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Äspö Hard Rock Laboratory

TRUE Block Scale Experiment

Allocation of Experimental Volume

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November 1996

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1. BACKGROUND

The TRUE project will during 1996 initiate a first characterization phase for the TRUE Block Scale experiment which involve *in-situ* tracer experiments in block scale (L=10-100m). The general objectives of the TRUE Block Scale experiment are to (Bäckblom and Olsson 1994);

- test numerical models and their predictive capability of radionuclide transport in a fracture network over distances 10-100m ,

- test and evaluate scaling relationships using data from block, detailed and laboratory scales.

Different experimental approaches and configurations where discussed during a TRUE Block Scale brainstorming workshop held at Äspö April 16-17, 1996. A general conclusion of this workshop was that the characterization of the selected experimental volume has to be divided into stages; a Preliminary Characterization stage where the overall feasibility of the selected block is evaluated, a second Detailed Characterization stage where a selected part of the block is investigated in a successive and iterative manner using hydraulic characterization and preliminary tracer tests, a Tracer Test stage including performance of long term tracer tests.

The selection of an experimental site is i.a. governed by the overall utilization of the laboratory space. The ambition is to select a volume that does not seriously affect experimental activities elsewhere, and likewise is not affected by adjacent simultaneous activities.

Scoping calculations will be performed to evaluate suitability of various experimental approaches and configurations, given a proposed experimental volume. In order to facilitate such calculations a data set has been compiled. In the process the existing site scale structural-hydraulic model of the laboratory (Stanfors *et al* 1996) has been updated using the detailed information collected within i.a. the ZEDEX, FCC, SELECT and TRUE-1 projects (Hermanson *et al* 1996).

2. DESIRED EXPERIMENTAL CONDITIONS

A restriction in selecting a block for the TRUE Block Scale Experiment is the over all usage of the experimental level of the laboratory. Figure 2.1 shows the usage of the experimental level (in progress or planned). The northeastern part of the laboratory is allocated for the REX and TRUE-1 experiments. The eastern part of the laboratory, outside the tunnel spiral has been sampled by boreholes in the SELECT programme, but cannot be used since hydraulic connection has been established between this area and the TRUE-1 site. The inner part of the tunnel spiral, south of the TBM is used by the ZEDEX experiment, the Demonstration Repository facility and by the Longterm tests on buffer materials. The area inside the tunnel spiral and north of the TBM is at present not used by any experiment. However, previous analysis has shown that the inner part of the laboratory show a high degree of hydraulic connectivity (Winberg *et al* 1996a). In the western part of the laboratory the Chemlab experiments will be performed in borehole KA2512A. This experiment is sensitive to changes in the chemical composition of the groundwater, but does not create any hydraulic disturbances. The final part of the TBM tunnel will be used for the development of a Prototype Repository.

A set of desired experimental conditions have been defined which will be used in positioning the TRUE Block Scale experiment, and for later assessment of potential for successful usage in meeting the set up experimental objectives (Winberg 1996);

- Location outside tunnel spiral
- Size of experimental block ~ 100x100x100m
- Location away from major fracture zones (i.e. EW-1 and NE-1)
- Access from multiple locations (vertically) in the laboratory
- No adverse hydraulic interference from other activities in the laboratory
- Transmissivity range of fractures making up the studied fracture network; $T = 5{\cdot}10^{-8} - 5{\cdot}10^{-7}$ m^2/s
- Small gradient ($I < 0.05$)
- Flow velocities such that diffusion can be a measurable process

Out of the defined desired experimental conditions listed above, the four first ones can be used directly in allocating a block on the basis of the updated structural-hydraulic model and the compiled data set. The latter constraints can only be applied to the extent that data are available, or possible to extrapolate to the area of interest.

3. ASSESSMENT OF DATA AND UPDATED MODEL

The updated structural model of the experimental level developed by Hermanson *et al* (in press) is shown in Figure 3.1. Together the major northeasterly trending fracture zones delimiting the experimental area, EW-1 and NE-1 and zones NNW-4 and NE-2 effectively bound the spiral tunnel. The building of the updated model including minor zones is presented by Hermanson *et al* (in press) and will not be detailed in this report. It is evident that the area enclosed by the spiral tunnel contains a number of minor possible fracture zones trending east-west to northwest, generally with steep to vertical dip.

