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Äspö Hard Rock Laboratory

Prototype Repository

Preparation of deposition holes prior to emplacement of buffer and canisters in Section I

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July 2001

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PROTOTYPE REPOSITORY

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Preparation of deposition holes
prior to emplacement of buffer
and canisters in section I

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ABSTRACT

The deposition holes were drilled by use of a Robbins SBM 1.8 TBM machine equipped with a vacuum system for removal of the muck. The average drilling rate was 0.45 m per hour. During drilling the turning momentum, pressure in the thrust cylinders, rate of rotation, and rate of penetration was recorded. In adjacent boreholes gauges for rock stress/strain and temperature measurements were cemented and an AE, Acoustic Emission, system was implemented before the drilling of the deposition holes.

The average diameter of the six deposition holes varied between 1760 and 1762 mm. The requirements concerning straightness and orientation specified by SKB were achieved.

Geological mapping of the walls and bottom of the six holes as well as mapping of water inflow spots has been made and measurement of the inflow rates has been made as well. These measurements demonstrate that the majority of the water inflow is at the bottom of the holes and that very few fractures in the walls contribute to the inflow.

Rock stress measurements have given the average primary stresses and calculation of the stress conditions in the near-field based on these stresses has yielded data of the maximum stresses caused by the excavation. These calculations indicate that the maximum compressive stress is generated at the uppermost part of the deposition holes and that it should not yield failure, which was also confirmed by the observations.

SAMMANFATTNING

Deponeringshålen borrades med en vertikal tunnelborrmaskin tillverkad av Robbins med beteckningen SBM 1.8 TBM. Ett vakuumsystem användes för att transportera bort borrkaxet från borrhålsbottnen under borrning. Den genomsnittliga borrsjunkningen vid borrning var 0,45 m per timme. Under borrningen registrerades kontinuerligt bland annat vridmomentet, kraften i cylindrarna som pressar borrhuvudet mot berget, rotationshastigheten och borrsjunkningen. Vid borrningen av de två sista hålen var spännings-/töjningsgivare tillsammans med givare för temperaturmätning installerade i näraliggande kärnborrhål. Även ett system för registrering av akustisk emission användes vid borrningen.

Deponeringshålens genomsnittliga diameter varierade mellan 1760 och 1762 mm. De av SKB uppställda toleranskraven uppfylldes. Toleranser var givna på bland annat hålens rakhet och deras start- och slutkoordinater.

Deponeringshålens har karterats med avseende på geologi och inflödespunkter för vatten. Inflödet från de enskilda inflödespunkterna såväl som det totalt inflödet har mätts. Inflödesmätningarna visar att majoriteten av vatteninflödena i deponeringshålen härrör från hålbotten och endast en liten andel härrör från sprickor i hålväggarna.

Bergspänningsmätningar har genomförts i närområdet av Prototypförvaret och resultaten därifrån har använts för att beräkna lasten på deponeringehålens närområde. Beräkningarna påvisar att den största påkänningen erhålles i den övre delen av deponeringshålen men att brottlast ej uppnås. Dessar resultat stämmer väl med gjorda observationer.

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1 DRILLING OF DEPOSITION HOLES

1.2 Background

The requirements with respect to the geometry of the deposition holes were defined by SKB to be as follows:

1. The nominal diameter of the hole shall be 1750 mm –5 and +50 mm.

2. The starting centre point of the hole shall divert no more than 25 mm from the theoretical starting point measured perpendicular to the tunnel axis. The deviation parallel to the tunnel axis may be no more than 50 mm.

3. Hole alignment. The measured centre point in the bottom of the hole shall not divert more than 25 mm from a vertical projection of the starting centre point.

4. Straightness. A measured centre point of the bore hole at any depth shall not divert more than 16 mm from a theoretical line drawn between the starting and bottom centre point. This criterion includes deviation due to re-gripping.

5. Re-gripping or any other operational activity may not result in an instant horizontal displacement of the centre point that is more than 10 mm.

6. The hole wall surface should not have larger irregularities than 10 mm.

7. No criteria have been defined for the bottom shape of the hole.

Several bids for the boring were considered but the company Drillcon AB was contracted for making the drillings by use of a TBM-type boring with vacuum extraction of the debris. The six holes in the test area were drilled between June and September 1999.

1.3 Drilling process

The drilling operations were performed successfully by use of a Robbins SBM 1.8 TBM machine with a drilling head illustrated by Figure 1-1. The average drilling rate was 0.45 m per hour. Cutters were not changed in the course of the drilling of the respective holes. During drilling of all the holes the rig was instrumented so that the turning momentum, pressure in the thrust cylinders, rate of rotation, rate of penetration among other things were recorded. These data were used to evaluate this new shaft-drilling technique. In boreholes adjacent to deposition holes No. 5 and 6 gauges for rock stress/strain and temperature measurements were fixed by cementation. The readings taken were used to study the rock mechanical response close to the deposition holes due to excavation. Around the same deposition holes an AE, Acoustic Emission, system was implemented. Two rock stress measurements in the vicinity of the Prototype Repository area had given rather different results regarding the direction of the major principal stress. When monitoring the volume around a deposition hole during boring with an AE-system most events will occur in the hole walls that are perpendicular to the direction of the major principal stress. After analyse of the AE-information the far field stress orientation could be assessed. This assessment agreed very well with one of the rock stress measurements made and the stress field orientation could be determined. After a later recalculation of the rock stress measurement that did not agree with the AE-measurement it was found that the consultant had used a wrong co-ordinate set for the calculations. The new results now agreed with the orientation derived from the AE-measurements.

