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Geological single-hole interpretation of KFM24

Peter Dahlin
Jesper Petersson
Håkan Mattsson

SVENSK KÄRNBRÄNSLEHANTERING AB

SWEDISH NUCLEAR FUEL
AND WASTE MANAGEMENT CO

Box 3091, SE-169 03 Solna
Phone +46 8 459 84 00
skb.se

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Peter Dahlin, Svensk Kärnbränslehantering AB

Jesper Petersson, Norconsult AB

Håkan Mattsson, GeoVista AB

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Abstract

This report presents the geological single-hole interpretation (SHI) of the cored borehole KFM24, which was drilled in the Söderviken area. The aim of the borehole was to investigate the rock volume where a skip shaft will be located.

The interpretation combines the geological mapping and interpreted geophysical logs to identify rock units.

The SHI shows that the dominant rock is granite-granodiorite (101057) interrupted by subordinate occurrences of pegmatite (101061) and amphibolite (102017), and the interpretation is that KFM24 consists of only one rock unit (RU1).

No possible deformation zone was identified during the SHI.

Sammanfattning

Föreliggande rapport behandlar resultaten och tolkningarna som gjordes under den geologiska enhålstolkningen (SHI) av KFM24. Syftet med borrningen var att undersöka bergvolymen där ett skipschakt kommer att byggas.

Tolkningarna av bergenheter och möjliga deformationszoner baseras på en kombination av geologisk kartering och geofysiska loggar.

Endast en bergenhet (RU1) har konstaterats i KFM24 vilken består av granit-granodiorit (101057) med mycket underordnade förekomster av pegmatit (101061) och amfibolit (102017).

Inga möjliga deformationszoner (PDZ) identifierades i KFM24.

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1 Introduction

Much of the primary geological and geophysical borehole data stored in the SKB database SICADA need to be integrated and synthesized before they can be used for modelling in the 3D-CAD Rock Visualization System (RVS). The end result of this procedure is a geological single-hole interpretation, which consists of an integrated series of different logs and accompanying descriptive documents.

This document reports the geological single-hole interpretations of borehole KFM24 in the Forsmark area. The horizontal projection of the borehole is shown in Figure 1-1.

The work was carried out in accordance with activity plan AP SFK-16-016 (in Swedish). The controlling documents for performing this activity are listed in Table 1-1. Both the activity plan and method description are SKB's internal controlling documents. General information about KFM24 is displayed in Table 1-2.

