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GEOTHERMAL MAPPING AT REYKJAKOT IN ÖLFUS, SW-ICELAND

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ABSTRACT

Geothermal mapping has been done in the Reykjakot area by carrying out geological and hydrogeological mapping, detailed soil temperature and magnetic surveys and borehole geology data interpretation. Reykjakot is a part of the Hveragerdi high-temperature geothermal field which lies at the eastern border of an active spreading zone. Surface geology to the north of the mapping area and borehole data show an eroded and faulted basement composed of a sequence of subglacially extruded hyaloclastites, interbedded with subaerial basalts and minor sediments. Late glacial sediments, thought to be of glaciofluvial and marine origin, overlie the basement in the flat ground south of Reykjakot farm. These were covered by postglacial lavas, which cover the southern part of the mapping area. The edge of the lavas is buried but, according to the results of the magnetic survey, it lies well to the north of River Varmá.

The thermal survey shows an anomalously hot ground with a N-S trend. It lines up with hot springs to the south and a fumarole field to the north, strongly suggesting a tectonic control. Details in the thermal anomaly pattern suggest NE-SW en echelon fractures superimposed on the main trend. Most of the geothermal manifestations along the zone became active in 1915 or 1916. A deflection of the thermal anomaly into a NW-SE direction near river Varmá is related to the general groundwater flow within the permeable postglacial lavas.

A geological model has been developed for the area which shows that the area is supplied by NE-SW flowing hot geothermal water, heated by a source northeast of the area. These waters move along the NNE-SSW and NE-SW fractures.

The siting of some boreholes in the area did not take advantage of the fracture permeability which seems to control the upflow of hot waters there.

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1. INTRODUCTION

1.1 The purpose of the geothermal exploration

The geology of Reykjakot and its surrounding area (Hveragerdi central volcano) has been mapped by Kristján Saemundsson and Gudmundur Ómar Fridleifsson (work in progress). In this area, basaltic hyaloclastites, pillow lavas and associated sediments of the upper Pleistocene (younger than 0.7 m.y.) outcrop. This sequence is part of an extinct central volcano which has been eroded and covered by discontinuous layers of glacial sediments, talus and soil. The geothermal mapping described in this report was done on flat ground where the upper Pleistocene basement was completely hidden below sediments and postglacial lavas. The project in the Reykjakot area was to define, if possible, fractures and different geological contacts where hidden by soil, talus and lavas.

This was done by: 1) mapping in detail hot springs and hot ground; 2) correlating the findings of the soil temperature measurements to the geological structures as seen in the hills north of the area; 3) defining, by ground magnetic survey, the probable extent of the postglacial lavas underneath stream deposits and soil since the permeable lava might have an effect on the hydrogeology of the area; and 4) acquiring the basic knowledge of the geothermal field that might be useful for evaluating the current locations of the boreholes in the area and planning for future drilling programmes.

1.2 General description of the survey area

Reykjakot area is located north of the Hveragerdi municipality, 45 km southeast of Reykjavik along the road to the southern lowlands of Iceland (Figure 1). This study was restricted to the area covered by Reykjakot farm, which is about 250,000 m^2. There is a line of four hot springs with temperatures higher than 20°C, bounded by two springs of 15°C to the west and east of the line (Figure 2). The line runs NE-SW through a fossil, tepid hydrothermal explosion crater. River Varmá marks the southern boundary of the farm, and the hills in the north mark the northern part of the farm. A small stream runs through the farm from north to south. Geothermal manifestations in the area include: hot springs at River Varmá, a solfatara in the gully north of the farm, a hot spring south of River Varmá near borehole 102, and two fossil explosion hot springs which dried up when boreholes were drilled in the area. There is also warm ground in the southern part of the farm where temperatures of 52°C have been recorded at a depth of 80 cm. No information exists about three boreholes of seven. Only two of the boreholes are useable. The area can be reached by two roads, one from the south across the river, and the other from the southeast over a bridge on River Varmá. The area is gently sloping, bounded by hills in the north and a lava and soil covered plain in the south.

According to Steinthor Sigurdsson (1944) no geothermal manifestations existed along the present line of hot springs through Reykjakot Farm until 1915 or 1916. He specifically mentions that the eastern explosion hot spring, the steam vents up the gully and the hot springs on the bank of the river, formed successively at that time. The explosive hot springs were spouting vigorously in the beginning but gradually calmed down to their present state of inactivity.

Describing the formation of the geothermal manifestations, Steinthor Sigurdsson (1944) had this to say: " People first became aware of the manifestations on the night of Christmas Eve, 1915

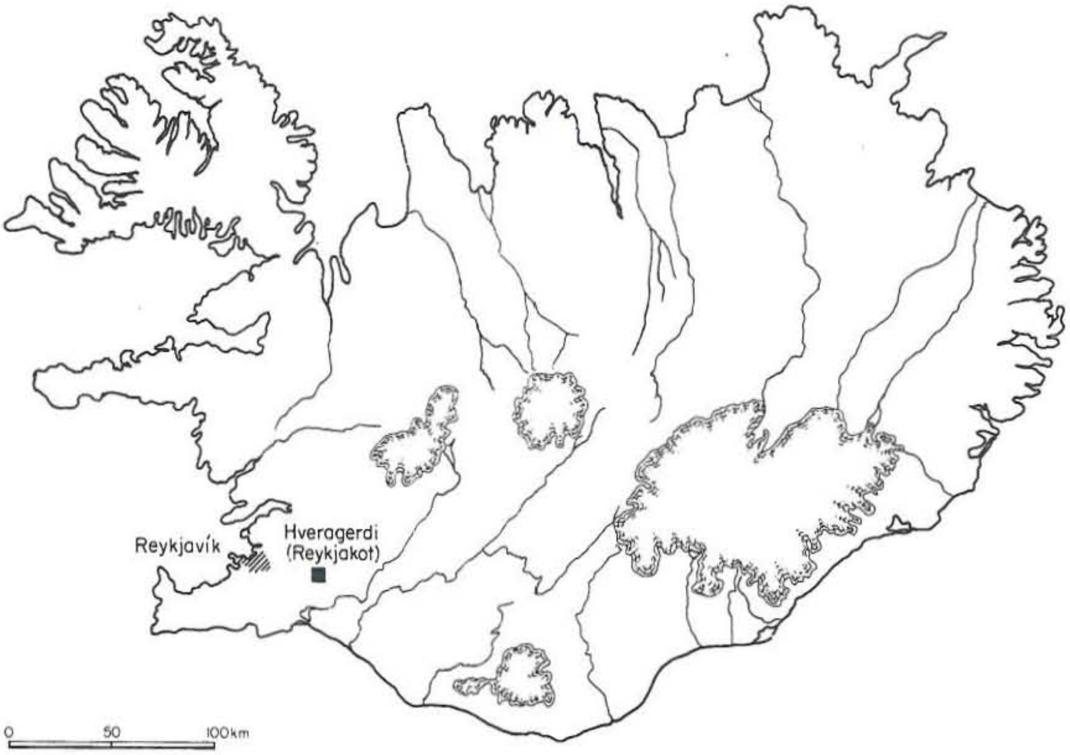

FIGURE 1: Location map showing Reykjakot and Hveragerdi municipality. Reykjakot is immediately north of the village

or 1916. The farmer at Reykjakot was going to see off a guest, when they heard a rumblingnoise. They smelt a very strong odor of sulphur and found the surroundings unusual. The guest stayed overnight and the next day, they found that a big crater had formed southeast of the farm house near the location of the present recreation house. Even at large distances, randomly spattered mud and soil could be seen everywhere. Gradually, the crater filled with hot water and formed a big hot spring about 8 m in diameter, named the Christmas Night hot spring. Another sudden geothermal eruption occurred the next summer, so great that the steam column could be seen by motorists from the Hellisheidi road near Skídaskálinn in Hveradölum. The hole widened gradually as the eruption calmed down. There was great unrest in the area, with frequent earthquakes. Some escarpments formed near the hot spring and could still be seen in 1944. I would think they formed as the soil slid towards the hot spring. In the main crater (measuring 8-10 m across and 6 m deep) where the eruption occurred, a flow of 3 litres per second was observed in 1944 (the larger fossil explosion crater). Sometime later, a hot spring and mud pools were formed up in the gorge (present location of steam vents north of study area). At first, the volume of steam was very large, and the steam column projected high into the air. Considerable thermal activity began, primarily the venting of steam, at the bank of the river south of the hot spring, and in the meander plane (present warm ground). The Christmas Night hot spring cooled down after other springs became active. It is now a dull depression being filled up with rocks ".

