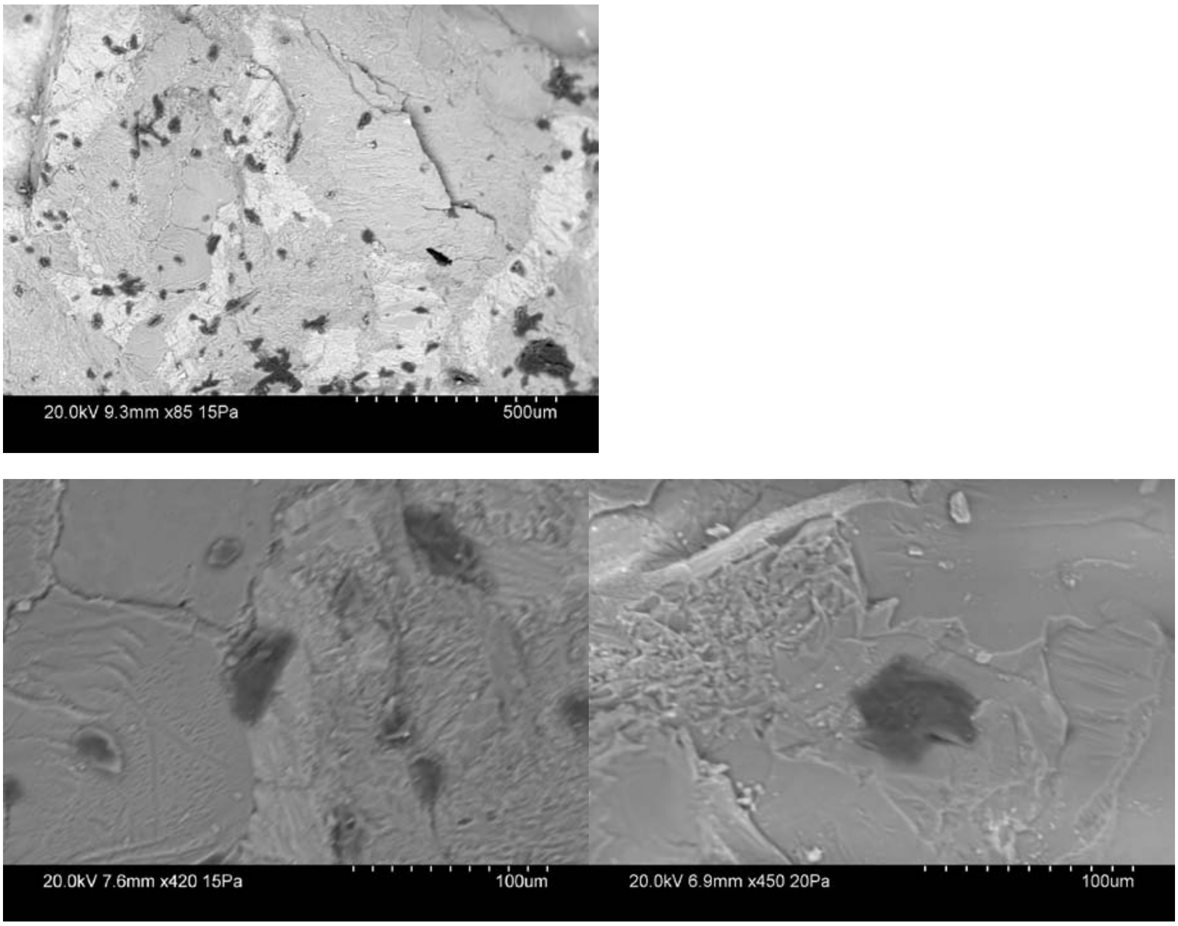
Open fracture

Fracture minerals: Unknown coating with C and Cl, possibly from drilling or HCl during mapping.

Wall rock: Unaltered fresh biotite.



Photograph of drill core and fracture surface.



Back-scattered SEM-image of unknown mineral coating on fracture surface.

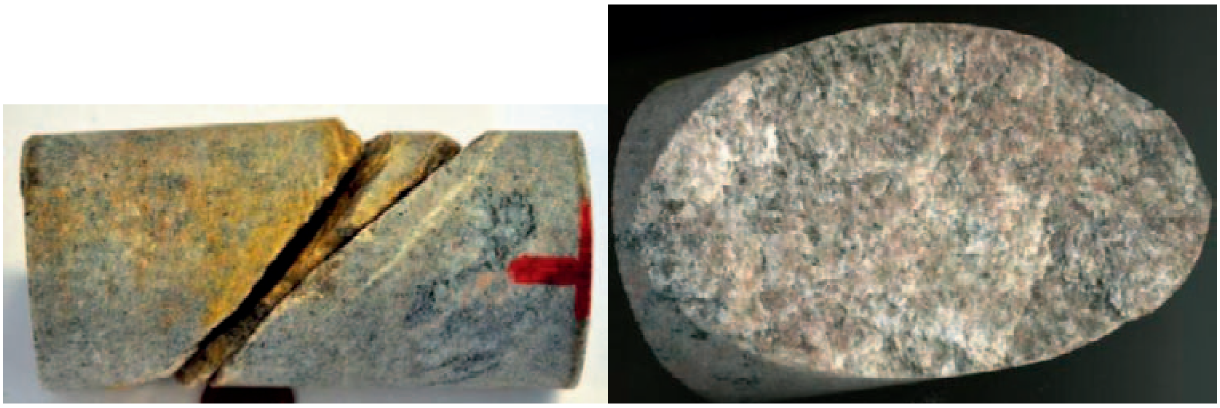
KFM02B 436.367 m

Open fracture

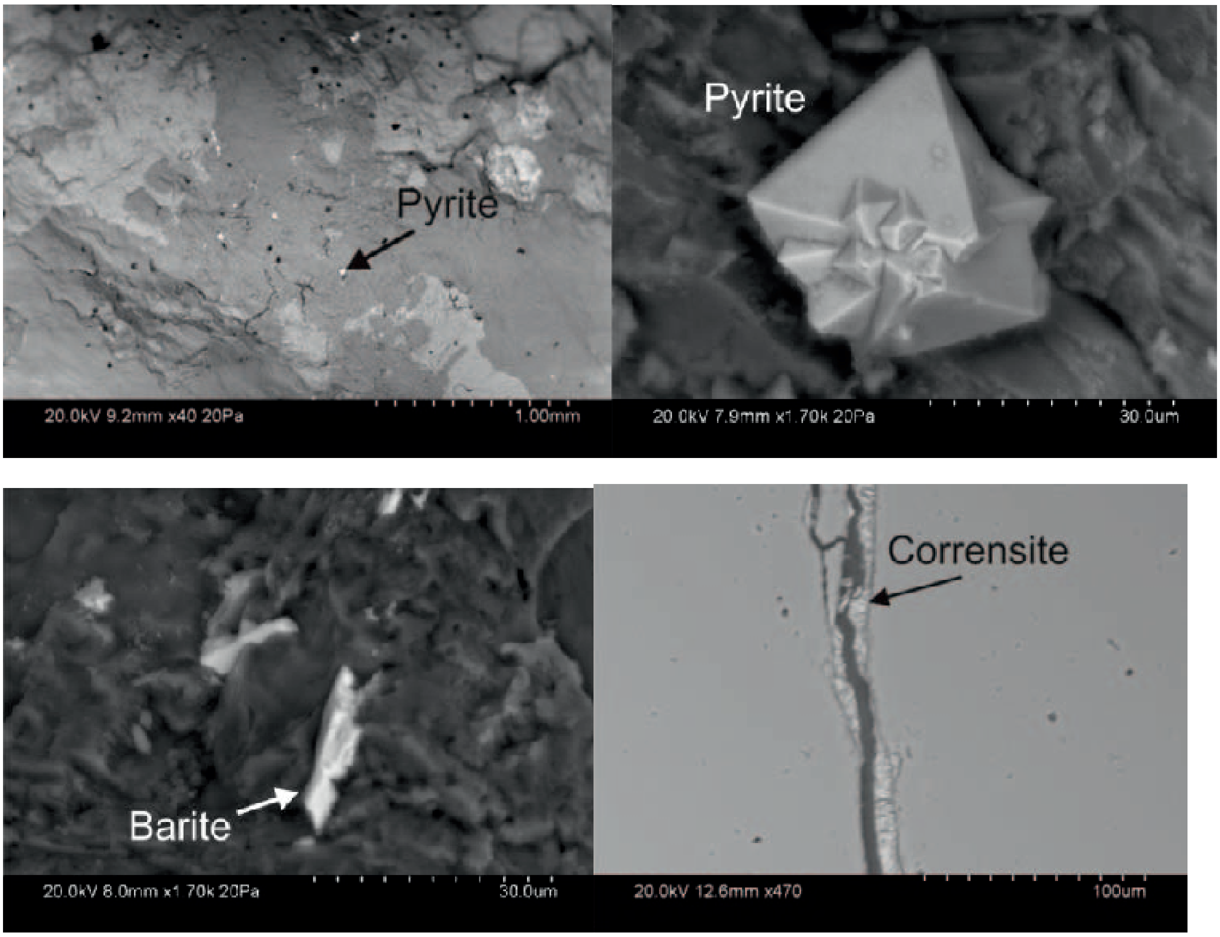
Fracture minerals: Pyrite, barite.

Wall rock: Altered, chloritised biotite.

Parallel to micro-fractures sealed with corrensite and allanite.



Photographs of drill core and fracture surface.



Back-scattered SEM-image of corrensite, barite and pyrite on fracture surface.

KFM02B 497.092 m

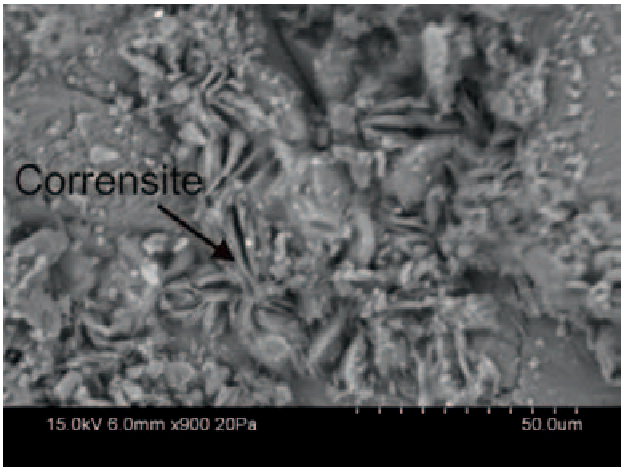
Open fracture

Fracture minerals: Corrensite.

Wall rock: Altered, chloritised biotite.

Parallel to micro fractures sealed with prehnite and adularia.

Photographs of drill core and fracture surface.



Back-scattered SEM-image of corrensite on fracture surface.

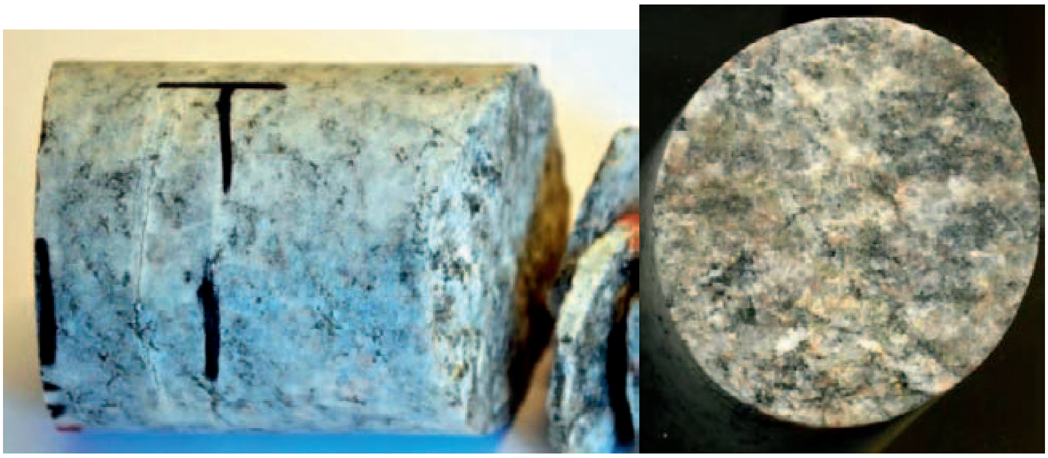
KFM03A 515.936 m

Open fracture

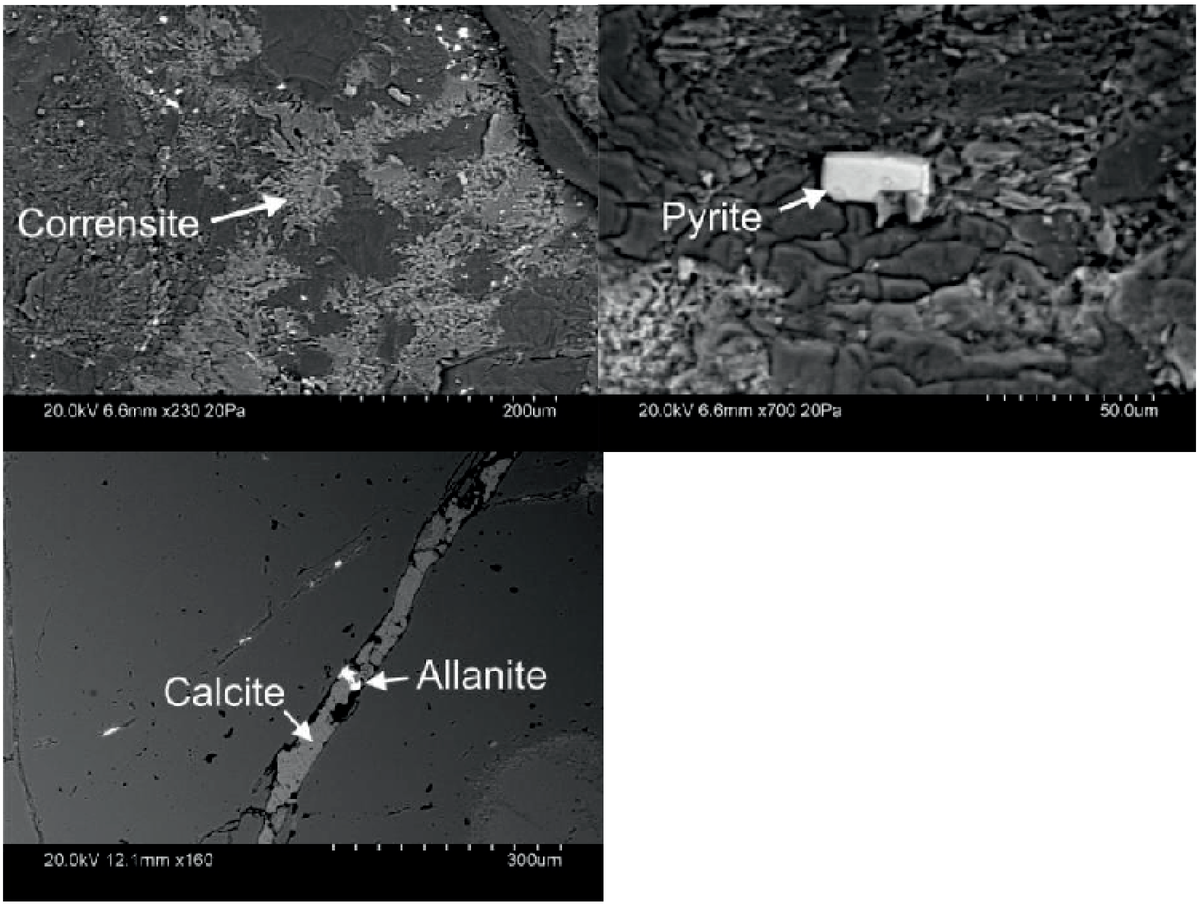
Fracture minerals: Corrensite, pyrite.

Wall rock: Altered biotite.

Fracture parallel to fracture sealed with calcite, allanite, adularia, corrensite.



Photographs of drill core and fracture surface.



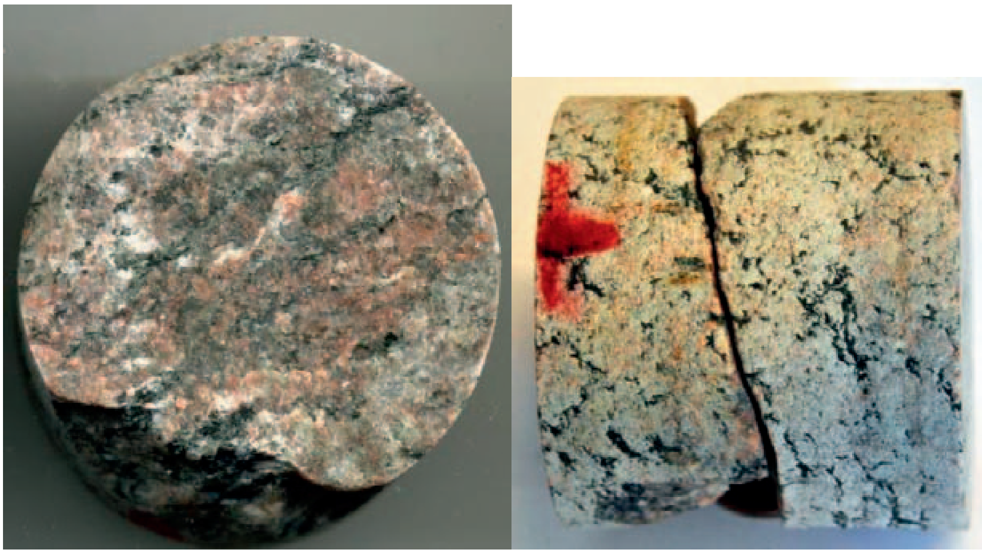
Back-scattered SEM-image of corrensite, pyrite, calcite and allanite on fracture surface and in micro-fracture.

KFM03A 846.04 m

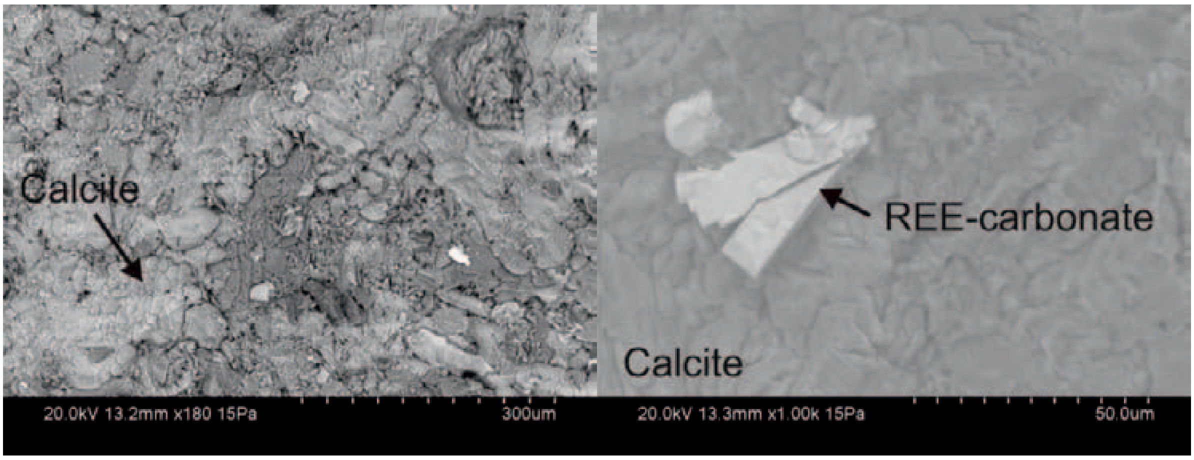
Open fracture

Fracture minerals: Calcite, corrensite, REE-carbonate.

Wall rock: Partly chloritised biotite closest to fracture.



Photographs of drill core and fracture surface.



Back-scattered SEM-image o calcite and REE-carbonate on fracture surface.

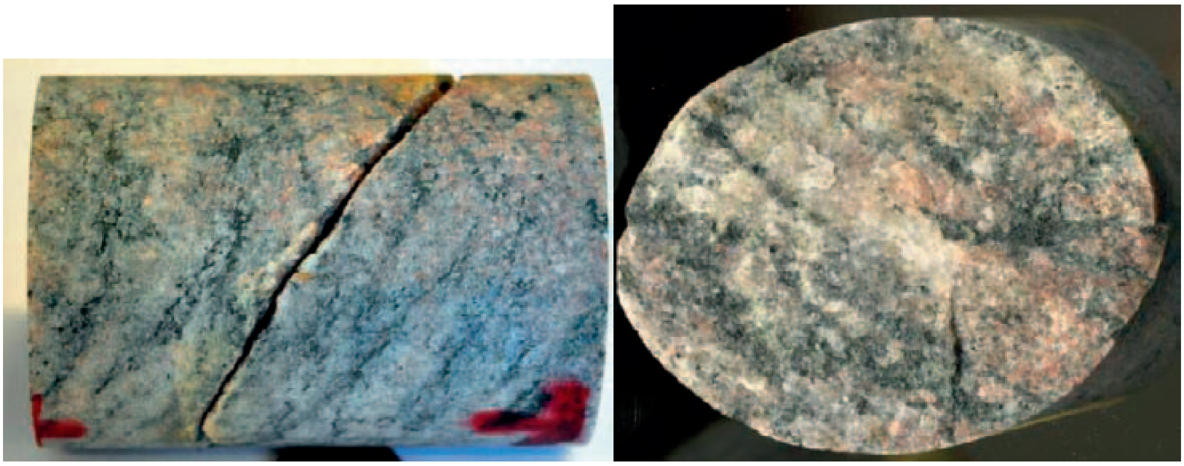
KFM08D 109.218 m

Open fracture

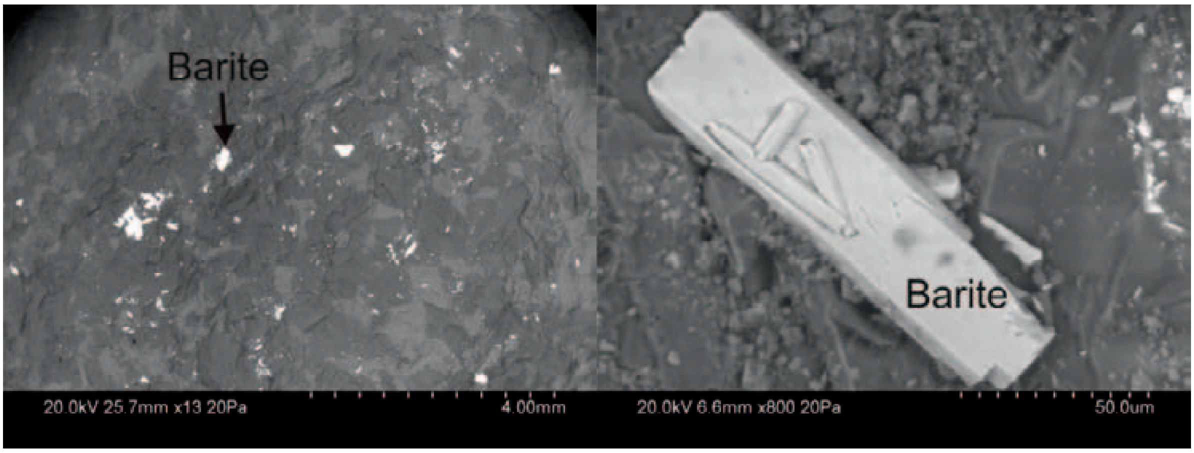
Fracture minerals: Barite.

Wall rock: Altered, chloritised biotite.

Fracture parallel to micro-fracture with wall rock fragments.



Photographs of drill core and fracture surface.



Back-scattered SEM-image of barite on fracture surface.

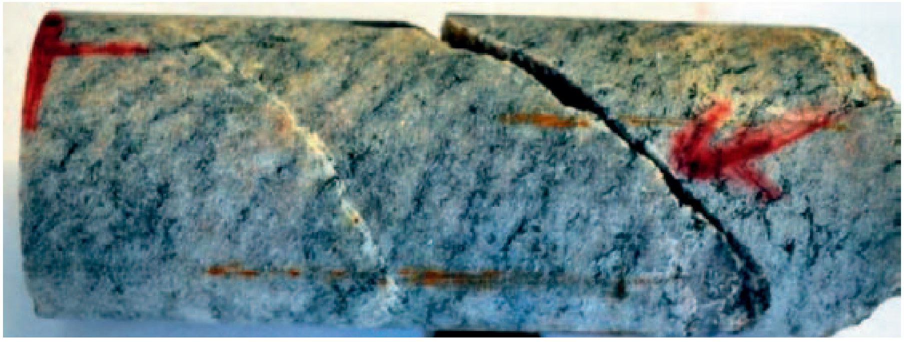
KFM08D 147.957 m

Open fracture

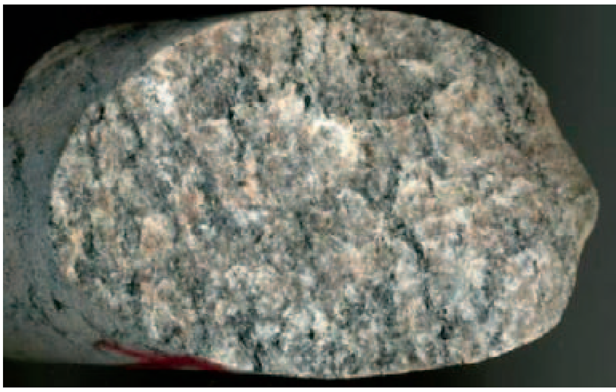
Fracture minerals: Barite.

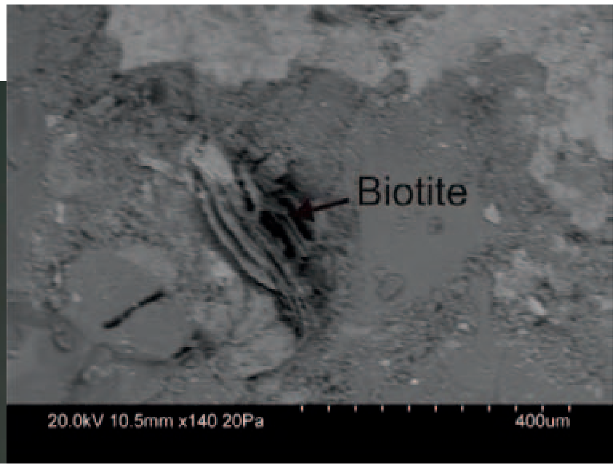
Wall rock: Altered, chloritised biotite.

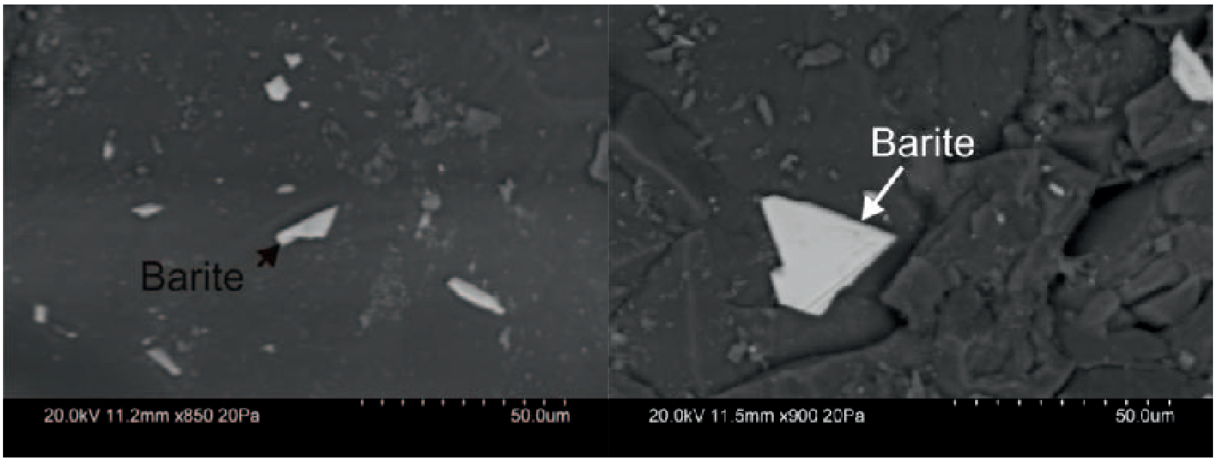
Fracture parallel to micro-fractures with no detected fracture minerals.



Photographs of drill core and fracture surface.







Back-scattered SEM-image of barite and biotite on fracture surface.

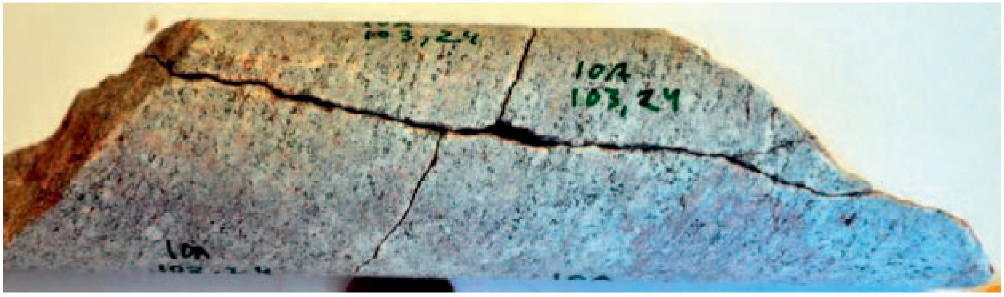
KFM10A 103.241 m

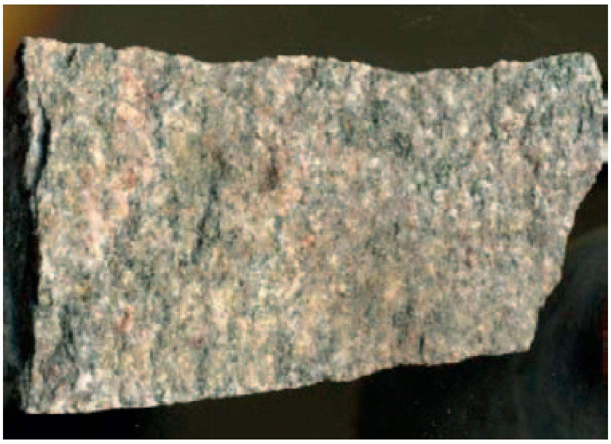
Open fracture

Fracture minerals: Pyrite, clay mineral.

