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Prospecting for fresh water, seawater and geothermal water near Skógalón in Öxarfjörður; Statusreport

Lúðvík S. Georgsson, Magnús Ólafsson, Oddur Sigurðsson

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PROSPECTING FOR FRESH WATER, SEAWATER AND GEOTHERMAL WATER NEAR SKOGALON IN ÖXARFJÖRDUR; STATUSREPORT.

1. Introduction

The Öxarfjördur coastland is flat and dominated by the delta of the Jökulsá glacial river. The Krafla fissure swarm extends into the eastern part of the Öxarfjördur depression, within which is located a high temperature geothermal area. Abundance of cold fresh water and geothermal fields are found on the lowlands near the shore, hence the Öxarfjördur region combines the conditions which are suitable for both fish-hatching and fish-farming. The Skogalon geothermal field is located east of the Skogalon lake, little more than a kilometre away from the sea. Several of the hot springs are boiling and the natural discharge has been estimated to be in excess of 10 l/s.

Prospecting for water in the vicinity of Skogalon started about a year ago. Several shallow wells have been sunk into the sandcoast between the ocean and Skogalon to evaluate the possibilities of extracting seawater and fresh water from the layers of sand and gravel. The depth of the holes ranges between 10 and 40 m. A rather specifique drilling technique has been adopted for this area, i.e. the use of high pressure waterpumps to sink steel casing into the loose sediments. Pumping from the the first wells gave a mixture of fresh water and seawater at a temperature varying between 5 and 20°C, which could possibly be used directly for fish-farming. Last summers work was aimed at investigating the available quantity and suitability of this mixture. Preliminary results proved negative. The main obstacle appears to be the mixture`s high iron content. But it can also be added that a large fish-farm cannot rely on a water resource comprising an unstable mixture of seawater and fresh water.

2. Status by the end of September 1986

A total of 12 wells have been sunk at Skogalon, though some of the pipes have since been reused elsewhere. A brief review of the drilling results is appropriate at this stage.

The drilling technique used, i.e to sink steel casing down into the loose sand and gravel layers with the help of high pressure water pumps, is promising and probably the best technique available for drilling shallow wells in these sedimentary layers. The deepest wells have been sunk in two or three steps, each step comprising 10-15 m. By changing to an inner casing of a smaller diameter, it has been possible to reach down to depths of more than 40 m. With the existing equipment wells can probably be sunk down to 50-60 m without mayor problems. Problems have, however, arisen when the casing has been slotted, especially below 20-30 m depth. There are several possible solutions to this, but they need to be tested to find the most suitable one.

Seawater production. The shallow wells have confirmed that a considerable quantity of water-mixture with salinity 0.6-0.9% can be produced just north of Skogalon. The temperature of this fluid is dependent on its interconnection with the Skogalon thermal field and ranges between 5 and 20°C. The warmest wells are straight north of the thermal field. This water-mixture has a higher iron contant than is suitable for fish-farming. Drilling of a pure seawater well close to the coast failed. Thus it still remains to be proved that pure seawater can be produced from wells close to the coast.

Fresh water is usually not necessary for fish-farming, though access to it is always convenient. If, however, the intention is to farm the fish in waters with a salinity of 0.8-1.0% by mixing cold fresh water and sea-water, then the fresh water is the most important resource for the fish-farm, as it would need two litres of fresh water to each one of seawater. So far there`s no definite proof of the existence of good fresh water close to Skogalon, but a few hour pumping test in well 3, close to Skogalon, gave promising results.

Geothermal potential. The Skogalon thermal field has not been investigated so far. Its natural discharge is thought to be at least 10 l/s of boiling water. We have estimated that by pumping shallow wells the yield might possibly be increased to 30-50 l/s. If the requirements exceed this yield the thermal water will have to be pumped from much deeper production wells, from which production can probably be increased considerably. However, these are speculations, based on vague premises untill some shallow exploration wells have been sunk.

