ORKUSTOFNUN

Drilling of Wells VL-11 and VL-13 at Vatnsleysa. Analysis of data from drillholes

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Analysis of data from the drillholes

INTRODUCTION

Under an agreement with Lindalax hf from August 1987 Orkustofnun undertookd to analyse data obtained from the drilling and logging of two wells named VL-11 and VL-13 at Vatnsleysa. The wells were drilled for Lindalax h.f., well VL-11 by the drilling contractor Ísbor and VL-13 by the drilling contractor Jarðboranir hf. The scope of the work was defined by contract no. 625061-1987. and includes analysis of drill cuttings, logging of temperature and salinity as well as recommendation of the next step in the investigation of the area.

DATA COLLECTION

The following data was collected and used in this report:

1. The drilling diaries from Jarðboranir and Ísbor

2. Drill cuttings from wells VL-11 and VL-13 for the depth interval 0-150m in both wells. Unfortunately no cuttings were obtained from below 150m depth in well VL-13 due to circulation loss so no direct information exists on the geological layering in this depth interval.

3. Water samples taken from well VL-11 at 50 m and 100 m depth with a downhole sampler.

4. Temperature logs carried out by the drilling crew and Orkustofnun

5. Salinity logs carried out by Orkustofnun

DRILLING OF WELL VL-11

The following notes are from the drilling diaries of Ísbor:

DATE NOTES

30.5.1987
Preparation for drilling. Drilled with 10 5/8" hammer down to 26.5m. Scoriaceous lava down to 14m. Sounder lava to 25m. Loose scoria below. Further drilling with hammer difficult. Drilling mud tried but without success.

31.5.1987
Drilled with hammer to 33m and with rotary bit down to 38.9m

1.6.1987
8 5/8" casing down to 38.5m

2.6.1987
Casing work finished. Boulder-gravels appears under air-lift pumping. Drilling continued with 6 1/2" hammerdrill. Relatively soft rock to 43m but denser rock with interbeds down to 150m. At 108m some fractures were hit followed by large inflow of seawater.

The drilling was completed in 4 days (24 hours/day)

DRILLING OF WELL VL-13

Following description is from the drilling diaries of Jarðboranir hf.:

DATE NOTES

3.7.1987
Preparation for drilling.

8.7.1987
Drilled with 17 1/2" hammerdrill to 2.4m.

9.7.1987
Drilling with 17 1/2" hammerdrill to 31.2m. Drilling difficult below 25m due to loose ground.

10.7.1987
Dealing with problems caused by inclination of the borehole.

13.07.1987
Drilling with 17 1/2" rotary bit down to 41.3m. Change in rock material at 40m.

14.7.1987
Casing work.

15.7.1987
Casing work. Slow progress. Finally 16 1/2" casing hammered down to 41.3m.

16.7.1987
Drilling with 15" hammerdrill to 58.3m. Mechanical breakdown.

20.7.1987
Drilling with 15" hammerdrill to 72m. Change of reamers.

21.7.1987
Drilling with 15" hammerdrill to 93m.

22.7.1987
Drilling with 15" hammerdrill to 108m. Good progress down to 103m but fractured rock together with large inflow of seawater slowed the drilling rate down between 103m and 108m.

23.7.1987
Casing with 11 3/4".

27.7.1987
Temperature measured at the bottom of the well 5.4°C. Drilling with 9 7/8" rotary bit to 144.9m.

28.7.1987
Drilling with 9 7/8" drillbit to 215.8m. No compressed air used in the drilling below 150m. Good progress in drilling but total loss of drilling fluid.

29.7.1987
Temperature measured 6.0°C at the bottom of the borehole. Drilling continued to 231m. Good progress to 225m where the rock became harder. No recovery of drilling fluid.

30.7.1987
Drilling continued to 256.4m.

31.07.1987
Drilling down to 300.7m. Fractured and loose rock collapsing at the bottom of the well.

4.8.1987
Temperature at the bottom of the borehole 6.9°C. Further drilling unsuccessful.

5.8.1987
Further driling tried but without any progress.

A total of 17 workdays were spent on the work. Two simple air-lift pumping tests were performed during the drilling. At the depth of 45m air was pumped into the well for approximately 30 minutes giving a discharge of 150 l/s of seawater at a temperature of 6.4°C. At 170m depth air was again pumped into the well for two hours resulting in a discharge 150 l/s of seawater at the same temperature as before. In both cases the discharge was estimated visually.

ANALYSIS OF DRILL CUTTINGS

The drill cuttings analysis is shown in figs. 1 and 2. In addition the drilling rate and a caliper log from VL-13 is shown in fig 2. Unfortunately the drilling rate of VL-11 was not recorded. The geological layering of these two wells is similar, just slight variation in the thickness of the individual layers.

