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Geology and hydrogeology of Heidmörk area with special regard to the Grenkriki well (Heiðmörk)

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GEOLOGY AND HYDROGEOLOGY OF HEIDMÖRK AREA WITH SPECIAL REGARD TO THE GRENKRIKI WELL

Thor hf in Reykjavík has engaged Orkustofnun (National Energy Authority of Iceland) to evaluate the Heidmörk area with regard to export of drinking water. This report is written in order to meet the UK "Natural Mineral Water Regulations SI 1985 No.71" in accordance with "Guidelines for the Recognition and Exploitation of Natural Mineral Waters, May 1989" prepared by the UK "Food Science Division, Ministry of Agriculture, Fisheries and Food".

The heading of each paragraph in the report refers to the numbers of the relevant sections in the Regulations (Schedule 1).

2(a)I Location of source

The source to be utilized specifically by Thor is a borehole at Grenkriki at an altitude of 170 m. Downhill from the borehole are copious spring areas (topographic maps and Fig 1). The groundwater level measured in the borehole is at about 115 m above s.l. whereas the spring areas are at 75-80 m above s.l. The distance from the borehole to the spring areas is 2.5-3 km. The source is located within the Heidmörk nature reserve east of Reykjavík. The reserve lies at the edge of the Reykjanes spreading zone, which is characterized by young volcanic rocks, and tectonic and volcanic fissures (Fig 2). Towards west progressively older rocks crop out. The ground in the Heidmörk area up to Bláfjöll in the SE is highly permeable. The precipitation varies from 1200-3000 mm/y across the area. The precipitation seeps into the ground to emerge at the edge of young lava flows or from fault zones at low altitude. The main spring area in the NW-part of Heidmörk has a total flow of over 1 m^3/s. This is utilized to provide Reykjavík and the neighbouring communities (~130.000 people) with tap water.

2(a)II Geology and hydrogeology of the surrounding terrain

The Heidmörk area is located a few km NW of the zone of active volcanism. Crater rows and piles of volcanic breccias (hyaloclastite) formed below ice during the last glaciation occur in the higher ground to the SE (Fig. 2 and 3). During ice free periods lavas have spread over the area. The bedrock of Heidmörk consists of interglacial and postglacial lava flows. The interglacial lavas are inferred to be of Eemian age, i.e. from the last interglaciation. These are fresh olivine rich basalts consisting of thin flow units with scoriaceous boundaries in between. Glacial mud has seeped into vugs, fractures and cavities and somewhat reduced the high primary permeability of the lava. The uppermost aquifers are located primarily within the interglacial lava. Its permeability is greatly enhanced by extensional faults and fractures which lie across Heidmörk from SW to NE. Deeper, probably fault related aquifers occur within older hyaloclastite units that are found below the interglacial lavas (Fig. 3).

The interglacial lavas are ice scoured on highs but moraine covered in lows and on gentle slopes. Glacier movement was towards NW from the mountain range of the central Reykjanes peninsula. The ice scouring and morainic deposits date from the last glaciation. The moraine is poorly permeable. From drilling at Bláfjöll it is known that layers of such deposits are interspersed with the subsurface strata. Locally they provide conditions for perched aquifers.

In postglacial time lavas have overflowed the southeastern part of Heidmörk. They lie above the groundwater table as far as the area around the Grenkriki borehole is concerned. The youngest lava flow was erupted some 1000 years ago. It has thin soil but a thick carpet of moss. The lavas are very permeable and practically all the precipitation is infiltrated to the groundwater.

Heidmörk is traversed from NE to SW by active faults. The fault scarps are fresh with throws of up to 40 m. Extensional fissures with opening of up to 1/2-1 m are seen. The Grenkriki borehole lies in an area of low fault density (Fig 4). This may be apparent only because existing faults may have been smoothed out by the most recent lavas.

With regard to groundwater flow the borehole is located close to a divide where the ground water flow is directed toward the spring areas to the north and toward spring-areas in the west (Kaldársel) (Fig 4). More recent contouring of the ground water level confirms this (map not yet available for distribution).