3. A schedule for investigation

The results of prospecting at Skogalon are so far rather inconclusive and have barely touched the important issues. The site appears to be favourable for a large fish-farm but thorough investigations are needed before a feasibility study can be made. The optimum size of the fish farm and hence need of the water resources must constitute the basis for the investigation. The schedule presented here is based on the following premises. The water to the fish-farm is to come from three different sources, i.e. seawater, cold fresh water and thermal water. The final mixture used for the fish-farm should have a salinity of 0.8-1%. The results of the first phase of the investigation should aim at providing a sound basis for a feasibility study of a fish-farm producing about 100 ton of salmon per year. This size of farm needs about 300 l/s of saline water of temperature suitable for production. From the above three sources the quantities required are roughly 100 l/s of seawater, 200 l/s of cold fresh water and about 20 l/s of boiling thermal water. Included in this phase are the following activities:

1. <u>The adopted drilling technique</u> needs to be developed further in order to solve the problems associated with pumping down slotted casing necessary to ensure maximum production from the wells. Several solutions are possible, but they need to be tried out and that will take some time.

2. <u>Production of seawater.</u> Because of the problems associated with the slotted casing, no information is available so far on the status of groundwater close to the shore. Consequently neither the thickness of the freshwater layer is known, nor the thickness of the transition layer from fresh water to seawater. In order to collect this information, we suggest that a 40 m deep production well be sunk in three steps as close to the shore as possible (e.g. near well nr. 8). The main objective should be to produce seawater. It can not be guarantied that 40 m will suffice but it is probable. After each step in the drilling the well should pumped for few hours and chemical samples taken in order to get a rough idea of the groundwater layering. After completion the well needs to be test pumped for about 10 days to sample information on its productivity.

3. <u>Search for fresh water.</u> In order to establish whether fresh water of acceptable quality can be found in the close vicinity of Skogalon we suggest that five 15 m deep exploration wells be drilled. Good results depend on finding extensive productive lenses of gravel. If two of these holes are successful, we can be optimistic about the fresh water resources. Subsequently larger diameter production wells need to be drilled at the successful sites and testpumped. Furthermore we suggest that all freshwater springs in the eastern part of Öxarfjördur be mapped. This would entail taking measurements of their discharge and their temperature and the elevation of the site. The information so obtained will provide a basic information about the quantity of fresh water available for the fish-farm if extraction of fresh water out of the sediments does not prove successful.

4. <u>Production of thermal water.</u> We suggest that two shallow production

size exploration wells be drilled into the geothermal field at Skogalon. One should be about 15 m deep and have slotted casing below 10 m depth and the other be 20-25 m deep. The wells need to be temperature and salinity logged, and at least one needs to be testpumped. At least two additional wells are probably needed in order to reach maximum yield. We suggest that the above drilling method be also tried within the geothermal field. It is, however, possible that conventional drilling methods may be necessary within the geothermal field as the sedimentary layers may be silicified and therefore harder than elsewhere, making it difficult to sink the casing using pumps.

The schedule for the second phase of the investigation relies of course heavily on the results of the first phase. The objective of the latter is to provide ample information for carrying out a feasibility study of a larger fish farm, producing about 600 tons of salmon per year, while at the same time finding sufficient water for a fish farm producing 100 tons of salmon per year. This phase encompasses the following activities.

1. Production of seawater. It is suggested that four additional production wells, evenly spread along the coast, be drilled within the possible production area. All the wells should be test pumped.

2. Production of fresh water. The productivity of the freshwater aquifers discovered in the first phase needs to be tested further. The drilling of two additional production wells into each discovered aquifer is suggested. Furthermore the drilling of four additional exploration wells needs to be scheduled for further freshwater exploration.

3. Production of geothermal water. It is assumed that two additional shallow production wells are necessary to ensure a production rate of 30-50 l/s of boiling water. However, this will not suffice for the largest fish-farm planned. For the production of 600 tons/year of salmon, about 100 l/s of boiling water are needed for optimal control of temperature. This quantity can probably be produced from the Skogalon geothermal field, but only by pumping water from much deeper wells (300-600 m deep). Deeper wells would also reduce the danger of cold water intrusion into the thermal system. Drilling of one deep exploration well is suggested. Some surface exploration is needed to site the well with the necessary accuracy and to yield information for future exploitation.