TEMPERATURE AND SALINITY LOGS

A total of 6 temperature logs exist from well VL-11 and 3 from well VL-13. From these measurements and the reports of the drilling contractors four main seawater aquifers were identified in the uppermost 300m at Vatnsleysa. These are at depths of approximately 25-40m, 108m, 150m and 300m. In all these cases the permeable zones are associated with scoriaceous layers in between basaltic lavas. The permeability of these aquifers is yet to be determined.

The temperature logs available from these boreholes were carried out by different thermometers whose calibration may differ. In looking for very small variations in temperature as in this case it is important to use the same instruments in all the temperature loggings in order to get accurate data.

The temperature logs from well VL-11 are shown in figs. 3 and 4. The higher temperature values of the first log are not quite understood. They may be due to thermometer error but as the logs show a decreasing values of temperatures with time, downflow of relatively cool water from the aquifer in 40m could be an alternative explanation of the different values of temperature.

The temperature logs from VL-13 are shown in figure 4. The difference in the temperature between the logs from 4.8.1987 and 9.9.1987 are within the accuracy limits of the measurements. Both these measurements show almost constant temperature of approximately 6.5°C from the aquifer in 108m and down to the aquifer in 150m but there after the temperature remains constant at close to 7.0°C down to the bottom aquifer at 300m depth.

The temperature logs from the two wells can be interpreted in two ways. The first is that there is a nearly constant temperature of 6.0 to 7.0°C seawater all the way from the aquifer in 25-40m and down to at least 300m. Such behaviour is known from some areas of high permeability in the volcanic riftzone of Iceland. If this is the case these low temperatures could continue down to 600-800m where low permeability rock of high temperature gradient is expected. The second interpretation is that the temperature profiles reflect a downflow of relatively cold water from shallow aquifers rather than the true temperature. In this case there is a downflow of 6.5-7.0°C seawater from the 25-40m aquifer in VL-11 down to the aquifer at 150m depth, with some added inflow from the 108m aquifer. Then it follows that the minimum temperature of the 108m aquifer is close to 7.5°C and the 150m aquifer is somewhat warmer. Furthermore, if the downflow explanation is valid the temperature of the aquifer at 300m could be still higher. Similar downflow phenomenon is known from other areas on the Reykjanes peninsula and are thought to be due to tidal effects in boreholes with permeable aquifers at different depths.

The only way to determine the temperature of the seawater is to carry out pumping tests with simultaneous measurements of temperature at different levels.

It should be stressed here that the temperature of the seawater might easily change with the pumping rate during production of seawater from boreholes. At the proposed pumping rate of several cubic meters per second the local heat flux will certainly not raise the temperature of the seawater. At the beginning of the production it might mine some heat from the local rocks but after moderate pumping for an extended period the temperature of the seawater is likely to approach the average temperature of the sea close to the coast of Vatnsleysa. Heavy pumping, especially from shallow aquifers, is likely to cause seasonal temperature fluctuations due to annual seawater fluctuation but attenuated and with a time lag.

Salinity logs by measurements of electrical conuctivity in the boreholes have been run in VL-11 (figs. 5 and 6). The interface between the freshwater and the seawater is does not show up because of the casing. Fig. 6 shows a salinity log from the borehole VL-8. There pure seawater is first obtained at the depth of 40m (33.6m b.s.l.). The wells VL-11 and VL-13 are closer to the coast so the seawater is probably at less depth there. It seems to be clear that the freshwater/seawater interface is somewhere within the scoriaceous layer at 25-40m depth.

Since the waterbearing layers are highly permeable it is not likely that large lateral variations in seawater temperature are present.

CHEMICAL ANALYSIS

The results of the chemical analysis of water from well VL-11 are shown in table 1.

The samples were taken with a downhole sampler at 50 m and 100 m depth.

The sampling was performed just over three weeks after completion of the well, but the well had not been pumped and therefore the water might still have been contaminated with drilling fluids.

The samples were reddish or rust-coloured when they came up in the downhole sampler. The colouring was especially pronounced in the sample from 100 m depth. No dissolved iron was encountered in either sample.

The salinity of the water at 50 m is just below 33 o/oo and 34 o/oo at 100 m depth, as compared to the seawater mean value of 35 o/oo.

The silica concentration is higher in the water than in sea-water, but as compared to seawater of similar salinity the water shows no other significant changes due to water-rock interaction. The water is not quite saturated with oxygen at the prevailing temperature and salinity.

