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Boremap mapping of core drilled borehole KFM25, KFM26 and KFM27

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Summary

This report presents the geological mapping of the core drilled boreholes KFM25, KFM26 and KFM27, drilled in the area of Forsmark nuclear power station. Each borehole is approximately 100 m long with a subvertical inclination. The main purpose of the boreholes is to measure and monitor the changes in water pressure during the construction of the repository access, but the mapping will also gain information to the current geological understanding.

The boreholes were mapped by the mapping Boremap system, which integrates information from the drill core with an OPTV-image to calculates the position and orientation of mapped structures.

The dominating rock type in all three boreholes is fine- to medium-grained metagranite (rock code 101057). The metagranite in KFM25 and KFM26 has a reddish grey color while the metagranite in KFM27 is whiteish grey with parts of more pale appearance and grain-size reduction due to albitization.

Subordinated rock types are pegmatite to pegmatitic granite (rock code 101061) and amphibolite (rock code 102017).

In addition, rock occurrences (rock types < 1 m in borehole length) of pegmatite (rock code 101061), amphibolite (rock code 102017), metagranite (rock code 101057), metagranitoid (rock code 101051), granite (rock code 111058), quartz-dominated hydrothermal veins (rock code 8021) and aplites (rock code (1062) occur sporadically in all three boreholes.

In KFM25 and KFM26 there are minor occurrences of chloritization and albitization of rock contacts in association with amphibolite and some additional short intervals of oxidation. In KFM27 albitization is the only alteration and is affecting the whole borehole length.

The foliation in the three boreholes strikes in an SSE direction dipping steeply towards the west.

Fracture frequencies for open and sealed fractures in KFM25 are 1.9 and 2.1 fractures/m, 2.2 and 3.3 fractures/m for KFM26 and 4.2 and 5.9 fractures/m for KFM27.

The most frequent fracture fillings in both open and sealed fractures for all three boreholes, but in different proportions, are calcite, chlorite, oxidized walls and fractures with no detectable mineral.

The orientation of both open and sealed fractures in KFM25, KFM26 and KFM27 show a pronounced set of horizontal to gently dipping fractures.

A total of 9 crush zones are registered in the three boreholes. The most extensive crush zone is found in KFM27 at 66.44–67.03 m with infillings of chlorite, clay minerals and hematite.

Sammanfattning

Denna rapport presenterar resultatet från Boremap-karteringen av kärnborrhålen KFM25, KFM26 och KFM27 som borrats i området för Forsmark kärnkraftverk. Borrhålen är ca 100 m långa vardera med subvertikal inklination.

Det huvudsakliga syftet med borrhålen är att mäta och övervaka förändringar i vattentrycket under byggtiden för slutförvaret , men karteringen av borrhålen bidrar även med information till den geologiska platsförståelsen.

Borrhålen karterades med Boremap-systemet, som integrerar information från borrkärnan med OPTV-bilden för att beräkna läge och orientering för karterade strukturer.

Den dominerande bergarten i alla tre borrhålen, KFM25, KFM26 och KFM27, är fin- till medelkornig metagranit (bergartskod 101057). Metagraniten i KFM25 och KFM26 har en röd-grå färg medans metagraniten i KFM27 är vit-grå med ställvis blekt utseende och kornstorleksförminskning pga albitisering.

Underordnade bergarter är pegmatit till pegmatitisk granit (bergartskod 101061) and amfibolit (bergartskod 102017).

Dessutom förekommer mindre bergartsförekomster (bergarter < 1 m i borrhålslängd) av pegmatit (bergartskod 101061), amfibolit (bergartskod 102017), metagranit (bergartskod 101057), metagranitoid (bergartskod 101051), granit (bergartskod 111058), kvartsdominerade hydrotermala ådror (bergartskod 8021) och apliter (bergartskod 1062) sporadiskt i alla tre borrhålen.

I KFM25 och KFM26 förekommer kortare intervall med kloritomvandling och albitisering i samband med amfibolit samt ett par korta intervall med oxidation. Albitisering är den enda förekommande omvandlingen i KFM27 men påverkar hela borrhålslängden.

Foliationen i de tre borrhålen stryker i en SSO-riktning och stupar brant mot väster.

Sprickfrekvensen för öppna och läkta sprickor i KFM25 är 1,9 respektive 2,1 sprickor/m, 2,2 respektive 3,3 sprickor/m för KFM26 och 4,2 respektive 5,9 sprickor/m för KFM27.

De vanligaste sprickmineralen i både öppna och läkta sprickor är i alla tre borrhålen, men i olika förhållanden, kalcit, klorit, oxiderade väggar och sprickor utan detekterbart mineral.

Orienteringen av både öppna och läkta sprickor i KFM25, KFM26 och KFM27 visar en tydlig gruppering av horisontella till svagt stupande sprickor.

Totalt 9 krosszoner har registrerats i de tre borrhålen. Den mest omfattande krosszonen finns i KFM27 vid 66,44–67,03 m med klorit, lermineral och hematit.

Contents

1 Introduction

This report presents the result from mapping of the core drilled boreholes KFM25, KFM26 and KFM27, drilled in the area of Forsmarks nuclear power station, Figure 1-1.

The main purpose for the three boreholes KFM25, KFM26 and KFM27, which are approximately 100 m long each with a subvertical inclination, is to measure and monitor the changes in water pressure but will in addition also gain information to the current geological understanding.

The boreholes were drilled during the period of August to October 2019 and was after completion logged by Optical Televiewer (OPTV).

The boreholes were mapped in the period October to November 2019 with the Boremap system, which integrates information from the drill core with the OPTV-image to calculate the position and orientation of mapped structures.

Figure 1-1. *Location of the three boreholes KFM25, KFM26 and KFM27.*

Table 1-1 presents some technical information about the three boreholes.

Tabell 1-1. Technical information of the boreholes KFM25, KFM26 and KFM27.

KFM25	
Northing (m)	6698868.99 (SWEREF 99 18 00)
Easting (m)	159804.37 (SWEREF 99 18 00)
Elevation at top of casing (m)	2.66 (RH2000)
Bearing (°)	140
Inclination (°)	−84
Diameter (mm)	76
Length, core drilled part (m)	100.72
KFM26	
Northing (m)	6698941.42 (SWEREF 99 18 00)
Easting (m)	159726.47 (SWEREF 99 18 00)
Elevation at top of casing (m)	3.00 (RH200)
Bearing (°)	17–40
Inclination (°)	−86
Diameter (mm)	76
Length, core drilled part (m)	100.74
KFM27	
Northing (m)	6698854.47 (SWEREF 99 18 00)
Easting (m)	159597.05 (SWEREF 99 18 00)
Elevation at top of casing (m)	2.54 (RH2000)
Bearing (°)	323–328
Inclination (°)	−74
Diameter (mm)	76
Length, core drilled part (m)	100.64

2 Objective and scope

The purpose of the geological mapping of KFM25, KFM26 and KFM27 is to document all structures and lithologies in the drill cores for future integration with the hydrological characteristics of these boreholes.

This report describes the data obtained from the Boremap mapping of the three drill cores, which was performed and documented in accordance with the controlling documents listed in Table 2-1.

Tabell 2-1. Controlling documents for the performance of the activity.

Documents	Number	Version
Boremapkartering 300 m borkärna	AP SFK-19-020	1.0
Mätsystembeskrivning för Boremap	SKB MD 146.005	2.0
Metodbeskrivning för Boremapkartering	SKB MD 143.006	3.0
Nomenklatur vid Boremapkartering	SKB MD 143.008	1.0
Instruktion: Regler för bergarters benämningar vid platsundersökningen i Forsmark	SKB MD 132.005	1.0

3 Equipment

3.1 Description of equipment and interpretation tools

The core logging was performed with the mapping software Boremap v. 7.0.0.1. The bedrock and mineral standard used for surface mapping at the Forsmark investigation site is used to enable correlation with the surface geology. Measurements of orientation of planar structures (fractures, foliations, lithological contacts etc) are made on the linked OPTV-image of the borehole wall, and orientations of the structures are calculated by the Boremap system. Azimuth and inclination of the borehole and the borehole diameter are used as in-data for the orientation calculations.

Equipment used to facilitate the core mapping are folding rule, 10 % hydrochloric acid, hand lens, paint brush and water.

3.2 OPTV-image

Optical televiewer (OPTV) makes a digital scan of the borehole and provides a highly resolved and oriented image of the borehole wall in one plane (360°).

The horizontal resolution of the OPTV-images is 720 pixels/circle. The vertical resolution depends on the logging speed, but when exporting the images in the OPTV software to the file format used in Boremap, the resolution becomes 1 mm.

For KFM26 and KFM27 the OPTV-files are too dark for thin fractures to be visible. Therefore, light-adjusted jpg-images generated by the OPTV-software, was simultaneously studied to be able to see all fractures. The jpg-images also have the original vertical resolution generated during logging, ranging between 0.5 to 0.6 mm.

The borehole images of KFM25, KFM26 and KFM27 are presented in Appendix 1 and information about the used OPTV-files are listed in Table 3-1.

Table 3-1. Information about the used OPTV-files.

KFM25	
OPTV-file	KFM25 ner 190926_H_LGX.HED
Logging date	2019-09-26
From, recorded lenght (m)	1.55
To, recorded lenght (m)	100.44
KFM26	
OPTV-file	KFM26 Ner 191022_H_LGX_HED
Logging date	2019-10-22
From, recorded lenght (m)	1.55
To, recorded lenght (m)	100.91
KFM27	
OPTV-file	KFM27 Ner 191022_H_LGX.HED
Logging date	2019-10-22
From, recorded lenght (m)	1.56
To, recorded lenght (m)	100.85

4 Execution

4.1 General

Boremap mapping of the core drilled boreholes KFM25, KFM26 and KFM27 was performed and documented according to activity plan AP SFK-19-020 at SKB's core mapping facility in Forsmark.

Core mapping with the Boremap system is based on the use of OPTV-image of the borehole wall and the simultaneously study of the drill core. Orientations of fractures and structures, as well as apertures and widths wider than 0.5 mm, are measured in the OPTV-image.

4.2 Preparations

The drill cores are disposed in their entire length on roller tables in the core mapping facility in Forsmark.

The length adjustment of the OPTV-image is based on clearly identifiable geological reference features as fractures and rock contacts, which are identified both in the OPTV-image and the core, Table 4-1. KFM25 is logged with another shorter winch compared to KFM26 and KFM 27. This explains the more significant length adjustments for KFM25.

Background data necessary for calculations of structure orientations in Boremap include diameter and orientation of the boreholes. When starting a new mapping the id-code, azimuth and inclination of the borehole are directly imported from SICADA and the borehole diameter is manually entered in Boremap.

Table 4-1. Depth positions of geological objects and applied length adjustments in KFM25, KFM26 and KFM27.