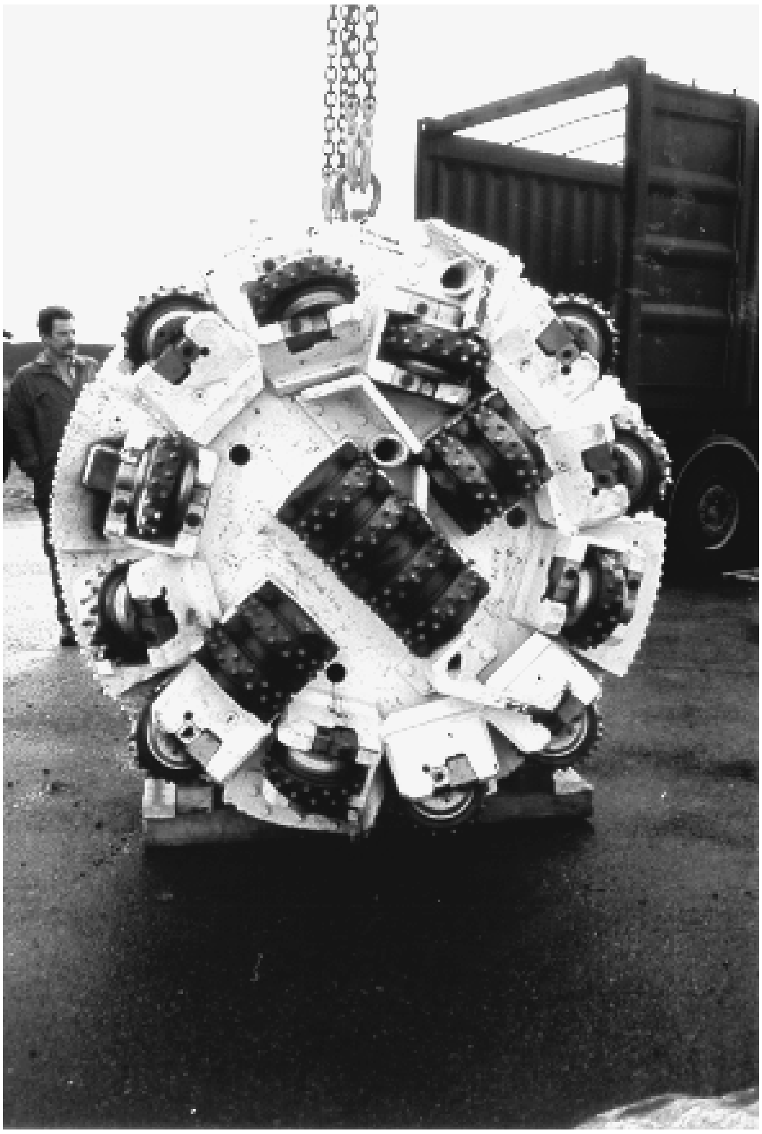

Figure 1-1. *Head of the drilling machine showing carbide cutters. Note some of the carbide cutters were replaced by disc cutters.*

The cuttings produced during boring had a sieved d_{50} value of 2.8 mm. The larger chips had an average size of approximately 28/18/7 mm (length/width/thickness). It was removed from the borehole during boring by a vacuum system (Andersson et al).

2. PROPERTIES OF THE DEPOSITION HOLES

2.1 Geometry

Measurements gave the data in Table 2-1, which certifies that the criteria specified in Section 1.2 were fulfilled. A special observation was that a block with a volume of a few cubic decimeters fell from the wall in hole 2 approximately 1.5 meters down the hole. This piece of rock was located in a part of the hole where modelling indicate increased compressive stress due to the excavation. The main reason for it's expulsion was the existence of unfavourably oriented pre-existing fractures.

Table 2-1. *Geometry of deposition holes.*

Section	Deposition hole	Maximum deviation from centre line [mm]	Offset between start and end point [mm]	Averaged diameter [mm]
1	Hole 1 DA3587G01	6	5.4	1760
1	Hole 2 DA3581G01	5	7.8	1760
1	Hole 3 DA3575G01	5	1	1761
1	Hole 4 DA3569G01	4	4	1761
2	Hole 5 DA3551G01	6	4	1762
2	Hole 6 DA3545G01	8	1.4	1760

2.2 Discontinuities in walls and bottoms of the deposition holes

Geological mapping of the walls and bottom of the six holes as well as mapping of water inflow locations has been made and is shown in Figures 2-1 to 2-6 (Forsmark et al 2001).

