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Seepage at Þórisós and Kaldakvísl dams

By
Haukur Tómasson and
Hrefna Kristmannsdóttir

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This report is intended to describe the conditions at Þórisós and Kaldakvísl dams before, during and after their construction. In figure 1 is a map showing roughly the geological circumstances at the two damsites

Two móberg formations, both permeable constitute the oldest rock unit. In a depression between the móberg formations is a pile of andesitic lava flows, on the whole rather impermeable in vertical direction, but can be a good aquifer along contacts. Both those units are covered with moraine and tillite, both generally poor aquifers. At a few places gravel deposits are found on top of the moraine by nature a fairly good aquifer. Yet the main ground water aquifer is the postglacial lava flow at Þórisós wherefrom numberous large springs were issuing both upstream and downstream of the dam prior to its construction and at the lava front at Kaldakvísl. The main concern of the foundation treatment at Þórisós dam was the cut off through this lava flow, which was done by a slurry trench.

Small springs also issued from the other units some of which can be seen on the topographical map. The foundation treament in these units was limited to some grouting at Kaldakvísl dam, but otherwise relied on the impervious blanket of the moraine cover.

During construction, the influence of the foundation treatment was first observed when the slurry trench was approching completion as then groundwater in the lava flow lowered substantially and many of the springs disappeared or decreased.

On August 11th the Þórisós dam was closed and the lake level began to rise behind that dam. On August 15th Kaldakvísl dam was closed and a lake started to form upstream of that dam. Immediately, the trend in ground-water and springs was reversed and gradually old springs were reactivated and new ones formed. On Exhibit 2 are shown spring areas. Most of these areas had springs, prior to diversion but the level of the springs is much higher now and the discharge also much greater. Yet the spring horizon at Kaldakvísl is still much smaller than before.

Nothing is more logical than sumpening of ground down-stream of a dam, but the water in these springs was not clear possibly indicating piping. XXXXX Piping could have especially serious consequences at the Þórisós dam where the cut off slurry trench is in some parts of the foundation not going through the gravelly deposits on top of the moraine. Just downstream of these are the largest springs.

In order to investigate this a sampling program has been undertaken and samples have been collected in Sauða-fellsvatn and Þórisvatn at the dams and in several of the springs. The sampling places are shown on Exh. 2, and each is marked with the number of the first sample taken there. Up to 3 samples has now been taken at many of the places. The purpose of the sampling was to measure the amount of solids by using photoadsorbsions. Keys for photo adsorption versus sediment load has been worked out for some localities at Búrfell power plant and one of that keys are used in this connection.

The absolute figure does in fact not matter very much, but rather the change from one time to another. The stated sediment load is not far from being correct.

Table 1.

Silt content according to adsopption measured with Fisher Photometer. Figures indicate mg/l.

place	Date	14/9 mg/l		29/9	12/10
S-1		59		57-50	41
P-1		63	(61)	52	32
P-2		66		46	33
PL-1		13	(18)	10	6
PL-2		8		9	10
PL-3		10		7	4
K-2		8		-	10
K-16		-		-	11
K-3		60		50	33
K-4		27		20	-
K-5		13		-	7
K-6		11		26	-
K-12				1	1
T-1					7
R-1					0
K-1		3		1	3

The samples are not always taken by the same person so there may be some inconsistency in sampling places from one date to another. In parenthesis for 14th of September, is the sediment content as measured in conventional manner.

These figures show that the sediment load in the springs at Þórisós is much lesser than in the lake. It does not indicate piping although complete filtration does not take place. The change with time is not great enough to support any statement on tightening effect of the sediments nor does it support a reversed statement. We have to wait and see what happens in the future.

The concentration difference in sediment load in the springs at Þórisós can also be due to mixture of clear groundwater in the lava with water from Kaldakvísl. The Kaldakvísl water has higher density than the ground water, at least at similar temperature, but this may be reversed when the Kaldakvísl water goes down to zero temperature and very low sediment concentration, while the groundwater may have temperature near 4°C. This makes interpretation more difficult and the need to wait and see and to go on with the investigation still more urgent.

At Kaldakvísl dam the sediment content in the springs is depending on the length of the leakage path. The leakage is along contacts in the andesite and through fractures in it. Danger of piping, which could threaten the stability of the dam, is not foreseen. The shortest leakage path is in the diversion canal and the concentration of sediments there is the same as in the lake above. All other springs have much lower concentration than in the lake and filtering is therefore very likely taking place, yet there is not clear indication of tightening. Piping in fractures in the diversion canal wall can not be found by measuring sedimentconcentration as it has the same as the lake, but has to be found through discharge measurements.

