

17. INTERSTITIAL-WATER STUDIES, LEG 58¹

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ABSTRACT

Interstitial waters from several sites drilled during Leg 58 have been analyzed for major constituents. Data for Sites 442, 443, and 444 in Shikoku Basin indicate that only small changes occur in the chemical composition. We did not note any influence on the interstitial water chemistry resulting from reactions taking place in the underlying basalts.

Site 445 data indicate that reactions must occur in the sediment column, leading to decreases in dissolved magnesium and increases in dissolved calcium. In addition, a source of dissolved calcium appears in the underlying basalts. At Site 446, changes appear in dissolved-calcium and -magnesium concentrations, resulting mainly from alteration reactions in the basalts.

Dissolved potassium has its main sink in deeper-lying sediments or basalts. Changes in dissolved strontium at Sites 445 and 446 can be explained in terms of carbonate recrystallization. At all sites, changes in dissolved manganese and lithium appear to be related to the presence of biogenic silica in the sediments.

INTRODUCTION

During Leg 58, a routine program of collection and analysis of interstitial waters was carried out on samples obtained from Sites 442, 443, 444, 445, and 446. Shipboard analyses included the following: pH, alkalinity, chlorinity, salinity, and calcium and magnesium concentrations. Inspection of the data indicated that further analysis of samples from Sites 443, 445, and 446 would be most profitable, as little change in interstitial water chemistry was observed for Sites 442 and 444.

Analyses were carried out using the procedures described by Gieskes (1974) and Gieskes and Lawrence (1976). Lithium was analyzed using the procedure described by Presley (1971). Sulfate analyses were carried out using a polarographic technique (Barnes et al., 1979; Luther and Meyerson, 1975).

The data, including shipboard data, are tabulated in Table 1, and are also presented in Figures 1, 2, and 3.

DISCUSSION

Sites 442, 443, and 444

These three sites are situated in the Shikoku Basin. Basalt ages are estimated to be at least 15×10^6 years, and the sediments are characterized by hemipelagic calcareous-siliceous muds with interbedded ash layers. Pleistocene sedimentation rates were fairly high (10 cm/1000 years at Site 442, 7.6 cm/1000 years at Site 443, and 2-3 cm/1000 years at Site 444). Typically, this has resulted in slight maxima in alkalinity in the upper 100 meters, accompanied at Site 443 (Fig. 1) by a minimum in dissolved-sulfate concentration.

At all three sites, slight decreases in dissolved-magnesium concentrations and increases in dissolved-calcium concentrations occur, but no signal of reactivity of basaltic basement is apparent. Basalts at Site 443 in-

dicating oxidative weathering, which probably occurred in contact with sea water when sediment cover was thin or nonexistent. Decreases in magnesium concentrations at Site 443 appear related to reactions taking place in Unit IIA, where volcanic ash is a substantial contributor to the sediments.

At Site 443, only slight changes occur in the concentration of dissolved strontium. At this time, in the absence of strontium isotope data (Hawkesworth and Elderfield, 1978), it is difficult to relate the increase in dissolved strontium to carbonate recrystallization processes or to alteration reactions of volcanic matter.

Decreases in the concentration of dissolved potassium are very small; perhaps there is a sink in the underlying basalts. The quality of the data however, does not permit detailed interpretation.

Concentrations of dissolved manganese and lithium increase at about 250 meters (Unit III); these increases are perhaps related to the presence of siliceous sediments. The association between manganese maxima and siliceous sediments has been noted previously (Gieskes et al., 1978; Gieskes and Reese, 1980).

Site 445

Sedimentation rates at Site 445 have been moderately low, with an increase to an estimated 4 cm/1000 years in the upper 65 meters. This has resulted in a small maximum in alkalinity and a slight decrease in sulfate concentration (Fig. 2).

The distribution of dissolved calcium and magnesium suggests reaction throughout the sediment column, perhaps related to the continued alteration of volcanic material in the sediments. Typically, no simple correlation between dissolved calcium and magnesium is observed at this site (Fig. 4). Future studies of the oxygen isotopic composition will be helpful to confirm this opinion (Lawrence, Gieskes, and Broecker, 1975; Lawrence, Gieskes, and Anderson, 1976). The continuation of the calcium gradient probably implies an additional source of calcium in the underlying basement rocks.

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Table 1. Interstitial-water data, Leg 58.

