Working report 97-50e

Studies of Hyrkkölä native-copper occurrence during summer 1997

Interim report

Lasse Ahonen
Geological Survey of Finland
Nuria Marcos
Helsinki University of Technology

October 1997

POSIVA OY
Mikonkatu 15 A, FIN-00100 HELSINKI, FINLAND
Tel. +358-9-2280 30
Fax +358-9-2280 3719

Working report 97-50e

Studies of Hyrkkölä native-copper occurrence during summer 1997

Interim report

Lasse Ahonen
Geological Survey of Finland
Nuria Marcos
Helsinki University of Technology

October 1997

TEKIJÄORGANISAATIOT:

Geologian tutkimuskeskus
PL 96 (Betonimiehenkuja 4)
02151 ESPOO

Teknillinen korkeakoulu
Insinöörigeologian ja geofysiikan lab.
PL 6200 (Vuorimiehentie 2 A)
02015 TKK

TILAAJA:

Posiva Oy
Mikonkatu 15 A
00100 HELSINKI

TILAAJAN YHDYSHENKILÖ:

Margit Snellman Posiva Oy

TILAUSNUMEROT:

9686/97/MVS
9687/97/MVS

TEKIJÄORGANISAATIOIDEN YHDYSHENKILÖT:

Lasse Ahonen GTK

Nuria Marcos TKK

TYÖRAPORTTI-97-50e

STUDIES OF THE HYRKKÖLÄ
NATIVE-COPPER OCCURRENCE
DURING SUMMER 1997

TARKASTAJAT:

Paavo Vuorela GTK
projektipäällikkö

Heikki Niini TKK
professori

ABSTRACT

Lasse Ahonen[*], Nuria Marcos[**]
[*]Geological Survey of Finland
[**]Helsinki University of Technology, Laboratory of Engineering Geology and Geophysics

STUDIES OF HYRKKÖLÄ NATIVE-COPPER OCCURRENCE DURING SUMMER 1997

A special feature of the Hyrkkölä uranium-copper mineralization in Nummi-Pusula, SW Finland is the occurrence copper as native metal. The present work aims at studying the stability of metallic copper in natural bedrock-groundwater conditions.

Two new boreholes, each about one hundred meters long, were drilled to the study site, and new samples of metallic copper were found in the drillcores. After drilling, drillholes were video-recorded to locate open fractures. During the summer and autumn, interesting copper-bearing zones were sampled for groundwater using the SKB mobile field laboratory.

KEYWORDS: copper, natural analogue, groundwater, corrosion

TIIVISTELMÄ

Lasse Ahonen[*], Nuria Marcos[**]
[*]Geologian tutkimuskeskus
[*]Teknillinen korkeakoulu, Insinöörigeologian ja geofysiikan laboratorio

HYRKKÖLÄN LUONNONKUPARIESIINTYMÄN TUTKIMUKSET KESÄLLÄ 1997

Nummi-Pusulan Hyrkkölässä sijaitsevan pienen uraani-kuparimineralisaation erityispiirre on kuparin esiintyminen metallimuodossa. Tämän työn tarkoituksena on tutkia metallisen kuparin pysyvyyttä luonnon kallioperä-pohjavesiolosuhteissa.

Tutkimusalueelle kairattiin kaksi uutta noin sata metriä pitkää kairareikää, kairasydännäytteistä saatiin uusia näytteitä metallisesta kuparista. Kairauksen jälkeen reiät videokuvattiin avoimien rakojen paikallistamiseksi. Kesän ja syksyn aikana on mielenkiintoisimmista kuparipitoisista vyöhykkeistä otettu vesinäytteet SKB:n kenttälaboratorion avulla.

AVAINSANAT: kupari, luonnonanalogia, pohjavesi, korroosio

CONTENTS

ABSTRACT

TIIVISTELMÄ

1 INTRODUCTION 6

2 DRILLING 7

3 MONITORING OF THE FLUSHING WATER 8

3.1 Composition 8

3.2 Uranine 9

3.3 Electrical conductivity and colour 12

3.4 Pressure monitoring 12

4 TV SURVEY 15

5 GROUNDWATER SAMPLING AND MEASUREMENTS 16

6 DRILL-CORE STUDIES 21

7 REFERENCES 24

APPENDICES

FOREWORD

The Hyrkkölä uranium-copper mineralization is studied as a joint project between Posiva and SKB. Contact persons are Lars Werme at SKB and Margit Snellman at Posiva.

1 INTRODUCTION

The small uranium-copper occurrence of Hyrkkölä village in Nummi-Pusula was discovered by Geological Survey of Finland (GTK) during an ore exploration campaign in the beginning of 1980's. A special feature of the mineralization is the occurrence native copper together with uranium-minerals.

Later Marcos (1996) considered this occurrence of natural metallic copper as a potential natural analogue to the behaviour of copper canisters placed into the bedrock. It was, however, recognized that the lack of representative groundwater samples associated with native copper made it difficult to infer the actual physicochemical conditions, which determine the stability or reactivity of copper in this surroundings.

Therefore, a field study focusing on the factors affecting copper stability was planned (Ahonen et al. 1997). According to the plan, new cored boreholes would be drilled to obtain more information about the characteristics of the site. After planning and evaluation of the background data, field work started during the spring 1997.

This report summarizes the results available from the work until mid-september.

2 DRILLING

Drilling operation started at 26.5.1997 by the decision and precise-levelling of the initiation point, and was completed at 3.7.1997, when the bore-holes were ready for further operations. Technical details and time table are reported by Rautio (1997). Drilling place and bore-hole directions (Table 1) are in accordance with the original plans (Ahonen et al. 1997).

Table 1. Location, direction and length of the Hyrkkölä drillholes

	Map coordin. (km)	Z (m) ground/ casing	Dir.	Init. incl.	Length (m)	
Y52/2024/97/324	X=6714,874 Y=2495,720	Gr:110,29 Cs:110,71	340°	74,8°	100,25	
Y52/2024/97/325	X=6714,874 Y=2495,720	Gr:110,20 Cs:110,58	310°	74,5°	104,10	

The complete ID-codes for the drillholes (cores) include the current number of the drillcore (here 324 and 325) available within the mapsheet 2024 (1:100 000). Hereafter the drillholes (and cores) are referred as HY324 and HY325.

After drilling, drill-hole inclination was measured in ten meters intervals in both holes. The vertical deviation from the initial drill-hole inclinations given in the Table 1 was less than 0.9 degrees in all measurements.

Drillhole and drillcore diameters are 76 mm and 62 mm, respectively.

Thickness of the quaternary cover on the drilling site was about 3.4 - 4 meters, consisting mainly of boulder-rich till. Uppermost surface of the bedrock was very broken, leading to the escape of the flushing water. Due to the later water sampling, a good return of the flushing water was considered important, and the earth-boring tube was drilled to the depth of about ten meters in both drill holes.

3 MONITORING OF THE FLUSHING-WATER

3.1 Composition

Flushing water for drilling was transported from the Nummi-Pusula fire station, and temporary stored in an eight cubic-meters tank before pumping into a three cubic-meters tank, in which 1.5 g of dye (uranine) was mixed to the water. A sample was taken for uranine analysis each time a new batch was mixed, a parallel sample was taken for the analysis of the chemical composition. Uranine sample flasks were wrapped into foil, stored in a refrigerator, and sent to the laboratory immediately after completion of each drillhole. Otherwise the chemical composition of the flushing water samples will be analyzed later, together with the groundwater samples.