Analysis of pressure responses in packed-off boreholes due to hydraulic events (Hermanson *et al.*, in press) indicate that the western and southwestern parts of the experimental area is well connected to the central parts contained by the spiral tunnel. The eastern parts of the experimental area (TRUE-1 and REX sites) are not connected to the central parts, or for that matter to the western parts. It appears that the highly conductive zone NNW-4 acts as a strong moderator to conveyance of pressure perturbations between the eastern and western parts of the experimental level. This was also identified by Winberg *et al* (1996a) when defining the SELECT site selection programme.

This implies that given the present usage of the experimental level of the Äspö HRL and the desired experimental conditions defined above, the southwestern part of the experimental level is the most favourable one. The reason for this statement are;

1) Location of the TRUE Block scale experiment in the southwestern part is not likely to create mutual disturbances between the TRUE Block Scale and the TRUE-1 and REX experiments,

2) A block positioned in the southwestern part can be accessed from two levels, from the TBM and the spiral tunnel some 150 m above,

3) A location in the southwestern part facilitates positioning outside the spiral tunnel thus avoiding complex boundary conditions.

4. ALTERNATIVE BLOCK LOCATIONS

Three blocks with the size 100x100x100m have been tentatively positioned in the southwestern part of the laboratory, denoted Block 1 through 3, c.f. Figure 4.1. All blocks are vertically centred on Z=-450m.

Block 1 is bounded by zone EW-1 in the west, two minor zones in the north and south, respectively (including the interpreted NNW-1), and the trace of the spiral tunnel in the east. Borehole KA2598A runs along the southern boundary of the block. The block contains one centrally located minor zone which runs parallel with NNW-1. Multi-level access is facilitated from the spiral tunnel and from the F-tunnel, the latter running parallel to the TBM.

Block 2 is bounded in the northwest by a minor zone which is parallel to NE-2, and in the east by a northwesterly zone running parallel with the tentatively interpreted zones NNW-5B and NNW-5C, respectively. Zone NNW-5C trending northwest constitutes a bounding zone some 50m southwest of the block. A northwesterly minor zone, NNW-5B, divides the block in two halves. Zone NNW-5 intersects the block immediately west of the easternmost corner of the block. The superficial parts of the block is sampled near its southeastern boundary by borehole KA2511A. This borehole penetrates all the northwesterly trending zones bounding or transecting the block. Multilevel access is facilitated from the spiral tunnel and from a niche along the TBM.

Block 3 is bounded in the northwest by zone NE-2 and in the south by zone NE-1 and/or zone EW-3. The southern and eastern boundaries of the block run near parallel with two minor zones. Multilevel access is more difficult here since the distance to the TBM tunnel is quite large (>150m). There is no problem to access the block from the spiral tunnel.

The relatively small degree of freedom in positioning possible blocks in the southwestern part of the experimental level entails that Block 1 and Block 3 are located close to major site scale fracture zones, EW-1 and NE-1, respectively. In contrast, Block 2 is located at a distance of 100-150 m, or more, away from any of the two mentioned zones. Considering the defined experimental conditions, Block 2 thus has the most favourable location. In addition, sampling of northwesterly features, interpreted to be the major conductors, is facilitated by the mutual geometries of the tunnels and structures.

As a consequence of the above reasoning, Block 2 is put forward as a prime candidate block for further study. In Chapter 5 the main characteristics of the block are presented facilitating scoping calculations. This compilation should be regarded as a focused condensate of the compilation made by Hermanson *et al* (in press). In Chapter 6 the planned first steps in the preliminary characterization of the block are presented.

5. CHARACTERISTICS OF THE SELECTED ROCK BLOCK

In the following sections a brief description of the characteristics of the rock volume including Block 2 is outlined. The main bulk of information regarding the rock volume in question and its relation to other parts of the Äspö HRL is presented by Hermanson et al (in press). **NOTE : Figure and table references in italics refer to figures and tables in Hermanson et al (in press).**

5.1 Lithology

Both the corelog of KA2511A (*Figure 2-1*) and relevant tunnel segments *(Figure 6-1)*, indicates that the geology in the southwestern corner of the laboratory appears to be made up of Äspö diorite. The distribution of Äspö diorite appears to be homogeneous.