For further investigation at the Þórisós dam samples were taken for petrographical analysis of mainly the clay fractions. These samples were water sample at Þ-1 Þórisvatn, water sample from ÞL-1 the largest spring, moraine sample from Þórisós dam and tillite sample from Þórisós damsite. The petrographical analysis were performed by Hrefna Kristmannsdóttir geologist.

The result of the X-Ray diffraction analysis is as follows, descriptions by Hrefna Kristmannsdóttir:

Sample Þ-1 from Þórisvatn.

70-80% of the total content of solid in the sample was of the clay fraction. X-ray diffraction examination of that fraction showed, that the crystalline matter in the sample was mostly clay-minerals, but it also contained traces of feldspar and an undentified mineral (could be zeolite). The clay mineral is a mixed-layer mineral of chlorite and monmorillonite with dominating chloritic structure layers (chlorite 7-8.5 : mont. 1,5-3).

Sample ÞL-1, seepage from Þórisós dam.
In this sample the clay fraction was about 40%. By x-ray diffraction analysis only chlorite was found in small quantities.

Sample Þ-101, moraine from Þórisós.
Three grain size fractions were analysed, 1) 53-2 μ
2) 2 μ - 0.2 μ 3) < 0.2 μ.
In the smallest grain fraction size the only crystalline material is a clay mineral, which could not be identified for sure, but is probably of the monmorillonite group. In

The main clay fraction 2) are clay minerals, both montmorillonite and chlorite. In this fraction plagioclase and calcite were also identified.

Sample Þ-102 is tillite from Þórisós.
Clay minerals in material scratched from jointing faces were identified as a member of the montmorillonite group. The rest of the sample was crushed in rather coarse chips and then mechanically vibrated in a glass bottle containing destillated water. The grain sizes < 53 μ were then separated in the same manner as sample Þ-101 and each grain size group analysed separately.

In the clayfraction < 0.2 μ there were no clay minerals identified. In the grain sizes 2 μ - 0.2 μ are poorly cryst- alline clay minerals. They could not be identified for sure, but seem to be of the montmorillonite group. In this grain size is also plagioclase, calcite and traces of a zeolite mineral (probably chabazite), but lines are too few and weak for definite identification). In the coarsest fraction size is the same clay mineral as described above, but (the clay is) not as abundant. Plagioclase is here the main mineral and calcite is also found.

Summing up the findings of the mineralogical analysis, it indicates that substantial filtering takes place when the leakage water penetrates the foundation of the dam. The montmorillonite is filtered out and even some of the chlorite.

The clay minerals in the moraine and tillite show poorly formed structures although they could be classified to the same groups as in the leakage water. Other minerals in the clay fractions are much more feldspar and even alteration minerals such as calcite and zeolites, which are not in the leakage water. Therefore, we cannot from these data find any indication of piping although the contrary is not absolutely proved.

Under the present circumstances the only thing to do is to wait and see and go on with the investigation program during at least the next year.