Data on the chemical composition of the flushing water was, however, available from the municipal authorities (Table 2). The same water has been also analyzed by GTK, because it was also used as flushing water in Palmottu.

Table 2. Chemical composition of the flushing water according to analysis by municipal authorities of Nummi-Pusula (Lohjan seudun elintarvike- ja vesilaboratorio).

F^- (mg/l)	0.0	
NO_3^- (mg/l)	2.2	
NO_2^- (mg/l)	0.007	
NH_4^+ (mg/l)	0.00	
Cl^- (mg/l)	6.0	
Mn (mg/l)	0.00	
Fe (mg/l)	0.09	
Alkalinity (mval/l)	~0.7	
pH	7.1	
el.cond. (mS/m)	10	

The nitrate concentration given in Table 2 is high if compared to $NO_3^- = 1.3$ mg/l, which is the average value for this water analyzed in Palmottu (Kaija et al.1997). Other chemical parameters of interest for Hyrkkölä are (from Kaija, op.cit.): Cu 1.3 - 4 µg/l, U 0.4 µg/l SO_4 about 8 mg/l, ^3H about 20 TU, ^2H about -84 per mil, and ^{18}O about -12 per mil.

3.2 Uranine

In general, uranine concentration of flushing-water coming out from the drillhole was about 70 - 90 % of the initial concentration, indicating that flushing water was partly mixed with formation water. In Fig. 1, this concentration ratio is plotted as a function of depth in each boreholes.

During cored drilling of HY 324 and Hy325, total amount of flushing water injected was 20400 liters, and 30400 liters, respectively, while the amounts of flushing-water returning back to the surface were 13300 l and 12300 l. If the mixing of formation-water with the flushing water is taken into account, it can be estimated that about 50 % and 35 % of flushing water could be recovered during drilling (corresponding to about 11000 l in both cases).

After drilling, each bore-hole was pumped using submergible pump continuously in about three days time, total water amounts pumped were 41400 l and 40700 l in drill-holes HY324 and HY325, respectively (Rautio 1997). Uranine concentration of the water was measured once a day. The results indicate that during the first day the contribution of flushing water decreased to less that 10 % of the total water volume (Fig. 2). At the end of the pumping, amount of the flushing water was 1.3 % and 3 % in the drillholes HY324 and HY325, respectively. Total amounts of flushing water received during pumping are graphically estimated from Fig. 2 as 4000 l and 6000 l in the drillholes HY324 and HY325, respectively. Consequently, less than 40 percent of the flushing water remained in the bedrock.

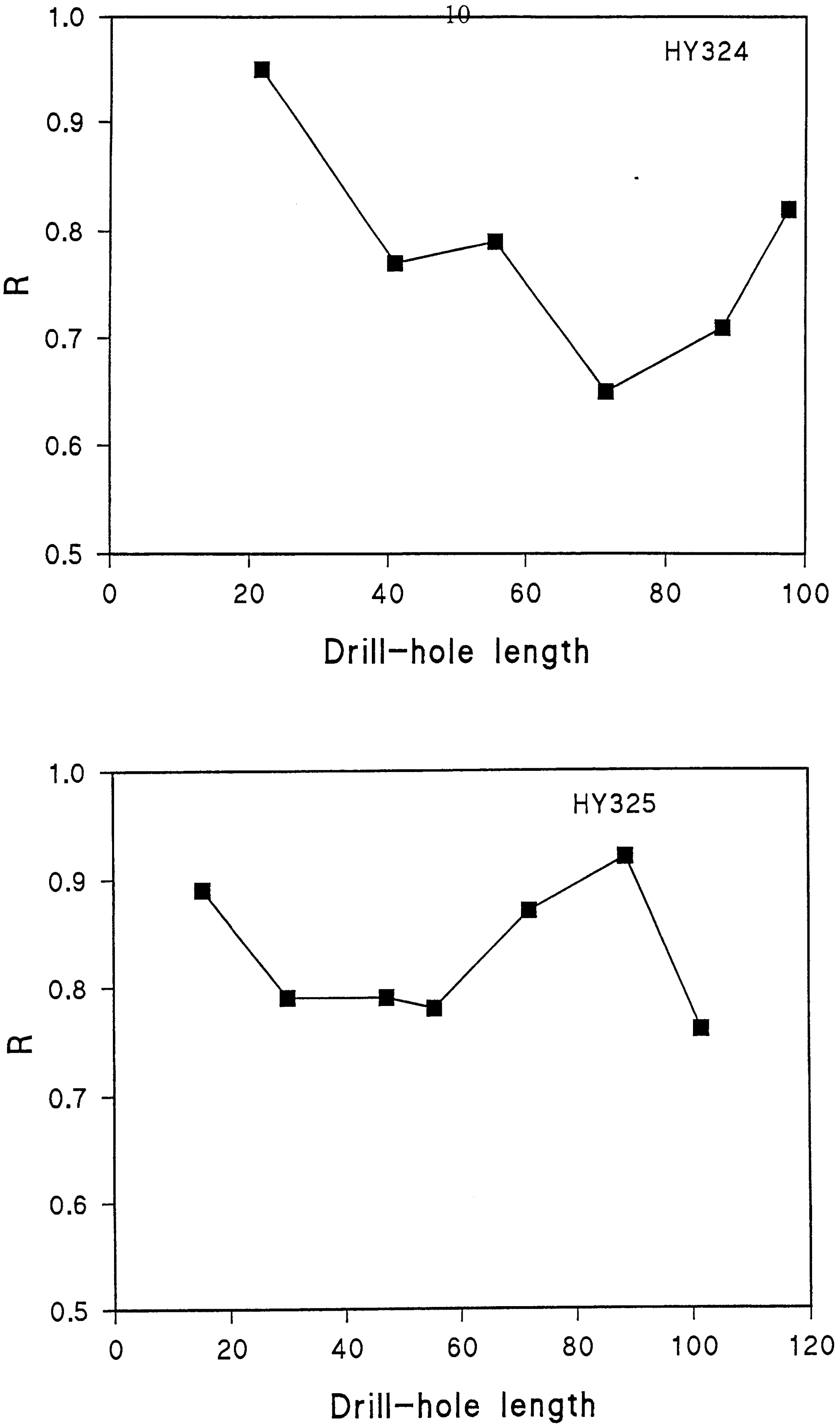

Fig. 1. The contribution of uranine-marked flushing water of the water recovered (R = C/C_0, $C_0 \approx 500$ μg/l uranine).

