International Progress Report

IPR-00-27

Äspö Hard Rock Laboratory

Select-2

Evaluation of fracture candidates in boreholes KA2865A01 and KA3065A02. Location of experimental site for the long term diffusion experiment

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August 2000

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Report no.
IPR-00-27
No.
F79K
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Keywords: KA2865A01, KA3065A02, LTDE, flow log, structural model

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1 Introduction

The objective of the Long-Term Diffusion Experiment (LTDE), Byegård et al. (1999) is to study the magnitude and extent of matrix diffusion from a natural fracture surface, through the altered zone, into the intact matrix rock. Further, to compare obtained in situ values on diffusivity with that obtained from corresponding studies on core samples in the laboratory. The experimental concept involves drilling of a telescoped large-diameter borehole to intercept a target feature identified in an existing small diameter pilot borehole. The feature is packed off using a special packer which seals around the developed core stub. The borehole is further packed of with mechanical and inflatable packers to avoid effects of the acting hydraulic gradient. A tracer solution consisting of conservative and sorbing radioactive tracers will be circulated in the section with the natural fracture for a period of 3-4 years. A penetration due to diffusion in the order of decimetres is expected over the duration of the experiment. Subsequently, the rock volume subject to diffusion will be over-cored, sectioned and analysed for tracer activity/concentration. The in situ experimentation is supported by various types of mineralogical, geochemical and petrophysical analyses.

The present report presents the results of the analysis of potential target structures in the pilot boreholes KA2865A01 and KA3065A02, both drilled within the SELECT-2 project. The data used in the assessment are structural data from the performed BOREMAP mapping, borehole radar investigations and data from performed POSIVA flow logging.

The report identifies the most suitable location for the experiment, presents a structural-geometric model of the area with the target feature and proposes a tentative geometry for a large diameter experimental borehole.

2 Flow logging in KA2865A01 and KA3065A02

Identified inflow points using the POSIVA continuous mode flow meter are in the following figures identified in terms of location and magnitude of inflow.

Total outflow from KA2865A01 is approximately 200 l/min, cf. Figure 2.1a and 2.1b.

Total outflow from KA3065A02 is approximately 21 l/min, cf. Figure 2.2a and 2.2b. Note that the borehole has been logged in its entirety, but for the the purpose of LTDE only the first 40 m are of relevance.

In order to protect the downhole equipment a flow limiter was employed in KA2865A01 effectively reducing all flows above Q=1 l/min (60000 ml/h). All reported values above this threshold value should be regarded as qualitative.

No flow limiter was used in KA3065A02 and the measured range in this case is 2-5000 ml/min (ie. up to 3 10^5 ml/h).

Outflow of gas was observed from both KA2865A01 and KA3065A02 when they were open. The highest outflow was observed for KA2865A01, visually estimated to about 4 l/min at the collar.