Regarding a blowout which destroyed a greenhouse that occurred during the drilling of borehole 0 in 1944, Steinthor Sigurdsson reports: " On inspection, it became clear that the greenhouse east of the borehole had been built on hot ground. From the greenhouse towards the big hot spring (Christmas Night spring) there is a line trending due south; and it seems that the soil is hot all along it, nearly continuously, but in certain places there are particularly hot points, and one such seems to have been under the greenhouse. From the drilling, it became clear that the hot water zone is mainly connected to a conglomerate layer above which are impermeable layers. Steam and water had no possibility of getting to the surface except along fractures. I think one such fracture lies between the big hot spring and the greenhouse. The water in borehole 0 was near to boiling at 22 m depth for the respective hydrostatic pressure".

A similar event of small magnitude earthquakes and opening of hot springs occurred in 1947 on a row of hot springs that passes through Hveragerdi (Sigurdsson and Hannesson, 1948). Small cracks, a few centimetres wide, were observed in the ground north of Hveragerdi, trending NE-SW (Saemundsson, oral communication).

1.3 Field methods

The methods used for this study included surveying, geological and hydrogeological mapping, detailed soil temperature and ground magnetic measurements and borehole geology data interpretation. In the context of this area, a description of each method used is provided in section 2.

2. DATA ACQUISITION AND TREATMENT

2.1 Surveying

Prior to taking temperature measurements, a survey was carried out in the area using a Silva compass, survey poles, a right angle lens, a measuring tape and a 300 m string marked at intervals of 5, 10, and 100 m, to produce a detailed base map at a scale of 1:1000 (Figure 2). First a reference point, borehole 0, was located. Then, one reference line was established to go through this point, and all other lines were established to cross this reference line. The position of each object was fixed relative to the reference line, measuring the distance at right angles to the line between it and the object. In this way, the location of all constructions, geothermal manifestations and structures controlling the hydrogeology in the area were mapped in Figure 2.

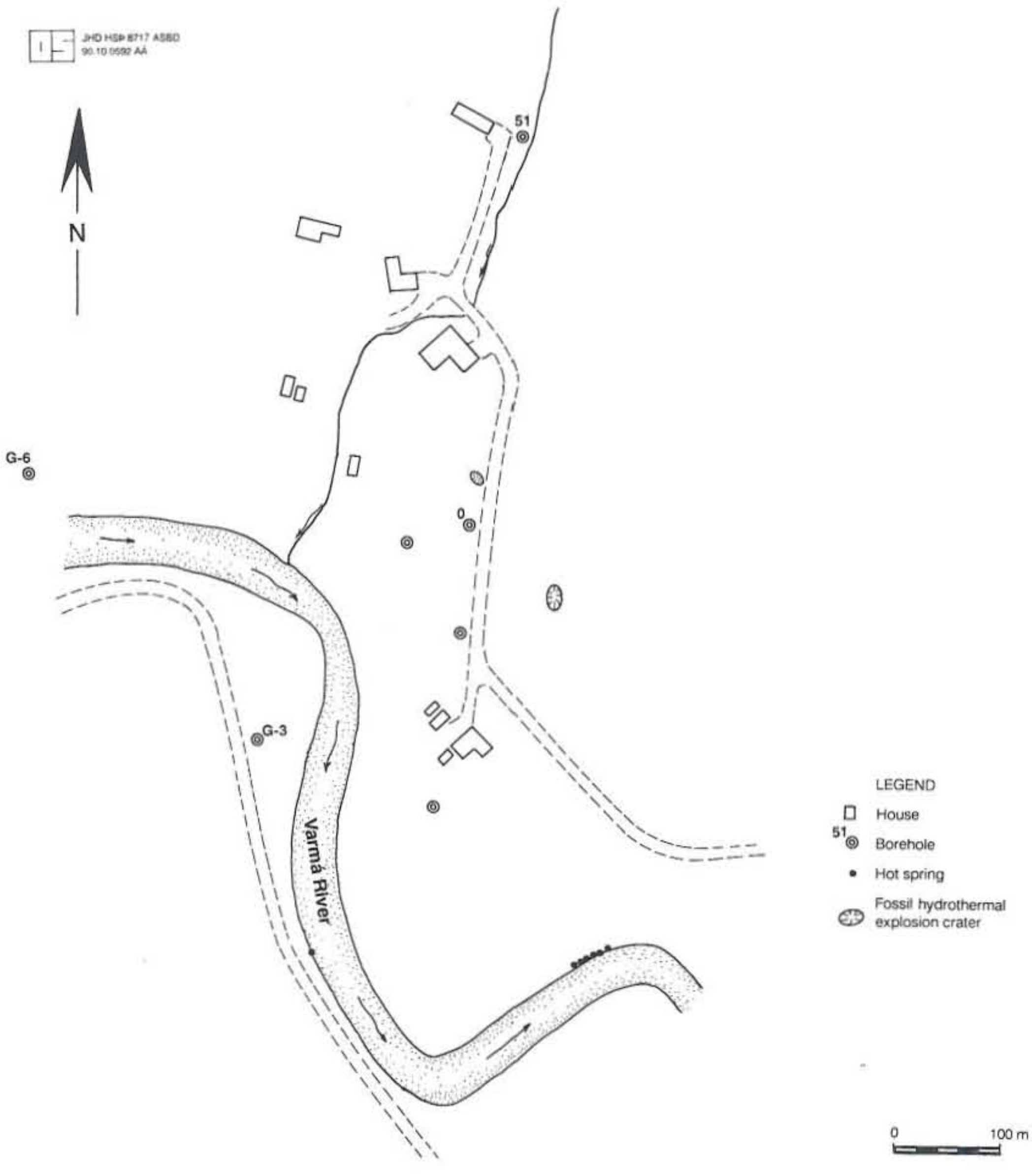

FIGURE 2: Location map of survey area around Reykjakot farm, Ölfus, Iceland

2.2 Geological and hydrological data

A geological excursion was taken to establish the main rocks and structures controlling the hydrogeology north of the area. A detailed geological and hydrogeological map of the study area was drawn at a scale of 1:5,000 (Figure 3). This was extracted from a detailed larger map at a scale of 1:10,000 by Kristján Saemundsson and Gudmundur Ómar Fridleifsson. This report helped to trace subsurface contacts through the Reykjakot area.

Geological measurements were taken with a Silva compass on structures and formations, mainly to establish the strike and dip directions. Surface alterations were also noted. Data was provided from drill holes along the line of hot springs. One of those is at the southern end of the line just outside the area (borehole 102); two others are inside the area (boreholes 51 and 0).

The borehole data was used to construct and check the geological model obtained from the study and to draw a geological cross-section through the study area (Figures 11 and 7, respectively).