Sample (interval in cm)	Z	pH	Alk (meq/l)	Cl (‰)	S (‰)	Ca (mM)	Mg (mM)	Sr (mM)	Mn (μ M)	Li (μ M)	K (mM)	Si (μ M)	SO ₄ (mM)	NH ₃ (mM)
Hole 442A														
2-3, 143-150	13.9	7.78	9.74	19.41	35.5	10.7	50.3							
7-4, 140-150	63	8.19	5.65	19.34	35.2	12.5	46.3							
13-2, 143-150	117	7.87	4.66	19.38	35.2	13.6	44.7							
19-3, 0-10	174	7.59	3.75	18.67	35.2	14.8	45.1							
23-2, 93-100	211	7.52	3.12	19.79	36.0	14.4	47.5							
27-3, 0-8	250	7.57	2.97	19.51	35.5	12.7	48.3							
Hole 442B														
2-4, 140-150	283	7.46	2.99	18.94	34.4	11.5	51.4							
Hole 443														
2-4, 6-8	11.5	7.84	9.08	19.31	35.5	10.0	50.2	0.083	98	21.5	12.4	627	23.3	0.60
6-2, 150-170	48	7.85	9.08	19.48	35.5	10.0	48.9	0.088	43	22.6	11.3	561	23.1	0.79
14-5, 140-150	128.5	8.38	7.07	19.44	35.2	13.5	44.1	0.098	19	27.8	12.2	414	24.7	0.51
18-2, 144-150	162	8.21	3.49	19.10	34.9	13.2	42.9	0.095	19	25.8	11.8	421	25.1	0.57
22-3, 0-5	200	6.78	1.74	19.51	34.6	14.9	42.5	0.104	39	28.5	11.4	586	24.7	0.42
27-3, 140-150	249	6.88	3.47	19.48	34.9	16.4	43.6	0.111	94	31.1	9.6	706	25.1	0.25
29-3, 140-150	268	7.56	4.13	19.41	35.2	16.6	43.3	0.112	78	29.7	10.5	786	25.3	0.23
34-1, 140-150	312.5	7.89	1.64	19.17	34.9	15.4	43.0	0.109	37	27.5	10.9	642	27.2	0.22
40-1, 140-150	369.5	8.30	3.96	—	35.5	17.3	41.9	0.111	40	25.5	10.7	642	25.9	0.18
45-1, 140-150	417	8.12	4.08	19.58	35.5	17.8	42.8	0.112	42	28.1	9.7	746	27.1	0.18
49-3, 14-18	456.5	7.80	3.61	(18.26)	(33.3)	16.7	42.2	0.139	60	23.9	8.3	384	26.5	0.22
Hole 444														
2-4, 144-150	12	7.75	4.24	19.24	35.8	13.1	48.4							
7-5, 144-150	61	7.52	3.46	19.11	36.0	12.4	50.9							
Hole 444A														
1-5, 144-150	89	7.61	3.40	19.04	35.8	12.1	51.1							
6-4, 140-150	135.5	7.54	3.20	19.08	36.0	11.8	50.8							
9-3, 140-150	162.5	7.27	3.08	19.31	35.8	11.6	52.0							
14-3, 90-100	209.5	7.60	3.29	19.34	35.8	11.8	51.7							
16-2, 140-150	227.5	8.10	3.11	19.04	35.5	11.3	50.4							
21-1, 135-150	254.5	8.16	2.89	18.98	35.5	11.3	48.5							
23-1, 61-68	272.5	7.26	1.39	19.54	36.6	10.2	49.1							