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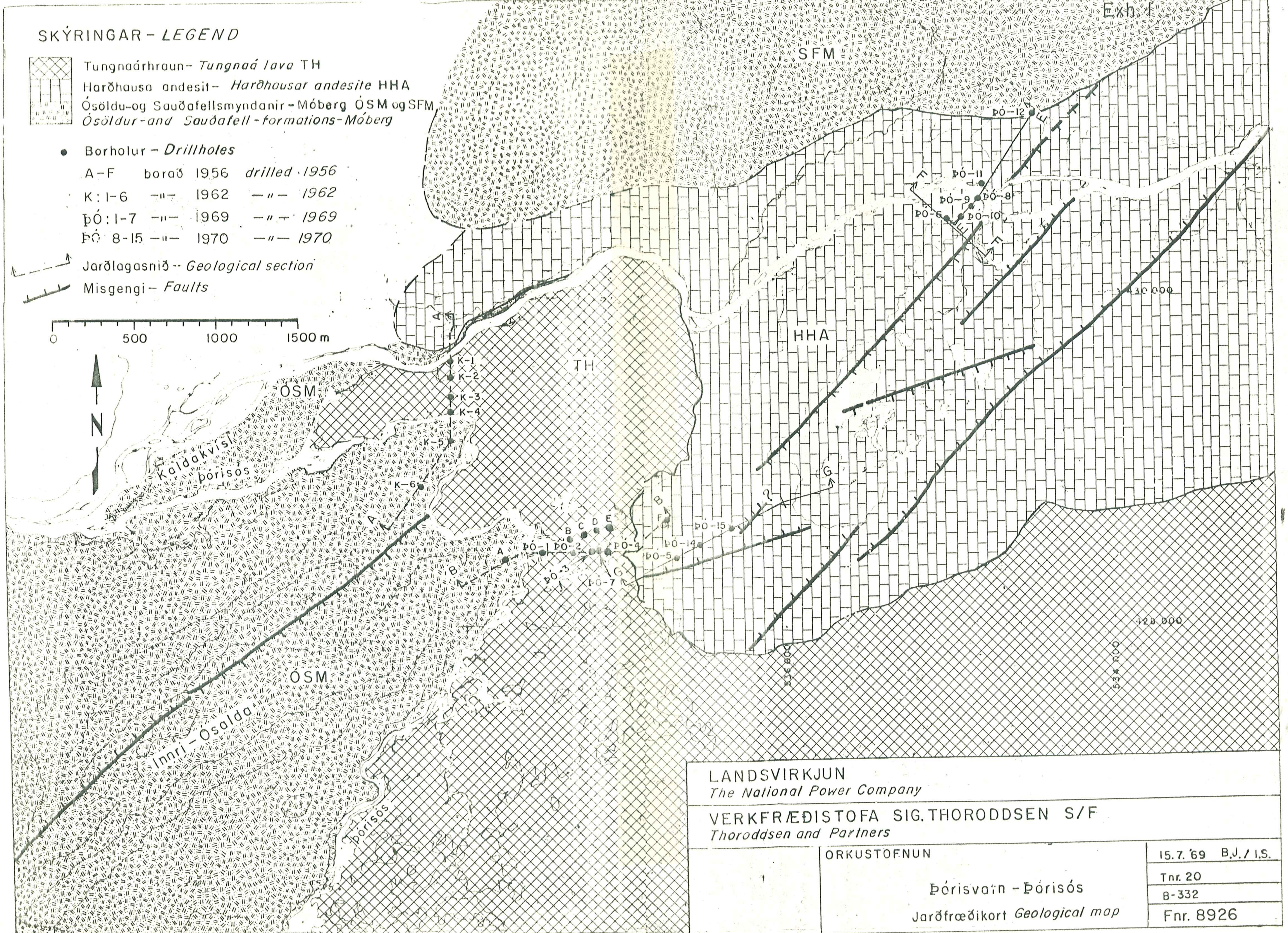
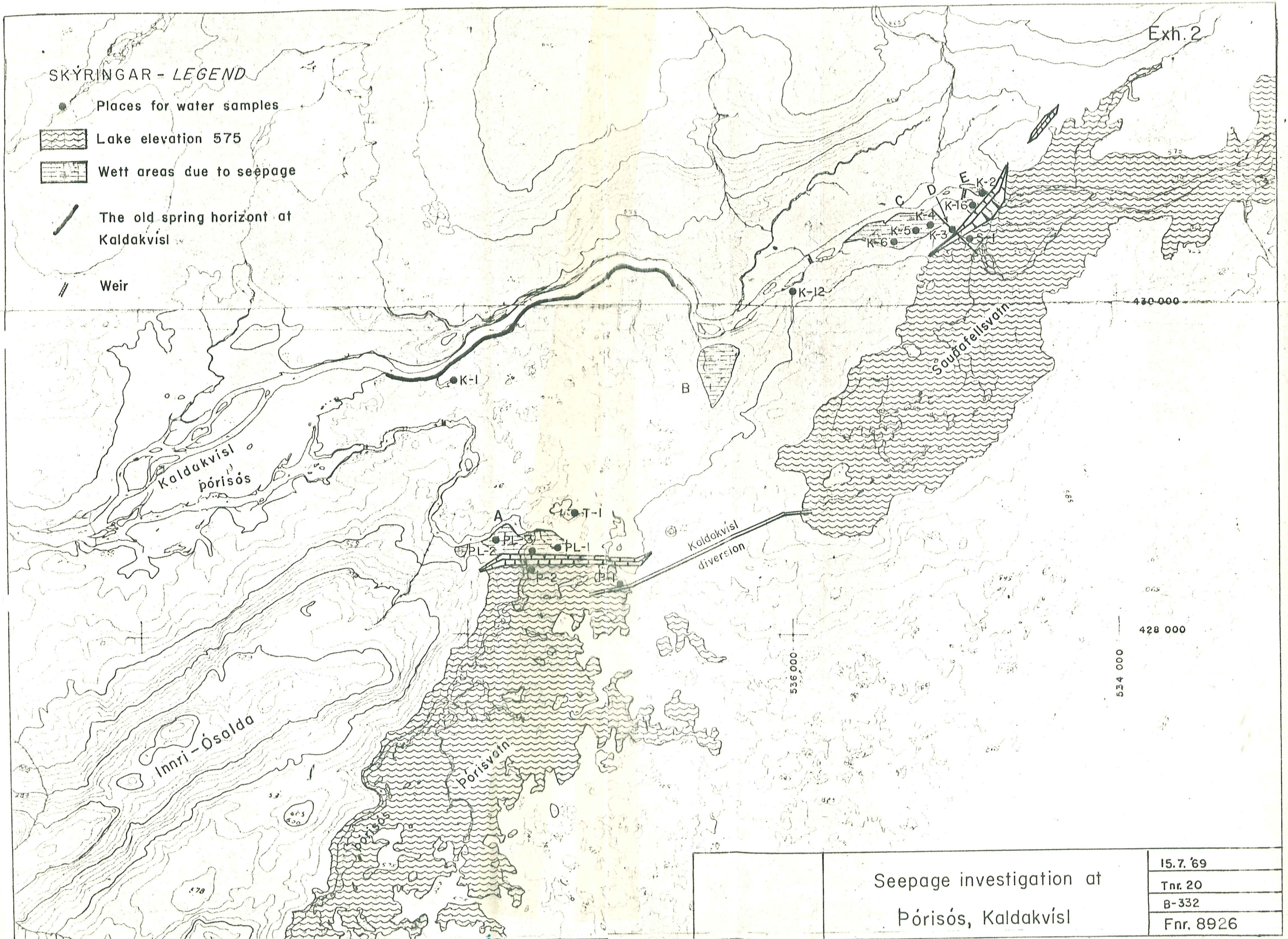
Haukur Tómasson


