42. INTERSTITIAL WATER GEOCHEMISTRY AND CLAY MINERALOGY OF THE MISSISSIPPI FAN AND ORCA AND PIGMY BASINS, DEEP SEA DRILLING PROJECT LEG 96[1]

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ABSTRACT

Interstitial water studies were done at 9 of the 11 sites visited in the Mississippi Fan and Orca and Pigmy Basins during DSDP Leg 96. High concentrations of sulfate were observed at Mississippi Fan Sites 616, 617, 620, and 623. The maximum sulfate value of 38.8 m*M*, recorded at Site 617, is the highest ever found in DSDP sediments. Hypersaline interstitial water was observed at Site 618 in Orca Basin. Concentration ratios of salinity to chlorinity and to sodium in interstitial waters are similar to those of Orca Basin bottom water, suggesting that the chemistry of interstitial water is affected by the dissolution of buried salt.

INTRODUCTION

On DSDP Leg 96, the last cruise of the Deep Sea Drilling Project, we investigated the Mississippi Fan in the Gulf of Mexico and Orca and Pigmy intraslope basins on the continental slope off Louisiana (Fig. 1; introductory chapter, this volume). Interstitial water studies on Leg 96 were performed at 9 of the 11 sites visited during this cruise. Most of the squeezed sediments consisted of silty clay; in spite of the sediments' similar lithologies, different diagenetic histories, and variable sedimentation rates, diffusive and advective transports of interstitial water cause a variety of chemical changes in the interstitial water. Although the reaction between interstitial water and clay minerals has not been examined much (Manheim and Sayles, 1974; Sayles and Manheim, 1975, Manheim, 1976; Lawrence et al., 1975; Donnelly and Merrill, 1977), it is considered one of the most important factors controlling early diagenesis. Thus, this chapter presents preliminary data on the interstitial water and separated clay minerals from DSDP Leg 96 and discusses the relationships between pore water chemistry and lithological units as an explanation of observed substantial changes in the chemical compositions of interstitial waters obtained during this cruise.

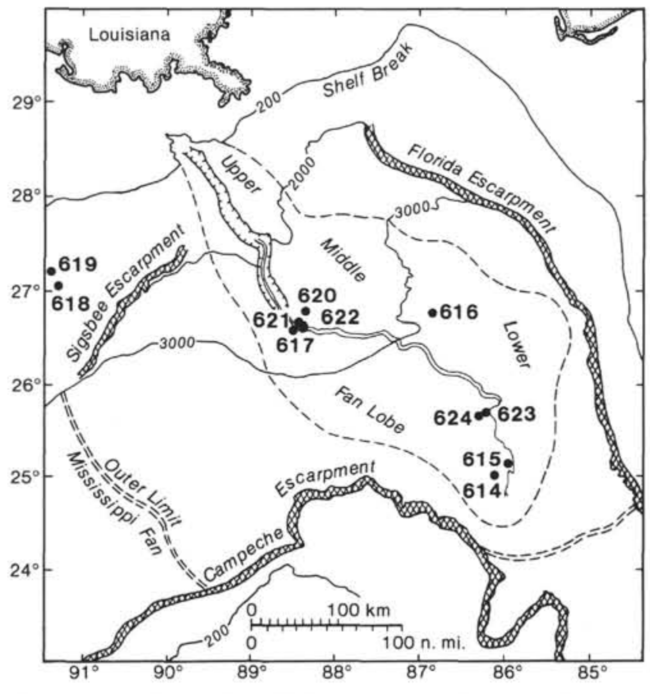

Figure 1. Location of sites visited on DSDP Leg 96. Interstitial water geochemical data from all sites except Sites 614 and 624 are presented in this chapter.

SAMPLING AND ANALYTICAL PROCEDURES

Interstitial Water Analyses

During Leg 96 (Fig. 1), samples of interstitial water were collected by standard shipboard squeezing techniques (Explanatory Notes, this volume). The samples obtained were analyzed on the ship for pH, alkalinity, chlorinity, salinity, and Ca concentration.

Splits of each of the interstitial water samples were taken for more detailed shore-based study. The concentrations of Li^+, Na^+, K^+, Ca^{2+}, and Mg^{2+} were measured with a Hitach 170-50A atomic absorption spectrophotometer. All solutions were adjusted to 4000 ppm with $LaCl_3$ solution to prevent interference from coexisting elements.

The colorimetric method was employed to analyze for silica (Strickland and Parsons, 1968; Presley, 1971). The concentration of silica was determined by measuring the absorbance of 800-μm wavelength light, using a Hitach 101 spectrophotometer. Sulfate analyses were carried out using a titration technique (Cescon and Macchi, 1973).

Identification of Clay Minerals

A total of 59 samples from Sites 615, 617, 618, and 619 were selected for clay mineral analysis. Each sample was dispersed in distilled water before the less than 2-μm clay fraction was separated by settling techniques. Semiquantitative and qualitative estimations of clay mineral percentage are based on the methods reported by Sudo et al. (1961) and Oinuma (1968). The diffractometer used for the clay mineral anal-

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yses was a Rigaku Densh Rad IIA. Samples were run with the 2θ range of 1–30°, scan speed of 1°/min., and settings of 15 mA and 30 kV. The amount of each clay mineral is expressed as a percentage of the total amount of clay minerals present by calculating from peak areas. The content of quartz was obtained from the quantitative curve which was made by measurement of the X-ray diffraction intensity of the standard sample of quartz.

RESULTS AND DISCUSSION

Middle Fan

Site 616

Site 616 is located on the outer flank of the middle fan lobe. The entire cored section was much finer grained than observed at the lower fan sites.

Interstitial water chemical data are presented in Table 1 and Figure 2. Of great interest are the sulfate (SO_4^{2-}) concentration values, which increase to a maximum of 36.3 m*M* at a depth of 20 m (Sample 616-3-3, 140–150 cm) and then decrease to about 20 m*M* at the base of the hole. Compared with the usual decrease resulting from sulfate reduction in other holes, the sulfate profile at this site is extraordinary. The Ca concentration increases in the upper 20 m of the hole to 20 m*M*, which is about twice that of normal seawater (Table 2). The Mg concentration is relatively constant, fluctuating between 67 and 55 m*M* throughout the hole. These values are large compared to those of normal seawater (Table 2). Chlorinity, pH, and the K^+ and Li^+ concentrations are all relatively constant. The SiO_2 is extremely variable, ranging from 0.67 m*M* to 0.15 m*M*.

Site 617

Site 617 is in a swale near the inner bend of a midfan channel meander. The cored section consists of levee-overbank deposits, characterized by thin fine-grained turbidites.

Interstitial water chemical data are shown in Table 1 and Figure 3. Chlorinity, pH, Li^+, and K^+ concentrations remain approximately constant throughout the hole. Alkalinity values are also relatively constant at 5 mEq/L, with the exception of a small maximum of 10.34 mEq/L at 11 m sub-bottom depth (Sample 617-2-2, 140–150 cm).

An interesting characteristic of the Site 617 interstitial water samples is the unusually high concentration of SO_4^{2-}, Ca^{2+}, and Mg^{2+} and the high salinity. All of these concentrations, below 21 m sub-bottom depth, are above seawater values. The sulfate is depleted within 11 m of the seafloor surface, probably a result of sulfate reduction. Sulfate concentrations average about 30 m*M* to a depth of 59 m sub-bottom, and about 37 m*M* below that depth. The maximum sulfate concentration of 38.3 m*M* at 78 m sub-bottom is about 140% of that of normal seawater (Table 2) and the highest ever recorded in DSDP samples.

Clay mineral compositions of samples taken adjacent to the interstitial water samples are shown in Figure 4. The abundance of the less than 2-μm size fraction shows little change downhole. About 40% of the clay minerals present is smectite, decreasing to a minimum of 18% at about 170 m sub-bottom. Illite and chlorite content increase slightly with depth, while kaolinite content decreases a little.

Site 620

Site 620 is in the overbank region of the middle fan, about 18 km northeast of the channel. The sediments consist mainly of terrigenous clay and mud with varying amounts of silt and fine sand interbeds.

At this site, interstitial water samples from 100 to 400 m sub-bottom depth were analyzed. Interstitial water data are shown in Table 1. Chlorinity, pH, alkalinity, and the K^+ and L^+ concentrations remain approximately constant throughout the analyzed section. The Sr^{2+}, Ca^{2+}, and Mg^{2+} concentrations remain constant to about 320 m sub-bottom and then decrease below that depth.

SO_4^{2-} concentration increases from 28 to 32 m*M* between 100 and 139 m, decreases slightly to 321 m, and then decreases rapidly to the base of the hole at 420 m sub-bottom depth.

This SO_4^{2-} profile mirrors that of salinity (Fig. 5). Salinity of interstitial water is generally higher than that of seawater from 100 to 321 m sub-bottom depth, decreasing below the depth to about 33‰.

Site 621

Site 621 is located in the middle fan channel near the deepest part of a meander bend. The recovered sediment section consists of a thin Holocene marly foraminiferal ooze, underlain by mud with some thin sandy and silty turbidites and, at the base of the hole, gravel.