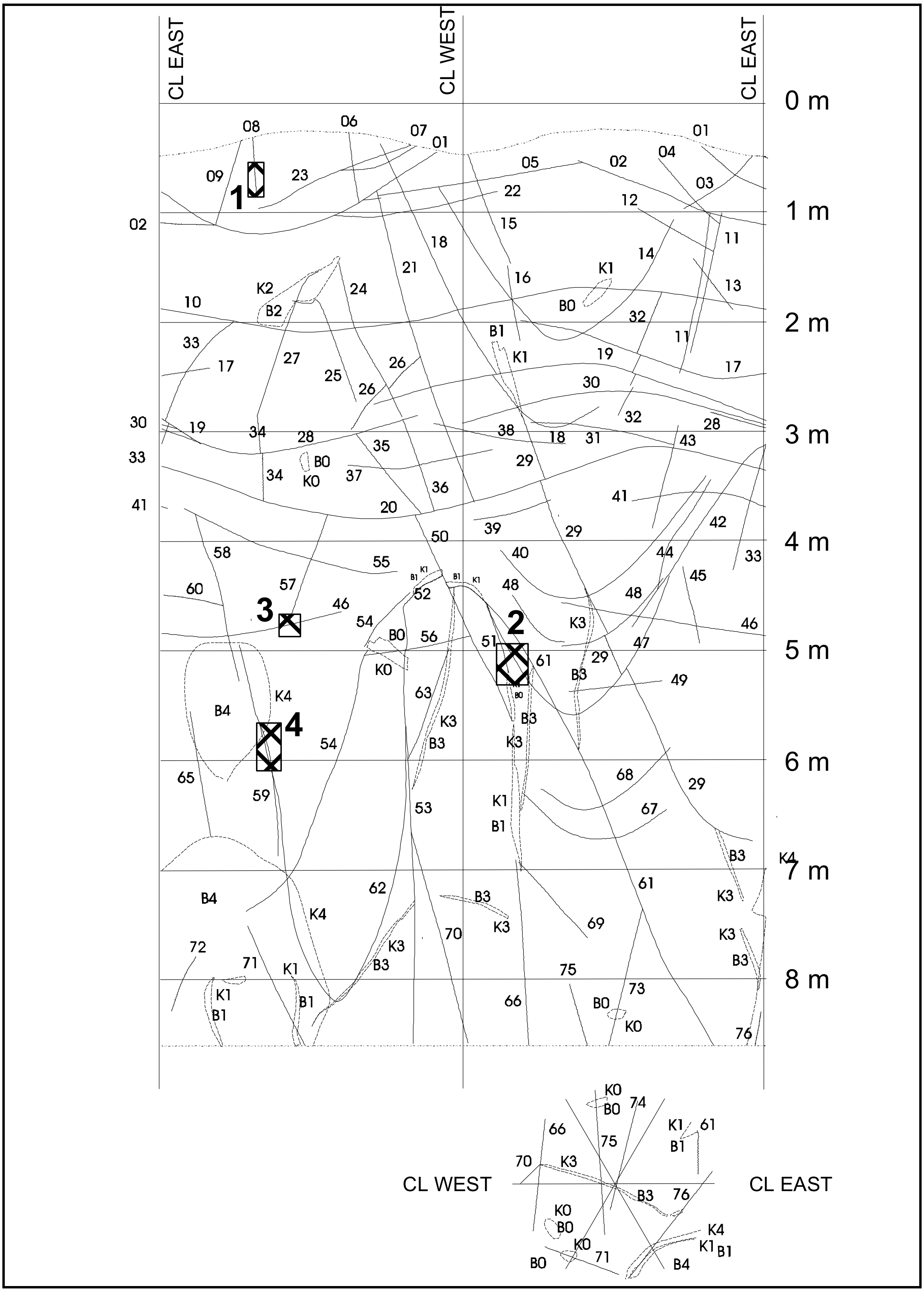

Figure 2-1. *Deposition hole mapping in DA3587G01. Mapped water-bearing features are marked with shaded areas.*