2.3 Temperature measurements

Temperature measurements were made along lines perpendicular to the suspected fracture trends. Altogether, 17 lines were measured.

Measurements were done with a digital thermometer with a 1 m extended sensor protected by a steel pipe with a cable to the digital sensor marked at 80 cm. A 1 m T-shaped steel rod marked at 80 cm was first driven into the ground, sometimes with the help of a hammer, before introducing the soil thermometer. Measurement was done at an interval of 5 m with line spacing of 20 m.

The acquired data was plotted on the map, and isothermal contour lines with 2°C spacings were produced by interpolation. This could also be achieved by using the SURFER programme available at Orkustofnun.

2.4 Magnetic measurements

Having established the thermal map, a NW-SE thermal anomaly was observed that was possibly related to the flow of groundwater in permeable postglacial lavas. It was decided to try to find the subsurface extent of the lava. This was accomplished by establishing magnetic lines perpendicular to the suspected margin of the lava. The lines were extended well onto the lava to get undisturbed readings of the magnetic intensity over it to use for defining the edge.

Magnetic measurements were taken with a proton magnetometer at intervals of 5 m on 14 lines running from southwest to northeast with line spacing of 20 m.

Magnetic profiles were constructed from the data to see the trend of the results. This was considered a better method than constructing a magnetic map, since the purpose was to establish contacts as opposed to studying dykes and other structures which had already been established by the soil temperature measurements and geological mapping.

3. RESULTS OF THE STUDY

3.1 The geology and hydrogeology of Reykjakot area

3.1.1 Stratigraphy

The area has been mapped geologically by Kristján Saemundsson and Gudmundur Ómar Fridleifsson (work in progress). Figure 3 is from their work and shows the rock sequence of the basement north of the study area. The basement is mainly composed of basaltic hyaloclastites, pillow lavas and associated sediments (tillites, sandstones, conglomerates) of upper Pleistocene age (younger than 0.7 m.y), deposited in an ice-melt or lacustrine environment. Basalt lavas also occur interspersed with the hyaloclastites. The deposition of these rock units was accompanied by the intrusion of many basaltic dykes. The youngest unit of the basement sequence is a narrow ridge of porphyritic hyaloclastite and a dyke of the same type, both trending N30°E. The dyke is found right above the solfatara in the gully and may be the controlling pathway for the steam. Several dykes were observed, mainly aphyric basaltic dykes, sometimes crosscut by younger feldsparphyric (porphyritic) dykes and andesitic ones. These dykes trend predominantly NE-SW (N30°E, Figure 4). The basement rocks have been eroded and slightly altered by hydrothermal activity. Strong clayey alteration occurs around the solfatara in the gully north of the farm.

A marine clay formation of about 10,000 years of age, grading upwards from clay to a sand or gravel, overlays the basement in the part that was the deeper end of the sea, while a talus breccia fills the shallower part of the sea, and the gully and slopes north of the former shore line.

A postglacial basaltic lava of 9,000 to 5,000 years overlays both of the two formations extending over the southern part of the area. It is exposed in the riverbed of Varmá in the bend south of Reykjakot. There is a 1-2 m thick soil cover on the flat ground and a thick talus on the slopes which made it hard to extend the contacts of geological formations through the area.

3.1.2 Structural geology

A fracture zone is indicated by the line of hot springs (Figure 3). From the thermal map, it seems to be made up of two sets of fractures trending N-S (in accordance with point 2 in the conclusions) and NE-SW. These trends (Figure 5) are found in many active volcanic areas of Iceland. No evidence was seen of very young open fractures such as were reported in Hveragerdi in 1947 when an event apparently similar to the one of Reykjakot in 1915 or 1916 hit the village (Sigurdsson and Hannesson, 1948). The trend of dykes and fractures along the walls of the gully north of Reykjakot were measured (Figures 4 and 5). The dykes trend 20° more easterly than the fractures. The latter are probably younger and related to the tectonic break-up that so strongly controls the hot spring areas around Hveragerdi. A measurement of fracture trends was also made for comparison (Figure 6) across a fracture zone with many hot springs at Hverahvammur on the northern bank of River Varmá. A NE-SW trend is very prominent at the last locality, with a slight increase in angle relative to the fracture trend at Reykjakot. The fracture zone at Hverahvammur, as a whole, trends NNE-SSW.

FIGURE 4: Trends of dykes north of Reykjakot (12 readings)

FIGURE 5: Trends of fractures north of Reykjakot (20 readings)

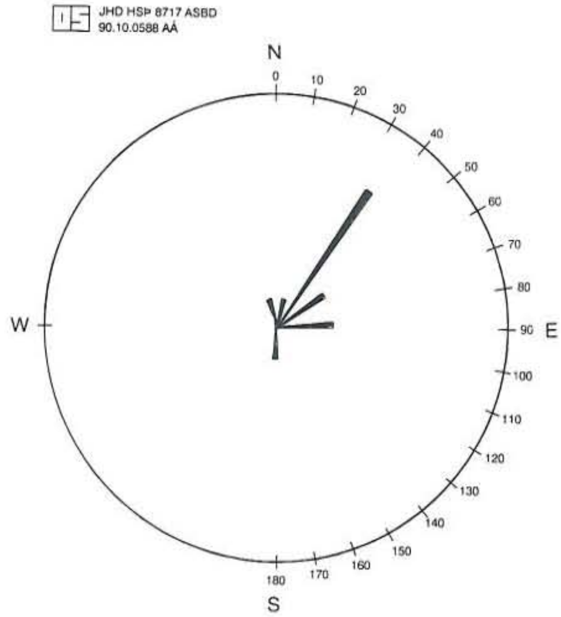

FIGURE 6: Trends of fractures near river Varmá at Hverahvammur (12 readings)

3.1.3 Hydrogeology

Figure 7 shows a NE-SW geological section of the area based partially on data from boreholes 51 and 102. The postglacial basaltic lava formation is highly permeable, with a thickness of less than 20 m according to a log of borehole 102 (Tryggvason, 1950). Borehole 0 encountered impermeable sediments overlying a conglomerate at 23 m (Sigurdsson, 1944). The conglomerate conducts geothermal water, which comes to the surface along N-S or NE-SW fractures that pass through the larger fossil explosion hot spring.