5.2 Minor fracture zones

5.2.1 Geometry of minor fracture zones

The geometry of the zones of enhanced connectivity (possible minor fracture zones) interpreted in the area of interest are presented in *Appendix A2.* The geometry of the bounding/intercepting zones discussed in Chapter 4 are listed in Table 5-1.

Table 5-1 Geometry of minor fracture zones interpreted in the southwestern part of the Äspö HRL (from Hermanson et al., (in press).

Fracture zone ID	Strike (°) [1)]	Dip (°)
NNW-5	164	76
NNW-5B	153	78
NNW-5C	?	?

[1)] All directional data are referenced to Äspö Local North.

5.2.2 Material properties of minor fracture zones

The results of hydraulic tests performed in borehole KA2511A are reported by Hermanson et al (in press), c.f. *Table 2-1*. Based on existing data transmissivities have been assigned to the identified fracture zones as reported in *Appendix A2.* The transmissivity data related to the identified fracture zones in the southwestern corner are detailed in Table 5-2.

Table 5-2 Transmissivity data assigned to identified minor zones in the southwestern part of Äspö HRL (from Hermanson et al., (in press).

Fracture Zone ID	Transmissivity T (m^2/s)
NNW-5	$3.6 \cdot 10^{-5}$
NNW-5B	$2.4 \cdot 10^{-5}$
NNW-5C	$2.4 \cdot 10^{-5}$

5.3 Rock mass

Fracture network properties relevant to the proposed rock block are presented in *Table 6-5* and *Table 6-6.*

Hydraulic conductivities measured on a 100m and 3m length scale, respectively, averaged in 100m intervals in the vertical direction are reported in *Table 6-7* and *Table 6-8.* The former data has large areal coverage and also include data from the (Laxemar borehole) KLX02. The latter data set is based on data from surface boreholes KAS02, KAS05-KAS08, and is regarded as being more representative of the rock mass (fracture zones excluded) in the studied block. However, to the above data should also be added the data reported for borehole KA2511A, c.f. *Table 2-1.*

6. PRELIMINARY CHARACTERIZATION

The first steps in the preliminary characterization of the selected block include drilling of a pilot borehole through the block and carrying out of a seismic survey. The aims of these studies are to; a) provide site-specific data on the block and b) sustain the developed deterministic description of possible minor fracture zones in the block.

6.1 Pilot boreholes

One pilot borehole will be drilled from a niche on the 340m level at length coordinate 2/563m. The borehole will be diameter ϕ=56mm and will be cored. The objectives of the first pilot borehole into the allocated rock block for TRUE Block Scale are to;

1) provide access to site-specific data from the selected rock block through various characterization methods (measurements during drilling, core logging (Petrocore), single packer flow logging, borehole radar and borehole TV (RAAX BIPS).

2) provide long-term registration of groundwater pressure in packed off sections.

A second borehole, tentatively KA3510A, will be drilled from the TBM tunnel with the dual aims of providing boundary conditions for the planned Prototype Repository and for the TRUE Block Scale experiment. A third objective for the latter borehole is to facilitate test of a new flowmeter developed by CRIEPI. The diameter of this borehole will be 76mm.

The collar coordinates, azimuth, inclination and length of the boreholes are presented in Table 6-1. Graphical representations of the boreholes in relation to KA2511A are shown in Figure 6.1a (horizontal) and Figure 6.b (vertical). Drilling of the pilot borehole KA2563A commences the second week of August (week 632).

Table 6-1. Geometrical data for the pilot borehole KA2563A drilled into the proposed experimental volume for the TRUE Block Scale Experiment and borehole KA3510A.