Hole 445														
1-4, 144-150	6	7.57	3.05	19.55	35.2	11.2	51.5	0.017	147	24.4	9.8	427	29.2	0.07
6-5, 144-150	54	7.36	3.33	19.82	35.5	15.7	43.5	0.23	127	27.5	8.9	486	28.1	0.12
11-4, 144-150	100	7.54	1.66	19.86	35.5	16.7	39.2	0.40	75	30.1	9.7	602	25.8	0.18
17-1, 140-150	152.5	7.21	0.87	19.93	35.2	20.0	33.7	0.71	4	48.4	9.9	299	24.8	0.13
22-1, 144-150	200	7.40	1.80	19.82	35.2	22.2	33.3	0.76	9	53.0	8.6	613	24.4	0.20
27-4, 140-150	252	7.38	1.76	19.96	36.3	24.6	31.1	0.81	64	55.0	7.5	695	25.5	0.19
32-2, 140-150	296.5	7.42	1.50	20.20	35.2	26.0	30.2	0.86	28	60.0	8.7	859	24.6	0.16
37-4, 140-150	347	7.18	1.70	19.51	34.6	26.9	30.6	0.98	21	65.5	6.7	795	23.9	0.15
42-5, 90-100	395.5	7.32	1.58	19.99	35.5	29.6	26.9	1.03	7	65.3	8.0	995	22.9	0.13
47-4, 90-100	441.5	7.37	1.31	20.06	36.3	34.1	22.9	1.17	6	71.6	7.4	1231	(26.1)	0.34
52-4, 90-100	489	7.58	1.40	20.20	36.3	36.0	22.7	1.03	5	68.5	6.0	1121	(26.0)	0.19
62-4, 140-150	584.5	7.63	0.68	20.10	36.3	38.1	23.4	1.06	14	71.6	3.9	1109	24.4	0.10
65-2, 90-100	609.5	7.44	1.39	20.37	36.3	40.2	23.1	1.04	38	71.3	4.5	1148	25.7	0.12
80-4, 90-100	755	8.08	0.36	20.41	36.3	44.0	(27.9)	0.49	3	70.7	2.0	102	23.8	0.09
Hole 446														
3-5, 140-150	18.5	7.51	2.63	19.44	35.5	16.9	46.6	0.11	144	30.4	9.5	419	27.2	0.06
9-4, 90-100	73.5	7.19	2.11	19.41	35.8	27.7	42.4	0.14	28	38.9	8.2	833	27.7	0.07
14-4, 144-150	121.5	7.31	1.82	19.08	35.8	36.2	37.9	0.13	13	47.7	6.5	424	24.0	0.05
21-2, 144-150	185	8.13	0.53	19.54	36.3	52.6	23.3	0.245	13	52.1	3.7	158	22.2	0.08
26-2, 140-150	232.5	8.34	0.58	19.61	36.3	65.8	15.0	0.29	34	54.0	2.2	103	21.6	0.11
30-5, 140-150	275	7.87	0.60	19.81	36.3	76.4	16.3	0.33	70	53.1	1.9	215	20.2	0.06
34-5, 140-150	313	8.25	0.35	19.48	36.3	82.0	6.8	0.35	73	52.2	1.1	153	18.3	0.06
41-2, 140-150	375	8.71	0.42	19.81	36.6	94.5	2.5	0.35	19	52.2	0.8	230	17.7	0.07
Hole 446A														
3-3	394	8.85	0.90	20.00	38.3	105.0	0	0.35	3	59.6	0.6	180	16.7	0.14
10-2	451	8.70	0.55	19.50	36.6	104.2	-1	0.32	5	59.5	0.3	138	14.9	0.11
25-3	595	8.20	0.75	19.85	38.2	126.0	0	(0.51)	0	51.0	0	102	—	0.42

