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Chemical composition of water from a hot spring in Siberia

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CHEMICAL COMPOSITION OF WATER FROM A HOT SPRING IN SIBERIA

Introduction

In the middle of July this year Orkustofnun received a water sample from a hot spring in Siberia, sampled by Haukur Baldursson of the consulting engineering company AFL OG ORKA ehf, Reykjavík, Iceland. The sample was collected between 16:00 and 17:00 (local time) on the July 8th following instructions from Orkustofnun. The hot spring is located in the hills close to the Bering Strait, some 20 distance km from the town of Lavrantia and 14 km from the town of Lorino. Due to the circumstances of the sampling the sample was not treated in the field as is the sampling procedure recommended by Orkustofnun, e.g. the sample was not filtered and not acidified. However, the sample was treated when it arrived at the laboratory and subsequently analysed for all major ions.

Results of chemical analyses

Results of the chemical analysis is shown in Table 1. The dissolved solids content of the water is rather high and pH low compared to most low temperature waters in Iceland. The salinity is 4.8‰.

Table 1: Chemical composition of thermal water (mg/l)

Date	1998.07.08
Sample #	1998-2001
Temperature(°C)	58
pH/°C	7,3/23
Carbonate (CO_2(t))	58,1
Hygrogen sulphide (H_2S)	0
Boron (B)	1,6
Conductivity ((µS/cm)/°C)	7050/25
Silica (SiO_2)	97,2
Total dissolved solids (TDS)	4790
Sodium (Na)	1293
Potassium (K)	85,4
Magnesium (Mg)	0,96
Calcium (Ca)	318
Fluoride (F)	3,14
Chloride (Cl)	2635
Sulphate (SO_4)	77,3
Aluminium (Al)	0,002
Manganese (Mn)	0,099
Iron (Fe)	0,025

Two triangular diagrams are commonly used to classify thermal waters and to test whether they are suitable for geochemical modelling. One diagram is based on the anions Cl, SO_4 and HCO_3, whereas the other is based on the cations Na, K and Mg. The diagrams are shown in Figures 1 and 2, and it is evident from them that the water

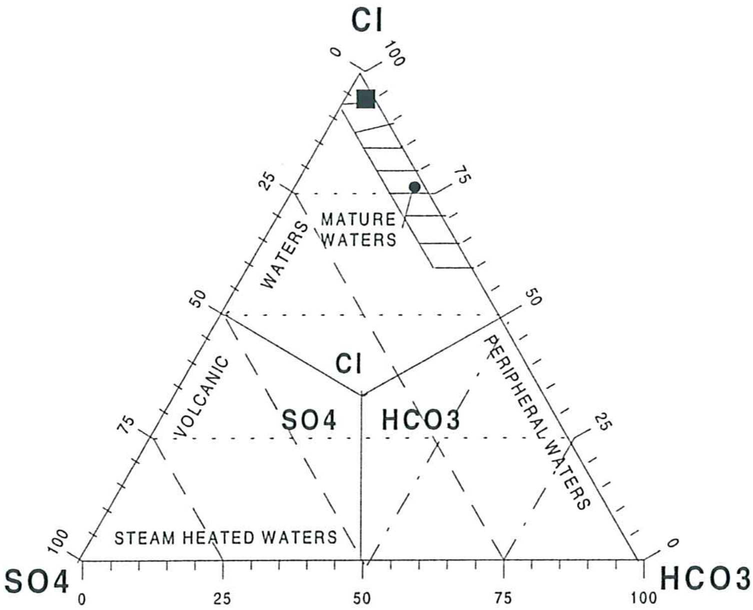

Figure 1: Classification og thermal water.

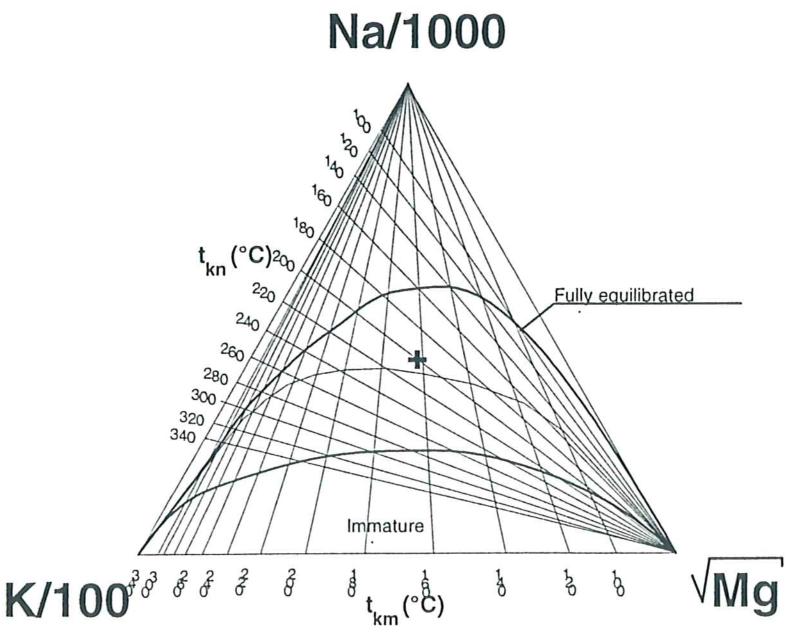

Figure 2: The "Giggenbach" diagram for thermal water.