The lithological log of the borehole is shown in Fig. 5. The postglacial lava at the well site is only 3 m thick. It is underlain by interglacial lava down to 200 m. From 200 m. to the bottom of the hole the rock is mainly hyaloclastite and breccia with thin intercalations of lava. All the rocks are of basaltic composition. From 315 m the borehole is impenetrable for instruments probably due to caving in of the walls.

Neutron- and gamma logs of the borehole are shown in Fig. 5. The neutron log is a measure of porosity whereas the gamma log is a measure of rock composition. The logs indicate layering throughout i.e. tuffrich layers alternating with dense lavas in the upper part and with breccia rich in clasts in the lower part. The gamma log shows basaltic composition of the rocks down to 315 m.

A fissure with infillings of clayey material was intersected at 280-285 m. This forms the main aquifer of the borehole. There are less clearly defined aquifers at 330-340 m depth. The borehole was specifically aimed at intersecting aquifers at a moderate depth where a maximum of stability and purity of the water would be attained.

The depth of the cold aquifer in this area is expected to be around 600 m on the basis of a 800 m deep borehole at Kaldársel, 7 km distant on the strike within the fissure swarm, and on the basis of a resistivity surrey (Fig. 6).

Description of the Grenkriki site.

The Grenkriki borehole was sited at 170 m a.s.l. The area to the SE is covered by postglacial lava flows of rough surface structure, whereas the area to the NW is mainly interglacial lava smoothed by glacial action The interglacial lava is cut by a number of subparallel NE-SW trending faults. Faults are no doubt also present below the sheets of postglacial lavas, but being growth faults they have not been displaced since the lavas were erupted. The youngest of these is some 1000 years old as against ~100.000 years for the interglacial lava unit.

The area to the NW downslope from the Grenkriki well is traversed by roads used during summer by people enjoying the nature of the reserve by car, on horseback or on foot. The area to the SE, upslope of the well, is virgin, rough lava avoided by man and domestic animals alike. The only construction upslope from the well is a power line 1.5 km distant. Protective measures have not been taken so far to keep off unauthorized persons apart from housing around the well itself. With regard to the depth of the aquifer and the porous lava around the well it should be sufficient to set up a fence 100 x 100 m in size.

Fluctuations in ground water level have been measured in a monitoring well 300 m NE of the Grenkriki well. Over a period of 20 years fluctuations of 5 m have been observed (117-112 m a.s.l).

Rate of flow

A short term completion test at the end of drilling indicates a yield of 50 l/s minimum at a drawdown of some 50 m within the well.

A 6 weeks pumping test at a constant rate of 20 l/s showed a drawdown of about m.

Temperature of the aquifer

The temperature of the aquifer measured in the well is 4.5-5.0°C A temperature profile of the borehole is shown in Fig. 5.

Water chemistry, hydrogeology and nature of the terrain.

The chemical contents of the water from the Grenkriki borehole are very low. Small absolute errors in the analyses may therefore be relatively great. A comparison with analyses from other wells and springs in the vicinity, especially the above mentioned spring area towards NW, shows that the water from the Grenkriki borehole is similar to the water from the other sites, with some deviations, which for every major component is indicative of the same hydrogeological difference of origin.

The chemical contents of the groundwater result partly from the precipitation, with a dominant marine factor (seaspray and marine aerosols), and partly from reactions with and dissolutions from the bedrock. The marine factor can easily be calculated away and the remaining chemistry reveals the hydrogeological conditions. In the discussion below the corrected values will be referred to, not the measured values.

The chloride content is higher at the coast than in the mountains. A content of 10.6 ppm Cl^- points to an area of origin farther inland, probably close to the Bláfjöll mountain cluster. The sulphate content points in the same direction. The bedrock components for sodium (rather high, Na^+ approximately 7 ppm) and potassium and magnesium (negative, calculated values) are strongly indicative of an origin from deep fissures and a relatively long stay in deep, confined aquifers. The high pH value (9.0) supports this interpretation. In equilibrium with the atmosphere, the water usually acquires a pH near to 7.5. The SiO_2 value of 14.8 ppm is in good agreement with the temperature of the water. The NO_3 value of 0.3 ppm is the same as observed for water from the high country, almost all over in Iceland.