Borehole	Eastings (m)	Northings (m)	Elevation (masl)	Azimuth[1)] (deg)	Inclination (deg)	Length (m)
KA2563A	2026.04	7271.88	-340.21	237.54	-41.45	354
KA3510A	1954.45	7260.42	-447.48	258.67	-30.0	150

[1)] Azimuth related to Äspö Local North

6.2 Seismic survey

In addition to the drilling the first pilot borehole, a seismic survey will be performed. The purpose of the high-resolution seismic survey is to sustain the updated structural model of the south-western part of the experimental level. Multiple source points and receiver locations (including receiver arrays in boreholes) will be used.

7. REFERENCES

Hermansson, J., Follin, S., Nilsson P., Nyberg, G., Winberg, A., 1996. TRUE Block Scale Updating of the Structural-Hydraulic model and Compilation of Scoping data set. IPR-02-13

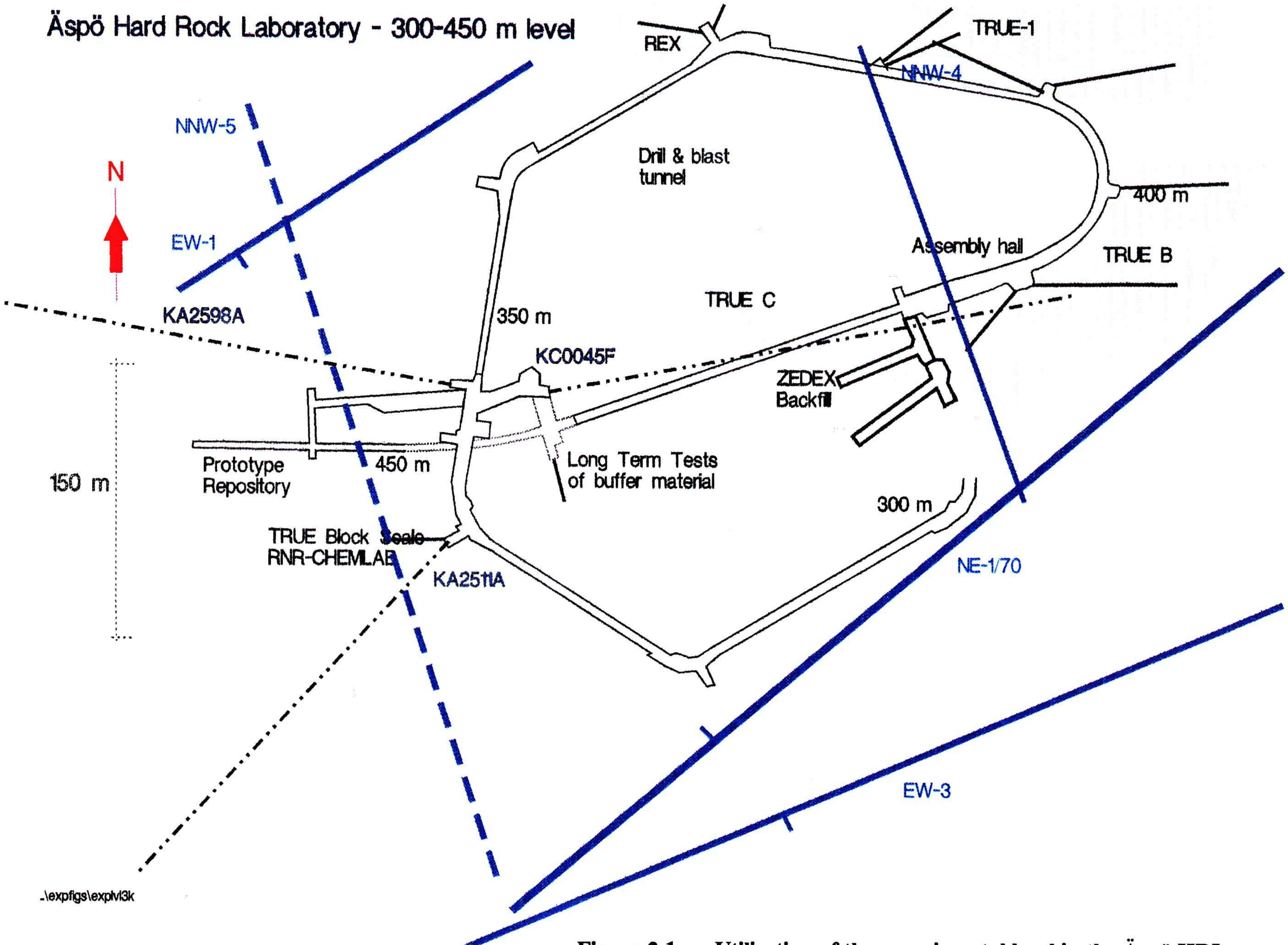

Figure 2.1 Utilization of the experimental level in the Äspö HRL - ongoing or planned

