REPORT ON A GEOLOGICAL SURVEY AT LAKE THÓRISVATN IN THE SUMMER 1956

by

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During the week July 6th-13th, 1956, I carried out a geological survey at possible sites of water power plants at Lake Thórisvatn. The surveyed areas were the proposed upper dam site on the Thórisós, where I supervised the drilling which was at that time being done there, and the area around the proposed tunnel lines from Thórisvatn to Kaldakvísl.

I. Upper Dam Site on Thórisós

On the upper dam site on Thórisós, proposed by Mr. Thoroddsen, Consulting Engineer, six boreholes were sunk in order to explore the dam foundation. One of these holes is situated on the hill east of the dam, in the vicinity of the proposed tunnel from the Kaldakvísl reservoir to the Thórisós.

In what follows, these holes will be designated by capital letters A to F in a west-east direction. Their location is shown on fig. 1. They are not lying exactly on a straight line, and it should be noted, that the section on fig. 2 is taken in planes defined by the axes of two adjacent holes. Hole F deviates most from the straight line; the deviations of the other boreholes are unimportant.

Below is a description of each borehole, based upon the drillers' diary and my studies of the cores, both at the site and in Reykjavík. The various strata are designated by number and letters, as in fig. 2. Numbers in brackets are elevations in metres.

A (564.4 - 548.1)

1. Moraine, consisting of sandy clay. No core recovery, but the moraine seemed rather compact, except the uppermost layer a, where the hole had to be lined. The lower part of it could be left standing. At b water poured into the hole.

2. A more compact material. Total core recovery 34%. On the part c, an unbroken core, 0.8 m in length, was recovered. All the cores consist of palagonite, more accurately of fine-grained breccia with small fragments of basalt embedded in a black and brown matrix. The poor core recovery, especially in the upper part, is undoubtedly due to the varying hardness of the rock; the basalt fragments get loose from the surrounding material, are carried around with the drill, and grind the rock. Here, the bedrock is certainly reached.

B (569.3 - 547.3)

1. Lava, very loose and cavernous. Core recovery only 31%.

2. Sandy clay, rather compact, so that the hole could be left standing, but no core recovery.

3. Distinctly more compact material. Some cores were recovered; they consisted sometimes of basalt, sometimes of breccia, similar to that of A2, but coarser. The basalt cores are presumably from boulders in the tuff.

C (673.15 - 544.4)

1. Lava, generally looking very solid. Unbroken cores up to 1.5 m in length were recovered. Total core recovery 80.2%.

2. Loose layer, 1.5-2 m thick (lower boundary indistinct), presumably clay or sand. Three small core-stubs were recovered; all of basalt, presumably boulders in a loose gravel deposit. No clay or other binding material adhered to to these stubs; an indication of a poor consolidation of the gravel deposit.

3. (Upper boundary indistinct). A more compact material. Core recovery 25%. Most of the core stumps are boulders of basalt, which have got free from a more soft embedding material, and ground it down. But this softer material is also contained in some of the cores. It is a rather well consolidated clay and sandstone, mixed with rock fragments of various origin and sizes. The rock as a whole is thus a breccia. Some core

stubs consist solely of the more fine-grained part of the breccia, in other stubs these materials stick solidly to larger basalt boulders. Characteristic for this breccia is a considerable amount of chips of a red rock embedded in it. The same characteristic is found in a layer of breccia underlying a thick layer of basalt in the gorge of Kaldakvísl, some 3-4 km above the mouth of Thórisós, and it may be supposed to be the same layer. There, the layer forms a hard and compact rock in the bottom of the river, but it has disintegrated by weathering where it is exposed above water level. The compactness of the breccia in the lowest part of the borehole and its similarity with the layer at Kaldakvísl areboth a proof thereof, that it is a part of the bedrock itself. The basalt layer overlying it at Kaldakvísl is missing in borehole C, but it might be the same basalt as in borehole F.

D (571.3 - 551.9)

The hole was sunk just well below the lava, which at this point proved to be more loose and cavernous than in borehole C. Total core recovery only 37.5%.