The hydrogeological interpretation of the water chemistry is as follows: The chemistry is typical for water from mountains and high country, in this case the surroundings of the Bláfjöll mountains, probably on the west side of the mountains, which has penetrated down to considerable depths and is flowing in strongly confined and fissured aquifers.

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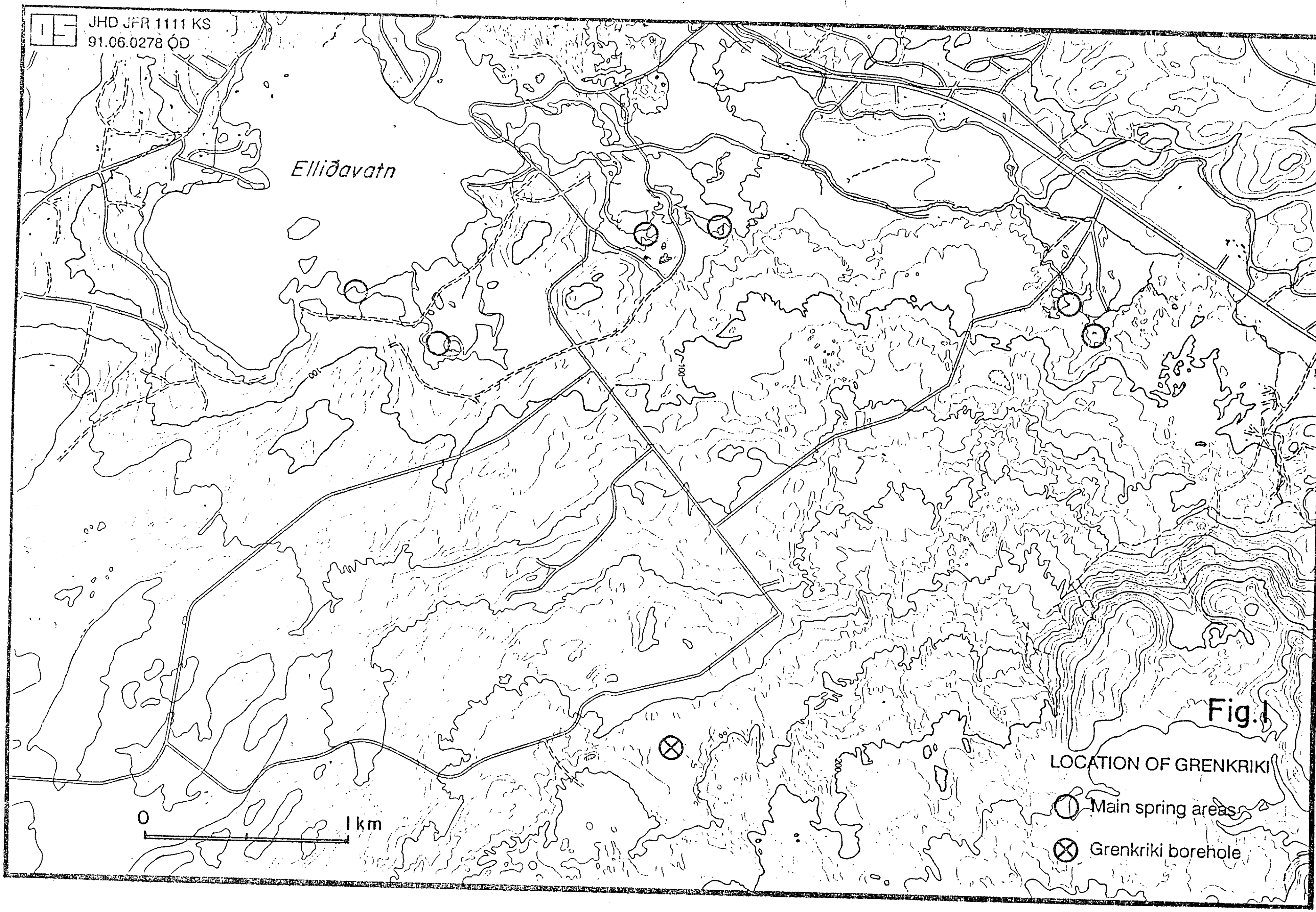
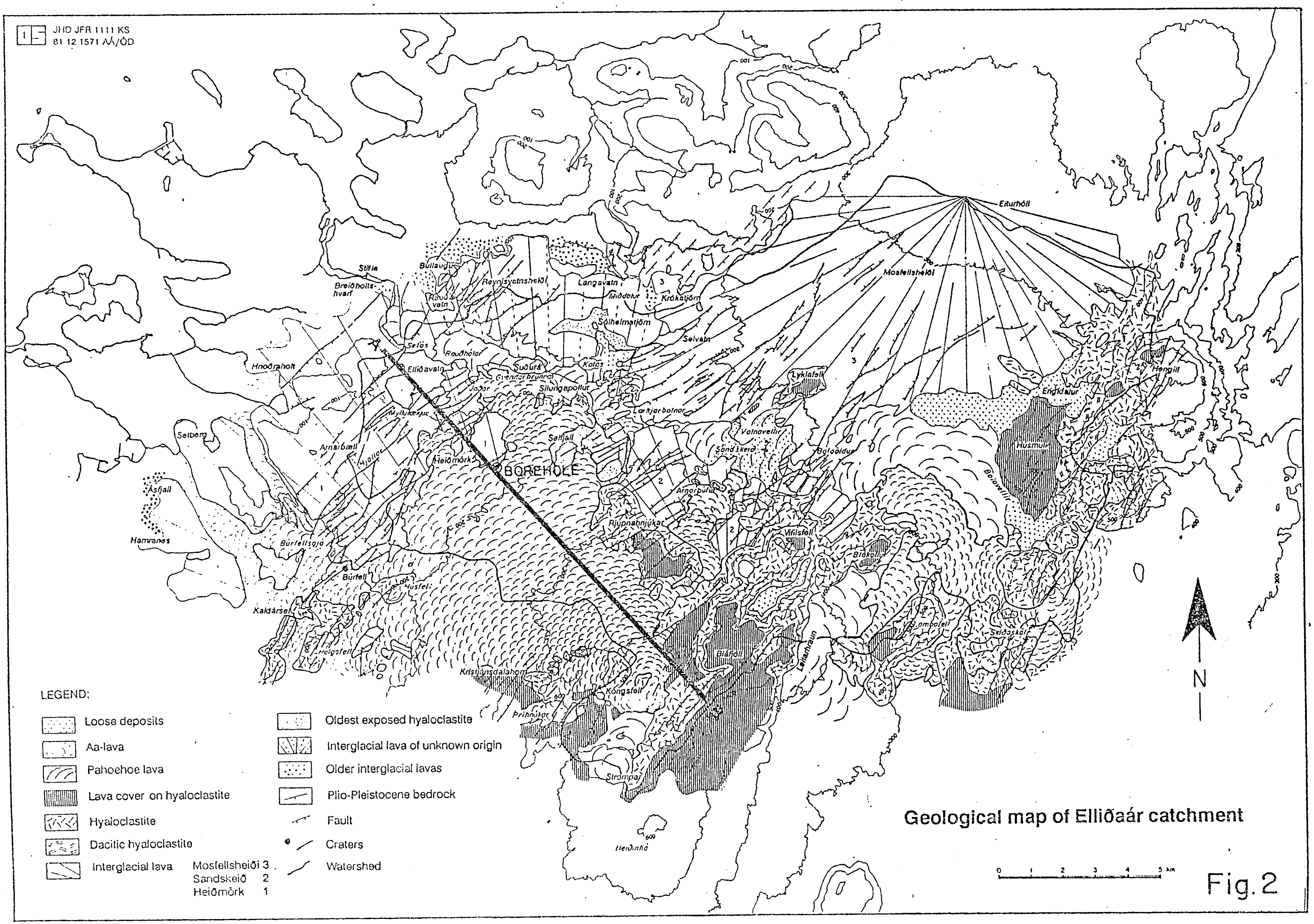