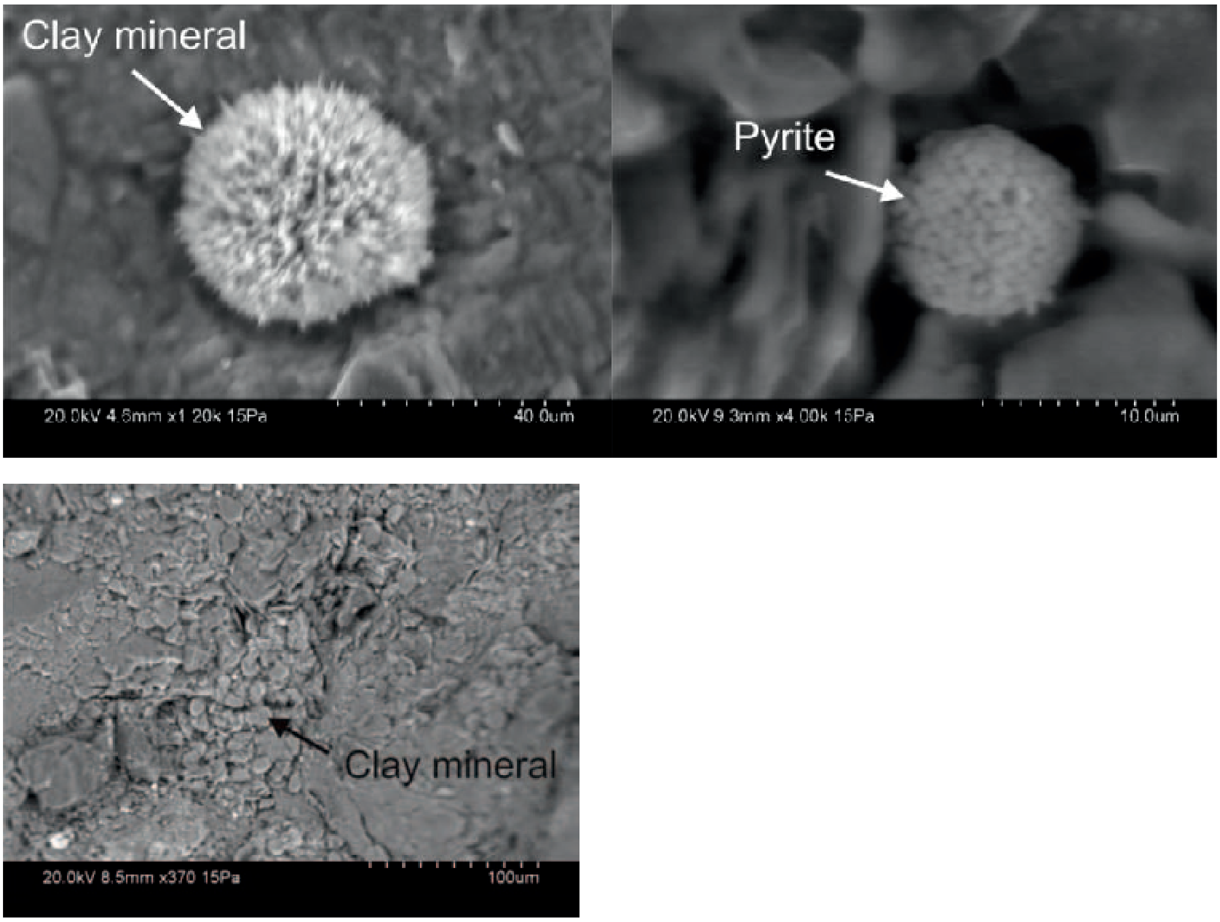
Wall rock: Altered, chloritised biotite.

Parallel to micro-fractures with no detected fracture mineral.





Photographs of drill core and fracture surface.



Back-scattered SEM-image of clay mineral and pyrite on fracture surface.

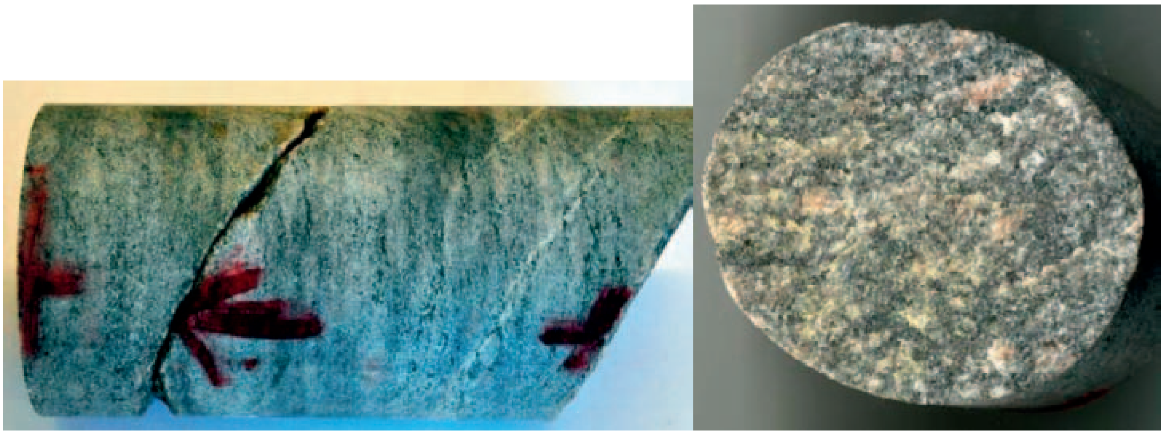
KFM10A 328.076 m

Open fracture

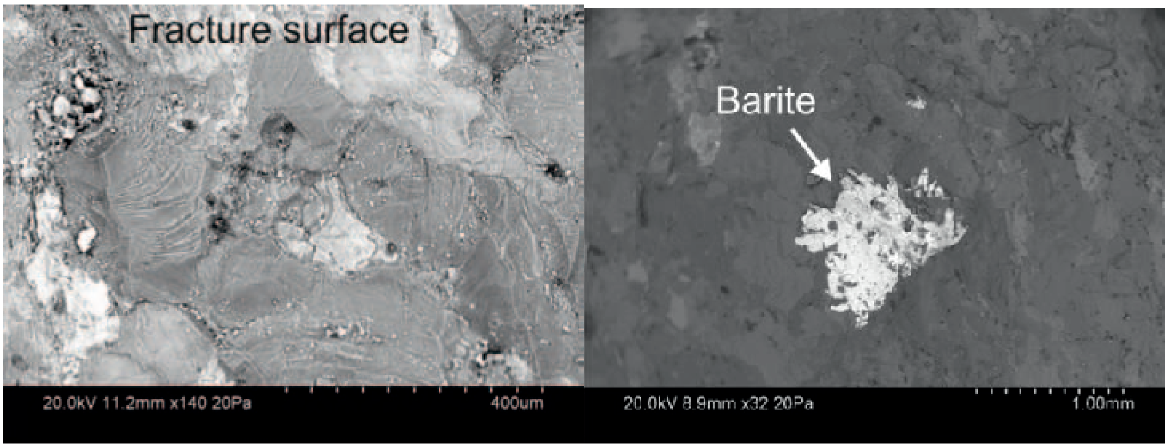
Fracture minerals: Barite.

Wall rock: Unaltered, fresh biotite.

Parallel to micro-fractures with no detected mineral.



Photographs of drill core and fracture surface.



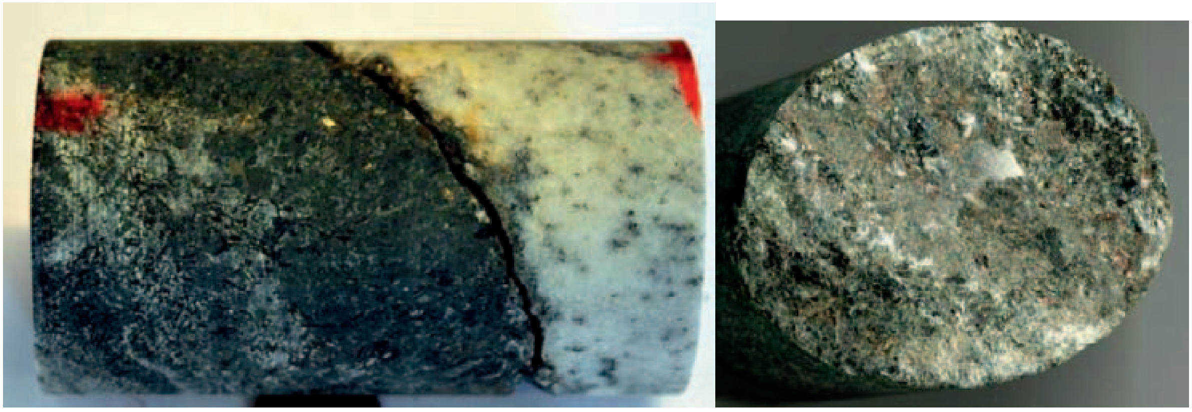
Back-scattered SEM-image of barite on fracture surface.

KFM10A 328.723 m

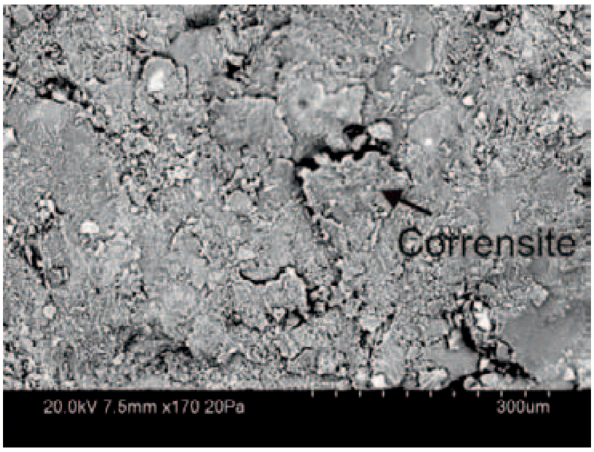
Open fracture

Fracture minerals: Corrensite, biotite, epidote, fluorite.

Wall rock: Partly altered biotite.



Photographs of drill core and fracture surface.



Back-scattered SEM-image of corrensite on fracture surface.

Appendix 2

Investigation of fracture surfaces by optical microscopy and SEM-EDS, Laxemar

Henrik Drake
Isochron GeoConsulting

Introduction and execution

This document presents the results from detailed investigations of fractures in drill cores from Laxemar, which are classified as non-mineralised in the Sicada database. Investigation has been carried out on thin sections and surface samples with optical microscope and with a Hitachi S-3400N scanning electron microscope equipped with an INCADryCool energy dispersive X-ray spectrometer (SEM-EDS) at the Department of Earth Sciences, University of Gothenburg. The EDS-system was used to aid mineral identification.

30 µm polished thin sections were prepared by Minoprep AB with the sections cutting the fracture surface. Samples were examined by petrographic microscope and subsequently carbon-coated before mounted in the SEM-EDS. Fracture surface samples were prepared by rock saw and examined with binocular microscope before mounted in the SEM-EDS. Low vacuum conditions was used to avoid coating the surface samples.

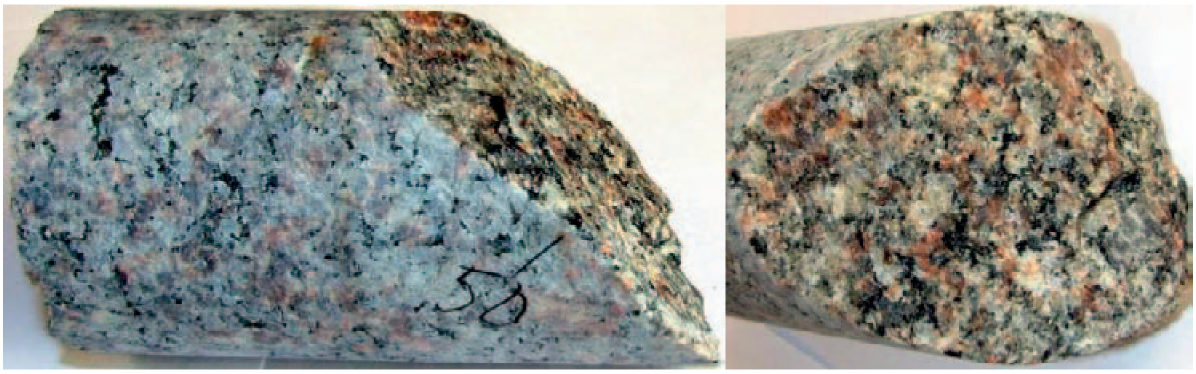
Results and sample descriptions

Table A2-1. Compilation of results from investigation of fracture surfaces.

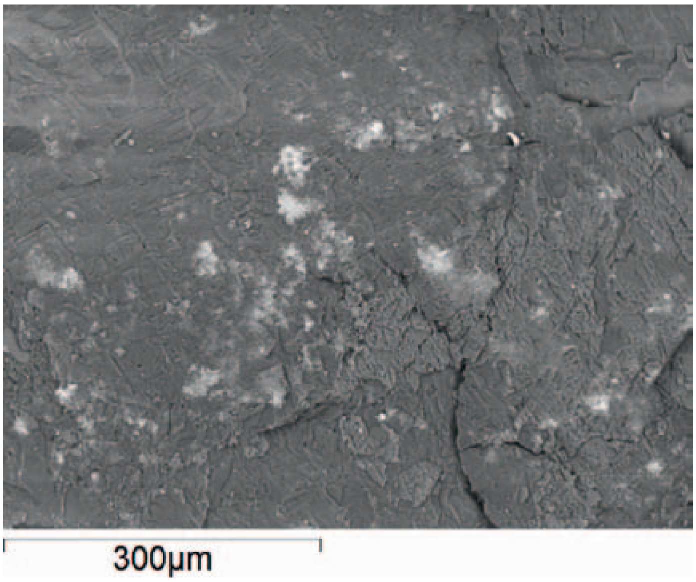
Borehole	Length (m) (ADJUSTEDSECUP)		Fracture minerals detected	No fracture minerals detected	Comment
KLX02	241.504	Open	X		
KLX05	143.527	Open	X		
KLX06	271.515	Open	X		
KLX06	296.037	Open	X		
KLX06	561.074	Open	X		
KLX07A	341.026	Open	X		
KLX07A	396.319	Open	X		
KLX08	303.912	Open	X		
KLX08	361.701	Open	X		
KLX08	491.453	Open	X		
KLX10	284.245	Open	X		
KLX13A	465.239	Open	X		
KLX13A	470.658	Open	X		
KLX18A	309.503	Open	X		
KLX18A	382.470	Open	X		
KLX18A	421.006	Open	X		
KLX18A	468.079	Open	X		
KLX18A	554.815	Open	X		
KLX19A	684.759	Open	X		
KLX19A	733.604	Open	X		

KLX02: 241.504 m
Fracture minerals: REE-carbonate and quartz.

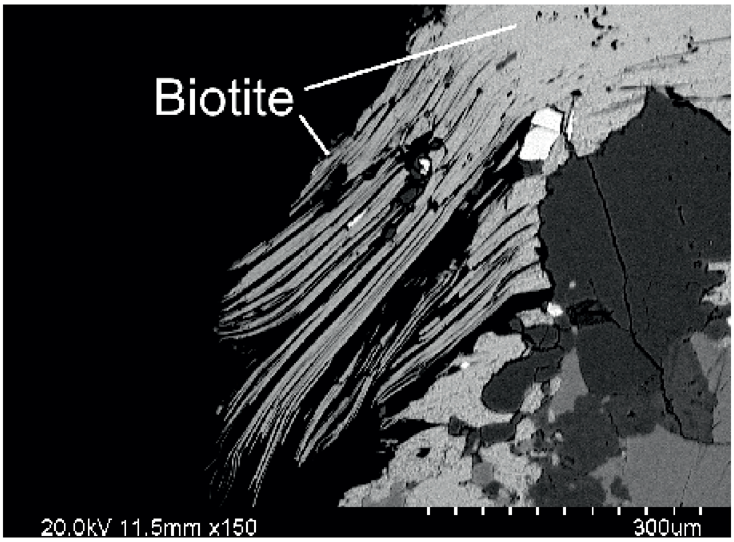
Wall rock: Magnetite is fresh in the whole sample. The wall rock shows no increasing alteration towards the fracture. Biotite crystals are altered at the fracture edge. There are some micro-fractures parallel to the fracture.



Photograph of drill core and fracture surface.



Back-scattered SEM-image of REE-carbonate (bright spots) on fracture surface.



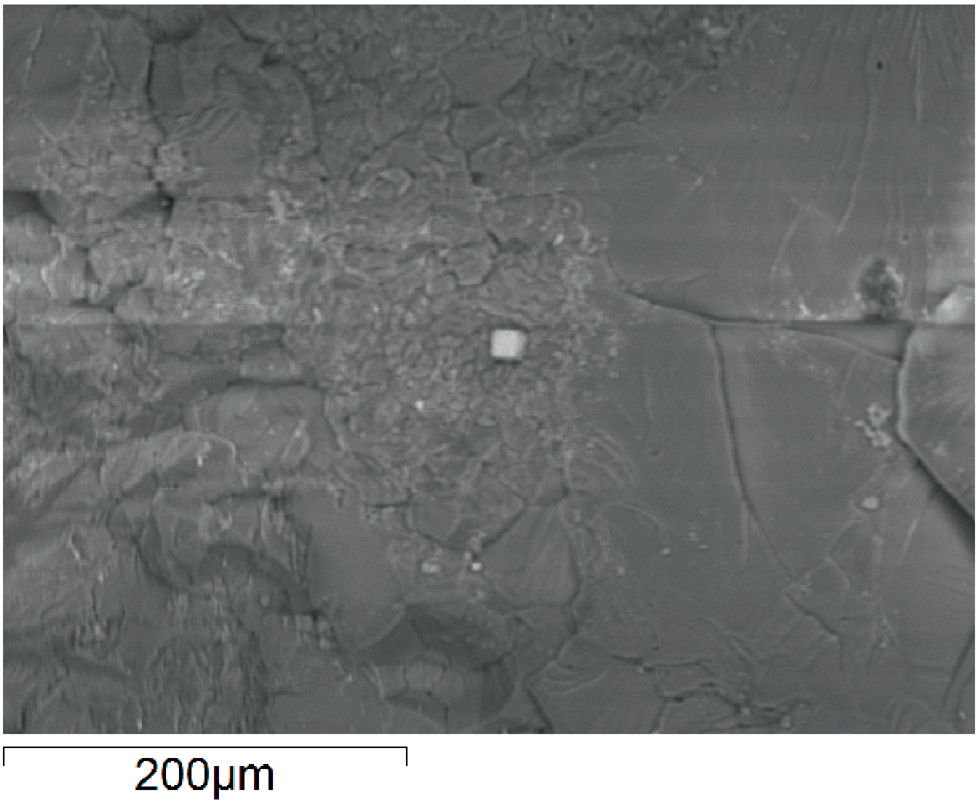
Back-scattered SEM-image of altered biotite at the fracture edge.

KLX05: 143.527 m

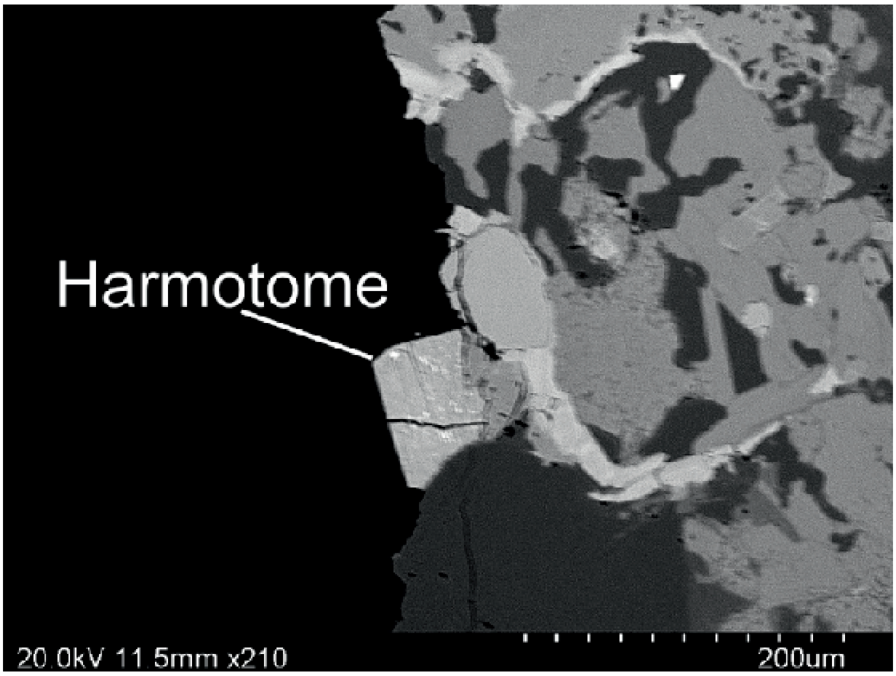
Fracture minerals: Pyrite and harmotome

Wall rock: Magnetite is fresh in the whole sample. No wall rock alteration intensity towards the fracture. No typical red-staining alteration. Local biotite alteration at the fracture rim.

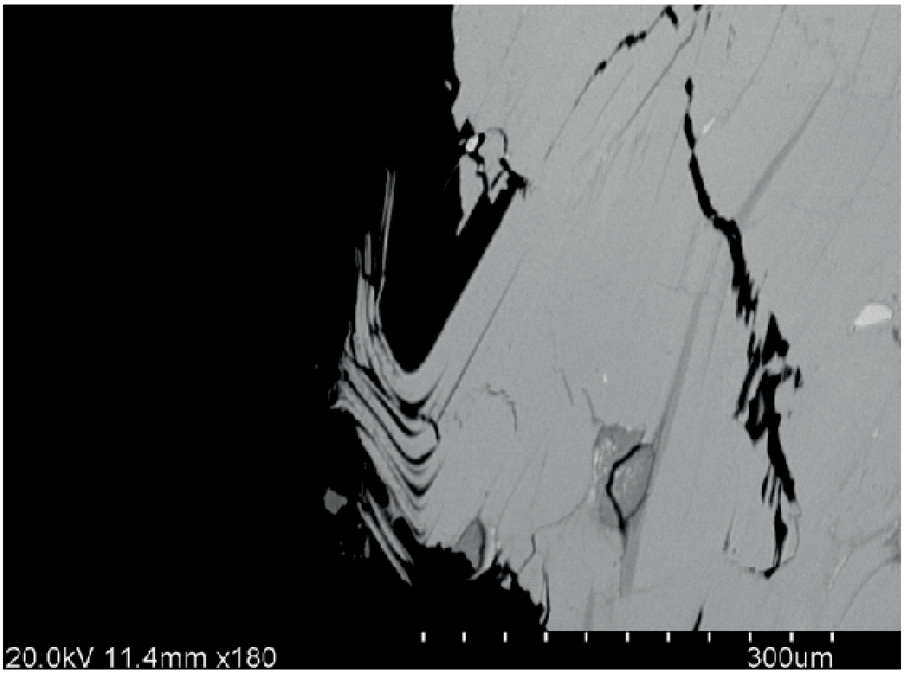
Photographs of drill core and fracture surfaces.



Back-scattered SEM-image of pyrite (bright cubic crystal).



Back-scattered SEM-image of the fracture mineral harmotome (in the thin section). Wall rock is to the right, fracture to the left.

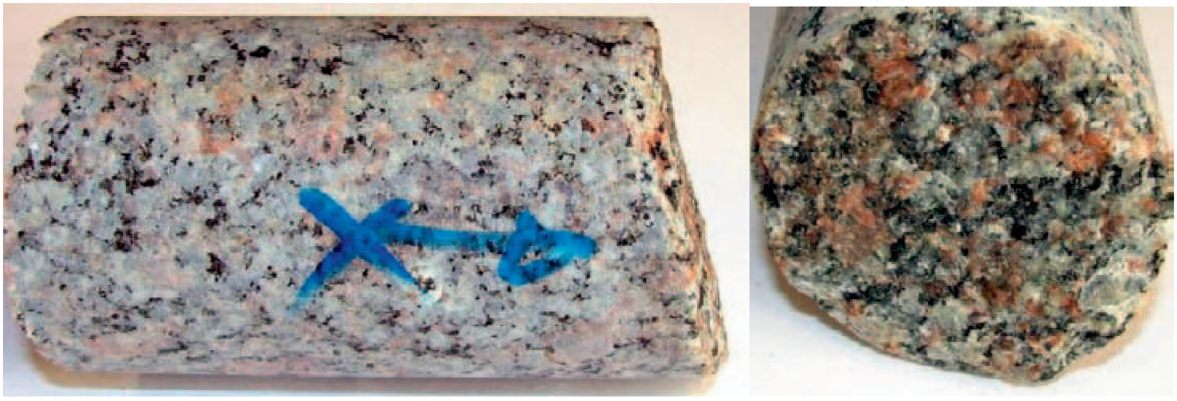


Back-scattered SEM-image of the biotite, which is altered at the fracture edge (to the left).

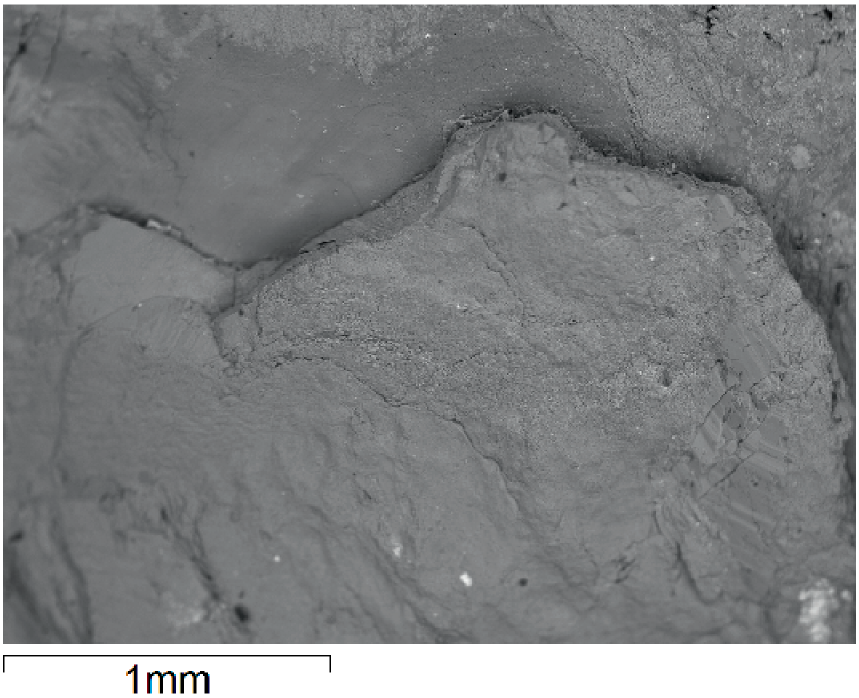
KLX06: 271.515 m

Fracture minerals: Calcite and pyrite.

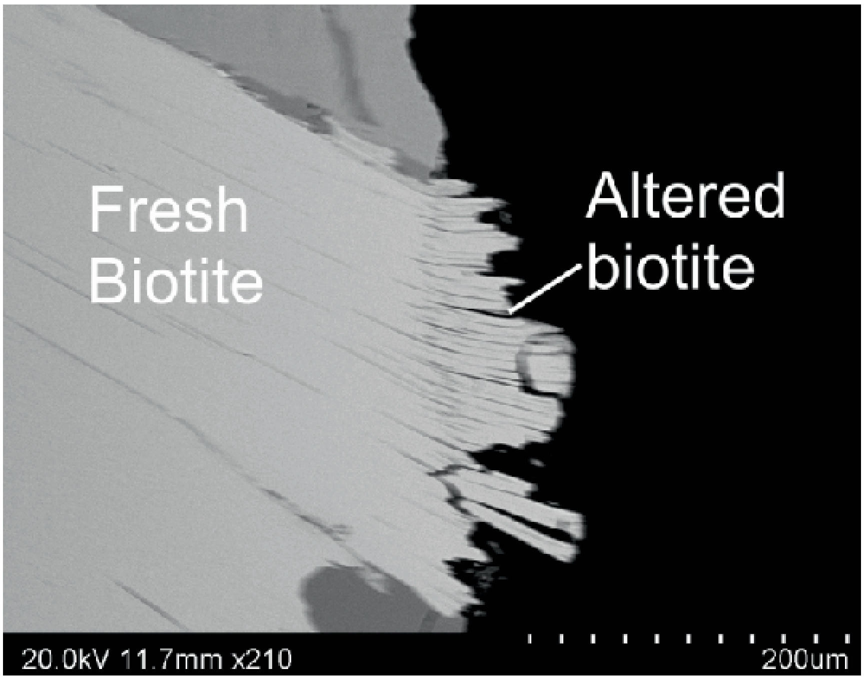
Wall rock: Magnetite is fresh in the whole sample. No increase in wall rock alteration towards the fracture. No typical red-staining alteration. Biotite alteration is evident at the fracture rim. Parallel micro-fractures are observed close to the fracture.



Photographs of drill core and fracture surface.



Back-scattered SEM-image of calcite. Pyrite is also present (small crystals).

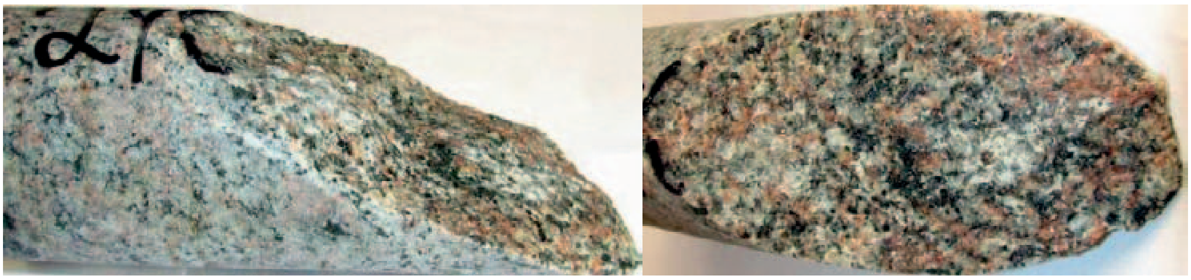


Back-scattered SEM-image of biotite alteration close to the fracture.

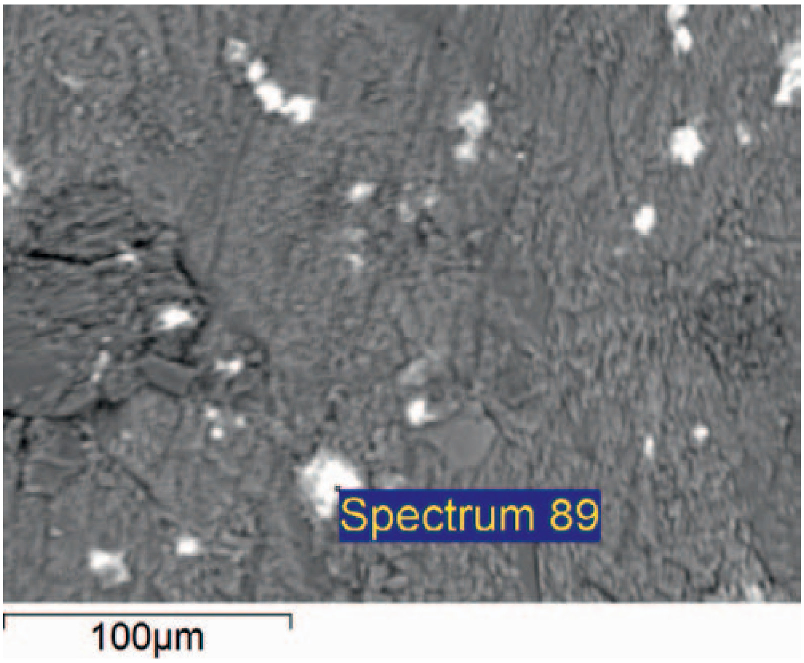
KLX06: 296.037 m

Fracture minerals: REE-carbonate, barite and adularia.