E (571.7.- 550.3)

1. Lava, considerably more jointed than at C and D, great downfall of sand into the hole was experienced while drilling.

2. Basalt cores up to 20 cm long, were recovered, with loose material in between. The basalt cores must be from large boulders (not solid rock), because the cores show different types of basalt. Presumably, this layer is moraine with large boulders, or a scree covering the steep slope of the old (buried) gorge.

3. The layer is similar to the overlying one, but with the difference that in this lower layer a rather well consolidated sandy clay adheres to the ends of some of the core stumps. This indicates, that the moraine as a whole is rather well cemented, although the fine grained materials in it were not

compact enough to form a core themselves. It may well be that this layer is the bedrock itself, although it appears to be somewhat different from the bedrock surface in the above mentioned boreholes. Total core recovery in 2 and 3 9.5%.

F (590 - 563.4)

1. Loose moraine; practically no core recovery; the hole had to be lined.

2. More compact layer, but the boundary between 1 and 2 is indistinct. Cores, both of basalt and breccia, were recovered. (Total core recovery 15%, but of this a part, viz the uppermost core-stumps, may be from layer 1). This is presumably the bedrock itself, in which case the uppermost layer of it is rather poorly consolidated. Another possibility is that this is a rather well consolidated moraine with many large boulders, from which the cores come. The tuff cores are in favour of the former possibility, because tuff boulders in a moraine are very rare in this area; they are hardly ever found on the surface of the moraine.

3. Basalt, very compact, with very few joints. Core recovery almost 100%.

As was clear previous to the boring, three strata of different age and structure are found at the dam site. Below, a more detailed description of each of the three layers, in an inverse order of age, will be given.

I. The lava

The borings showed the thickness of the lava at the dam site to be up to 22.5 m. This is somewhat more than I had estimated. In my report, given last year, I assumed that the gorge containing the old river bed of Thórisós, down which the lava has flown, had been 20 m deep, as a maximum, because the river bed of the Thórisós must have been at somewhat higher elevation at the dam site than at its moutn into the river Kaldakvísl, which latter must have been around 550 m above sea level. The borings showed this difference in elevation to be surprisingly small as the bottom of the lava (i.e. the old river bed) lies at only 550.5 m in borehole C on the dam site.

Between the boreholes, the line in the figure 1 indicating the bottom of the lava is conjectural. As the slope of the old Thórisós was very small, it may be concluded that its gorge had a wide, flat bottom. It seems to me to be very unlikely that the bottom was anywhere else in the section, to any extent lower than in borehole C, viz at an elevation of 550.5 m. The scetch is more likely to be inaccurate near the edges of the lava, where the slopes of the gorge are lying. The westermost part of the lava, between the edge and borehole B is shown quite thin, because local conditions indicate that it is there lying on the bank of the gorge. This part consists of a low and flat lobe of lava stretching out from the edge of a much higher and more uneven lava. North of this flat lobe, an inlet cuts into the lava; ending only 25 m from borehole B. The edge of the gorge must therefore be lying a very short distance west of that borehole. and it is likely then, that it continues to the south at about the same place where the flat lobe emerges from the higher, uneven lava.

In my previous report, I considered it to be somewhat probable that there were two lava flows lying in the old gorge of the Thórisós, the abovementioned lobe being a part of the older flow, which almost everywhere else had been covered by the younger one. The borings did not completely answer this question, but to me they more strongly indicate that the whole lava on the dam site is from a single eruption. As a matter of fact, some boreholes revealed a cavernous part with poor core recovery between parts of a more compact rock, as is to be expected at the boundary of two lava flows. But the cavernous parts found were neither distinctly separated from the more compact ones, nor could they be traced at corresponding depths from one borehole to another.

Thus, they do not seem do divide the lava horizontally as would be the case if two separate lava flows were lying one on top of the other. On the other hand, the structure of the lava seems to change in a horizontal as well as in a vertial direction. It is most compact in the middle (hole C), but more pervious along the edges, where it is at the same time thinner.