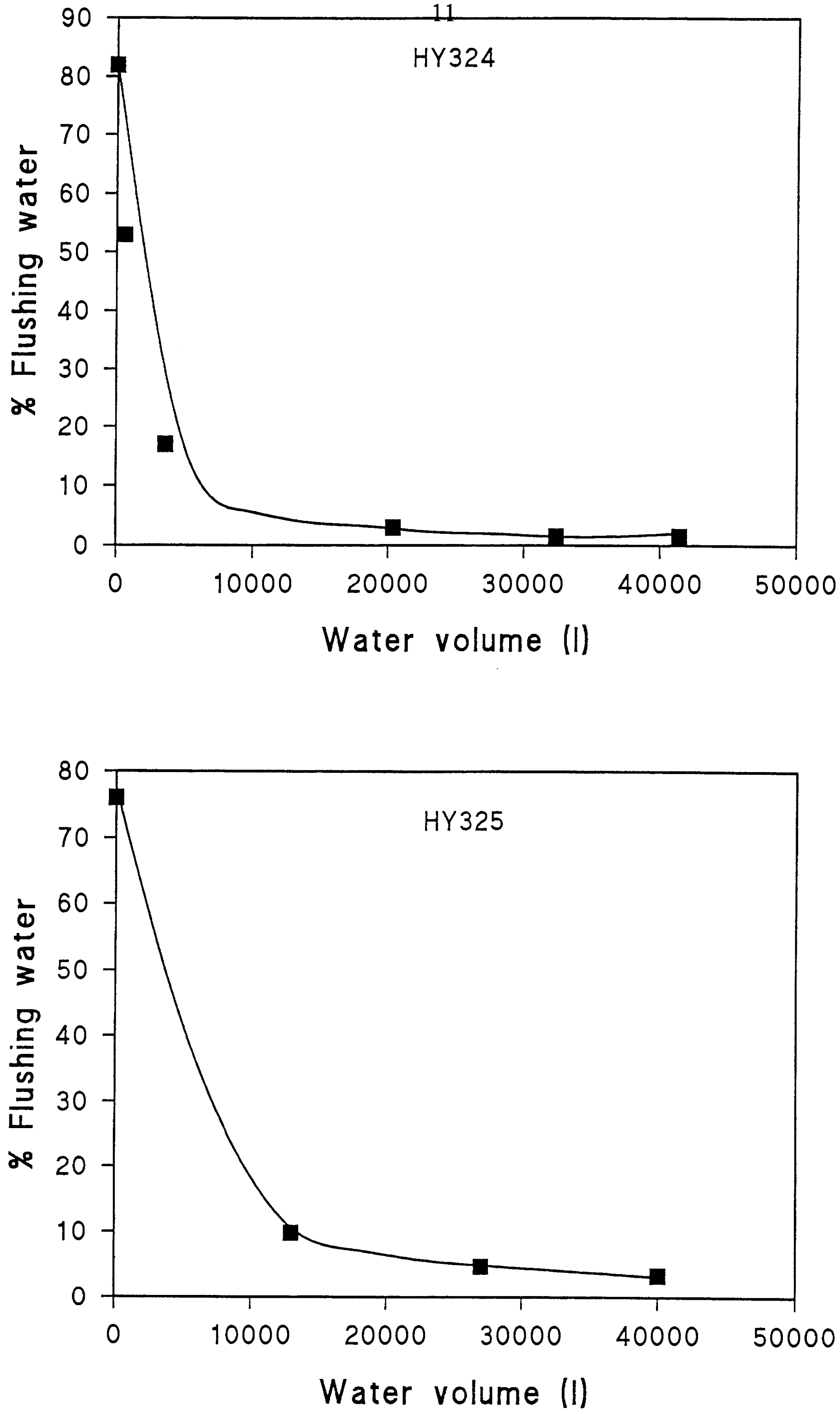

Fig. 2. Percentage of uranine-marked flushing-water during pumping after drilling.

3.3. Electrical conductivity and colour

Electrical conductivity (E.C.) of the returned flush-water was measured several times in a day. Before measurement, water was allowed to stay in a beaker at least one hour and the colour of water was also checked.

The electrical conductivity of the unused flushing water was checked occasionally, values between 9 to 10 mS/m were obtained. The electrical conductivity of the returned water varied normally between 9 and 11 mS/m. Slightly elevated E.C. values of returned water (up to 13 - 14 mS/m) were observed in HY324 at depths of about 60 - 70 m, about 85 m, and about 95 m. In drillhole HY325, E.C. values up 13 mS/m were observed at depth-interval 65 - 70 m.

Normally, the returned flushing water was slightly greyish - greenish after settling of the drilling mud. Occasionally, however, distinct reddish colours were observed: in HY324, depths 15 m, 36 m, 58 m, 89 m, and 98 to bottom; in drillhole HY325 at depth 99 m to bottom.

3.4. Pressure monitoring

During drilling of HY325, automatic head monitoring was carried out in the adjacent HY324, in which a pressure transducer was installed. The head values were recorded by a microcomputer in 15 seconds intervals. Scale of the head data was determined by the depth of pressure transducer, thus only the changes of head are of importance. Figure 3 shows the sharp peak in the water-level of HY324, when drilling of HY325 had advanced to the depth of about 12 meters just below the casing. Figures 4 to 6 show the head fluctuation in HY324 during drilling of HY325. The general pattern demonstrates the slight increase of head during advancing drilling (water injection) and more rapid decrease when drilling rods are lifted. Figure 6 shows a distinct response in HY324 when the drilling of HY325 reached the depth of about 88 meters (11.15 o'clock).

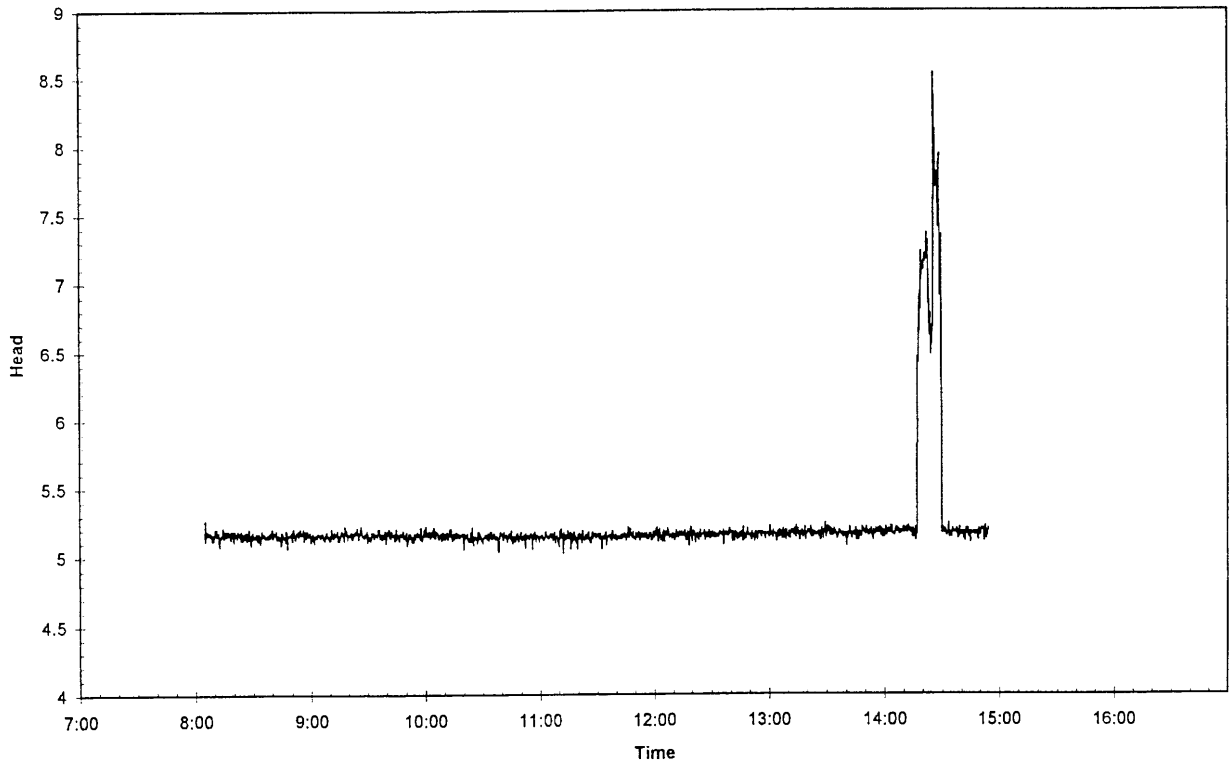

Fig. 3. Water-table fluctuation in HY324 during drilling of HY325. Date 17.06.97.