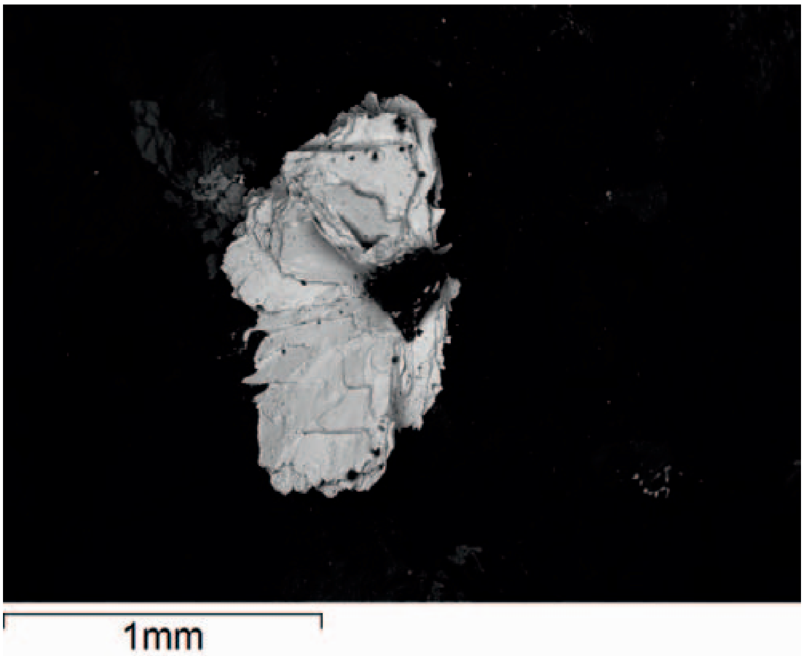
Wall rock: Magnetite is fresh in the whole sample. No increase in wall rock alteration towards the fracture. No typical red-staining alteration. Some indications of biotite alteration at the fracture rim. Parallel micro-fractures close to the fracture, partly filled with e.g. pyrite.



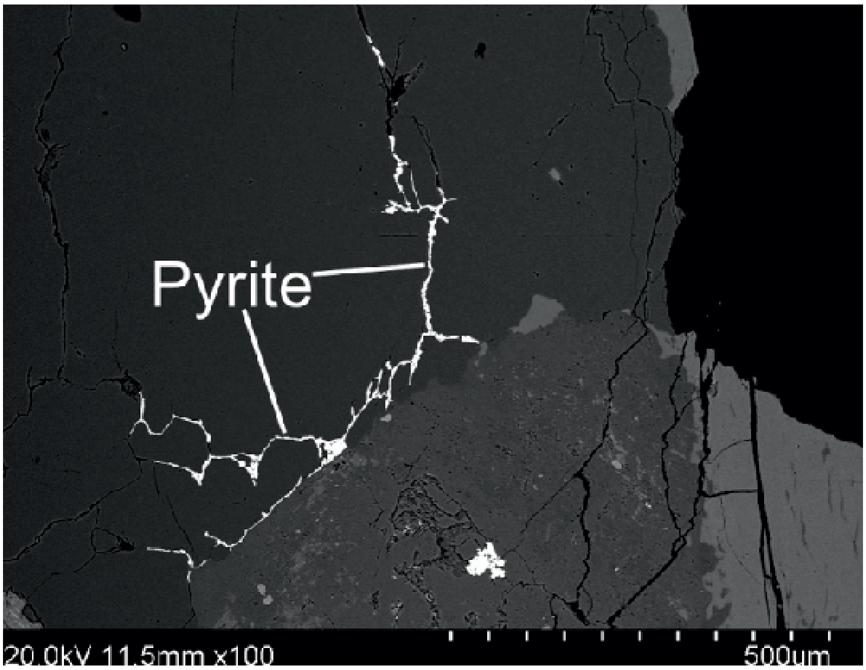
Photographs of drill core and fracture surface.



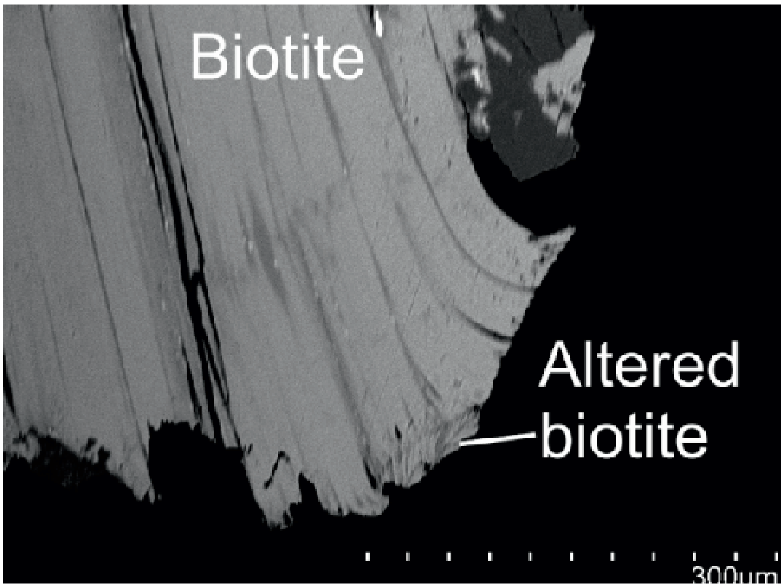
Back-scattered SEM-image of REE-carbonate (bright spot, EDS analyses indicate mixture with chlorite).



Back-scattered SEM-image of barite.



Back-scattered SEM-image of pyrite-filled micro-fracture in the wall rock. Main fracture is to the right.

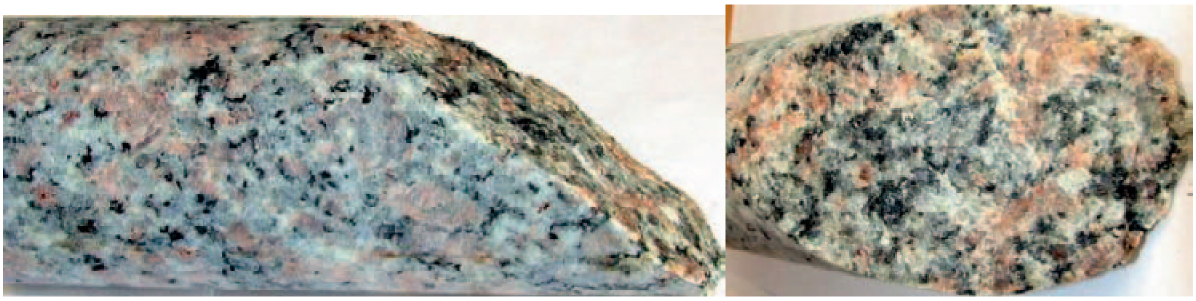


Back-scattered SEM-image of biotite alteration at the fracture edge.

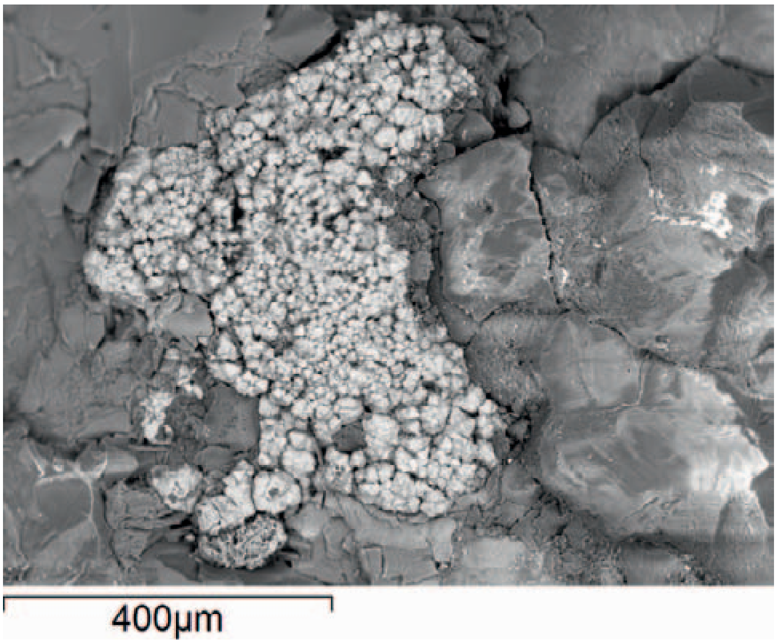
KLX06: 561.074 m

Fracture mineral: Pyrite

Wall rock: Magnetite is fresh in the whole sample. No wall rock alteration intensity towards the fracture. No typical red-staining alteration. Some indications of biotite alteration at the fracture rim. Micro-fractures close to the fracture, e.g. filled with adularia and REE-carbonate.



Photographs of drill core and fracture surface.



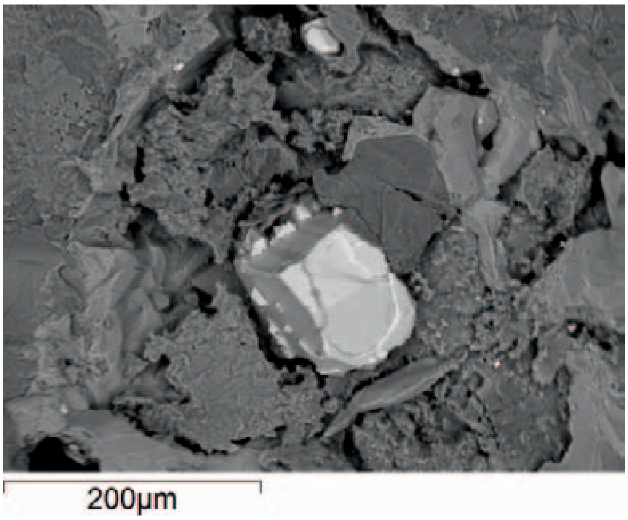
Back-scattered SEM-image of pyrite (bright crystals).

KLX07A: 341.026 m

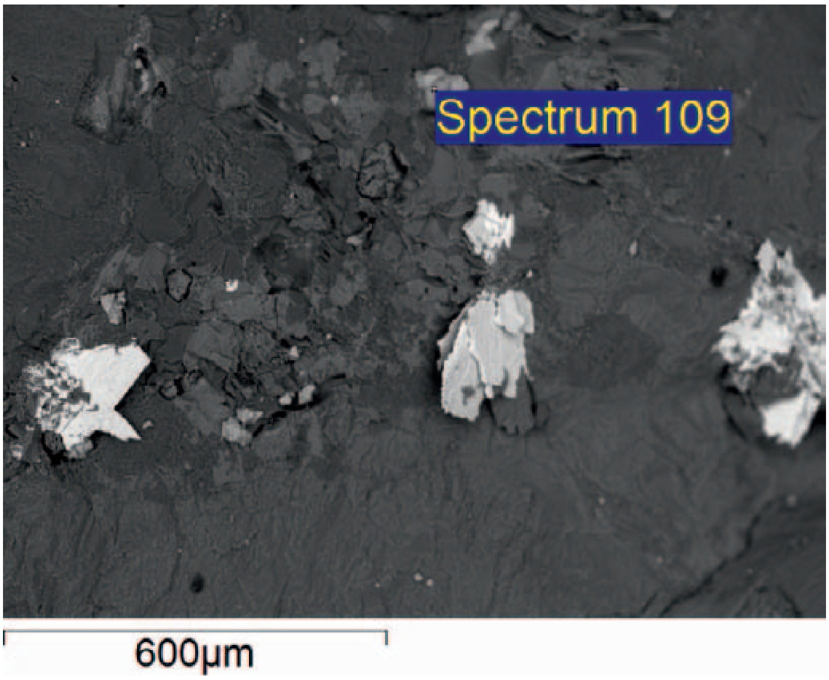
Fracture minerals: Pyrite, barite and illite

Wall rock: Magnetite and pyrite are fresh in the whole sample. No increase in wall rock alteration towards the fracture, and no typical red-staining alteration. Some indications of biotite alteration at the fracture rim. Parallel to the fracture is a calcite-filled fracture (other rim of thin section), also including albite and barite. Micro-fractures are present and are sub-parallel to the main fracture.

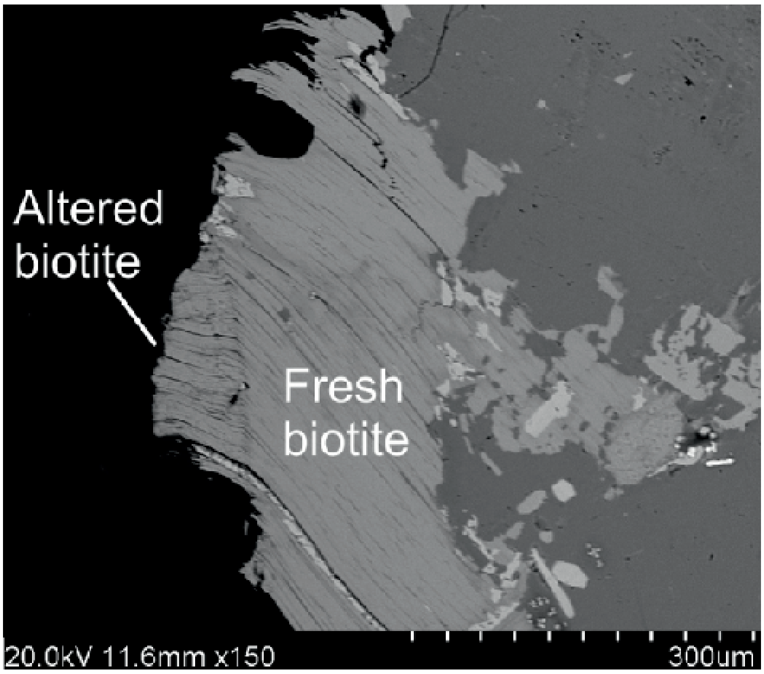
Photographs of drill core and fracture surface.



Back-scattered SEM-image of pyrite (bright crystal).



Back-scattered SEM-image of barite (Spectrum 106, brightest crystals) and pyrite (Spectrum 109, slightly darker crystals than barite).

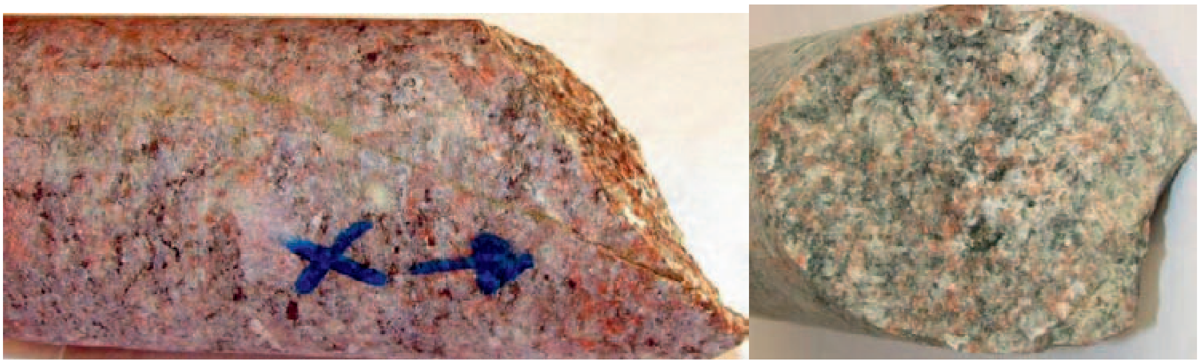


Back-scattered SEM-image of biotite alteration at the fracture edge.

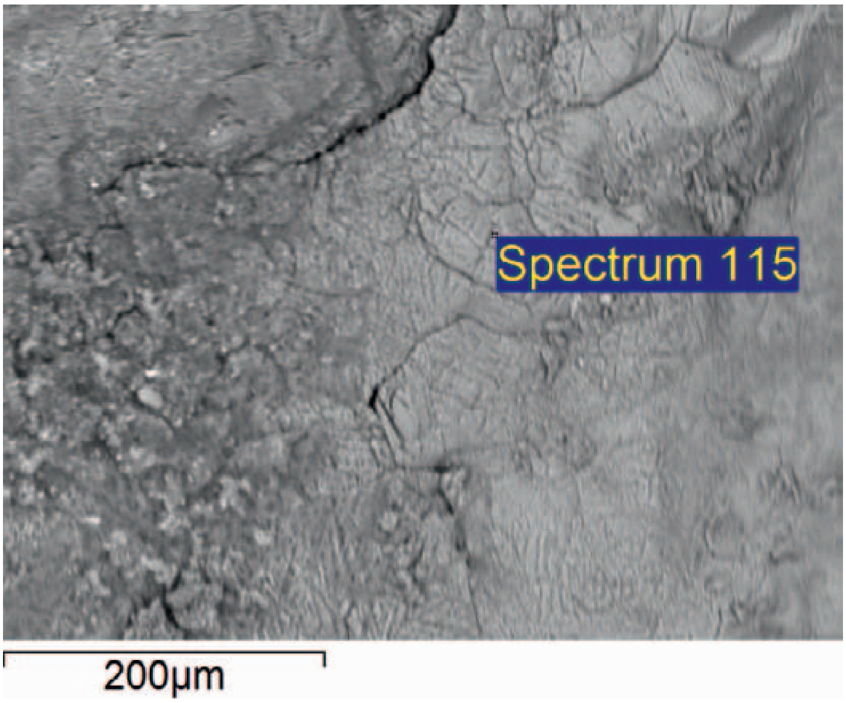
KLX07A: 396.319 m

Fracture minerals: Calcite and clay minerals.

Thin section: Magnetite and pyrite crystals are fresh in the whole sample. No increased wall rock alteration towards the fracture. This sample has typical red-staining alteration, e.g. red-staining of plagioclase crystals and chloritization of biotite (except for hematitization of magnetite). Parallel micro-fractures are observed close to the fracture.



Photographs of drill core and fracture surface.



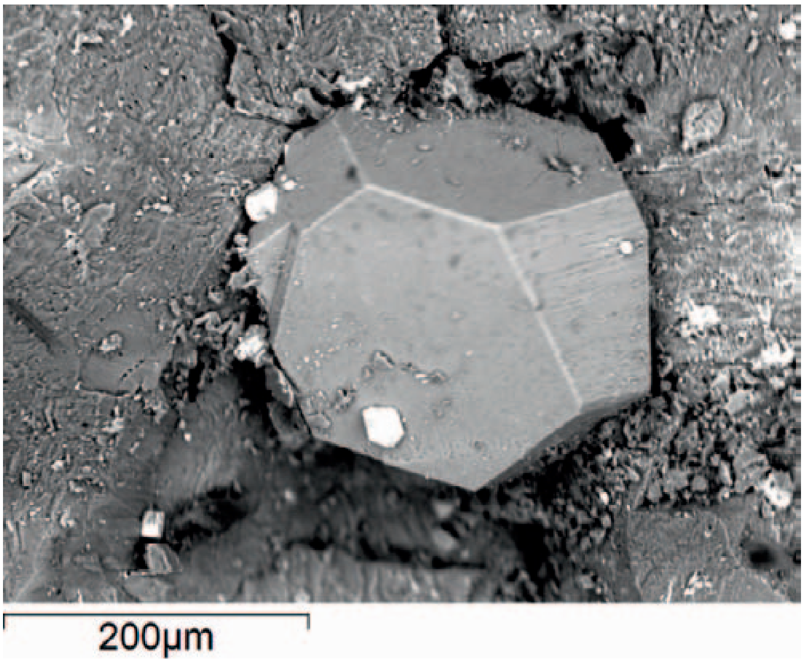
Back-scattered SEM-image of calcite.

KLX08: 303.912 m

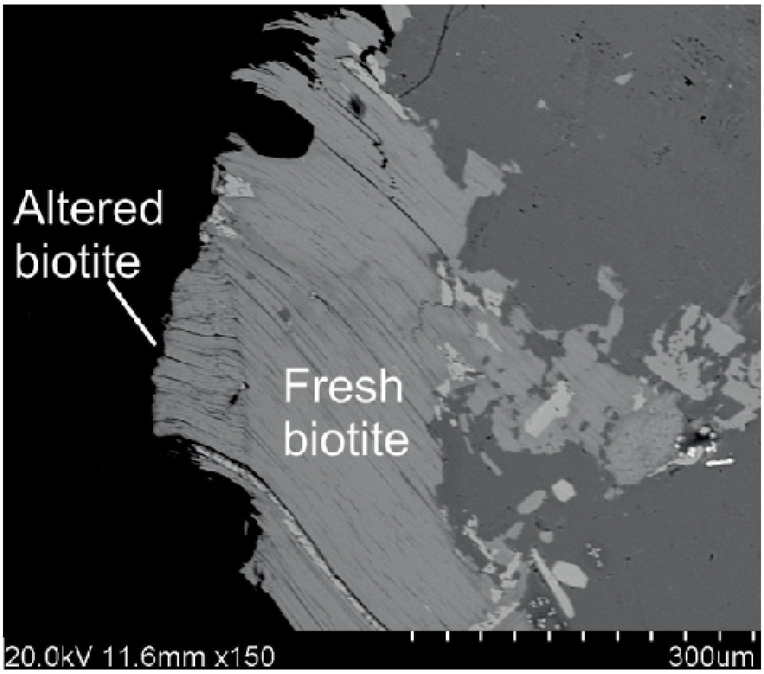
Fracture minerals: Harmotome, pyrite and REE-carbonate.

Wall rock: Magnetite is fresh in the whole sample. No increased wall rock alteration towards the fracture, but typical red-staining alteration is evident, e.g. plagioclase alteration and chloritization of biotite. An apophyse to the main fracture is filled with epidote and calcite and this indicates that the fracture has a hydrothermal precursor, with related hydrothermal alteration.

Photographs of drill core and fracture surface.



Back-scattered SEM-image of harmotome (big crystal). Small bright crystals are pyrite.

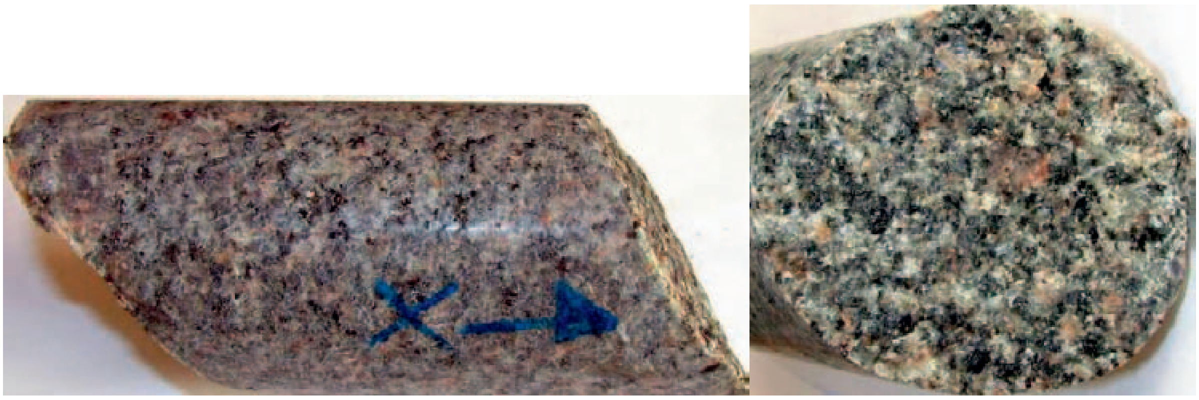


Back-scattered SEM-image of biotite alteration at the fracture edge.

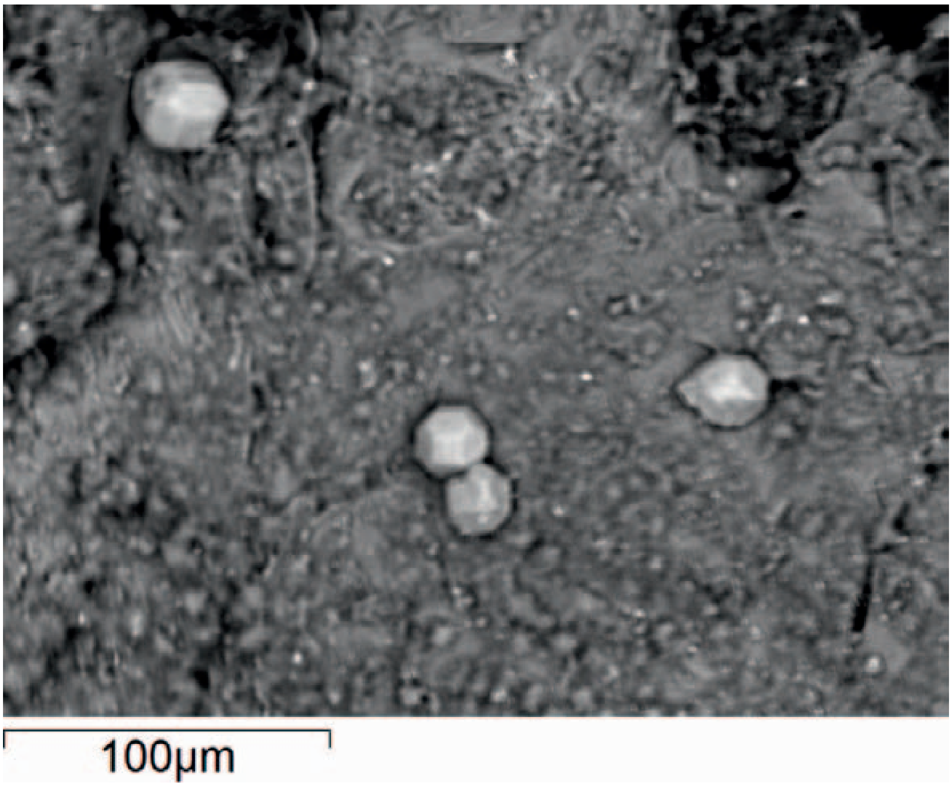
KLX08: 361.701 m

Fracture minerals: Pyrite and barite.

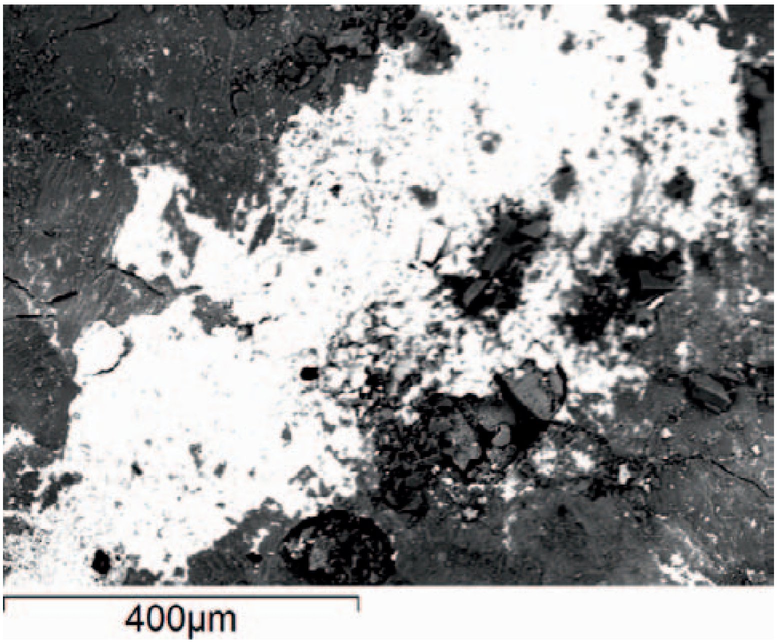
Wall rock: Magnetite is fresh in the whole sample. No increased wall rock alteration towards the fracture and no typical red-staining alteration. Some indications of biotite alteration at the fracture rim. Parallel micro-fractures exist and are filled with e.g. adularia.



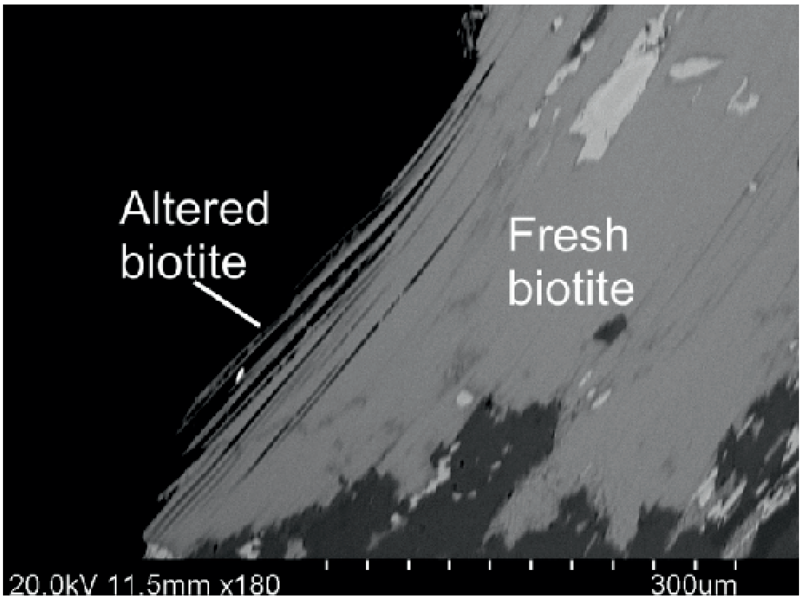
Photographs of drill core and fracture surface.



Back-scattered SEM-image of pyrite.



Back-scattered SEM-image of barite (bright mineral).

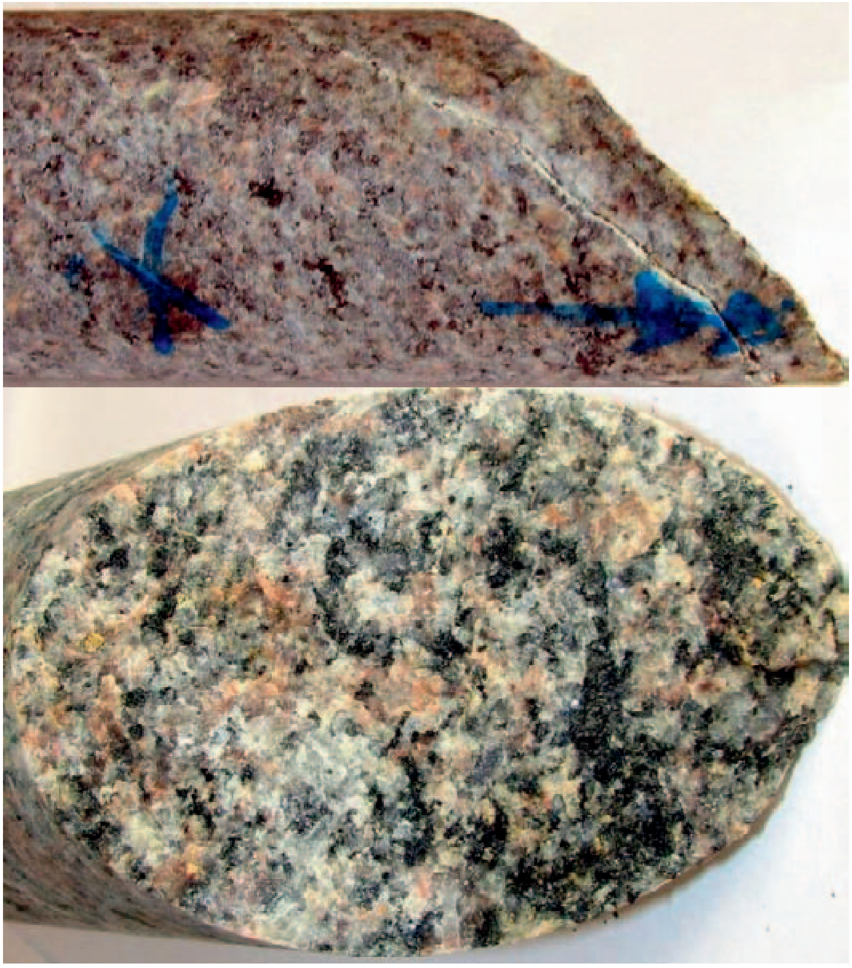


Back-scattered SEM-image of biotite alteration at the fracture edge.