II. Loose strata are lying nearest to the surface on both sides of the lava flow, as well as beneath it. They consist mostly of moraine, the main constituent of which is sandy clay, better consolidated at greater depths, with scattered boulders of basalt embedded in it. The size of these boulders varies up to several metres in diameter. On the bottom of the old gorge, beneath the lava, there seems to be a thin (somewhat within 2 m thick in borehole C) layer of alluvial gravel deposit between the lava and the bedrock. This deposit seems to be quite uncemented, but must be well compressed by the weight of the lava.

The clay, which is the main material in the moraine, is impervious, but in such formations there is always the danger of pervious lenses of sand and gravel. The borings do not indicate whether or not such faults are found in this section. The uppermost layer of the moraine is undoubtedly too loose for a dam to be founded upon it so that a cut-off inevitably has to be made to a considerable depth into the moraine. All parts of the moraine, even those at greatest depths, are too poorly consolidated to form the roof of a tunnel.

III. The bedrock In my previous report, I guessed that the bedrock at Thórisós was of basalt, of the same kind as is found in the hills north of it. The borings revealed, that this basalt bedrock does not reach farther south than just to the northern embankment of the proposed dam, to be followed by a tuff bedrock, which presumably reaches to the tuff outcrops in the hills west of the dam site. In the boreholes A, B and C, where the tuff is well compacted and looks solid, it is obviously a part of the bedrock. D does not reach down to it. In E too, a sort of tuff is found, but I do not feel quite certain that it is the bedrock. It might be a rather well consolidated moraine overlying the bedrock. The same applies to the layer overlying the basalt in borehole F. But only if the "tuff" there is, in fact, the bedrock is it consolidated enough to support a tunnel. This must be investigated by further borings before the choice is made between a tunnel and an open trench.

The basalt bedrock, which in the section appears in borehole F only, looks very solid, but is presumably lying somewhat too low for the whole of the tunnel to be driven through it. Its surface is at 577.7 m elevation in the borehole, which is lower than I had expected, as on the hills north of the damsite, basalt outcrops are found at an elevation of over 580 m. The surface of the basalt may well be considerably uneven, although shown to be even in the figure.

As the borehole F does not reach down through the basalt layer, the thickness of the latter is not known. Nor can the edge of the layer be traced with any certainty. My guess, that the edge lies near the hill side, as shown on the figure, is not based upon much evidence, and may be several tens of metres in error.

II. Tunnel Route[1] from Thórisvatn to Kaldakvísl

During this summer, I made a more detailed geological survey of the whole area between Lake Thórisvatn and Kaldakvísl, but did not find anything unexpected. The line designated "rock-boundary" on the geological map accompanying my report of 1954 seems to be correctly drawn, in main, although not accurately, because moraine deposits are covering the bedrock in large parts of the area. South-east of this line, the bedrock consists of the tuff-formation; northwest of it of basalt, the so-called "Hreppar"-formation.

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1) Since the writing of this report, another tunnel route has been suggested by Mr. Thoroddsen, south of the one referred to here.

The tunnel line, as proposed by Mr. Thoroddsen, is lying in the tuff-area; the west-end of the tailrace tunnel reaching to the boundary line between the basalt and tuff formations. At the boundary, the former disappears, but presumably continues eastward, under the tuff. The basalt formation seems to dip in direction south-east so that the depth of it in the tunnel area is too great for any part of the tunnel to lie in it. The tunnel, therefore, will lie entirely in the tuff and the moraine deposits overlying it in wide areas.

On the tunnel line, the bedrock is entirely covered with moraine, outcrops being found in hilltops and steep slopes only. The moraine appears to be by far too poorly consolidated to support a tunnel. Thus, the thickness of the moraine is of great importance for selecting the tunnel route. It is important to lay the route under the hills, avoiding low grounds as fas as possible.

In my report of 1954, I described the general structure of the tuff formation. This description applies to the bedrock in this area, in main. However, some features which are characteristic for this area shall be mentioned.