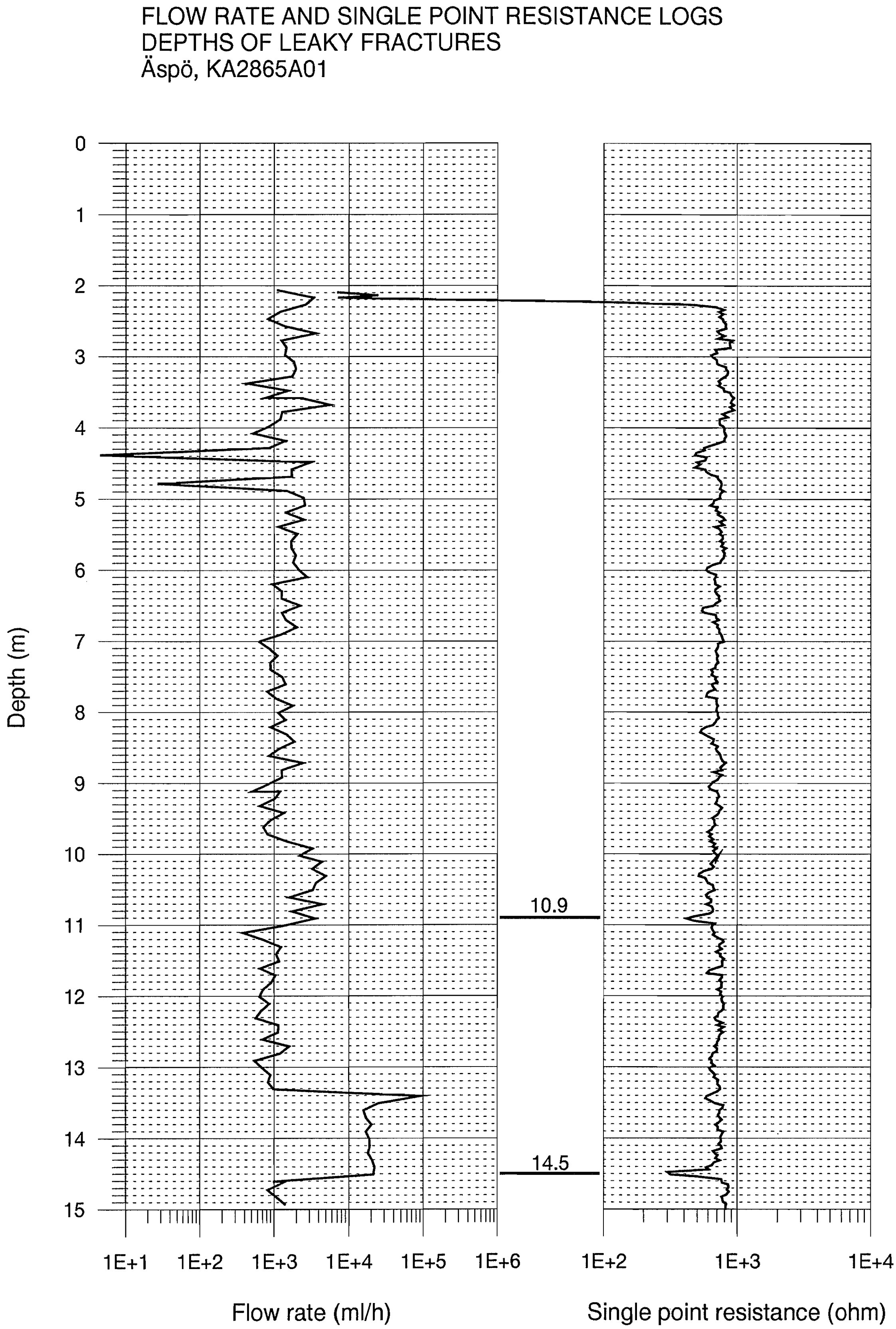

Figure 2-1a Results of POSIVA flow logging in KA2865A01, 0-15 m.

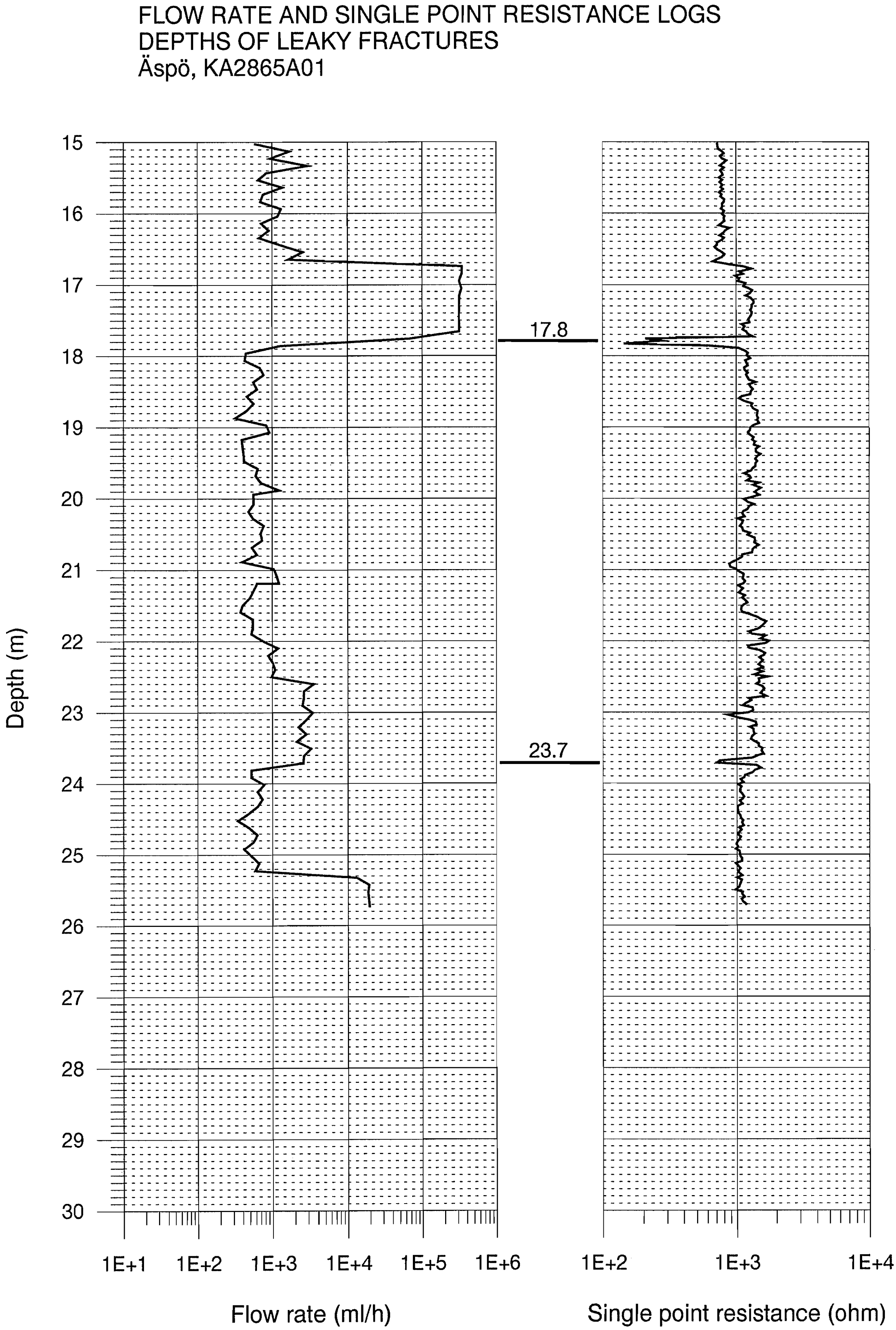

Figure 2-1b Results of POSIVA flow logging in KA2865A01, 15-30 m.