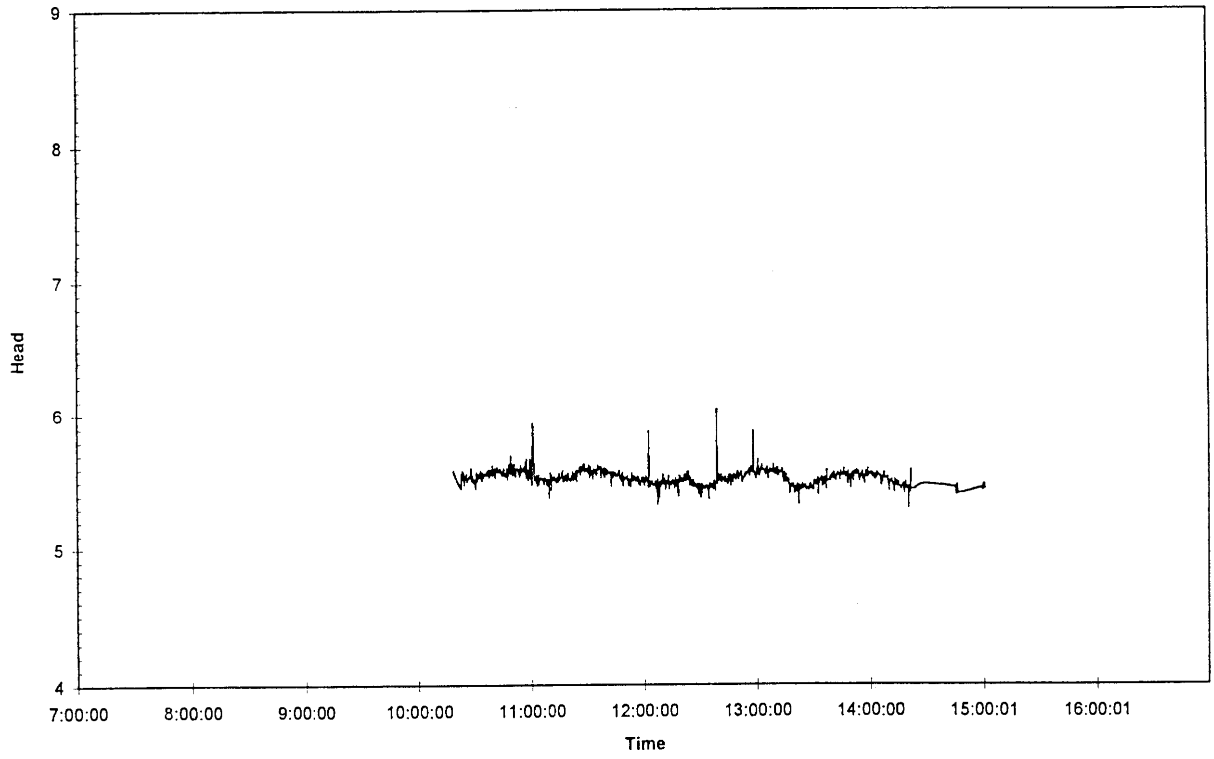

Fig. 4. Water-table fluctuation in HY324 during drilling of HY325. Date 23.06.97.

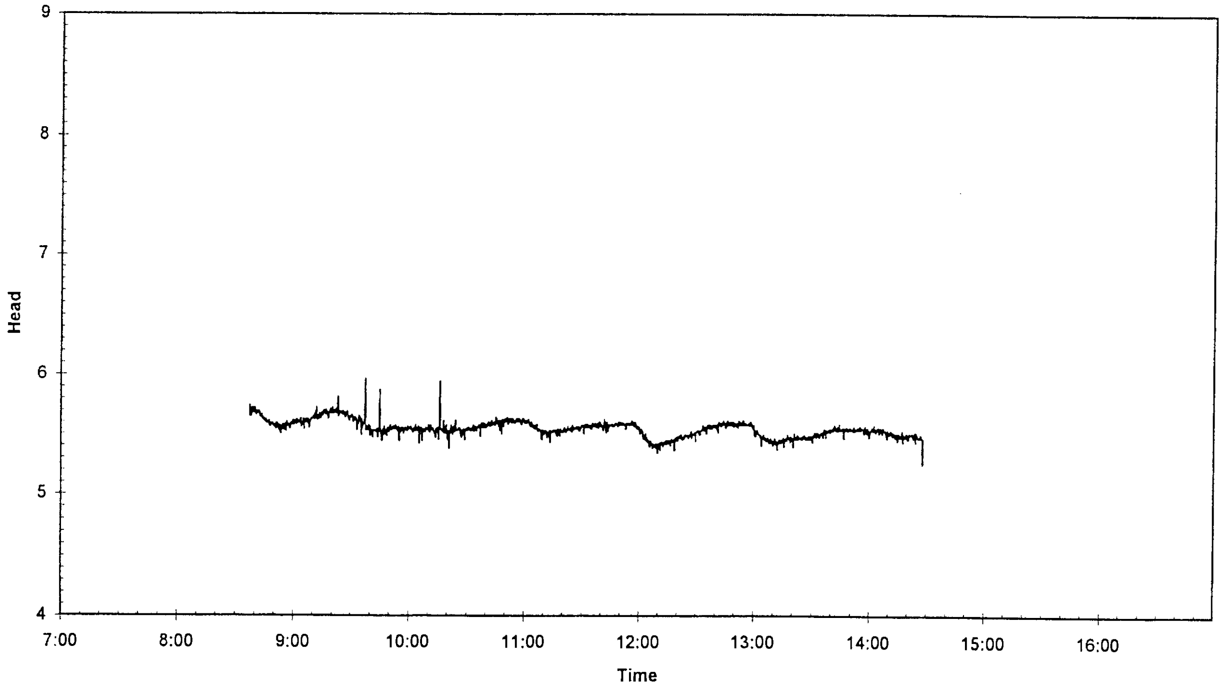

Fig. 5. Water-table fluctuation in HY324 during drilling of HY325. Date 26.06.97.