Borehole	Recorded length (m)	Adjusted length (m)	Difference (m)
KFM25	6.48	6.50	0.02
	31.10	31.21	0.11
	46.85	47.06	0.21
	68.57	68.91	0.34
	83.24	83.68	0.44
	99.34	99.92	0.58
Borehole	**Recorded length (m)**	**Adjusted length (m)**	**Difference (m)**
KFM26	6.096	6.027	0.07
	10.22	10.15	0.07
	13.225	13.15	0.07
	20.04	19.96	0.08
	26.99	26.91	0.08
	32.87	32.78	0.09
	38.9	38.815	0.09
	45.04	44.965	0.07
	54.09	54.01	0.08
	62.24	62.15	0.09
	71.9	71.83	0.07
	77.11	77.00	0.11
	80.48	80.38	0.10
	85.17	85.05	0.12
	87.41	87.27	0.14
	90.05	89.885	0.16
	91.39	91.22	0.17
	95.52	95.34	0.18
	99.01	98.84	0.17
	100.37	100.205	0.17
	100.67	100.5	0.17

Borehole	Recorded length (m)	Adjusted length (m)	Difference (m)
KFM27	9.17	9.03	0.14
	9.69	9.55	0.14
	15.072	14.935	0.14
	21.134	21.015	0.12
	28.093	27.97	0.12
	40.157	40.045	0.11
	45.3	45.18	0.12
	54.067	53.925	0.14
	60.13	59.99	0.14
	71.08	70.935	0.14
	76.143	75.99	0.15
	80.02	79.85	0.17
	91.09	90.905	0.19
	94.27	94.095	0.17
	100.635	100.46	0.18

4.3 Fracture definitions

Two types of fractures, broken and unbroken, are registered in Boremap depending on whether the core is split through the core axis or not. In the SICADA database fractures with apertures > 0 mm are registered as open, and fractures with apertures = 0 mm are registered as sealed, Figure 4-1.

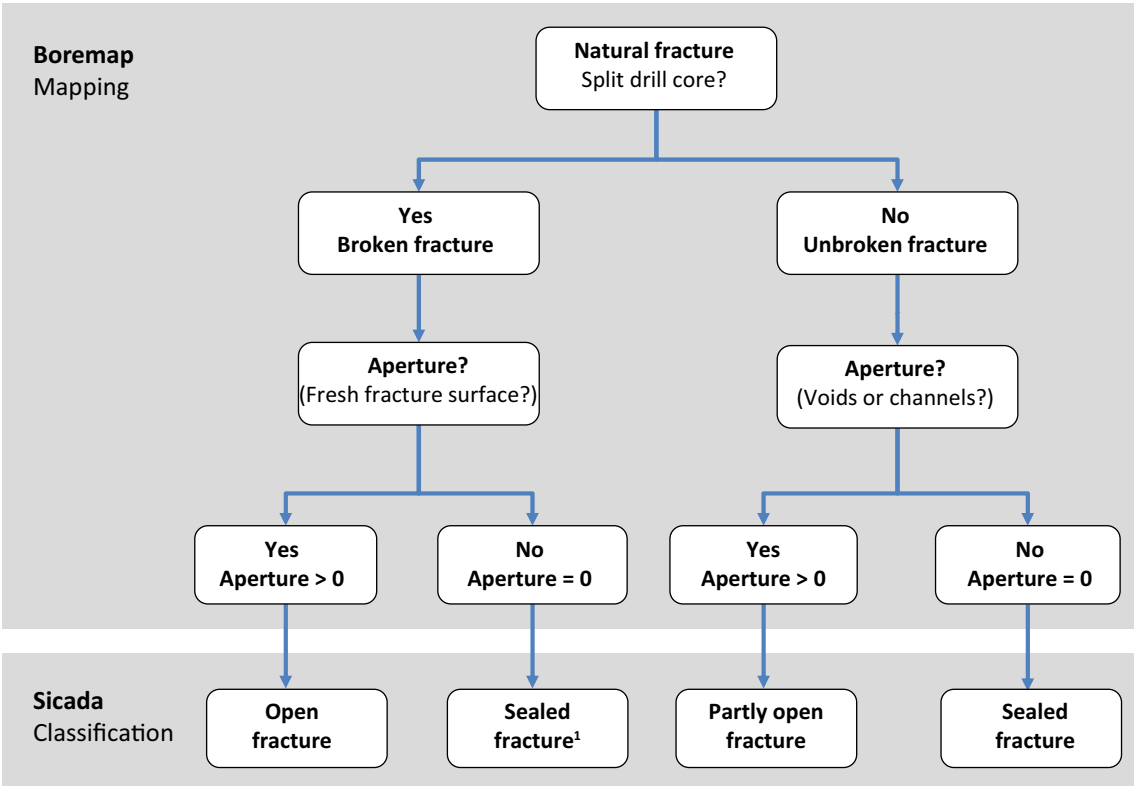


Figure 4-1. Connection between fracture concepts in Boremap and SICADA.

All fractures are described with their fracture minerals, width, aperture, roughness and alteration. To decide whether a fracture was open, partly open or sealed prior to drilling, the aperture confidence is expressed as “certain”, “probable” or “possible”. The confidence level depends on weathering of fracture surfaces, fit of the core pieces or if the fracture has a visible aperture in the OPTV-image.

Sealed networks are mapped in intervals with abundant sealed fractures that makes it difficult to discern individual fractures, or if they are too many to map individually within a reasonable time. The sealed networks are mapped with main fracture orientations, the most common minerals, alteration and the average fracture distance.

Crush zones are accumulations of open fractures where the drill core cannot be reconstructed or has such a high fracture frequency that detailed mapping is not possible. Crush zones are mapped with main fracture orientations, most common minerals, roughness and alteration of the fracture with the lowest strength in the crush zone and the average length of the core pieces.

4.4 Data handling

The mapping of KFM25, KFM26 and KFM27 is performed with automatic synchronization with SKB’s database SICADA. When the mapping is completed it is quality checked by the operator, the “Check mapping” routine in Boremap and a reviewer.

The Data from the reported activity are stored in SKB’s database SICADA and are also traceable by the Activity Plan number (AP SFK-19-020). Only data in the SICADA database are accepted for further interpretation and modelling. The data may be revised, if needed, but such revisions will not necessarily result in a revision of the P-report. However, the normal procedure is that major data revisions entail a revision of the P-report. Minor data revisions are normally presented as supplements, available at www.skb.se.

4.5 Non conformities

There is one core loss in KFM25 at 62.63–62.73 m and one in KFM27 at 77.83–77.87 m.

Due to the reaction with hydrochloric acid, calcite is detected even in very small amounts, whereas other minerals in the same fracture as calcite run the risk of getting underestimated, relative to calcite.

5 Results

5.1 KFM25

5.1.1 Lithology

96 % of the logged core consists of medium-grained metagranite (rock code 101057). The rock is rather equigranular with elongated quartz and feldspar and thin streaks of biotite. The color is greyish-red with varying intensity of the red color.

A short interval of amphibolitic rock (rock code 102017) occur at 47.07–48.57 m. The amphibolite is fine-grained and equigranular with a dark greenish-gray color. The structure is massive or shows very weak signs of foliation.

One occurrence of pegmatite (rock code 101061) exceeds one meter in borehole length, at 39.28–40.37 m, and appears otherwise sparsely as veins and dykes throughout the borehole with widths rarely exceeding one decimeter. The pegmatitic occurrences are generally texturally heterogenous and medium- to coarse grained with no, or little signs of deformation.

Five minor occurrences of fine- to medium grained metagranitoid (rock code 101051), with a total borehole length of 1.24 m, located at 37–38 and 89–91 m. The rock is granitic to tonalitic in composition, with massive structure and equigranular texture.

Additionally occurrences are metagranite (rock code 101057), amphibolite (rock code 102017), aplites (rock code 1062) and quartz-dominated hydrothermal vein (rock code 8021).

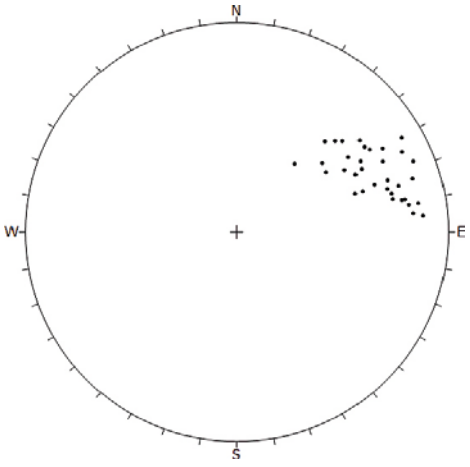
Rock occurrences, rock types < 1 m in borehole length, occupy 7.3 % of the logged drill core.

5.1.2 Alterations

Two short intervals of amphibolite are altered by chloritization and the adjacent metagranite contacts are weakly altered by albitization. In addition, there is a short interval in a core loss mapped as altered by chloritization based on the OPTV-image and a nearby fracture.

5.1.3 Ductile structures

The metagranite (rock code 101057) shows medium intensity foliation and lineation. As shown in the stereographic projection in Figure 5-1, the foliation in KFM25 strikes in an SSE direction and dipping steeply to the west. The foliation is measured in KFM25 on average every third meters.



Figur 5-1. *Orientation of poles to foliation planes (n = 34) in KFM25, plotted on lower hemisphere equal area projection.*

5.1.4 Fractures

The total number of open and sealed fractures in KFM25 are 178 and 206, respectively, and two fractures are partly open (sealed fractures with apertures > 0 mm). The resulting fracture frequency is 1.9 open fractures/ m and 2.2 sealed fractures/m.

Intervals with increased fracture frequencies, > 9 fractures/m, are listed in Table 5-1.

Table 5-1. Intervals with increased fracture frequencies, > 9 fractures/m, in KFM25.

Open	Interval (m)	Fracture/m	Sealed	Interval (m)	Fracture/m	Open + Sealed	Interval (m)	Fracture/m
	7–8	10		62–63	12		6–7	10
	8–9	10		98–99	12		7–8	14
							8–9	12
							16–17	10
							61–62	11
							62–63	14
							73–74	10
							90–91	11
							93–94	11
							98–99	15

Figure 5-2a and b displays the orientation of the open and sealed fractures in stereographic projections. The open fractures show a well-defined group with near horizontal or gently dipping fractures. The sealed fractures show a lager orientation spread, but with a slight concentration of near horizontal fractures.

One small interval, 2 cm wide at borehole length 66.54 m, is mapped as crush in KFM25.The crush is moderately altered with chlorite and calcite, Figure 5-3.

No sealed networks or brecciated zones are registered in KFM25.

The different minerals detected in open and sealed fractures are presented in Table 5-2. The most common minerals in both types of fractures, but in different proportions, are calcite, chlorite and oxidized walls.

A large number of fractures are mapped without mineral filling with fresh surfaces. These fractures are visible in the OPTV-image and some of them also exhibit visible aperture. The orientation of these fractures is all horizontal to subhorizontal.

