ORKUSTOFNUN

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water samples from the Byssa geothermal
field, Amur District, U.S.S.R.

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Report
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NOTES ON THE CHEMICAL COMPOSITION OF TWO WATER SAMPLES FROM THE BYSSA GEOTHERMAL FIELD, AMUR DISTRICT, U.S.S.R.

Orkustofnun (The National Energy Authority of Iceland) has recently received, and agreed to review briefly, the results of chemical analyses of two water samples from the Byssa geothermal field. The samples are from wells 1C and 2C, and they were collected in April of 1989.

The intent of the review is to look for clues that the chemical composition might provide about the source of the water, especially its temperature. Information of this kind can be helpful when decisions on geothermal prospecting are made.

The chemical composition of geothermal water reflects, among other things, the temperature of its most recent equilibration with rock. The equilibrium constants for many ion exchange and solubility reactions, in particular, are strongly dependent on temperature. Relationships between chemical concentrations and temperature, based on such reactions, are generally referred to as chemical geothermometers.

The most widely used of these are the silica, the Na-K, and the Na-K-Ca geothermometers. The latter two are based on the ratios of cation concentrations, whereas the first uses the solubility of silica. At high temperatures, above 150°C or so, dissolved silica reaches equilibrium with quartz rather quickly, and in this range the silica geothermometer is calibrated accordingly. At lower temperatures, the dissolved silica is often found to reach metastable equilibrium with chalcedony. In low-temperature (<130°C) areas in Iceland, the chalcedony geothermometer has been found to be the most reliable and useful indicator of geothermal reservoir temperatures.

Table 1 recapitulates the data from the two wells, in component form. Thus, ionized and un-ionized dissolved silica have been added up and are given as SiO_2; similarly the sum of carbonate species is given as CO_2. The gas data has been omitted here, since the meaning of the numbers for the total amount of gas in water in the original Russian document is not clear to us. Unless the amount of carbon dioxide gas is large, however, its omission will not change our conclusions here.

To help interpret the analyses we used the computer program WATCH, originally developed by Stefán Arnórsson and others (S. Arnórsson, S. Sigurðsson, and H. Svavarsson, Geochimica et Cosmochimica Acta, Vol. 46, pp. 1513-1532, 1982). This program solves chemical equilibrium and mass balance equations simultaneously, and computes the concentrations of aqueous species at the desired temperature, given the

component concentrations as input. The program calculates activity coefficients, activity products, and solubility products as well. This permits the straightforward evaluation of chemical geothermometer temperatures and saturation indices.

Table 1. Chemical composition of water from the Byssa geothermal field. Concentrations in mg/kg.

Site	Well 1C	Well 2C
Date	April 1989	April 1989
Temperature °C	43.	43.5
pH	9.55	9.15
SiO_2	78.6	75.5
CO_2	42.4	41.8
Na	71.6	71.3
K	0.6	0.55
Ca	4.	4.
Mg	1.2	1.
Cl	32.6	32.3
F	10.	10.
SO_4	14.	14.
Chalcedony geothermometer temperature °C	75. ±5	80. ±5

Briefly, the results of our review are as follows.

The fluid is close to calcite ($CaCO_3$) saturation, which is not surprising, since such is nearly universally the case in geothermal systems around the world. This is because equilibrium with calcite is very rapidly attained.

The concentration of fluoride in the water seems to be controlled by the solubility of fluorite (CaF_2). This high concentration, 10 mg/kg, makes it undesirable as a primary source of drinking water.

The water is supersaturated with respect to quartz and chalcedony at the sampling temperature. This suggests that the water reached equilibrium with the rock at a higher temperature, and that the silica has not had time to reach a new equilibrium at the lower (sampling) temperature. The temperatures at which the water would be in equilibrium with rock are roughly 75°C and 80°C for wells 1C and 2C, respectively. These values differ a little even though the total silica concentrations are quite similar. This is because the pH of the samples differs somewhat.

Although chemical geothermometers are by no means exact, these samples give indications that warmer water, perhaps 70°C – 80°C, might be available in the vicinity or at a deeper level.

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