Interstitial water chemical data are shown in Table 1 and Figure 6. Chlorinity and pH are nearly constant with depth. Alkalinity is highest in the near-surface sediments (22.39 mEq/L maximum at 11 m sub-bottom depth) owing to sulfate reduction. No clear reason for this maximum value can be given at this time, but further analyses of the organic matter may throw light on this matter.

Sulfate concentration decreases to about 2 m*M* within the upper 11 m of the sediment section and remains nearly constant below that depth. This indicates that sulfate reduction occurs actively only from the surface to about 11 m sub-bottom depth.

Although the data are somewhat scattered, a slight overall decrease in silica is observed downhole. Downhole changes in Ca^{2+}, K^+, Mg^{2+}, and Li^+ are all very slight, indicating that no significant postdepositional alteration involving these elements in the interstitial fluids has occurred.

Site 622

Site 622 is near the inner bend of a middle fan meander belt, one meander "downstream" from where Site 621 is located.

Interstitial water chemistry data are shown in Table 1 and Figure 7. Chlorinity, pH, Li^+, Mg^{2+}, Ca^{2+}, and K^+ concentrations all remain relatively constant throughout the sediment column. The dissolved sulfate concentration is about 1 m*M* at 7 m sub-bottom depth and gradually increases with depth to 12.7 m*M*. The sulfate reduction process is also reflected in the alkalinity maxima. Owing to the decrease of these two constituents, in-

Table 1. Interstitial water analyses, Leg 96.

Core-Section (interval in cm)	Sub-bottom depth (m)	pH	Alkalinity (mEq/L)	Salinity (‰)	Ca (mM)	Mg (mM)	Cl (‰)	SO_4 (mM)	K (mM)	Sr (ppm)	Mn (ppm)	Li (ppm)	Si (μM)
Hole 615													
Surface seawater		8.33	2.30	35.5	10.85	54.40							
1-1, 132-142	1	7.23	4.24	34.1	11.20	54.57	17.78	25.4	13.90	7.8	0.85	0.12	580
2-2, 140-150	6	6.98	8.58	34.5	12.27	56.65	17.79	22.0	10.50	8.7	0.49	0.11	335
3-2, 140-150	15	7.01	10.74	35.1	15.11	56.54	18.12	21.5	9.16	10.0	0.20	0.12	640
5-2, 140-150	33	7.08	8.28	35.5	17.25	56.81	18.11	24.6	9.35	10.4	0.24	0.12	210
6-2, 140-150	42	7.18	7.15	35.0	15.94	60.32	18.09	24.2	9.30	11.2	0.30	0.12	160
7-5, 140-150	56	7.84	7.35	35.5	16.34	56.48	—	—	—	—	—	—	—
8-1, 140-150	59	7.28	5.71	34.8	16.86	58.99	17.74	25.1	7.62	11.2	0.43	0.12	900
9-2, 140-150	70	6.98	6.90	35.5	17.73	57.01	18.26	26.0	10.21	11.2	0.33	0.12	260
11-2, 132-142	89	7.15	8.93	35.2	13.88	60.11	18.19	24.1	8.76	11.7	0.43	0.12	580
12-2, 140-150	99	7.33	10.46	35.8	14.08	58.16	18.19	25.8	10.88	12.4	0.10	0.12	250
19-1, 140-150	164	7.52	7.43	35.0	15.51	58.47	17.82	24.6	10.48	11.6	0.39	0.12	570
22-5, 132-142	198	6.88	7.58	33.9	18.09	63.41	17.38	23.0	6.65	11.5	0.33	0.13	480
23-1, 140-150	202	7.48	7.27	34.9	16.08	57.97	17.79	24.0	9.83	11.7	0.38	0.13	610
27-1, 140-150	240	7.36	6.51	35.3	16.78	54.00	18.09	23.8	11.57	12.1	0.45	0.13	290
33-1, 140-150	306	7.30	8.98	34.5	16.08	51.20	18.06	19.0	11.40	11.6	0.27	0.12	290
34-2, 140-150	317	7.44	8.88	34.0	15.73	53.47	17.94	17.0	10.99	11.6	0.42	0.12	520
38-1, 140-150	354	7.55	10.37	32.8	11.10	48.90	18.04	8.64	10.18	11.0	0.31	0.12	460
40-1, 132-142	373	7.34	12.54	31.2	11.42	46.65	18.10	5.04	9.05	11.7	0.26	0.12	650
47-1, 138-150	449	7.79	11.78	32.3	7.34	44.31	18.32	2.78	8.82	13.9	0.21	0.12	270
49-2, 138-150	479	7.39	7.66	31.8	6.60	39.75	18.14	2.78	12.59	24.9	0.00	0.13	190
50-2, 138-150	488	7.44	6.95	32.1	6.35	39.47	17.94	3.54	11.85	25.0	0.00	0.13	370
52-1, 132-144	506	7.70	6.26	32.2	6.74	44.39	17.68	6.54	9.77	11.0	0.26	0.12	170
Hole 616													
Surface seawater		8.23	2.33	35.5									
1-1, 140-150	1	6.85	5.95	35.0	7.78	—	17.83	29.4	11.78	8.3	0.62	0.13	400
2-3, 140-150	11	6.65	11.31	36.2	18.44	62.03	17.75	33.3	8.76	9.8	0.29	0.14	280
3-3, 140-150	20	6.64	11.53	36.8	19.90	63.34	17.84	36.25	8.97	10.2	0.29	0.14	540
4-1, 140-150	27	6.86	12.04	36.1	17.60	64.76	17.60	34.35	8.80	10.5	0.16	0.15	260
5-3, 140-150	39	6.76	13.15	36.3	18.62	66.95	18.16	34.64	8.54	9.3	0.32	0.15	360
6-1, 140-150	46	6.73	12.70	36.2	18.40	66.37	17.98	34.81	8.83	9.6	0.49	0.15	590
7-4, 138-150	60	6.89	11.36	36.2	18.58	65.61	17.77	34.01	8.95	9.9	0.72	0.15	310
8-1, 138-150	65	6.85	8.76	36.1	20.33	62.40	18.05	33.45	9.98	10.6	0.66	0.14	240
9-3, 138-150	77	7.07	9.11	36.1	20.95	55.94	17.81	32.65	9.03	11.5	0.27	0.14	350
10-2, 138-150	86	6.66	9.55	36.1	20.44	63.47	17.96	32.37	8.01	11.4	0.28	0.14	260
11-2, 138-150	95	6.86	7.77	35.8	19.24	62.07	17.64	31.85	8.39	11.8	0.42	0.14	260
16-2, 138-150	145	7.18	6.86	35.1	18.49	62.17	17.54	27.90	6.90	11.7	0.31	0.13	180
17-2, 138-150	155	6.81	9.03	35.5	17.82	55.12	18.21	23.50	10.66	12.3	0.38	0.12	280
18-1, 138-150	164	7.27	9.26	35.5	—	55.13	18.31	22.59	12.48	12.3	0.20	0.12	370
21-3, 66-78	194	7.19	6.13	35.5	17.63	57.93	18.13	26.62	9.98	11.8	0.61	0.12	460
24-1, 138-150	249	6.86	7.17	35.9	16.32	56.99	18.36	26.86	10.38	12.6	0.92	0.13	670
28-1, 138-150	307	7.17	10.89	34.9	15.44	59.75	17.74	23.33	7.26	11.6	0.22	0.14	370
30-2, 138-150	327	7.06	7.55	34.9	18.44	60.29	17.69	23.96	6.64	11.8	0.42	0.13	530
32-2, 138-150	346	7.23	9.00	33.9	16.68	60.32	17.30	20.89	6.51	11.7	0.39	0.13	150
33-2, 138-150	354	6.90	8.38	35.0	17.19	62.74	17.95	20.67	6.63	11.6	0.41	0.14	300
34-2, 138-150	365	7.03	9.13	32.5	16.72	60.77	17.31	19.81	6.58	11.3	0.30	0.13	300
Hole 617													
Surface seawater		8.26	2.34	35.4	10.62								
1-2, 140-150	3	6.57	6.03	34.1	10.95	53.65	17.86	23.92	11.38	8.0	0.73	0.12	240
2-2, 140-150	11	6.85	10.34	35.0	14.93	58.32	17.93	27.01	8.14	9.2	0.39	0.14	130
3-2, 140-150	21	6.75	7.83	35.8	19.02	60.17	17.98	29.95	7.35	10.4	0.38	0.14	330
4-2, 138-150	30	6.84	7.37	35.8	22.09	59.85	17.87	30.66	8.36	10.4	0.46	0.14	140
5-3, 140-150	41	7.18	5.55	36.0	21.87	57.76	18.15	31.45	9.70	11.1	0.30	0.14	140
6-3, 138-150	51	7.18	5.62	35.9	22.23	60.74	17.82	30.89	8.17	12.0	0.39	0.14	190
7-2, 138-150	59	6.85	5.39	35.5	19.09	58.42	18.07	30.67	8.40	11.7	0.47	0.13	180
8-3, 138-150	70	7.11	5.54	35.9	19.28	59.71	18.25	38.12	8.39	12.0	0.49	0.13	190
9-2, 138-150	78	7.45	4.70	35.5	20.95	60.11	17.85	38.78	8.41	12.1	0.52	0.13	140
10-3, 82-94	88	6.96	6.05	35.2	20.04	62.54	17.42	38.08	7.16	12.3	0.49	0.13	190
11-2, 138-150	97	6.90	5.63	35.8	20.94	59.28	—	37.77	8.46	12.0	0.40	0.13	570
12-2, 138-150	107	7.23	5.67	35.8	17.96	59.40	18.03	37.71	8.15	11.9	0.42	0.13	360
14-2, 138-150	126	7.07	5.50	35.8	19.24	64.45	17.74	36.68	7.71	12.3	0.35	0.13	310
15-2, 138-150	135	6.93	5.87	35.9	19.88	60.44	17.97	36.32	7.23	12.3	0.44	0.13	180
17-2, 138-150	154	7.22	5.09	36.0	23.62	59.24	18.10	36.18	7.91	12.6	0.42	0.14	320
18-2, 138-150	164	6.86	5.20	35.7	20.15	56.10	18.16	34.44	8.95	12.4	0.39	0.13	190
20-2, 138-150	184	7.55	4.50	35.8	22.12	56.84	19.35	33.81	8.67	12.5	0.38	0.13	160
Hole 618													
Surface seawater		7.96	2.42	35.4									
1-1, 0-2	0	7.23	3.93	237.0	26.77	42.95							
1-2, 140-150	3	6.54	7.56	220.0	22.82	59.12	119.2	12.9	15.45	9.9	0.51	0.23	150
2-4, 140-150	12	7.42	21.54	119.7	7.81	45.55	70.15	4.51	14.18	9.9	0.18	0.19	120
3-2, 140-150	19	7.41	19.64	100.2	6.90	39.78	57.49	1.43	12.75	10.2	0.19	0.17	280
4-2, 140-150	29	7.59	11.65	57.0	10.48	49.39	55.50	2.26	9.89	12.0	0.25	0.14	280
5-5, 140-150	43	7.72	8.08	47.8	10.19	58.99	27.54	1.78	10.93	12.2	0.08	0.14	270
6-3, 140-150	49	7.54	8.46	50.1	10.70	47.71	29.13	1.21	11.52	14.4	0.10	0.17	240
7-1, 188-150	52	7.52	8.49	50.0	10.15	50.26	28.55	1.17	11.05	12.7	0.17	0.14	270
8-1, 140-150	58	7.67	7.38	50.1	8.62	46.92	28.66	1.49	10.87	12.6	0.16	0.14	270
9-2, 138-150	73	7.74	7.25	55.8	10.73	53.62	31.25	0.90	11.83	13.6	0.16	0.14	240
10-2, 135-150	77	7.72	9.92	54.0	8.73	51.65	30.64	0.74	10.82	13.1	0.15	0.14	340
11-1, 135-150	91	8.17	6.46	50.2	4.38	47.03	29.54	0.62	14.14	10.2	0.06	0.14	160
Hole 618A													
1-1, 5-20	9	7.63	19.31	128.4	6.53	47.81	66.40	1.32	15.35	10.1	0.19	0.19	200
1-3, 135-150	14	7.43	20.31	110.2	7.58	46.03	72.19	3.52	13.72	9.9	0.15	0.18	130
2-2, 130-150	31	7.54	10.67	46.1	9.46	50.68	28.28	1.92	9.96	12.0	0.15	0.13	190
3-3, 124-139	42	7.79	8.66	42.1	9.50	50.09	23.05	1.78	9.13	10.6	0.07	0.13	270