CHEMICAL COMPOSITION OF WATER FROM WELL VL-11 IN STÓRA VATNSLEYSA

Sample	no.	9055	9056
Depth	m	50	100
pH/°C		7.92/25	7.96/25
Conductivity/ S/°C		47900/22	50000/22
SiO_2	mg/kg	7.2	8.1
Na	"	10300	10531
K	"	424	426
Ca	"	417	423
Mg	"	1232	1285
CO_2	"	100	107
SO_4	"	2504	2557
Cl	"	18264	18846
F	"	0.66	0.66
Dissolv.	"	33690	34640
O_2	"	7.8	7.0
Salinity $^{o}/oo$		32.9	34.0

SUMMARY AND RECOMMENDATIONS

The main results of the drilling of VL-11 and VL-13 are:

1. There are four main permeable zones containing seawater in the uppermost 300m at Vatnsleysa. They are at 25-40m depth, 108m depth, 150m depth and 300m depth. The boundaries between freshwater and seawater seems to be at 25-40m.

2. The temperature of the aquifers is not known in spite of several temperature logs from both wells. The temperature of the 25-40m aquifer seems to be close to 6.0C. The minimum temperature of the aquifer at 108m is 6.5-7.0C and somewhat higher for the deeper aquifers.

3. In order to get reliable information on the actual temperature of the seawater in different aquifers it is necessary to carry out a pumping test with simultaneous downhole temperature measurements. This is recommended as the next step in the seawater investigation.

4. The chemical composition of the water is quite comparable to seawater of similar salinity, 33-34 $^{o}/oo$, and charges due to water-rock interaction are insignificant. The

cause of insignificant discolouration of the water must be explained.

5. The aquifers at 25-40is in pillow breccia, and those at 108m and presumably also the aquifers at 150 and 300m are in scoriaceous layers, which are difficult to drill through.

6. It is likely that pumping of seawater from boreholes will after some time give seawater with temperature approaching the average temperature of the sea off the coast of Vatnsleysa. Heavy pumping, especially from shallow aquifers, can lead to seasonal fluctuations in the temperature.