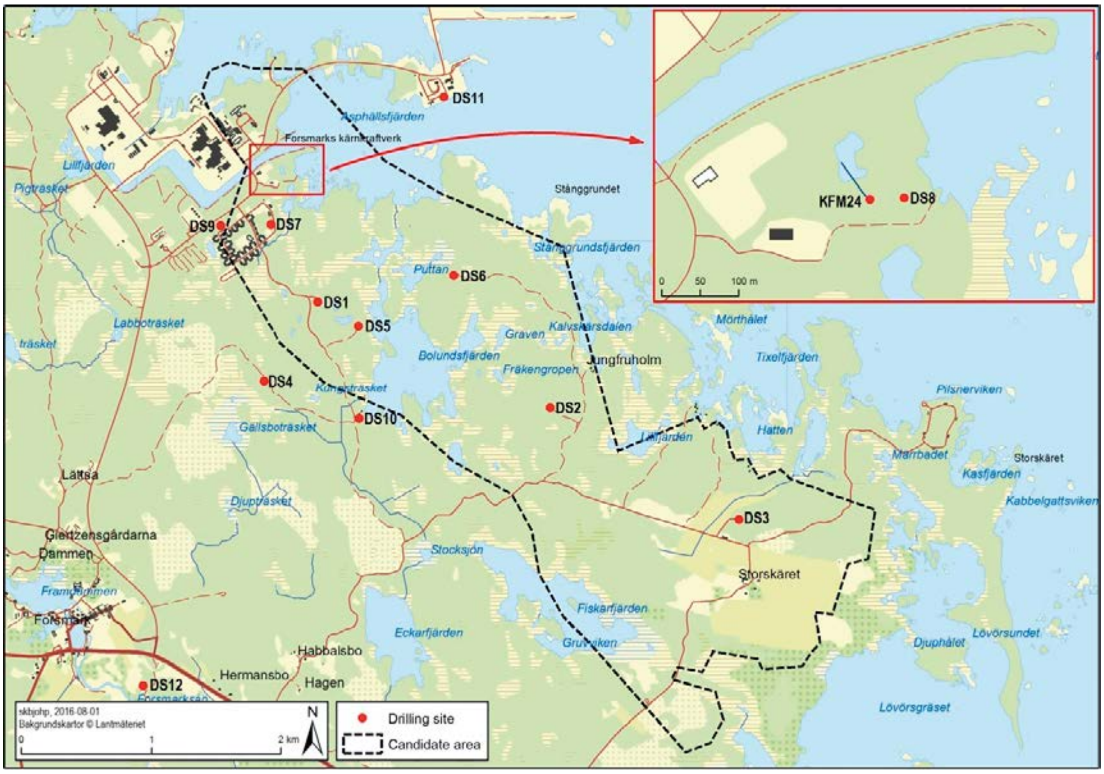

Figure 1-1. Location of KFM24 and drill sites 1 to 12.

Table 1-1. Controlling documents.

Document	Number	Version
Geologisk enhålstolkning (SHI) av KFM24.	AP SFK-16-016	1.0
Method descriptions	**Number**	**Version**
Metodbeskrivning för geologisk enhålstolkning.	SKB MD 810.003	3.0

Table 1-2. General information about KFM24.

Plane coordinates (RT90 2.5 Gon W)	y: 6700492, x: 1631153
Elevation	1.03 m.a.s.l.
Bearing	311°
Inclination	−83° (from the horizontal plane)
Length, percussion drilled part	35.7 m (from the surface)
Length, core drilled part	35.7 m to 550.17 m (from the surface.)

2 Objectives and scope

A geological single-hole interpretation is carried out in order to identify and to describe briefly the characteristics of rock units and possible deformation zones (PDZs) within a borehole. The work involves an integrated interpretation of data from the geological mapping of the borehole and different borehole geophysical logs.

The geological mapping of the cored boreholes involves a documentation of the character of the bedrock with the Boremap system, which combines drill core mapping by inspection of the oriented image of the borehole walls, obtained by the Optical Televiewer (OPTV).

The interpretations of the borehole logs are available when the single-hole interpretation is carried out. The result from the geological single-hole interpretation is presented in a WellCad plot. A more detailed description of the technique is provided in the method description for geological single-hole interpretation (SKB MD 810.003, internal document).

3 Data used for the geological single-hole interpretation (SHI)

The following data and interpretations have been used for the single-hole interpretation of KFM24:

- Boremap data (including OPTV and mapping data).
- Generalized geophysical logs and their interpretation.

The material used as a basis for the geological single-hole interpretation was a WellCad plot consisting of parameters from the geological mapping in the Boremap system and geophysical logs. The plot consists of eight main columns and several subordinate columns. These include:

1. Length along the borehole
2. Rock type
   - Rock type
   - Rock occurrence (< 1 m)
   - Rock type structure
   - Rock type texture
   - Rock type grain size
   - Structure orientation
   - Rock alteration
   - Rock alteration intensity
3. Fracture frequency
   - Open total
   - Sealed total
   - Fracture, open frac, orientation / Fracture, sealed frac, orientation
   - Fracture, broken frac, orientation / Fracture, unbroken frac, orientation
   - Total fractures
4. Fracture alteration orientation
   - Open alteration
   - Sealed alteration
   - Surface
5. Crush zones and core loss
   - Crush zone
   - Piece length
   - Core loss
6. Geophysics
   - Magnetic susceptibility (SI)
   - Natural Gamma Radiation (cps)
   - Focused resistivity (ohm-m)
   - Density (kg/m^3)
7. OPTV

The geophysical logs are described below.

Magnetic susceptibility: The rock has been classified into sections of low, medium, high, and very high magnetic susceptibility. The susceptibility measurement is strongly connected to the magnetite content in the different rock types.

Natural gamma radiation: The rock has been classified into sections of low, medium, and high natural gamma radiation. Low radiation may indicate mafic rock types and high radiation may indicate younger, fine-grained granite or pegmatite. The rocks with high natural gamma radiation have been included in the younger, Group D intrusive suite.