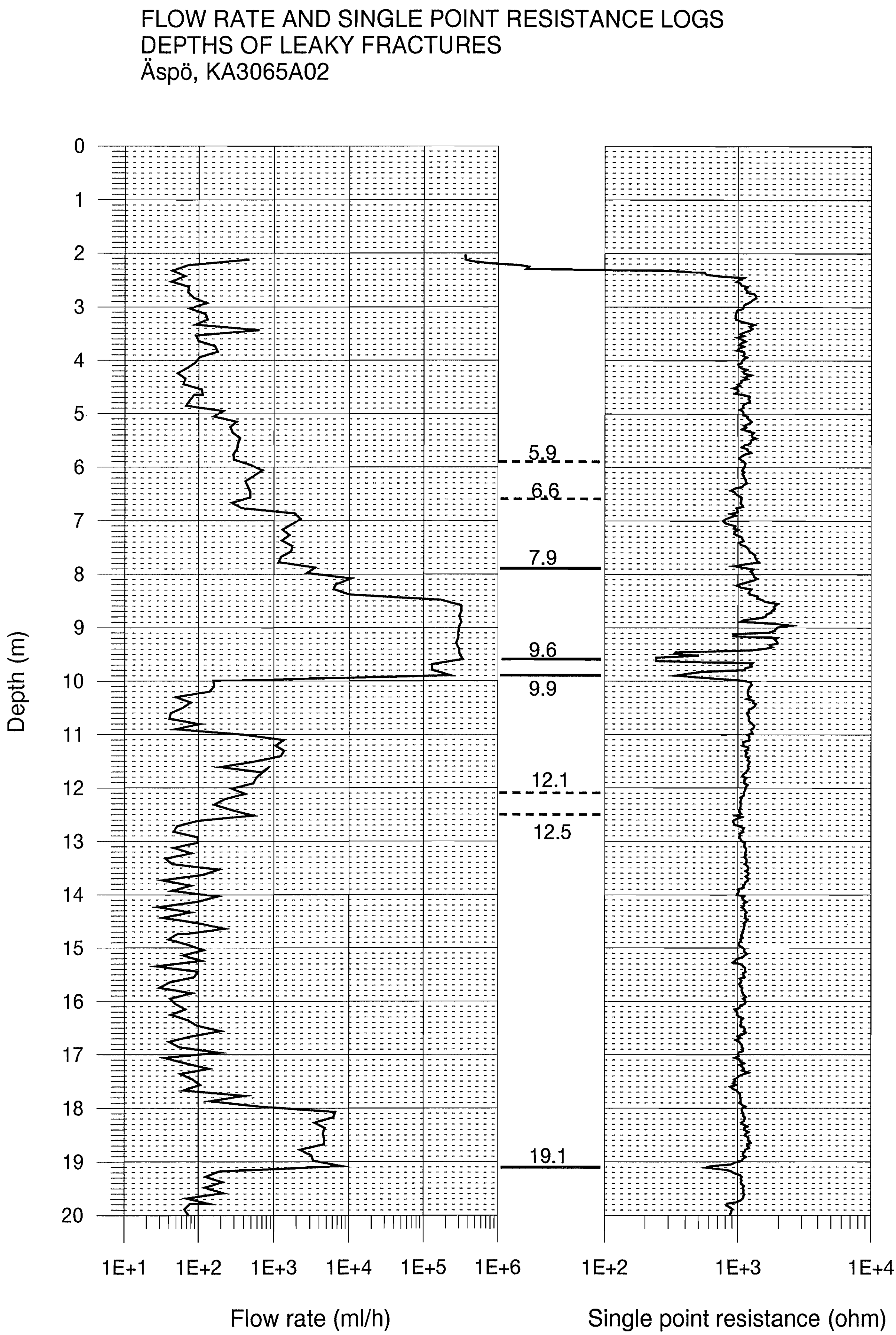

Figure 2-2a Results of POSIVA flow logging in KA3065A02, 0-20 m.