plots within the fields of mature and partly equilibriated waters respectively. The Giggenbach diagram (Figure 2) indicates reservoir tempertures of 160 to 200°C, which is higher than other geothermometers and equilibrium calculations indicate.

Evaluation of chemical data

In order to evaluate the subsurface temperature of a geothermal system one can apply the so called chemical geothermometers, which for low temperarure waters are basically of two types: Those that are based on temperature dependent variations in the solubility of individual minerals (e.g. silica geothermometers) and those that are based on temperature dependent exchange reactions between different minerals (e.g. cation geothermometers). In Iceland a silica geothermometer based on equilibrium between the silica mineral chalcedony and water has been used extensively for low temperature geothermal water. Calculations based on that particular geothermometer for the water from Siberia indicates a temperature of approximately 110°C.

In order to further evaluate the equilibrium condition of the thermal water with respect to several hydrothermal minerals, the so-called saturation index (SI) has been calculated at temperatures between 110 and 20°C. The index gives information on whether a particular mineral is likely to precipitate or dissolve at a specific temperature, and it is usually represented as a value of log(Q/K) where Q is the ionic activity product and K is the solubility product. When $Q < K$, so that the saturation index is negative, the solution is undersaturated and the mineral will not precipitate. When $Q > K$, the water is said to be supersaturated, and scale (precipitate) may form. If $Q = K$ and $SI = 0$, the water is exactly saturated and in equilibrium with that mineral. If a group of minerals is close to equilibrium ((log(Q/K) =0) at one particular temperature one can assume that the water has equilibriated with this group of minerals and the temperature represents the temperature of the reservoir.
This kind of mineral equilibrium diagram has been constructed for the thermal water from Siberia based on ten different hydrothermal minerals. The diagram is shown in Figure 3, and one can see that the equilibrium temperature for several minerals is approximatly 75 to 85°C. This temperature is lower than the calculated temperature based on equilibrium with chalcedony (110°C), but higher than the measured temperature of the hot spring (58°C). The geochemical calculations therefore indicate that the reservoir temperature is higher than measured temperature, and it may be in the range 80 to 110°C. The alkali geothermometers (Figure 2) however, indicate considerably higher temperatures, in the range 160 to 200°C.

As shown in Figure 4, the water is supersaturated with respect to calcite at temperatures higher than 40°C. According to experience in Iceland calcite scaling will usually not cause any major problems in pipes and equipment as long as the saturation index value (log(Q/K)) is below approximately 0.4 as indicated by the dotted line in Figure 4. Therefore, calculations do not indicate that calcite scaling should become a problem when utilizing the water.

Calculations show that free CO_2 is present in the water. This indicates the possibility of carbonate corrosion. The water has a high chloride (Cl) content and will therefore become very corrosive if it contains any dissolved oxygen.