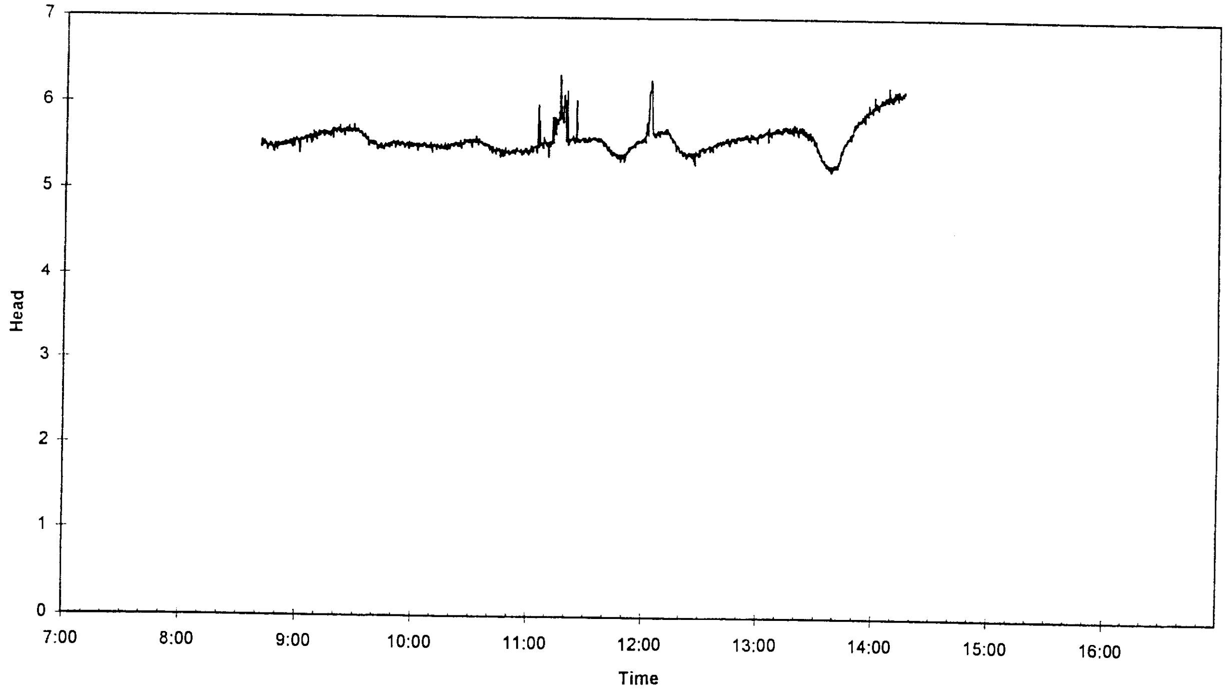

Fig. 6. Water-table fluctuation in HY324 during drilling of HY325. Date 27.06.97.

4 TV SURVEY

Immediately after the accomplishment of the drilling and subsequent pumping of the drillhole HY325, both drillholes were video-recorded. The operation was carried out by Kivikonsultit Oy using a bore-hole TV-camera with a mirror of diameter 70 mm. Depth of the camera was read from a measuring tape lowered to the drillhole before the camera.

The fracture-properties and rock type (with an emphasis to pegmatites) were then analyzed from the video-tape. According to the aperture, fractures were classified to four categories from probably sealed (R1) to fractures showing apertures in centimetres (R4). The angle between fracture and drillhole was classified as approximately perpendicular or oblique. The results are summarized in diagrams (appendix 1 and 2).

A striking feature observed was that almost all fractures in HY324 were filled with light-coloured, fluffy, clayey material, while fractures in HY325 were clean. The difference is obviously due the fact that HY325 was cleaned by long-term pumping immediately before the TV-survey, while cleaning of HY324 took place before drilling of HY325.

5 GROUNDWATER SAMPLING AND MEASUREMENTS

Groundwater sampling and measurements (e.g., redox, pH) were carried out using the SKB mobile laboratory. In this system, groundwater redox-potential can be measured both downhole (in situ) and on the surface (on line) using different inert electrodes (Pt, Au, C), also pH is measured both in situ and on line. An additional measurement apparatus ('Ecolys') carried out automatic titration of alkalinity, measurement of pH and chloride concentration (ion-selective electrode). Groundwater sampling for chemical analysis took place after a pumping period of about 2 - 4 weeks. Iron and sulfide were analyzed in the field, as well as uranine concentrations.

General characteristics and analytical results are summarized in Table 3.

Table 3. A summary of the pumping results.

HY	depth	time	Q l/h	V m^3	Fe_{tot} mg/l	Fe^{2+} mg/l	Alk. HCO_3 mg/l	E.C. mS/m	pH	uranine µg/l
325	90-104.1	15.7.-4.8.	6.8	2.7	0.050	0.013	-	-	-	15.
325	65-70.6	4.8.-18.8.	6.5	2.3	<0.01	<0.01	78.9	17.4	7.39	6.0
325	67-68.5	20.8.-17.9.	7/3.8	3.2	<0.01	<0.01	72.0	17.3	7.02	11.
325	43.5-45	18.9.-14.10.	*	*	0.02	<0.01	73.7	18.2	7.11	3.0
324	52.4-53.9	15.10.-03.11.	*	*	*	*	*	*	*	5.0

- Ecolys-results not available

* Results not yet available

Results of the measurement during pumping in drillhole 325 are summarized in Figs. 7 - 9, only Eh values obtained by Pt electrodes are given. All the water samples are fresh (E.C. below 20 mS/m), neutral in pH, very oxidizing (Eh about 400 - 500 mV), and contain dissolved oxygen. Bore-hole Eh values are about 100 mV lower than those measured on the surface. A striking feature is the daily fluctuation of pH and O_2 concentration.

Fig. 10 shows the alkalinity and pH measured by automatic titrator (Ecolys).