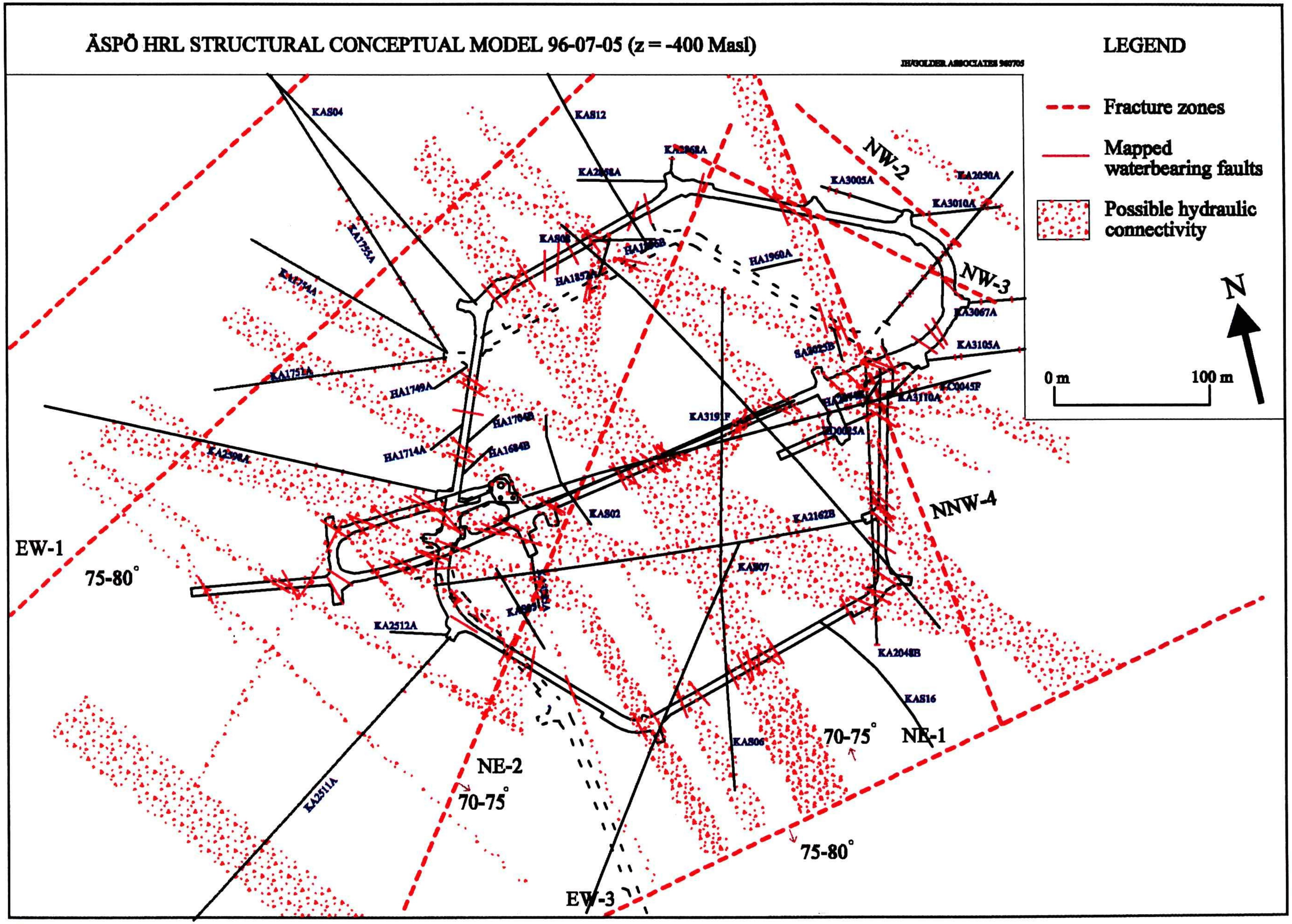

Figure 3.1 Updated structural model at Z=-400 masl (from Hermanson et al., in press).