A small valley cuts itself into the hills in a direction approximately parallel to the proposed tunnel line. It is to be expected that the rock outcropping on the slopes and in gorges in this valley is indicative of the rock in the tunnel. The whole of this outcropping rock is a typical tuff formation, a mere tuff with the basalt intrusions usually accompanying such formations.

In the uppermost part of these slopes, as well as in the few outcrops in the moraine on the tunnel line, very few basalt intrusives are to be seen in the tuff, but they become more apparent in the lower part of the slopes.

The uppermost tuff layer has often a special appearance. It is clayy, scisty and rathersoft, often more grey than brown in colour. The flakes lie approximately parallel to the surface in each place, in the slopes too. This is a sort of consolidated moraine, but it bears a much more resemblance to ordinary tuff as regards hardness and structure than to the moraine previously described. The thickness of this tuff-moraine is about 1-1.5 m where gorges have been cut through it, but on the steepest slopes it is completely abcent. Below this cover is the main material of the mountains; unstratified, tuff or breccia, with small irregular basalt intrusions, although these are not frequent in the upper part of the tuff.

As a rule, the basalt intrusions are small and so irregular in shape that it is almost impossible to trace them below ground level. The rock in these intrusions is usually heavily jointed, forming small columns with various orientation; often radiating from single point. However, a typical pillow-structure is rare in it. At same places, basalt stumps are embedded in a brownish, tuff-like material, forming a kind of breccia and making indistinct the boundary between basalt intrusions and the breccia proper. The joints and pores in this basalt have not to any extent been filled with secondary minerals.

Being a tuff-formation, the bedrock in the tunnel area as a whole is pervious. In the above mentioned valley and at other places in the vicinity, some large springs issue from beneath the slopes, flowing together into a single stream,which, in turn discharges into Kaldakvísl.

The total discharge of these springs has been measured 5.2 m^3/s, corresponding to about 260 l/s pr. km^2 of the drainage area, whereas the average discharge pr. km^2 in this part of the country is of the order of 40 l/s. The excessively high discharge of this stream, therefore, must be due to leakage across the topographic watershed, viz. from Lake Thórisvatn. However, not all leakage from the lake is likely to reappear in this stream, so that the total leakage is greater than indicated by the above figures. It may be expected that the total leakage from Lake Thórisvatn through the tuff threshold to the west and south of it may be comparable to the discharge of the Thórisós at the outlet from the lake (6 m^3/s). In discussing a possible development, it should be borne in mind that raising the water level in the lake increases the leakage, while lowering the water level reduces it.

To the north of the proposed tunnel line, there is a great depression in the bedrock. In this depression, two small lakes are found. One of these, the larger one, does not have any superficial outflow (According to the topographical map, the level of this lake would have to be raised by more than 40 m to get a superficial outflow). This shows, that the bedrock in the basin is very pervious. The same is indicated by numerous other lakes without any superficial outflow all over this tuff area. The other lake, however, which is much smaller, and lies in a rock basin high in the south slopes of the depression, fills its basin and there is a small gully trench from it down the slopes to the larger lake. No water flowed in this gully as I was there, on July 8th to 11th 1956, but it seemed that the gully had just recently dried, and the water level in the lake stood only a few centimetres below the outlet control. The bedrock around this lake, therefore, appears to be considerably impervious, an indication that the permeability of the bedrock in the area may vary appreciably from one location to another.

In the gully from this upper lake, I found an outcrop of basalt. This basalt may form the bottom of the lake and thus account for its relative imperviousity.

Below, an assessment of the geological conditions on the proposed tunnel line is given.