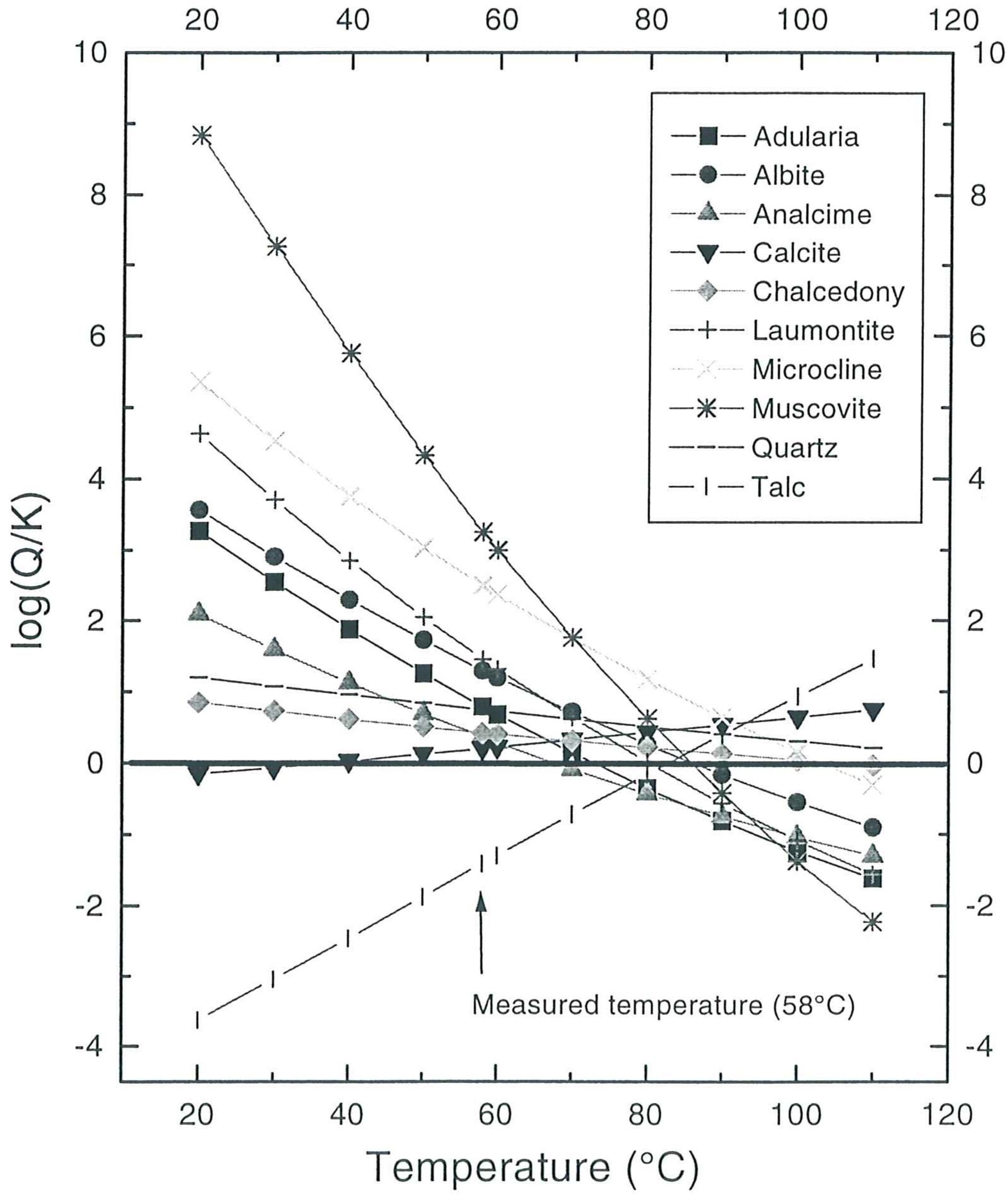

Figure 3: Equilibrium calculations for water sample.

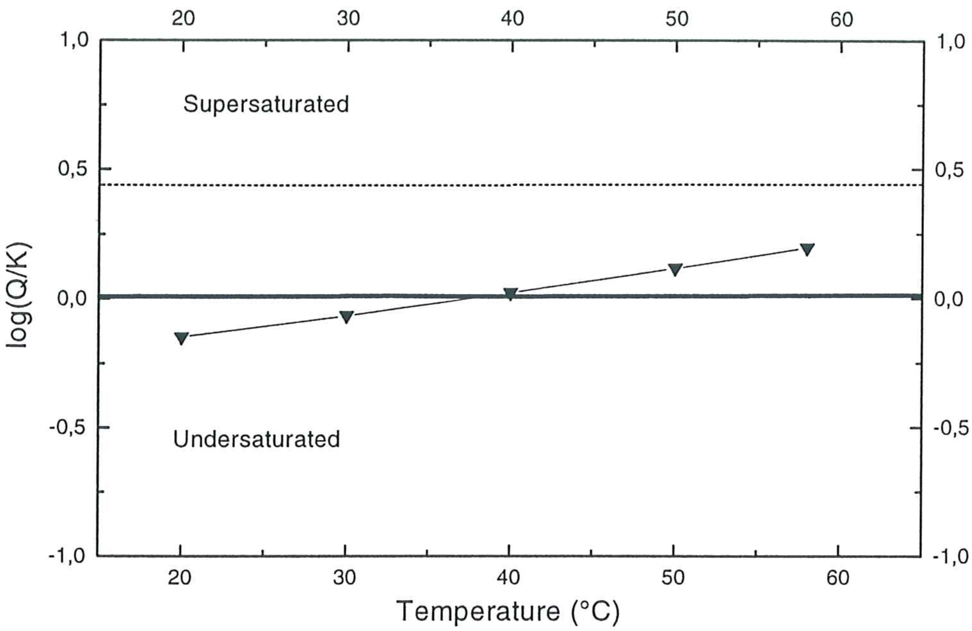

Figure 4: Calcite scaling potential of the water.