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Vatnsorkudeild

SIGALDA
Fissures in the head race canal

Haukur Tómasson, Birgir Jónsson

Client: Landsvirkjun (National Power Co.)

HT, BJ-87/02 July 1987

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Reykjavík 20/7 1987

Mr. Helgi Bjarnason
c/o Landsvirkjun
Háaleitisbraut 68

Re: Fissures in the head race canal of the Sigalda Hydro Plant.

At the request of Mr. Helgi Bjarnason from the Dept. of Engineering at Landsvirkjun, the undersigned two employees of the Division of Hydro Power of Orkustofnun, went to The Sigalda Hydro Plant on June 19th to inspect fractures that appeared when the head race canal was emptied last week.

Two almost parallel fractures running ca. ENE can be seen in the canal. They are just downstream of the cut and cover gallery and the distance between them is ca. 30-35m at right angles. On this location the "bedrock" is a very loose volcanic breccia and a clear fracture was not seen when geological mapping of the canal walls was done during construction. However, some irregularities that might indicate the presence of faults or weakness zones were seen there. This ENE tectonic direction appears quite clearly in the Sigalda area landscape and the fracture zone that has now opened up in the canal, seems to control the course of the Tungnaá river just upstream of the Sigalda waterfall (see accompanying map). The distance from the head race canal to the Tungnaá river along the fracture zone is ca. 600 m. Piezometer PZ-10 is very close to the fracture zone and could give indications of when the present fractures opened up.

Ot the two fractures the one further SE can be seen in the canal bottom, the right wall and on the rigth berm. The fracture is located in the shotcrete, near its edge. It has opened up by about 3-4 cm and water from the cut and cover gallery flows into it. The fracture can not be seen in the left wall or the right one above the berm, because of the presence of rip rap. The fracture further NW is easily visible on the bottom (ca. 8-10 cm opening), and on the right berm, but the rip rap covers it elsewhere. Still, there is a slight depression in the rip rap in the left wall, indicating the presence of the fracture.

The fractures look incredibly young and there were sharp edges in the silt/clay layer that now covers the canal bottom on the right berm. Everything suggests that the opening of the fractures are very recent. These fractures seem similar phenomenon to the ones that opened up during the operation of the experimental Langalda reservoir further downstream. This happens when the ground water level is at some depth below the reservoir bottom, a fracture with rather impermeable walls is under the reservoir and the horizontal stress in the crust/bedrock is extremely low. If the fracture connects with the water in the reservoir the water level in the fracture will be much higher than in the surrounding rock. If that difference in water pressure exceeds the horizontal stress in the rock the fracture will open up.

It is not certain what has caused the opening of these present fractures in the Sigalda canal. One possible cause could be an earthquake, 5.5 on Richter scale, that took place on May 25th at Vatnafjöll, just east of Hekla. The distance from Sigalda is ca. 40 km. Another thing that has caused great changes in the crustal stress at Sigalda is the emptying of the Sigalda reservoir during the last few weeks, when a load of over 100 million tons has been lifted off this almost stressless and fissured crust in the area. However, the experience from Langalda shows that fractures in the reservoir tended to open up during impounding and close during lowering of the water level, so the emptying of the Sigalda reservoir should, according to that, not have opened up the fractures. On the other the model is probably more complex than just these two fractures, and the closing of some fractures in the area might have caused the opening of others.

One plausible course of events might have been something like this: The Vatnafjöll earthquake caused the fractures to link up with the water in the reservoir; the increased head of water causes the opening of the fractures very soon afterwards, and then the emptying of the reservoir results in closing the fractures to some extent.

In order to prevent leakage through these fractures we suggest that they should be filled with sand, flushed with water jet down into the fractures. In the last stage of filling it would be beneficial to add bentonite to the sand, for lubrication and expansion after the sand is in place. When impounding of the reservoir and canal starts, one can expect the fractures to open up again, as happened at Langalda, and then the expansion of the bentonite will be of great use. No doubt it will be hard to get the sand into the fractures in the canal walls, so some cement/bentonite grouting might be neccessary there. Where rip rap covers the