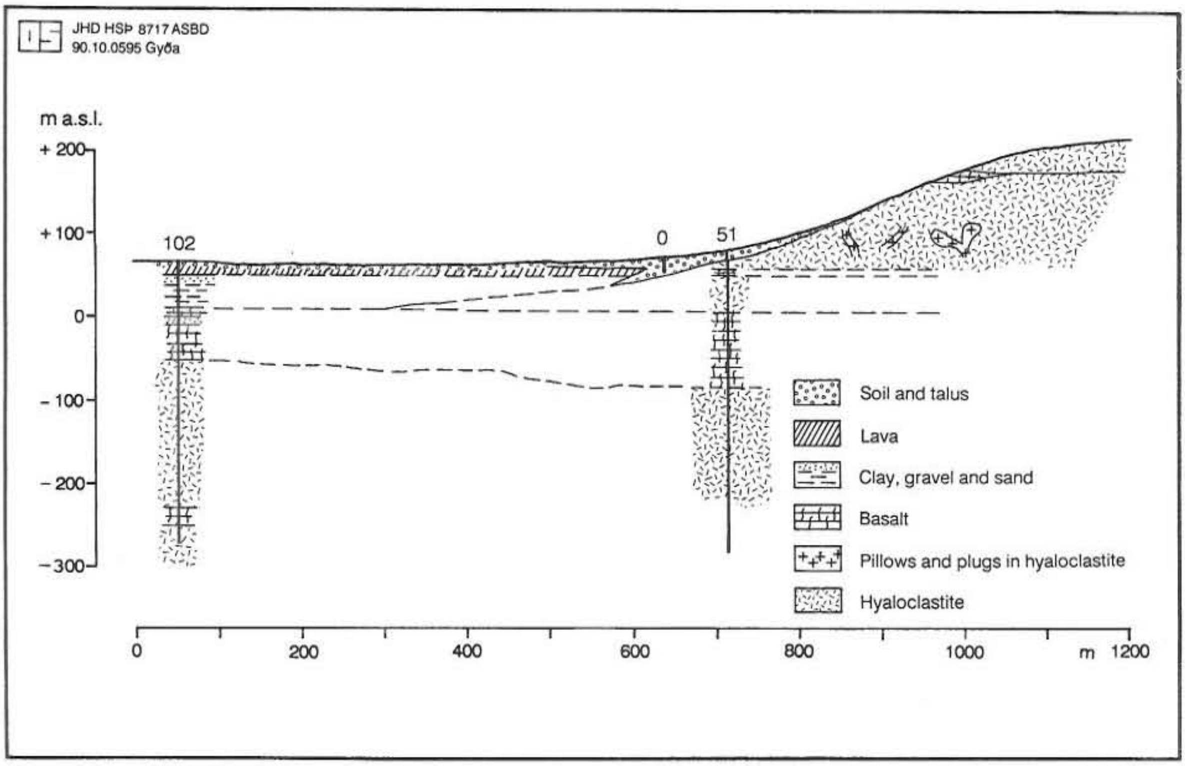

FIGURE 7: A NE-SW geological section based on data from boreholes 51 and 102

The marine clay formation below the lava is impermeable. It is, however, overlain by a permeable horizon of coarse sediments. These sediments interfinger with, and are overlain by talus from the nearby gully and slopes. This, and in particular the postglacial lava, is the formation conducting rainwater run-off and cold regional groundwater.

3.2 Results of the thermal survey

Figure 8 shows the isothermal lines, constructed by interpolation on a gridded paper, of the results of the temperature measurements (Figure 9) at intervals of 2°C. The figure shows that at a depth of 80 cm the temperatures vary from 8-52°C in the area, with four significant but well distributed hot spots, one in the south near the river, the second occurring as the warm ground in the farm, the third located near the farmer's house which stretches NNE towards the two fossil explosion hot springs, and the last one further NNE where the ground begins to rise.

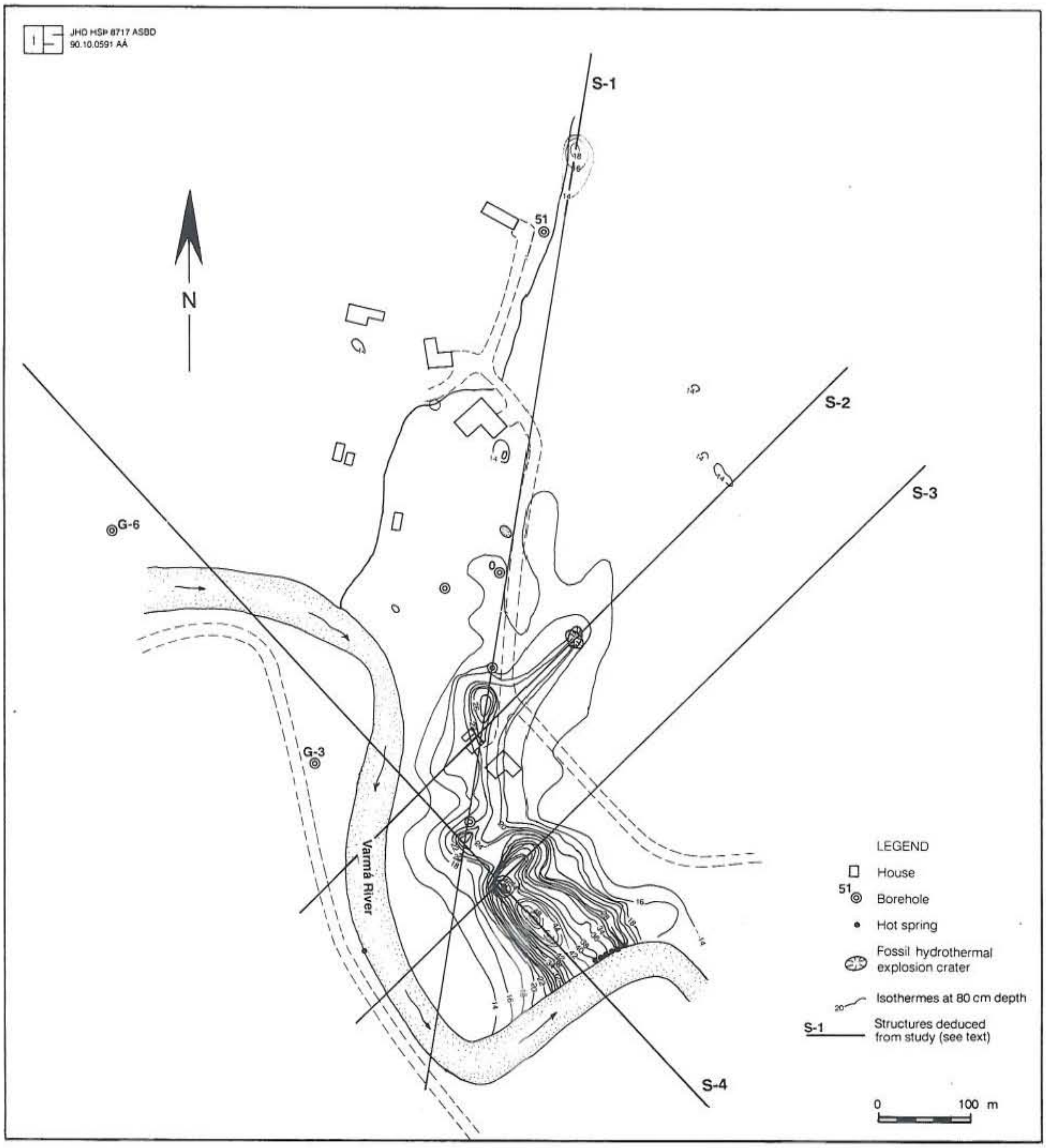

FIGURE 8: Isothermal map of the Reykjakot area, isotherms with an interval of 2°C