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LINDALAX
WELL VL-11

Fig. I

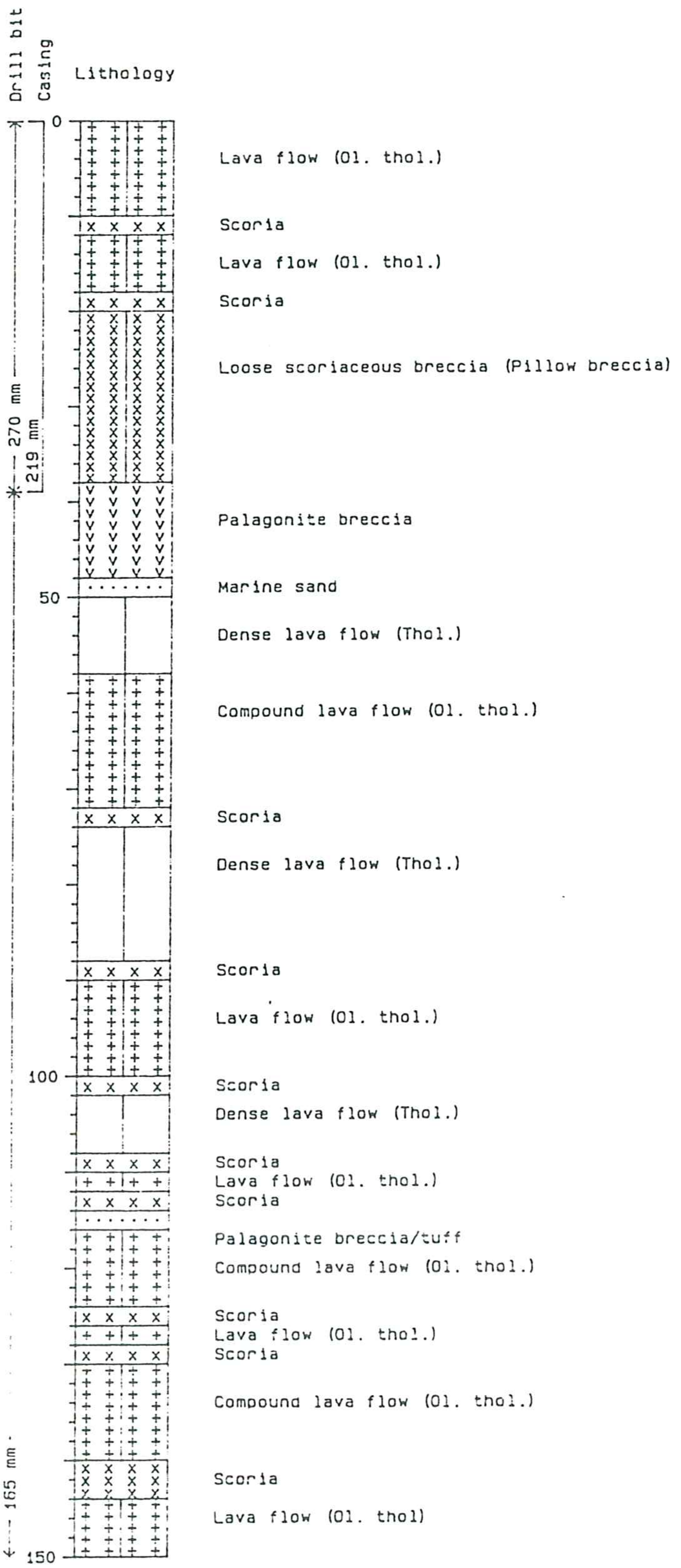

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Fig. 2a

