16. INTERSTITIAL-WATER STUDIES, LEG 61[1]

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ABSTRACT

Concentration gradients of Ca, Mg, K, Sr, and Li at Site 462, Leg 61, are linear with depth; large changes occur in the unsampled, low-porosity limestone–chert zone between 375 and 445 meters. Correlations between Ca and Mg are linear, but breaks occur in Ca–Sr and Ca–K correlations. These breaks imply release of strontium in the limestones (recrystallization of carbonate) and uptake of potassium (formation of authigenic K-feldspar?).

INTRODUCTION

During Leg 61, interstitial waters were recovered in Hole 462 in the Nauru Basin. Shipboard determinations of calcium and magnesium contents indicate distinct increases in calcium and decreases in magnesium concentrations with depth, with apparently a large discontinuity across the 50-meter-thick section of limestone-chert between 375 and 445 meters. For these reasons, we found it imperative to augment the shipboard chemical data with further analyses.

Methods used were essentially the same as those described by Gieskes and Johnson (in press). The data are presented in Table 1.

DISCUSSION

Sedimentation rates at this site have been less than 10 meters/10^6 years in the upper 350 meters and considerably slower during the later history of the site (see Site Summary). Consequently, only little sulfate reduction would be expected, in agreement with the data (Table 1). Even below the chert complex, only a small depletion in sulfate is noted. As a consequence of this sulfate reduction, slight increases in alkalinity occur in the upper 300 meters, but below the complex the values are very low.

The data for Li, Sr, K, and even Si indicate linear concentration changes with depth in upper 350 meters (Figure 1). Below the chert complex, however, all data show an offset in these trends, similar to those observed for Ca and Mg on board ship.

In Figure 2 we present the correlation between Ca and Mg at this site, and one notes a strong correlation between Ca and Mg, with $\Delta Ca/\Delta Mg = 1.1$. We interpret this correlation in terms of alteration of volcanic matter in the volcanic sediments of Unit III and/or in the underlying basalts. Further studies of oxygen isotopic composition of the pore waters will enable us to estimate more accurately the mass balance of oxygen and consequently the thickness of the reaction zone (Lawrence et al., 1975; Gieskes and Lawrence, in press). The break in the Ca and Mg concentration–depth pro-files can then be understood in terms of lower diffusion coefficients in the limestone–chert layers. Similar observations have been made before at Sites 253 and 356 (McDuff, 1978).

Because of the good correlation between Ca and Mg concentrations, we decided to investigate the correlation among Ca and Sr and K. In these cases, one observes only a linear correlation above the chert complex (data on K are less reliable than those for Sr), but concentrations below the chert complex are different from those expected from an extrapolation of the correlation line; specifically, one would expect zero potassium concentration below 450 meters, and much higher strontium concentrations. Thus, diffusion from Unit III cannot be responsible for the observed gradients in Unit I and II, and we must postulate a source for Sr in the chert–limestone complex, as well as a sink for K. Since Unit III consists mostly of volcanic sediments and such sediments are not likely to be a major source for dissolved strontium, one must postulate that the strontium source is associated with the recrystallization reactions occurring in the chert–limestone complex. Similarly, the formation of K-feldspar, associated with chert formation (Kastner and Gieskes, 1976; Gieskes and Lawrence, in press), provides a convenient sink for K. Changes in Li are too subtle to be readily interpreted in a similar manner.

Dissolved silica also gradually increases with depth, but this, rather than resulting from diffusion processes, is more likely to result from increasing contributions, with depth, of biogenic silica to the sediments. In the absence of quantitative data on opal contents, this interpretation relies mainly on the observed increased abundance of radiolarians with depth. Dissolved-silica values below the sill represent concentrations supported by the volcanic sediments assemblage.

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Table 1. Interstitial-water data, Hole 462.

Core-Section	Depth (m)	pH	Alk[a] (meq/l)	Cl[a] (× 10^{-3})	S[a] (× 10^{-3})	Ca[a] (mM)	Mg[a] (mM)	Sr (mM)	Mn (mM)	Li (μM)	K (mM)	Si (μM)	SO$_4$ (mM)	NH$_3$[b] (mM)
1-6	9.5	7.65	2.94	19.68	35.3	10.5	52.4	0.095	0.000	25.2	9.9	446	31.4	0.06
5-4	44.5	7.54	2.95	19.94	36.1	11.6	52.1	0.115	0.017	23.6	7.1	527	29.9	0.04
10-4	92	7.42	3.44	19.61	36.0	12.2	50.6	0.127	0.021	24.3	8.4	686	27.7	0.04
16-3	147.5	7.25	3.77	19.34	35.2	13.8	48.7	0.148	0.014	28.0	8.2	746	28.4	0.05
20-4	187	7.22	3.97	19.58	35.4	14.8	47.9	0.180	0.004	26.5	8.8	806	28.4	0.05
26-4	244	7.21	3.87	19.64	35.4	15.7	47.1	0.201	0.000	29.1	8.2	889	27.9	0.07
30-2	279	7.23	4.18	19.51	35.5	16.6	46.5	0.212	0.002	28.1	8.0	907	27.9	0.06
36-3	337.5	7.21	4.13	19.61	35.6	17.5	45.7	0.223	0.009	28.1	8.0	1020	27.9	0.07
48-1	448.5	7.33	0.72	19.61	35.7	55.0	10.7	0.488	0.003	35.0	2.7	540	—	0.12
54-2	507	7.54	0.39	19.81	35.6	57.1	9.7	0.461	0.006	34.8	2.8	584	24.9	0.13
58-3	544.5	7.58	0.88	19.14	34.2	58.0	10.7	0.458	0.016	31.9	2.5	690	—	0.08

[a] Shipboard data.