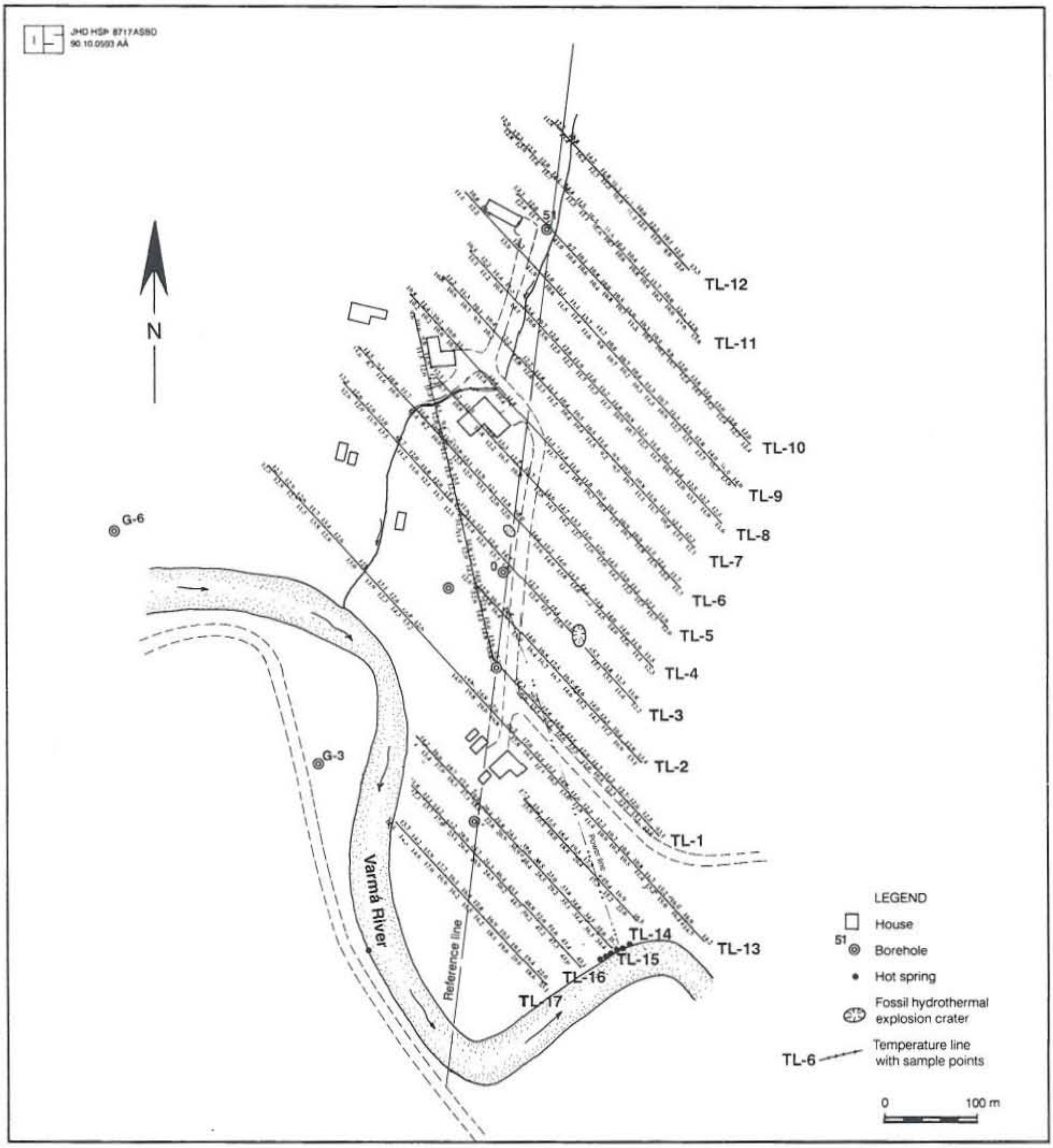

FIGURE 9: The data from the temperature survey

3.3 Results of the ground magnetic survey

Table 1 presents the results of the ground magnetic measurements which have been plotted to give the profiles shown in Figure 10. The results show a consistent lowering of readings to 52,000 gamma (or nT) followed by a consistent drop and rise, before and at the basalt ridge, respectively. Disturbances occur near fences, boreholes, heat exchangers and hot water pipelines on the surface, houses and farm implements. In general, values vary from 49,000 to 57,000 gamma, but if man-made disturbances are disregarded, the values range between 51,000 and 55,000 gamma.

TABLE 1: Results of magnetic measurements taken in the Reykjakot area

Line	Readings in gammas taken from southwest to northeast
1	51710, 51756, 51798, 51858, 51924, 51990, 52079, 52145, 52218, 52289, 52364, 52413, 52453, 52516, 52544, 52501, 52503, 52517, 52548, 52581, 52590, 52602, 52622, 52619, 52645, 52700, 52731, 52730, 52731, 52990, 52720, 52695, 52660, 52663, 52642, 52545, 52484, 52448, 52418, 52416, 52405, 52451, 52474, 52594, 52729, 52797, 52869, 53021, 53390, 53411.
2	52244, 52283, 52365, 52313, 52380, 52434, 52462, 52490, 52506, 52514, 52496, 52484, 52580, 52607, 52607, 52614, 52633, 52636, 52636, 52635, 52638, 52632, 52616, 52603, 52594, 52571, 52570, 52615, 52606, 52737, 52579, 52659, 52692, 52764, 52935, 53024, 53107, 53226, 53380, 53877, 54366, 54295, 53979, 53954, 54202.
3	52451, 52498, 52494, 52615, 52562, 52585, 52591, 52604, 52603, 52617, 52634, 52648, 52656, 52665, 52677, 52687, 52683, 52688, 52692, 52690, 52685, 52665, 52661, 52657, 52642, 52632, 52615, 52589, 52598, 52517, 52544, 52547, 52732, 53,595, 53594, 54438, 54959, 54455, 54074, 54412, 55030, 55052, 54885, 54792, 54702, 54528, 54900.
4	51713, 51929, 52114, 52242, 52324, 52393, 52463, 52493, 52547, 52600, 52626, 52619, 53097, 52661, 52685, 52690, 52699, 52703, 52704, 52709, 52711, 52720, 52712, 52733, 52742, 52731, 52697, 52704, 52712, 52702, 52702, 52697, 52671, 52637, 52608, 52586, 52600, 52528, 52504, 52449, 52479, 52508, 52648, 53036, 53653, 53983, 54405, 54926, 54930, 54652, 54155, 53728, 54280, 54293, 54251, 54163, 54035, 53892, 53785, 53760, 54126, 54751.
5	52158, 52292, 52252, 52640, 52313, 52320, 52377, 52407, 52457, 52493, 52546, 52567, 52561, 52590, 52578, 52596, 52598, 52599, 52609, 52619, 52618, 52618, 52632, 52662, 52650, 52682, 52666, 52641, 52645, 52637, 52637, 52626, 52603, 52568, 52549, 52531, 52457, 52410, 52347, 52350, 52239, 52191, 52087, 51998, 52148, 52482, 52748, 53218, 53178, 53073, 53786, 54216, 54047, 53934, 54032, 53921, 53800, 53603, 53278.
6	52758, 52121, 52576, 52674, 52949, 52533, 52613, 52346, 52245, 52271, 52326, 52388, 52563, 53228, 52536, 52519, 52641, 53119, 52545, 52450, 52521, 52411, 52463, 52494, 52506, 52455, 52442, 52434, 52388, 52368, 52265, 52188, 52090, 51962, 51858, 51723, 51594, 51495, 51397, 51332, 51457, 51605, 51655, 52409, 53466, 53589, 53378, 53504, 53388, 53236, 53001, 53923, 54465, 54651, 54447, 54285, 53749, 53869, 54145.
7	53602, 54232, 54117, 53913, 53936, 54071, 54479, 54623, 54259, 53824, 53561, 53254, 52673, 52393, 52311, 52643, 52292, 51734, 49985, 51994, 51056, 51475, 52144, 52384, 52475, 52516, 52495, 52489, 52459, 52469, 52429, 52419, 52346, 52277, 52208, 52140, 52061, 51958, 51832, 51705, 51574, 51440, 51329, 51250, 51184, 51207, 51594, 52685, 53305, 53214, 53028, 53089, 52886, 52521, 52936, 54055, 54451, 54573, 54306, 54192.
8	53733, 53686, 53570, 53569, 53493, 53479, 53426, 53284, 53286, 53399, 53618, 53663, 53274, 53491, 54969, 51835, 51188, 50563, 50608, 56808, 57182, 52356, 50456, 52186, 62532, 52539, 52562, 52557, 52570, 52503, 52482, 52461, 52451, 52426, 52396, 52350, 52318, 52271, 52211, 52143, 52065, 51993, 51873, 51749, 51615, 51482, 51348, 51218, 51097, 51101, 51277, 51986, 52525, 52804, 52972, 52702, 53066, 53930, 54068.
9	53554, 53683, 53742, 53776, 53750, 53592, 53481, 53332, 53586, 53212, 53211, 53416, 53638, 53780, 53700, 53272, 52747, 52276, 51739, 51042, 50651, 52475, 52577, 52598, 53610, 52748, 53645, 52677, 52633, 52616, 52607, 52576, 52558, 52533, 52510, 52542, 52684, 52467, 52328, 52258, 52196, 52119, 52035, 51954, 51875, 51805, 51726, 51678, 51651, 51706, 51920, 52206, 52594, 53122, 53212, 52906, 52450, 52126, 52713, 53098, 53326, 53398, 53435, 53018.
10	54119, 54228, 54461, 54961, 54345, 53525, 53443, 53502, 53637, 53641, 53613, 53738, 53693, 53239, 53458, 53531, 54055, 53625, 53386, 52938, 52463, 52107, 54579, 52824, 52616, 52708, 52715, 52773, 52914, 52669, 52788, 52806, 52777, 52781, 52741, 52715, 52688, 52656, 52612, 52562, 52485, 52413, 52335, 52258, 52178, 52111, 52029, 51991, 51961, 51950, 51970, 51990, 51989, 51936, 51954, 52347, 53138, 53515, 53198, 52995, 53072, 53036, 52902.
11	53676, 53515, 53604, 53630, 53492, 53618, 53874, 54083, 53979, 53491, 53438, 53864, 53819, 53251, 52702, 52576, 52527, 52485, 52607, 52589, 52514, 52810, 52835, 52893, 52907, 52753, 52759, 53242, 52853, 52931, 53125, 55428, 53347, 52898, 52847, 52811, 52794, 52760, 52727, 52682, 52632, 52561, 52472, 52382, 52358, 52219, 52149, 52082, 52037, 52008, 51986, 51953, 51950, 51957, 51981, 52073, 52250, 52741, 53282, 53516, 53407, 53142, 53057, 53011, 53081, 53375.
12	53597, 53551, 53379, 53287, 53361, 53364, 53375, 53444, 53616, 53915, 53986, 53351, 52951, 52205, 52179, 52308, 52500, 52638, 52698, 52749, 52784, 52806, 52808, 52823, 52839, 52840, 52759, 52722, 52839, 52815, 52781, 52738, 52745, 52668, 52629, 52688, 52648, 52418, 52746, 52719, 52693, 52640, 52579, 52518, 52448, 52391, 52315, 52250, 52178, 52103, 52038, 51987, 51944, 51878, 51815, 51782, 51738, 51754, 51910, 52112, 52370, 52300, 52243, 52223, 52186, 52414.
13	53425, 53376, 53383, 53359, 53455, 53443, 52883, 52456, 52967, 53301, 53720, 53986, 53747, 53462, 53035, 52642, 52611, 52671, 52872, 52793, 52823, 52842, 52832, 52830, 52707, 52707, 52818, 52854, 52846, 52840, 52829, 52821, 52805, 52758, 52829, 52799, 52698, 52701, 52685, 52667, 52642, 52610, 52854, 52525, 52436, 52399, 52343, 52282, 52220, 52160, 52101, 52032, 51944, 51824, 51785, 51743, 51676, 51645, 51627, 51570, 51549, 51667, 52105, 51851, 52181.
14	53440, 53415, 53518, 53557, 53417, 54194, 53473, 53626, 53709, 53845, 54080, 53765, 53525, 53404, 53187, 52857, 52730, 52755, 52828, 52908, 52873, 52978, 53325, 52772, 52802, 52910, 52924, 52905, 52913, 52937, 52948, 52947, 52952, 52978, 53032, 52893, 52822, 52736, 52569, 52437, 52109, 52325, 52552, 52598, 52688, 52542, 52484, 52437, 52427, 52348, 52274, 52220, 52172, 52094, 51971, 51934, 51813, 51811, 51739, 51693, 51656, 51620, 51572, 51550, 51672, 51616, 52009, 52568, 52898, 53076.