LINDALAX
WELL VL-13

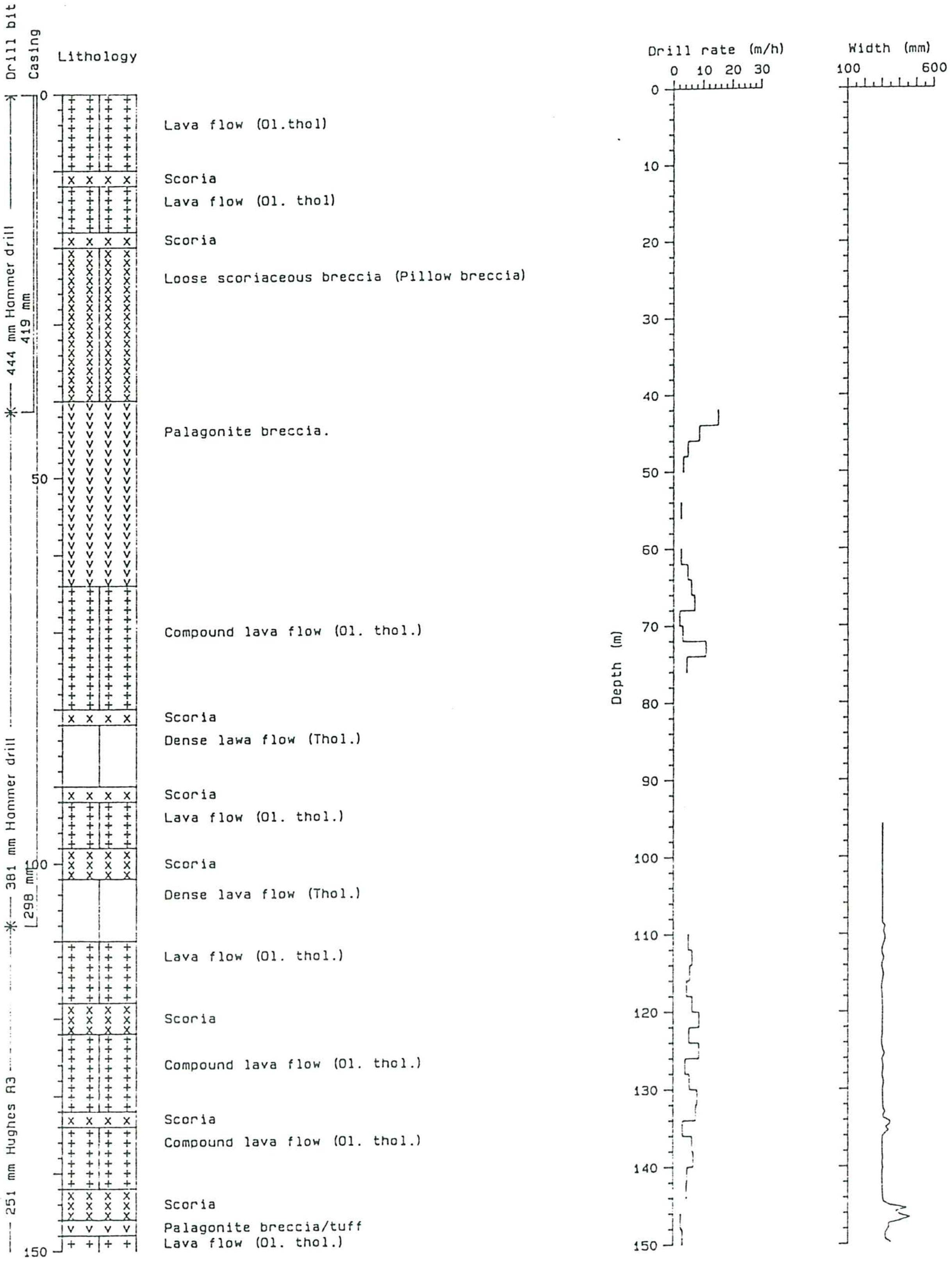

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Fig. 2 b

LINDALAX
WELL VL-13