Table 1 (continued).

Core-Section (interval in cm)	Sub-bottom depth (m)	pH	Alkalinity (mEq/L)	Salinity (‰)	Ca (mM)	Mg (mM)	Cl (‰)	SO_4 (mM)	K (mM)	Sr (ppm)	Mn (ppm)	Li (ppm)	Si (μM)
Hole 619													
Surface seawater		8.13	2.47	34.2									
1-6, 138-150	10	7.04	8.47	34.5	13.36	58.91	18.04	23.0	10.76	7.8	0.00	0.12	310
3-5, 138-150	18	6.99	6.94	34.8	12.74	57.78	18.03	21.1	11.05	8.1	0.75	0.12	160
4-4, 138-150	26	6.76	5.89	34.5	14.34	56.42	18.08	19.7	10.01	8.7	0.58	0.13	180
5-3, 138-150	34	6.83	5.69	34.2	14.97	56.88	18.03	17.7	8.56	8.7	0.64	0.12	180
6-2, 138-150	43	6.77	4.94	33.8	13.32	54.66	18.06	14.6	8.28	8.2	0.38	0.12	180
7-2, 138-150	52	6.82	6.17	32.6	12.89	50.62	18.21	9.06	7.60	7.9	0.31	0.12	140
8-2, 135-150	62	6.90	6.83	32.2	11.94	51.09	18.68	3.18	7.17	8.6	0.28	0.12	330
9-2, 135-150	72	7.01	6.21	32.0	12.07	46.73	18.30	1.04	6.62	9.6	0.29	0.12	150
10-2, 135-150	76	7.02	5.37	32.0	10.82	42.67	18.44	1.07	6.64	8.8	0.24	0.12	110
11-2, 135-150	91	7.26	5.47	32.0	9.57	50.20	18.46	1.28	7.61	8.0	0.19	0.12	110
12-2, 135-150	101	7.48	6.35	32.1	7.85	43.59	18.30	1.17	8.42	7.5	0.45	0.12	120
13-2, 135-150	110	7.29	5.24	32.0	7.50	43.45	18.25	1.99	9.35	7.5	0.37	0.13	170
14-1, 135-150	118	7.35	5.76	32.2	6.80	43.43	18.35	2.05	9.59	7.3	0.18	0.12	190
15-2, 135-150	129	7.50	2.98	32.1	5.39	41.34	18.31	0.88	10.87	7.1	0.19	0.12	150
16-2, 135-150	139	7.62	7.19	32.2	5.35	43.04	18.45	1.80	10.33	7.3	0.51	0.12	260
17-2, 135-150	149	7.78	7.59	32.2	5.16	43.26	18.38	2.00	9.98	7.4	0.17	0.12	150
18-2, 112-127	158	7.82	7.55	32.1	—	—	18.38	1.82	9.12	7.4	0.10	0.12	160
19-1, 135-150	167	7.51	7.59	32.3	—	—	18.43	3.03	10.48	7.5	0.07	0.12	210
20-2, 135-150	178	7.65	6.80	32.3	—	—	18.69	1.83	9.54	7.4	0.08	0.11	180
22-1, 135-150	189	7.89	4.38	32.6	6.06	43.93	18.96	1.63	12.02	7.6	0.08	0.12	120
Hole 620													
Surface seawater		8.21	2.31	35.2	10.63	57.07							
13-2, 135-150	111	6.56	5.94	36.1	21.18	64.13	18.12	27.86	6.01	12.4	0.00	0.14	160
14-1, 135-150	118	6.71	6.55	36.2	20.91	67.97	18.16	28.95	7.73	12.5	—	0.14	180
16-2, 135-150	139	6.73	5.16	36.0	19.81	63.63	17.86	32.12	8.19	12.2	—	0.14	200
18-5, 135-150	163	7.13	6.54	36.1	20.08	64.44	18.35	32.11	8.59	11.9	—	0.14	110
21-1, 135-150	185	7.14	4.13	35.2	19.50	64.18	17.72	31.49	4.67	12.4	—	0.13	150
23-3, 135-150	207	6.69	4.64	36.0	20.12	60.36	18.28	31.38	8.19	12.2	—	0.14	170
25-5, 135-150	229	6.60	4.38	35.8	20.01	62.10	18.08	30.84	8.90	12.4	—	0.13	170
28-6, 135-150	259	7.01	4.55	35.6	12.93	66.28	18.24	27.82	9.34	12.0	—	0.13	120
31-1, 135-150	281	7.17	4.55	35.7	17.94	65.80	18.21	27.78	8.99	11.0	—	0.13	260
33-3, 135-150	303	7.01	5.73	35.5	18.80	61.32	18.18	27.53	8.76	11.4	—	0.14	110
35-2, 135-150	321	7.06	4.83	35.5	20.67	61.64	18.29	26.07	7.93	11.8	—	0.13	260
40-3, 135-150	370	6.87	3.76	32.5	15.24	47.49	18.00	14.98	6.23	9.0	—	0.12	140
44-4, 135-150	409	6.99	4.20	33.8	11.06	52.82	18.18	14.04	8.21	8.1	—	0.12	280
Hole 621													
Surface seawater		8.31	2.38	35.1									
1-2, 138-150	3	7.21	9.94	33.9	8.67	52.55	17.90	17.80	13.00	7.2	—	0.12	290
2-5, 138-150	11	7.41	22.39	32.4	8.09	50.84	17.84	2.16	8.61	8.6	—	0.12	230
3-5, 138-150	21	7.06	12.62	32.0	6.10	50.29	17.96	1.61	7.28	9.3	—	0.12	280
4-4, 140-150	29	7.01	9.08	32.1	6.29	51.43	18.09	1.04	7.02	9.6	—	0.12	240