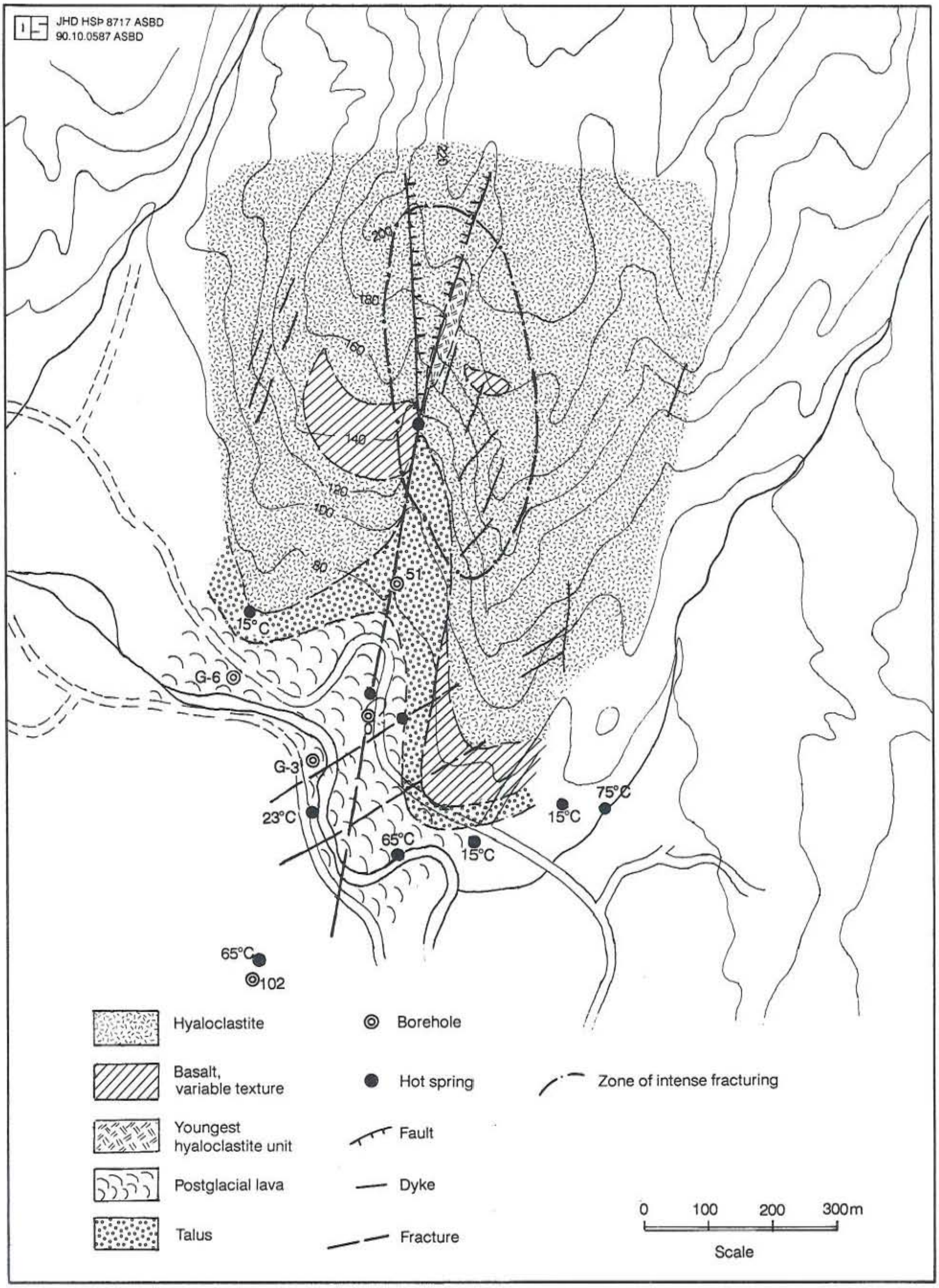

FIGURE 3: The geology of Reykjakot (from unpublished maps by K. Saemundsson and G. Ó. Fridleifsson)