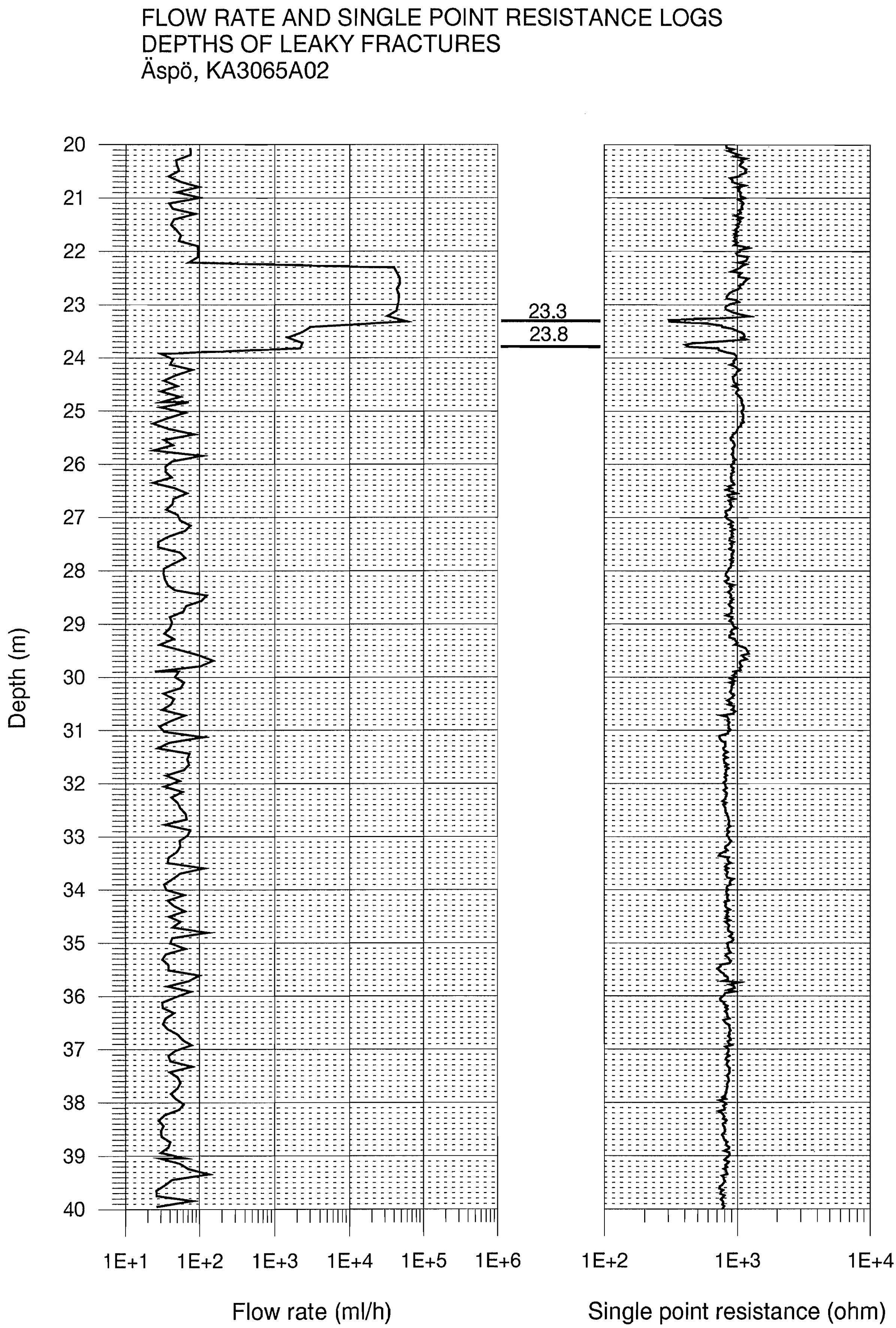

Figure 2-2b Results of POSIVA flow logging in KA3065A02, 20-40 m.

3 Geological indications in boreholes KA2865A01 and KA3065A02

3.1 Borehole KA2865A01

3.1.1 BIPS and drillcore inspection in KA2865A01

The initially proposed candidates for the LTDE experiments are based on inflow points along the borehole from the POSIVA flow logging of the two boreholes. These inflow points have been mapped in detail by visual inspection of the drill core in combination with the BIPS image. Tables 3-1 and 3-2 presents the lithology, structural geology and mineralisations around each of these potential experimental candidates.

Table 3-1 Drill core and BIPS inspection of potential target structures for LTDE in KA2865A01

Location	Strike/Dip	Comments
10.86 m	138/88	No fracture minerals and lies in diorite. Orientation close to orthogonal to the borehole axis.
14.5 m	131/82	No fracture minerals and lies in diorite. Orientation close to orthogonal to the borehole axis. The core has rotated during drilling and the fracture surfaces are worn down.
17.7 m	312/57	Crush in the drillcore the fracture surface is worn down by the drilling. Calcite-chlorite filling. The fracture is oriented with an smaller than orthogonal angle to the borehole axis.
23.60 m	(347/77) 325/86	The two fractures lies in a thin finegrained granite (oriented). The fractures has different orientations orthogonal to the borehole axis. BIPS image is diffuse and the orientation is not clear.

3.1.2 Radar reflectors in KA2865A01

The radar investigation in KA2865A01 reveals four major reflectors interpreted to be related to fractures along the borehole. One reflector, at L=18 m, corresponds relatively well with the structure at 17.7 m with orientation 312/57.

Table 3-2 List of radar reflectors in KA2865A01

Location in KA2865A01	Strike	Dip
3 m	265	57
18 m	355	81
21 m	343	85
27.2 m	186	87

3.2 Borehole KA3065A02

3.2.1 BIPS and drillcore inspection in KA3065A02

Table 3-3 Drill core and BIPS inspection of potential target structures for LTDE in KA3065A02

Location	Strike/Dip	Comments
6.54 m		Not in question due to its zone like character and the close proximity to the tunnel.
7.96 m	331/8X	Chlorite filling in a fracture with a close to orthogonal orientation to the borehole axis. The fracture surface is worn down due to rotation of the core.
9.34 m 9.37 m 9.40 m 9.43 m 9.45 m	350/89 151/77 155/80 162/65 164/81	Inflow 16.1 l/min in a complex zone of at least 5 fractures over a distance of 15 cm. Not suitable.
9.81 m	140/81 (main fault) (see Figure 3-3)	Main fault with slicken lines on fault surface. Mylonitic character in greenstone/diorite with increasing alteration towards the fault centre. 5 fractures over 25 cm where at least the two bottom most fractures are not mapped. The BIPS picture is in bad condition due to large inflow and degassing. Suitable candidate below main fault as good rock is penetrated just beyond these features (80 cm).
11.9 m	116/33	Sealed, not suitable
12.6 m	115/90	Calcite-Chlorite filled fracture in diorite with no or very little rim zone. Possible target as good rock is penetrated below the feature (approx 30 cm). Homogeneous rock with few fractures. The angle to the borehole axis is relatively small making this feature a somewhat more difficult target. The first fracture below (154/51) has a different direction implying a different situation 0.5 – 1 m away from the pilot hole.
18.98 – 19.04 m	325/70	A section of four calcite-chlorite filled fractures over the distance of approximately 1 dm in homogeneous greenstone. 4 dm below this section there are homogeneous greenstone with a few sealed calcite-chlorite-epidote filled thin fractures.
23.2 m	155/68	Chlorite-calcite filled fracture in a complex fractured section with crosscutting open structures and a mixed rock of greenstone and fine grained granite. Not suitable due to crosscutting features.
23.6-23.7 m		Fine grained granite in a complex section of fractures. Chlorite filling. Not suitable due to the complexity of the fracturing.
23.79 m (23.86)	153/82 (233/52)	Calcite filled fracture in a thick section of greenstone. Above the fracture there are a large packet of other faults and fractures. Below the core is homogeneous and no fractures over a distance of approximately 1 m. Just above the target, there is one unmapped fracture with an orientation parallel to the borehole axis. This feature is possible but has a risk of crosscutting features.
42.8 m	332/76	This calcite-chorite filled fracture cuts both aplite and diorite and is almost orthogonal to the borehole axis. There is another calcite fracture crosscutting the target. Not suitable due to both crosscutting and dual rocktypes.
43.87	141/84	Calcite-chlorite-epidote filled fracture with crosscutting (sealed) fractures almost parallel to the drill core. The fracture surface is worn due to rotation of the drill core.
45.24 m	337/89	Fracture with a rim zone in diorite. The fracture filling is both chlorite and calcite. A fracture almost parallel to this feature crosscut the target. Not suitable due to the cross cutting of two fractures.

