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Chemical composition of saltwater from four wells on the Reykjanes Peninsula, southwestern Iceland

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CHEMICAL COMPOSITION OF SALTWATER FROM FOUR WELLS ON THE REYKJANES PENINSULA, SOUTHWESTERN ICELAND

At the request of Hitaveita Suðurnesja (Sudurnes District Heating), water samples for chemical analysis were collected from four wells on the Reykjanes peninsula on March 29, 1996. Two of these wells, SJ-01 and SJ-04, are located at Staður, about 5 km to the west of the town of Grindavík, and the other two, KAL-6 and KAL-10, at Kalmanstjörn, approximately 3 km south of the village of Hafnir. The sample of fluid from well SJ-04 was obtained at the end of a large-diameter synthetic pipe, which feeds into a tank at the local fish farm, but the sample from SJ-01 was collected at the wellhead. The KAL-10 sample was obtained by way of a valve on a pipe about 4 m south of the wellhead, and KAL-6 fluid was collected from a vertical pipe inside the north wall of a fish farm building.

The fluids in question are all saline. In fact, the discharge from two of the wells, *viz.* SJ-04 and KAL-6, is essentially seawater, whose composition has been slightly modified by reaction with rock. In wells SJ-01 and KAL-10, however, the seawater has been somewhat diluted by fresh groundwater.

The sample collection and the analyses were carried out by the staff of the Chemical Laboratory of Orkustofnun (The National Energy Authority of Iceland). This work forms a part of the preliminary investigation of the feasibility of building a magnesium extraction plant in the area.

Table 1 displays the concentrations, in mg per liter, of the major dissolved constituents of these samples, and some of the minor ones as well. Here, CO_2 represents total carbonate calculated as carbon dioxide, and H_2S denotes total sulfide calculated as hydrogen sulfide. The figure for dissolved solids represents the total mineralization, as measured by evaporating an aliquot to dryness at 110°C.

The exact positions, in geographical coordinates, of the four wells in question are included in the table. These were determined by differentially corrected GPS measurements. Fifty determinations were made at each site at half-minute intervals and averaged to give the values in the table. The standard deviations of these measurements range from 0.6 m to 1.5 m in each direction (N - S and E - V). The positions are given in the Hjörsey 1955 datum. The locations of the sampling points are indicated in Figure 1, which displays a map of the Reykjanes peninsula. They are labeled with the sample numbers.

The concentrations of iron and manganese are highest in well KAL-6, which is deeper and slightly warmer than the other wells. This agrees with what is generally observed