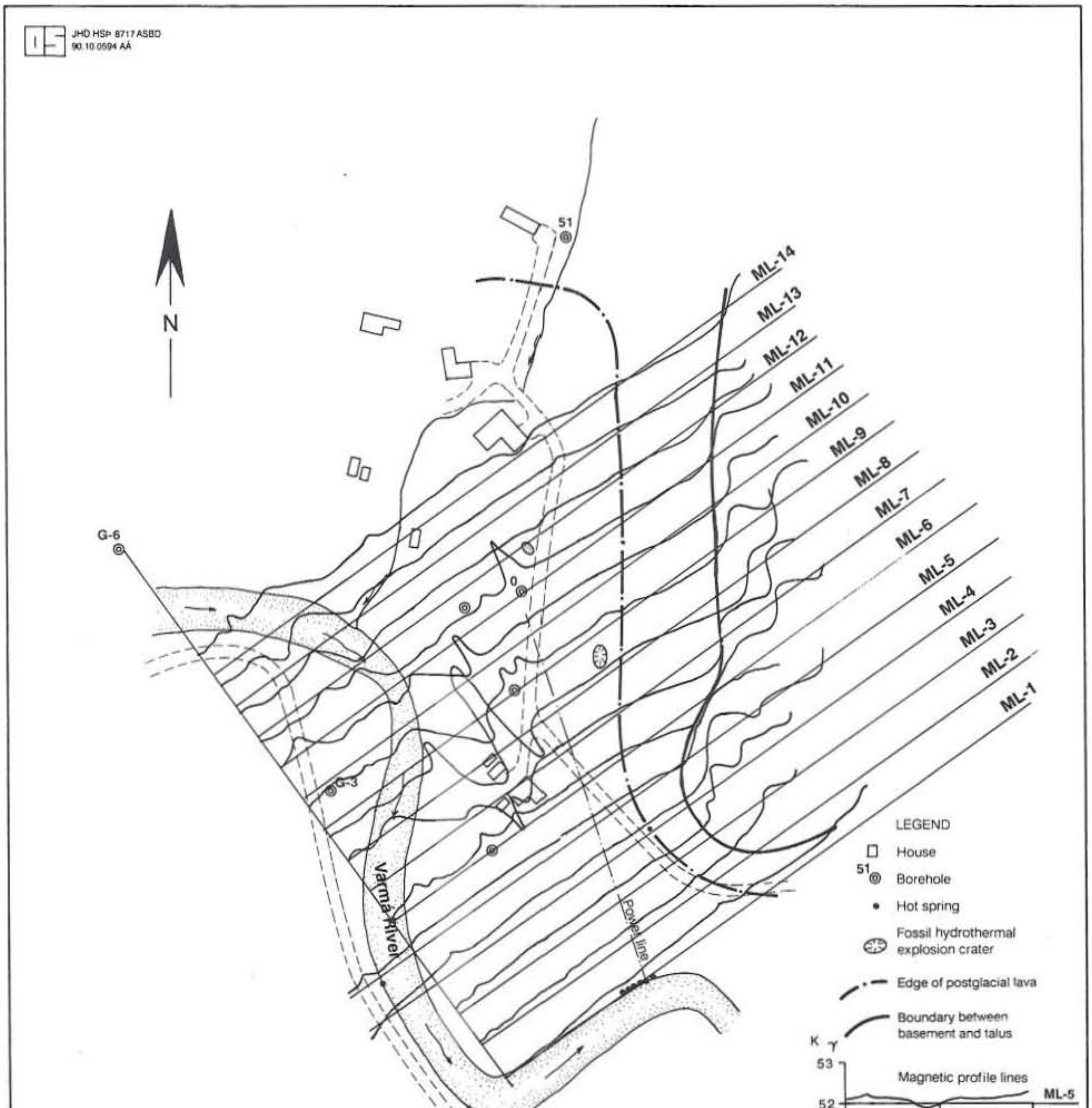

FIGURE 10: The results of the magnetic survey (data in Table 1)

4. DISCUSSION OF RESULTS

4.1 Temperature results

Temperature results show the existence of four structures named S1, S2, S3 and S4 in Figure 8, which seem to control the temperature distribution pattern. These structures, upon further studies, have been identified as: 1) S1 representing NNE-SSW trending faults, one of which is seen in the northern part of the study area; 2) S2 and S3 are probably echelon fractures trending NE-SW, controlling the movement of hot water in the study area, with S2 as the one deep enough to be the possible local source of the NE-SW flowing geothermal waters in the area, and S3 as the shallowest confined to the postglacial lava formation; and 3) S4 represents the permeable horizon above the marine clay controlling the regional groundwater movement in the area.

4.2 Magnetic results

Magnetic results have been interpreted to associate 52,000-53,000 gamma to the postglacial lavas. This has possibly given a location of the edge of the postglacial basaltic lava. It runs close to the big fossil explosion crater, following the contour to avoid borehole 51 (which did not encounter this formation). The gully infilling breccia is randomly oriented and, therefore, less magnetic than both the postglacial lava formation and basalts in the northeast of the measured area. Both of these contacts are shown in Figure 11. The highest magnetic values to the northeast were found on a projecting hill composed of normally magnetized basalts.

4.3 Geological model of the Reykjakot area

A combination of the results of the surface geological and hydrogeological mapping and the borehole geology data of boreholes 51 and 102 was used to draw the NE-SW geological section, taken as shown in Figure 3 and presented in Figure 7. The interpretation of the results of the temperature and magnetic surveys has given rise to the geological model of the area (Figure 11). The fracture zone controls the movement of hot geothermal groundwater flowing from the heat source in the northeast. The geothermal waters come up along deep fractures NNE-SSW or NE-SW creating big explosion hot springs of diameters of up to 10 m in the study area, where the waters manage to break through to the surface. In this area, most of the hot water flows along the contact of the marine clay and lava formations where permeability is highest coming up at the river and farm along S3 and S4. Some of the hot water continues to rise along S2 stretching out in two directions, one towards the farmer's house along the good permeability resulting from the junction of two faults, and the other towards the smaller explosion hot spring along the plane of the NNE-SSW fault.

The model is supported by a temperature profile (Figure 12) constructed from data of boreholes 102 and 51, which also indicates a NE-SW movement of the geothermal water in the area.