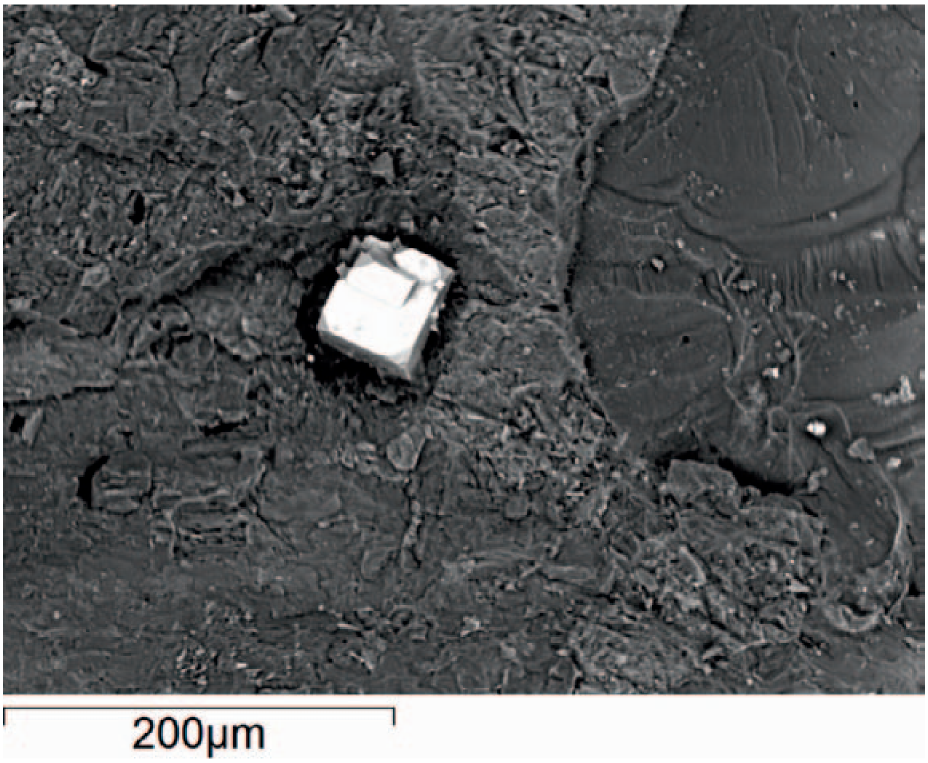
KLX08: 491.453 m

Fracture minerals: Pyrite and REE-carbonate.

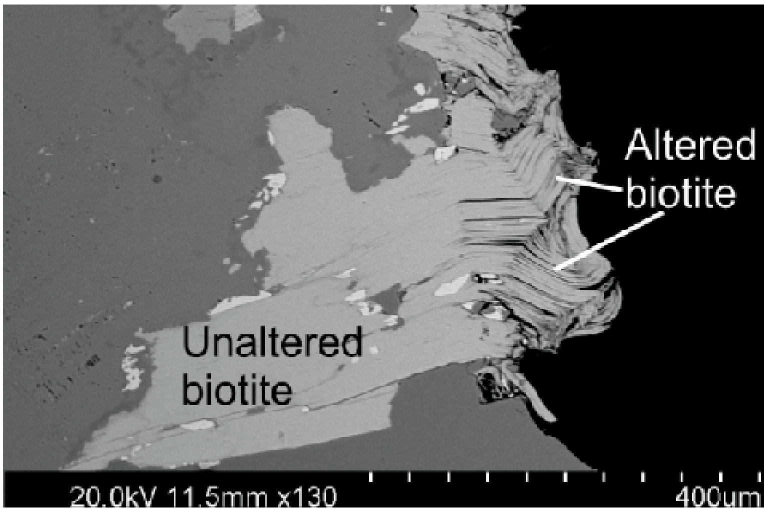
Wall rock: Magnetite is fresh in the whole sample. No wall rock alteration intensity towards the fracture. No typical red-staining alteration. Biotite alteration is observed at the fracture rim. Micro-fractures exist and are partly filled with e.g. pyrite. There is also a macroscopically visible sealed fracture sub-parallel to the open fracture. This fracture has a bleached rim.



Photographs of drill core and fracture surface.



Back-scattered SEM-image of pyrite.

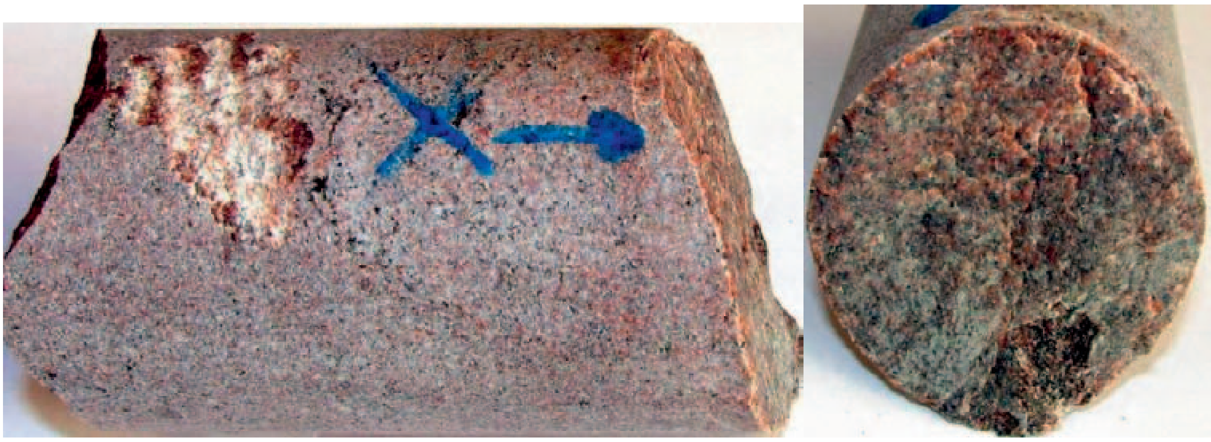


Back-scattered SEM-image of biotite alteration at the fracture edge.

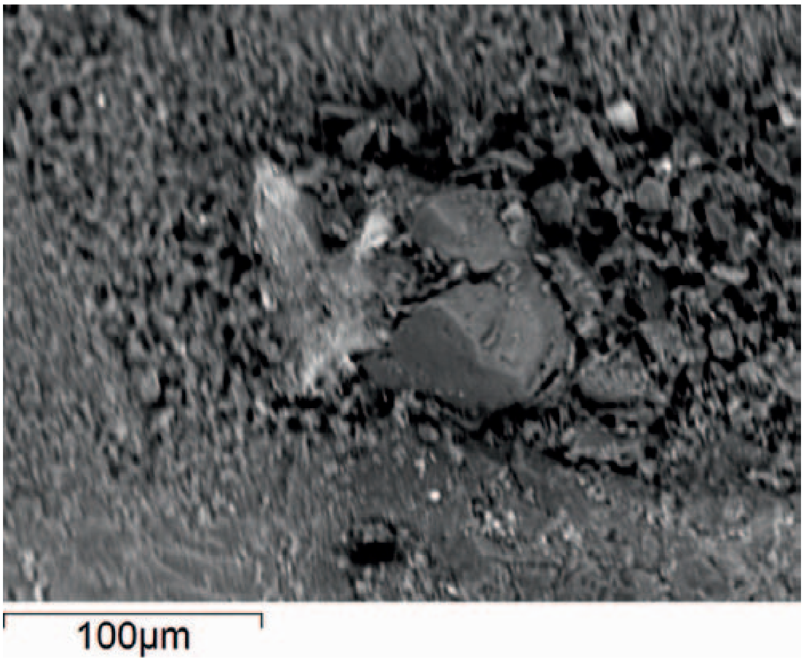
KLX10: 284.245 m

Fracture minerals: Calcite, REE-carbonate and galena.

Wall rock: Magnetite and pyrite are fresh in the whole sample. No increased wall rock alteration towards the fracture. Typical red-staining alteration exist (e.g. plagioclase alteration, chloritization of biotite). Micro-fractures running sub-parallel to the open fracture are partly filled with e.g. REE-carbonate.



Photographs of drill core and fracture surface.



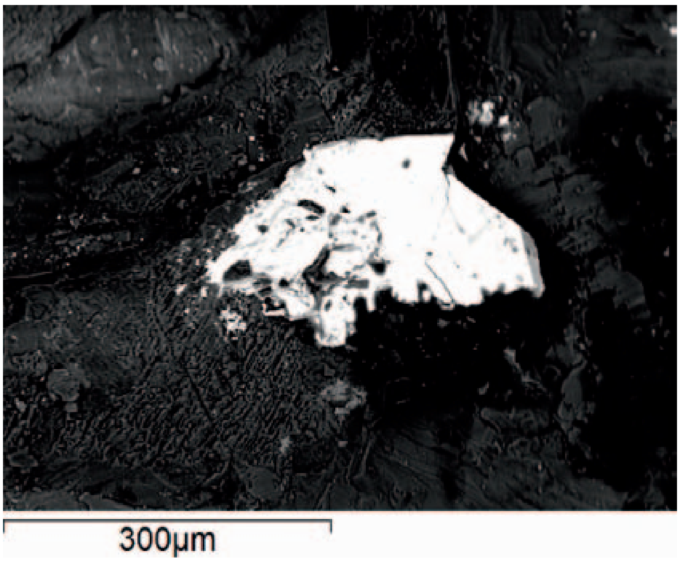
Back-scattered SEM-image of calcite (dark crystal)

KLX13A: 465.239 m

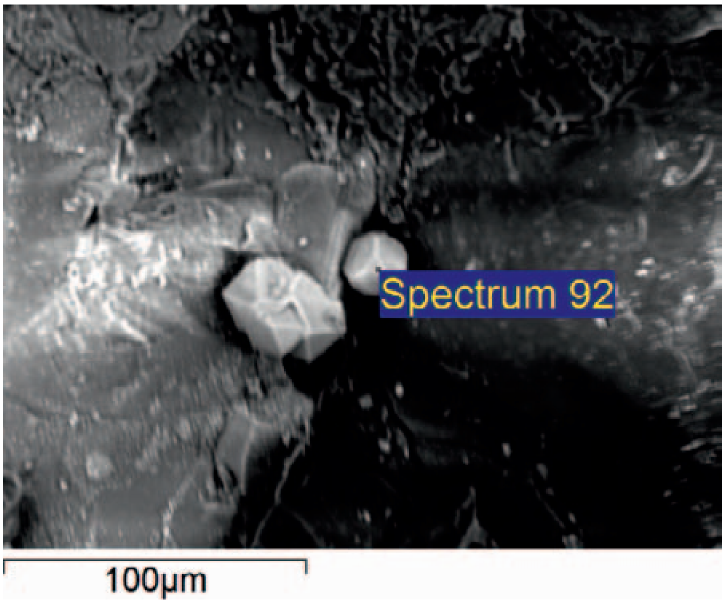
Fracture minerals: Pyrite and barite.

Wall rock: The wall rock is generally quite fresh and unaltered. No increased wall rock alteration is observed towards the fracture. No typical red-staining alteration. Biotite alteration is observed at the fracture rim. Non-mineralised micro-fractures run parallel with the main fracture.

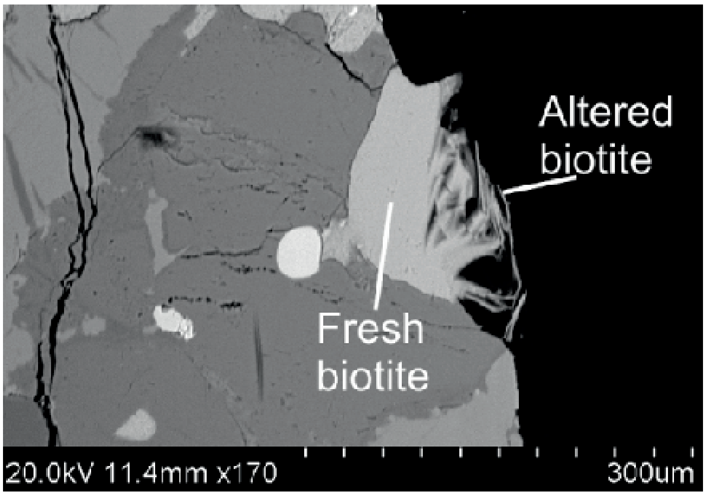
Photographs of drill core and fracture surface.



Back-scattered SEM-image of barite (bright crystal).



Back-scattered SEM-image of pyrite.



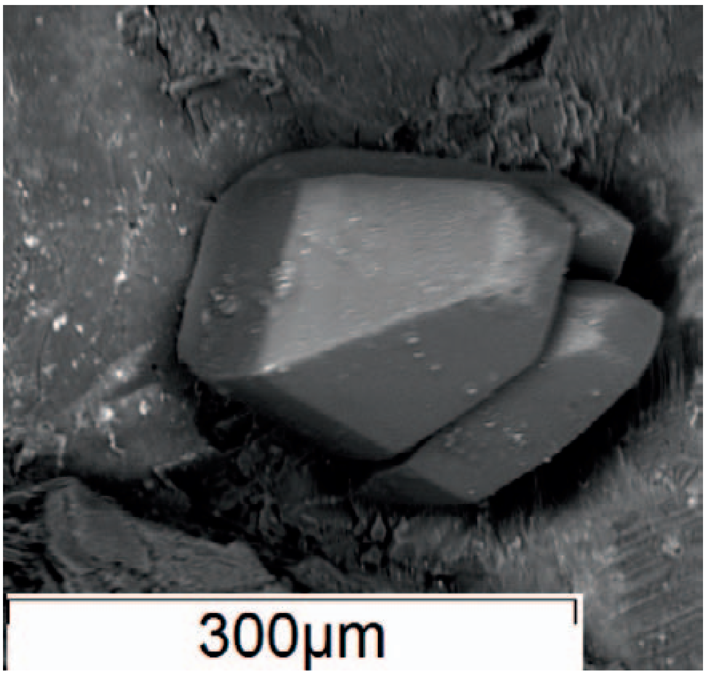
Back-scattered SEM-image of biotite alteration at the fracture edge.

KLX13A: 470.658 m

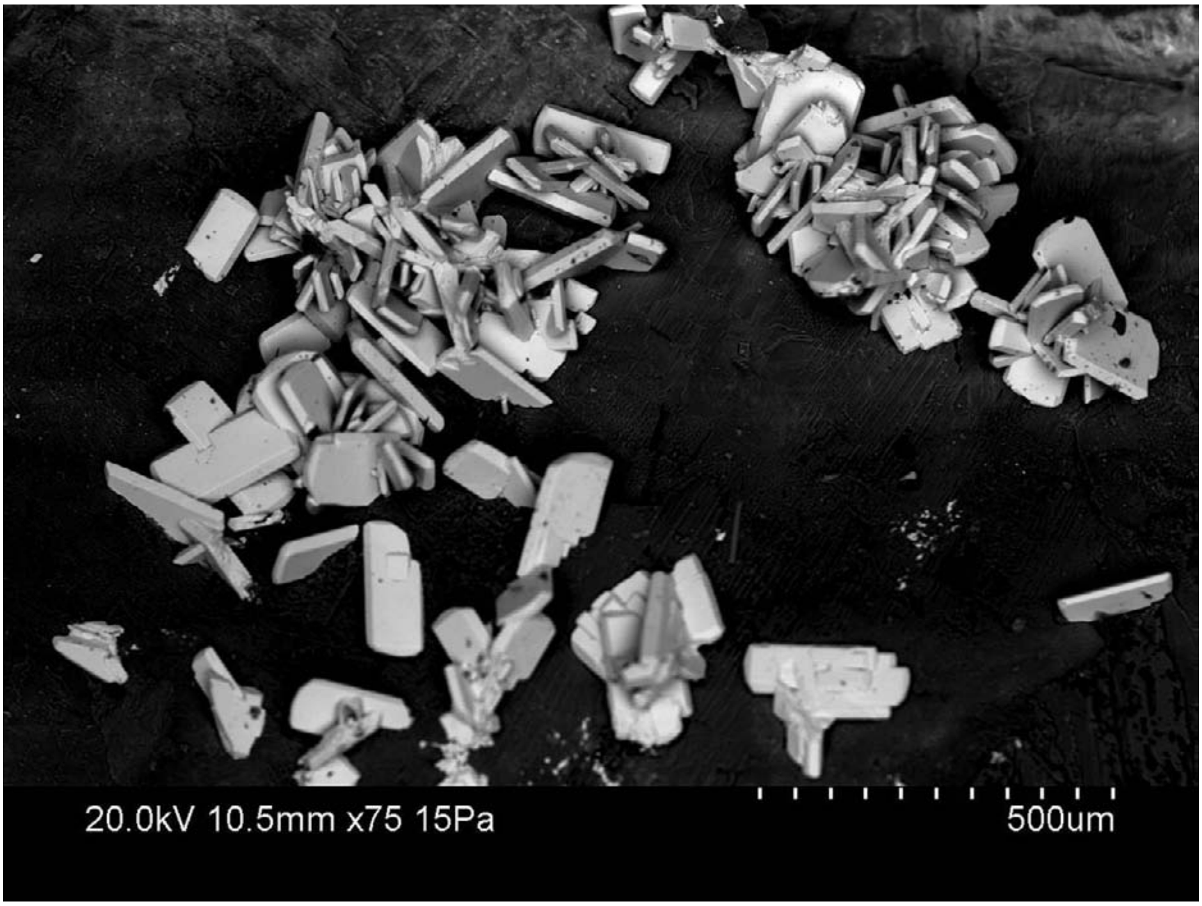
Fracture minerals: Barite, calcite and adularia.

Thin section: The wall rock is generally quite fresh and unaltered. No increase in wall rock alteration towards the fracture. No typical red-staining alteration. Some indications of biotite alteration at the fracture rim. K-feldspar shows indications of alteration at the fracture rim and secondary K-feldspar (adularia) is formed. Very few micro-fractures.

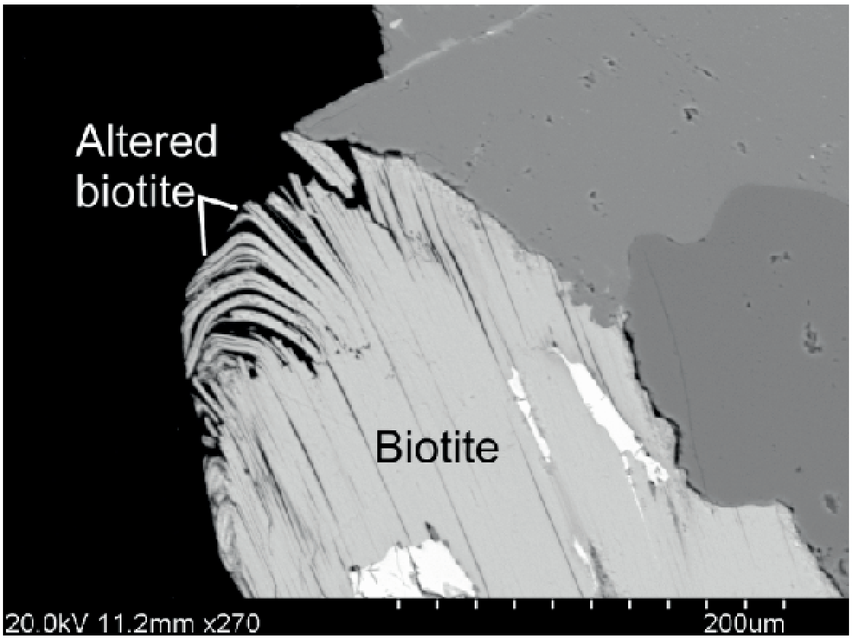
Photographs of drill core and fracture surface.



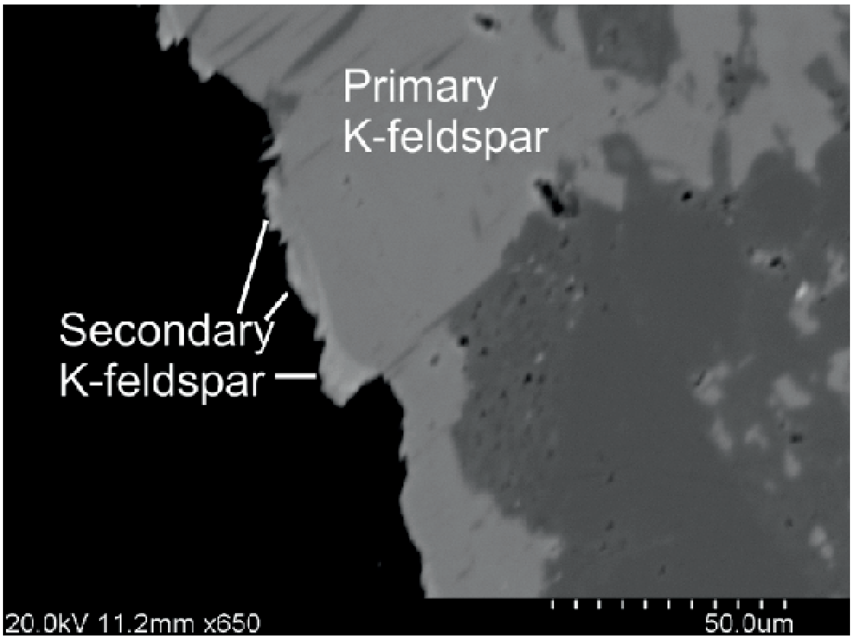
Back-scattered SEM-image of REE-carbonate.



Back-scattered SEM-image of barite (bright crystals).



Back-scattered SEM-image of biotite alteration at the fracture edge.



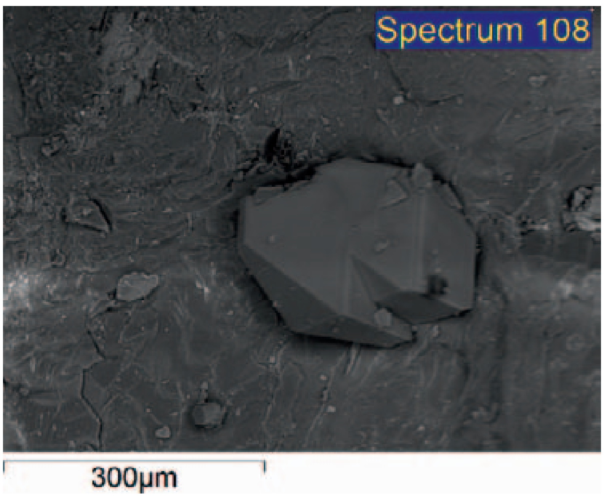
Back-scattered SEM-image of overgrowths of secondary K-feldspar (adularia) on primary K-feldspar at the fracture edge.

KLX18A: 309.503 m

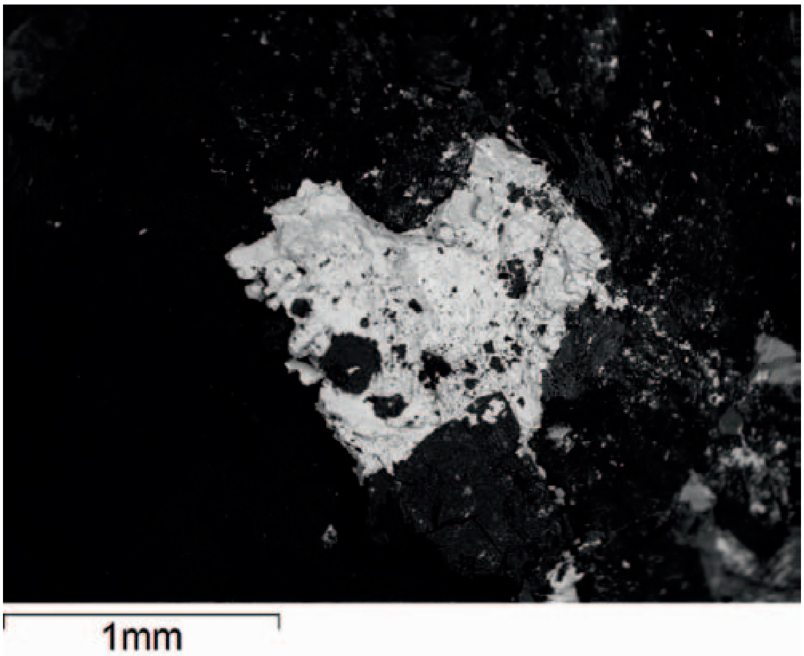
Fracture minerals: Barite and calcite, prehnite and quartz.

Wall rock: The wall rock is generally quite fresh and unaltered (e.g. fresh magnetite, pyrite and chalcopyrite). No increase in wall rock alteration towards the fracture. No typical red-staining alteration. Some indications of biotite alteration at the fracture rim. Sub-parallel micro-fractures exist close to the fracture and are filled with e.g. quartz. Prehnite, calcite and quartz exist in an apophyse to the main fracture, and prehnite also borders to the main fracture. This indicates that the fracture is an old hydrothermal fracture (but without intense wall rock alteration) that has been re-activated during the Paleozoic when barite was formed.

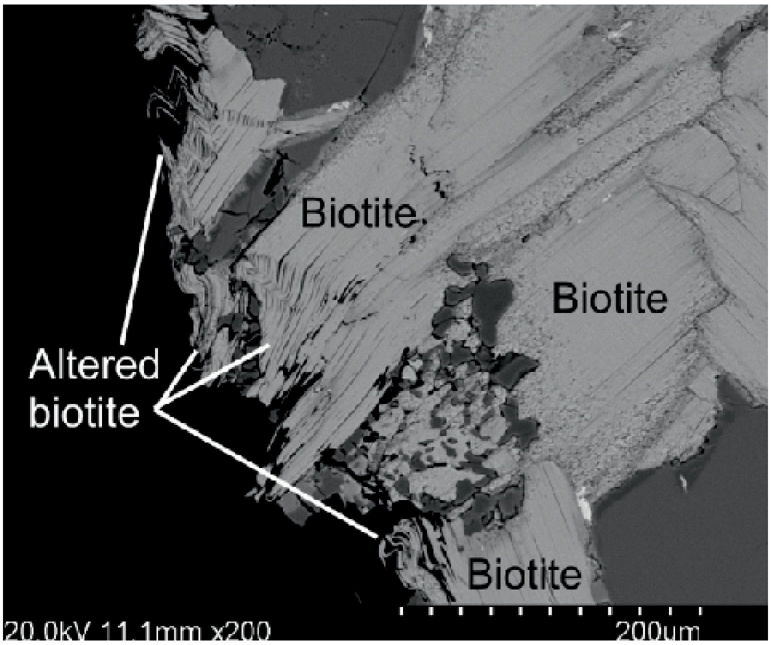
Photographs of drill core and fracture surface.



Back-scattered SEM-image of calcite.



Back-scattered SEM-image of barite (bright mineral).

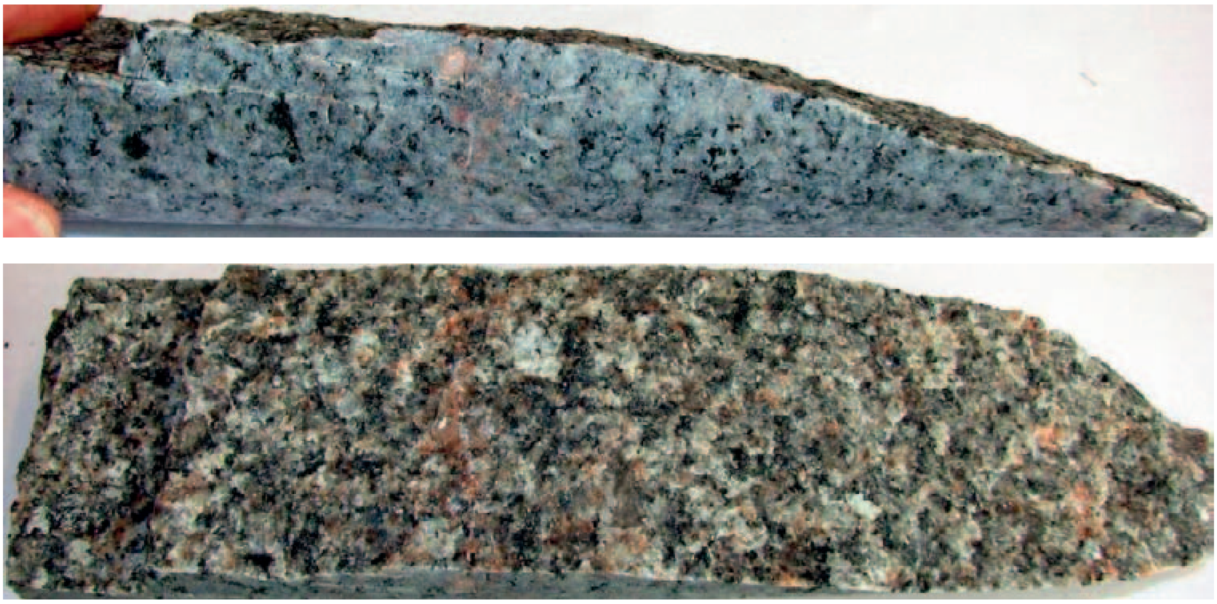


Back-scattered SEM-image of biotite alteration at the fracture edge.