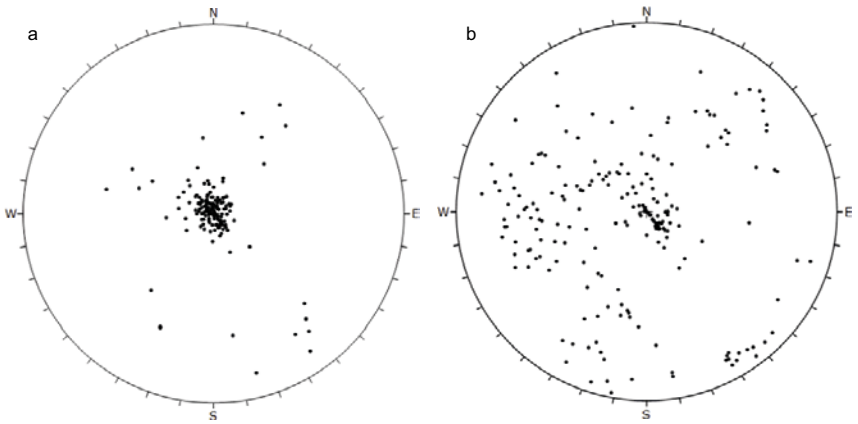


Figure 5-2. *Orientation of poles to a) open (n = 178) and b) sealed fracture planes (n = 208) in KFM25, plotted on lower hemisphere equal area projection.*

Figure 5-3. *OPTV-image of the only crushed interval in KFM25 at 66.54 m.*

Table 5-2. The different minerals and their representation in open and sealed fractures in KFM25.

Open	%	No	Mineral	Sealed	%	No	Mineral
	60.7	108	Calcite		62	128	Oxidized walls
	40.4	72	Chlorite		41.5	83	Calcite
	33.1	59	No detectable mineral		15.5	31	Chlorite
	11.2	20	Oxidized walls		14.6	30	No detectable mineral
	10.7	19	Polished walls		12.6	26	Adularia
	7.3	13	Pyrite		4.4	9	Quartz
	6.7	12	Quartz		1.5	3	Bleached walls
	1.7	3	Hematite		1.0	2	Hematite
	1.7	3	Bleached walls		1.0	2	Pyrite
	1.1	2	Adularia		0.5	1	Laumontite
	0.6	1	Unknown mineral		0.5	1	Biotite
	0.6	1	Clay mineral				
	0.6	1	Iron hydroxide				

The fracture with the widest aperture, 30 mm, in KFM25 is located just below the casing at 6.63 m, Figure 5-4.

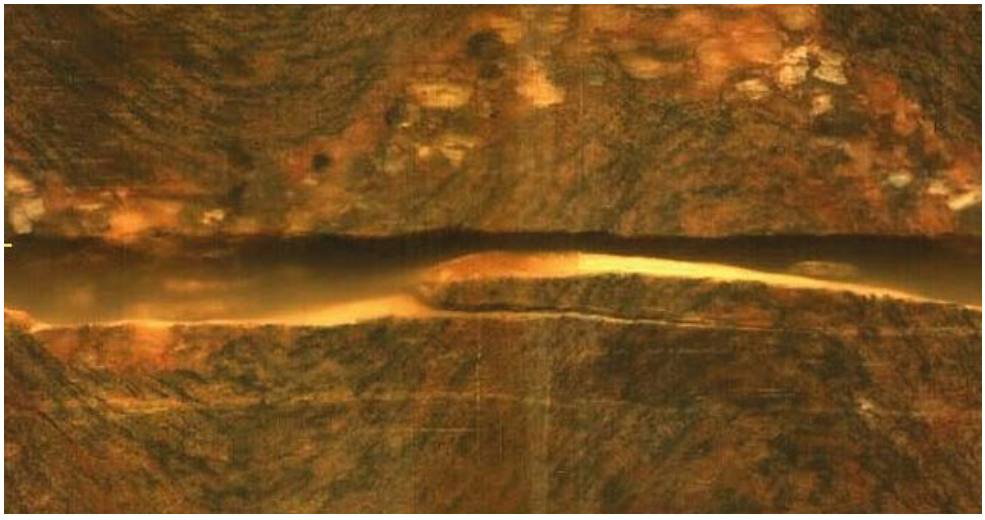


Figure 5-4. *The fracture with the widest aperture, 30 mm, at borehole length 6.63 m.*

5.2 KFM26

5.2.1 Lithology

Medium-grained metagranite (rock code 101057) occupies 89 % of the logged interval and is relatively equigranular with quartz and feldspar and thin streaks of biotite. The color is reddish-gray with varying intensity of the red color due to intervals affected by weak to faint oxidation.

There are three intervals of amphibolite (rock code 102017) located in the lower part of KFM26, occupying 12 % of the mapped interval. The amphibolite at 54.22–60.06 m, have contacts and pronounced foliation parallel with the foliation in the adjacent metagranite. This interval has a large proportion of biotite which is altered into chlorite. The other two amphibolitic intervals are more fine-grained, equigranular and with no or faintly developed foliation.

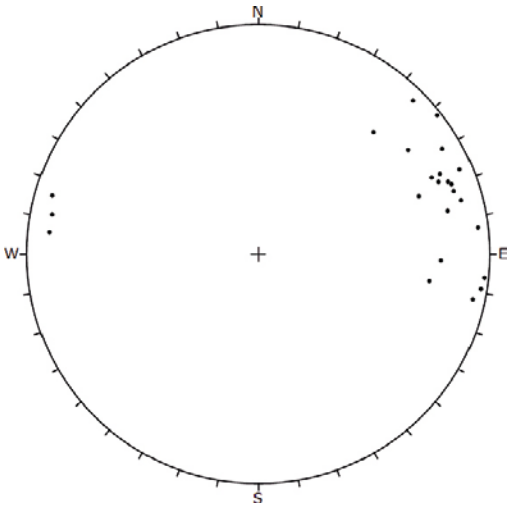
Rock occurrences (rock types < 1 m in borehole length) of veins, dykes and segregations of pegmatite (rock code 101061), metagranite (rock code 101057), aplite (rock code 1062), quartz-dominated hydrothermal veins (rock code 8021), metagranitoid (rock code 101051), amphibolite (rock code 102017) and granite (rock code 111058) occur sporadically throughout the boreholes. These occurrences occupy 5.4 % of the logged drill core and have often a width less than 1 dm.

5.2.2 Alterations

Chloritization and locally also oxidation is affecting the amphibolite at 54.21–60.05 m. In addition, the metagranite is oxidized in a short interval just below the casing and have contacts to the amphibolites altered by albitization.

5.2.3 Ductile structures

The metagranite (rock code 101057) that dominates in KFM26 shows medium intensity foliation. As shown in the stereographic projection in Figure 5-5, the foliation in KFM26 strikes in an SSE direction and dipping steeply towards the west. The foliation is measured in KFM26 on average every fourth meters.



Figur 5-5. *Orientation of poles to foliation planes (n = 24) in KFM26, plotted on lower hemisphere equal area projection.*

5.2.4 Fractures

The total number of open and sealed fractures in KFM26 are 204 and 308, respectively, and five fractures are partly open (sealed fractures with apertures > 0 mm). The resulting fracture frequency is 2.2 open fractures/ m and 3.3 sealed fractures/m.

Intervals with increased fracture frequencies, > 9 fractures/m, are listed in Table 5-3. The high frequency of sealed fractures at interval 73–74 m, consist of thin fractures with mainly oxidized walls in an amphibolitic rock.

Tabell 5-3. Intervals in KFM26 with fracture frequencies > 9 fractures/m.

Open	Interval (m)	Fracture/m	Sealed	Interval (m)	Fracture/m	Open + Sealed	Interval (m)	Fracture/m
	7–8	13		72–73	12		7–8	21
	8–9	11		73–74	33		8–9	15
				75–76	14		16–17	11
				84–86	18		22–23	13
				85–86	12		53–54	12
							54–55	10
							55–56	12
							72–73	12
							73–74	37
							74–75	10
							75–76	16
							80–81	10
							83–84	10
							84–85	22
							85–86	13
							87–88	14

Figure 5-6a and b displays the orientation of the open and sealed fractures in stereographic projections. The orientation of the sealed fractures is more scattered, but both open and sealed fractures show a pronounced set of horizontal to gently dipping fractures.

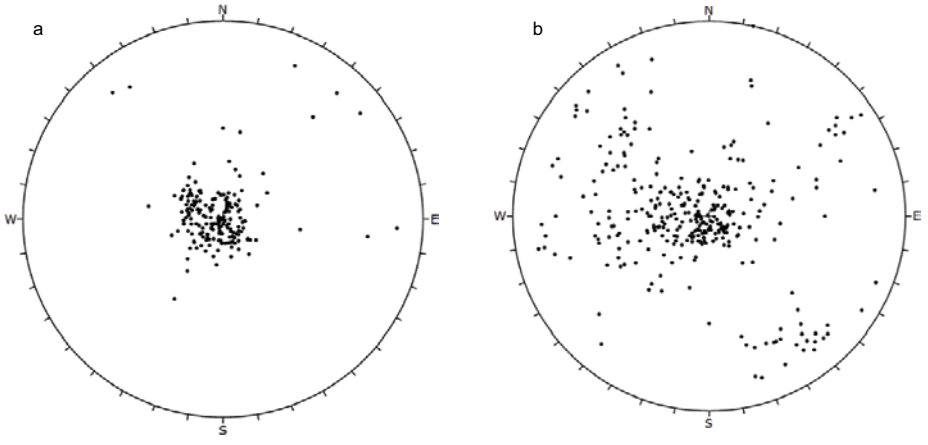


Figure 5-6. *Orientation of poles to a) open (n = 204) and b) sealed fracture (n = 313) planes in KFM26, plotted on lower hemisphere equal area projection.*

Three short intervals of crush are registered in KFM26, Table 5-4. The OPTV-image of the three crushed zones are shown in Figure 5-7.

Table 5-4. Crushed intervals in KFM26.

Interval (m)	Minerals	Alteration
35.16–35.21	Chlorite, clay minerals, calcite, asphalt	Highly altered
97.46–97.61	Calcite, chlorite, oxidized walls	Moderately altered
98.71–98.79	Chlorite, calcite, Iron hydroxide, hematite	Moderately altered

The different minerals detected in open and sealed fractures are presented in Table 5-5. The most common minerals in both types of fractures, but in different proportions, are calcite, chlorite and oxidized walls.