OS
JHD JFR 1111 KS
91.06.0278 ÓD
Elliðavatn
100
0
1km
Fig.1
LOCATION OF GRENKRIKI
Main spring areas
Grenkriki borehole



Geological map of Elliðaár catchment

Fig. 2

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90.06.0284 Gyða

Geological section across Heidmörk

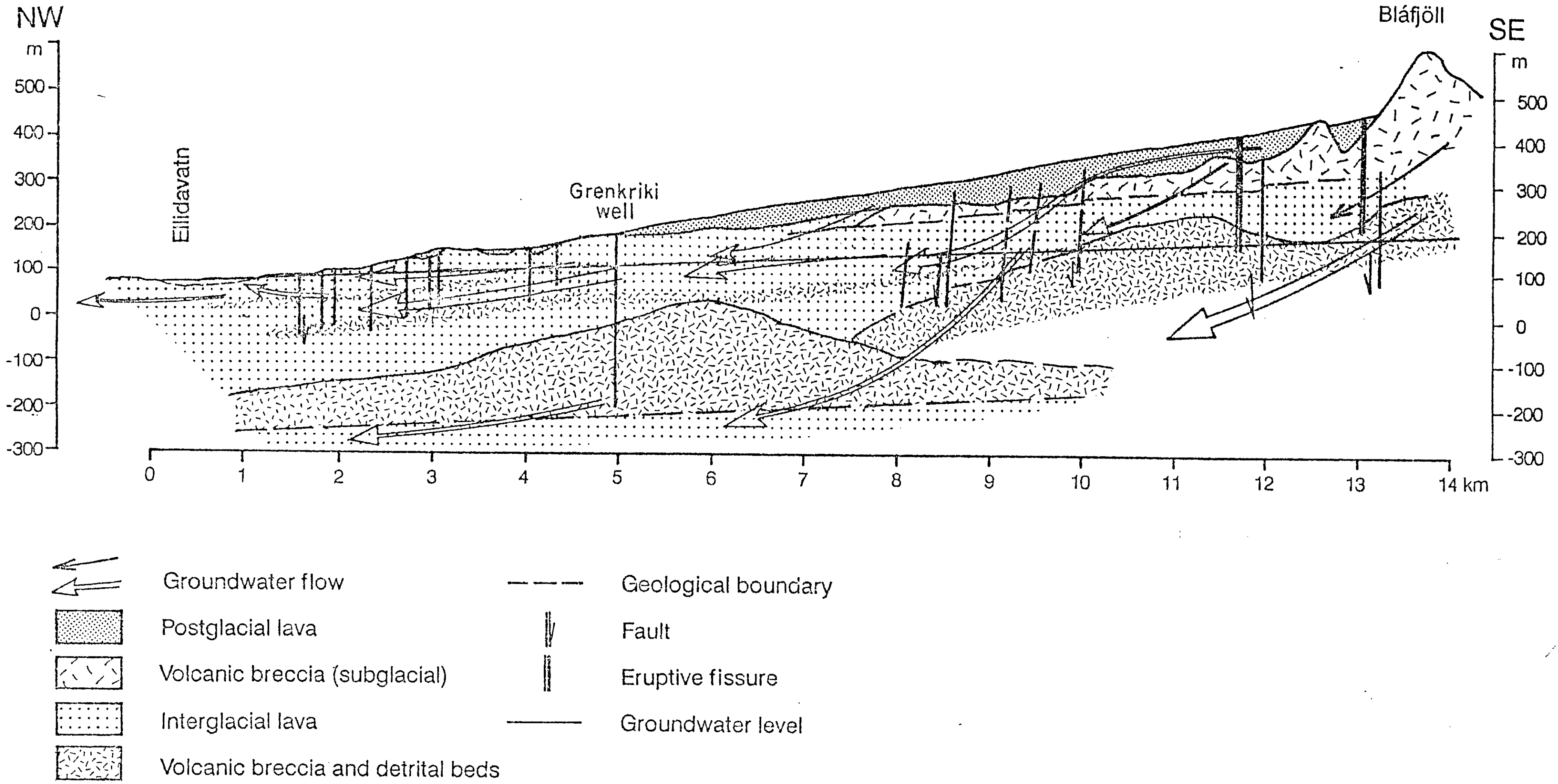
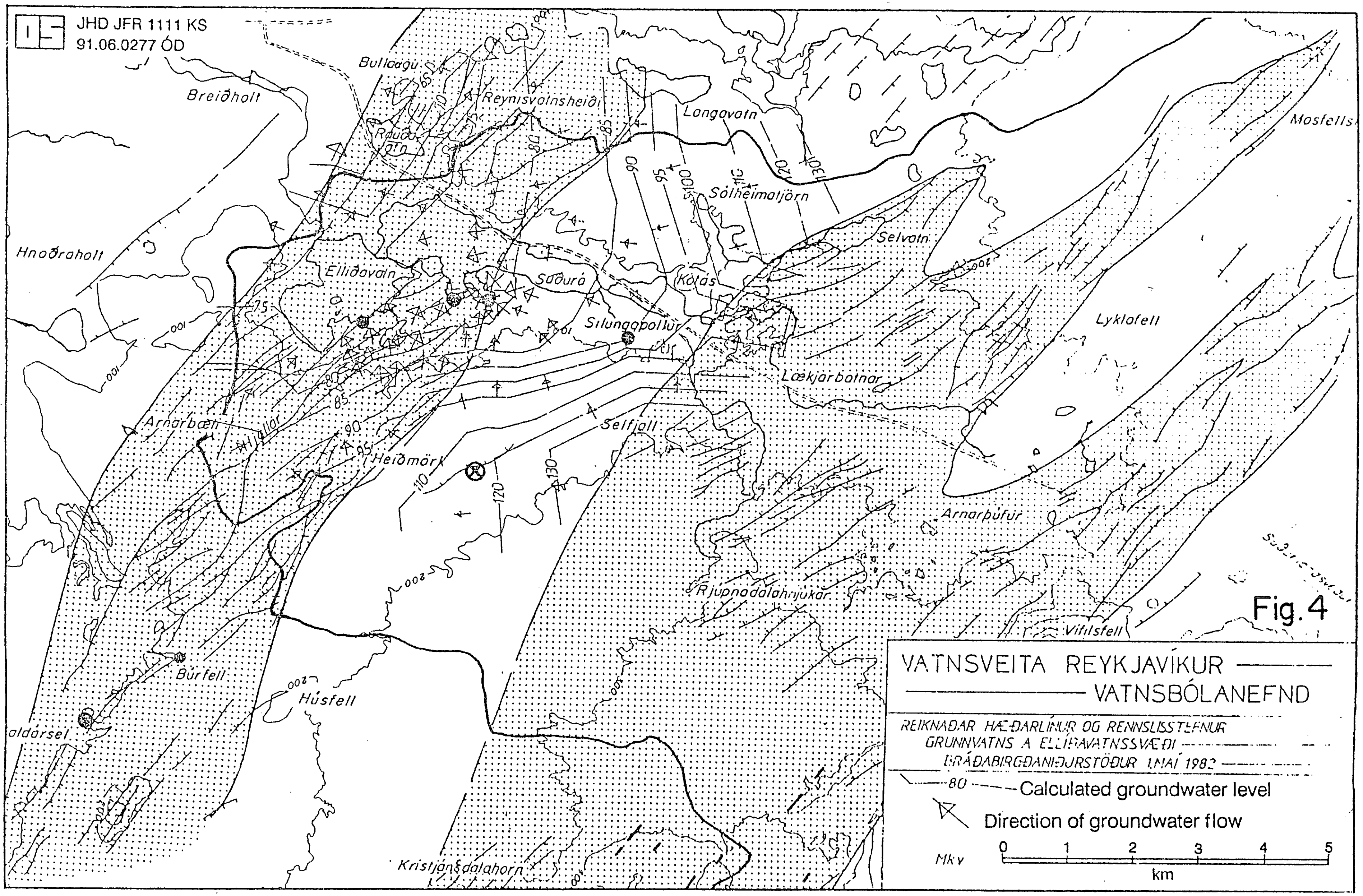