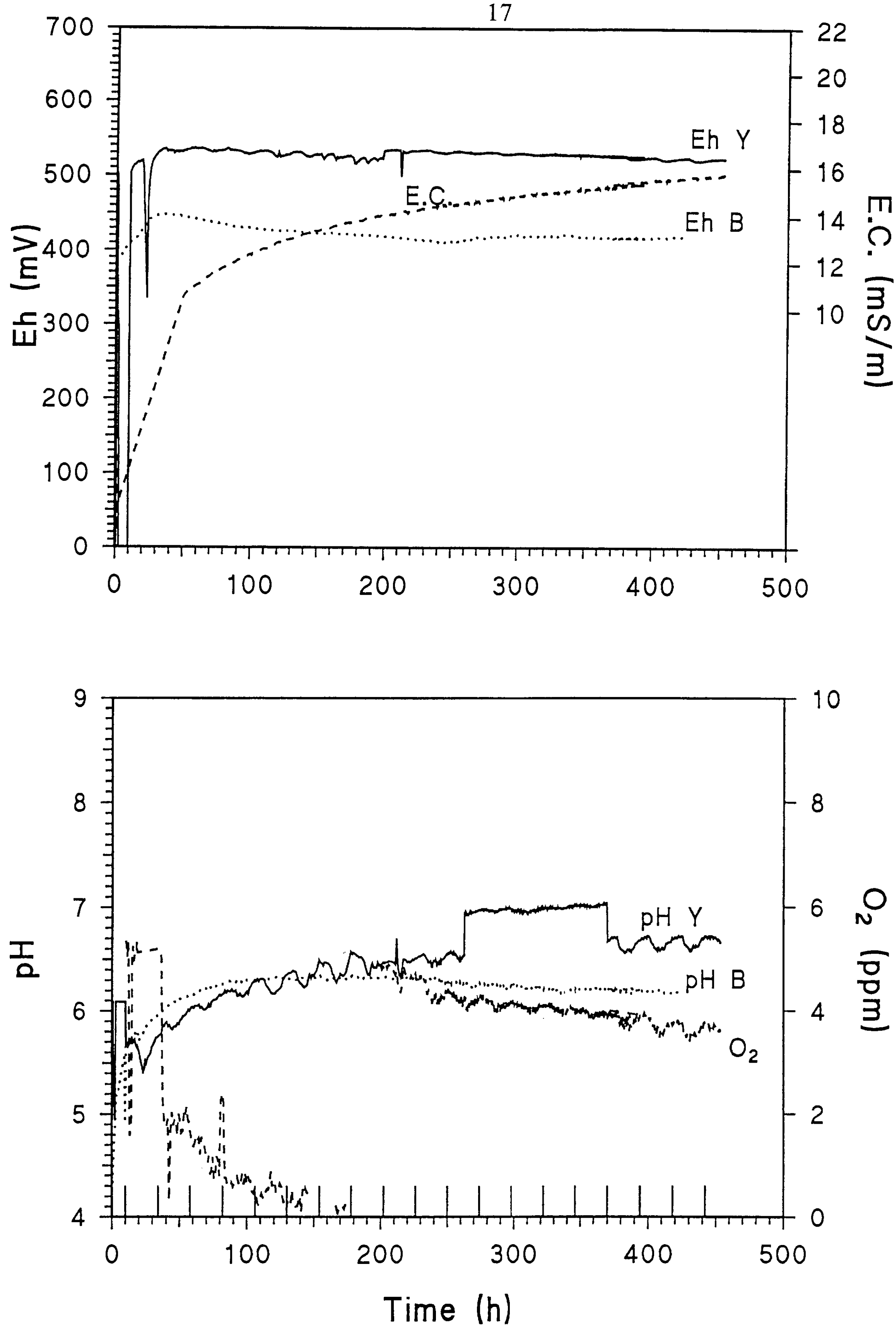

Fig. 7. Time-course of parameters measured during pumping. Drillhole HY325, section 90 - 104.1 m. Y and B refer to surface- and borehole electrodes, respectively.

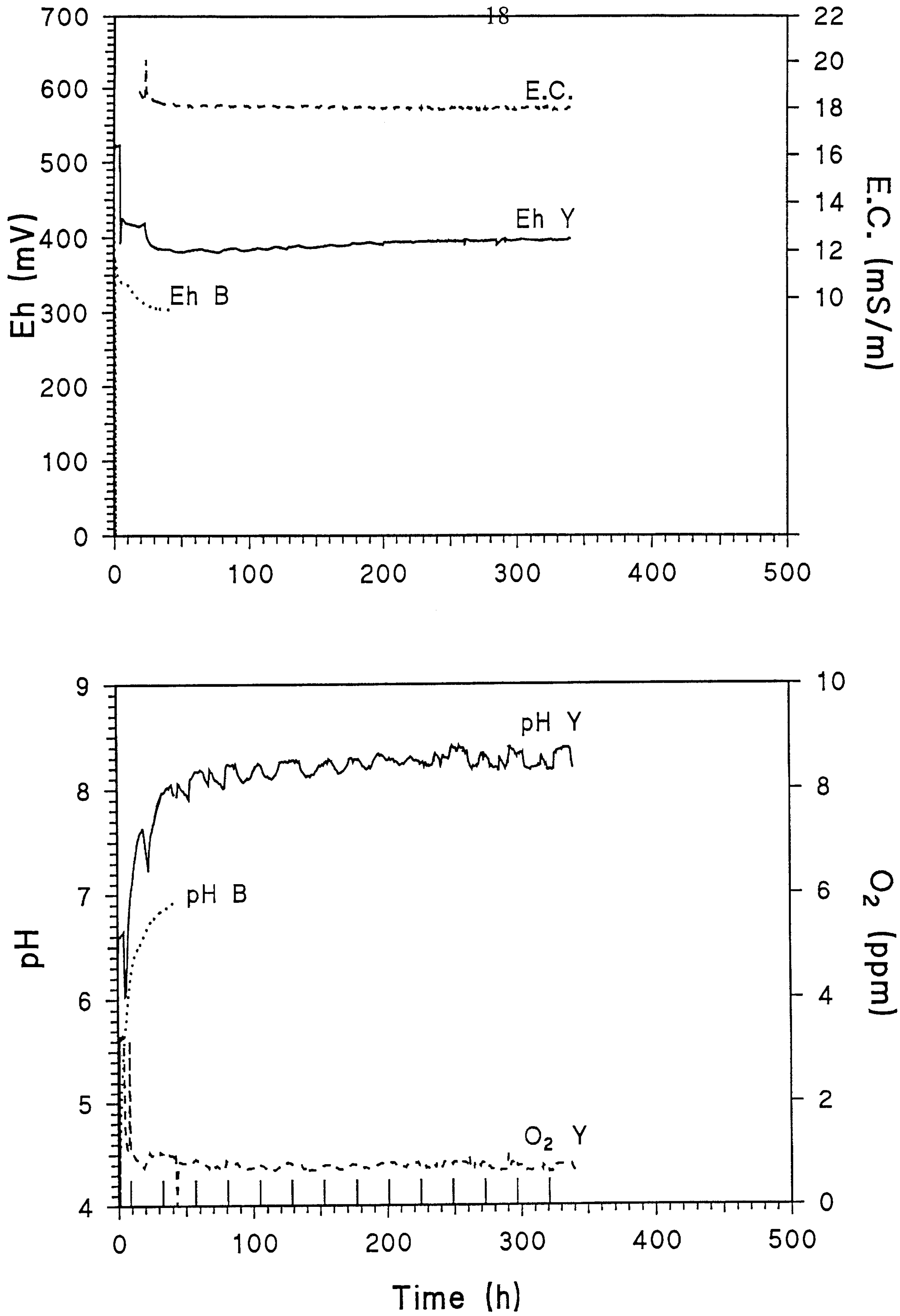

Fig. 8. Time-course of parameters measured during pumping. Drillhole HY325, section 65 - 70.6 m. Y and B refer to surface- and borehole electrodes, respectively.