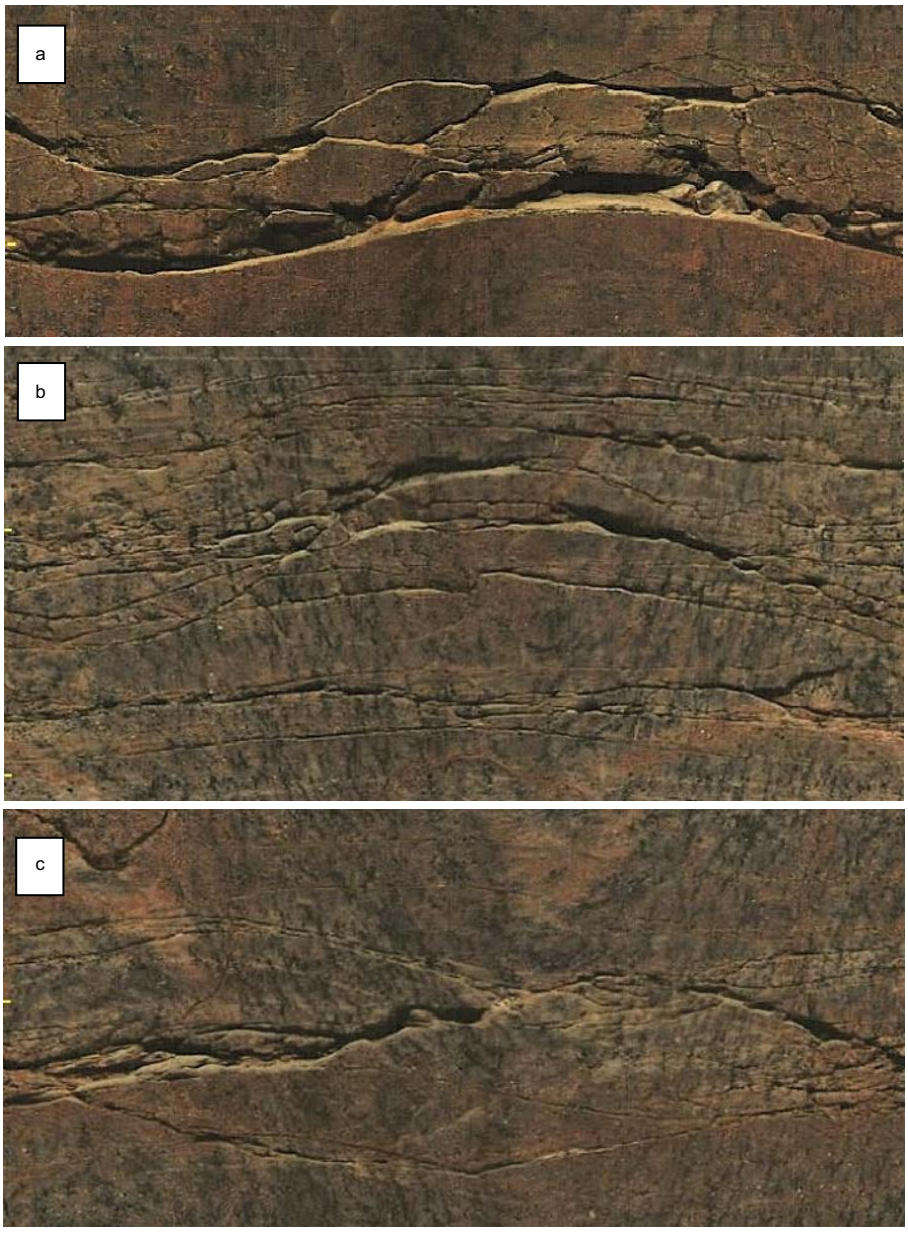


Figure 5-7. *OPTV-images of the three crushed intervals in KFM26, a) 35.16–35.21 m b) 97.46–97.61 m and c) 98.71–98.79 m.*

Both red feldspar and adularia are mapped in KFM26. Adularia is mapped when the mineral is colored by hematite and red feldspar where the red color is inferred to be the feldspar's own inherent color.

A large number of fractures are mapped without mineral filling with fresh surfaces. These fractures are visible in the OPTV-image and some of them also with a visible aperture. The orientation of these fractures is predominantly horizontal to gently dipping.

Table 5-5. The different minerals and their representation in open and sealed fractures in KFM26.

Open	%	No	Mineral	Sealed	%	No	Mineral
	60.3	123	Calcite		71.1	219	Oxidized walls
	38.7	79	Chlorite		26.3	81	Calcite
	32.4	66	No detectable mineral		18.5	57	Chlorite
	16.2	33	Oxidized walls		11.4	35	No detectable mineral
	13.2	27	Polished walls		6.5	20	Quartz
	4.4	9	Pyrite		5.9	18	Adularia
	3.9	8	Red feldspar		2.9	9	Bleached walls
	2.5	5	Quartz		0.7	2	Pyrite
	2.0	4	Hematite		0.3	1	Prehnite
	1.0	2	Laumontite				
	0.5	1	Asphalt				
	0.5	1	Iron hydroxide				
	0.5	1	Clay minerals				

The two fractures with the widest apertures are located just below the casing, as in KFM25, at depths 6.31 and 6.56 m. The apertures are 44 and 55 mm, respectively, Figure 5-8.

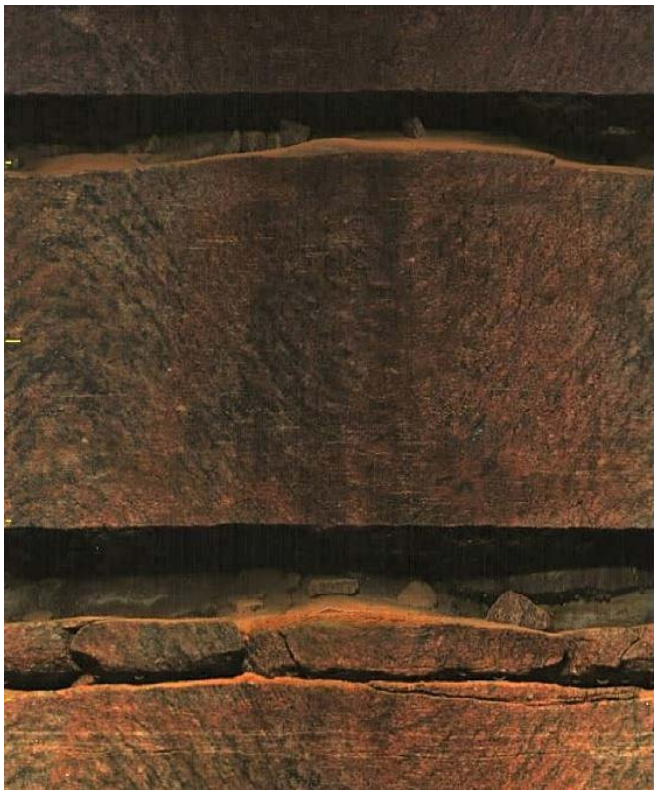


Figure 5-8. *The two fractures in KFM26 with widest apertures, 44 and 55 mm, at borehole length 6.31 and 6.56 m, respectively.*

5.3 KFM27

5.3.1 Lithology

Metagranite (rock code 101057) occupies 77 % of the logged interval. The rock type is generally finely-medium grained and have due to albitization a whiteish grey color, partly with a pale appearance and reduction of grain-size and obliterated or diffuse texture. Intervals with bleached feldspars occur, mainly associated with fractures but also in a scattered appearance in the rock mass.

Pegmatite to pegmatitic granite (rock code 101061) is found in several intervals throughout the borehole and occupies 23 % of the logged interval. The pegmatitic occurrences are generally texturally heterogenous and medium- to coarse grained with no or little signs of deformation. Coarse hematite grains, up to 2 cm in diameter, is found in some of the pegmatites.

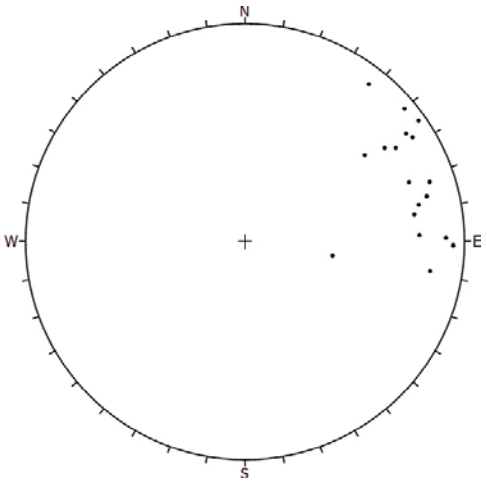
Rock occurrences (rock types < 1 m in borehole length) with metagranite (rock code 101057), pegmatite (rock code 101061), granite (111058) and aplite (rock code 1062) occupy 3.7 % of KFM27.

5.3.2 Alterations

The only alteration in KFM27 is faint to weak albitization and is affecting the entire borehole length.

5.3.3 Ductile structures

The metagranite (rock code 101057) that dominates in KFM27 shows medium intensity foliation. As shown in the stereographic projection in Figure 5-9, the foliation strikes in an SE-SSE direction and dipping steeply towards the west. The foliation is measured in KFM27 on average every fifth meters.



Figur 5-9. *Orientation of poles to foliation planes (n = 19) in KFM27, plotted on lower hemisphere equal area projection.*

5.3.4 Fractures

The total number of open and sealed fractures in KFM27 are 380 and 517, respectively, and 20 fractures are partly open (sealed fractures with apertures > 0 mm). The resulting fracture frequency is 4.2 open fractures/m and 5.9 sealed fractures/m, which is markedly higher compared to fracture frequencies in KFM25 and KFM26.

Intervals with increased fracture frequencies, > 9 fractures/m, are listed in Table 5-6.

Tabell 5-6. Intervals in KFM27 with fracture frequencies > 9 fractures/m.

Open	Interval (m)	Fracture/m	Sealed	Interval (m)	Fracture/m	Open + Sealed	Interval (m)	Fracture/m
	52–53	13		17–18	12		10–11	10
	55–56	11		30–31	10		17–18	15
	87–88	15		31–32	15		18–19	10
				32–33	16		28–29	12
				35–36	12		30–31	14
				45–46	10		31–32	17
				49–50	10		32–33	24
				51–52	10		33–34	17
				55–56	12		34–35	13
				61–62	11		35–36	15
				70–71	12		36–37	12
				77–78	10		38–39	12
				80–81	17		40–41	13
				81–82	12		41–42	12
				82–83	17		45–46	13
							47–48	11
							48–49	10
							49–50	13
							51–52	15
							52–53	21
							53–54	13
							54–55	11
							55–56	24
							56–57	10
							58–59	12
							60–61	11
							61–62	15
							62–63	10
							63–64	10
							69–70	11
							70–71	15
							73–74	16
							76–77	16
							77–78	17
							80–81	20
							81–82	15
							82–83	21

Tabell 5-6, continuation. Intervals in KFM27 with fracture frequencies > 9 fractures/m.

Open	Interval (m)	Fracture/m	Sealed	Interval (m)	Fracture/m	Open + Sealed	Interval (m)	Fracture/m
							85–86	10
							86–87	12
							87–88	23
							88–89	15
							90–91	10
							91–92	10
							95–96	12
							97–98	12

Figure 5-10a and b displays the orientation of the open and sealed fractures in KFM27 in stereographic projections. Both the open and sealed fractures show some orientation scattering, but both types of fractures have a pronounced set of horizontal to gently dipping fractures.

Five crush zones are registered in KFM27, Table 5-7 and Figure 5-11. The widest occur at 66.44–67.03 m but looks more extensive in the core than indicated in the OPTV-image. The most fractured part of this crush is in the interval 66.79–66.89 m, with several apertures up to 7 mm and mineral filling with chlorite, clay minerals and hematite.