Fig. 3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Breiðholt
Hnoðraholt
Bullaugu
Reynisvatnsheiði
Rauðavatn
Langavatn
Sólheimatjörn
Selvatn
Elliðavatn
Suðurá
Kolás
Silungapollur
Lækjarbotnar
Lyklafell
Mosfells
Arnarbæli
Hjallar
Heiðmörk
Selfjall
Arnarþúfur
Bláfjallahnjúkar
Vífilsfell
Búrfell
Húsfell
Kristjánsdalahorn
Fig. 4
VATNSVEITA REYKJAVÍKUR
VATNSBÓLANEFND
Calculated groundwater level
Direction of groundwater flow
0 1 2 3 4 5
km

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91.04.0189 ÓD

GRENKRIKI

Borehole and borehole logs

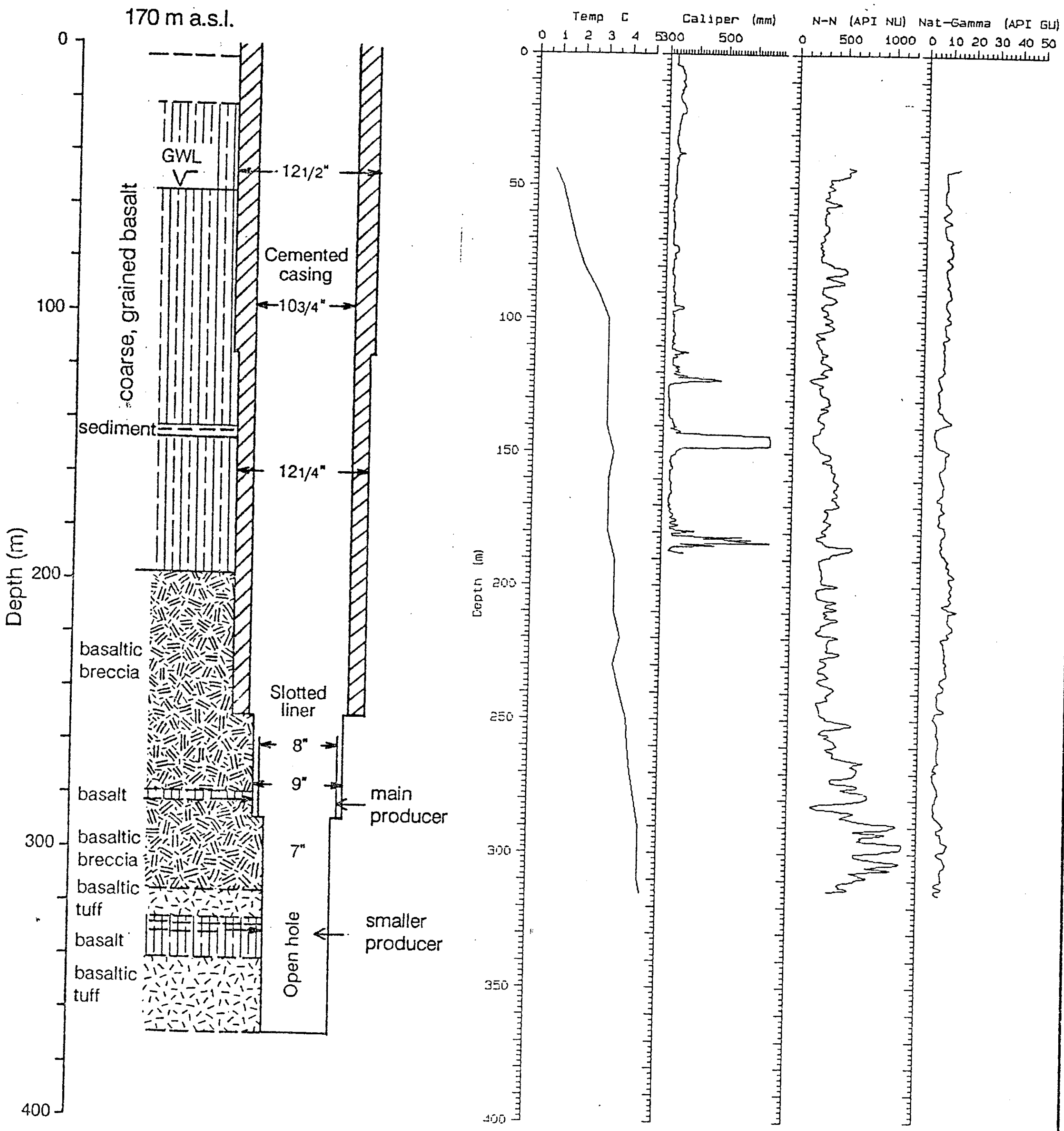
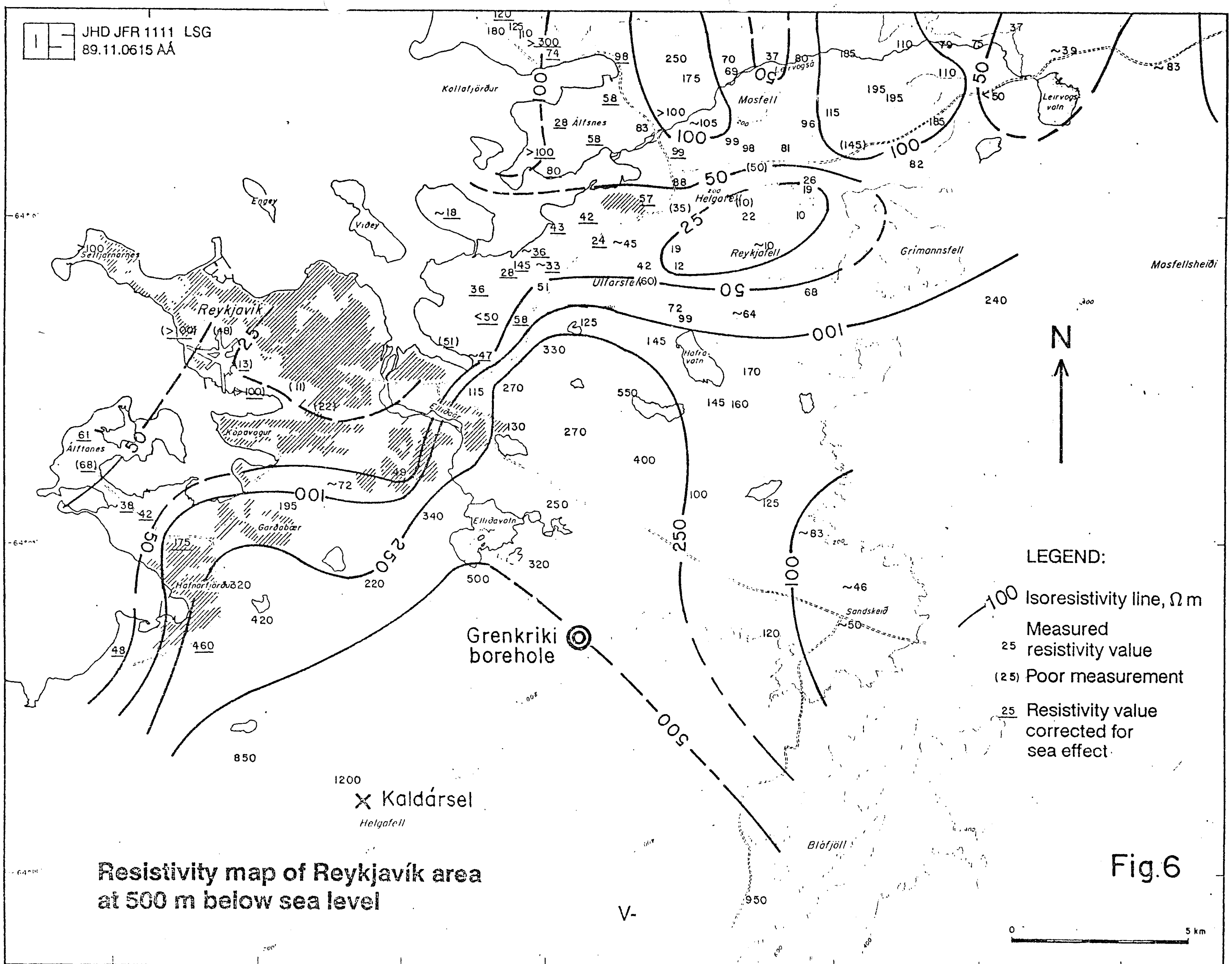


Fig. 5



Resistivity map of Reykjavík area at 500 m below sea level

Fig.6