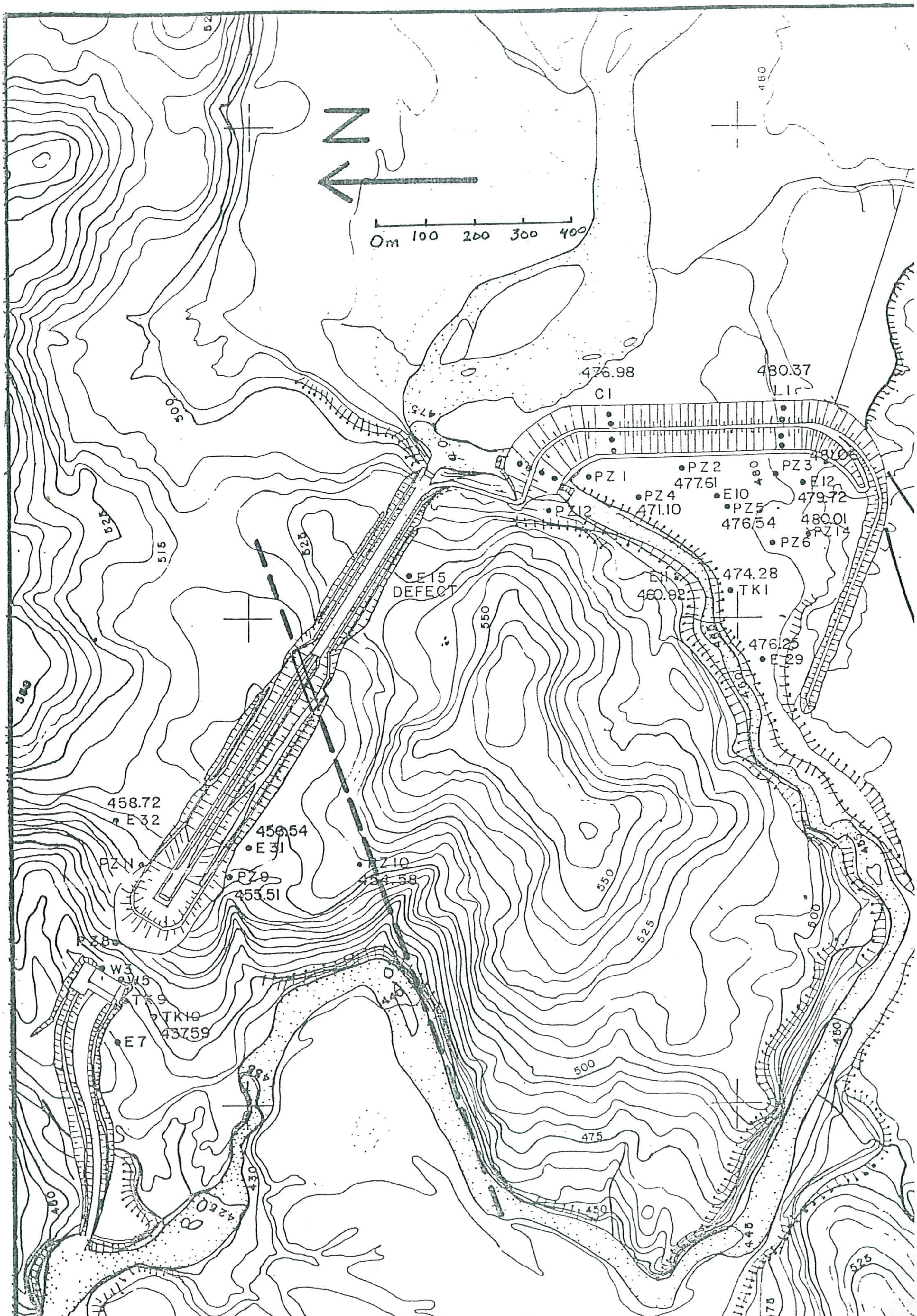
fracture it must be removed to make the fractures more easily accessible. More than adequate volume of sand is in the delta of the Vatnsfell canal at a distance of ca. 1.5-2 km. It might be economical to pump the sand this distance as possibly a few thousand cubic meters might be needed to fill the fractures.

We looked quickly over the rest of the canal but could nowhere see any indication on the shotcrete or concrete lining the fracture opening had taken place apart from the above mentioned two fractures. However, where rip rap covers the canal walls it is not easy to see if there are fractures or swallow holes underneath.

Yours respectfully

Haukur Tómasson

Birgir Jónsson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PZ1
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PZ4
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E10
PZ5
476.54
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E11
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E29
E15
DEFECT
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E32
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E31
PZN
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PZ10
454.58
PZ8
W3
W5
TK9
TK10
437.59
E7
550
525
515
505
500
475
450
445
440
430
425

SIGALDA

Tailrace Canal

Power House

Headrace Canal

Dam

Spillway

Reservoir limit

Tungnaá River

Útkvísl

Blautakvísl

Hnubbafossar

THf

THh

THj

THi

Exh.

LEGEND

- Tungnaá lava flows THf - THj
- Lava fronts: a) younger, b) older, c) uncertain lava margin
- Bedrock from last glaciation at or near surface
- Recent sedimentary deposits
- Tectonic lineations: a) faults, b) fractures, c) indistinct fracturing
- Sedimentary deposits on lava flows on reservoir bottom
- Location of schematic sections, see Exh. 9 and 10

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SIGALDA AREA
GEOLOGICAL MAP

'77-10-28. E.G.V./ Bj.J./Ó.D	T. 607 B-332	F. 16472