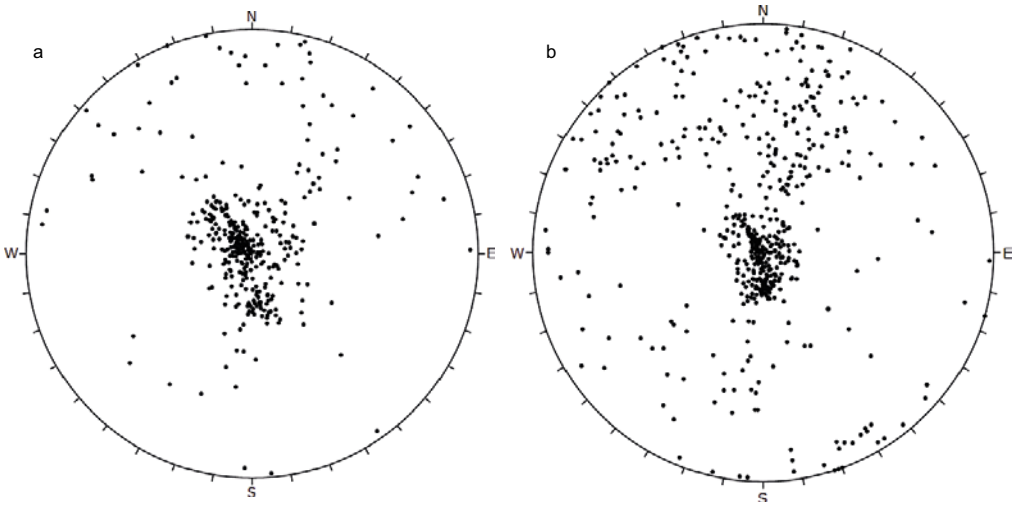


Figure 5-10. *Orientation of poles to a) open (n = 380) and b) sealed fracture (n = 537) planes in KFM27, plotted on lower hemisphere equal area projection.*

Table 5-7. Crush intervals in KFM27.

Interval (m)	Minerals	Alteration
19.53–19.56	Calcite	Slightly altered
66.44–67.03	Chlorite, clay minerals, hematite, calcite	Highly altered
86.70–86.74	Calcite	Slightly altered
87.85–87.92	Quartz, Iron hydroxide, chlorite, oxidized walls	Slightly altered
88.32–88.36	Clay minerals, Iron hydroxide, oxidized walls	Highly altered

The widest apertures in KFM27 is found in the crush zones, with the single widest ca 8 mm in the crush at 86.70–86.74 m.

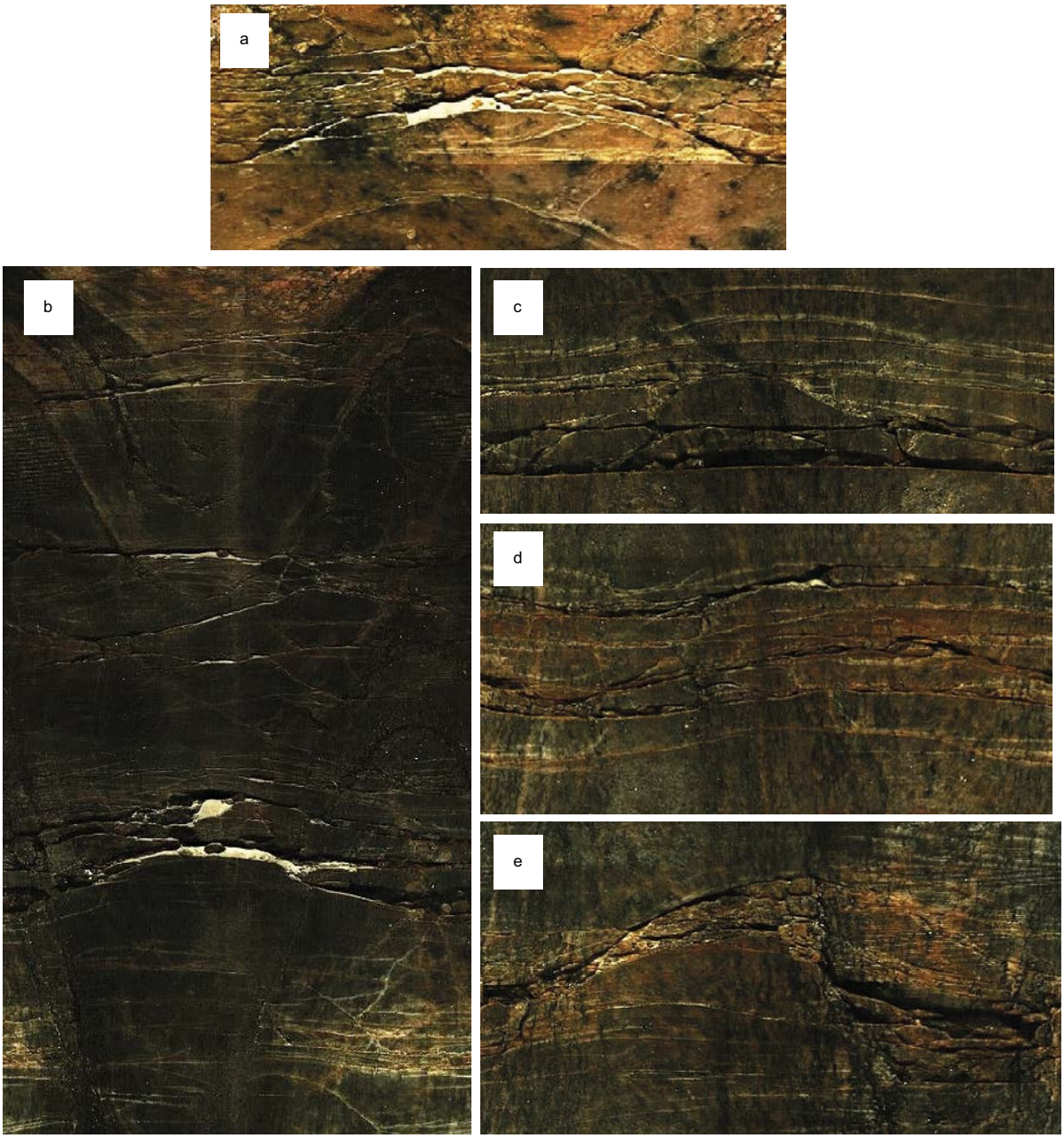


Figure 5-11. *OPTV-images of the five crushed intervals in KFM27, a)19.53–19.56 m, b) 66.44–67.03 m, c) 86.70–86.74 m d) 87.85–87.92 m and e) 88.32–88.36 m.*

The different minerals detected in open and sealed fractures are presented in Table 5-8. The most common minerals in both types of fractures, but in different proportions, are calcite, chlorite and oxidized walls.

Just like in KFM25 and KFM26 there is a large number of fresh fractures with no detected mineral and with a near horizontal orientation.

Table 5-8. The different minerals and their representation in open and sealed fractures in KFM27.

Open	%	No	Mineral	Sealed	%	No	Mineral
	66.3	252	Calcite		40.6	210	Oxidized walls
	41.6	158	Chlorite		29.2	151	Calcite
	22.9	87	Oxidized walls		24.2	125	Chlorite
	19.7	75	No detectable mineral		23.0	119	No detectable mineral
	7.9	30	Polished walls		17.8	92	Bleached walls
	6.8	26	Pyrite		4.8	25	Laumontite
	3.9	15	Asphalt		2.7	14	Quartz
	3.2	12	Bleached walls		2.3	12	Adularia
	2.9	11	Quartz		0.4	2	Biotite
	2.6	10	Laumontite		0.2	1	Hematite
	1.6	6	Iron hydroxide				
	0.8	3	Clay minerals				
	0.3	1	Fluorite				
	0.3	1	Adularia				
	0.3	1	Hematite				
	0.3	1	Biotite				

Six intervals of sealed networks, Table 5-9, is registered in KFM27.

Table 5-9. Intervals with sealed networks in KFM27.

Interval (m)	Minerals
55.96–56.21	Calcite
56.57–56.88	Chlorite, oxidized walls
57.71–57.78	Chlorite, oxidized walls
65.46–65.82	Chlorite, oxidized walls
66.94–68.24	Calcite, chlorite, oxidized walls
71.45–72.93	Calcite, bleached walls, oxidized walls

Appendix 1

Borehole image report of KFM25

Borehole Name: KFM25

Mapping Name: KFM25

Mapping Range: 6,040 - 100,720 m

Diameter: 76,0 mm

Printed Range: 1,550 - 100,439

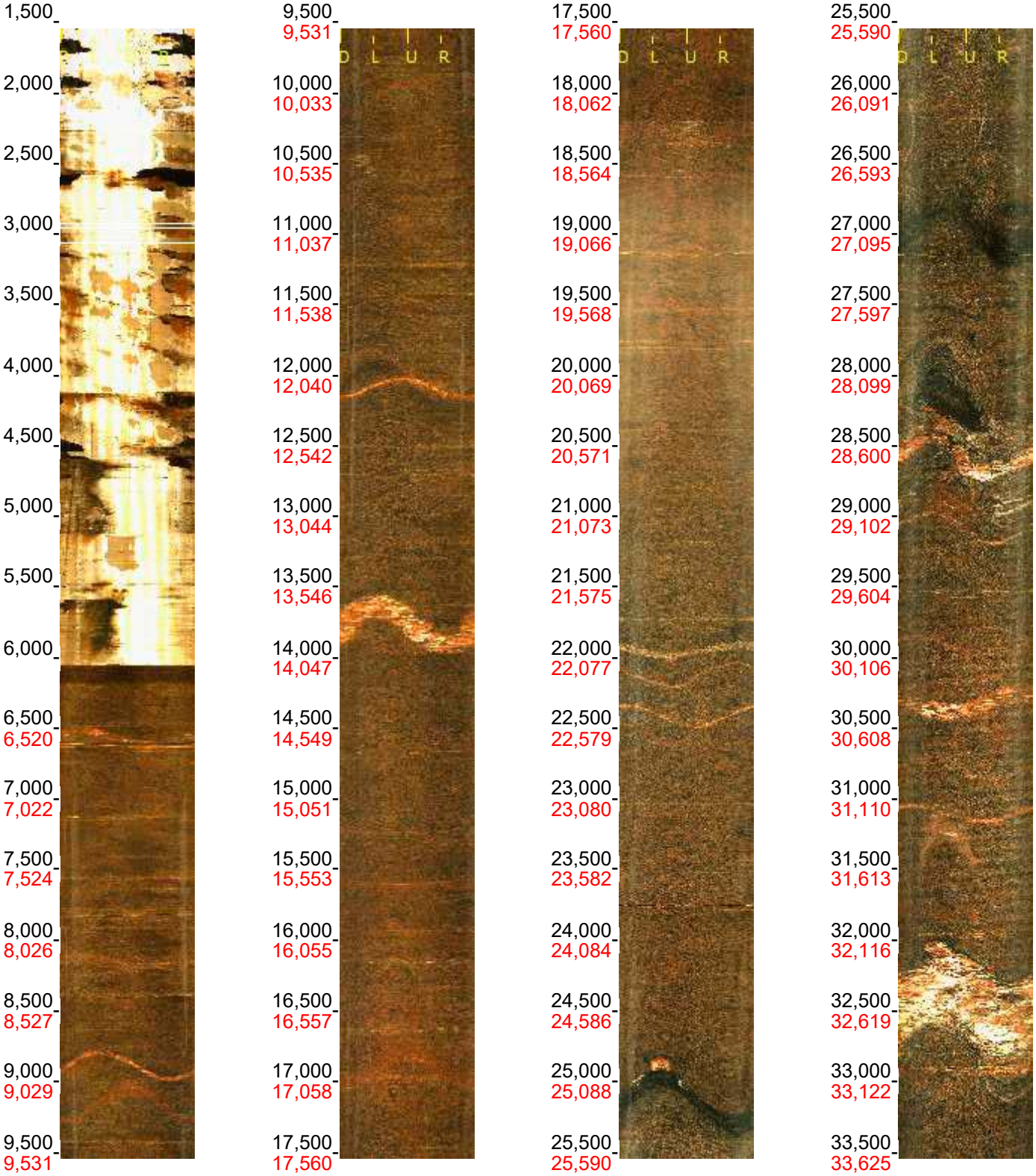
Pages: 5

Image File Information:

File:	M:\Documents\Boremap-7.0\KFM25\LGX\Kfm25ner 190926_H_LGX.HED
Date/Time:	2019-09-26
Start Depth:	1,550 m
End Depth:	100,439 m
Resolution:	1,00 mm/pixel (depth)
Orientation:	Gravimetric
Image height:	98890 pixels
Image width:	720 pixels
Intrinsic angle:	180 degrees
LGX Version:	101
Locality:	
Wellname:	
Scan Direction:	Down

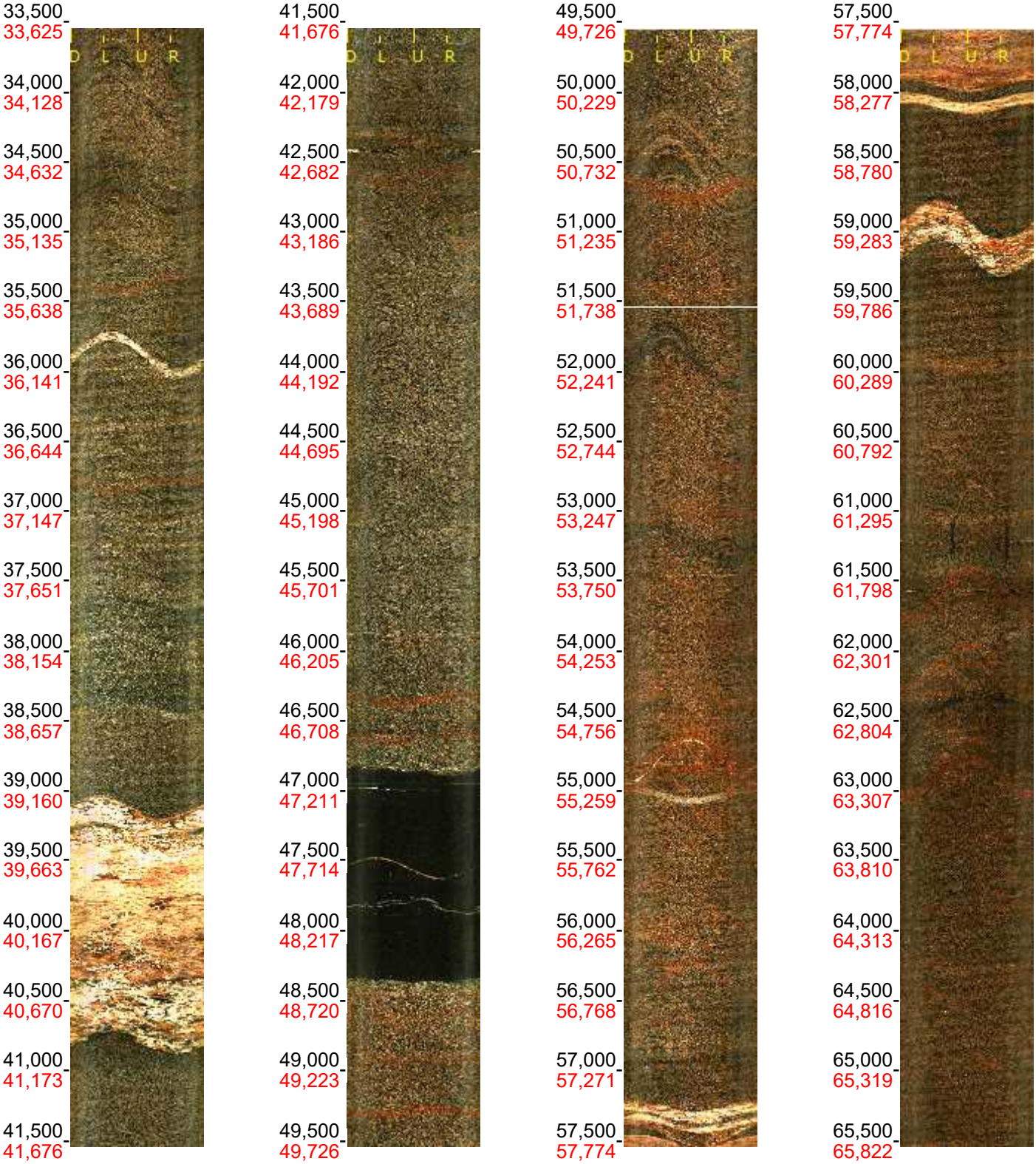
Borehole: KFM25
Mapping: KFM25

Depth range: 1,550 - 33,550 m
Azimuth: 140,1
Inclination: -84,6



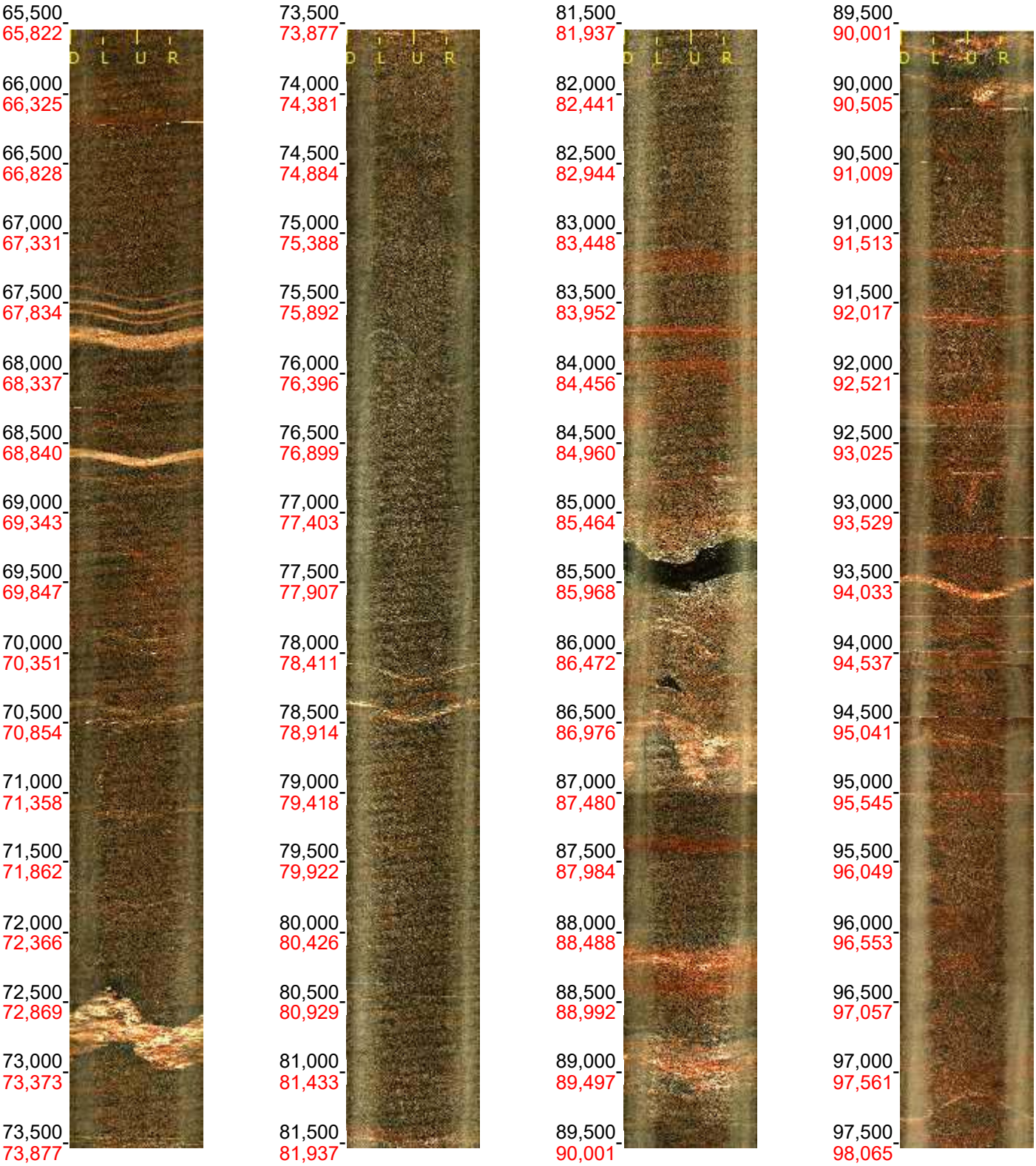
Borehole: KFM25
Mapping: KFM25

Depth range: 33,550 - 65,550 m
Azimuth: 142,4
Inclination: -84,8



Borehole: KFM25
Mapping: KFM25

Depth range: 65,550 - 97,550 m
Azimuth: 140,3
Inclination: -84,8



Borehole: KFM25
Mapping: KFM25

Depth range: 97,550 - 100,439 m
Azimuth: 141,0
Inclination: -84,8

97,500
98,065

98,000
98,569

98,500
99,073

99,000
99,577

99,500
100,081

100,000
100,585

100,500
101,089

101,000
101,593

101,500
102,097

102,000
102,601

102,500
103,106

103,000
103,610

103,500
104,114

104,000
104,618

104,500
105,122

105,000
105,626

105,500
106,130

Borehole image report of KFM26

Borehole Name: KFM26

Mapping Name: KFM26

Mapping Range: 6,027 - 100,710 m

Diameter: 76,0 mm

Printed Range: 1,550 - 100,910

Pages: 5

Image File Information:

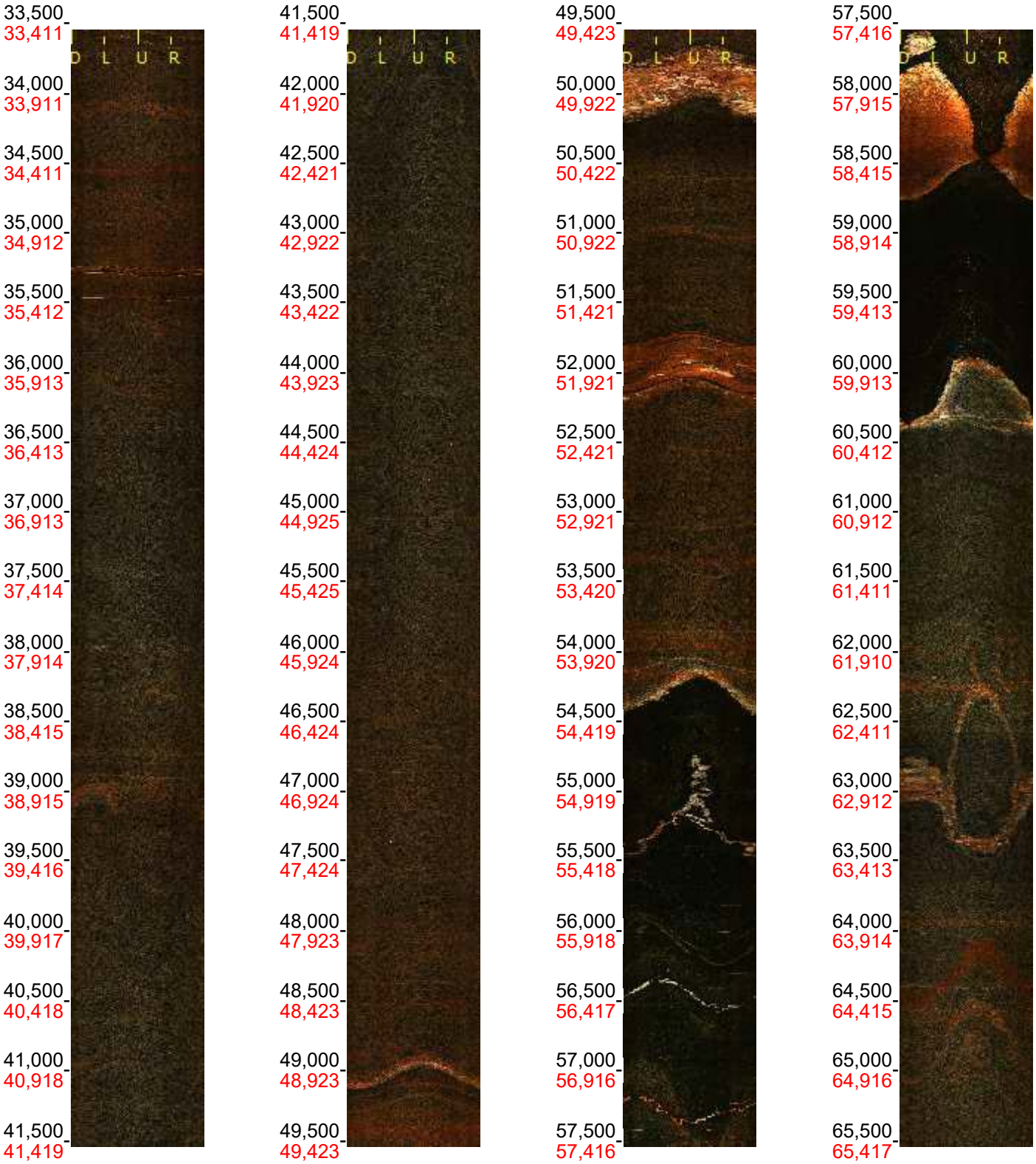
File:	\\sv50-402\home$\konsowi\Documents\Boremap-7.0\KFM26\LGX\KFM26 Ner 191022 _H_LGX.HED
Date/Time:	2019-10-22
Start Depth:	1,550 m
End Depth:	100,910 m
Resolution:	1,00 mm/pixel (depth)
Orientation:	Gravimetric
Image height:	99361 pixels
Image width:	720 pixels
Intrinsic angle:	180 degrees
LGX Version:	101
Locality:	
Wellname:	
Scan Direction:	Down