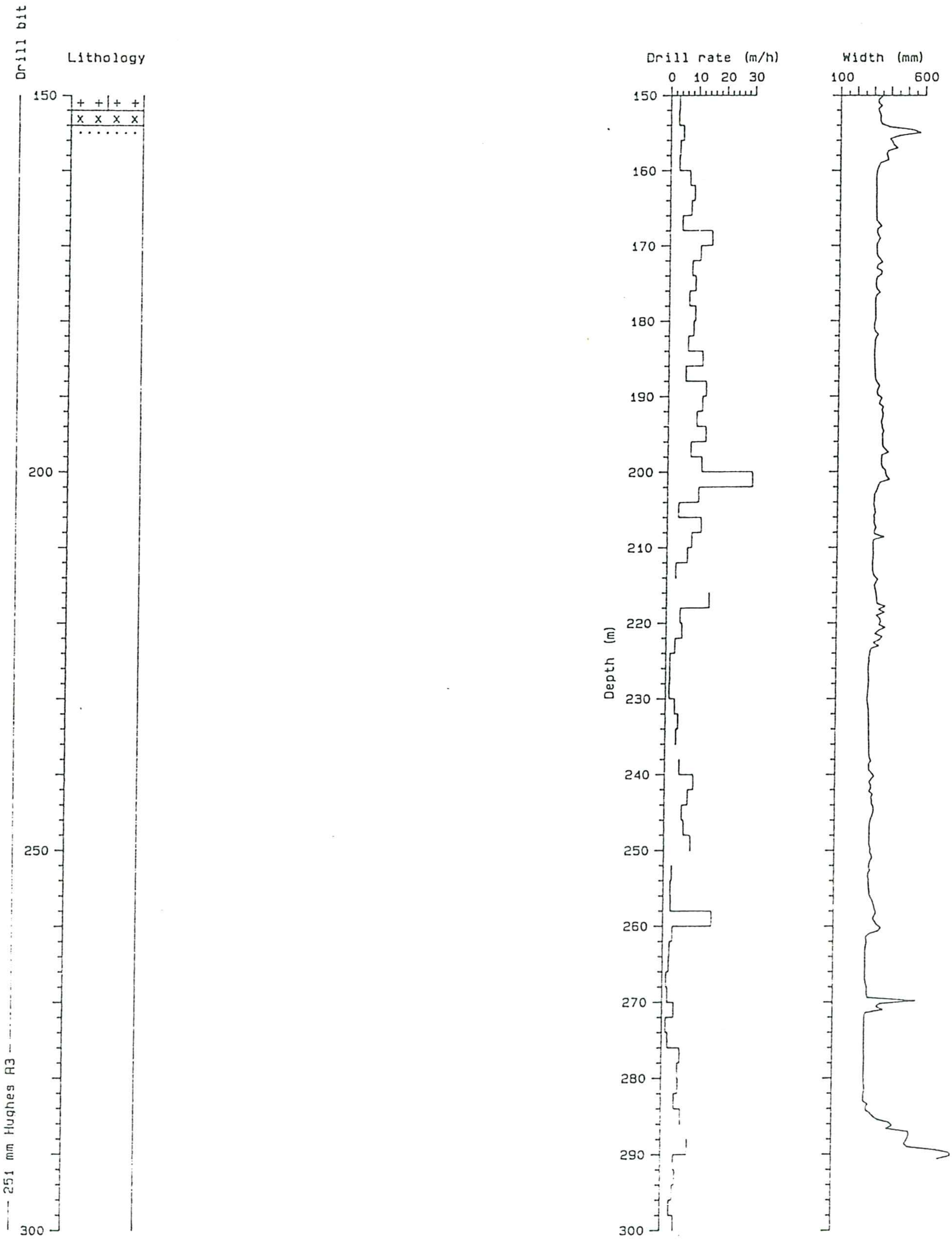

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Fig. 3

LINDALAX
TEMPERATURE MEASUREMENTS
VL-11