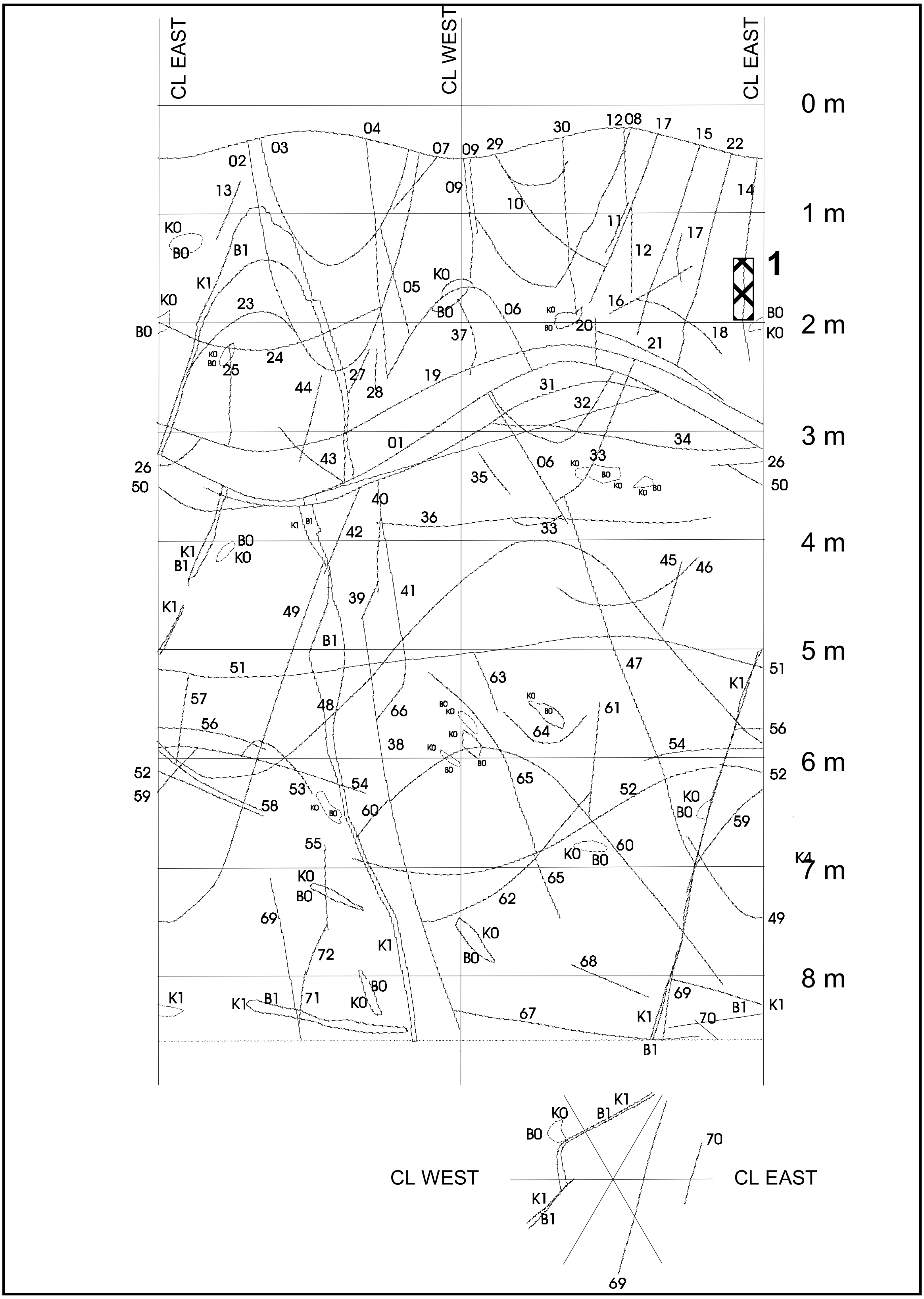

Figure 2-2. *Deposition hole mapping in DA3581G01. Mapped water-bearing features are marked with shaded areas.*