Borehole: KFM26
Mapping: KFM26

Depth range: 1,550 - 33,550 m
Azimuth: 17,2
Inclination: -85,2

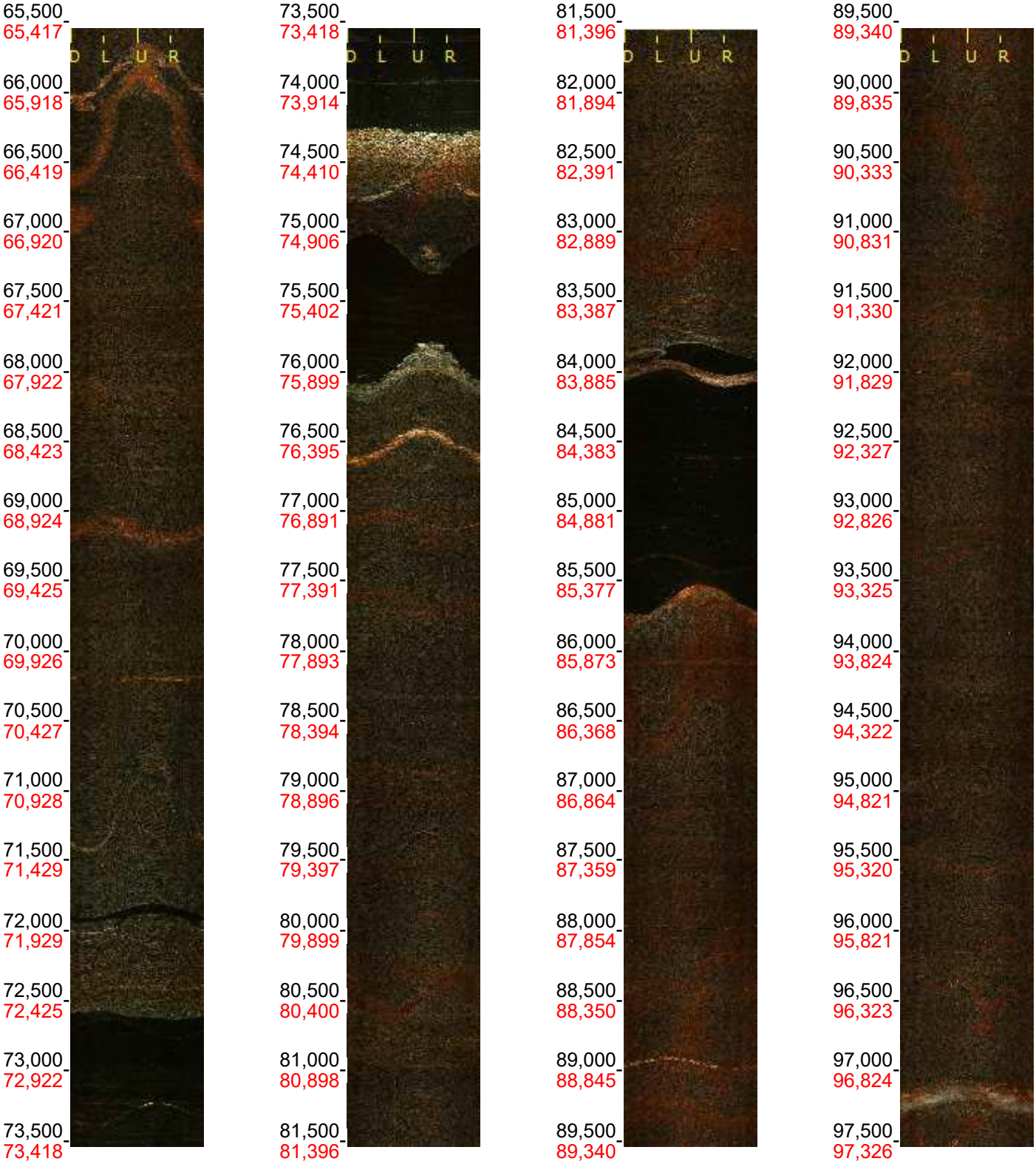
Borehole: KFM26
Mapping: KFM26

Depth range: 33,550 - 65,550 m
Azimuth: 30,1
Inclination: -85,7



Borehole: KFM26
Mapping: KFM26

Depth range: 65,550 - 97,550 m
Azimuth: 35,4
Inclination: -85,6



Borehole: KFM26
Mapping: KFM26

Depth range: 97,550 - 100,910 m
Azimuth: 40,3
Inclination: -85,6

97,500
97,326

98,000
97,827

98,500
98,329

99,000
98,830

99,500
99,332

100,000
99,834

100,500
100,333

101,000
100,825

101,500
101,316

102,000
101,808

102,500
102,300

103,000
102,791

103,500
103,283

104,000
103,775

104,500
104,266

105,000
104,758

105,500
105,250

Borehole image report of KFM27

Borehole Name: KFM27

Mapping Name: KFM27

Mapping Range: 9,000 - 100,640 m

Diameter: 76,0 mm

Printed Range: 1,560 - 100,850

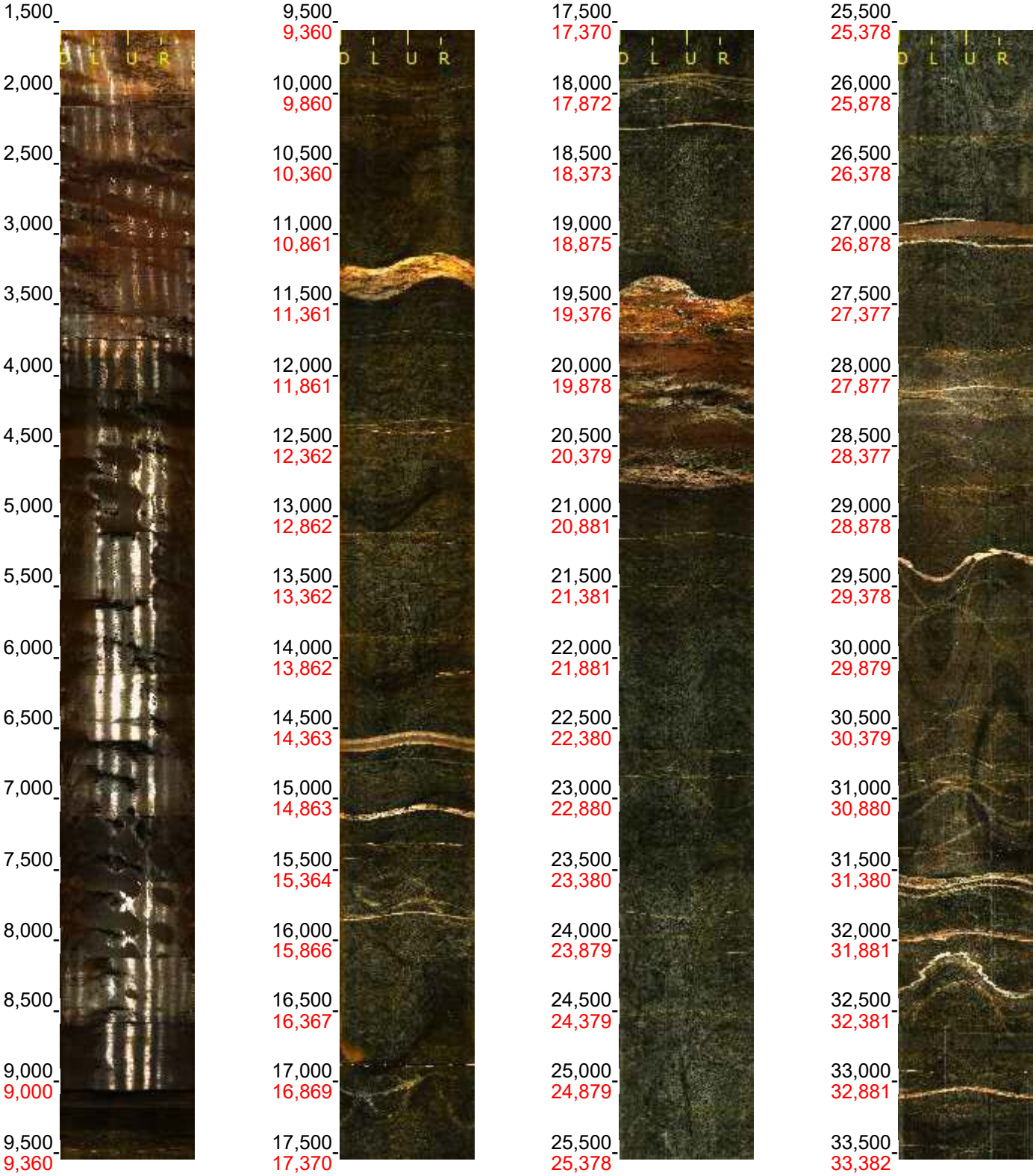
Pages: 5

Image File Information:

File: \\sv50-402\home$\konsowi\Documents\Boremap-7.0\KFM27\LGX\KFM27 Ner 191022_H_LGX.HED
Date/Time: 2019-10-22
Start Depth: 1,560 m
End Depth: 100,850 m
Resolution: 1,00 mm/pixel (depth)
Orientation: Gravimetric
Image height: 99291 pixels
Image width: 720 pixels
Intrinsic angle: 180 degrees
LGX Version: 101
Locality:
Wellname:
Scan Direction: Down

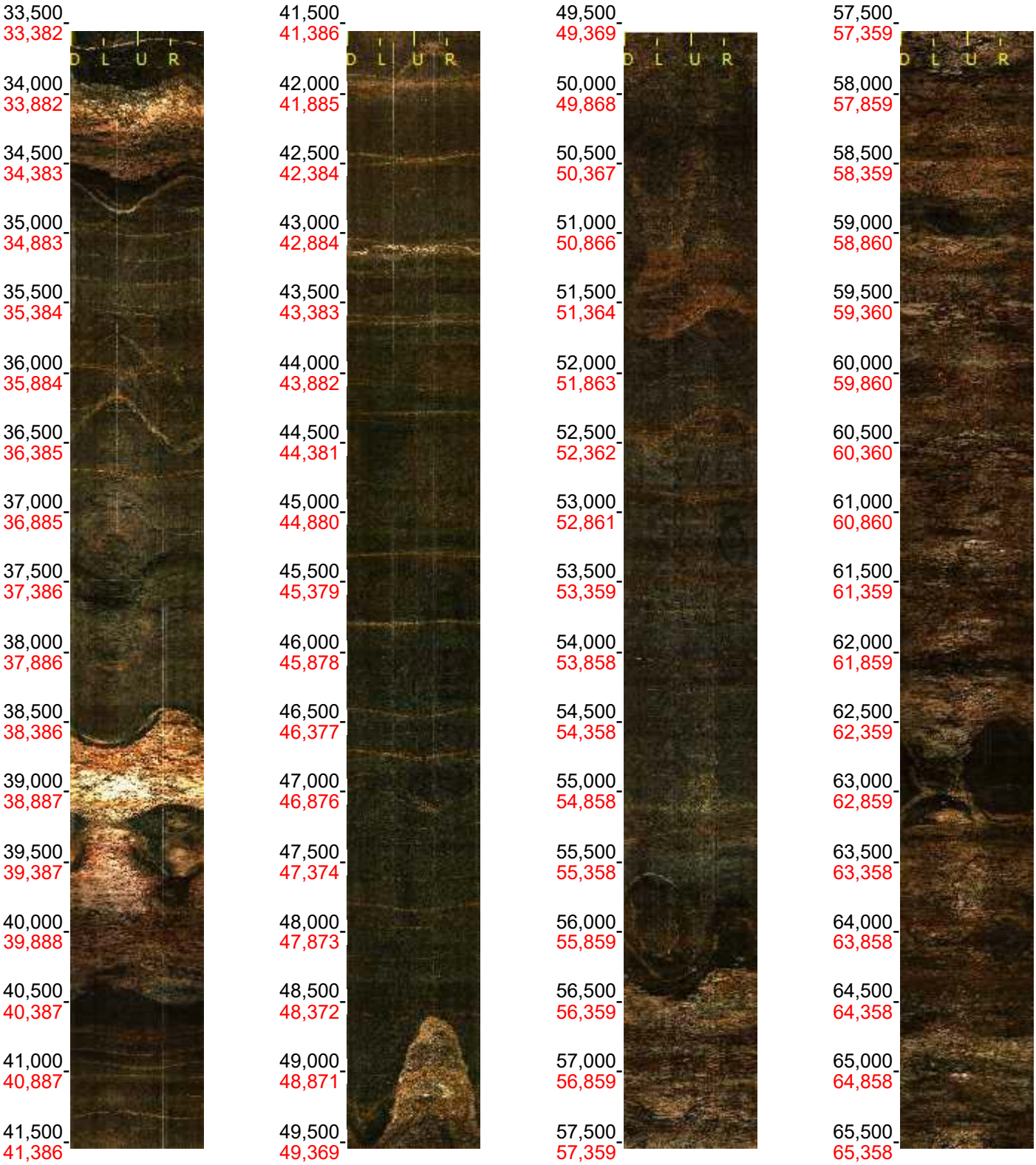
Borehole: KFM27
Mapping: KFM27

Depth range: 1,560 - 33,560 m
Azimuth: 322,5
Inclination: -74,8



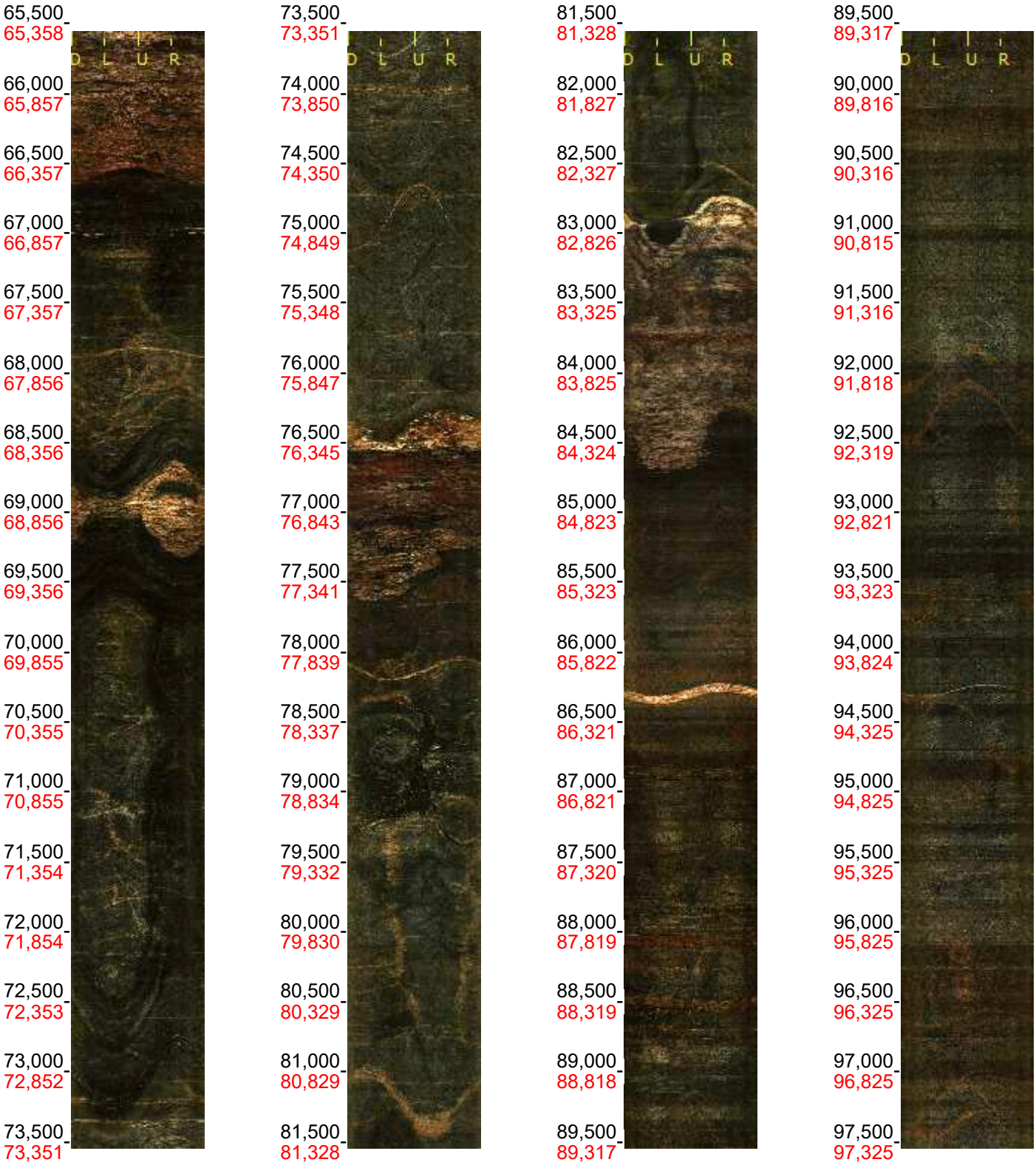
Borehole: KFM27
Mapping: KFM27

Depth range: 33,560 - 65,560 m
Azimuth: 326,4
Inclination: -74,5



Borehole: KFM27
Mapping: KFM27

Depth range: 65,560 - 97,560 m
Azimuth: 326,5
Inclination: -74,2



Borehole: KFM27
Mapping: KFM27

Depth range: 97,560 - 100,850 m
Azimuth: 327,5
Inclination: -74,2

97,500
97,325
98,000
97,825
98,500
98,325
99,000
98,825
99,500
99,325
100,000
99,825
100,500
100,325
101,000
100,825
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103,500
103,325
104,000
103,825
104,500
104,325
105,000
104,825
105,500
105,325

Arkitektkopia AB, Bromma, 2020

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