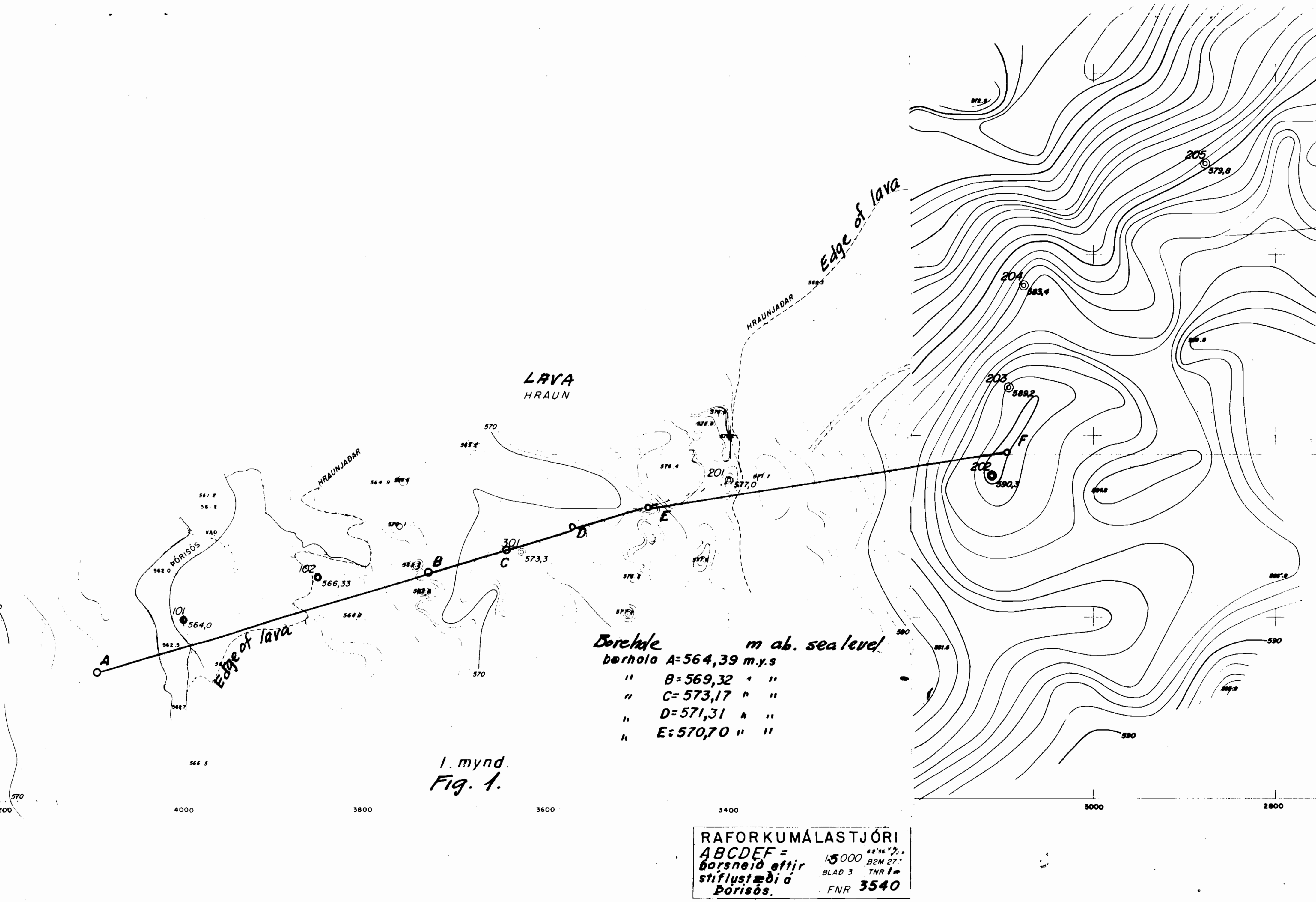
Headrace tunnel The intake will be located in basalt. Most part of the tunnel will lie in tuff and breccia with basalt intrusions. On low grounds, where the tunnel comes nearest to the surface, the tuff-moraine deposits might reach the tunnel, and even the poorly consolidated moraine might do so, too.

Penstocks and power-house Both are safely within the bedrock. The tuff decreases, the basalt increases, with depth. At the powerhouse, both may be in approximately equal quantities.

<u>Tailrace tunnel</u> The eastern part lies in a rock similar to that at the powerhouse. The western part, on the other hand, will lie in a loose layer, presumably moraine, alluvial gravel deposits and soil.

The length of this part is not known.