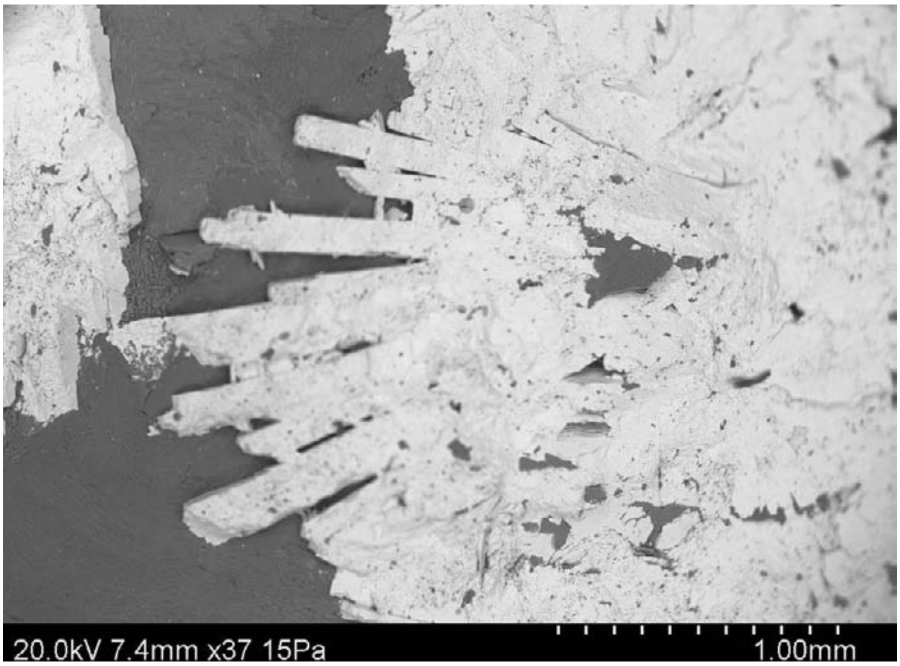
KLX18A: 382.470 m

Fracture minerals: Barite and adularia.

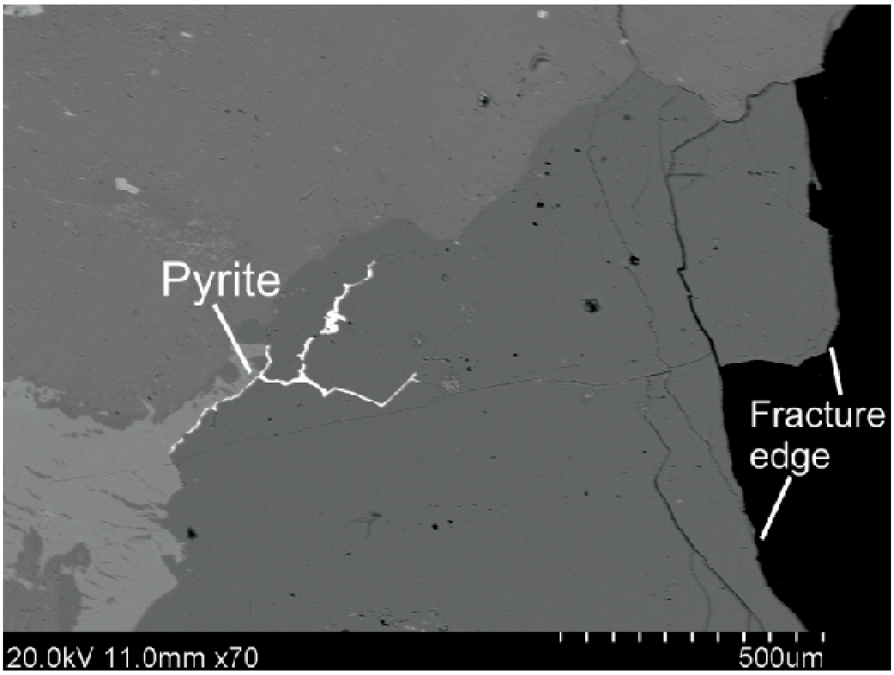
Wall rock: The wall rock is generally quite fresh although alteration of plagioclase is evident. Wall rock minerals biotite and magnetite are generally fresh and unaltered. No increase in wall rock alteration towards the fracture is observed. No typical red-staining alteration exists. Some indications of biotite alteration at the fracture rim. Micro-fractures exist parallel to the main fracture, but also perpendicular to the fracture. These are partly filled, e.g. with pyrite and adularia. Secondary adularia has grown on primary K-feldspar at the fracture edge.



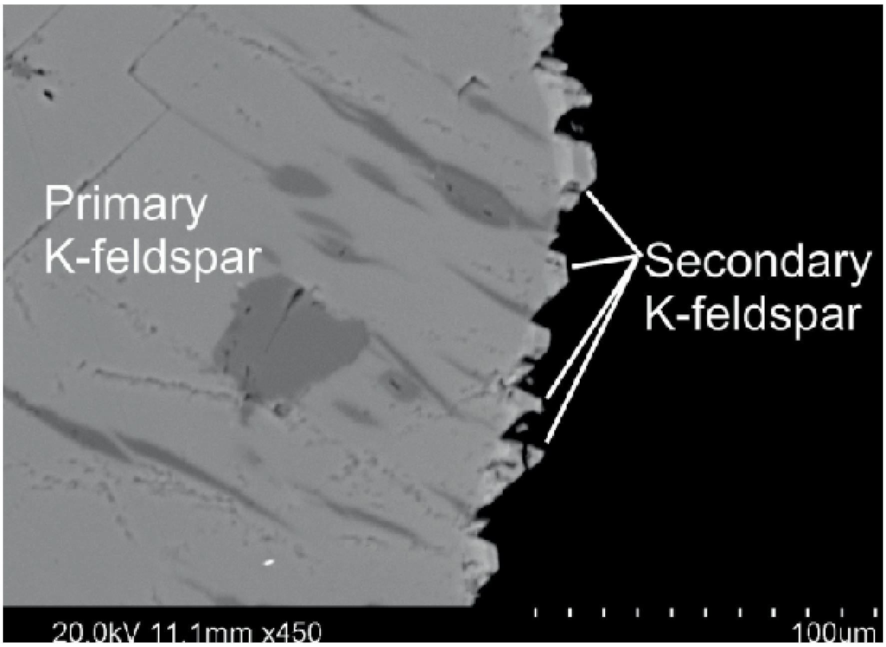
Photographs of drill core and fracture surface.



Back-scattered SEM-image of REE-carbonate (bright mineral).



Back-scattered SEM-image of pyrite in micro-fractures close to the main fracture.



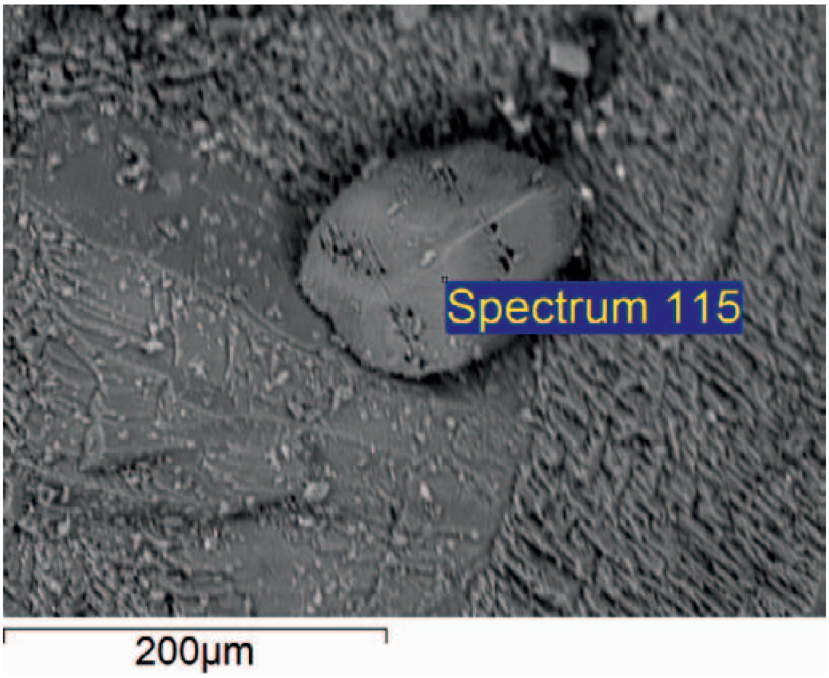
Back-scattered SEM-image of overgrowths of secondary K-feldspar (adularia) on primary K-feldspar at the fracture edge.

KLX18A: 421.006 m

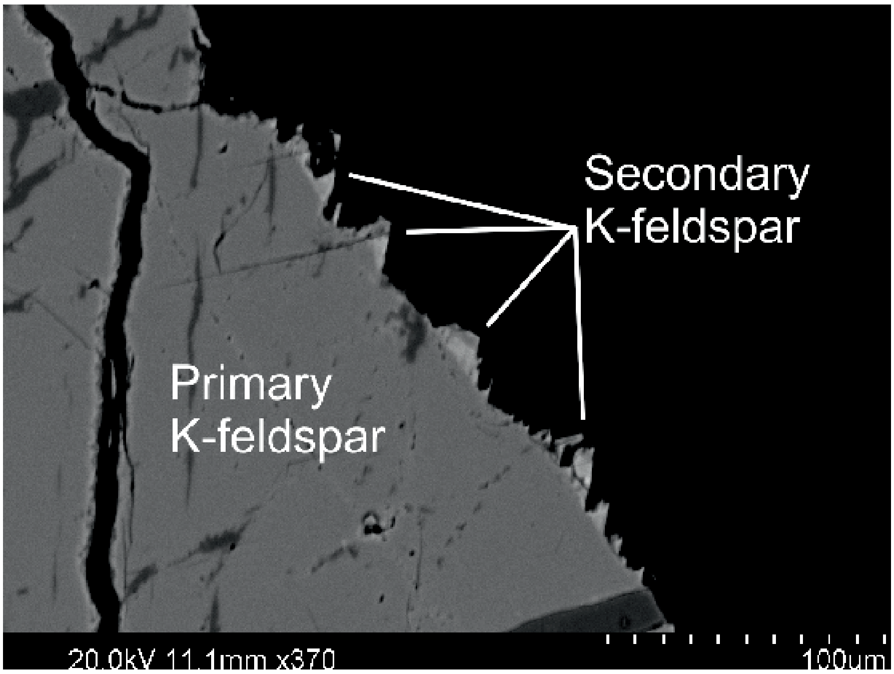
Fracture minerals: Calcite and adularia.

Wall rock: The wall rock is generally quite fresh and unaltered. No increase in wall rock alteration towards the fracture is observed. No typical red-staining alteration exists. Some indications exist of biotite alteration at the fracture rim. Micro-fractures parallel to the main fracture are filled with adularia and epidote. Euhedral adularia has grown as a secondary mineral from primary K-feldspar at the fracture edge.

Photographs of drill core and fracture surface.



Back-scattered SEM-image of calcite.



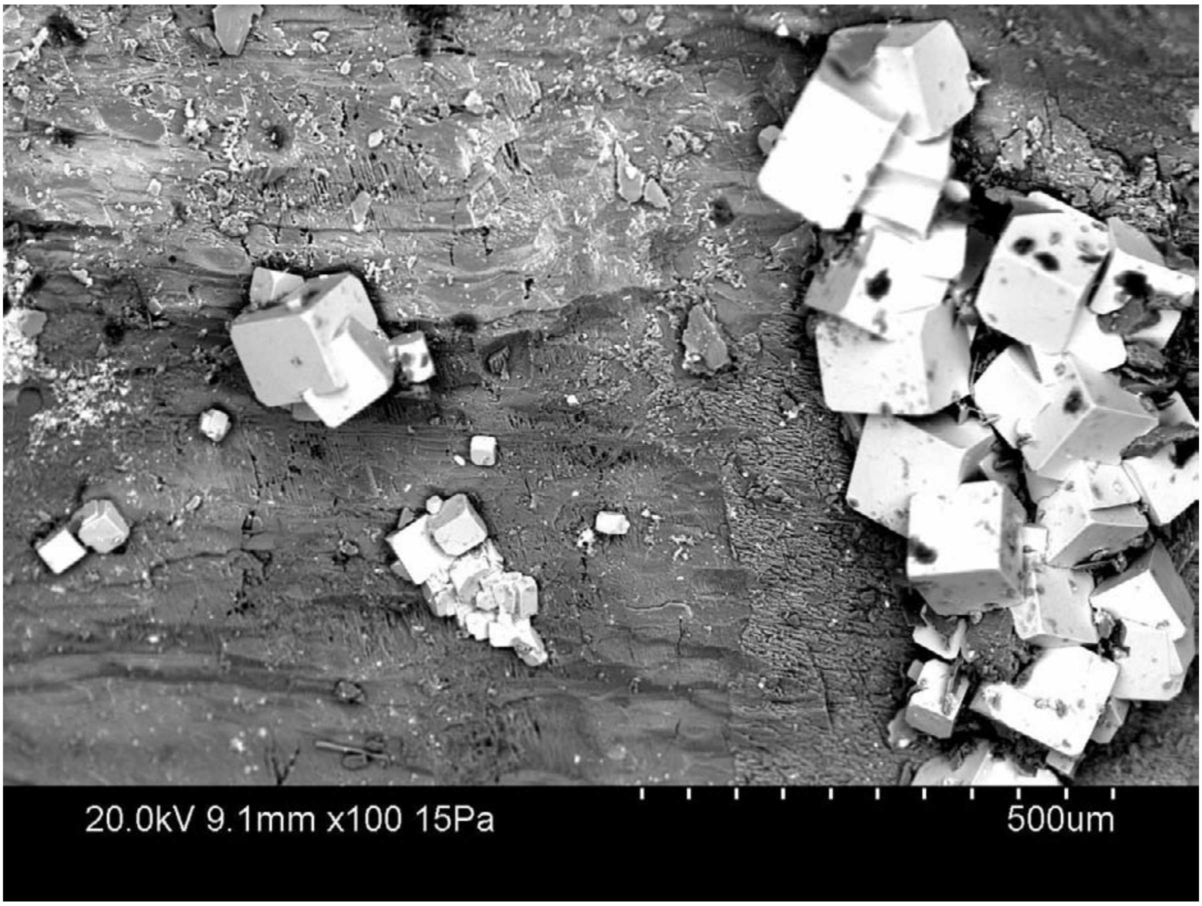
Back-scattered SEM-image of overgrowths of secondary K-feldspar (adularia) on primary K-feldspar at the fracture edge.

KLX18A: 468.079 m

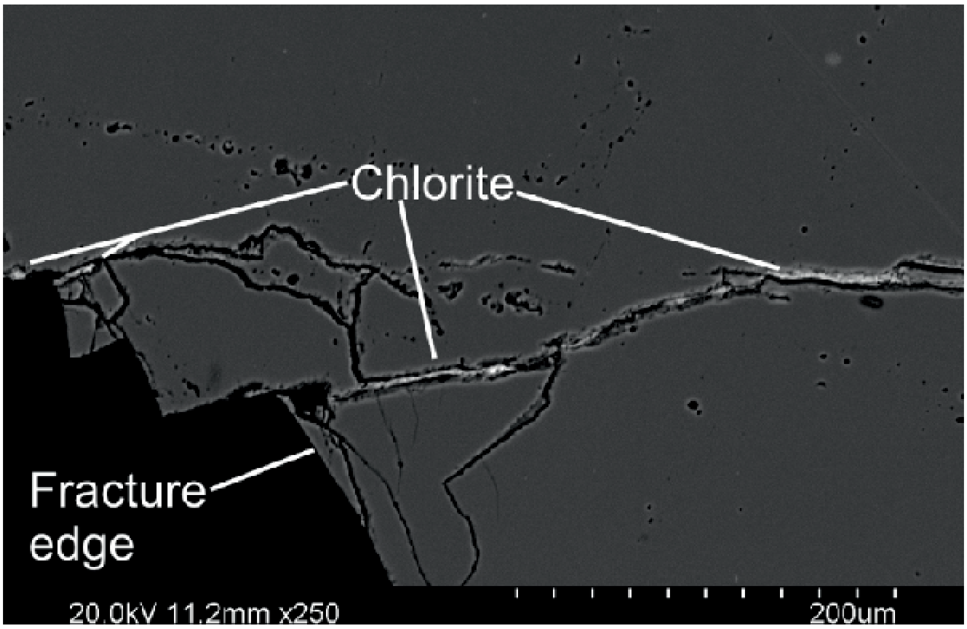
Fracture mineral: Pyrite and chlorite.

Wall rock: The wall rock is generally quite fresh and unaltered. No increase in wall rock alteration is observed towards the fracture and no typical red-staining alteration is observed. There are no significant indications of biotite alteration at the fracture rim. Micro-fractures parallel to the main fracture are partly filled with e.g. chlorite.

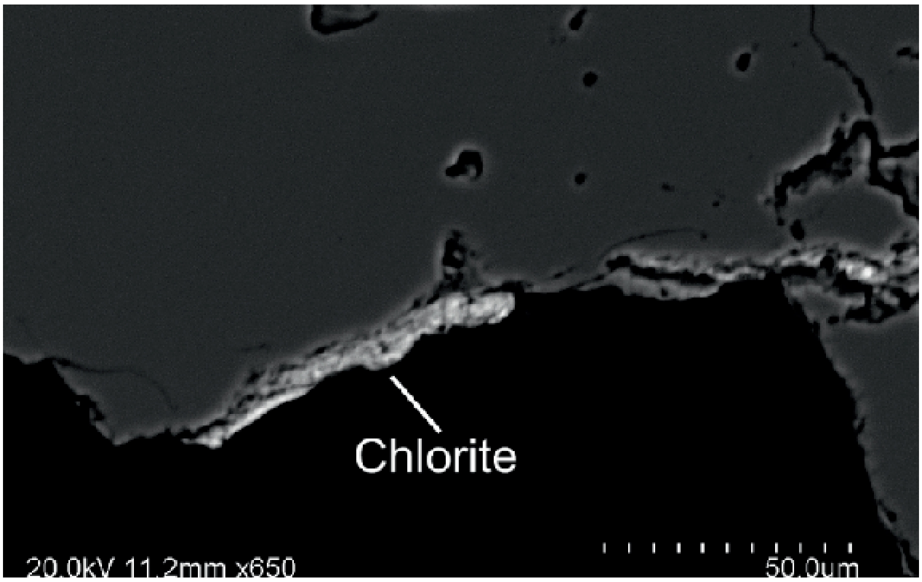
Photographs of drill core and fracture surface.



Back-scattered SEM-image of pyrite (bright, cubic crystals).



Back-scattered SEM-image of chlorite in the main fracture and in micro-fractures close to the main fracture.



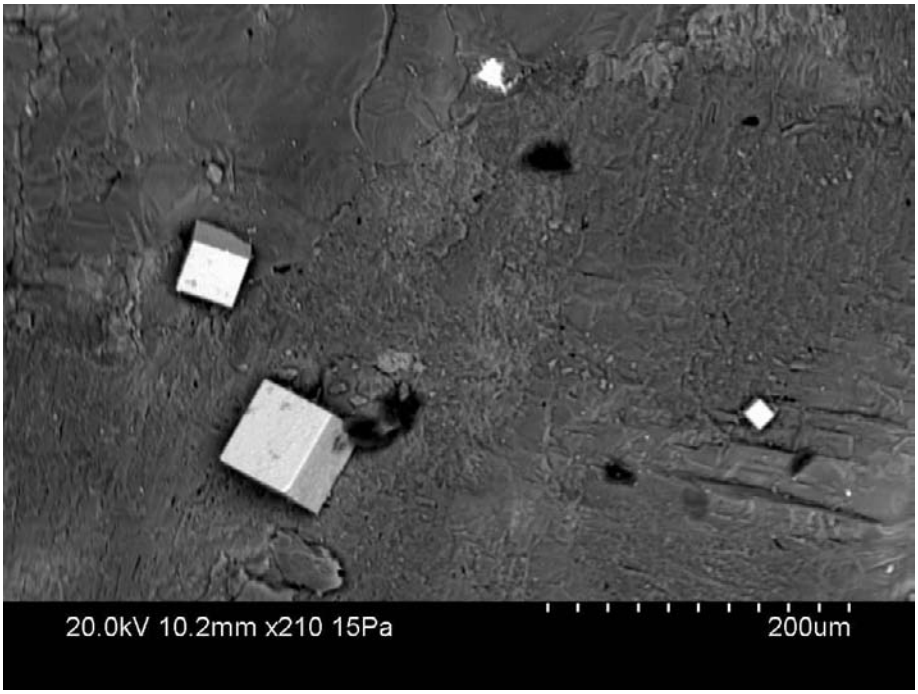
Back-scattered SEM-image of chlorite coating the fracture wall of the main fracture.

KLX18A: 554.815 m

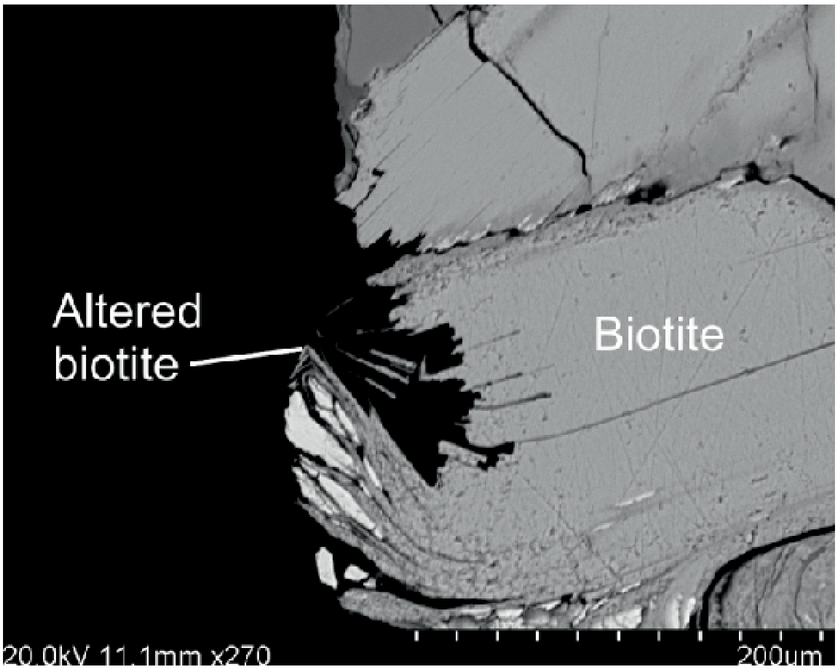
Fracture minerals: Pyrite, chalcopyrite and REE-carbonate.

Wall rock: The wall rock is generally quite fresh and unaltered. Magnetite is preserved and one fresh pyrite crystal is observed at the fracture surface. There is no increase in wall rock alteration towards the fracture and no typical red-staining alteration is observed. Biotite alteration is observed close to the fracture. There are four sets of parallel micro-fractures at different distance to the fractures (but very close to the fracture). These fractures are partly filled with e.g. pyrite.

Photographs of drill core and fracture surface.



Back-scattered SEM-image of pyrite (bright, cubic crystals).

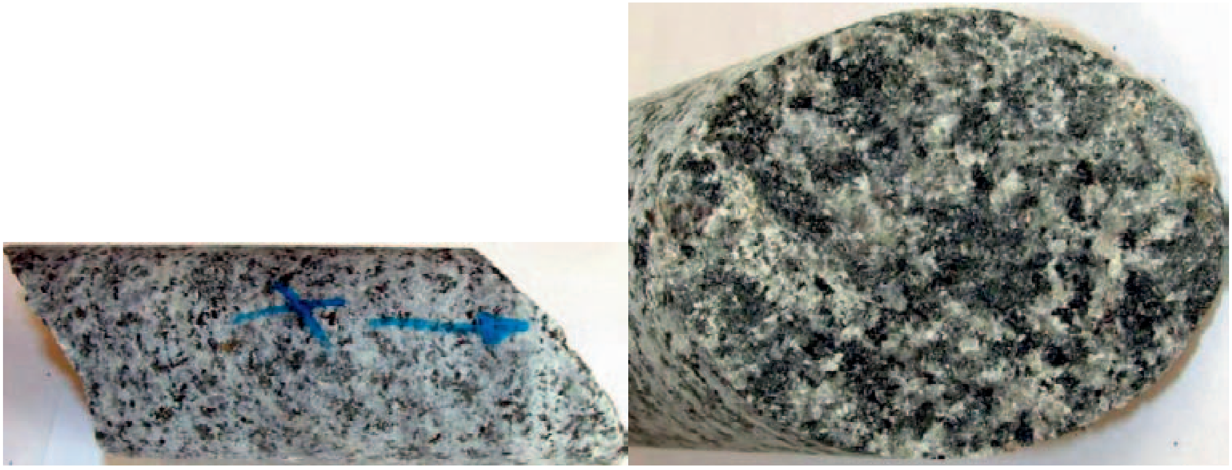


Back-scattered SEM-image of biotite alteration at the fracture edge.

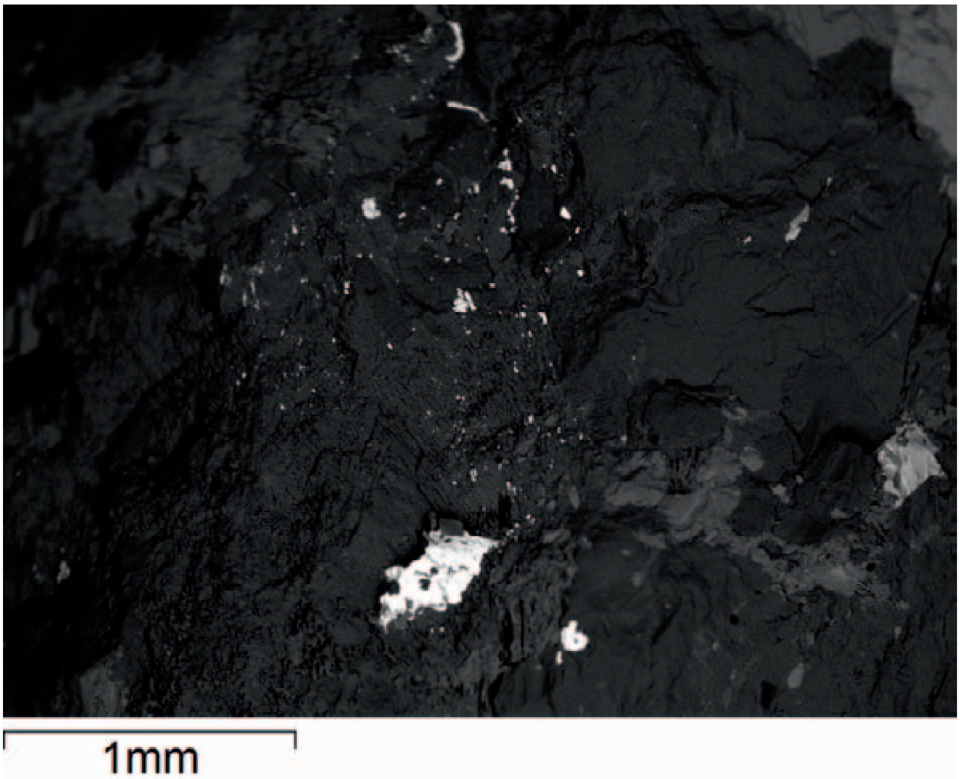
KLX19A: 684.759 m

Fracture minerals: Barite, pyrite, adularia and albite.

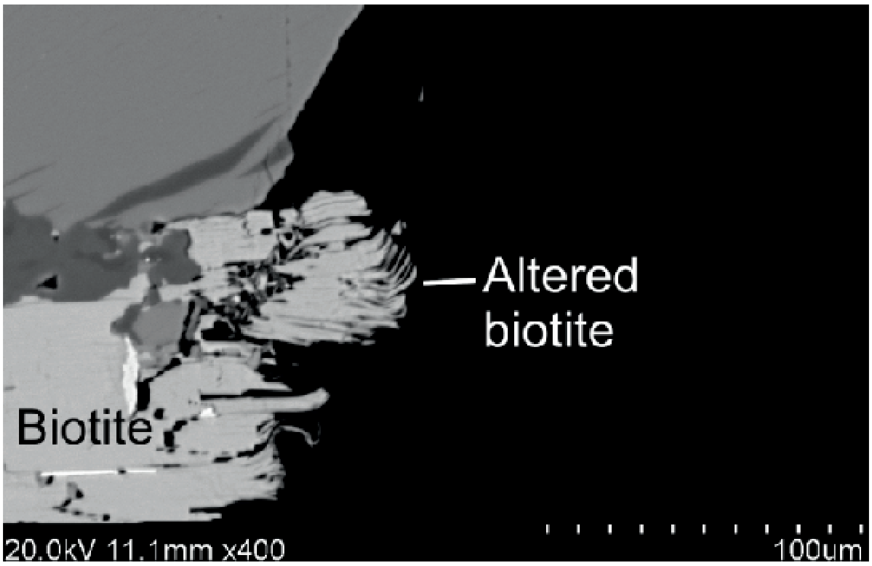
Wall rock: The wall rock is generally quite fresh and unaltered. There is no increase in wall rock alteration towards the fracture and no typical red-staining alteration is observed. Biotite alteration at the fracture edge is indicated.



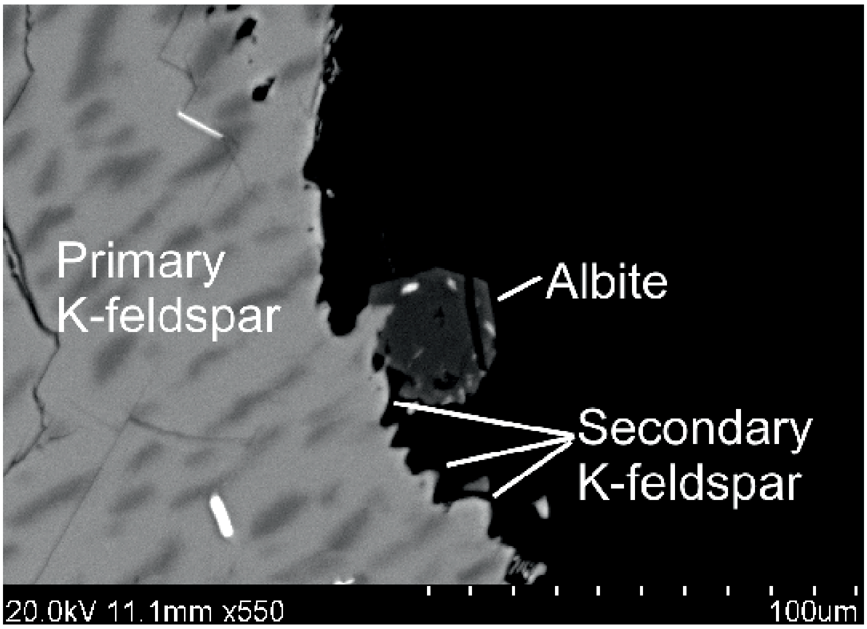
Photographs of drill core and fracture surface.



Back-scattered SEM-image of barite (bright crystals).



Back-scattered SEM-image of biotite alteration at the fracture edge.