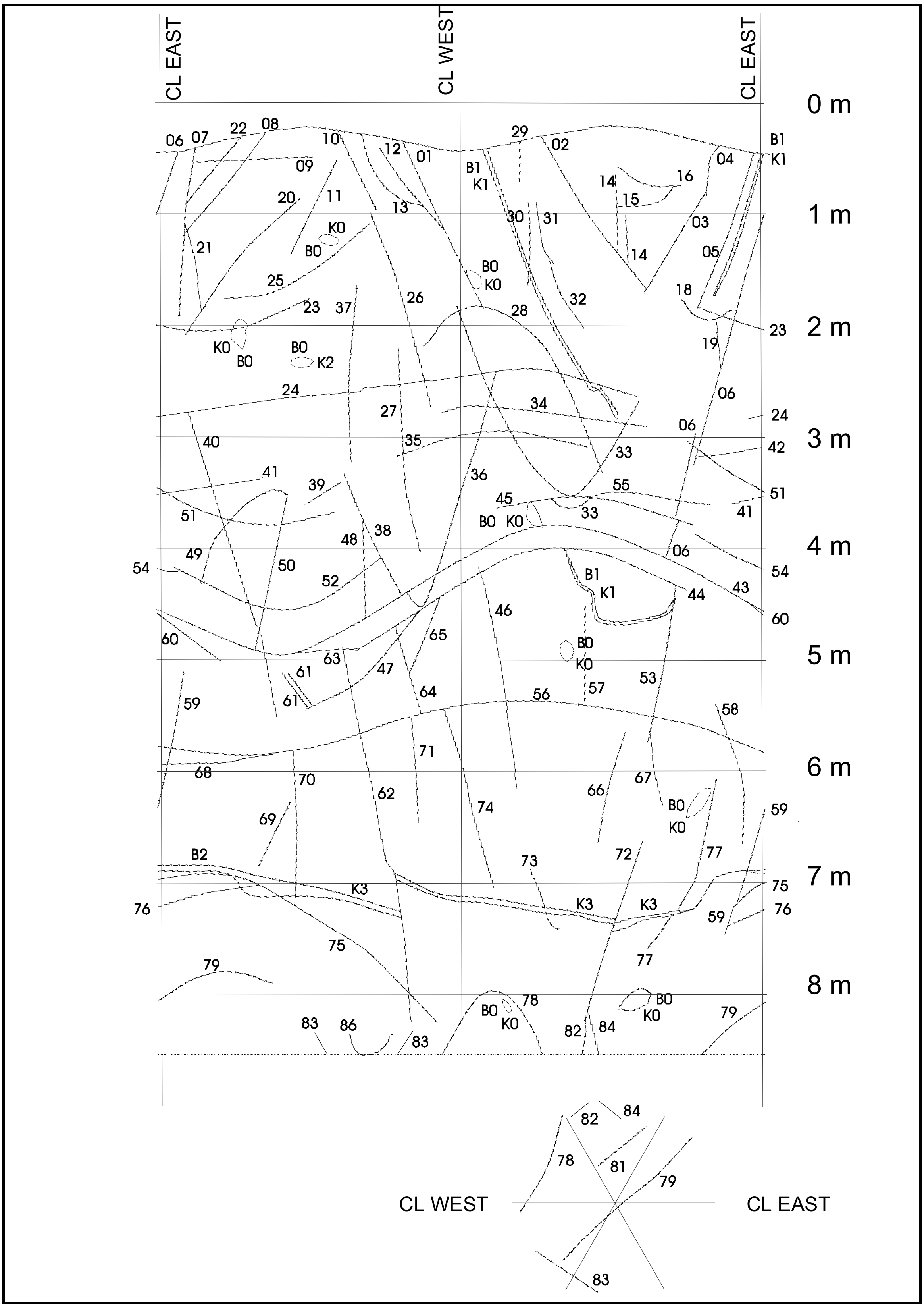

Figure 2-3. *Deposition hole mapping in DA3575G01. No water-bearing features were observed.*

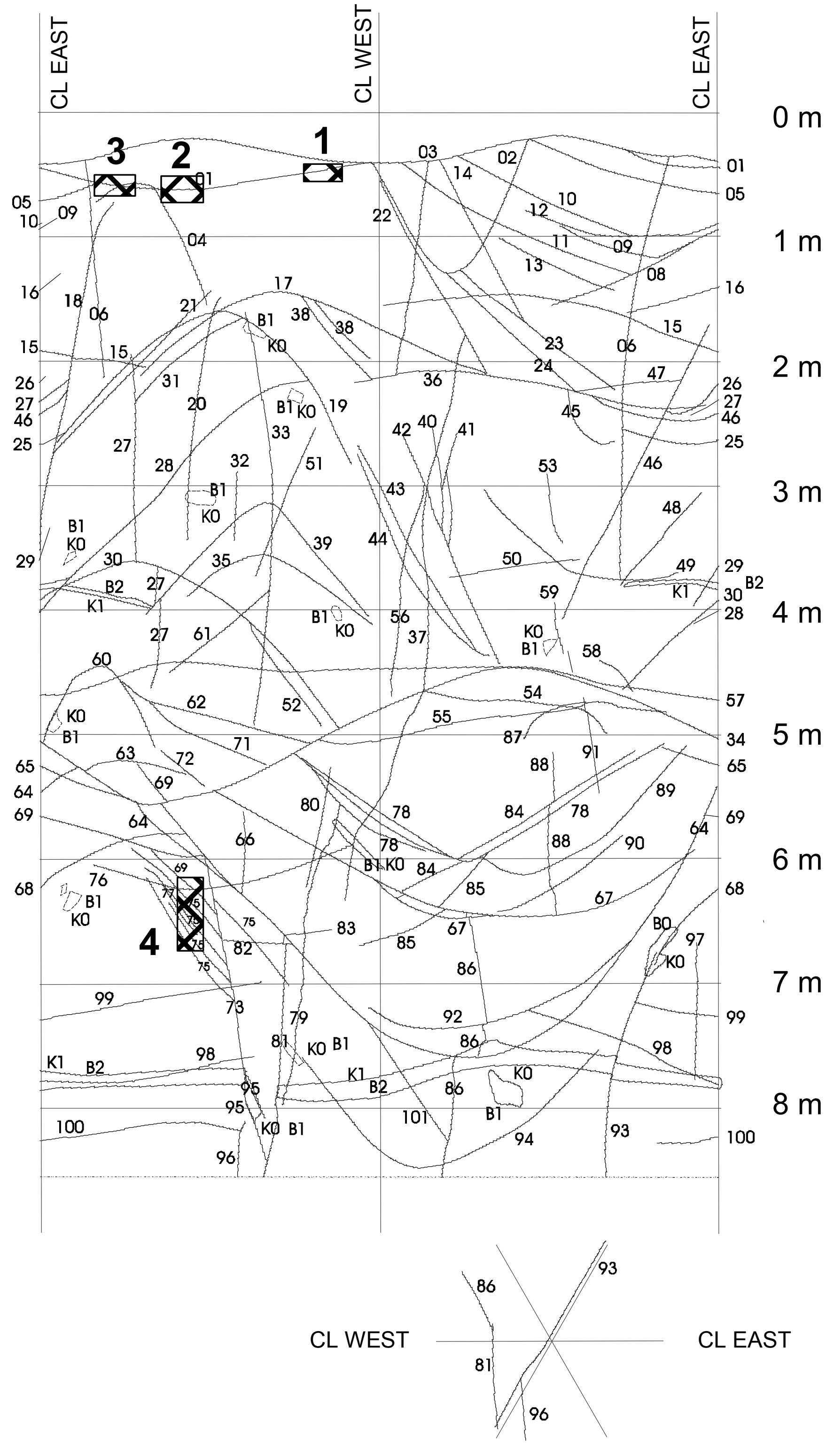

Figure 2-4. *Deposition hole mapping in DA3569G01. Water-bearing features are marked with shaded areas.*