Dissolved potassium indicates a sink located in the deeper sediments and/or basement rocks. Increases in dissolved-strontium content are relatively large and are related to the presence of calcium carbonate at this site. Below 600 meters, calcium carbonate contents are substantially lower, and a reversal occurs in the strontium gradient.

Increases in dissolved-lithium concentrations are relatively large, and are probably related to release of lithium in the siliceous section at this site.

Site 446

Site 466 in the Daito Basin, south of the Daito Ridge, is characterized by very low sediment accumulation

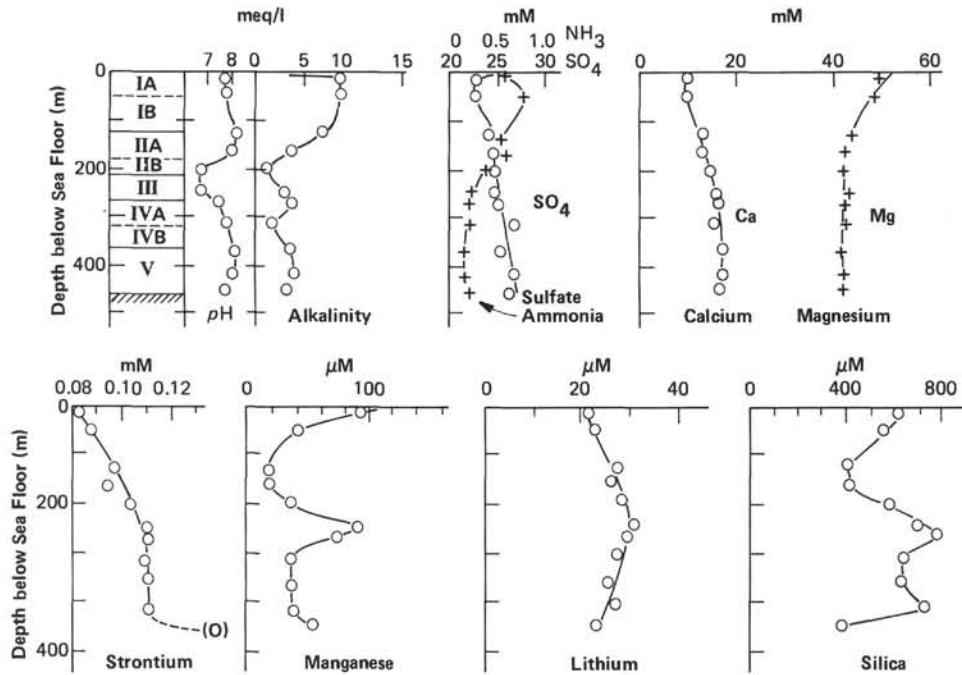


Figure 1. Interstitial-water data, Site 443. IA: greenish gray mud; IB: nanofossil mud, calcareous mud, clayey nanofossil ooze; IIA: ashy clay and mud; IIB: clay/mud; III: clayey nanofossil ooze to mud; IVA: mudstone and ash layers; IVB: nanofossil chalk-mudstone; V: claystone, mudstone, chalk.

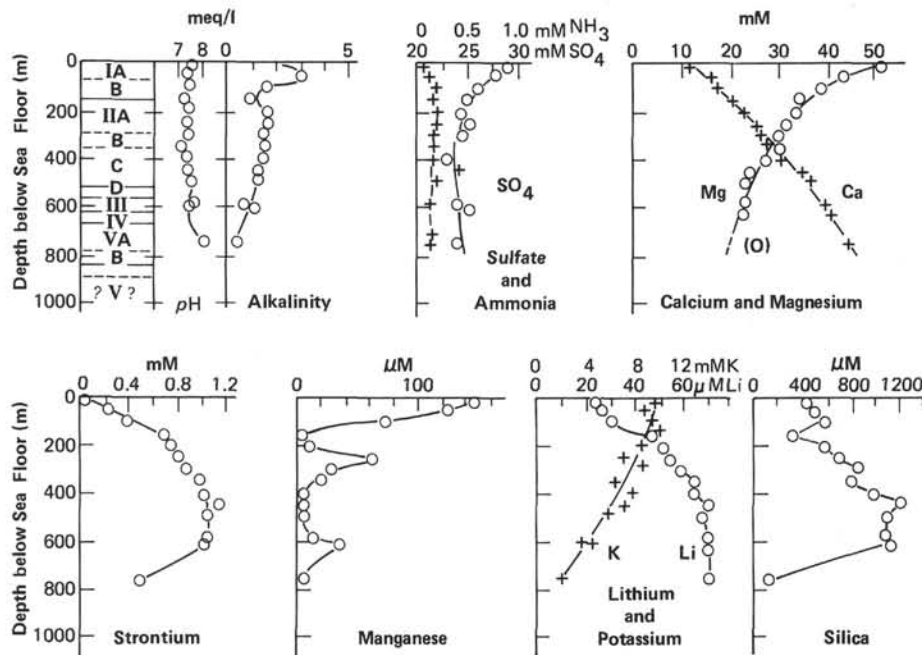


Figure 2. Interstitial-water data, Site 445. IA: clayey foraminifer/nanofossil ooze; nanofossil ooze; IB: foraminiferal nanofossil ooze; nanofossil ooze; IIA: clayey nanofossil chalk; nanofossil chalk; IIB: clayey nanofossil chalk; calcareous siliceous mudstone; IIC: clayey nanofossil chalk; nanofossil chalk; calcareous mudstone; IID: clayey nanofossil chalk; siliceous nanofossil chalk; III: siliceous clayey nanofossil chalk; siliceous mudstone; nanofossil tuff; IV: chert; radiolarite; V: mudstone; calcareous mudstone; conglomerate; VB: mudstone; sandy mudstone; conglomerate; VI: conglomerate; sandstone; calcareous mudstone.

rates. No clear maximum occurs in alkalinity, and alkalinity values decrease rapidly below sea-water values in the upper part of the section (Fig. 3).

Increases in dissolved calcium are large, and magnesium is essentially gone altogether at the basalt/sediment interface. In the sediment section, calcium and magnesium changes are linearly correlated with $\Delta\text{Ca}/\Delta\text{Mg} = -1.63$ (Fig. 4). Such linearly correlated concentration changes in calcium and magnesium have been interpreted as indicating a conservative nature of the calcium and magnesium gradients (McDuff, 1978), with reactions in the underlying basalts mainly responsible for the observed concentration changes.

Dissolved potassium indicates a sink in the sediment of Unit IV and/or the underlying basalts. In the absence of mineralogical information, it is difficult to define a logical sink for this potassium.