3.2.2 Radar reflectors in KA3065A02

The radar investigation in KA3065A02 reveals 7 radar reflectors which can be related to BIPS mapped fractures. One of the reflectors coincide with the target fracture at 9.90 m, another seem to intersect close to the inflow point at 23.8 m.

Table 3-4 List of radar reflectors in KA3065A02

Location in KA3065A02	Strike	Dip
10 m	123	86
18 m	124	60
24 m	169	85
25 m	283	40
26 m	92	79
47 m	213	62
49 m	16	86

3.3 Structural modelling of potential candidate structures in boreholes KA2865A01 and KA3065A02

3.3.1 Structural model of KA2865A01

KA2865A01 contains few candidates some of which are not considered plausible for the LTDE experiment. The main structures are shown in Figure 3-1 as blue and green discs along KA2865A01. The new data is visualised with the structural model from Winberg et al (1996), (DGN file from Per Askling, GEOSIGMA AB). The small blue discs represent fractures mapped as natural, i.e. fractures that are not sealed with minerals. Large green discs indicate which of the natural fractures that are conductive. Blue lines and green "~" shows interpreted zones and increased foliation in the area.

The features early in the borehole are not considered suitable for the experiment due to the fact that they do not have mineral coating and does not show any alteration rim. The structure at 17.7 m is oriented with a high inclination to the borehole which has the effect that an experimental hole needs to be drilled far from the pilot hole to intersect the structure with an orthogonal angle. The last feature lies in fine grained granite and is not considered to represent the geological surroundings of a typical conductor in the rock mass.

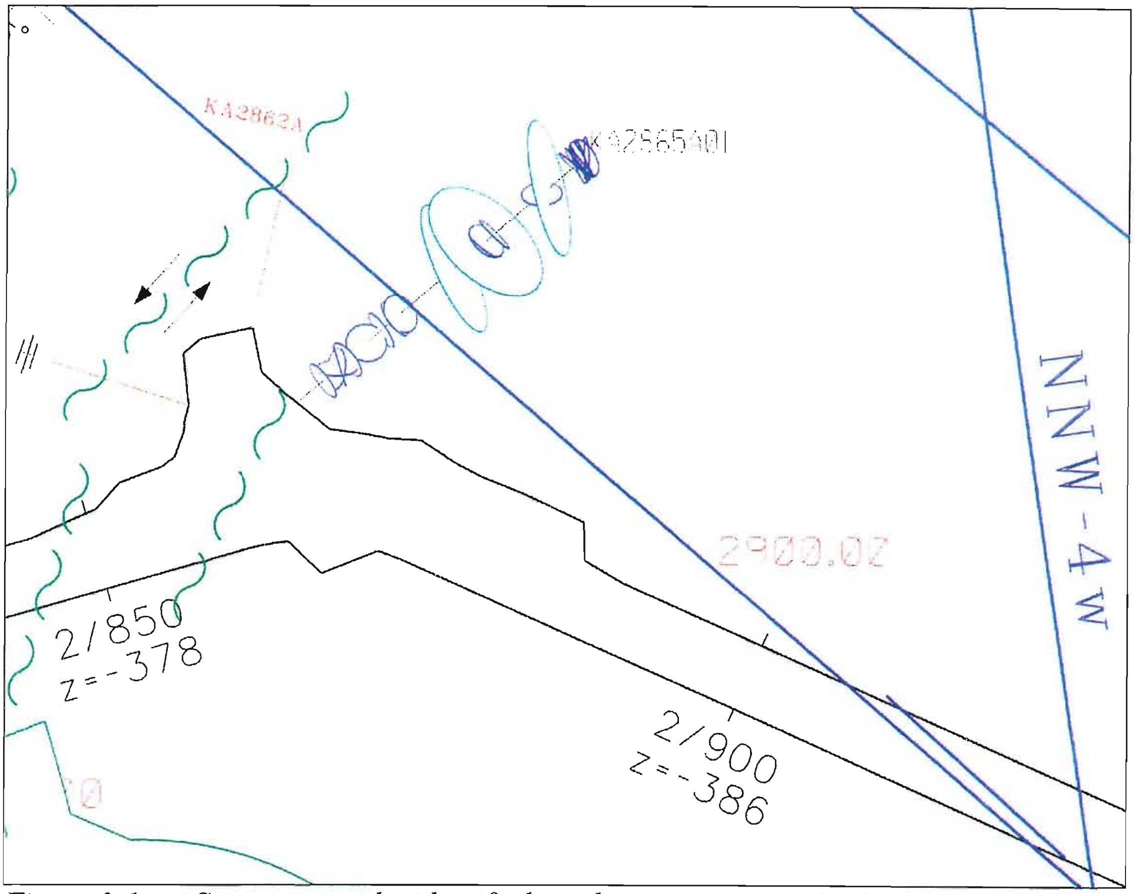

Figure 3-1 Structures at the identified conductive points in KA2865A01.

3.3.2 Structural model of KA3065A02

This borehole has 13 candidate sections with appropriate hydraulic conditions as shown in Chapter 2. Green discs in Figure 3-2 represent natural fractures interpreted to be the conductors in the respective section. Blue lines indicate areas where larger structures intersect. The deeper conductors seem to be part of the zone NW-2 and could be in indirect contact with the TRUE-1 site.

The first two targets are considered to be too close to the tunnel to completely avoid the draw down. At 9.40 m a large package of fractures is intersected. This section gives 16 l/min and is geologically complex with faults and splays. As the experimental setup is in need of good rock directly beneath the target fracture, this section is considered unsuitable on geological grounds.

The most suitable candidate from a structural geological point of view is the structure at 9.90 m in KA3065A02. This structure consists of a package of five fractures with a main fault in the centre. A drawing showing the individual location of these features is shown in Figure 3-3. The bottom most fracture is located next to a 80 cm section of good rock just beneath the structure. The target fracture is almost orthogonal to the core. The whole structure above the target is quite altered with chlorite, epidote, calcite mineralisations. This structure resembles the A-feature in TRUE-1. The target fracture could be interpreted as a splay to the main fault in this section.