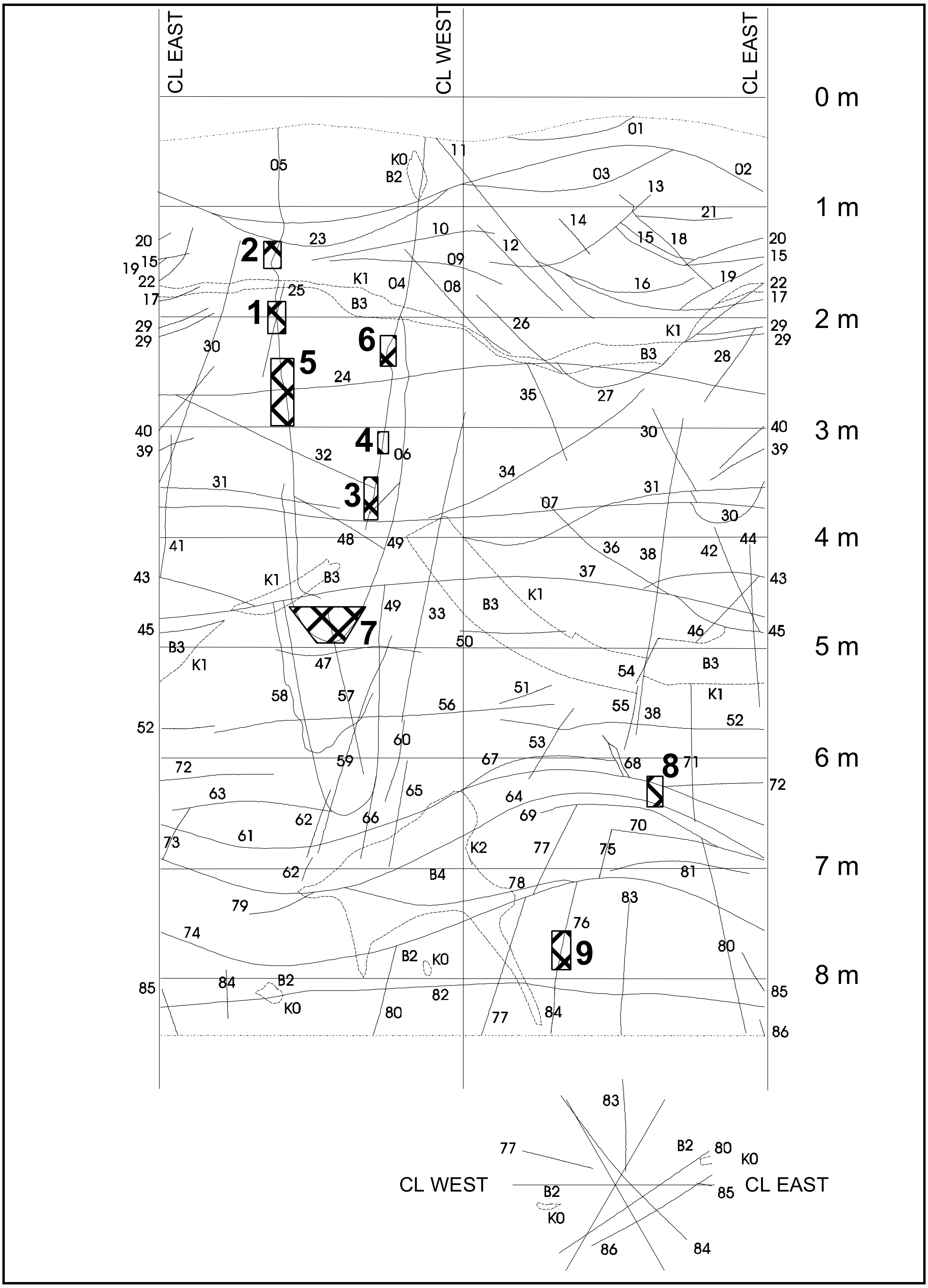

Figure 2-5. *Deposition hole mapping in DA3551G01. Water-bearing features are marked with shaded areas.*