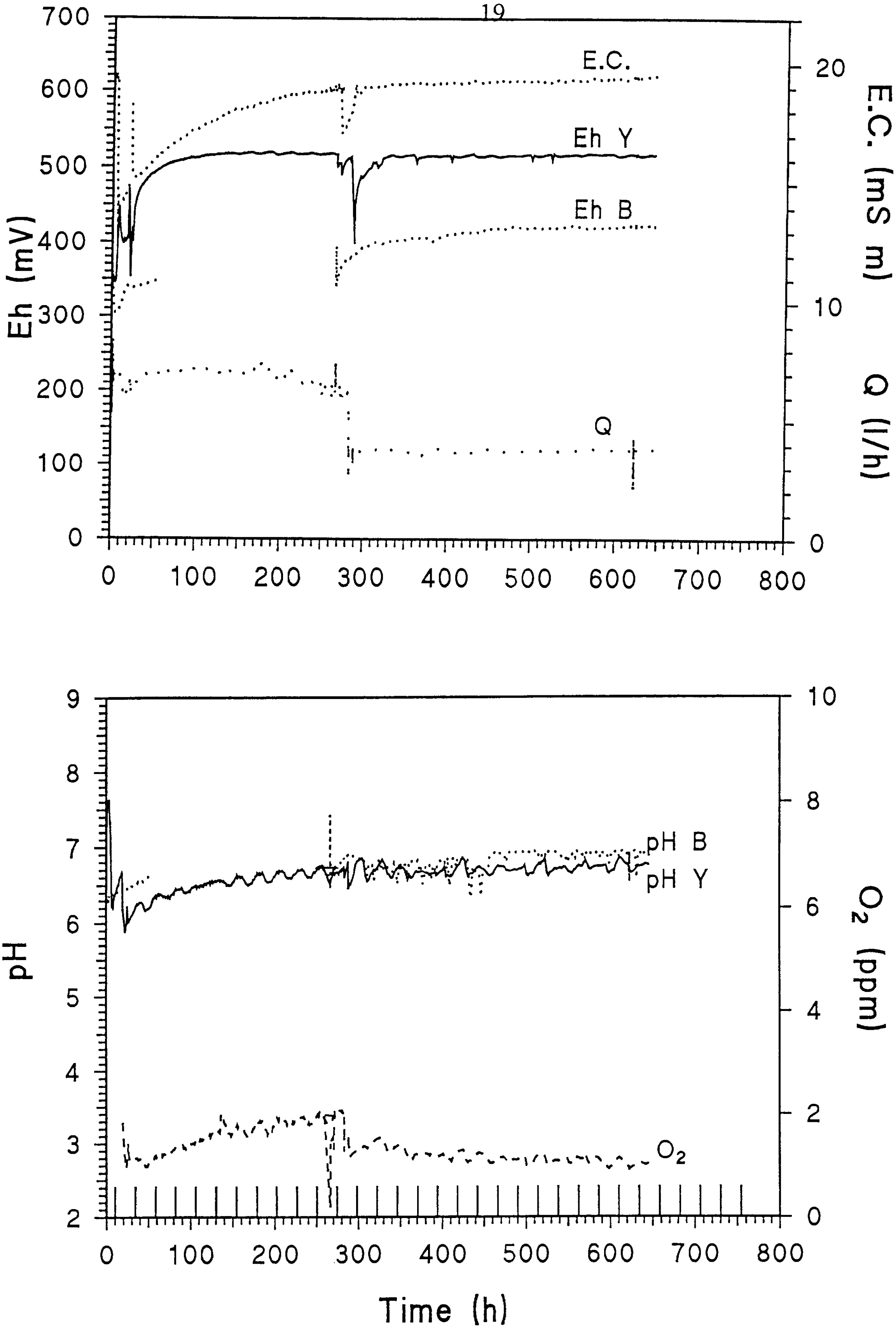

Fig. 9. Time-course of parameters measured during pumping. Drillhole HY325, section 67 - 68.5 m. Y and B refer to surface- and borehole electrodes, respectively.

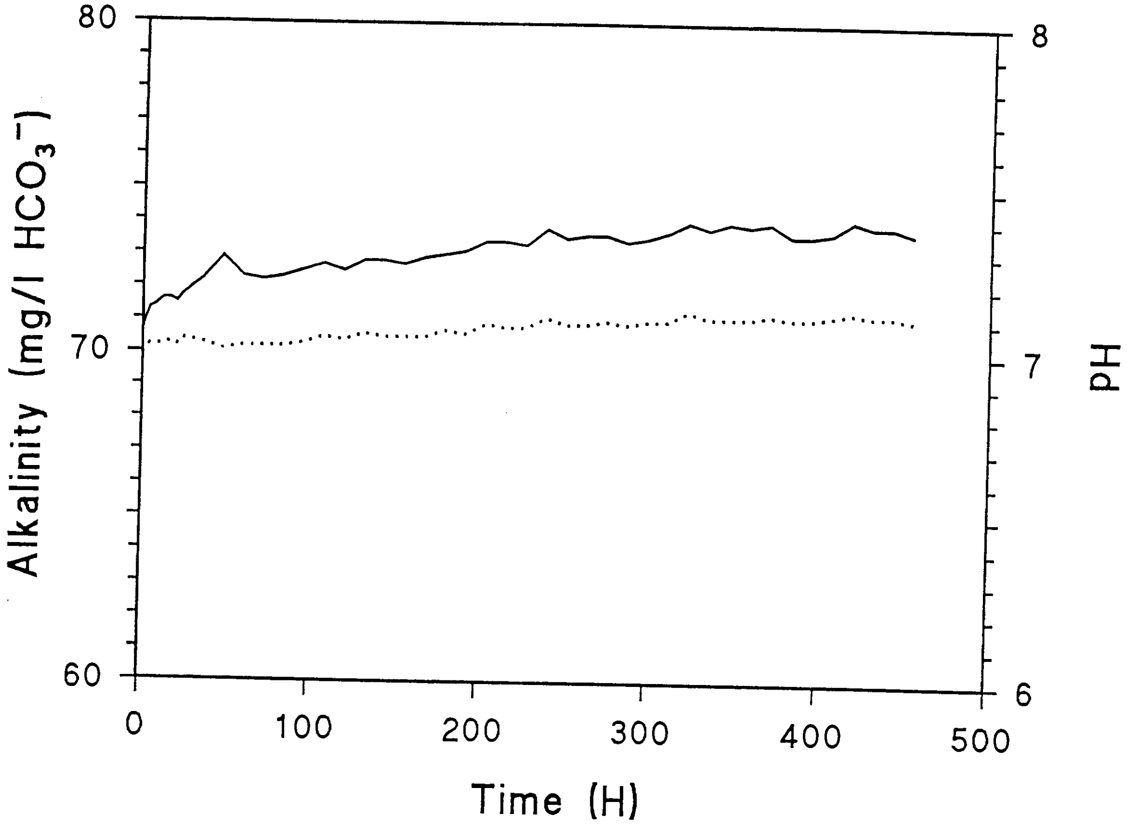

Fig. 10. Time-course of the alkalinity-titration and pH during pumping. Drillhole HY325, section 43.5 - 45 m.

6 DRILL-CORE STUDIES

Drillcores were studied in the field for rock types and fractures immediately when retrieved. After the accomplishment of drilling of each drillhole, drill cores were transported and stored in the GTK's storage (Loppi).

Drillcores were re-examined, photographed, and preliminary sampled in august, the main sampling-campaign took place in september.

The petrography for the drill cores R324 and R325 is briefly listed in Appendix 2. Quartz-feldspar gneisses (QFG) may be homogeneous or present interlayers of amphibolite, QFG (A). Amphibolite (A) may be also homogeneous or present interlayers of quart-feldspar gneiss A (QFG). The contacts between quartz-feldspar gneiss and amphibolite and viceversa are gradual. There are few examples of a sharp contact between these rock types.

Granite pegmatite (GP) veins intersect quartz-feldspar gneisses and amphibolites. The contacts of these veins with the other rock types are sharp but conformable with schistosity. Where granite pegmatites are rich in tourmaline, accumulations of this mineral occur in the basal contact of granite pegmatites with the amphibolites (e.g. R324/15.35 m) or quartz-feldspar gneisses.