Exh. I
SKÝRINGAR - LEGEND
Tungnaárhraun - Tungnaá lava TH
Harðhausa andesit - Harðhausar andesite HHA
Ósöldu-og Sauðafellsmyndanir - Móberg ÓSM og SFM
Ósöldur-and Sauðafell-formations - Móberg
Borholur - Drillholes
A-F borað 1956 drilled 1956
K: 1-6 -"- 1962 -"- 1962
ÞÓ: 1-7 -"- 1969 -"- 1969
ÞÓ 8-15 -"- 1970 -"- 1970
Jarðlagasnið - Geological section
Misgengi - Faults
0 500 1000 1500 m
N
SFM
HHA
TH
ÓSM
Kaldakvísl
Þórisós
Innri-Ósalda
Þórisós
K-1
K-2
K-3
K-4
K-5
K-6
A
B
C
D
E
F
G
ÞÓ-1
ÞÓ-2
ÞÓ-3
ÞÓ-4
ÞÓ-5
ÞÓ-6
ÞÓ-7
ÞÓ-8
ÞÓ-9
ÞÓ-10
ÞÓ-11
ÞÓ-12
ÞÓ-14
ÞÓ-15
430.000
428.000
534.000
LANDSVIRKJUN
The National Power Company
VERKFRÆÐISTOFA SIG. THORODDSEN S/F
Thoroddsen and Partners
ORKUSTOFNUN
15.7.'69 B.J./I.S.
Tnr. 20
B-332
Þórisvatn - Þórisós
Jarðfræðikort Geological map
Fnr. 8926


Exh. 2
SKÝRINGAR - LEGEND
Places for water samples
Lake elevation 575
Wett areas due to seepage
The old spring horizont at Kaldakvísl
Weir
K-1
K-2
K-3
K-4
K-5
K-6
K-12
K-16
S-1
T-1
PL-1
PL-2
PL-3
P-1
P-2
A
B
C
D
E
Kaldakvísl
Þórisós
Sauðafellsvatn
Kaldakvísl diversion
Innri-Ósalda
Þórisvatn
Þórisós
430 000
428 000
536 000
534 000
Seepage investigation at
Þórisós, Kaldakvísl
15.7.'69
Tnr. 20
B-332
Fnr. 8926