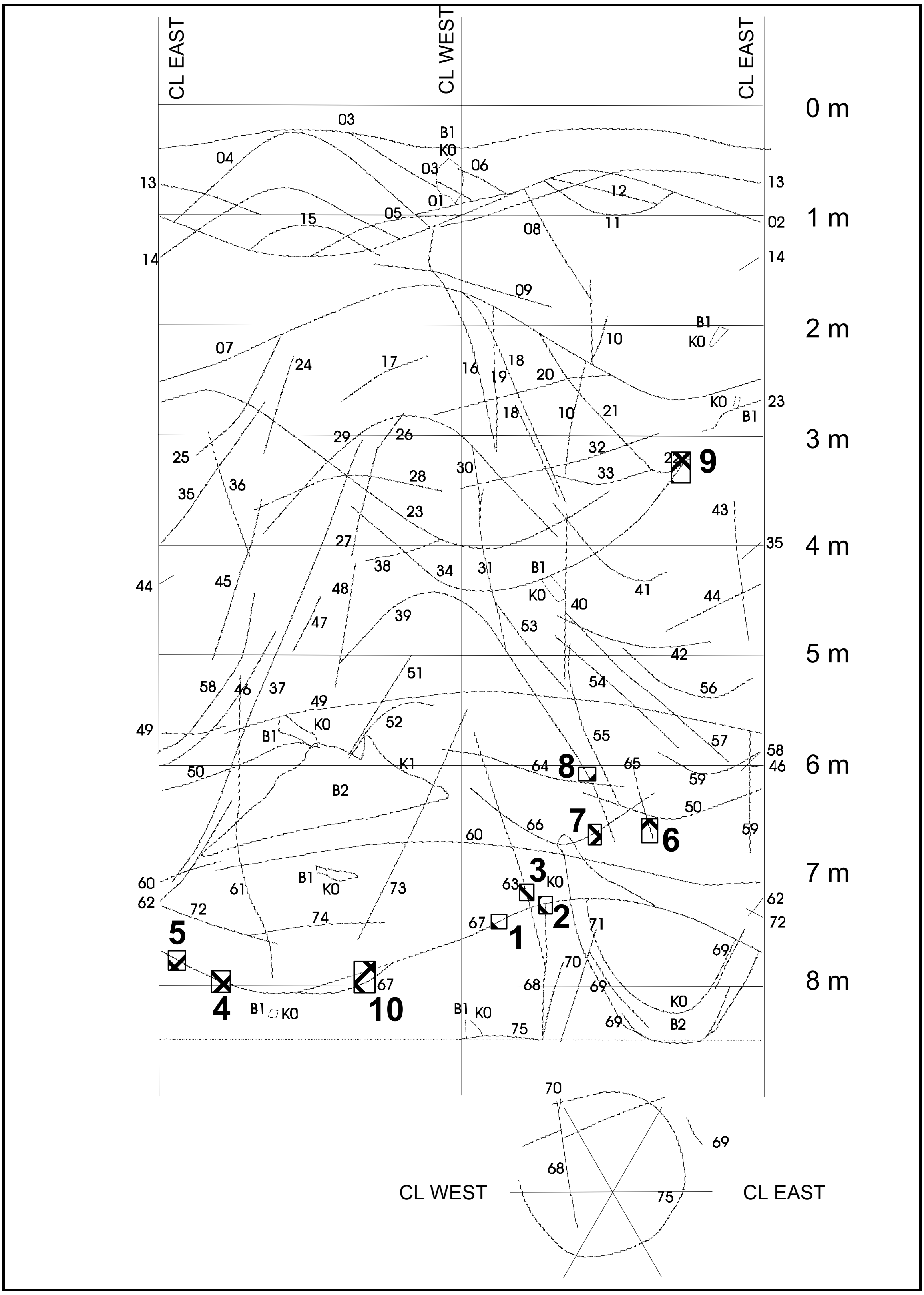

Figure 2-6. *Deposition hole mapping in DA3545G01. Water-bearing features are marked with shaded areas.*

2.3 Preparation of deposition holes

Sump holes have been drilled at the bottom of the deposition holes close to the eastern walls. They were drilled by overlapping of six 100-mm diameter core drillings in two rows. The sumps are 200 mm deeper than the bottom of the deposition hole. Drainage has been made by use of suction pumps located on the tunnel floor and connected to the sump through a hose.

The bottom of each hole has been covered by concrete in order to level them. A copper mesh was placed between the hole bottom and the concrete to prevent water pressure build-up.

In Holes 3 and 4 cores with 95 mm diameter and 350-500 mm length have been taken for examination of the excavation-disturbed zone. These analyses have not yet been reported.

In holes 5 and 6, subhorizontal core drilling has been made in the hole walls to 2.3 m distance from the wall. The holes will be used for installation of thermocouples and instruments for rock mechanical measurements. Subvertical core drillings were made to1 m depth in the center of the bottom of each deposition hole for installation of thermocouples.

2.4 Inflow in deposition holes

The inflow into the deposition holes has been measured both qualitatively and quantitatively. The latter measurements were made by having an ultrasonic transducer logging the rise of the water table in the hole during a week after emptying it. Since the hole geometry is well known the total net inflow could easily be calculated. The qualitatively measurements were of two kinds. Firstly, the water-bearing fractures as identified were covered with plastic sheets. The water collected was sampled in plastic bottles and the volume measured regularly, which made it possible to assess the amount of water inflow from to the individual water-bearing fractures. It was concluded that most of the water originated from the bottom of the hole and could not be measured for practical reasons. In the holes where diaper measurements were performed the inflow from the hole bottom can though be assessed since the total inflow as well as the inflow from the hole walls are known.

The second qualitative method implied measuring of the inflow from the hole walls by use of water-absorbing diapers during a certain period of time. The diapers were pressed against the hole wall with wooden boards. These measurements were performed in deposition holes No. 2 and 3. Table 2-2 gives the results from the quantitative inflow measurements and Figure 2-7 shows the outcome of the diaper measurements in deposition hole No. 2. As expected from the mapping, practically all water entered the hole walls from a single very steep fracture striking ENE/WSW. From this fracture water was distributed over an adjacent 0.5 m wide wall surface through finer fractures and by capillary forces. For the H-modelling work it is concluded that this fracture can be considered as the most important water source in deposition hole 2.