[b] NH$_3$ < 0.08 not reliable.
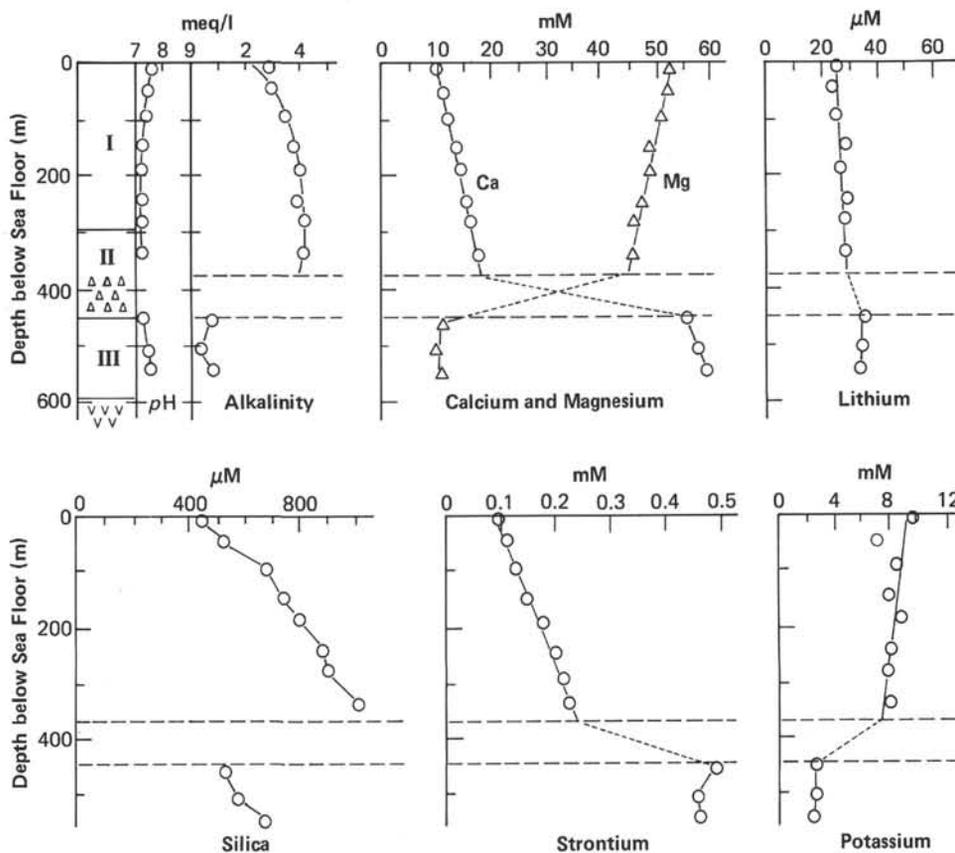
Figure 1. Interstitial-water data, Hole 462. Lithology: I: calcareous and radiolarian oozes and chalks, mainly turbiditic; II: cherts, chalks, limestones; III: volcanogenic and zeolitic sandstones, mudstones, and limestones.
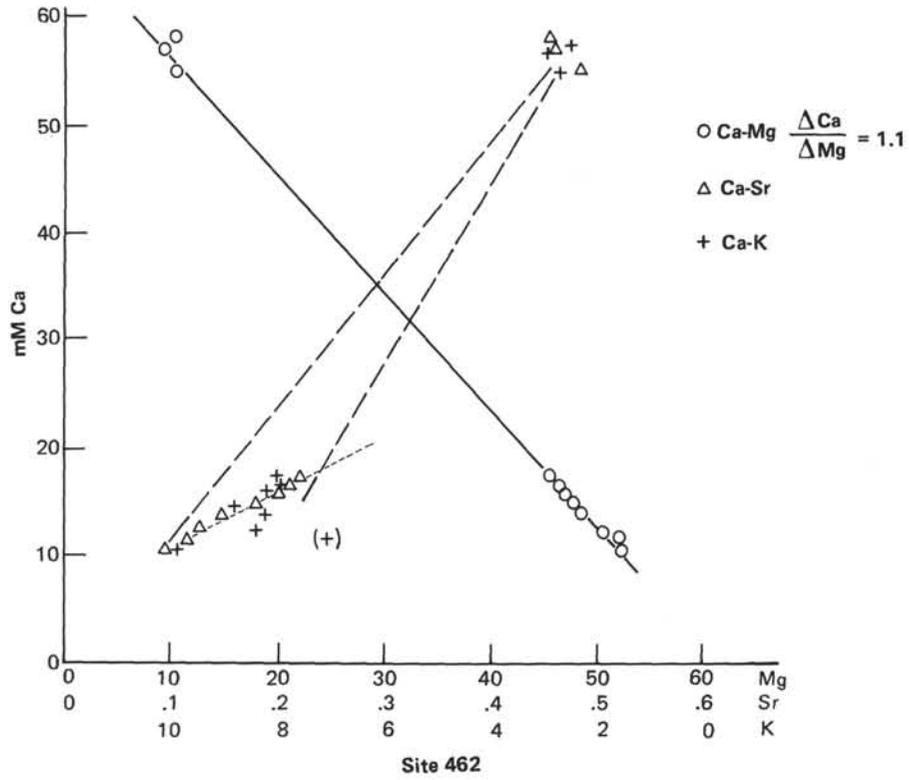
Figure 2. Correlation diagram Ca–Mg, Ca–K, and Ca–Sr, Hole 462.