Furhher information on the subsurface conditions in the area can only be acquired by borings. It is especially important to determine the thickness of the overlying moraine deposits, both on low grounds on the line of the headrace tunnel, and on the flatter gsound around the tailrace tunnel.


LAVA
HRAUN
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Edge of lava
Edge of lava
ÞÓRISÓS
VAÐ
A
B
C
D
E
F
101
564,0
102
566,33
201
577,0
202
590,3
203
589,2
204
583,4
205
579,8
301
573,3
570
590
Borehole m ab. sea level
borhola A=564,39 m.y.s
" B=569,32 " "
" C=573,17 " "
" D=571,31 " "
" E=570,70 " "
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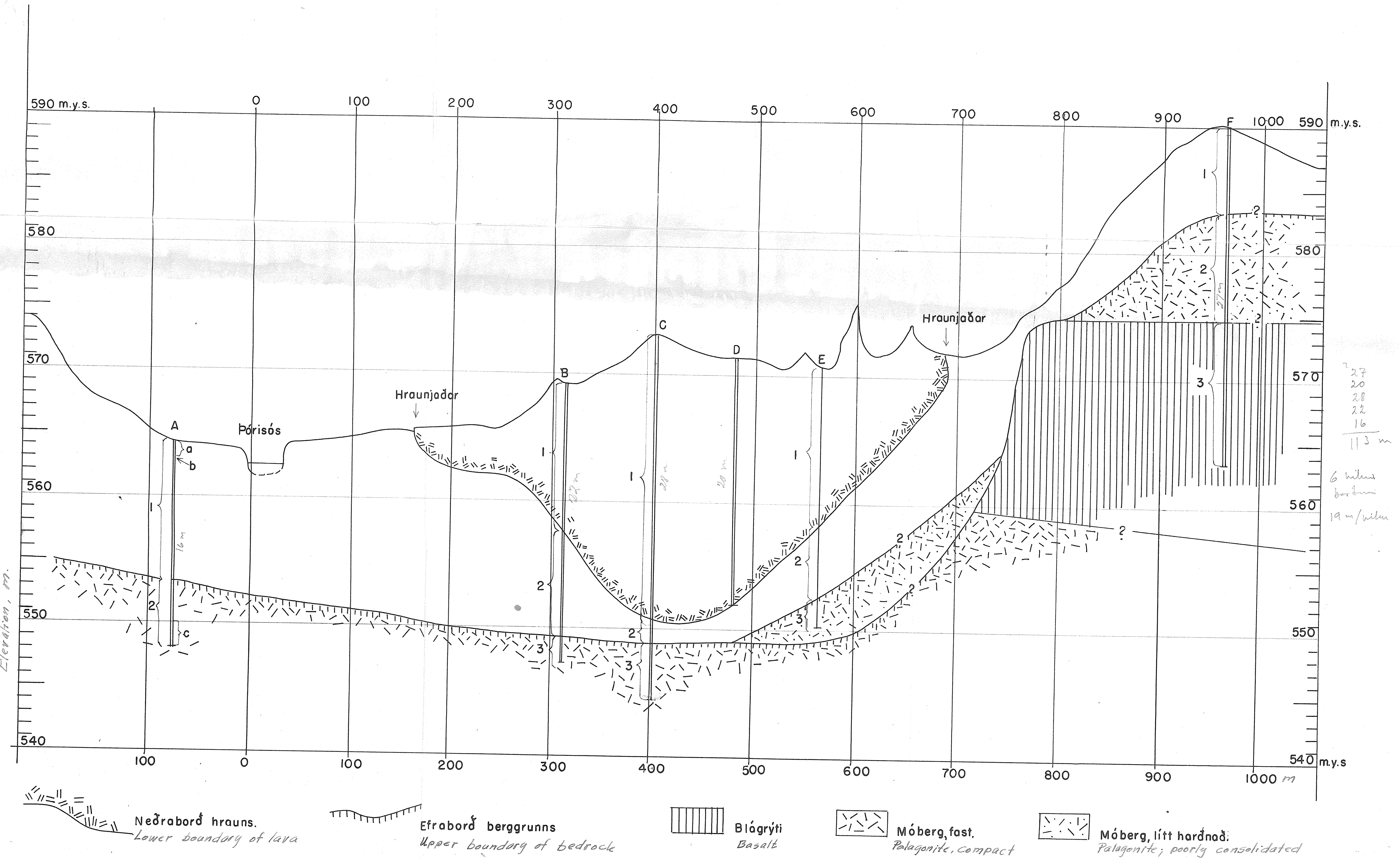
RAFORKUMÁLASTJÓRI
ABCDEF =
Þorsneið eftir
stíflustæði á
Þórisós.
1:5000
BLAÐ 3
FNR 3540