Granite pegmatites containing metallic copper GP (m.c.) and/or copper sulfide GP (m.c./c.s.) are also listed in Appendix 2. Except the granite pegmatite veins presenting some interesting mineralogical features which are marked with !, others thinner than 15 cm are not in the list.

In order to get relevant groundwater samples, the possible open fractures within granite pegmatites have been searched and listed in Table 2. The bold numbers indicate the most interesting fracture zones, that is, fractures where circulating groundwater may have been in contact with native copper and/or other relevant fracture minerals (e.g. smectite).

Table 4. Possible fracture zones within granite pegmatites.

R 324/ Possible fracture zones in granite pegmatites GP (m.c.)	R 325/Possible fracture zones in granite pegmatites
14.90 - 15.10	15.65 - 15.70 (no m.c.)
23.95 - 24.10	17.60 - 17.80
39.25 - 39.45	**24.10 - 24.45** (In amphibolite)
36.50 - 36.65 (no m.c.)	26.10 - 26.20
52.90 - 53.10	**29.80 - 30.40**
57.30 - 57.50	**43.85 - 45.00**
64.00 - 64.50	65.20 - 65.30
82.00 - 82.30	67.90 - 67.70
86.10 - 86.20	**68.20 - 68.60**
92.90 - 93.10 (In amphibolite)	78.75 - 78.85
97.85 - 98.25 (no m.c., but smectite)	102.90 - 103.20

In the following, selection of samples for whole-rock analysis/fracture filling analysis is given.

Drill core R324

Box no.	
L-4	12.45/14.25 - 14.90
L-7	23.65 - 24.02 (A)/ 24.02 - 24.72 24.72 - 25.40
L-10	- 35.10/35.10 - 36.80
L-11	- 39.25/39.25 - 40.00
L-14	/- 48.60
L-15	54.70 (A)
L-16	- 56.35/57.39
L-18	/64.40 - 64.55
L-19	/1st & 2nd rows
L-20	/2nd row
L-21	3rd row
L-22	4th row/- 77.15
L-24	Broken pieces/Hem, epid.
L-27	Hematite & U(VI) min.
L-28	Smectite ...

Drill core R325

Box no.	
L-2	/See "field report"
L-4	4th row - 17.10
L-5	/4th row, hematite, calcite
L-7	- 24.45/- 24.45, epid.
L-8	/1st row
L-9	GP, open fracture
L-12	hematite
L-13	43.85 - 45/2nd row
L-14	/49.00
L-15	/4th row
L-19	4th row, 67.30/4th row
L-20	
L-22	4th row/4th row
L-23	2nd row
L-24	- 84.50/- 84.50
L-25	87.35, hematite
L-28	/97.30
L-30	3rd row

7 REFERENCES

Ahonen, L., N. Marcos, M. Paananen, S. Paulamäki, 1997. Research plan for field studies at the Hyrkkölä native copper mineralization, SW Finland. Posiva work report 97-49e, (in print).

Marcos N., 1996. The Hyrkkölä native copper mineralization as a natural analogue for copper canisters. Report Posiva-96-15, Posiva Oy, Helsinki

Rautio, T., 1997. Reikien Y52/2024/97/324 ja Y52/2024/97/325 kairaus Hyrkkölässä. Posiva työraportti 97-23, (in Finnish with English abstract).

Kaija et al. 1997. The hydrogeochemical dataset of Palmottu. The Palmottu Natural Analogue Project. Technical Report 97-11 (in prep.)

APPENDICES

Appendix 1.	Fracturing and rock types inferred from the bore-hole video data, bore holes HY324 and HY325.
Appendix 2.	Petrography observed in drillcores HY324 and HY325.

APPENDIX 2

Petrography, R 324

metres$^{\text{Box no.}}$		
3.55	Soil	
7.10		QFG
9.35		QFG (A)
12.50		QFG
12.65^{L-4}	GP	
14.25		QFG (A)
15.35^{L-4}	GP (m.c.)	
15.90		A ?
21.05		QFG (GP)
22.10		A
22.95		QFG (A)
23.06^{L-7}	GP	
24.02		A
24.72^{L-7}	GP (m.c.)	
26.00		A (GP)
29.17		QFG
30.90		A
31.88		QFG
32.08		A
35.90		QFG
36.80^{L-10}	GP (m.c.?)	
39.25		QFG (A)
39.50^{L-11}	GP (m.c.)	
44.00?		QFG (A)
46.20		A
48.03		QFG

metres$^{\text{Box no.}}$		
49.44		A
52.64		QFG (A)
53.27^{L-15}	GP (m.c.)	
54.40		A (GP !)
55.05		QFG (A)
57.30		A (GP)
57.56^{L-16}	GP (m.c.)	
63.95		A (GP !)
64.40^{L-18}	GP (m.c./c.s.)	
74.04		A (GP$^{L-19,20)}$!)
75.38		QFG
77.15		A (QFG)
77.85		QFG (A)
81.35		A (GP$^{L-22,23}$!)
81.47	GP	
81.63		A
81.83	GP	
85.28		A
85.78		A (QFG)
86.22^{L-25}	GP (m.c.)	
87.02		A (GP !)
88.63		QFG (A)
89.40^{L-26}	GP (A)	
91.70?		A
97.97		QFG/A
98.25^{L-28}	GP!	
100.25		A (hematite)

Hyrkkölä 97

APPENDIX 2

Petrography, R 325

metres$^{\text{Box no.}}$	
10.60	Soil + crushed rock (cored)
10.70	GP
11.56	QFG
11.69^{L-3}	GP (big tourmaline grains)
13.68	QFG
14.80	QFG (A)
15.07	A
15.46	QFG (A)
15.58^{L-4}	GP
17.35	QFG (A)
17.84^{L-5}	GP (m.c.)
26.11	QFG (A)
26.21^{L-7}	GP (m.c.?)
26.46	A
26.56	QFG (A)
29.80	A (Q, GP < 1 cm)
30.32^{L-9}	GP (m.c.)
31.95	A
32.15^{L-9}	GP
32.25	A
33.40	QFG
33.76	QFG (A)
37.90	QFG
44.00	QFG (A)
44.05	A
44.90^{L-13}	GP (m.c.)
45.05	A (GP)
48.85	QFG
49.13	A

metres$^{\text{Box no.}}$	
49.23	QFG
54.75	A
56.90	QFG
59.53	A
59.73	QFG
62.40	A (GP)
62.52^{L-18}	GP
65.00	A
65.20^{L-19}	GP (m.c.)
67.30	A
68.74^{L-20}	GP (m.c./c.s.)
78.10	A
79.74^{L-23}	GP (A)
81.35	A (GP)
84.35	QFG
84.75	QFG (A)
88.45	A
90.30	QFG (A)
90.85	A (QFG)
90.95^{L-26}	GP (m.c.)
93.30	A (Q)
97.78	A
97.90^{L-28}	GP
102.95	A
103.15^{L-30}	GP
104.10	A

Note:

QFG	Quartz-Feldspar Gneiss
A	Amphibolite
GP	Granite Pegmatites
m.c.	metallic copper
c.s.	copper sulfide

The petrography at R 324 is not so well defined as at R 325.