The plans for the second phase will be revised when the results of the first phase are known. Orkustofnun is ready at a short notice to participate in this project. The following is a rough cost estimate for the two project phases outlined above.

COST ESTIMATE FOR THE SKOGALON PROJECT

First phase

	cost in Ikr.
1. Drilling technique	
1.1 Material and labour	150.000
1.2 Extra cost due to delays in drilling	150.000
tot.	300.000
2. Seawater	
2.1 Drilling of one 40 m deep 8" well	210.000
2.2 Siting of wells	49.500
2.3 Temp. and salinity logging /chem. sampling	330.000
2.4 Supervision of drilling/tidal response	33.000
2.5 Test pumping (10 days)	160.000
2.6 Chemical analysis (1 complete sample, 20 part.)	41.000
2.7 Management/data interpretation/report	123.750
tot.	947.250
3. Freshwater prospecting	
3.1 Drilling of five 15 m deep 4" exploration wells	350.000
3.2 Drilling of two 15 m deep 12" wells	200.000
3.3 Siting of wells (included in 2.2)	
3.4 Temp. and salinity logging /chem.sampl.(incl. 2.3)	
3.5 Supervision of drilling /tidal repsponse	82.500
3.6 Chemical analysis (7 compl. samp., 21 part. sam.)	192.000
3.7 Test pumping (2x10 days)	320.000
3.8 Mapping of surface springs	49.500
3.9 Management/data interpretation/report	165.000
tot.	1359.000
4. Geothermal production	
4.1 Drilling of one 15 m deep 8" well	90.000
4.2 Drilling of one 25 m deep 8" well	140.000
4.3 Siting of wells (included in 2.2)	
4.4 Supervision of drilling	33.000
4.5 Temp. and salinity logging /chem.sampling	33.000
4.6 Test pumping (2x10 days)	320.000
4.7 Chemical analysis (2 compl. samp., 20 part.samp.)	66.000
4.8 Management/data interpretation/report	123.750
tot.	805.750
Total travel expenses	
10 trips Reykjavik- Husavik-Reykjavik	56.000
Total costs in Ikr	3.468.000

Second phase

	cost in Ikr
1. Seawater	
1.1 Drilling of four 40 m deep 8"(?) produc. wells	840.000
1.2 Siting of wells	66.000
1.3 Temp. and salinity logging /chem. sampling	165.000
1.4 Supervision of drilling	66.000
1.5 Test pumping (4x5 days)	320.000
1.6 Chemical analysis (4 compl.samp., 8 part.sam.)	107.000
1.7 Management/data interpretation/report	132.000
tot.	1696.000

2. Freshwater	
2.1 Drilling of four 15 m deep 4" exploration wells	280.000
2.2 Drilling of two 25 m deep 4" exploration wells	120.000
2.3 Drilling of four 15 m deep 12" production wells	600.000
2.4 Siting of wells (incl. in 1.2)	
2.5 Supervision of drilling	132.000
2.6 Test pumping (4x5 days)	320.000
2.7 Temp. and salinity logging /chem. sampling (inc. 1.3)	
2.8 Chemical analysis (10 compl.sam., 30 part.sam.)	274.000
2.9 Management/data interpretation/report	165.000
tot.	1891.000

3. Geothermal water	
3.1 Drilling of two 15 m deep production wells	200.000
3.2 Drilling of a 500 m deep exploration well	4.000.000
3.3 Geophysical surface investigations	500.000
3.4 Siting of wells (inc. in 1.2)	
3.5 Supervision of drilling	115.500
3.6 Test pumping (2x5 days)	160.000
3.7 Temp. and salinity logging /chem. sampling (inc. 1.3)	
3.8 Chemical analysis (4 compl.sam., 8 part.sam.)	107.000
3.9 Management/data interpretation/report	214.500
tot. kr	5.297.000

Total travel expenses:	
10 trips Reykjavik-Husavik-Reykjavik	56.000
Total cost in Ikr	8.940.000

These figures include air tickets and cars but not accomodation and sustenance.

Drilling costs are based on last years experience and exclude reuse of the outer casings.