Table 2-2. *Inflow measurements in the deposition holes.*

Section	Deposition hole	Inflow, litres per minute
1	Hole 1 DA3587G01	0,08
1	Hole 2 DA3581G01	0,002
1	Hole 3 DA3575G01	0,003
1	Hole 4 DA3569G01	0,0007
2	Hole 5 DA3551G01	0,002
2	Hole 6 DA3545G01	0,003

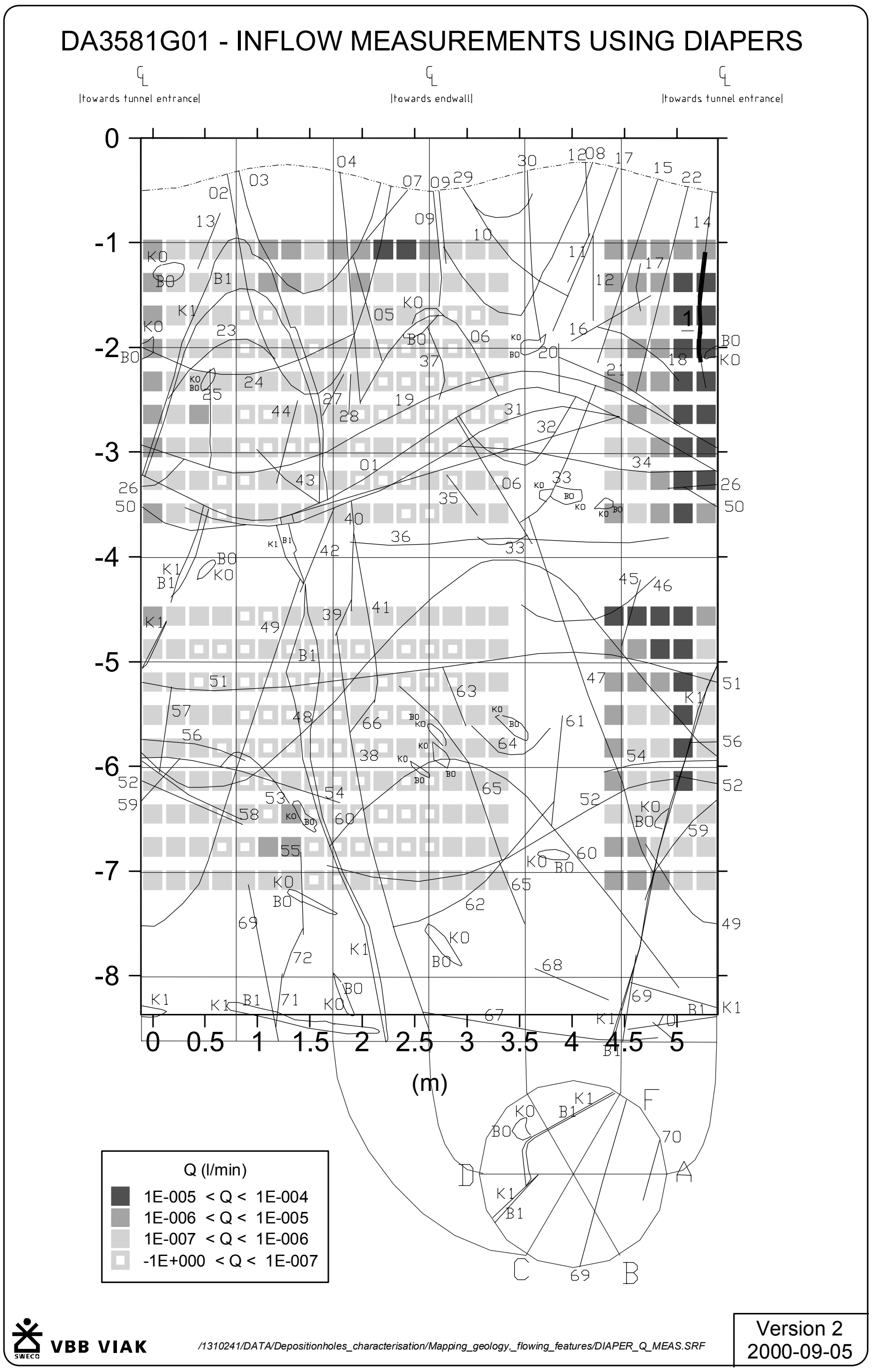

Figure 2-7. *Distribution of inflowing water determined by use of the diaper method.*

2.5 Stress situation in the rock around the deposition holes

Three dimensional rock stress measurements have been performed in areas close to the prototype repository. The average stress magnitudes and orientations are presented in Table 2-3.

Table 2-3. *Averaged rock stress magnitudes and orientations*

	σ_1	σ_2	σ_3
Stress (MPa)	29	21	10
Trend/plunge	133/19	049/42	234/33

3 REFERENCES

Svemar C, Pusch R, 2000. Prototype Reporsitory, Project description FIKW-CT-2000-00055. Int. Progress Report IPR-00-30, SKB, Stockholm.

Forsmark T., Rhén I., Andersson C., Prototype Repository: Hydrogeology - Deposition- and lead-through boreholes: Inflow measurements, hydraulic responses and hydraulic tests. SKB IPR-00-33.

Andersson C., Johansson Å., Full face boring of Ø 1,75 metre holes in Äspö HLR. Compilation of results after boring of 13 holes. SKB Technical Report in draft.