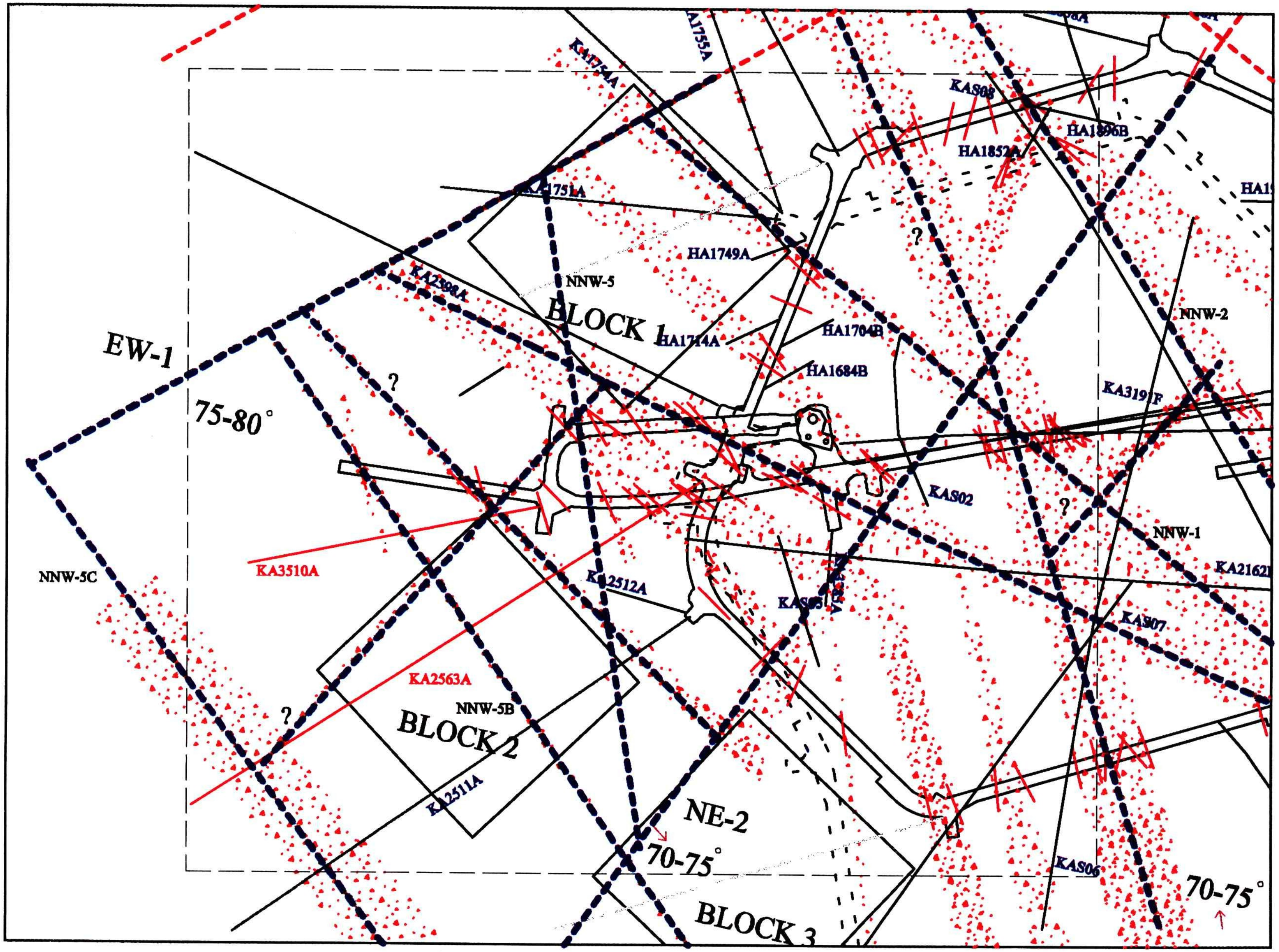

Figure 4.1 Alternative experimental block positions for TRUE Block Scale in the southwestern part of the Äspö HRL.