5-3, 128-140	37	7.06	8.11	32.0	7.54	50.48	18.16	0.79	6.91	10.0	—	0.12	190
6-2, 138-150	45	7.18	9.76	32.0	7.46	50.62	18.11	2.44	6.50	11.0	—	0.12	180
7-4, 138-150	52	7.03	11.23	32.5	8.21	50.96	18.19	3.68	6.58	11.0	—	0.12	250
8-2, 138-150	59	7.18	15.77	32.2	7.82	53.15	17.95	0.93	—	10.9	—	0.12	150
9-4, 140-150	66	6.71	15.27	32.2	7.46	52.30	17.76	0.93	5.90	10.9	—	0.12	160
10-3, 129-143	70	7.11	16.00	32.3	7.66	49.21	17.70	0.74	6.36	10.7	—	0.12	140
11-1, 138-150	73	7.36	12.44	33.0	7.74	52.39	17.91	2.85	6.81	10.6	—	0.12	110
12-3, 0-14	82	7.22	14.92	32.3	7.42	50.16	17.89	0.83	6.18	11.1	—	0.12	140
13-1, 128-140	82	7.36	10.75	33.0	8.17	52.97	17.91	0.97	6.63	11.2	—	0.12	230
14-2, 135-150	90	7.02	11.11,	32.3	8.05	53.19	18.23	4.26	6.29	10.8	—	0.12	200
15-2, 138-150	97	7.36	10.62	32.0	7.23	47.71	18.05	2.93	6.67	10.4	—	0.12	280
16-2, 135-150	103	7.19	10.12	31.9	6.17	45.44	17.92	3.20	7.17	9.2	—	0.12	290
17-1, 135-150	106	7.36	8.76	31.9	6.25	47.75	17.70	2.70	6.68	9.5	—	0.12	210
19-2, 135-150	127	7.69	4.12	31.9	6.53	45.96	18.18	2.63	8.27	8.7	—	0.12	160
20-1, 135-150	129	7.56	5.24	31.5	5.55	47.63	17.79	2.67	6.77	9.0	—	0.12	140
21-2, 85-100	133	7.30	4.80	31.0	7.35	48.48	17.94	1.34	6.14	9.2	—	0.12	290
23-1, 135-150	139	7.26	4.68	32.0	7.44	48.05	18.03	2.23	6.51	9.1	—	0.12	280
25-1, 135-150	158	7.70	4.62	31.8	6.80	32.67	17.99	2.04	9.26	8.9	—	0.12	170
27-1, 135-150	177	7.24	7.10	32.2	8.42	46.19	18.33	2.46	8.85	10.2	—	0.12	200
Hole 622													
Surface seawater		8.18	2.36	35.1									
2-2, 135-150	6	7.25	14.99	33.8	8.10	51.14	18.02	0.96	10.80	8.0	—	0.12	360
4-3, 135-150	27	7.17	9.27	32.0	5.91	50.38	18.15	1.04	6.54	9.6	—	0.12	220
6-3, 127-142	46	7.06	10.79	32.2	7.12	50.84	18.09	2.17	5.98	10.3	—	0.12	290
8-2, 135-150	64	6.91	13.98	32.2	6.32	51.62	17.92	2.27	5.88	10.6	—	0.12	300
9-2, 135-150	73	6.94	12.17	31.9	6.39	50.53	18.04	1.23	5.93	10.8	—	0.12	300
11-3, 135-150	103	7.40	6.05	32.0	7.19	48.37	18.05	3.41	6.92	9.5	—	0.12	350
13-3, 135-150	117	7.30	12.93	32.1	7.67	51.21	18.08	3.07	6.25	9.4	—	0.12	340
15-4, 135-150	129	7.65	13.24	32.1	7.70	47.49	18.27	3.96	8.03	9.6	—	0.13	340
17-1, 135-150	144	7.07	12.68	33.5	11.92	50.19	18.32	8.84	9.52	11.2	—	0.13	370
23-1, 135-150	180	7.13	9.03	33.9	4.80	50.52	18.14	12.67	9.77	11.0	—	0.13	210
Hole 623													
Surface seawater		8.15	2.25	35.8	9.82								
1-3, 135-150	4	6.70	6.60	34.9	12.34	56.73	17.97	26.88	10.83	7.9	—	0.13	300
3-2, 135-150	19	6.69	11.23	35.9	9.60	63.06	18.08	28.64	8.08	9.6	—	0.15	260
5-2, 135-150	38	7.21	9.50	36.0	9.56	62.23	18.05	30.03	7.64	10.00	—	0.15	350
7-2, 135-150	58	6.96	6.33	35.3	8.83	62.65	18.09	30.34	6.80	11.5	—	0.14	260
9-5, 0-15	80	6.65	4.93	35.9	7.76	57.43	18.20	30.25	9.76	11.1	—	0.14	200
11-3, 135-150	97	7.05	8.08	35.2	9.56	61.85	17.95	29.76	7.33	11.3	—	0.15	240
14-2, 135-150	124	6.76	6.55	35.5	7.96	60.13	17.95	29.33	8.05	11.0	—	0.14	210
17-3, 1-15	152	7.09	6.89	35.2	7.01	55.38	18.25	27.67	11.14	11.2	—	0.14	250

Note: pH, salinity, chlorinity, alkalinity, and Ca were analyzed by Ishizuka on board the *Glomar Challenger*. Dash means not determined.

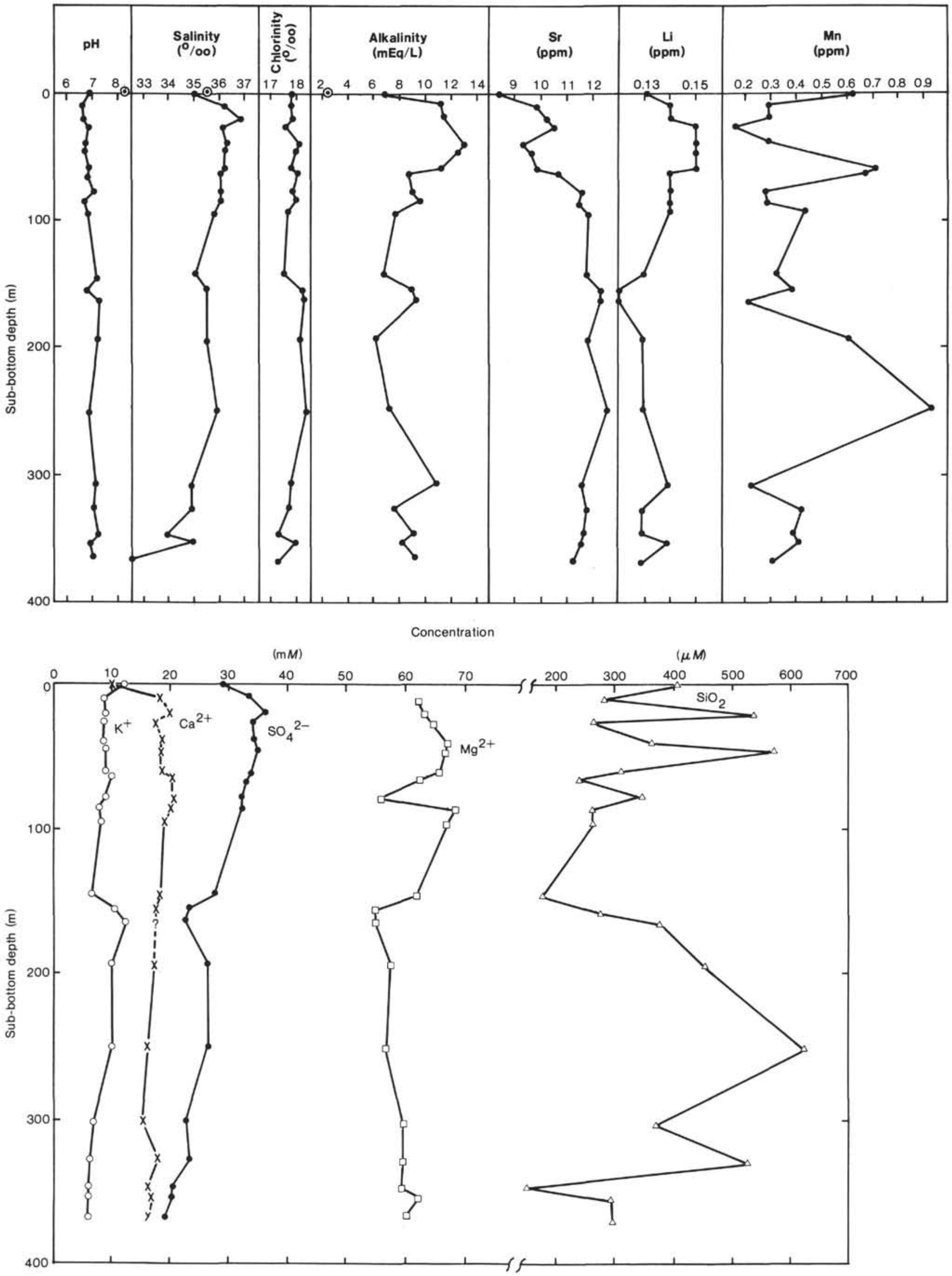

Figure 2. Interstitial water chemistry at Site 616. Data given in Table 1. ⊙ = surface seawater.