Estimated fracture frequency: This parameter provides an estimate of the fracture frequency along 5 m sections, calculated from short and long normal resistivity, SPR, P-wave velocity as well as focused resistivity 140 and 300. The estimated fracture frequency is based on a statistical connection after a comparison has been made between the geophysical logs and the mapped fracture frequency. The log provides an indication of sections with low and high fracture frequencies.

4 Execution of the geological single-hole interpretation

The geological single-hole interpretation has been carried out by a group of geoscientists consisting of both geologists and geophysicist. Several of these geoscientists previously participated in the development of the source material for the single-hole interpretation. All data to be used (see Chapter 3) are visualized side by side in a borehole document extracted from the software WellCad. The working procedure is summarized in Figure 4-1and in the text below.

4.1 General

The SHI is initiated with a study of all types of primary data (rock type, rock alteration, natural gamma radiation, etc.) related to the character of the rock type and to merge sections of similar rock types, or sections where one rock type is very dominant, into rock units (minimum length of c. 5 m). Each rock unit is defined in terms of the borehole length interval and provided with a brief description for inclusion in the WellCad plot. The confidence in the interpretation of a rock unit is made on the following basis: 3 = high, 2 = medium and 1 = low.

The working procedure proceeds with identification of PDZs by visual inspection of the results of the geological mapping (fracture frequency, fracture mineral, aperture, alteration, etc.) in combination with the geophysical data. The section of each identified PDZ is defined in terms of the borehole length interval and provided with a brief description for inclusion in the WellCad plot. This includes a brief description of the rock types affected by the PDZ. The confidence in the interpretation of a PDZ is made on the following basis: 3 = high, 2 = medium and 1 = low.

Inspection of the OPTV image is carried out wherever it is judged necessary during the working procedure. Furthermore, following the definitions of rock units and PDZs, with their respective confidence estimates, the drill cores are inspected in order to check the selection of the boundaries between these geological entities. If judged necessary, the location of these boundaries is adjusted. Potential candidates for PDZs as identified on the basis of the WellCad compilation, may be omitted/rejected if the interpretation lacks sufficient support in the drill core. In addition, the estimated confidence level may be revised based on the ocular inspection.

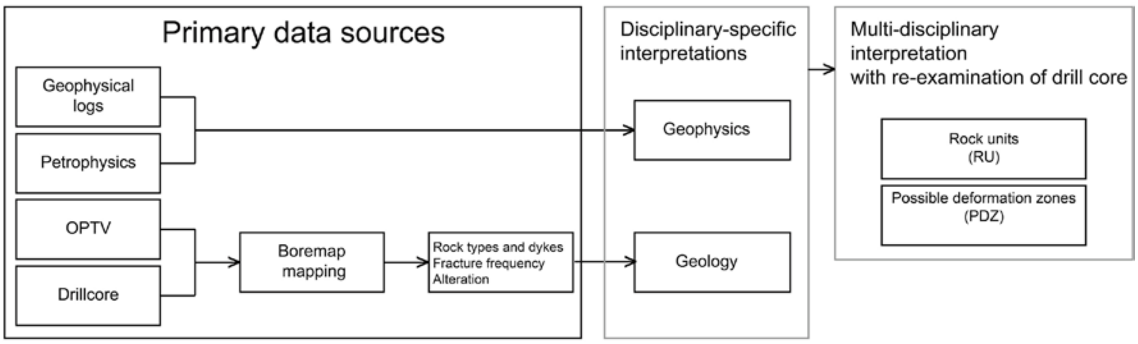

Figure 4-1. *Schematic flow chart showing the procedure for the development of a geological single-hole interpretation.*

Brittle PDZs have been identified primarily on the basis of the frequency of fractures, according to the concept presented in Figure 4-2. Brittle deformation zones defined by an increased fracture frequency of extensional fractures (joints) or shear fractures (faults) are not distinguished. Both the damage zone, with a fracture frequency in the range 4–9 fractures/m, and the core part, with a fracture frequency > 9 fractures/m, have been included in each zone (Figure 4-2). It should be emphasized that the identification of a PDZ is not limited to the absolute fracture frequency; the basis is the *relative* fracture frequency along with other indications. The frequencies of open and sealed fractures have been assessed in the identification procedure, and the character of the zone has been described accordingly. Partly open fractures are included together with open fractures in the brief description of each zone.