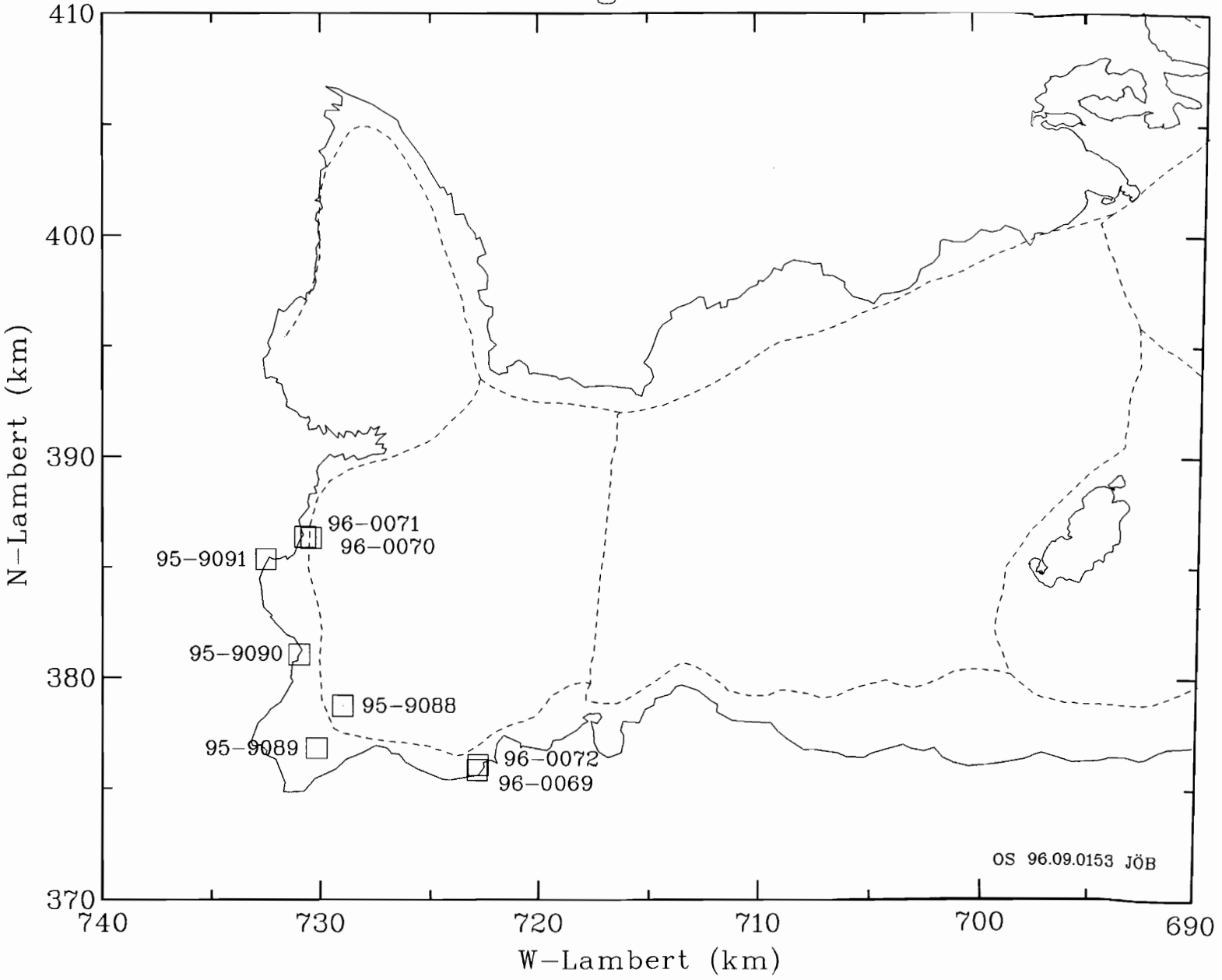
Table 1. Chemical composition of saltwater samples from the Reykjanes peninsula. Concentrations in mg/liter.

Sample no.	96-0070	96-0071	96-0072	96-0069
Date	March 29, 1996	March 29, 1996	March 29, 1996	March 29, 1996
Location	Kalmanstjörn well KAL-6	Kalmanstjörn well KAL-10	Staður well SJ-01	Staður well SJ-04
Latitude Longitude	63° 54.220' N 22° 41.773' W	63° 54.231' N 22° 42.098' W	63° 49.012' N 22° 31.549' W	63° 48.896' N 22° 31.587' W
Temperature (°C)	12.1	7.5	8.0	7.3
pH/°C	7.83/21.5	7.93/21.5	7.86/21.7	7.90/21.7
Carbonate (CO_2)	101.1	84.4	107.3	108.2
Sulfide (H_2S)	<0.03	<0.03	<0.03	<0.03
Boron (B)	4.40	2.93	3.73	4.13
Silica (SiO_2)	11.8	7.58	5.76	3.77
Dissolved solids (TDS)	39280	25500	32660	35840
Fluoride (F)	0.45	0.51	0.54	0.52
Chloride (Cl)	19480	12850	16330	18000
Bromide (Br)	64.2	43.7	54.1	59.9
Sulfate (SO_4)	2730	1800	2260	2500
Sodium (Na)	10770	7120	9010	9960
Potassium (K)	374	255	329	358
Magnesium (Mg)	1280	870	1090	1210
Calcium (Ca)	481	283	365	390
Aluminum (Al)	0.002	0.002	0.003	0.005
Manganese (Mn)	0.016	0.002	0.004	0.001
Iron (Fe)	0.035	0.003	0.024	0.004
Zinc (Zn)	0.020	0.222	0.027	0.022
Standard salinity ($\times 10^3$)	34.4	22.9	29.0	31.9

Table 2. Chemical composition of freshwater, saltwater, and seawater samples from the Reykjanes area. Concentrations in mg/liter.