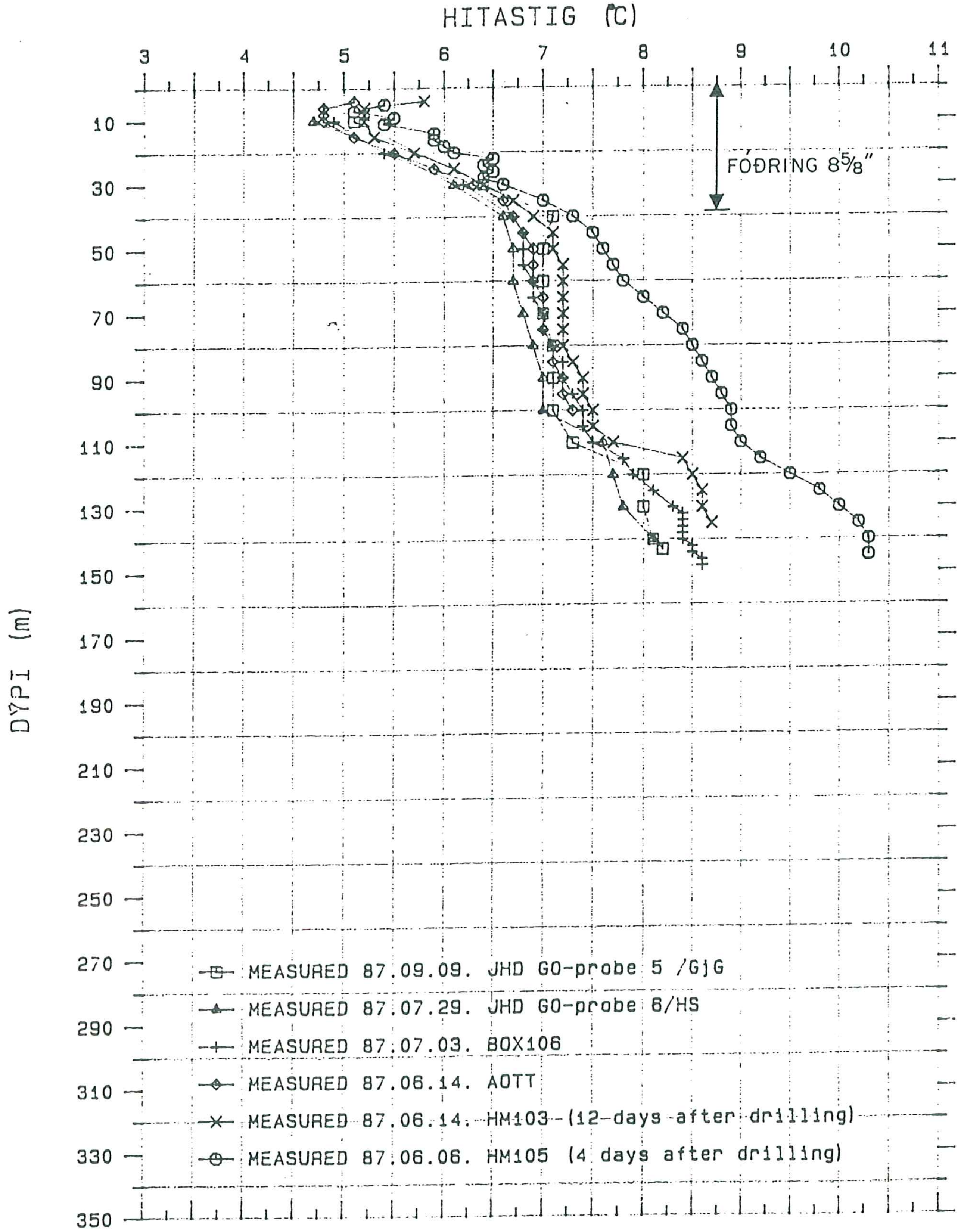

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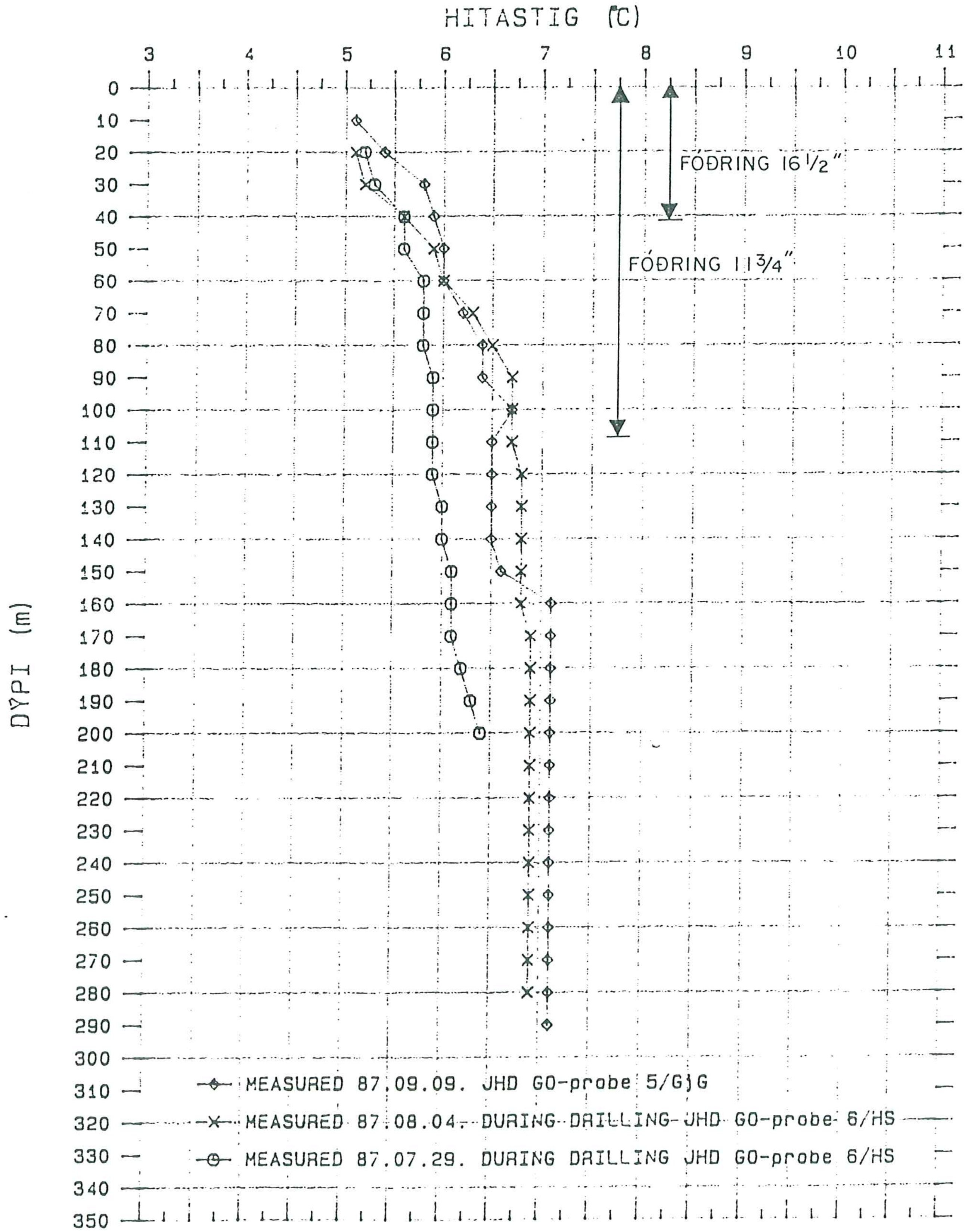
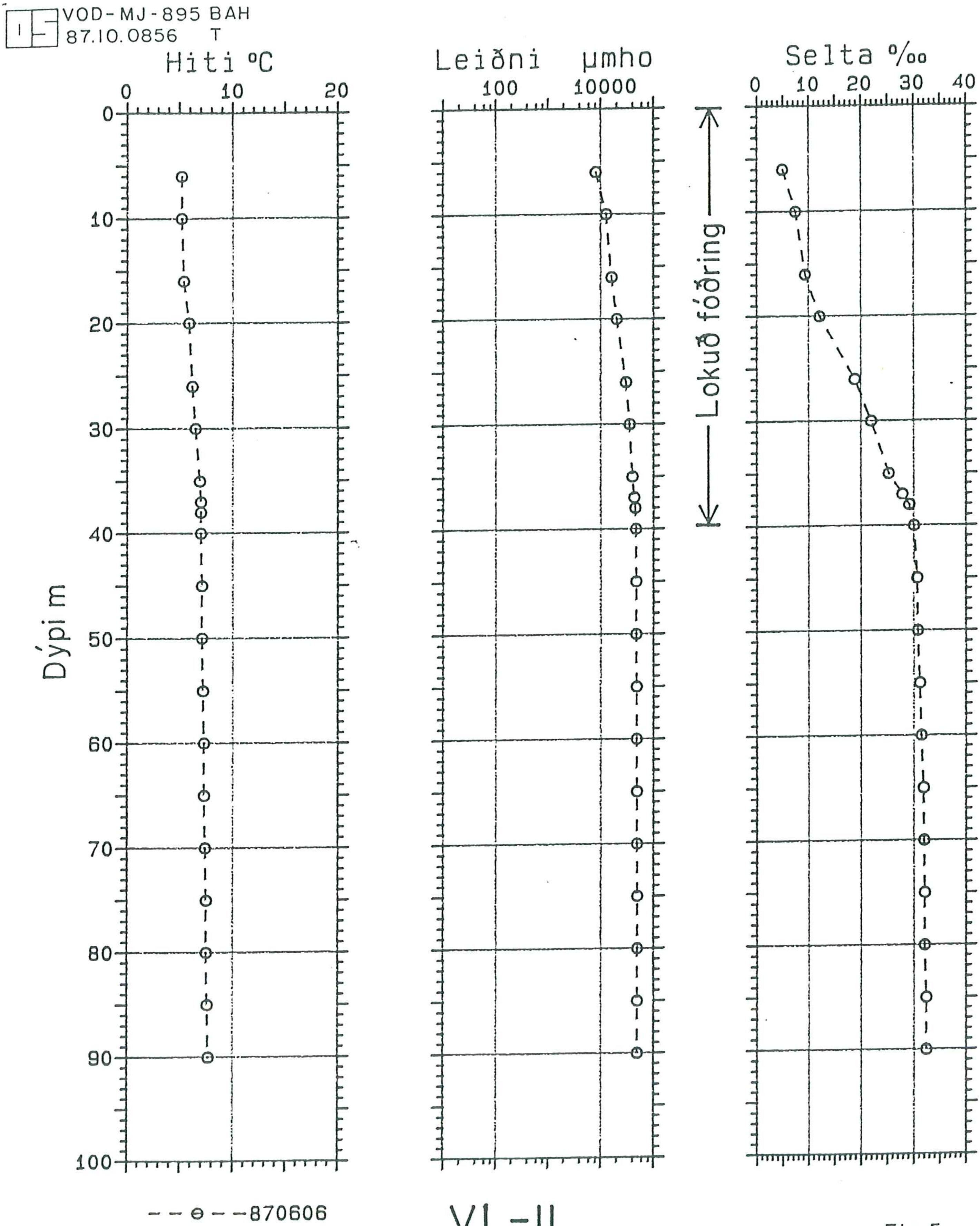
Fig. 4