1. mynd.
Fig. 1.



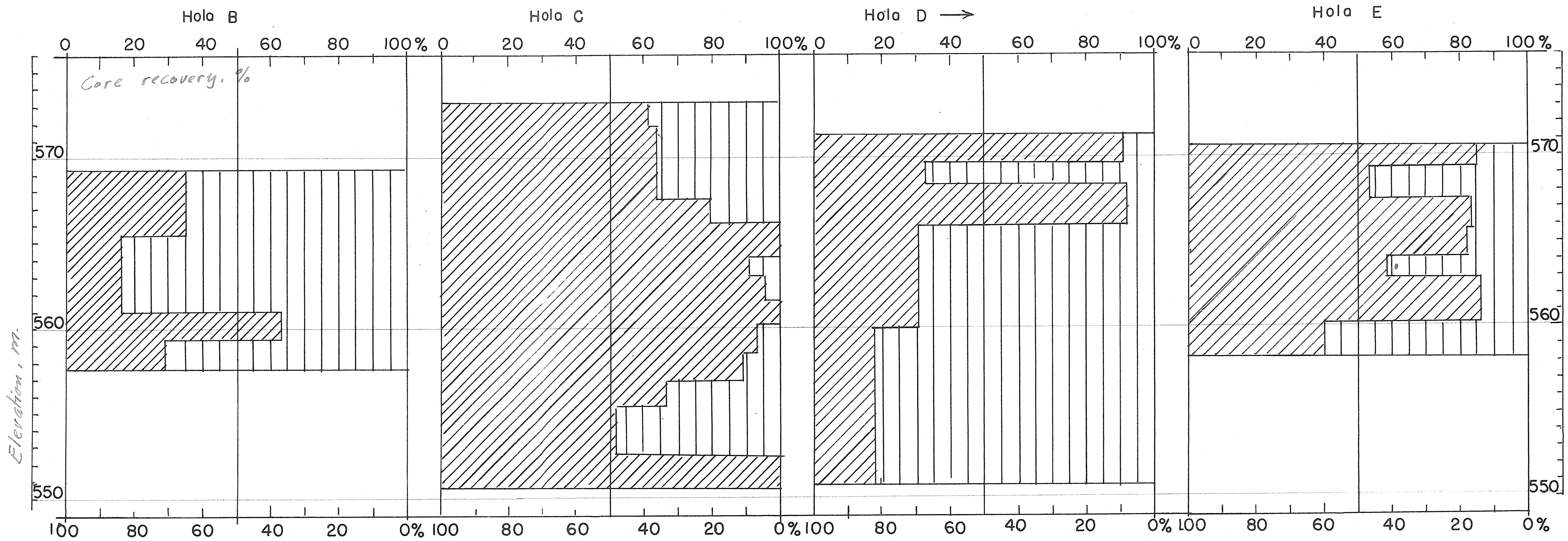
2. mynd
Fig. 2

RAFORKUMÁLASTJÓRI

ÞÓRISÓS,
ABCDEF = borsneið eftir stíflustæði

okt. 56. G.K./p
TNR. 103
B2M-277

FNR. 3539



Rýrnun borkjarna í hrauni við Þórisós. Kjarni með skástrikum, rýrnun með lóðréttum strikum.

//// Core recovery

3. mynd

Fig. 3

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ÞÓRISÓS Rýrnun borkjarna í hrauni.	okt.'56.GK/Þ TNR. 102 B2M-277
	FNR. 3538