Density, natural gamma radiation and magnetic susceptibility are used to estimate the mineral composition, which supports the geological mapping. The FWS (full wave sonic) and resistivity methods are used to characterize fractures and deformation zones, and acoustic televiewer is used for fracture analysis and borehole diameter determination. The occurence of bedrock alteration can be identified by use of the resistivity, SPR, P- and S-wave velocity, and magnetic susceptibility data. The fluid temperature is an important tool for identifying water bearing fractures.

4.2 Nonconformities

The geophysical logging data used during the SHI-meeting were only preliminar and not complete. However, comments and text regarding the geophysical data in this report are based on the complete dataset retrieved from SICADA after the SHI-meeting.

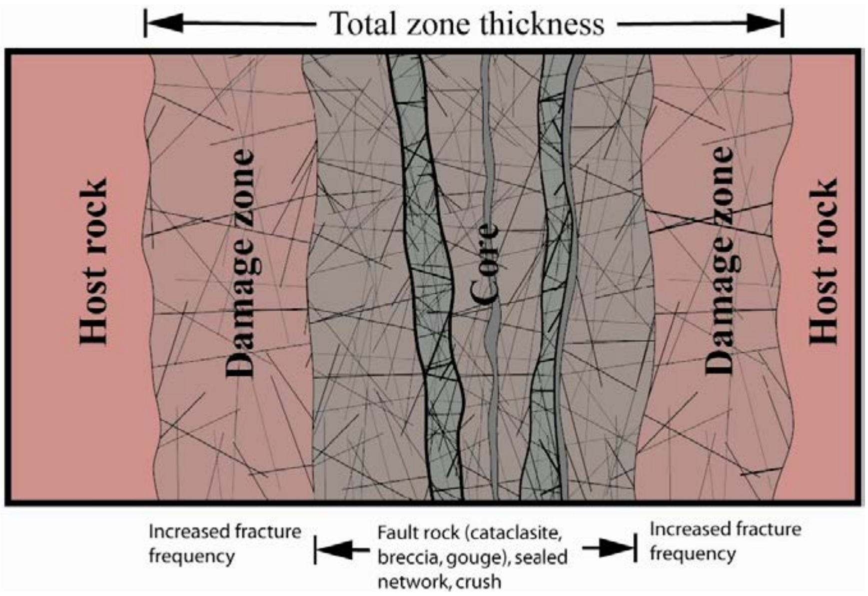

Figure 4-2. *Terminology for brittle deformation zones (modified after Munier et al. 2003).*

5 Results

5.1 Rock units in KFM24

The bedrock along the borehole has been defined as one single rock unit (denoted RU1)

37.3–550.17 m

RU1: Dominated by metamorphic granite-granodiorite (101057) with subordinate occurrences of pegmatitic granite (101061) and amphibolite (102017). The unit contain a few occurrences of fine- to medium-grained metagranitoid (101051) with a maximum borehole length of 6 m. The metamorphic granite-granodiorite is L-S tectonites, i.e. mineral stretching lineation combined with various degrees of foliation. The density is in the range of 2.660–2.680 kg/m^3 along the major part of the borehole (average density = 2.669 ± 51 kg/m^3). This density interval indicates a mineral composition that corresponds to granite rock. There are about 20, unevenly distributed, less than 0.5 m long sections with significantly increased density and decreased natural gamma radiation, indicating mafic rocks. Many of these sections are spatially related with adjacent anomalies with increased natural gamma radiation, which suggests the occurrence of pegmatite or fine-grained metagranitoid. Confidence level = 3.

5.2 Possible deformation zones in KFM24

According to the geological interpretation, none of the structures intersected by KFM24 fulfil the criteria of being a PDZ.

References

SKB's (Svensk Kärnbränslehantering AB) publications can be found at www.skb.com/publications.

Munier R, Stenberg L, Stanfors R, Milnes A G, Hermanson J, Triumf C-A, 2003. Geological site descriptive model. A strategy for the model development during site investigations. SKB R-03-07, Svensk Kärnbränslehantering AB.

Arkitektkopia AB, Bromma, 2017

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