Table 2. The major element composition of normal seawater.[a]

Ion	Concentration at S = 35‰ (m*M*)
Cl^-	545.91
SO_4^{2-}	28.23
Br^-	0.842
F^-	0.0684
B	0.416
Na^+	468.47
Mg^{2+}	53.06
Ca^{2+}	10.28
K^+	10.20
Sr^{2+}	0.0901

[a] From Wilson (1975).

terstitial water salinity in that interval is also lower than that of surface seawater by about 3‰.

Lower Mississippi Fan

Site 615

Site 615 is on the western levee of the central channel in the lower fan. The sediments are dominantly graded sands, silts, and muds containing displaced fauna. The major mode of sediment emplacement was by turbidity currents.

The interstitial water data are shown in Table 1 and in Figure 8. Chlorinity and pH are nearly constant with depth.

The SO_4^{2-} concentration decreases to about 25 m*M* within the upper 1 m, remains approximately constant to 240 m, then decreases below that depth. Sulfate reduction appears to occur mainly below 200 m and results in the minimum value of 2.78 m*M* observed at 449 and 479 m sub-bottom depth, which is a tenth the sulfate concentration of normal seawater (Table 2).

The Mg^{2+} concentration remains constant within the upper 200 m of sediments, below which it decreases to the base of the hole. The Ca concentration increases downhole to 17 m*M* within the upper 50 m of sediments, remains constant between 50 and 300 m sub-bottom, and then decreases below normal seawater (Table 2) values below 300 m. These distributions of dissolved calcium and magnesium suggest diagenetic reaction below 300 m sub-bottom, probably related to the reduction of clay minerals or the formation of Mg-rich carbonate.

Salinity remains almost constant to 200 m sub-bottom, decreases rapidly between 200 and 380 m, and then again remains approximately constant to the base of the hole. The salinity profile is roughly similar to those of Mg^{2+}, SO_4^{2-}, and Ca^{2+}. The calculation of ion species concentration by charge balance considerations indicates that no significant net concentration change occurs in Na^+.

Alkalinity shows a variable distribution, with a maximum between 400 and 500 m sub-bottom and, below that maximum, decreases in value toward the base of the hole.

Of great interest at this site are the dissolved Sr and Mn values. Both values are related to the lithology. Dissolved Mn minima (almost 0 m*M*) occur in the nannofossil foraminifer ooze in Ericson Zone X (Ericson and Wollin, 1968; Cores 615-48 through 615-51). On the contrary, dissolved Sr indicates a maximum value within the same zone. This increase in dissolved Sr from 400 m to 520 m sub-bottom appears to be related to carbonate recrystallization and diffusive processes. Subsequent investigations of the solids may reveal the cause of these observations.

Dissolved silica shows a highly variable distribution ranging from 0.2 to 0.9 m*M* downhole.

Clay mineral compositions of samples taken adjacent to the interstitial water samples are shown in Figure 9. The overall percentage of the less than 2-μm size fraction is highly variable, ranging from 0 to 55%. Chlorite, illite, and kaolinite percentages all increase with depth at the expense of smectite. The smectite content is particularly low within the carbonate oozes of Ericson Zone X (from 485 to 514 m sub-bottom depth).

Site 623

Site 623 is located in the transitional area between the middle and lower fan areas. Hole 623 was drilled through the edge of a buried channel. Interstitial water data show only relatively minor change in pH, salinity, and chlorinity (Table 1, Fig. 10). This suggests that little reaction that would affect the chemical composition of the interstitial solution has been occurring in these sediments.

Intraslope Basins

Site 618

Orca Basin is an interdomal type of intraslope basin and contains a hypersaline anoxic layer of bottom water (introductory chapter, this volume). Site 618 is located in this basin near the center of the northern sub-basin at a water depth of about 2420 m. Hole 618 was cored to a depth of 92.5 m.

The interstitial water data are shown in Table 1 and Figure 11. Chlorinity concentration of the interstitial water decreases from 118 to about 30‰ at a sub-bottom depth of 40 m, below which it is approximately constant. This downhole trend is similar to that for salinity. It is clear from paleontological evidence (Site 618 chapter, this volume) that the salt diapirs forming Orca Basin have actively risen and that salt cropped out at the seafloor during the Holocene, as the dramatic increase in salinity begins at that time.

The Ca concentration of the interstitial water at Site 618 is 2.5 times greater than that of normal seawater and the Mg and K concentrations are approximately equal to those of seawater (Table 2). Sulfate concentration of the interstitial water is about half that of seawater (Table 2) in the surface sediment, but decreases to about 1 to 2 m*M* below about 20 m sub-bottom. K^+ concentration is similar to that of seawater. Those results indicate that the hypersaline interstitial water originates from dissolution of the salt dome.

Alkalinity is 7.6 mEq/L in the upper 3 m of sediment and suddenly increases to a maximum of 21.5 mEq/L at

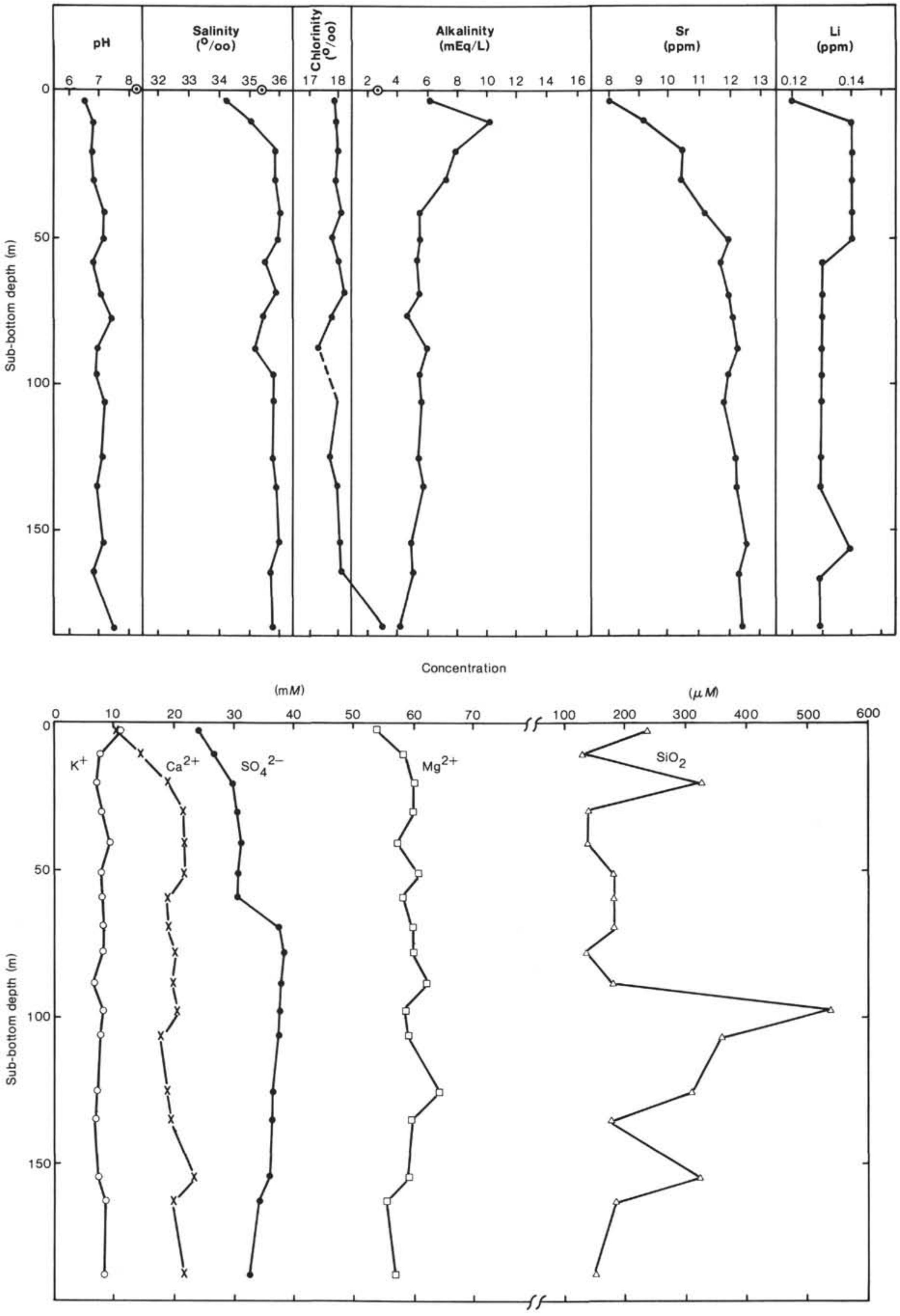

Figure 3. Interstitial water chemistry at Site 617. Data given in Table 1. ⊙ = surface seawater.