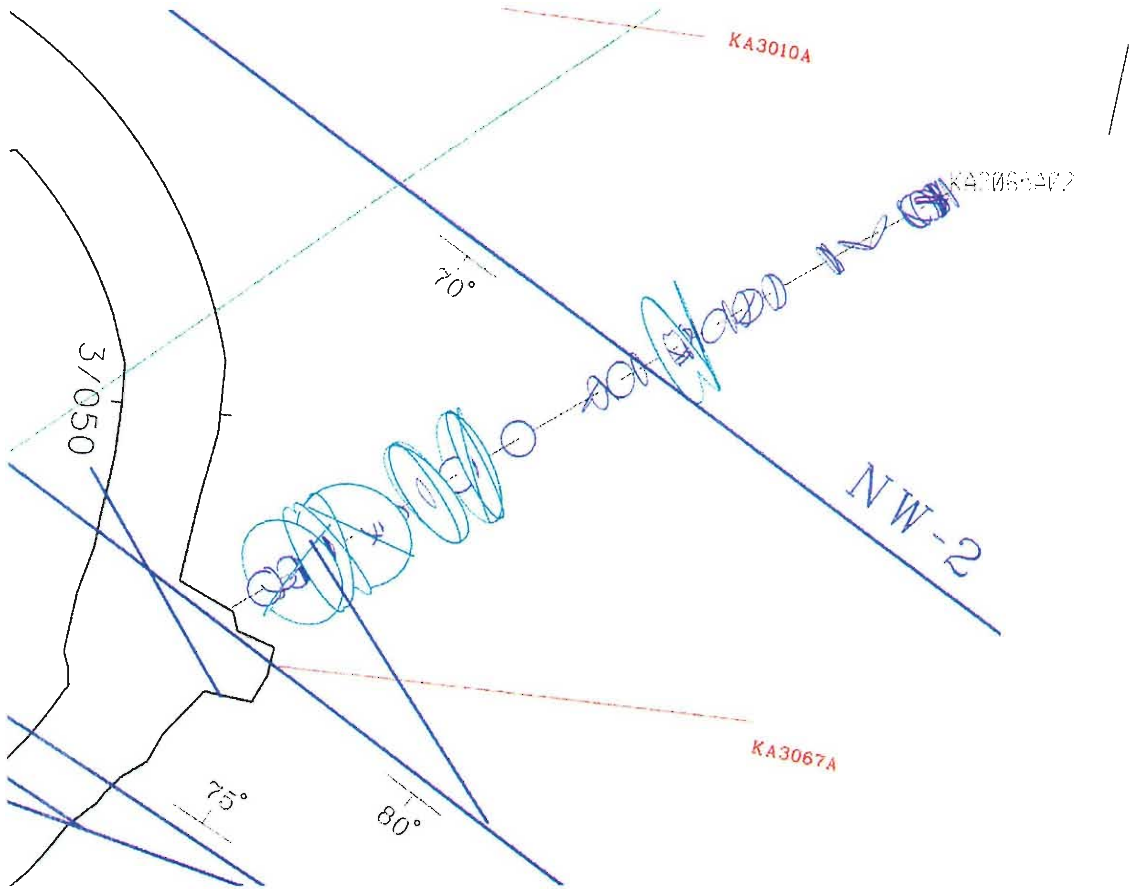

Figure 3-2 Structures at the identified inflow points in KA3065A02.