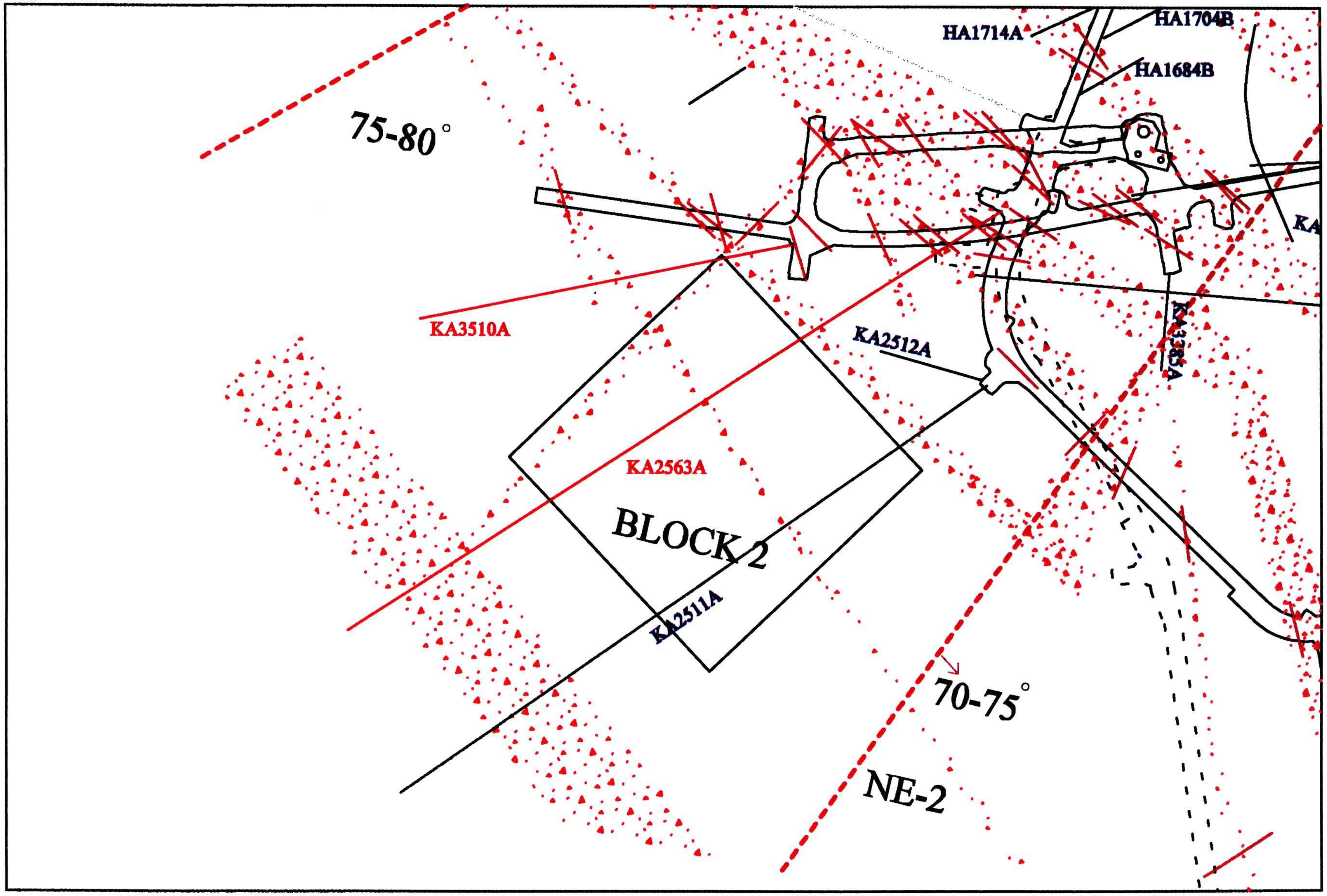

Figure 6.1a **Traces of boreholes penetrating the vicinity of Block 2 (projected on a horizontal plane).**