LINDALAX
TEMPERATURE MEASUREMENTS
VL-13





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VL-II

Fig. 5

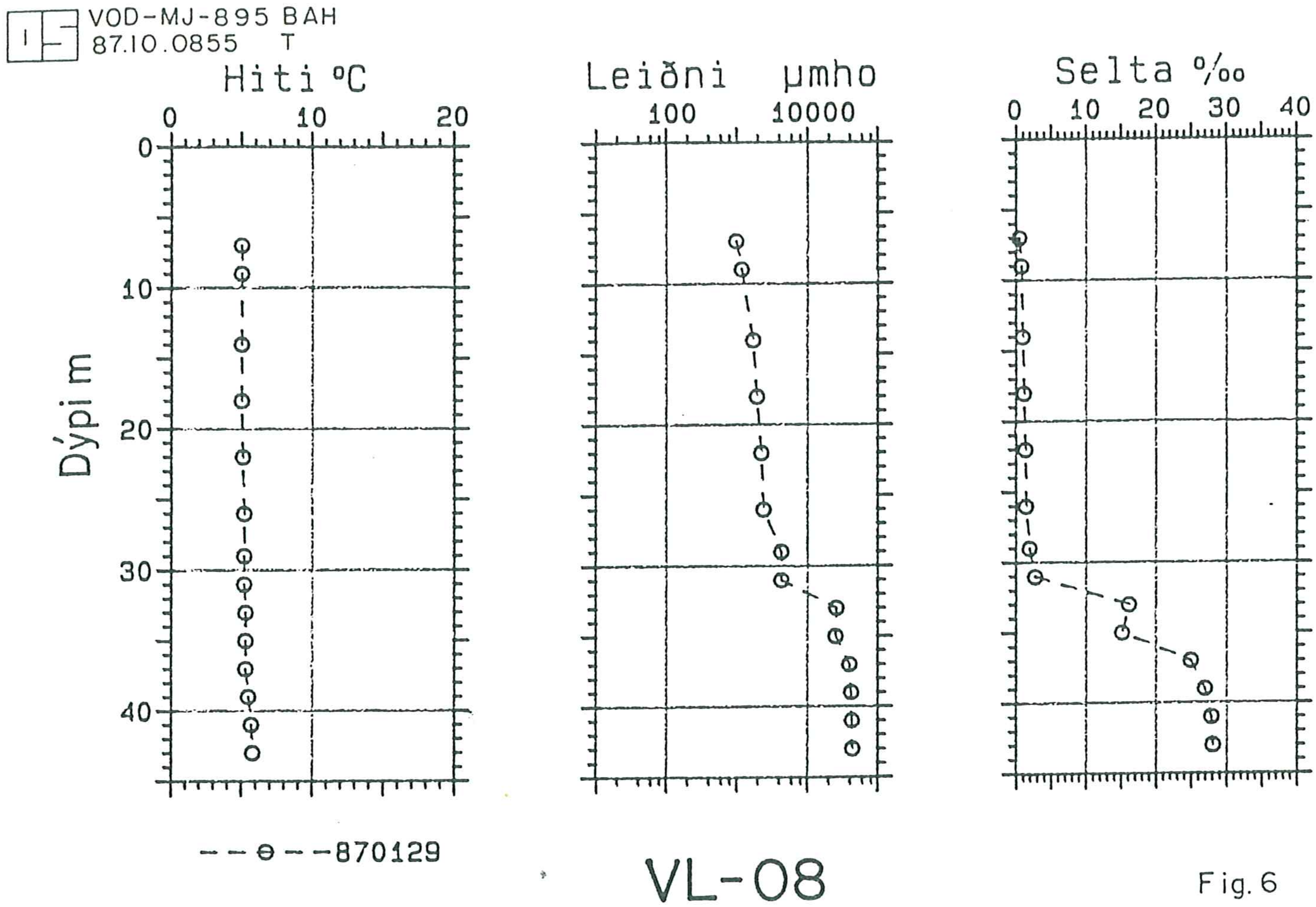
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Fig. 6