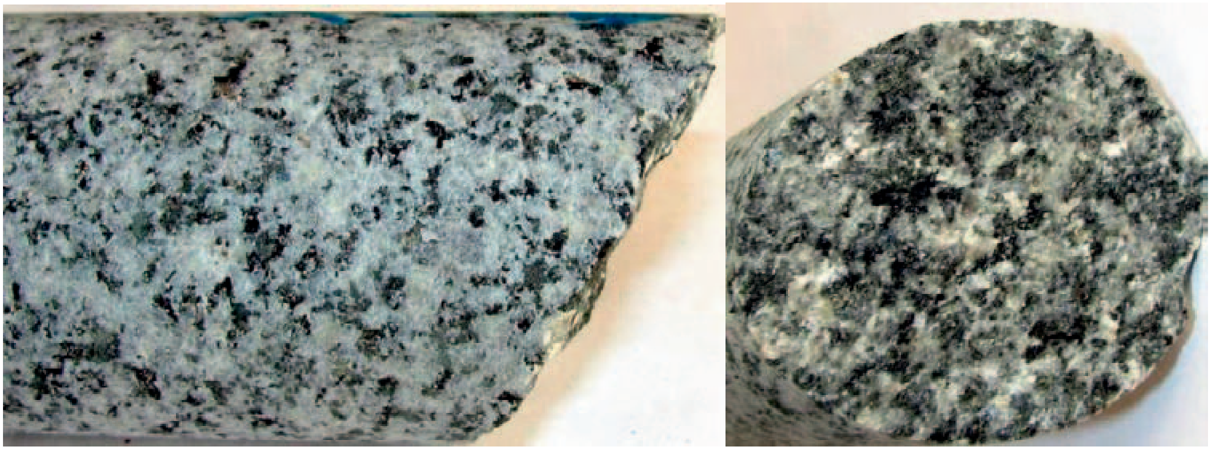


Back-scattered SEM-image of overgrowths of secondary K-feldspar (adularia) and albite on primary K-feldspar at the fracture edge.

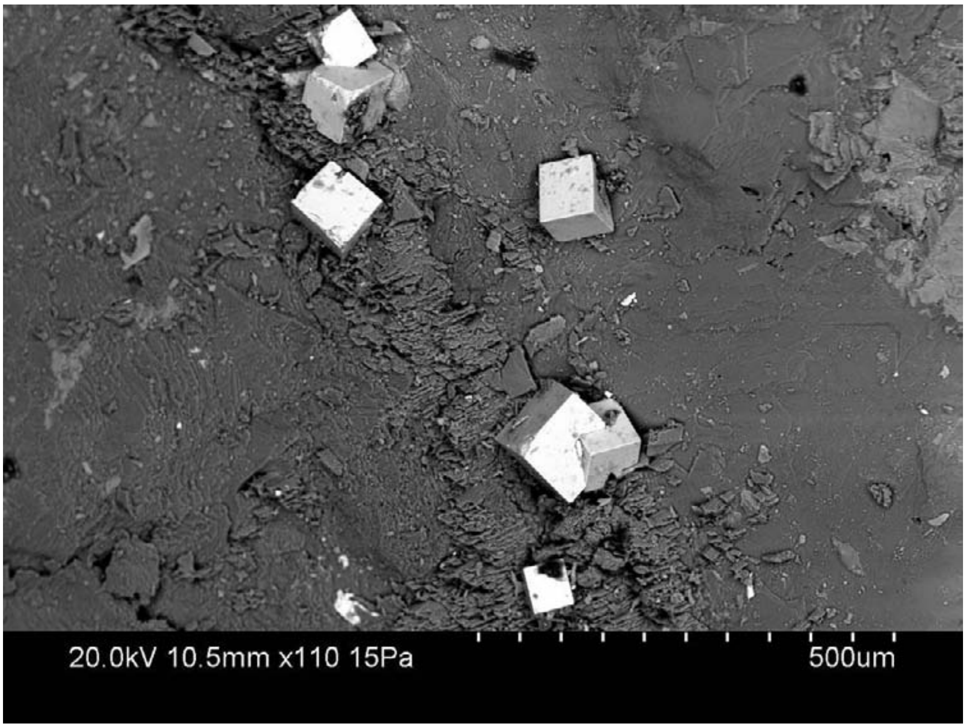
KLX19A: 733.604 m

Fracture minerals: Pyrite and Na-zeolite.

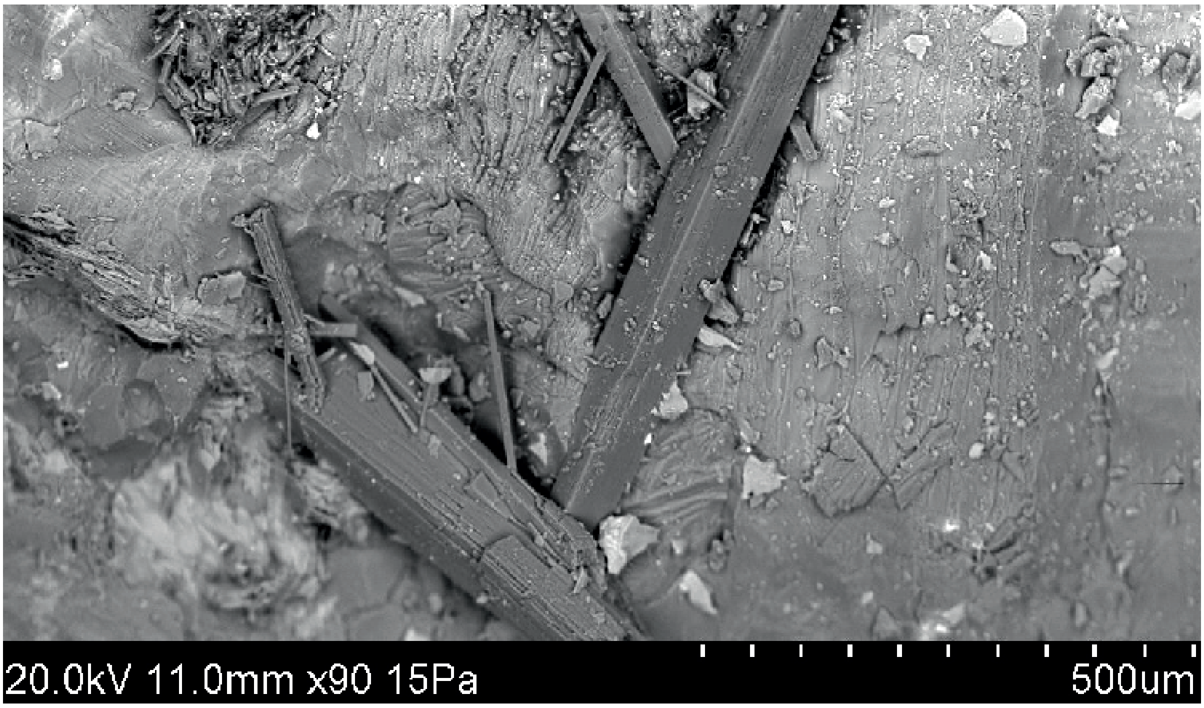
Wall rock: The wall rock is generally quite fresh and unaltered. Magnetite and pyrite is fresh, biotite is generally fresh, but plagioclase is partly altered. There is no increase in wall rock alteration towards the fracture. Some very clear indications of biotite alteration at the fracture rim exist. Empty micro-fractures run parallel with the main fracture.



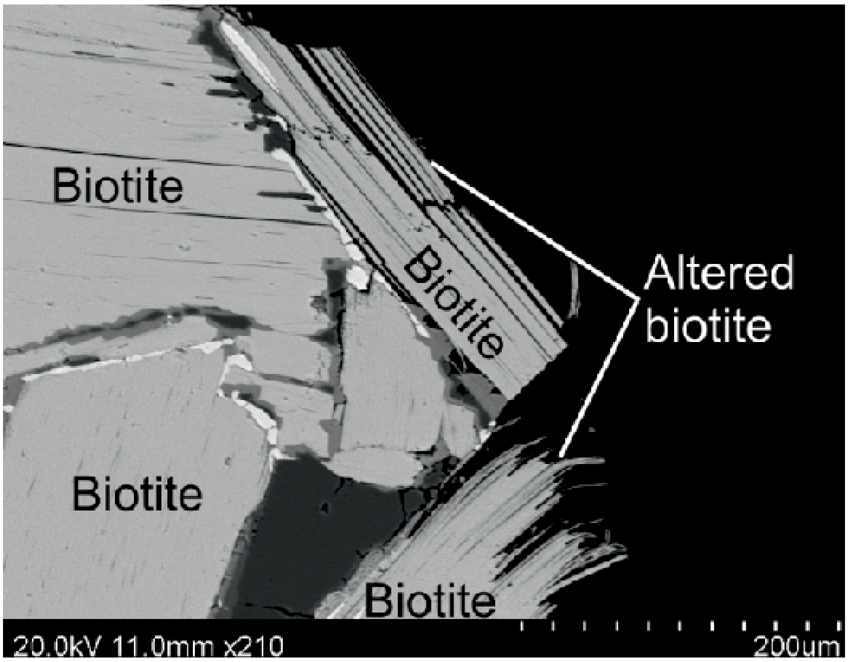
Photographs of drill core and fracture surface.



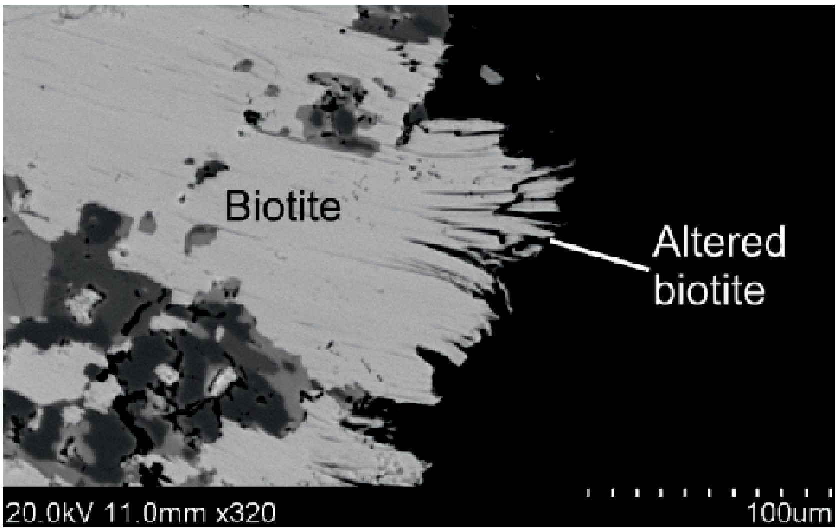
Back-scattered SEM-image of pyrite (bright, cubic crystals).



Back-scattered SEM-image of Na-zeolite (euhedral crystals).



Back-scattered SEM-image of biotite alteration at the fracture edge.



Back-scattered SEM-image of biotite alteration at the fracture edge.

Description of table: p_fract_core_eshi columns

--- Short Description: ---

Single fractures with rock type, domains, deformation zones, ESHI.

--- Long Description: ---

The data shown in this parameter table comes from the Boremap table bm3_mapping_data. Information from Extended Single Hole Interpretation (ESHI) is included showing to which rock_unit or deformation_zone a fracture belong. This information is fetched from the tables bh_reinterpret_ru and bh_reinterpret_dz. Additionally, the deterministically interpreted domains (e.g. fracture-, rock-domains and deformation zones from the table model_domain_dz) are included.

Fractures are mapped as Broken or Unbroken depending how they occur in the core box. An interpretation based on BIPS/Televiewer image and fracture observation from the core is made to classify if the fracture was Open or Sealed in the bedrock. The Confidence tells how accurate this interpretation is.

Numeric codes has been transformed to text.

Best_rock is the Rock Type or Rock Occurence, if any, at the fracture location. The Rock Type is mapped as a continuous variable and thus always present, but if there also is a Rock Occurence it is taken instead. In case of multiple Rock Occurences the one with the closest secup is chosen.

Uncertainty of the alpha angle is dependent on the size of the angle itself and is calculated and included.

Uncertainty of beta angle due to beta angle mesurement and BIPS tool rotation in the borehole may be determined by investigating the logging tape registrations and is also included.

Some vital columns deserve longer explanations than can be provided in the column descriptions (restricted to 60 signs).

Column	Description
strike	Fracture strike measured clockwise from north using the right hand rule (0-360º)
alpha	Alpha angle, angle between the core axis and the fracture plane, (0-90 degrees, 90 = perpendicular to axis)
beta	Beta angle. Fracture orientation measured from a reference line (0-360º)

--- Columns: ---

Column Name	Unit	Domain Name	Short Description
site		site	Investigation site name
idcode		idcode	Object or borehole identification code
adjustedsecup			
recorded_secup	m	m_3	Adjusted borehole length
fract_mapped	m	m_3	Recorded borehole length (not adjusted)
fract_interpret		text_10	Fractures mapped as Broken or Unbroken
aperture		text_20	Fracture interpretation as Open, Sealed or Partly Open
visible_in_bips	mm	mm	Fracture aperture
min1	code	mineral_type_code	Dominating fracture mineral code
min2	code	mineral_type_code	Second dominating fracture mineral code
min3	code	mineral_type_code	Third dominating fracture mineral code
min4	code	mineral_type_code	Fourth dominating fracture mineral code
roughness	code	rock_roughness_code	Fracture roughness code
fract_alteration	code	rock_alteration_code	Fracture alteration code
strike		text_60	Strike north reference system (e.g. RT90 or Magnetic north)
dip	degrees	degrees_strike	Fracture strike meas clockwise from north, right hand rule
alpha	± degrees	degrees_uncert	Dihedral angle of uncertainty strike/dip
beta	± degrees	degrees_uncert	Uncertainty alpha angle due to alpha measuring uncert
rock_name		text_50	Best rock name at fracture location (rock / rock occurrence)
rock_code		text_50	Mapped rock type name at fracture location
rock_domain	code	rock_type_code	Fourth rock occurrence type code
fracture_domain		text_20	Rock domain defined on lithological/structural properties
deformation_zone		text_20	Fracture domains i.e. FFM01
rock_unit		text_30	Possible or modelled deformation zone
feature_id		flag_1	If in_use = "*" the activity contains latest valid data

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Forsmark Inspection sheet

Feature ID	Bore-hole	PFL	Elevation adjusted secup (meter)	Adjusted secup (meter)	Recorded secup (meter)	Fract mapped	Fract interpret	Aperture	Confidence	Roughness	Surface	Fract alteration	Rock name	Rock domain	Fracture domain	Rock unit	Strike	Dip	Alfa	Beta	Inspection Comment	Group	Sample	Photo-ID	Additional Photo-ID (taken during sampling)	Sampling Comment (ELT and BS)	Fracture minerals detected (SEM-EDS)	Double check
B29142D98A21C190	KFM01A	X		115,219	115,088	broken	open	2	certain	planar	smooth	fresh	Granite to grano-diorite, meta-morphic, medium-grained	RFM029	FFM02	RU01	343,3	6	84,9	65,8	Material missing due to drilling (rotation damage). Excellent in BIPS, with aperture.	2		1, 2				
895142D98A21E45B	KFM01A		-120,440	124,178	123,995	broken	open	0,5	possible	stepped	rough	fresh	Granite to grano-diorite, meta-morphic, medium-grained	RFM029	FFM02	RU1	246,7	13,6	71	23,2	Material missing	1		3				
DA1142D98A2257FD	KFM01A		-150,036	153,952	153,597	broken	sealed	0	certain	irregular	smooth	fresh	Amphi-bolite	RFM029	FFM02	RU1	148,1	60,1	26,9	299,6	Mineralisation (chlorite, calcite) is clearly visible - so this is NOT a FRESH fracutre, but rather a mineralised fracture.	6		4				
681142D98A22779E	KFM01A	X		162,091	161,694	broken	open	1	certain	planar	smooth	fresh	Granite to grano-diorite, meta-morphic, medium-grained	RFM029	FFM02	RU01	155,3	36,9	49,2	310	Barely visible in BIPS.	7		5				
239142D98A24AA7E	KFM01A	X		306,927	305,790	broken	open	1	certain	planar	smooth	fresh	Granite to grano-diorite, meta-morphic, medium-grained	RFM029	FFM01	RU2a	155,4	6,1	78,3	333,1	Material missing due to drilling. The PFL is more likely the lower fracture and not this one (check with Sven F).	2		6, 7, 8				
931142D98A24D08B	KFM01A	X		316,726	315,531	broken	open	1,5	certain	planar	smooth	slightly altered	Granite to grano-diorite, meta-morphic, medium-grained	RFM029	FFM01	RU2a	156,4	19	66,4	315,3	Indications of mineralisation, chlorite?	4	SAMPLE		1b, 2b,3b, 4b, 5b, 6b, 7b, 8b, 9b	Probable wall rock alteration, possibly some mineral coating. 2 parallel sealed (white filled: prehnite and adularia?) fractures	Yes	
D71142D98A26DDE1	KFM01A		-445,427	451,899	450,017	Broken	Open	0,5	Possible	Planar	Smooth	Fresh	Granite to grano-diorite, meta-morphic, medium-grained	RFM029	FFM01	RU2a	101,6	8,8	80,4	302,7	Missing box	8		no box				
1DD142D98A2E8272	KFM01A		-937,819	955,507	950,898	Broken	Open	0,5	Probable	Undulating	Rough	Fresh	Granite to grano-diorite, meta-morphic, medium-grained	RFM029	FFM01	RU2c	11,1	55,6	47,3	148,7	Indications of mineral coating	4	Yes	61,62,63,64		Indications of mineral coating		
D81142D989121522	KFM01B		-131,341	137,448	136,482	broken	open	0,5	probable	irregular	rough	fresh	Granite to grano-diorite, meta-morphic, medium-grained	RFM029	FFM02	RU1	96,3	9,4	72,9	326,7	Core disking close to the fracture	3		9, 10				

Feature ID	Bore-hole	PFL	Eleva-tion adjust-ed secup (meter)	Adjust-ed secup (meter)	Recorded secup (meter)	Fract mapped	Fract interpret	Aperture	Confidence	Roughness	Surface	Fract alteration	Rock name	Rock domain	Fracture domain	Rock unit	Strike	Dip	Alfa	Beta	Inspection Comment	Group	Sample	Photo-ID	Additional Photo-ID (taken during sampling)	Sampling Comment (ELT and BS)	Fracture minerals detected (SEM-EDS)	Double check
165142D98913299C	KFM01B		-199,900	208,093	207,260	broken	open	0,5	probable	planar	smooth	Slightly altered	Granite to grano-diorite, meta-morphic, medium-grained	RFM029	FFM02	RU1	73,9	10,3	74,1	320,9	Smooth not rough. Material missing and probable rest of mineral? Indication of core disking	1	SAMPLE	11, 12, 13	73b, 74b, 75b, 76b, 77b, 78b	Fracture parallel to white sealed fractures. Appears that some coating exist on the fracture surface.	YEs	
4F1142D98F116614	KFM01D		-72,023	91,669	91,668	broken	open	1	certain	planar	rough	Slightly altered	Granite to grano-diorite, meta-morphic, medium-grained	RFM029	FFM02	RU1	340,4	2,1	53,4	2	Changed drill diameter 5 cm from the fracture - the mapping seems to be correct apart from the change in drill diameter. Some material is missing.	5	SAMPLE	14, 15	10b, 11b, 12b, 13b	Indications on mineral coating on part of the fracture surface (possibly Fe-oxides). Probable wall rock alteration. White sealed fractures (prehnite and adularia) close by.	Yes	
F29142D98F12669A	KFM01D	X		157,451	157,338	broken	open	1	certain	undulating	rough	fresh	Granite to grano-diorite, meta-morphic, medium-grained	RFM029	FFM02	RU1	253	11,2	46,9	347	Yellowish fracture (uranine?). A whole "family" of similar fractures exist in this part of the core. Crossing fracture with calcite. Potential core disking? The location of PFL may need to be adjusted.	3		16, 17, 20				
521142D98F180CA9	KFM01D		-415,234	529,080	527,529	Unbroken	Sealed	0	Probable			Fresh	Granite to grano-diorite, meta-morphic, medium-grained	RFM029	FFM01	RU4	326,8	86,9	34,9	208	No fracture - instead folation discontinuity. Not visible in BIPS!	7		22, 23, 24				
9E5142D98F1B5B6B	KFM01D		-574,457	746,780	744,299	Broken	Sealed	0	Probable	Planar	Rough	Fresh	Granite to grano-diorite, meta-morphic, medium-grained	RFM029	FFM01	RU4	113,8	89,1	44,6	168,7	Not visible in BIPS	7		25,26				
E8D242D98A31E7B6	KFM02A	X		124,924	124,854	broken	open	1	probable	planar	smooth	fresh	Granite to grano-diorite, meta-morphic, medium-grained	RFM029	FFM03	RU1a	118,5	9,6	78,7	305	Material missing (may have been an old fracture). Occurs at the uptake and change of rock type. The core has rotated, which has resulted in some missing material (i.e. there may have been a mineral coating).	2		27, 28				
2FD242D98A31EB97	KFM02A	X		125,921	125,847	broken	sealed	0	probable	undulating	rough	fresh	Amphi-bolite	RFM029	FFM03	RU1a	155,8	19,9	66,9	328,7	Is this a true PFL? Faintly visible in BIPS (no aperture). Assessment: weakness that was broken during handling.	7		29, 30				
D45242D98A31FA52	KFM02A	X		129,707	129,618	broken	open	1	probable	undulating	rough	fresh	Granite to grano-diorite, meta-morphic, medium-grained	RFM029	FFM03	RU1a	110,3	34,7	54,6	283	Material missing. Fractures on both sides are weathered and chloritised. Will probably require adjustment of the PFL - the fracture below is more likely to be a PFL (this fracture is visible in BIPS and has aperture).	1	SAMPLE	31 (fel), 32, 33	14b, 15b, 16b, 17b	Probably some mineral coating (chlorite/clay minerals?). Fracture is parallel to foliation and the other nerby fractures. Weak indications of white sealed fractures.	Yes	

Feature ID	Bore-hole	PFL	Elevation adjusted secup (meter)	Adjusted secup (meter)	Recorded secup (meter)	Fract mapped	Fract interpret	Aperture	Confidence	Roughness	Surface	Fract alteration	Rock name	Rock domain	Fracture domain	Rock unit	Strike	Dip	Alfa	Beta	Inspection Comment	Group	Sample	Photo-ID	Additional Photo-ID (taken during sampling)	Sampling Comment (ELT and BS)	Fracture minerals detected (SEM-EDS)	Double check
73D242D98A3216F6	KFM02A	X		137,068	136,950	broken	open	2	certain	planar	rough	fresh	Amphibolite	RFM029	FFM03	RU1a	159,5	22,9	63,6	330,4	Lot of material missing. The core has rotated (the core piece between the fractures is conical).	1		34, 35				
D71242D98A3641AC	KFM02A	X		411,321	410,028	broken	open	1	probable	planar	rough	fresh	Granite to granodiorite, metamorphic, medium-grained	RFM029	FFM03	RU1c	353,7	46,1	48,1	144,3	Slightly altered rather than Fresh! Close to uptake - problem at the uptake = the "gripklo" seems to have slipped during uptake.	4	SAMPLE	36, 37	18b, 19b, 20b, 21b	Indications of alteration on the fracture surface. Likely wall rock alteration. An area where white sealed parallel fractures exist.	YEs	
0FD242D98A3655CC	KFM02A	X		416,498	415,180	broken	open	2,5	certain	stepped	smooth	slightly altered	Granite to granodiorite, metamorphic, medium-grained	RFM029	FFM03	RU1c	349,5	42,3	51,7	139,3	Missing material. Probably old fracture (indication of mineral coating).	1	SAMPLE	38, 39	22b, 23b, 24b, 25b	Possible mineral coating - the surface is not fresh. White sealed fracture near by.	Yes	
921242D989119063	KFM02B	X		102,496	102,499	broken	open	4	certain	undulating	rough	fresh	Granite to granodiorite, metamorphic, medium-grained			RU1a	264,3	50,6	32,5	39	No core to examine (bergmekanikholk). Can possibly be a PFL-crush rather than PFL-f (check with Sven F).	8		No material				
7C1242D9891508C0	KFM02B	x	-317,801	330,696	329,923	Broken	Open	1,5	Certain	Undulating	Rough	Slightly Altered	Granite, fine- to medium-grained			RU2	294,6	46,4	39,7	62,2	Not fresh surface. Potential PFL fracture. Yellowish due to acid. Parallell to micro-fracture (white thin fracture).	5	Yes	1, 2, 3, 4		No detectable minerals		
045242D98916494C	KFM02B	x	-398,658	413,066	411,980	Broken	Open	0,5	Probable	Undulating	Rough	Fresh	Pegmatite, pegmatitic granite			RU2	203,6	31,1	49,6	341,6	No detectable minerals. 2 fractures 10-15 cm above this fracture have mineral coating and are more likely PFL-fracture(s) (photo 8-9).	5	Yes	5,6, 7, 8		No detectable minerals		
3BD242D989167149	KFM02B	x	-408,742	423,349	422,217	Broken	Open	2	Certain	Undulating	Rough	Fresh	Pegmatite, pegmatitic granite			RU2	343,3	15,8	75,6	79,3	Clearly visible in BIPS. Very fractured part of the core. Close to uptake. No detectable minerals.	5	Yes	9		No detectable minerals		
BF9242D989167C1C	KFM02B	x	-411,472	426,132	424,988	Broken	Open	1	Certain	Planar	Rough	Fresh	Pegmatite, pegmatitic granite			RU2	312	15,8	70,7	55,1	Fracture close to many open fractures. Indications of mineral coating (chlorite?).	4	Yes	10,11,12		Possibly chlorite		
F8D242D989167CF9	KFM02B	x	-411,690	426,354	425,209	Broken	Open	2	Certain	Planar	Rough	Fresh	Pegmatite, pegmatitic granite			RU2	306,2	14,9	70,7	49,7	Indications of mineral coating (corrensite?).	4	Yes	13,14,15		Possibly corrensite.		
8D5242D98916893D	KFM02B	x	-414,783	429,508	428,349	Broken	Open	2	Certain	Planar	Smooth	Fresh	Granite to granodiorite, metamorphic, medium-grained			RU1b	337,7	18	72,8	78,8	No detectable minerals.	5	Yes	16,17,18,19, 20		No detectable minerals. Extra sample taken of yellow-coloured core 10 cm below the fracture to see what the reason for the yellow colouring) PhotoID 20		
A51242D98916A3ED	KFM02B	x	-421,508	436,367	435,177	Broken	Open	0,5	Probable	Undulating	Rough	Fresh	Pegmatite, pegmatitic granite			RU1b	277,9	40,8	42,3	43	No detectable minerals. Fracture parallell to micro-fractures (white thin bands).	5	Yes	21,22,23		No detectable minerals. White "powder" on the fracture surface - is it from drilling?		
285242D989178D72	KFM02B	x	-480,351	497,092	494,964	Broken	Open	0,5	Certain	Undulating	Rough	Fresh	Granite to granodiorite, metamorphic, medium-grained			RU1b	3,7	30,4	66,2	120,5	No detectable minerals. Fracture parallell to micro-fractures (white thin bands). PhotoID 24-25 shows how white micro-fractures ends!	5	Yes	24,25,26,27		No detectable minerals. Parallel to micro-fractures.		