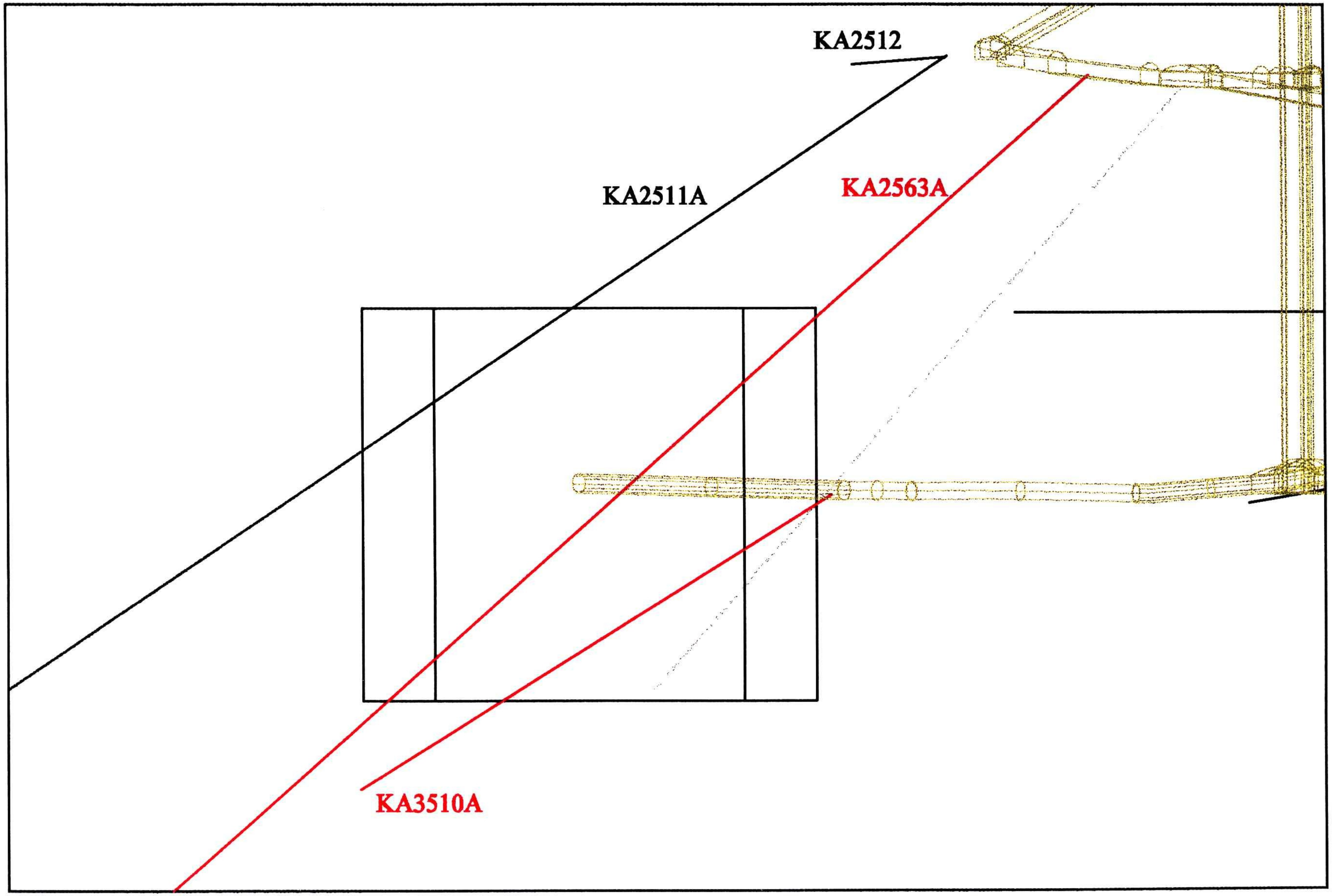

Figure 6.1b **Traces of boreholes penetrating the vicinity of Block 2 (projected on a vertical plane parallel to the plane including the planned borehole KA2563A).**