Sample no.	95-9088	95-9089	95-9090	95-9091
Date	July 27, 1995	July 27, 1995	July 27, 1995	July 27, 1995
Location	Sýrfellshraun well SY-02	Reykjanes well 5	Stóra-Sandvík at the beach	Eyri, Hafnaberg at the beach
Latitude Longitude	63° 50.205' N 22° 39.328' W	63° 49.130' N 22° 40.606' W	63° 51.363' N 22° 41.947' W	63° 53.611' N 22° 44.188' W
pH/°C	7.84/22.2	7.81/22.7	8.15/23.1	8.13/22.5
Carbonate (CO_2)	17.0	111.2	99.9	100.3
Sulfide (H_2S)	<0.03	<0.03	<0.03	<0.03
Boron (B)	0.02	4.14	4.17	4.19
Silica (SiO_2)	14.4	13.9	0.7	0.7
Dissolved solids (TDS)	240	36700	36700	37600
Fluoride (F)	0.05	0.62	0.81	0.81
Chloride (Cl)	113	18700	18800	18900
Bromide (Br)	0.35	61.4	62	62.2
Sulfate (SO_4)	15.1	2510	2550	2560
Sodium (Na)	61.2	10490	10560	10580
Potassium (K)	2.2	384	380	379
Magnesium (Mg)	9.0	1190	1240	1240
Calcium (Ca)	7.9	451	377	371
Aluminum (Al)	0.009	0.005	0.001	0.001
Manganese (Mn)	0.0002	0.003	0.001	0.002
Iron (Fe)	0.011	0.008	0.002	0.006
Zinc (Zn)	–	0.092	0.002	0.003
Standard salinity ($\times 10^3$)	–	33.1	33.2	33.4

Figure 1


410
400
390
380
370
740
730
720
710
700
690
N-Lambert (km)
W-Lambert (km)
96-0071
96-0070
95-9091
95-9090
95-9088
95-9089
96-0072
96-0069
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on the Reykjanes peninsula. The relatively high iron concentration in the fluids of well SJ-01, however, probably derives from the casing, or from the wellhead, which is somewhat corroded. The high zinc concentration of well KAL-10 is likewise ascribed to contamination from piping.

The standard (Knudsen) salinity, S, in parts per thousand, is given at the bottom of the table. It is defined as:

$$S = 0.03 + 1.805 \cdot C,$$

where C is the chlorinity in g per kg of seawater. C includes chloride, bromide, and iodide, all reported as chloride. Iodide is negligible in the present context. In the calculation, a density of 1.024 kg/l at 25°C was used for the fluids of well KAL-6, 1.022 for well SJ-04, 1.019 for SJ-01, and 1.015 for well KAL-10.

Table 2 displays the chemical composition of freshwater, saltwater, and seawater from four other locations in the Reykjanes area. This data has already been presented in an earlier short report (Orkustofnun, JÖB-95/04), but is included here for comparison. Several things are worth noting.

The silica concentrations in the seawater samples (95-9090 and 95-9091) are quite low, and lower than one would expect on chemical grounds alone. This is generally true of surface and coastal seawater. The reason is that plankton, which is retained by the 0.45 μm membrane through which the liquid is filtered during sampling, has depleted the dissolved silica. We see that the water from well SJ-04, which is very close to the beach, has recovered some of the silica. The nearby well SJ-01, which is located about 200 m farther inland, has recovered even more silica, some of it from a freshwater admixture to the seawater. At Kalmanstjörn, well KAL-10 displays a silica concentration lower than the equilibrium value. In well KAL-6, however, which is farther inland and, at 185 m, three times deeper than SJ-01, SJ-04, and KAL-10, the silica concentration is close to the equilibrium concentration, as observed in Reykjanes well 5 and Sýrfellshraun well SY-02.

The salinity varies from one well to another. The two seawater samples and the Reykjanes well 5 fluids are nearly identical in this regard, and well SJ-04 fluids are quite similar. The sample from KAL-6 is slightly more saline, however. The reason for this difference may be the voluminous stream of fresh groundwater that drains the peninsula near sea level. Thus, the surface seawater near the beach may have been slightly diluted, whereas the lower, denser layers, from which well KAL-6 presumably draws, have not. The fluids from wells SJ-01 and KAL-10 are seawater that has been significantly mixed with freshwater, approximately 12% and 30%, respectively.

The pH of all the well samples is slightly lower than that of the seawater samples. This is presumably because of ion exchange between water and rock.

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