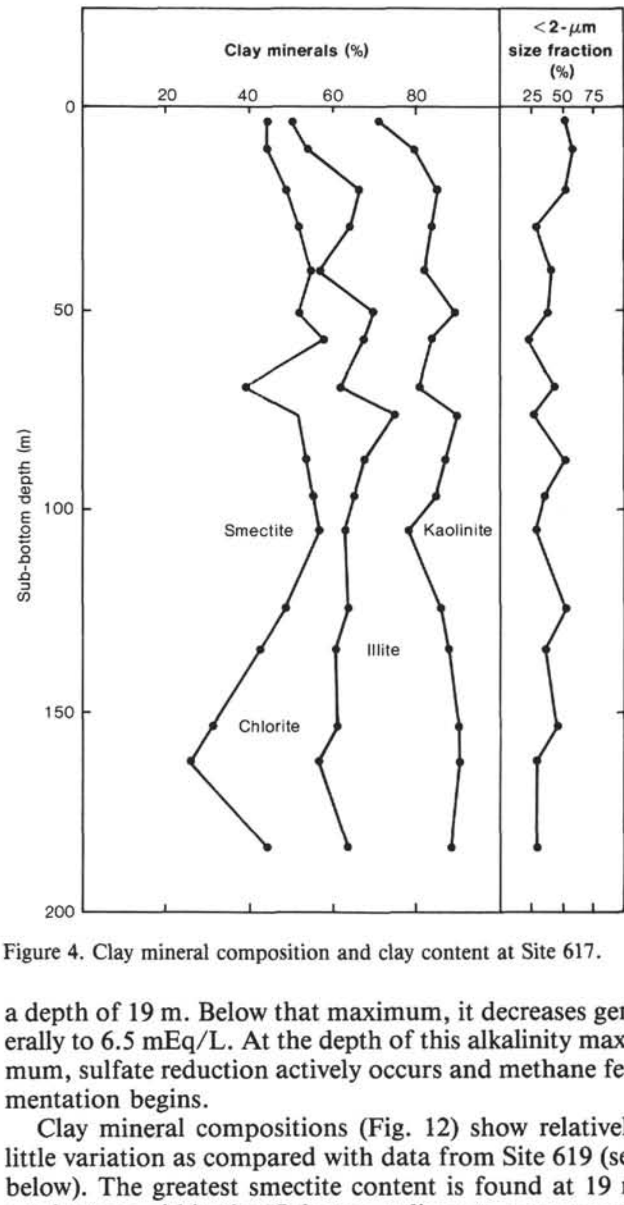

Figure 4. Clay mineral composition and clay content at Site 617.

a depth of 19 m. Below that maximum, it decreases generally to 6.5 mEq/L. At the depth of this alkalinity maximum, sulfate reduction actively occurs and methane fermentation begins.

Clay mineral compositions (Fig. 12) show relatively little variation as compared with data from Site 619 (see below). The greatest smectite content is found at 19 m sub-bottom within the Holocene sediments, corresponding to the interval with the lowest illite and chlorite contents. The minimum smectite content is found at 52 m sub-bottom, corresponding to the level of greatest chlorite content. Illite is also abundant at that depth. It is suggested, by comparison of the clay mineralogy of samples of Sites 618 and 619, that the two sites were located in different sedimentological environments during the late Pleistocene.

Site 619

Site 619 is located near the center of Pigmy Basin, a blocked-canyon intraslope basin on the middle continental slope off Louisiana (introductory chapter, this volume).

Interstitial water chemical data are shown in Table 1 and Figure 13. Chlorinity increases slightly with depth. Salinity decreases to a sub-bottom depth of 70 m, coincident with the decrease in sulfate content. Salinity and sulfate concentrations are both relatively constant (32‰ and 2 m*M*, respectively) below that depth. These low salinity values result from a decrease in the sulfate, Mg^{2+}, and Ca^{2+} concentrations with depth. Alkalinity is relatively constant, ranging from 5 to 8 mEq/L throughout the sediment column. The ratio of salinity to chlorinity is larger than that of seawater.

Clay mineral compositions of sediment samples taken adjacent to the interstitial water samples are shown in Figure 14. Illite concentration does not vary as greatly as the other clay minerals and shows an inverse relationship to smectite percentage. Smectite content is greatest in the Holocene and indicates numerous fluctuations within the Pleistocene sediments. Smectite content decreases to 34 m sub-bottom depth, remains rather constant to 76 m sub-bottom, and increases downward to the total depth of the hole.

Kaolinite percentages vary inversely with chlorite. Like illite, chlorite content shows an inverse relationship to smectite content and fluctuates greatly within the upper part of the Pleistocene section cored. The weight percentage of the <2-μm clay fraction ranges from 65 to 32%, averaging 46%.

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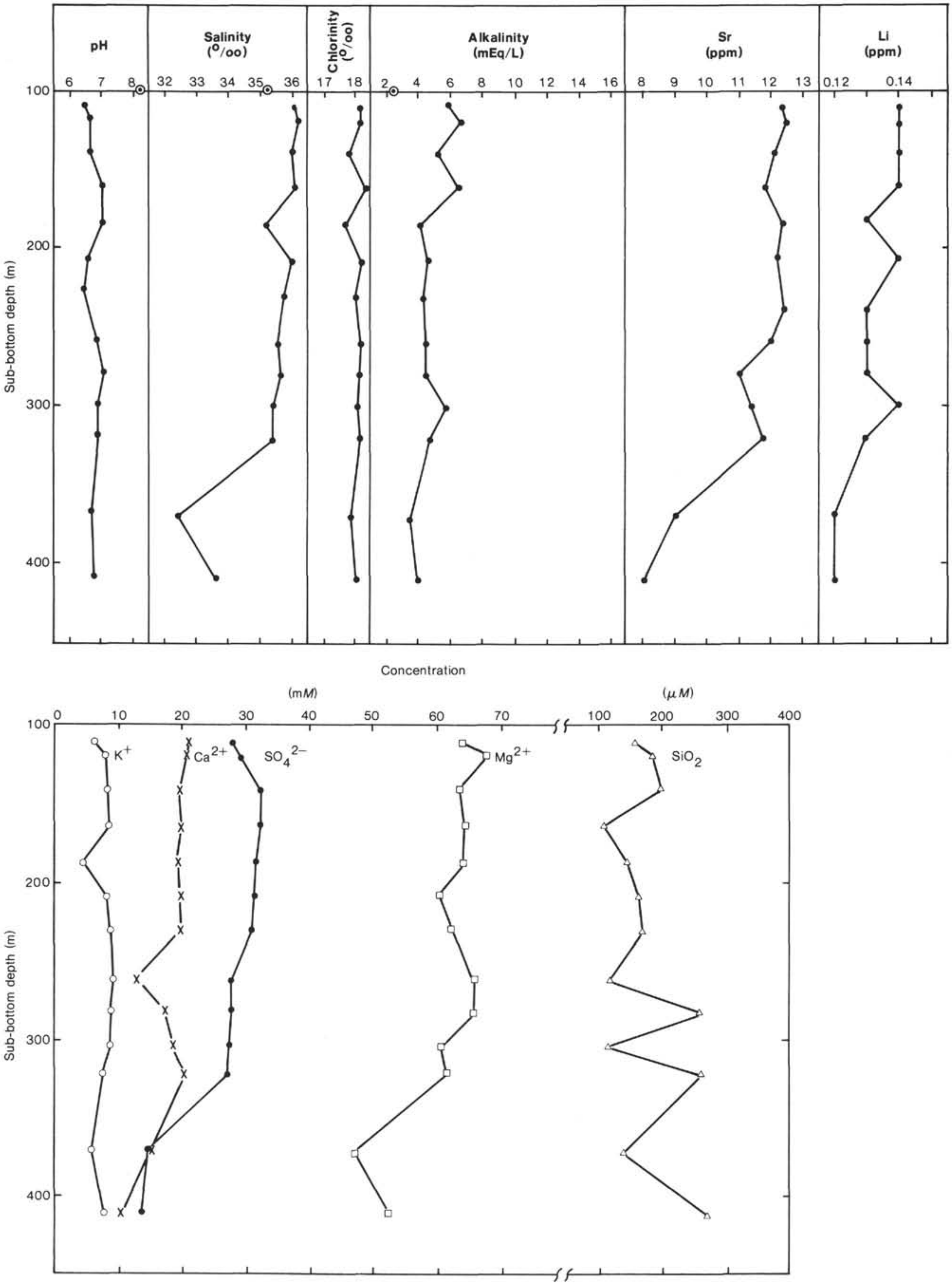

Figure 5. Interstitial water chemistry at Site 620. Data given in Table 1. ⊙ = surface seawater.