Dissolved strontium, manganese, and lithium clearly have sources in the sediment column.

Of interest is the sharp, linear decrease in concentration of dissolved sulfate with depth in the sediments above the basalts. Slightly higher ammonia values below the sills suggest that sulfate reduction processes in the sediments of the sill complex are responsible for these sulfate decreases.

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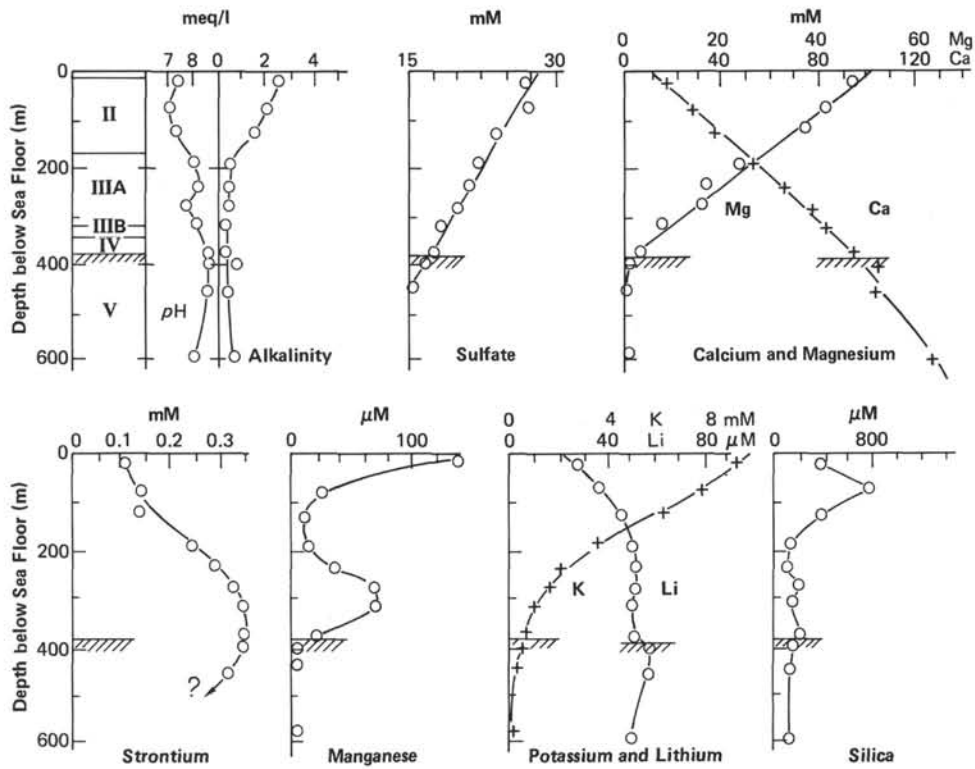


Figure 3. Interstitial-water data, Site 446. I: brown terrigenous mud; clay; II: pelagic clay and ash; IIIA: mudstone; claystone; siltstone; sandstone; IIIB: calcareous clay and mudstones; turbidites; IV: calcareous claystones; nanofossil claystones, glauconite; mudstones; V: basalt sills and intrusions.

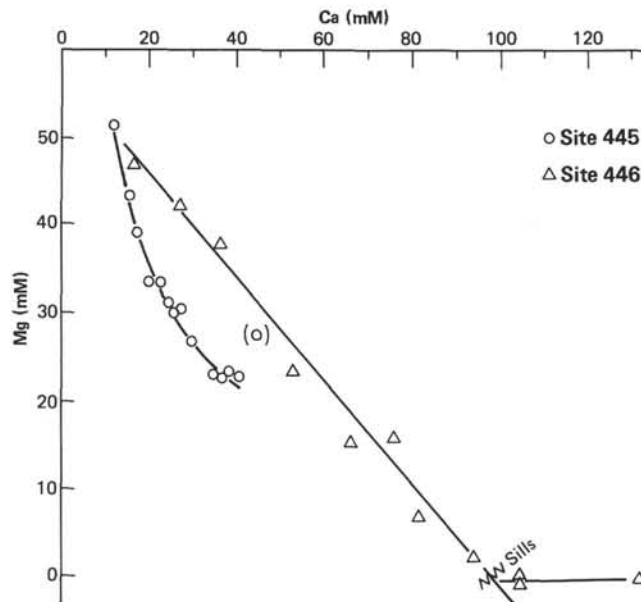


Figure 4. Correlations between dissolved calcium and magnesium, Site 445 (dots) and Site 446 (triangles).