Feature ID	Bore-hole	PFL	Elevation adjusted secup (meter)	Adjusted secup (meter)	Recorded secup (meter)	Fract mapped	Fract interpret	Aperture	Confidence	Roughness	Surface	Fract alteration	Rock name	Rock domain	Fracture domain	Rock unit	Strike	Dip	Alfa	Beta	Inspection Comment	Group	Sample	Photo-ID	Additional Photo-ID (taken during sampling)	Sampling Comment (ELT and BS)	Fracture minerals detected (SEM-EDS)	Double check
DA5342D98A21D597	KFM03A	X		120,518	120,215	unbroken	partly open	1	certain			fresh	Granite to granodiorite, metamorphic, medium-grained	RFM029	FFM03	RU1a	115,1	74,4	12,5	319,6	Old fracture with thin chlorite coating.	6		40, 41, 42, 43, 44				
24D342D98A21EDD2	KFM03A	X		126,755	126,418	broken	open	1	probable	planar	smooth	fresh	Granite to granodiorite, metamorphic, medium-grained	RFM029	FFM03	RU1a	306,2	73,6	20	149,8	Rotation of drill cuttings (loss of core material). White mineral visible in BIPS (calcite?).	4		45, 46				
339342D98A21FB4F	KFM03A	X		130,227	129,871	broken	open	1	possible	planar	rough	fresh	Granite to granodiorite, metamorphic, medium-grained	RFM029	FFM03	RU1a	76,6	27,9	61	288,4	Old fracture. Material is missing. Reddish core suggest it is old. Gammal spricka. Material missing. Rödfärgad kärna = gammal. Network of thin fractures (<mm), with calcite, close by with in the same direction. Core disking? Check if the PFL is correct - may need to be adjusted.	1		47, 48				
0D5342D98A21FDDF	KFM03A	X		130,887	130,527	unbroken	partly open	1	certain			fresh	Pegmatite, pegmatitic granite	RFM029	FFM03	RU1a	42,5	18,4	72,8	259,3	Weak in BIPS. The aperture (1mm) and the PFL-f does probably belong to the next fracture (needs to be adjusted). Aperturen (1mm) och PFL-f tillhör troligen nästa spricka - korrigera. Initiation of core disking close by. Raymond induced core disking while holding the core!!	7		49-50 (fel ställe), 51, 52 (core disking)				
F1D342D98A27D5EA	KFM03A	x	-505,930	515,936	513,514	Broken	Open	1	Probable	Planar	Smooth	Fresh	Granite to granodiorite, metamorphic, medium-grained	RFM029	FFM03	RU1b	50,4	30	64,2	224,9	No detectable minerals. The fracture just above has mienral coating and is a more likely PFL.	5	Yes	28,29,30,31,32		No detectable mineral coating. Fracture above is a more likely PFL.		
955342D98A27D5F6	KFM03A	x	-505,942	515,948	513,526	Broken	Open	1	Probable	Planar	Smooth	Fresh	Granite to granodiorite, metamorphic, medium-grained	RFM029	FFM03	RU1b	46,9	27	67,4	221,9	No detectable minerals. The fracture just above has mienral coating and is a more likely PFL.	5	Yes	28,29,30,31,32		No detectable mineral coating. Fracture above is a more likely PFL.		
955342D98A2C0DB2	KFM03A		-782,221	793,761	789,938	Broken	Open	3	Probable	Irregular	Smooth	Fresh	Granite to granodiorite, metamorphic, medium-grained	RFM029	FFM03	RU1b	139,6	31,6	55,3	303,8	Difficult to identify correct fracture because there seems to have been some mix ups and part of the core has been off for sampling/analysis.	9	No	No				
221342D98A2CD8D3	KFM03A		-834,160	846,040	841,939	Broken	Open	1	Possible	Planar	Rough	Slightly Altered	Granite to granodiorite, metamorphic, medium-grained	RFM029	FFM03	RU1b	299,8	4,7	82	36,4	Indications of mineral coating.	4	Yes	33,34,35		Indications of mineral coating.		x
23D442D98A62B8F9	KFM04A	X		178,913	178,425	broken	open	0,5	probable	planar	rough	fresh	Granite to granodiorite, metamorphic, medium-grained	RFM012	FFM04	RU3a	198,1	35,2	54,9	291	Fresh and rough surface. Suspecting core disking (however only a single fracture). The PFL will probably need to be corrected to the steep fracture, which cuts this fracture (recorded_Secup 178.507: calcite, chlorite,	3	SAMPLE	53, 54, 55 (propagering)	26b, 27b, 28b, 29b, 30b, 31b	Fracture parallel to white sealed fracture. Fracture surface does not look fresh. Possible mineral	Yes	

Feature ID	Bore-hole	PFL	Elevation adjusted secup (meter)	Adjusted secup (meter)	Recorded secup (meter)	Fract mapped	Fract interpret	Aperture	Confidence	Roughness	Surface	Fract alteration	Rock name	Rock domain	Fracture domain	Rock unit	Strike	Dip	Alfa	Beta	Inspection Comment	Group	Sample	Photo-ID	Additional Photo-ID (taken during sampling)	Sampling Comment (ELT and BS)	Fracture minerals detected (SEM-EDS)	Double check
																					laumontite, and unbroken)					coating.		
341442D98A62D8B3	KFM04A	X		187,094	186,547	broken	open	2	certain	undulating	rough	slightly altered	Granite to granodiorite, metamorphic, medium-grained	RFM012	FFM04	RU3a	262,7	17,5	47,6	341	Calcite bearing fracture (Kalcitförande spricka (fizzing)!	6		56 (kalcitfräs), 57, 58				
335442D98A62E743	KFM04A	X		190,849	190,275	broken	open	2	certain	irregular	rough	fresh	Granite to granodiorite, metamorphic, medium-grained	RFM012	FFM04	RU3a	249,6	32,2	37,9	324,1	Crushed material, impossible to map (is however clearly visible in BIPS). Suggestion: for future mapping it would be useful to create a mapping code where this kind of feature can be mapped.	4		59, 60				
B95442D98A685430	KFM04A		-458,573	548,132	545,840	Unbroken	Sealed	0	Certain			Fresh	Granite to granodiorite, metamorphic, medium-grained	RFM029	FFM01	RU6a	144	70	55,2	205	Obvious laumontite-calcite-bearing fracture. Visible as a red line in BIPS.	6		61-62 (fel fokus), 63, 64				
BB1442D98A6A2EEF	KFM04A		-554,274	670,244	667,375	Unbroken	Partly open	0,5	Possible			Slightly altered	Granite to granodiorite, metamorphic, medium-grained	RFM029	FFM01	RU6a	320	88,2	37,1	193	No box.	8						
735542D98A12893B	KFM05A	X	-138,664	166,372	166,203	broken	open	0,5	probable	planar	rough	slightly altered	Granite to granodiorite, metamorphic, medium-grained	RFM029	FFM02	RU1	117.4	10.5	67.5	23.3	Suspected core disking. White thin bands/lines ("fractures") close by - these should be sampled for thin sections (what is that white stuff??)- Adjust the PFL to the fracure 4 cm above this fracture.	3	SAMPLE	65,66	32b, 33b, 34b, 35b	Fracture parallel to white sealed fracture. Fracture surface is cut by a discordant fracture (probably calcite and laumontite?).	No	
6B9542D98A128C3A	KFM05A	X	-139,328	167,142	166,970	broken	open	0,5	probable	stepped	rough	slightly altered	Granite to granodiorite, metamorphic, medium-grained	RFM029	FFM02	RU1	107.9	16.8	62	31.4	Material missing. Suspected core disking (indications of fracturing at the rim of the core).	3	SAMPLE	67	36b, 37b, 38b, 39b	Fracture parallel to white sealed fractures. Difficult to see coating on the fracture surface. Probable wall rock alteration.	No	
D21542D98A129225	KFM05A	X		168,663	168,485	broken	open	0,5	probable	planar	rough	slightly altered	Granite to granodiorite, metamorphic, medium-grained	RFM029	FFM02	RU1	132,2	22,8	69,9	49,7	Material missing at the rim of the core (wedge in the lower part of the fracture - the wedge occur in the lower part of the fracture) Difficult to believe that this is a true PFL - check with Sven F. "Spalling".	1		68, 69, 70				x
555542D98A1319B6	KFM05A		-170,639	203,509	203,190	broken	sealed	0	certain	planar	rough	fresh	Granite to granodiorite, metamorphic, medium-grained	RFM029	FFM02	RU1	157	44.5	72.8	135	What is the white stuff (light bands/lines). No visible fracture in BIPS. Indication of core disking.	3	SAMPLE	71, 72, 73-75 (pågående spalling)	40b, 41b, 42b, 43b	Fracture parallel to white sealed fracture and also perpendicular white sealed fracture. Possible indications of	No	

Feature ID	Borehole	PFL	Elevation adjusted secup (meter)	Adjusted secup (meter)	Recorded secup (meter)	Fract mapped	Fract interpret	Aperture	Confidence	Roughness	Surface	Fract alteration	Rock name	Rock domain	Fracture domain	Rock unit	Strike	Dip	Alfa	Beta	Inspection Comment	Group	Sample	Photo-ID	Additional Photo-ID (taken during sampling)	Sampling Comment (ELT and BS)	Fracture minerals detected (SEM-EDS)	Double check
																										mineral coating but very difficult to see with naked eye.		
28D542D98A135231	KFM05A		-183,059	218,012	217,649	unbroken	sealed	0	certain			fresh	Amphibolite	RFM029	FFM02	RU1	26,9	10,2	50	9	Barely visible BIPS (overinterpreted)	7		76				x
C09642D98A31A11A	KFM06A		-88,641	106,806	106,778	unbroken	sealed	0	certain			fresh	Granite to granodiorite, metamorphic, medium-grained	RFM029	FFM02	RU1a	42,1	14,1	73,7	348	No material (cut off material). Barely visible in BIPS.	7						
A05642D98A31AAA3	KFM06A	X		109,262	109,219	broken	open	0,5	probable	planar	rough	fresh	Granite, metamorphic, aplitic	RFM029	FFM02	RU1a	54,7	25,2	77,2	302	Saddle shaped fracture surface. Wedge-shaped edges. Fine-grained rock type (aplite?). Check if the PFL is correct (can it be a channel?). Boremap comment: probably a pressure released fracture.	3	SAMPLE	77, 78, 79, 80	44b, 45b, 46b, 47b	Network of white sealed fracture close by. Indications of coating on fracture surface?	Yes	
60D642D98A327BFD	KFM06A	X		163,157	162,813	broken	open	1	certain	planar	rough	fresh	Granite to granodiorite, metamorphic, medium-grained	RFM029	FFM01	RU1a	21,4	11,5	71,1	6	Missing material (wedge). Visible in BIPS. It is possible that another discontinuity (than the one visible in BIPS) has been mapped in the core. Check how significant the PFL is and if it is a true PFL (the fracture 1 cm above is a more likely PFL-fracture).	1		81				
69D642D98A32A549	KFM06A	X		173,771	173,385	broken	open	0,5	probable	planar	rough	fresh	Granite to granodiorite, metamorphic, medium-grained	RFM029	FFM01	RU1a	311	18,1	57,8	35,1	Visible in BIPS. Possibly drilling induced fracture?	2		82, 83				
945642D98A3485D4	KFM06A	X	-252,487	297,253	296,404	broken	open	2	certain	planar	rough	fresh	Granite to granodiorite, metamorphic, medium-grained	RFM029	FFM01	RU1a	146.1	6	55.9	350	Some material missing. Correctly mapped (schoolbook example of visible fracture in BIPS). Korrekt karterad (skolexempel på synlig spricka i BIPS). Bankningsspricka at great depth? Why is there no mineral coating if this is a PFL (how long time does it take for the water-rock interaction before coating is developed?).	5	SAMPLE	??	48b, 49b, 50b, 51b	Fracture surface is cut by a sealed fracture. Difficult to say something about mineral coating.	No	
C3D642D98A349C05	KFM06A	X		302,955	302,085	broken	sealed	0	probable	undulating	rough	fresh	Granite to granodiorite, metamorphic, medium-grained	RFM029	FFM01	RU1a	158,4	5,4	55,1	352	Fresh fracture. Clearly visible in BIPS. How significant is the PFL? Why PFL when it is interpreted as "sealed"? Boremap comment: possible core disking.	5		84, 85, 86				
FE9642D98A34A848	KFM06A	X		306,109	305,224	broken	open	2	certain	planar	rough	fresh	Granite to granodiorite, metamorphic, medium-grained	RFM029	FFM01	RU1a	140,5	9,5	54,8	344	No box.	8						
D75642D98A34B162	KFM06A	X		308,450	307,554	broken	open	3	certain	planar	rough	fresh	Pegmatite, pegmatitic granite	RFM029	FFM01	RU1a	140,5	6,3	56,2	349	Material missing. Bankningsplan? If it is a PFL, why is there no mineral coating?	1		87, 88				

Feature ID	Bore-hole	PFL	Elevation adjusted secup (meter)	Adjusted secup (meter)	Recorded secup (meter)	Fract mapped	Fract interpret	Aperture	Confidence	Roughness	Surface	Fract alteration	Rock name	Rock domain	Fracture domain	Rock unit	Strike	Dip	Alfa	Beta	Inspection Comment	Group	Sample	Photo-ID	Additional Photo-ID (taken during sampling)	Sampling Comment (ELT and BS)	Fracture minerals detected (SEM-EDS)	Double check
E21642D98A399D7F	KFM06A		-532,405	632,348	630,143	Broken	Open	0,5	Possible	Irregular	Rough	Slightly altered	Granite to grano-diorite, meta-morphic, medium-grained	RFM029	FFM01	RU2a	33,2	27,3	80,1	37	Undulating core (wobbly), which has probably cracked along a foliation plane. Induced fracture. Mapping problem (is most likely not an open non-mineralised fracture).	2		89, 90				
5F5642D98A3BDAE7	KFM06A		-652,704	779,917	776,935	unbroken	sealed	0	certain			fresh	Granite, meta-morphic, aplitic	RFM045	FFM06	RU4	224,9	89,1	34,9	8,6	Barely visible in BIPS (doubtful - and bad BIPS-image quality). Fracture is clearly visible in the core (calcite bearing, suggesting old fracture.).	7		91, 92				
389642D98A3DD9F7	KFM06A		-757,685	911,474	907,767	broken	sealed	0	probable	irregular	rough	fresh	Granite, meta-morphic, aplitic	RFM045	FFM06	RU4	116	72,7	33	255	No box. Not visible in BIPS.	7						x
E51642D989203789	KFM06B		-10,025	14,239	14,217	unbroken	sealed	0	probable			fresh	Granite to grano-diorite, meta-morphic, medium-grained	RFM029	FFM02	RU1	227,4	48,4	35,6	19	probably an old fracture. Reduced grain size in the wall. Probably mineral coated.	6		93, 94				
149642D9881917EF	KFM06C		-482,970	598,243	595,951	broken	open	0,5	probable	planar	smooth	fresh	Granite, meta-morphic, aplitic	RFM045	FFM06	RU2a	216,6	26,8	52,4	317	Visible in BIPS. No mineral - a clean fracture!	5		95, 96, 97				
EB5642D988193F82	KFM06C		-490,716	608,432	605,751	unbroken	sealed	0	probable			fresh	Granite, meta-morphic, aplitic	RFM045	FFM06	RU2a	233,9	13,1	48,9	340	Correct featureID =EB5642D988193F82, the other provided featureID=AE5642D988193E37 (by Lillemor) is probably wrong. No box.	8						
041642D988196ABC	KFM06C		-499,163	619,565	617,148	unbroken	sealed	0	certain			fresh	Granite, meta-morphic, aplitic	RFM045	FFM06	RU2a	284,6	26,1	28,7	339	Thin fracture. Affected wall.	4	SAMPLE	98, 99	52b, 53b, 54b	A sealed fracture filled with something (possible prehnite?)		
FD5642D9881A4F1E	KFM06C		-543,468	678,361	675,614	broken	sealed	0	probable	planar	rough	fresh	Granite, meta-morphic, aplitic	RFM045	FFM06	RU2a	203,7	6,2	52,3	352	No box.	8						
5A5642D9881A755A	KFM06C		-550,852	688,201	685,402	broken	open	0,5	probable	planar	smooth	fresh	Pegmatite, pegmatitic granite	RFM045	FFM06	RU2a	290,6	14,4	37,1	348	No box.	8						
089642D9881B43D9	KFM06C		-590,622	741,348	738,265	broken	sealed	0	probable	irregular	smooth	fresh	Amphi-bolite	RFM045	FFM06	RU2a	126,6	81,9	43,3	140	Weakly visible in BIPS (difficult to see the fracture since it exists? In a dark area of the core). Fractured along foliation plane (biotite). Assessment: mechanically drilling induced?	7		100, 101				
7C9642D9881B5146	KFM06C		-593,201	744,804	741,702	broken	sealed	0	probable	planar	rough	fresh	Granite, meta-morphic, aplitic	RFM045	FFM06	RU2a	257,5	33,8	32,5	320	No fresh fracture - has some kind of coating (on one part of the fracture). Visible in BIPS (seems to be more partly open than sealed). Assessment: propagation during drilling?	4	SAMPLE	102, 103, 104	55b, 56b, 57b, 58b, 59b	Fracture surface is predominantly fresh but has a small part where it looks altered (or have a coating). White parallel sealed fracture close by.	Yes	
BAD742D98A29E98A	KFM07A		-546,769	651,708	649,610	Broken	Sealed	0	Probable	Planar	Rough	Fresh	Granite to grano-diorite, meta-morphic, medium-grained	RFM029	FFM01	RU3	39,4	84,4	36	216	No box.	8						x

Feature ID	Bore-hole	PFL	Elevation adjusted secup (meter)	Adjusted secup (meter)	Recorded secup (meter)	Fract mapped	Fract interpret	Aperture	Confidence	Roughness	Surface	Fract alteration	Rock name	Rock domain	Fracture domain	Rock unit	Strike	Dip	Alfa	Beta	Inspection Comment	Group	Sample	Photo-ID	Additional Photo-ID (taken during sampling)	Sampling Comment (ELT and BS)	Fracture minerals detected (SEM-EDS)	Double check
6C1742D98910A6FE	KFM07B		-31,540	42,690	42,750	broken	open	0,5	probable	irregular	rough	fresh	Granite to granodiorite, metamorphic, medium-grained	RFM029	FFM02	RU1	260,6	28,9	70,2	303,3	Visible in BIPS (bad image quality though). Some mineral coating exist (chlorite and adularia). Not a fresh fracture.	4		105, 106, 107 (coating i hårfin spricka)				
7DD842D98A21B23F	KFM08A	X		111,198	111,167	broken	open	2	certain	planar	rough	fresh	Granite to granodiorite, metamorphic, medium-grained	RFM029	FFM01	RU1	350,3	6,4	61	11	Missing material. Problem during drilling. Part of the fracture appears weathered. Potentially an old fracture. Spalling in the core wall. PFL but no mineral coating - why?	2	SAMPLE	108, 109	60b, 61b, 62b	Possibly rotated surface. White thins sealed fractures close by.	Yes	
F4D842D98A21D49C	KFM08A	X		120,026	119,964	broken	open	1	certain	planar	rough	fresh	Granite to granodiorite, metamorphic, medium-grained	RFM029	FFM01	RU1	336,5	6,4	59,4	12	Some material is missing. Visible in BIPS and have been interpreted as a PFL. The fracture 15 cm above this fracture (adjusted_secup: 119.854) has coating and aperture - could this be the "true PFL"? Check with Sven F.	5		110, 111, 112				
1A1842D98A21FC60	KFM08A	X		130,242	130,144	broken	open	2	certain	planar	rough	fresh	Pegmatite, pegmatitic granite	RFM029	FFM01	RU1	213,8	8,1	49,7	357,1	Missing material. Wedges in the edges. Most likely PFL-fracture if you consider the BIPS.	1		113, 114, 115				
3D5842D98A294E15	KFM08A		-493,914	611,585	609,813	Unbroken	Sealed	0	Certain			Fresh	Granite to granodiorite, metamorphic, medium-grained	RFM029	FFM01	RU1	16,6	83,1	34,6	123	Not visible in BIPS. Thin fracture with chlorite and calcite.	7		116, 117				
2CD842D98A2B173A	KFM08A		-579,352	729,131	726,842	Broken	Open	0,5	Possible	Planar	Rough	Slightly altered	Amphibolite	RFM029	FFM01	RU1	113,8	71	42,2	253	No box.	8						
031842D988261AD2	KFM08C		-336,740	399,858	400,082	broken	sealed	0	probable	planar	rough	fresh	Granite, metamorphic, aplitic	RFM045	FFM06	RU2a	25,5	15,4	48,5	22	Visible in BIPS, no mineral. Quartz-rich rock type, which requires a more roguh drilling. An open fracture 10 cm below this one with aperture (adjusted_secup: 399:955 exist.	5		118, 119, 120				
849842D988280291	KFM08C	x	-439,903	524,763	524,945	Broken	Open	0,5	Probable	Irregular	Rough	Fresh	Granite, metamorphic, aplitic	RFM045		RU2a	334,8	9,6	45,9	4,6	Fractured part of the core with some surfaces with obvious mineral coating and other surfaces with less obvious mineral coating. Difficult to distinguish correct fracture. The fracture surface has probably fractured during drilling.	9	No	36,37,38				
295842D98F11A9F7	KFM08D	x	-86,578	109,218	109,047	Broken	Open	0,5	Possible	Undulating	Rough	Fresh	Granite to granodiorite, metamorphic, medium-grained				311,5	6,6	50,3	351	No detectable mineral coating. True PFL?	5	Yes	39,40,41			No detectable minerals	
FE1842D98F1240C5	KFM08D	x	-117,607	147,957	147,652	Broken	Open	0,5	Certain	Planar	Rough	Fresh	Granite to granodiorite, metamorphic, medium-grained				311,8	27,4	35	330,7	No detectable mineral coating. True PFL (there are many potential fractures in this part of the core that can host a PFL). Fracture parallell to white micro-fracture (photoID 46,47)	5	Yes	42,43,44,45,46,47			No detectable minerals	
209842D98F15E6E6	KFM08D	x	-312,053	387,812	386,790	Broken	Open	0,5	Possible	Undulating	Rough	Fresh	Granite to granodiorite, metamorphic, medium-				108,9	81,7	12,7	93,3	Not inspected due to missing box	8	No					

Feature ID	Bore-hole	PFL	Elevation adjusted secup (meter)	Adjusted secup (meter)	Recorded secup (meter)	Fract mapped	Fract interpret	Aperture	Confidence	Roughness	Surface	Fract alteration	Rock name	Rock domain	Fracture domain	Rock unit	Strike	Dip	Alfa	Beta	Inspection Comment	Group	Sample	Photo-ID	Additional Photo-ID (taken during sampling)	Sampling Comment (ELT and BS)	Fracture minerals detected (SEM-EDS)	Double check
													grained															
3E5942D98A1814F7	KFM09A		-431,064	531,827	529,655	Broken	Sealed	0	Probable	Planar	Rough	Fresh	Granite to grano-diorite, meta-morphic, medium-grained	RFM034	FFM01	RU7	131,3	71,4	21,7	177	No box.	8						
BF5046D98A11738D	KFM10A	x	-67,562	94,811	95,117	Broken	Open	2	Certain	Irregular	Rough	Fresh	Granite to grano-diorite, meta-morphic, medium-grained	RFM029		RU1	300,7	17,1	32,2	7,1	Mixed up fracture. Fracture contain mineral coating	6	No	48		Contain mineral coating		
1B9046D98A1194AE	KFM10A	x	-73,899	103,241	103,598	Broken	Open	1	Certain	Irregular	Rough	Fresh	Granite to grano-diorite, meta-morphic, medium-grained	RFM029		RU1	325,5	45,9	10,6	31,4	No detectable mineral. There is a more likely PFL fracture cutting this fracture with mineral coating (photoID 51)	5	Yes	49,50,51,52		No detectable mineral		
F11046D98A15022F	KFM10A	x	-232,465	328,076	328,239	Broken	Open	0,5	Certain	Undulating	Smooth	Fresh	Granite to grano-diorite, meta-morphic, medium-grained	RFM029	FFM03	RU1	151,2	26,5	56,9	327	No detectable mineral. A more likley PFL-fracture is located 5 cm above this fracture and is parallell to the fracture. The inspected fracture is parallell to two white micro-fractures.	5	Yes	53,54,55,56,57		No detectable mineral		
2ED046D98A1504B4	KFM10A	x	-232,889	328,723	328,884	Broken	Open	1	Certain	Undulating	Rough	Fresh	Granite to grano-diorite, meta-morphic, medium-grained	RFM029	FFM03	RU1	168,7	17,7	47,9	337	Indications of mineral coating.	4	Yes	58,59,60		Indications of mineral coating		
F21046D98A1514B5	KFM10A	X		332,834	332,981	broken	open	0,5	certain	undulating	rough	fresh	Granite to grano-diorite, meta-morphic, medium-grained	RFM029	FFM03	RU1	212	12.4	37.2	344.7	Correctly mapped fracture. A mapped, unbroken fracture exists 2 cm below this fracture (indication of fracturing "brottanvisning", does not split the coreadjusted_secup:332.865, Boremap comment: X5)	5	SAMPLE	121, 122	63b, 64b, 65b	White sealed parallel fracture. Difficult to say something about mineral coating - the fracture surface appears fresh.	No	
BAD046D98A151AEC	KFM10A	X		334,430	334,572	broken	open	2,5	certain	undulating	rough	fresh	Granite to grano-diorite, meta-morphic, medium-grained	RFM029	FFM03	RU1	178	10.8	44	346	The surfaces do not match perfectly - some material missing. Yellowish core (uranine?). Clearly visible in BIPS.	4	SAMPLE	123, 124, 125	66b, 67b, 68b	Indications of some coating on the surface. Possible wall rock alteration. Sub-parallel white sealed fracture.	No	
D49046D98A159EBF	KFM10A	X		368,314	368,319	broken	open	0,5	probable	undulating	rough	fresh	Granite to grano-diorite, meta-morphic, medium-grained	RFM029	FFM03	RU1	169,2	35,4	49,3	311,3	Material missing (indication of minor fractures where material has been flushed out? during drilling or due to running water?). Indication of alteration (due to water?). There is a fracture 5 cm above this fracture (with aperture and visible in BIPS + it has mineral coating, adjusted_secup:368.387 this is a more likely PFL). "Greppklon" slipped vertically and during rotation.	2		126, 127, 128				
25D046D98A15B32C	KFM10A	X		373,567	373,548	broken	open	2	certain	planar	rough	fresh	Granite to grano-diorite,	RFM029	FFM03	RU1	176,1	13,7	43,9	342,7	Clearly visible in BIPS and perfect core disking close by. Material missing in the	3	Kärnprov taget!	129, 130				

Feature ID	Bore-hole	PFL	Elevation adjusted secup (meter)	Adjusted secup (meter)	Recorded secup (meter)	Fract mapped	Fract interpret	Aperture	Confidence	Roughness	Surface	Fract alteration	Rock name	Rock domain	Fracture domain	Rock unit	Strike	Dip	Alfa	Beta	Inspection Comment	Group	Sample	Photo-ID	Additional Photo-ID (taken during sampling)	Sampling Comment (ELT and BS)	Fracture minerals detected (SEM-EDS)	Double check
													metamorphic, medium-grained								wall rock (rotation induced).							
C99046D98A15BC79	KFM10A	X		375,959	375,929	broken	open	2	certain	undulating	rough	fresh	Pegmatite, pegmatitic granite	RFM029	FFM03	RU1	150,2	13,7	49,2	346,7	Some material missing. No mineral on fracture surface. Clearly visible in BIPS. Yellowish edges (uranine?) and PFL..	5		131, 132				
009146D98A1177ED	KFM11A	X		96,289	96,237	broken	open	1	certain	undulating	rough	fresh	Felsic to intermediate volcanic rock, metamorphic				292,1	30,7	33,1	348	Clearly visible in BIPS - connects to a filled fracture (laumontite, chlorite, calcite). Fresh fracture with aperture and it follows an old en echelon fracture filled with laumontite.	5		133, 134, 135, 136				
609146D98A117FE5	KFM11A	X		98,333	98,277	broken	sealed	0	probable	undulating	rough	fresh	Felsic to intermediate volcanic rock, metamorphic				163,1	8,2	69,4	348	Weakly visible in BIPS. It is possible that an uptake has been mapped. Saddle-shaped fracture surface - and there are also saddle-shaped and parallell deformation bands within 1 cm from the fracture surface. Is this a true PFL?	3		137, 138 (ca100.3 i spricka m kalcit)				
609146D98A11A26E	KFM11A	X		107,169	107,118	broken	open	0,5	probable	irregular	rough	fresh	Felsic to intermediate volcanic rock, metamorphic				272,8	12,5	52,2	347	Barely visible in BIPS. Drilling induced fracture (10 cm below uptake). Is this a true PFL?	7		139				
A09146D98A11C5AB	KFM11A	X		116,179	116,139	broken	sealed	0	probable	planar	rough	fresh	Amphibolite				322,3	17,1	45,4	4	Weakly visible in BIPS (lighter band, reddish due to traces of adularia). Is this a true PFL (the core is entirely solid around this "lighter band".	7		140 (ca 10 cm nedanför, sprickan går halvvägs in i hålet/kärnan), 141				
409146D98A1288BF	KFM11A	X		166,059	166,079	broken	open	1	certain	irregular	rough	fresh	Amphibolite				289,1	24,2	38,8	347	A network of fractures (the core is in small pieces, which makes it difficult to tell which one of the fractures that is visible in BIPS). Old mineral exist on parts of these fractures, some of the fractures are also entirely fresh. Indications of drilling induced fracture formation. It is possible that an ajdustment of the PFL is needed (to the fracture 10 cm below this one).	4		142				x
409146D98A13ED7A	KFM11A	X		257,327	257,402	broken	open	1	certain	planar	rough	fresh	Felsic to intermediate volcanic rock, metamorphic				244,9	15,3	52,4	336	Non-mineralised. Visible in BIPS. PFL.The core fractured in the hand (along an old fracture 4 cm below this fracture)..	5		143, 144				
C09146D98A13EE2D	KFM11A	X		257,506	257,581	broken	open	1	certain	planar	rough	fresh	Granite, fine- to medium-grained				302	21	39,5	354	Clearly visible in BIPS. En echelon-fractures occur close by, with the same direction. PFL.	5						
009146D98A13FDAC	KFM11A	X		261,473	261,548	broken	open	1	certain	irregular	rough	fresh	Felsic to intermediate volcanic rock, metamorphic				227,6	29,1	48,4	313	Visible in BIPS (partly open rather than open). Coincident with uptake. Material is missing.	5		145, 146, 147 148-150 (en echelon sprickserie)				

Feature ID	Bore-hole	PFL	Eleva-tion adjust-ed secup (meter)	Adjust-ed secup (meter)	Recorded secup (meter)	Fract mapped	Fract interpret	Aperture	Confidence	Roughness	Surface	Fract alteration	Rock name	Rock domain	Fracture domain	Rock unit	Strike	Dip	Alfa	Beta	Inspection Comment	Group	Sample	Photo-ID	Additional Photo-ID (taken during sampling)	Sampling Comment (ELT and BS)	Fracture minerals detected (SEM-EDS)	Double check
E09146D98A141AD0	KFM11A	X		268,932	269,008	broken	open	0,5	probable	planar	rough	fresh	Felsic to inter-mediate volcanic rock, meta-morphic				329,9	4,5	55,7	2	Weakly visible in BIPS. Fracture without mineral (though a dull surface) - slightly alterad rather than fresh. Gently dipping fracture. PFL.	7		151, 152				
E09146D98A160900	KFM11A	X		395,422	395,520	broken	open	0,5	probable	irregular	rough	slightly altered	Felsic to inter-mediate volcanic rock, meta-morphic				102,9	82	32,3	135,7	Correctly mapped fracture.	5	SAMPLE	153, 154	69b, 70b, 71b, 72b	Fine-grained, difficult to say what belongs to fracture or wall rock. Fracture parallel to adularia/prehnite-fractures.	Yes	
809146D98A1612E9	KFM11A	X		397,958	398,057	broken	open	1	certain	planar	rough	fresh	Pegmatite, pegmatitic granite				238	16,3	52,8	332,6	Clearly visible in BIPS. Correctly mapped. Is this a PFL? It is possible that the PFL needs to be adjusted to the fracture 13 cm below this one (adjusted_secup: 397.958).	5		155, 156				

Laxemar Inspection sheet

Feature ID	Borehole	PFL	Elevation adjusted secup (meter)	adjusted secup (meter)	Recorded secup (meter)	Fract mapped	Fract interpret	Aperture	Confidence	Roughness	Surface	Fract alteration	Rock name	Rock domain	Fracture domain	Rock unit	Strike	Dip	Inspection Comment	Group	Sample	Photo-ID	Sampling Comment (ELT and HD)	Fracture minerals detected (SEM-EDS)
0B52438B2B13A655	KLX02	x	-219,84	239,2042	239,1890	Broken	Open	0,5	Possible	Planar	Rough	Fresh		RSMA01		RU1	329,1	64,2	Mineral coating exist. Unknown mineral rather than X7.	6		62		
C352438B2B13AF51	KLX02	x	-222,13	241,5036	241,4890	Broken	Open	0,5	Possible	Planar	Rough	Fresh		RSMA01		RU1	317,3	41,2	No visible mineral coating.	5	Yes	63		Yes
0092438B2B170E97	KLX02		-442,049	462,487	462,487	Broken	Sealed	0	Certain	Planar	Rough	Fresh	Granite to quartz monzodiorite, generally porphyritic	RSMA01	FSM_EW007	RU2	275	59	Wrong box!	10				
F252438B2B17BCBB	KLX02		-486,353	507,066	507,067	Unbroken	Sealed	0	Certain			Slightly Altered	Granite to quartz monzodiorite, generally porphyritic	RSMA01	FSM_EW007	RU2	220	46	Wrong box!	10				
9752438B2B1F5756	KLX02		-981,001	1005,2	1005,398	Broken	Open	0,5	Certain	Planar	Rough	Slightly Altered	Granite to quartz monzodiorite, generally porphyritic	RSMA01	FSM_NE005	RU5	153	28	Sealed fracture, which has been artificially broken	6		1		
9954438B2B15D765	KLX04	x	-359,15	385,1300	382,8210	Broken	Open	0,5	Possible	Irregular	Rough	Fresh	Granite to quartz monzodiorite, generally porphyritic	RSMA01		RU1	331,8	73,6	Mineral coating exist (greenish probably chlorite and pyrite)	6		64		
6B95438B2B12310C	KLX05	x	-111,331	143,527	143,628	Broken	Open	0,5	Probable	Planar	Rough	Fresh	Granite to quartz monzodiorite, generally porphyritic	RSMM01	FSM_NE005	RU1	284	75	10 cm to uptake, rotated core, no visible minerals. Is this PFL best choice, may need adjustment.	5	Yes	2, 3		Yes
F3D5438B2B13B3F5	KLX05	x	-200,17	242,8080	242,6770	Broken	Open	0,5	Possible	Planar	Rough	Fresh	Granite, medium- to coarse-grained	RSMM01		RU2	296,6	77,0	Mineral coating exist. Unknown mineral (sheet like mineral) rather than X7.	6				
AC16438B2B140793	KLX06	x	-220,86	265,1430	264,0830	Broken	Open	0,5	Probable	Planar	Rough	Fresh	Granite to quartz monzodiorite, generally porphyritic	RSMA01		RU2	121,0	8,0	Mineral coating exist. Clay minerals. No X7. This was an erroneously inspected fracture since it is not a X7-coded but x8-coded fracture	6		66		
2A56438B2B142061	KLX06	x	-226,53	271,5150	270,4330	Broken	Open	0,5	Probable	Planar	Rough	Fresh	Granite to quartz monzodiorite, generally porphyritic	RSMA01		RU2	97,0	22,3	No visible mineral coating.	5	Yes	67		Yes
77D6438B2B14275B	KLX06	x	-228,12	273,3080	272,2190	Broken	Open	0,5	Probable	Planar	Rough	Fresh	Granite to quartz monzodiorite, generally porphyritic	RSMA01		RU2	49,8	18,3	Mineral coating exist. Calcite and chlorite. No X7.	6		68		
B556438B2B142C0C	KLX06	x	-229,19	274,5130	273,4200	Broken	Open	0,5	Certain	Planar	Rough	Fresh	Granite to quartz monzodiorite, generally porphyritic	RSMA01		RU2	113,5	21,0	Mineral coating exist (possibly zeolites). No X7.	6		69		
4AD6438B2B147FD6	KLX06	x	-248,25	296,0370	294,8700	Broken	Open	0,5	Probable	Planar	Rough	Fresh	Granite to quartz monzodiorite, generally porphyritic	RSMA01		RU2	125,4	81,5	No visible minerals. Uptake 10 cm above.	5	Yes	71		Yes