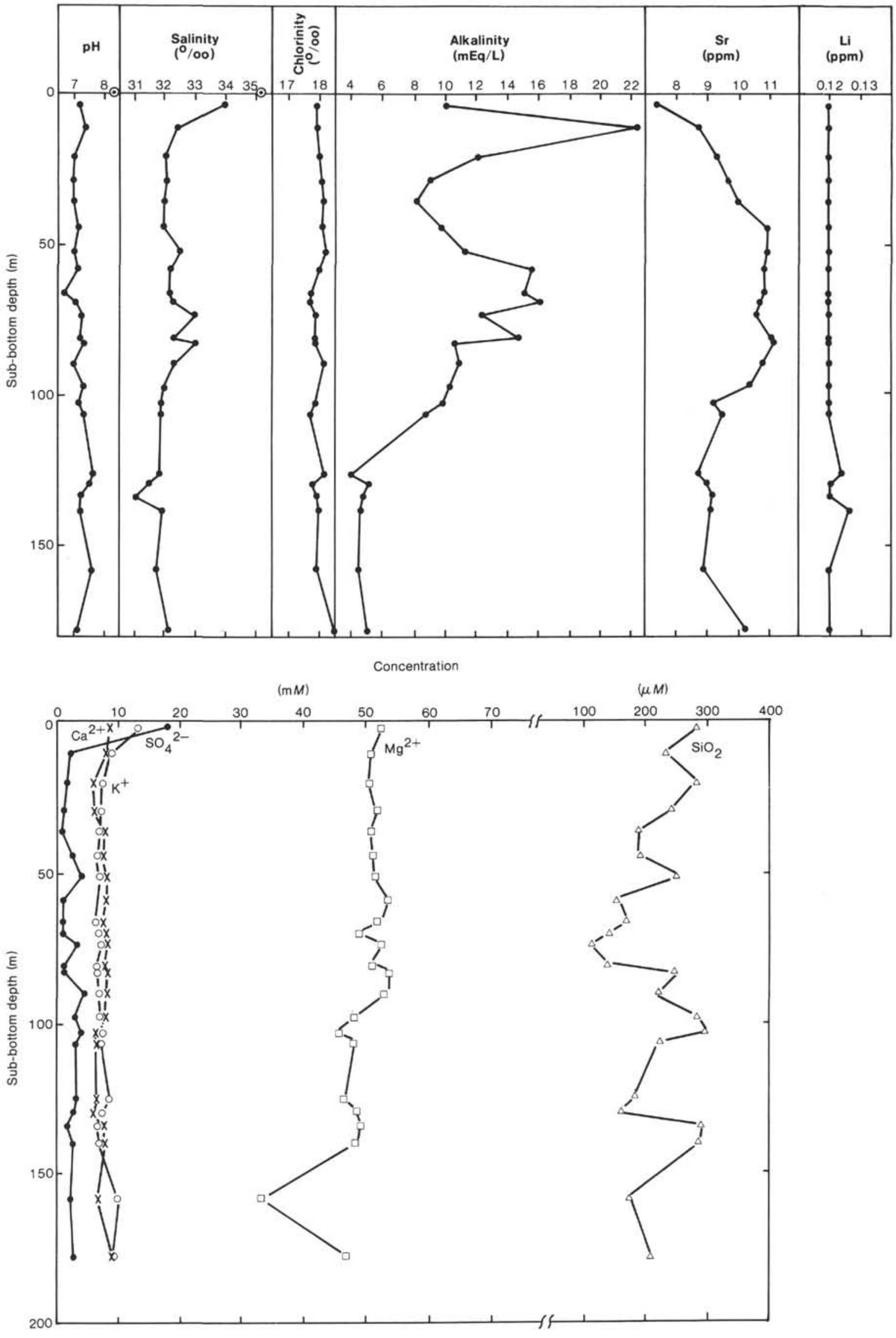

Figure 6. Interstitial water chemistry at Site 621. Data given in Table 1. ⊙ = surface seawater.

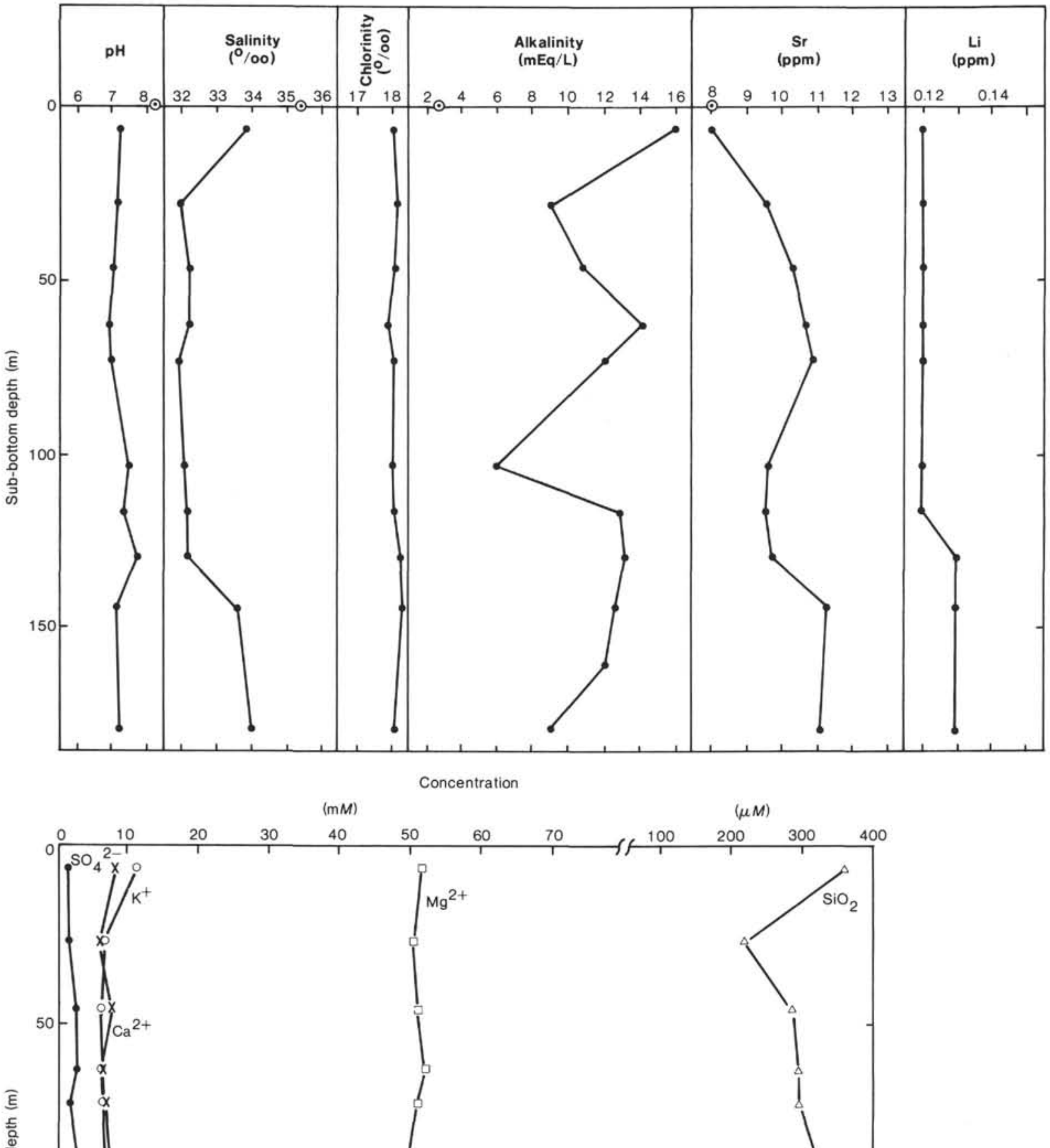

Figure 7. Interstitial water chemistry at Site 622. Data given in Table 1. ⊙ = surface seawater.