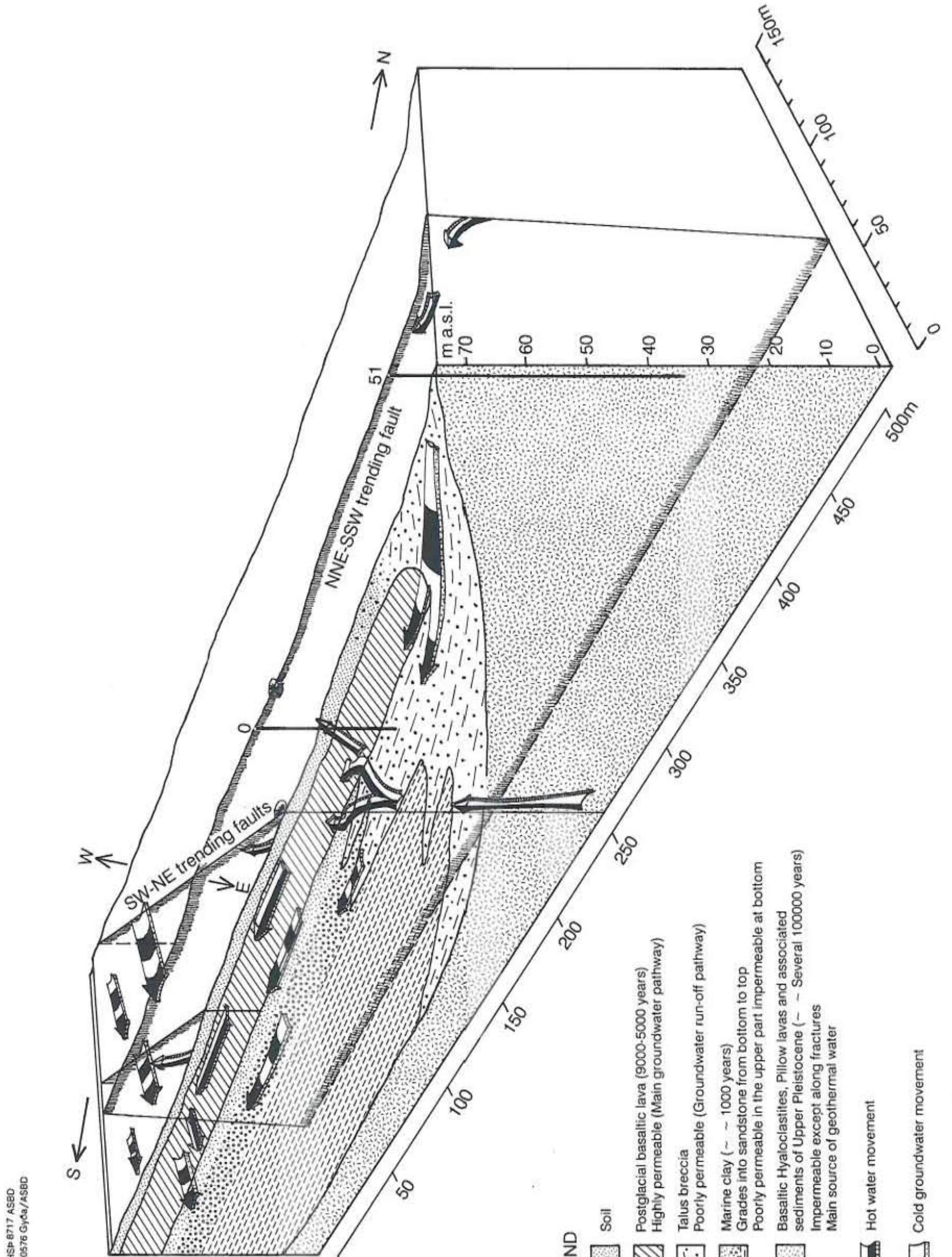

FIGURE 11: The geological model of the Reykjakot area

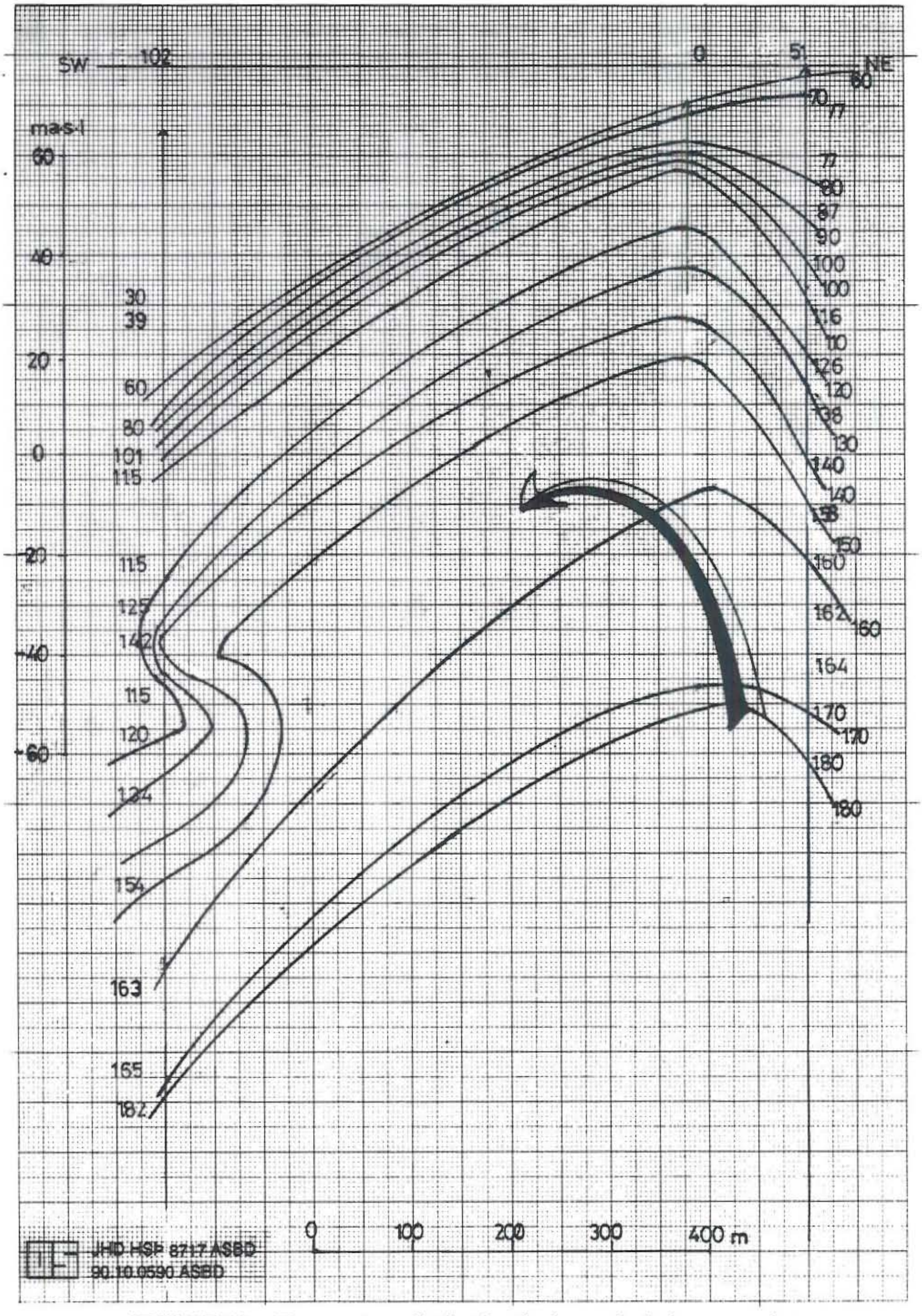

FIGURE 12: Temperature distribution in the geological cross-section

5. CONCLUSIONS AND RECOMMENDATIONS

1. The Reykjakot farm is situated in an area where geothermal activity is near the surface on many fracture zones acting as channels for the main flows of hot water.

2. The temperature distribution shows two sets of fractures (N-S and NE-SW) which are probably faults arranged en echelon, which control the movement of hot geothermal water, together with the regional groundwater movement in the area. The near-surface off-flow is mainly confined to the postglacial lava formation. The heat source is in the north of the area.

3. The movement of the hot geothermal water is either from north to south or from northeast to southwest, coming up along fractures to meet the regional groundwater flow that deviates the hot water flow to the southeast, and restricts it to the postglacial lava formation overlying the marine clay formation (clay grading into a sandstone). The cold rainwater run-off from the hills in the north flows along the gully infilling formation (a poorly permeable formation) to join the regional groundwater flow.

4. None of the boreholes drilled so far took advantage of the junction of these structures where permeability might be the best; borehole 0 located on the N-S thermal anomaly was the only productive one of the shallow boreholes. It suffered a blowout during drilling, but was brought under control.

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