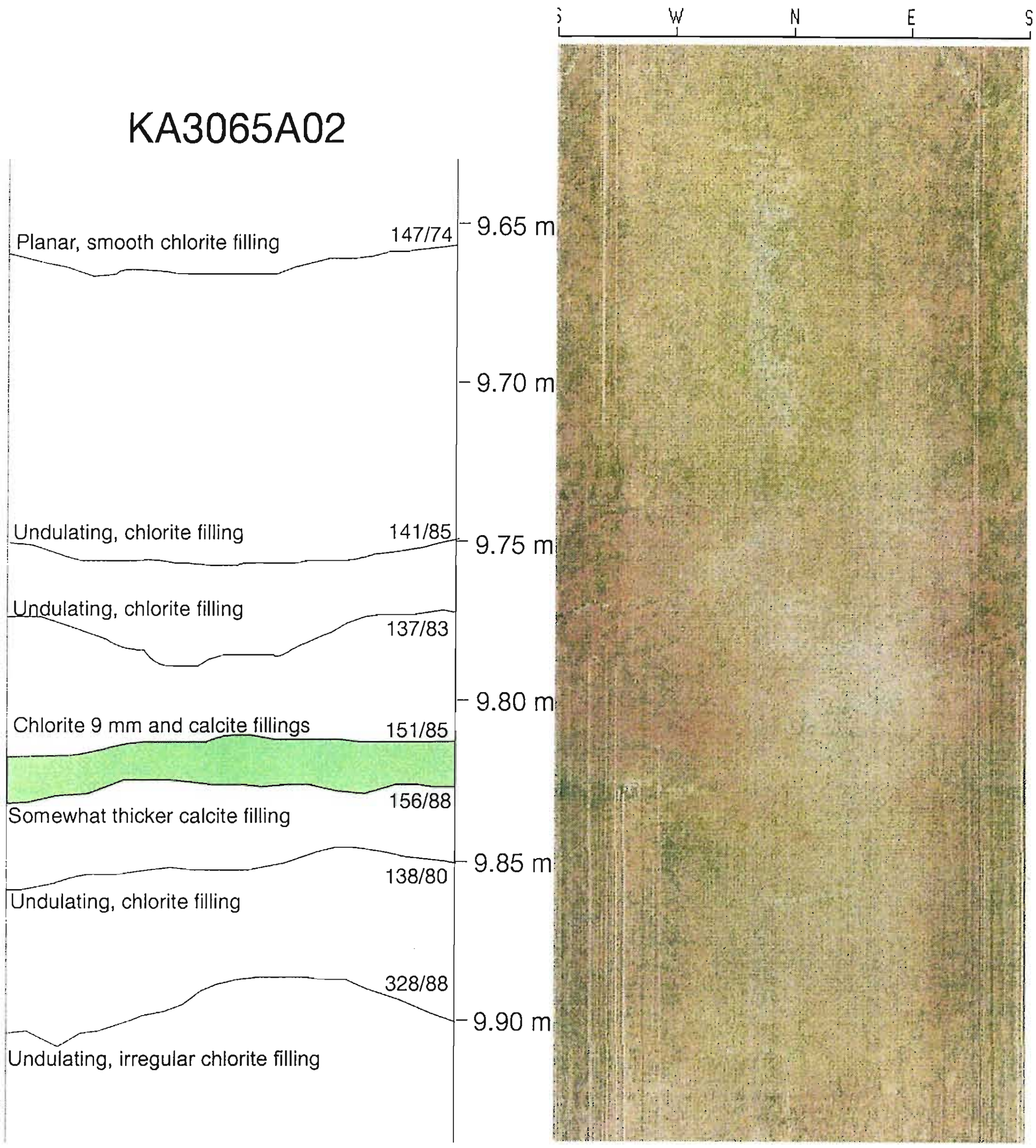

Figure 3-3 Illustration of the location of fractures around the main fault at L=9.81 m in KA3065A02 as observed in the core. The BIPS image shows poor mainly due to degassing (grey-white foggy shading along the central axis of the folded out BIPS image, corresponding to vertical up in the borehole).

Target structures beyond the fracture at 9.90 m are of less interest due to either undeveloped alteration rim zones, complex fracturing, lack of fracture mineralisation, or unusual rock type, c.f. Table 3-3.

3.3.3 Proposed location of LTDE experimental borehole

Based on the identified target fracture in KA3065A02 a tentative geometry for a large diameter LTDE experimental borehole is proposed. The target fracture is orthogonal to KA3065A02. To maintain an orthogonal intercept, an experimental borehole is therefore best drilled sub-parallell to the pilot borehole. A simplistic detailed model of the target area reveals that if all fractures are extended in a planar fashion along their respective strike directions, c.f. Figure 3-5, the target fracture will still be the lowermost fracture within a 0.3-0.4 m circle around the intercept in KA3065A02.

For conservative reasons the proposed borehole is estimated to intersect the target 0.9 m away from KA3065A02. Figure 3-5 also show in detail the orientations of the closest fractures as well as preliminary collar data for the proposed LTDE experimental borehole and projected intercept. The distance to the intersection with the target feature in the proposed experimental borehole is estimated to be 10.6 m.

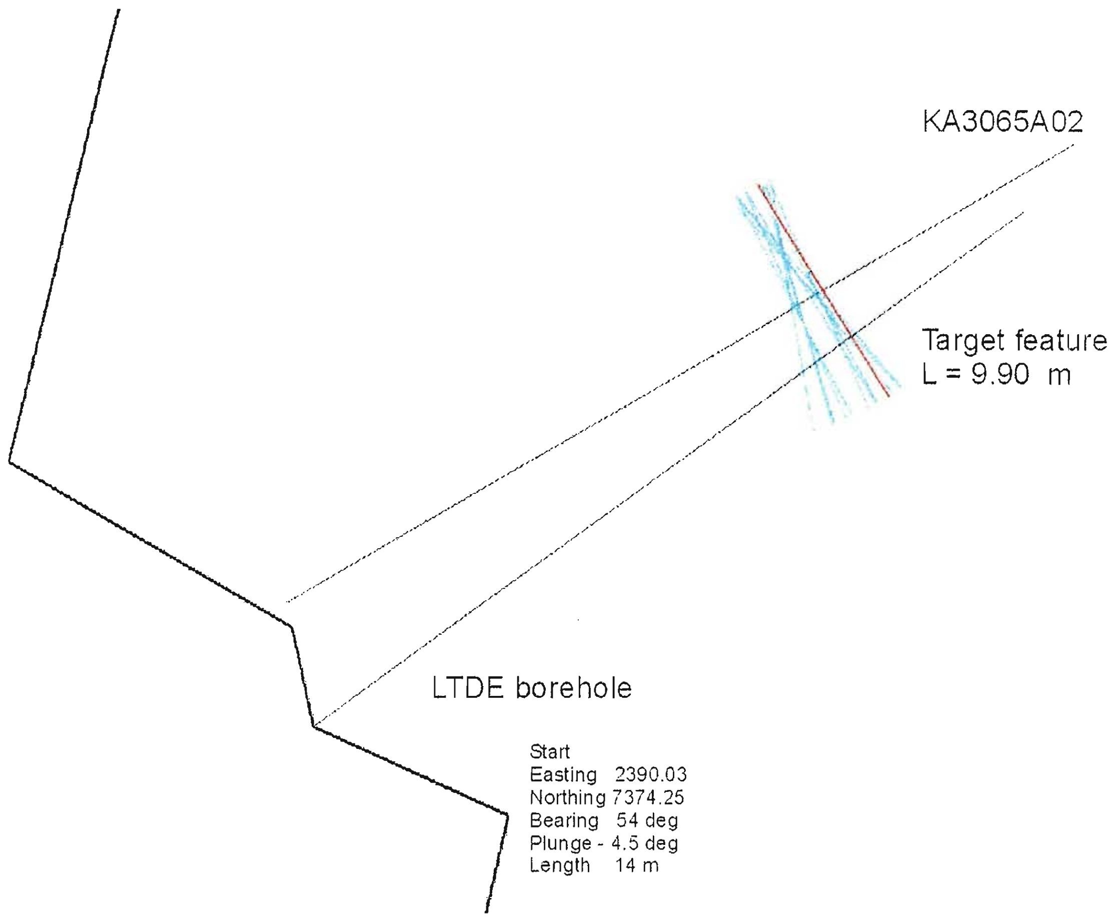

Figure 3-4 Proposed LTDE experimental borehole to intersect the target fracture identified at L=9.90 m in KA3065A02.