Feature ID	Borehole	PFL	Elevation adjusted secup (meter)	adjusted secup (meter)	Recorded secup (meter)	Fract mapped	Fract interpret	Aperture	Confidence	Roughness	Surface	Fract alteration	Rock name	Rock domain	Fracture domain	Rock unit	Strike	Dip	Inspection Comment	Group	Sample	Photo-ID	Sampling Comment (ELT and HD)	Fracture minerals detected (SEM-EDS)
3016438B2B1886E6	KLX06	x	-474,51	561,0740	558,8220	Broken	Open	0,5	Probable	Planar	Rough	Fresh	Granite, medium- to coarse-grained	RSMA01		RU3	260,9	89,1	Vague indications of mineral coating, but difficult to say if it belongs to the rock or the fracture.	4	Yes	72		Yes
8196438B2B188B01	KLX06	x	-475,37	562,1280	559,8730	Broken	Open	0,5	Probable	Planar	Rough	Fresh	Granite, medium- to coarse-grained	RSMA01		RU3	260,3	71,2	Missing box.	10				
9397438B0A153081	KLX07A	x	-244,86	341,0260	340,0970	Broken	Open	0,5	Probable	Undulating	Rough	Fresh	Granite to quartz monzodiorite, generally porphyritic	RSMA01		RU1	218,6	83,9	Mineral coating probably exist, but needs to be further investigated. Rather unknown mineral than X7	4	Yes	73		Yes
A717438B0A1607CC	KLX07A	x	-284,45	396,3190	395,2120	Broken	Open	0,5	Probable	Planar	Rough	Fresh	Granite to quartz monzodiorite, generally porphyritic	RSMA01		RU1	299,9	74,4	Fracture surface do not look fresh, but it is difficult to say if it is left overs from the drilling or actual mineral coating.	4	Yes	74		Yes
B817438B0A17BBEE	KLX07A	x	-365,24	508,4000	506,8620	Broken	Open	0,5	Probable	Undulating	Rough	Fresh	Granite to quartz monzodiorite, generally porphyritic	RSMA01		RU2	114,0	80,3	Mineral coating exists: pyrite. No X7	6		76		
7B57438B0A17EAC1	KLX07A	x	-374,57	520,4430	518,8490	Broken	Open	0,5	Probable	Undulating	Rough	Fresh	Granite to quartz monzodiorite, generally porphyritic	RSMA01		RU2	286,8	82,3	Mineral coating exists: calcite. No X7	6		77		
B9D7438B09126F5D	KLX07B	x	-141,358	160,333	159,581	Broken	Open	0,5	Probable	Undulating	Rough	Fresh	Granite to quartz monzodiorite, generally porphyritic	RSMA01		RU3	98	89	Natural fracture, partly mineralized	4		5, 6	Amphiboles are not fresh	
8E97438B0912748C	KLX07B	x	-142,687	161,667	160,908	Broken	Open	0,5	Possible	Undulating	Rough	Fresh	Granite to quartz monzodiorite, generally porphyritic	RSMA01		RU3	231	82	Part of the same system as KLX07B:159,581. Amphiboles are not totally fresh. Partly coated.	4		7	Tiny pyrites visible	
4CD8438B2B149FB3	KLX08	x	-238,74	303,9120	303,0270	Broken	Open	1,5	Certain	Planar	Rough	Fresh	Granite to quartz monzodiorite, generally porphyritic	RSMA01		RU1	302,4	81,2	Mineral coating probably exists. Unknown mineral rather than X7.	4	Yes	78		Yes
2098438B2B158076	KLX08	x	-288,45	361,7010	360,5660	Broken	Open	0,5	Probable	Planar	Rough	Fresh	Granite to quartz monzodiorite, generally porphyritic	RSMA01		RU1	1,9	2,3	Some material missing. Mineral coating probably exist. Unknown mineral rather than X7.	4	Yes	79		Yes
14D8438B2B177925	KLX08	x	-399,83	491,4530	489,7650	Broken	Open	0,5	Possible	Undulating	Rough	Fresh	Granite to quartz monzodiorite, generally porphyritic	RSMA01		RU1	306,0	78,2	Mineral coating exist (possibly apophyllite). Unknown mineral rather than X7.	6	Yes	80		Yes
83D8438B2B18DA66	KLX08		-477,662	582,346	580,198	Unbroken	Sealed	0	Certain			Slightly Altered	Granite to quartz monzodiorite, generally porphyritic	RSMA01	FSM_EW007	RU1	28	15	Sealed fracture with mineral, erronously mapped fracture	6		8		
2C98438B2B194C97	KLX08		-502,808	611,729	609,431	Unbroken	Sealed	0	Certain			Slightly Altered	Diorite to gabbro				6	64	Impossible to locate the correct fracture	8				
9319438B2B13F79F	KLX09		-235,455	260,712	259,999	Unbroken	Sealed	0	Certain			Slightly Altered	Granite to quartz monzodiorite, generally porphyritic	RSMA01	FSM_N	RU1a	344	12	Mineral coating exist	6		9, 10		

Feature ID	Borehole	PFL	Elevation adjusted secup (meter)	adjusted secup (meter)	Recorded secup (meter)	Fract mapped	Fract interpret	Aperture	Confidence	Roughness	Surface	Fract alteration	Rock name	Rock domain	Fracture domain	Rock unit	Strike	Dip	Inspection Comment	Group	Sample	Photo-ID	Sampling Comment (ELT and HD)	Fracture minerals detected (SEM-EDS)
9299438B2B1516C4	KLX09		-308,719	334,548	333,508	Broken	Open	0,5	Probable	Undulating	Rough	Slightly Altered	Granite to quartz monzodiorite, generally porphyritic	RSMA01	FSM_N	RU2	109	72	Mineral coating exist	6		11	possible calcite and quartz	
6299438B2B15CB0A	KLX09		-354,709	380,885	379,658	Unbroken	Sealed	0	Certain			Slightly Altered	Mafic rock, fine-grained	RSMA01	FSM_N	RU2	209	15	Sealed fracture with mineral, difficult to say what kind of mineral filling	6		12, 13	possibly epidote	
B399438B2B164BF8	KLX09		-387,612	414,028	412,664	Unbroken	Sealed	0	Certain			Slightly Altered	Granite to quartz monzodiorite, generally porphyritic	RSMA01	FSM_N	RU3	319	7	Missing box	10			possibly epidote	
DF19438B2B191189	KLX09		-568,535	596,27	594,313	Unbroken	Sealed	0	Certain			Slightly Altered	Granite to quartz monzodiorite, generally porphyritic	RSMA01	FSM_EW007	RU6	243	17	Missing box	10			possible hematite and chlorite	
5B59438B2B19CC33	KLX09		-616,119	644,196	642,099	Unbroken	Sealed	0	Certain			Slightly Altered	Diorite to gabbro	RSMA01	FSM_EW007	RU6	29	41	Very fine and thin fractures. Sealed fracture with mineral, probably epidote	6		14	calcite, pyrite, kfsp, fluorite	
2659438B2B1C4A46	KLX09		-778,989	808,235	805,446	Unbroken	Sealed	0	Certain			Slightly Altered	Granite to quartz monzodiorite, generally porphyritic	RSMA01	FSM_EW007	RU8	222	73	Very fine and thin fractures. Sealed fracture with mineral, probably calcite and quartz	6		15		
9099438B2B1C4DC9	KLX09		-779,886	809,139	806,345	Unbroken	Sealed	0	Certain			Slightly Altered	Granite to quartz monzodiorite, generally porphyritic	RSMA01	FSM_EW007	RU8	345	58	Very fine and thin fractures. Sealed fracture with mineral, probably hematite, chlorite	6		16		
AAD9438B2B1C5646	KLX09		-782,055	811,323	808,518	Unbroken	Sealed	0	Certain			Slightly Altered	Granite to quartz monzodiorite, generally porphyritic	RSMA01	FSM_EW007	RU8	197	62	Missing box	10				
1E59438B2B1C9880	KLX09		-798,983	828,37	825,472	Unbroken	Sealed	0	Certain			Slightly Altered	Granite to quartz monzodiorite, generally porphyritic	RSMA01	FSM_EW007	RU1c	135	36	Missing box	10				
FC10478B2B145053	KLX10	x	-263,68	284,2450	282,7070	Broken	Open	2,0	Certain	Planar	Rough	Fresh	Granite to quartz monzodiorite, generally porphyritic	RSMA01		RU1	263,5	21,4	Probably some mineral coating, but difficult to tell without SEM/microscopy.	4	Yes	81		Yes
60D0478B2B1BFBFF	KLX10		-764,894	788,833	785,407	Unbroken	Sealed	0	Certain			Slightly Altered	Granite to quartz monzodiorite, generally porphyritic	RSMA01	FSM_C	RU5	246	2	Erronously mapped, no fracture exist in the core	8		17		
3CD0478B2B1CF3D0	KLX10		-828,173	852,566	848,848	Unbroken	Sealed	0	Certain			Slightly Altered	Granite to quartz monzodiorite, generally porphyritic	RSMA01	FSM_C	RU3c	341	87	Missing box	10				
79D0478B2B1E7FDE	KLX10		-929,281	954,385	950,238	Unbroken	Sealed	0	Certain			Slightly Altered	Diorite to gabbro	RSMM01	FSM_C	RU7	101	36	Missing box	10				
BDD0478B2B1EAA19	KLX10		-940,069	965,245	961,049	Unbroken	Sealed	0	Certain			Slightly Altered	Granite to quartz monzodiorite, generally porphyritic	RSMM01	FSM_C	RU7	171	10	Missing box	10				
A0D1478B0F1038F6	KLX11D		13,129	14,553	14,582	Unbroken	Sealed	0	Certain			Fresh	Quartz monzonite to monzodiorite, equigranular to weakly porphyritic		RSMD01	FSM_W	352	10	No fracture exist (also commented in Boremap)	8		18		
C093478B0A16F4AE	KLX13A	x	-427,11	454,8330	455,8540	Broken	Open	0,5	Probable	Undulating	Rough	Fresh	Granite to quartz monzodiorite,	RSMM01		RU2	14,9	63,8	Mixed up fractures, this fracture contain	6		38, 39, 40		

Feature ID	Borehole	PFL	Elevation adjusted secup (meter)	adjusted secup (meter)	Recorded secup (meter)	Fract mapped	Fract interpret	Aperture	Confidence	Roughness	Surface	Fract alteration	Rock name	Rock domain	Fracture domain	Rock unit	Strike	Dip	Inspection Comment	Group	Sample	Photo-ID	Sampling Comment (ELT and HD)	Fracture minerals detected (SEM-EDS)
													generally porphyritic						calcite. No X7					
6093478B0A17138D	KLX13A	x	-434,96	462,7470	463,7570	Broken	Open	4,0	Certain	Planar	Rough	Fresh	Granite to quartz monzodiorite, generally porphyritic	RSMA01		RU3	337,0	46,2	Mixed up fractures, this fracture contains minerals (possibly calcite). No X7	6		44		
6093478B0A171D45	KLX13A	x	-437,44	465,2390	466,2450	Broken	Open	4,0	Certain	Undulating	Rough	Fresh	Granite to quartz monzodiorite, generally porphyritic	RSMA01		RU3	62,0	74,5	Sharpening of the drill bit close by. No visible minerals.	5	Yes	45, 46		Yes
4093478B0A1720BE	KLX13A	x	-438,32	466,1290	467,1340	Broken	Open	7,0	Certain	Undulating	Rough	Slightly Altered	Granite to quartz monzodiorite, generally porphyritic	RSMA01		RU3	96,4	87,8	Indications of mineral coating, but difficult to say if it is part of the rock or the fracture. May need PFL adjustmen - fracture below (466,277 m adjusted) is a more likely PFL (which is mineral coated). Strange fracture, very gentle dipping.	4		47		
2093478B0A173268	KLX13A	x	-442,81	470,6580	471,6560	Broken	Open	3,0	Certain	Planar	Rough	Fresh	Granite to quartz monzodiorite, generally porphyritic	RSMA01		RU3	5,6	65,1	No visible minerals	5	Yes	41		Yes
4093478B0A173BB1	KLX13A	x	-445,18	473,0380	474,0330	Broken	Open	2,0	Certain	Undulating	Rough	Fresh	Granite to quartz monzodiorite, generally porphyritic	RSMA01		RU3	327,9	84,6	Indications of mineral coating. Drilling disturbances, which makes it difficult to interpret the fracture.	4		48		
C093478B0A1746AD	KLX13A	x	-447,97	475,8540	476,8450	Broken	Open	1,0	Certain	Planar	Rough	Slightly Altered	Granite to quartz monzodiorite, generally porphyritic	RSMA01		RU3	359,6	24,4	Mineral coating exist: calcite. No X7.	6		49, 50		
E093478B0A17520E	KLX13A	x	-450,86	478,7710	479,7580	Broken	Open	2,0	Certain	Planar	Rough	Fresh	Granite to quartz monzodiorite, generally porphyritic	RSMA01		RU3	333,0	50,9	Detectable mineral = Calcite visible	6		42		
3316478B0A204F5F	KLX16A		0,435	20,33	20,319	Unbroken	Sealed	0	Certain			Slightly Altered	Quartz monzonite to monzodiorite, equigranular to weakly porphyritic	RSMD01	FSM_S	RU1	18	46	Sealed fracture with mineral coating (brownish mineral)	6		19		
0156478B0A229071	KLX16A		-133,341	168,361	168,049	Unbroken	Sealed	0				Slightly Altered	Quartz monzonite to monzodiorite, equigranular to weakly porphyritic	RSMD01	FSM_S	RU1	343	24	Sealed fracture with mineral coating	6		20	Brownish mineral	
5197478B0A21B7D6	KLX17A	x	-71,254	113,041	112,598	Broken	Open	0,5	Probable	Undulating	Rough	Slightly Altered	Granite to quartz monzodiorite, generally porphyritic	RSMM01		RU1	136	44	Box missing for pore water sampling John Smellie	10				
4B17478B0A21B7EF	KLX17A	x	-71,276	113,066	112,623	Broken	Open	2	Certain	Undulating	Rough	Slightly Altered	Granite to quartz monzodiorite, generally porphyritic	RSMM01		RU1	148	41	Box missing for pore water sampling John Smellie	10				

Feature ID	Borehole	PFL	Elevation adjusted secup (meter)	adjusted secup (meter)	Recorded secup (meter)	Fract mapped	Fract interpret	Aperture	Confidence	Roughness	Surface	Fract alteration	Rock name	Rock domain	Fracture domain	Rock unit	Strike	Dip	Inspection Comment	Group	Sample	Photo-ID	Sampling Comment (ELT and HD)	Fracture minerals detected (SEM-EDS)
4557478B0A21B7F2	KLX17A	x	-71,278	113,069	112,626	Broken	Open	7	Certain	Undulating	Rough	Slightly Altered	Granite to quartz monzodiorite, generally porphyritic	RSMM01		RU1	134	52	Box missing for pore water sampling John Smellie	10				
5957478B0A21B811	KLX17A	x	-71,305	113,1	112,657	Broken	Open	0,5	Probable	Undulating	Rough	Slightly Altered	Granite to quartz monzodiorite, generally porphyritic	RSMM01		RU1	148	30	Box missing for pore water sampling John Smellie	10				
AD57478B0A21BF76	KLX17A		-72,952	114,987	114,55	Unbroken	Sealed	0	Certain			Slightly Altered	Granite to quartz monzodiorite, generally porphyritic	RSMM01	FSM_W	RU1	109	67	Box missing for pore water sampling John Smellie	10				
BCD7478B0A21C000	KLX17A		-73,073	115,125	114,688	Unbroken	Sealed	0	Certain			Slightly Altered	Granite to quartz monzodiorite, generally porphyritic	RSMM01	FSM_W	RU1	87	69	Box missing for pore water sampling John Smellie	10				
C097478B0A21C131	KLX17A		-73,338	115,429	114,993	Unbroken	Sealed	0	Certain			Slightly Altered	Granite to quartz monzodiorite, generally porphyritic	RSMM01	FSM_W	RU1	91	49	Box missing for pore water sampling John Smellie	10				
C4D7478B0A21C207	KLX17A		-73,524	115,642	115,207	Broken	Open	0,5	Probable	Planar	Rough	Slightly Altered	Granite to quartz monzodiorite, generally porphyritic	RSMM01	FSM_W	RU1	113	41	Box missing for pore water sampling John Smellie	10				
FFD7478B0A21C219	KLX17A		-73,540	115,66	115,225	Broken	Open	0,5	Probable	Planar	Rough	Slightly Altered	Granite to quartz monzodiorite, generally porphyritic	RSMM01	FSM_W	RU1	86	24	Box missing for pore water sampling John Smellie	10				
E957478B0A21C38C	KLX17A		-73,862	116,03	115,596	Broken	Open	0,5	Probable	Undulating	Rough	Slightly Altered	Granite to quartz monzodiorite, generally porphyritic	RSMM01	FSM_W	RU1	97	63	Box missing for pore water sampling John Smellie	10				
F2D7478B0A21C3A8	KLX17A		-73,887	116,058	115,624	Broken	Open	0,5	Probable	Undulating	Rough	Slightly Altered	Granite to quartz monzodiorite, generally porphyritic	RSMM01	FSM_W	RU1	85	61	Box missing for pore water sampling John Smellie	10				
F997478B0A21C5CE	KLX17A		-74,365	116,606	116,174	Unbroken	Sealed	0	Certain			Slightly Altered	Granite to quartz monzodiorite, generally porphyritic	RSMM01	FSM_W	RU1	135	54	Box missing for pore water sampling John Smellie	10				
33D7478B0A21C929	KLX17A		-75,112	117,462	117,033	Broken	Open	0,5	Probable	Undulating	Rough	Slightly Altered	Granite to quartz monzodiorite, generally porphyritic	RSMM01	FSM_W	RU1	118	53	Box missing for pore water sampling John Smellie	10				
3E97478B0A21CB96	KLX17A		-75,652	118,081	117,654	Unbroken	Sealed	0	Certain			Slightly Altered	Granite to quartz monzodiorite, generally porphyritic	RSMM01	FSM_W	RU1	152	78	Box missing for pore water sampling John Smellie	10				
67D7478B0A21D092	KLX17A		-76,763	119,353	118,93	Broken	Open	0,5	Probable	Undulating	Rough	Slightly Altered	Granite to quartz monzodiorite, generally porphyritic	RSMM01	FSM_W	RU1	58	66	Mineral coating exist - calcite, chlorite, pyrite	6		21		
A9D7478B0A21D4EF	KLX17A		-77,734	120,466	120,047	Unbroken	Sealed	0	Certain			Slightly Altered	Granite to quartz monzodiorite, generally porphyritic	RSMM01	FSM_W	RU1	62	82	No fracture exist	8		22		
AE17478B0A21D5A0	KLX17A		-77,888	120,643	120,224	Unbroken	Sealed	0	Certain			Slightly Altered	Granite to quartz monzodiorite, generally porphyritic	RSMM01	FSM_W	RU1	35	86	Core missing	10				

Feature ID	Borehole	PFL	Elevation adjusted secup (meter)	adjusted secup (meter)	Recorded secup (meter)	Fract mapped	Fract interpret	Aperture	Confidence	Roughness	Surface	Fract alteration	Rock name	Rock domain	Fracture domain	Rock unit	Strike	Dip	Inspection Comment	Group	Sample	Photo-ID	Sampling Comment (ELT and HD)	Fracture minerals detected (SEM-EDS)
B1D7478B0A21D717	KLX17A		-78,214	121,016	120,599	Unbroken	Sealed	0	Certain			Slightly Altered	Granite to quartz monzodiorite, generally porphyritic	RSMM01	FSM_W	RU1	132	87	Core missing	10				
1F97478B0A21D9E3	KLX17A		-78,837	121,73	121,315	Broken	Open	0,5	Probable	Planar	Rough	Slightly Altered	Granite to quartz monzodiorite, generally porphyritic	RSMM01	FSM_W	RU1	84	71	Mineral coating exist: clay minerals, pyrite, chlorite	6		23		
E317478B0A21DDD9	KLX17A		-79,719	122,741	122,329	Unbroken	Sealed	0	Certain			Slightly Altered	Granite to quartz monzodiorite, generally porphyritic	RSMM01	FSM_W	RU1	250	82	Mineral coating exist: quartz, fsp, calcite. Fracture or part of the rock?	6		24		
3497478B0A21F03D	KLX17A		-83,813	127,433	127,037	Broken	Open	1	Certain	Undulating	Rough	Slightly Altered	Granite to quartz monzodiorite, generally porphyritic	RSMM01	FSM_W	RU1	66	81	Mineral coating exist: chlorite, pyrite, calcite	6		25		
3C17478B0A21F4AD	KLX17A		-84,801	128,566	128,173	Unbroken	Sealed	0	Certain			Slightly Altered	Granite to quartz monzodiorite, generally porphyritic	RSMM01	FSM_W	RU1	105	31	Core missing	10				
5917478B0A21FAED	KLX17A		-86,193	130,161	129,773	Unbroken	Sealed	0	Certain			Slightly Altered	Diorite to gabbro	RSMM01	FSM_W	RU1	245	41	Mineral coating exist: calcite	6		26		
5957478B0A21FB22	KLX17A		-86,238	130,213	129,826	Broken	Open	0,5	Probable	Planar	Rough	Slightly Altered	Diorite to gabbro	RSMM01	FSM_W	RU1	125	86	Mineral coating exist: calcite, chlorite, pyrite	6		27		
65D7478B0A21FB68	KLX17A		-86,299	130,283	129,896	Broken	Open	0,5	Probable	Planar	Rough	Slightly Altered	Diorite to gabbro	RSMM01	FSM_W	RU1	72	39	Mineral coating exist: calcite, chlorite, pyrite	6		28		
7197478B0A21FCE4	KLX17A		-86,630	130,662	130,276	Unbroken	Sealed	0	Certain			Slightly Altered	Diorite to gabbro	RSMM01	FSM_W	RU1	6	74	Mineral coating exist. Calcite, chlorite, epidote	6		29		
A4D7478B0A21FD1E	KLX17A		-86,680	130,72	130,334	Unbroken	Sealed	0	Certain			Slightly Altered	Diorite to gabbro	RSMM01	FSM_W	RU1	196	79	Mineral coating exist. Calcite, chlorite, epidote	6		29		
A997478B0A21FE38	KLX17A		-86,926	131,001	130,616	Unbroken	Sealed	0	Certain			Slightly Altered	Diorite to gabbro	RSMM01	FSM_W	RU1	167	83	Barely visible fracture	7		30		
3417478B0A220456	KLX17A		-88,287	132,562	132,182	Unbroken	Sealed	0	Certain			Slightly Altered	Diorite to gabbro	RSMM01	FSM_W	RU1	342	89	Part of the rock	8		31		
38D7478B0A220520	KLX17A		-88,462	132,763	132,384	Unbroken	Sealed	0	Certain			Slightly Altered	Diorite to gabbro	RSMM01	FSM_W	RU1	30	60	Part of the rock	8		32		
53D7478B0A2207AF	KLX17A		-89,032	133,416	133,039	Unbroken	Sealed	0	Certain			Slightly Altered	Diorite to gabbro	RSMM01	FSM_W	RU1	19	28	Core missing	10				
5C97478B0A2207C7	KLX17A		-89,053	133,44	133,063	Unbroken	Sealed	0	Certain			Slightly Altered	Diorite to gabbro	RSMM01	FSM_W	RU1	238	16	Core missing	10				
5817478B0A2207E7	KLX17A		-89,081	133,472	133,095	Unbroken	Sealed	0	Certain			Slightly Altered	Diorite to gabbro	RSMM01	FSM_W	RU1	138	12	Core missing	10				
8098478B0A14B6C6	KLX18A	x	-284,49	309,5030	308,9340	Broken	Open	0,5	Possible	Planar	Rough	Fresh	Granite to quartz monzodiorite, generally porphyritic	RSMM01		RU2	######	####	Indications of mineral coating. No X7.	6	Yes	52		Yes
2098478B0A151B59	KLX18A	x	-309,92	335,3270	334,6810	Broken	Open	0,5	Possible	Planar	Rough	Fresh	Granite to quartz monzodiorite, generally porphyritic	RSMM01		RU2	######	####	Missing box	10				
0098478B0A1540D8	KLX18A	x	-319,40	344,9540	344,2800	Broken	Open	0,5	Possible	Planar	Rough	Fresh	Granite to quartz monzodiorite, generally porphyritic	RSMA01		RU1b	######	####	Mineral coating exist: pyrite. No X7	6		53		
8098478B0A15D2C5	KLX18A	x	-356,34	382,4700	381,6370	Broken	Open	0,5	Possible	Stepped	Rough	Fresh	Granite to quartz monzodiorite, generally porphyritic	RSMA01		RU1b	######	####	Vague indications of mineral coating.	4	Yes	54		Yes
6098478B0A15E888	KLX18A	x	-361,85	388,0660	387,2080	Broken	Open	0,5	Probable	Planar	Rough	Fresh	Granite to quartz monzodiorite, generally	RSMA01		RU1b	######	####	Indications of mineral coating: pyrite. No X7	6		56		

Feature ID	Borehole	PFL	Elevation adjusted secup (meter)	adjusted secup (meter)	Recorded secup (meter)	Fract mapped	Fract interpret	Aperture	Confidence	Roughness	Surface	Fract alteration	Rock name	Rock domain	Fracture domain	Rock unit	Strike	Dip	Inspection Comment	Group	Sample	Photo-ID	Sampling Comment (ELT and HD)	Fracture minerals detected (SEM-EDS)
													porphyritic											
4098478B0A1668A8	KLX18A	x	-394,29	421,0060	420,0080	Broken	Open	0,5	Probable	Planar	Rough	Fresh	Granite to quartz monzodiorite, generally porphyritic	RSMA01		RU1b	######	####	No visible mineral coating.	5	Yes	57		Yes
2098478B0A16737C	KLX18A	x	-397,03	423,7890	422,7800	Broken	Open	4,0	Certain	Planar	Rough	Fresh	Granite to quartz monzodiorite, generally porphyritic	RSMA01		RU1b	######	####	Drilling disturbances. Indications of mineral coating: pyrite.	2		58, 59		
8098478B0A171FDD	KLX18A	x	-440,64	468,0790	466,9090	Broken	Open	0,5	Probable	Planar	Rough	Fresh	Granite to quartz monzodiorite, generally porphyritic	RSMA01		RU1b	######	####	No visible mineral coating, but maybe pyrite.	5	Yes	60		Yes
E098478B0A187193	KLX18A	x	-526,04	554,8150	553,3630	Broken	Open	0,5	Probable	Planar	Rough	Fresh	Granite to quartz monzodiorite, generally porphyritic	RSMA01		RU1b	######	####	Indications of mineral coating, but difficult to say what kind of minerals. Probably no X7.	4	Yes	8		Yes
A099478B0A1A6EDE	KLX19A	x	-556,60	684,4950	683,7420	Broken	Open	1,0	Certain	Undulating	Rough	Fresh	Quartz monzonite to monzodiorite, equigranular to weakly porphyritic	RSMD01		RU1c	######	####	Mineral coating may exist, need to be investigated.	4	Yes	82		Yes
0099478B0A1A6FE7	KLX19A	x	-556,82	684,7590	684,0070	Broken	Open	1,0	Certain	Undulating	Rough	Fresh	Quartz monzonite to monzodiorite, equigranular to weakly porphyritic	RSMD01		RU1c	######	####	Mineral coating exist: chlorite, pyrite. No X7.	6		84		
2099478B0A1B2E84	KLX19A	x	-597,45	733,6040	732,8040	Broken	Open	0,5	Probable	Undulating	Rough	Fresh	Quartz monzonite to monzodiorite, equigranular to weakly porphyritic	RSMD01		RU1c	######	####	Mineral coating probably exist, but needs to be further investigated.	4	Yes	85		Yes
C0D04B8B0A163B80	KLX20A		-279,016	409,74	408,448	Unbroken	Sealed	0	Certain			Slightly Altered	Quartz monzonite to monzodiorite, equigranular to weakly porphyritic	RSMD01		RU1b	326	65	Part of the rock	8		33		
C0D04B8B0A166163	KLX20A		-285,667	419,476	418,147	Unbroken	Sealed	0	Certain			Slightly Altered	Quartz monzonite to monzodiorite, equigranular to weakly porphyritic	RSMD01		RU1b	13	61	Missing box	10				
BF514B8B0916DFFF	KLX21B		-410,314	450,738	450,559	Unbroken	Sealed	0	Certain			Slightly Altered	Granite to quartz monzodiorite, generally porphyritic	RSMA01	FSM_NE005	RU6a	199	41	Mineral coating exist	6		34		
C0924B8B0A1023DA	KLX22A		14,007	9,167	9,178	Broken	Open	4	Certain	Planar	Rough	Fresh	Quartz monzonite to monzodiorite, equigranular to weakly porphyritic	RSMD01	FSM_W	RU1	270	15	Clearly visible fracture with mineral coating: calcite, kfsp	6		35, 36		
C0964B8B0A1080C3	KLX26A	x	-13,027	32,971	32,963	Broken	Open	0,5	Probable	Undulating	Rough	Slightly Altered	Granite, fine- to medium-grained	RSMM01	FSM_NE005	RU2	335	20	Material missing due to drilling	2		37		
20964B8B0A1080F4	KLX26A	x	-13,070	33,02	33,012	Broken	Open	0,5	Probable	Undulating	Rough	Slightly Altered	Granite, fine- to medium-grained	RSMM01	FSM_NE005	RU2	309	11	Material missing due to drilling	2		37		
40964B8B0A1081A9	KLX26A		-13,227	33,201	33,193	Broken	Open	0,5	Possible	Undulating	Rough	Slightly Altered	Granite, fine- to medium-grained	RSMM01	FSM_NE005	RU2	228	88	Material missing due to drilling	2		37		