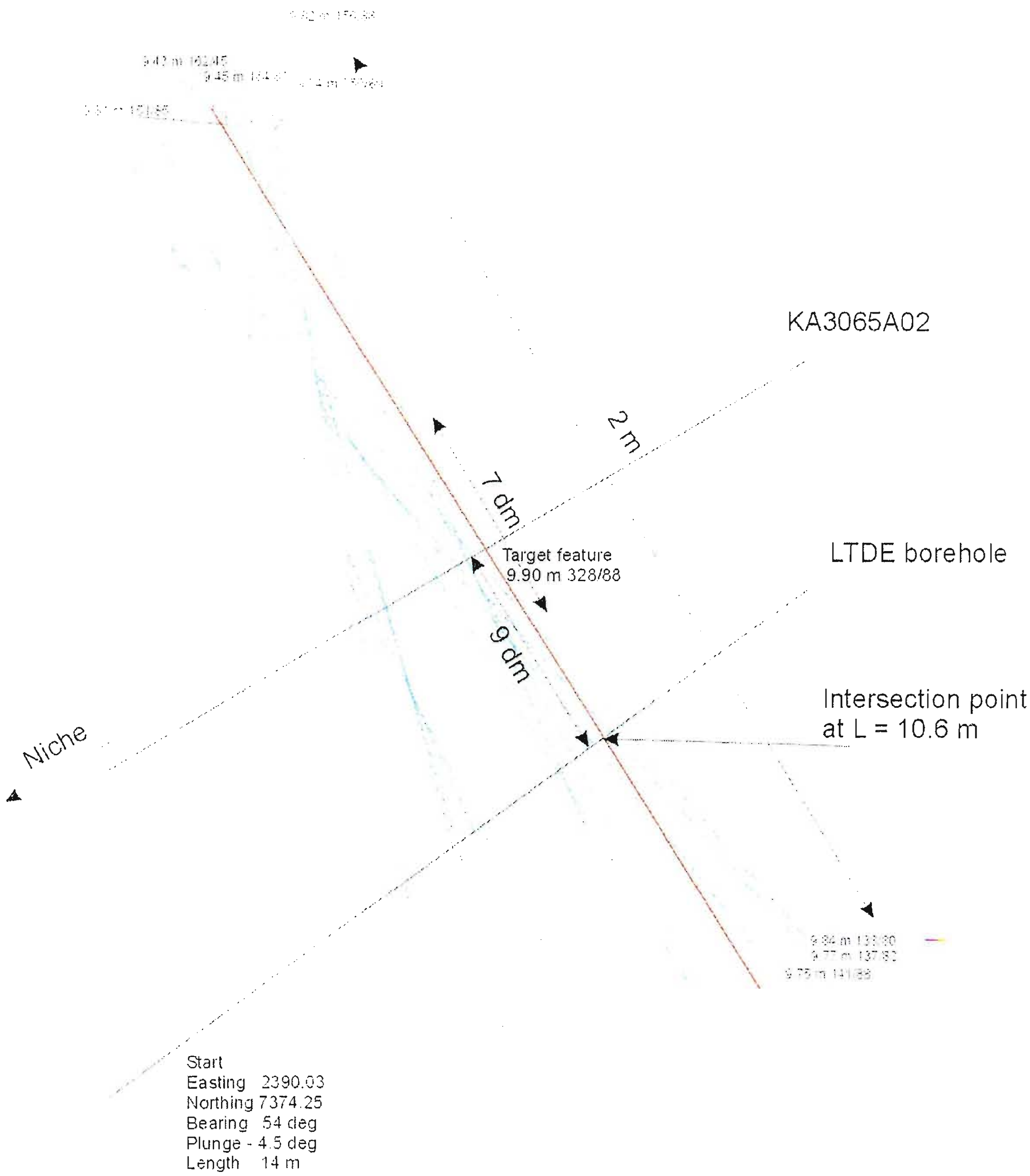

Figure 3-5 Detailed structural model of the target structure identified in KA3065A02 at L=9.90 m. All fractures located at coordinates prior to the target structure have been extrapolated 2 m from the borehole. The illustration shows that most of the fractures are sub-parallel, and that it is likely to find a similar pattern 0.4 to 1 m away from KA3065A02.

4 Conclusions

The assessment of data collected from the pilot boreholes KA2865A01 and KA3065A2 has identified as suitable candidate fracture for the Long-term Diffusion Experiment at approximately 10 m in KA3065A02. The fracture is consequently beyond the possible effects of excavation damage and stress relief. Beyond the identified fracture follow a > 0.5 m long portion of intact homogeneous Äspö diorite. The identified fracture is associated with a choritic/calicite filled marker main fault, which can be used for geometrical reference when drilling the experimental borehole.

A tentative geometry for the proposed experimental borehole is presented with a projected intercept with the identified

5 References

Byegård, J., Johansson, H., Andersson, P., Hansson, K. and Winberg, A. 1999 : Test Plan for the Long-Term Diffusion Experiment. Swedish Nucelar Fuel and Waste Management Company. Äspö Hard Rock Laboratory. Progress Report HRL-96-01.

Winberg, A., Andersson, P., Hermanson, J. and Stenberg, L. 1996 : Results of the SELECT project – Investigation Programme for Selection of Experimental Sites for the Operational Phase. Swedish Nucelar Fuel and Waste management Company. Äspö hard Rock Laboratory. Progress Report HRL-96-01.