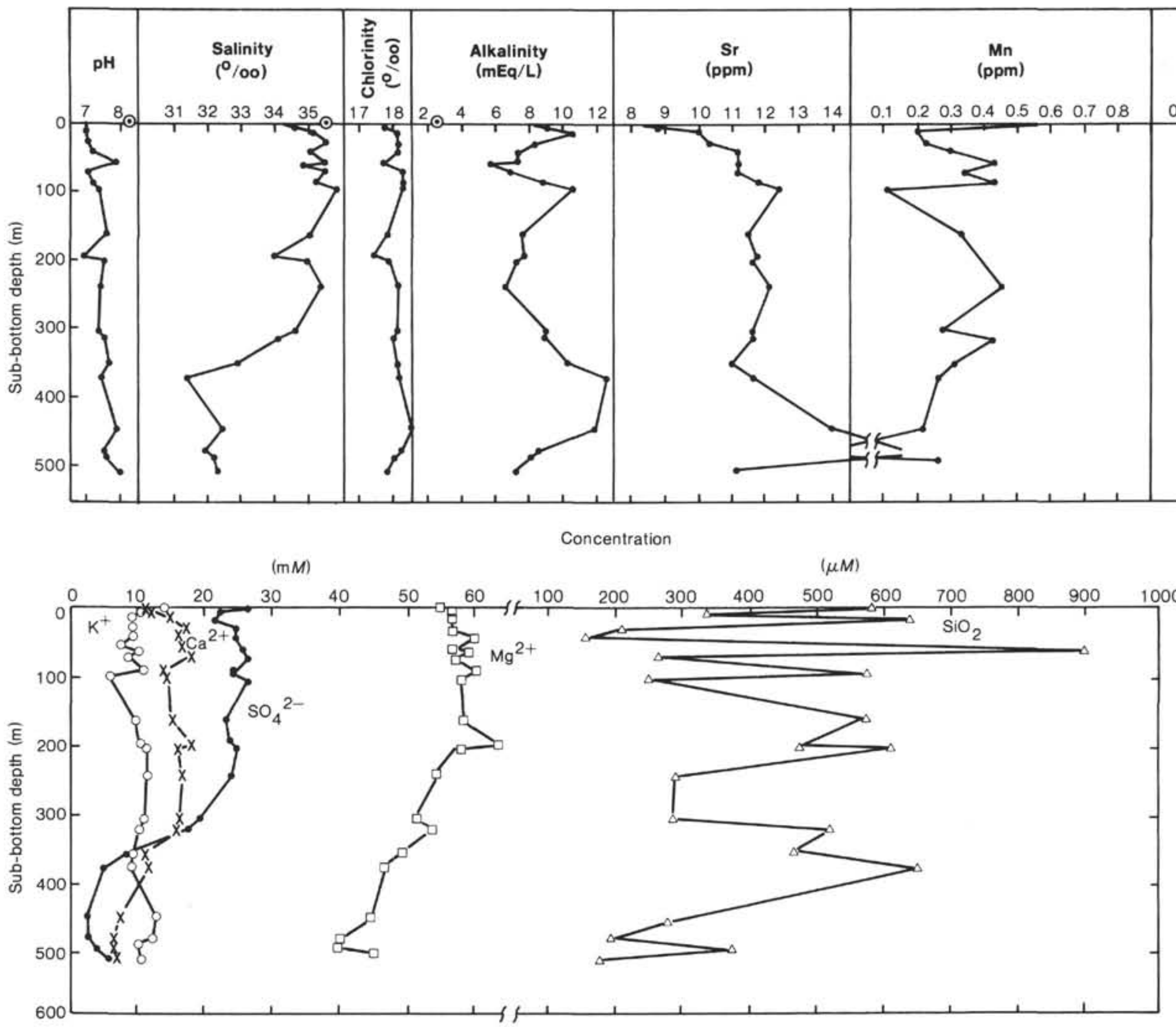

Figure 8. Interstitial water chemistry at Site 615. Data given in Table 1. ⊙ = surface seawater.

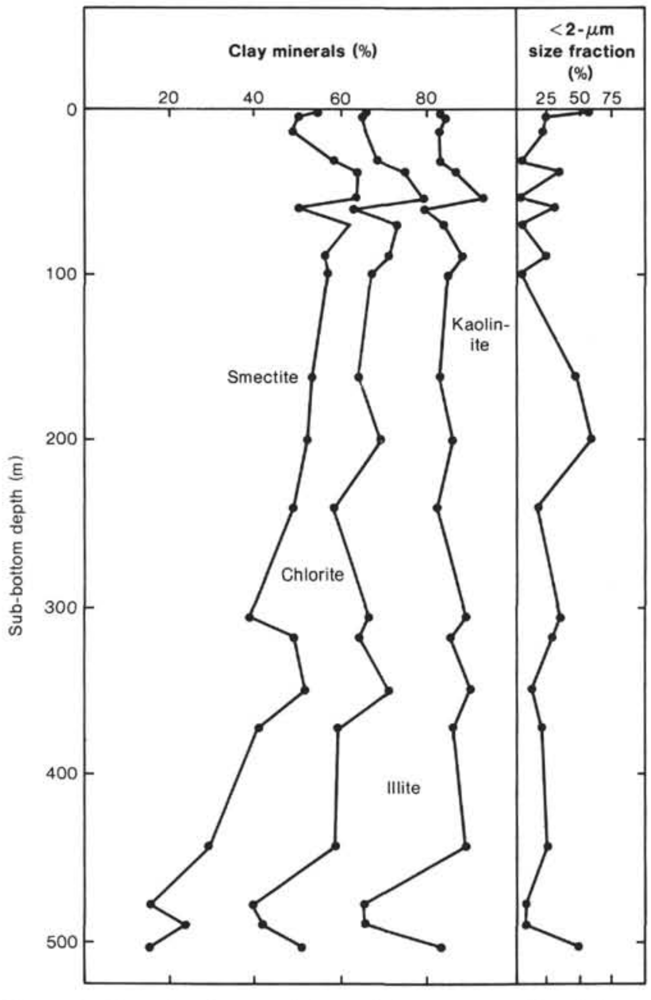

Figure 9. Clay mineral composition and clay content at Site 615.

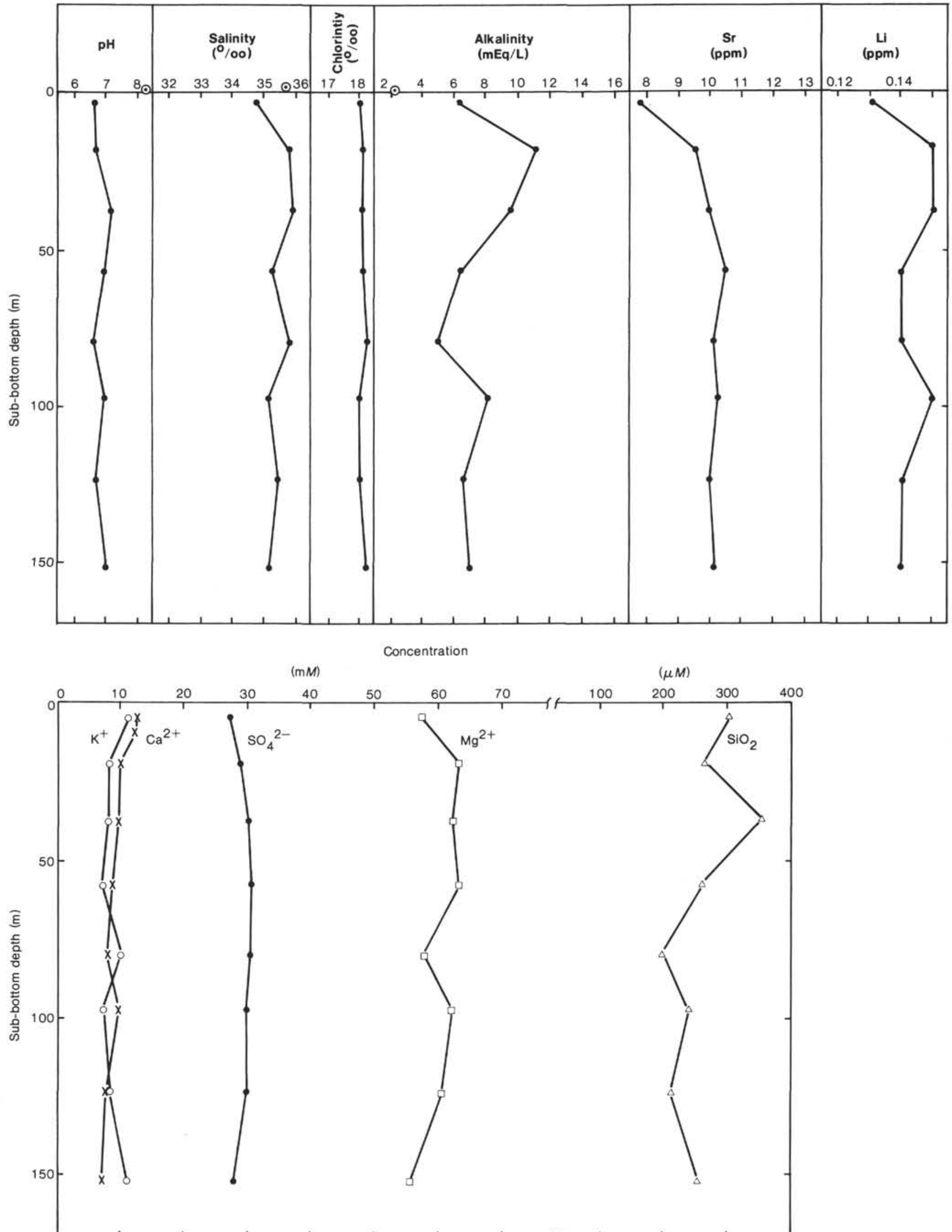

Figure 10. Interstitial water chemistry at Site 623. Data given in Table 1. ⊙ = surface seawater.

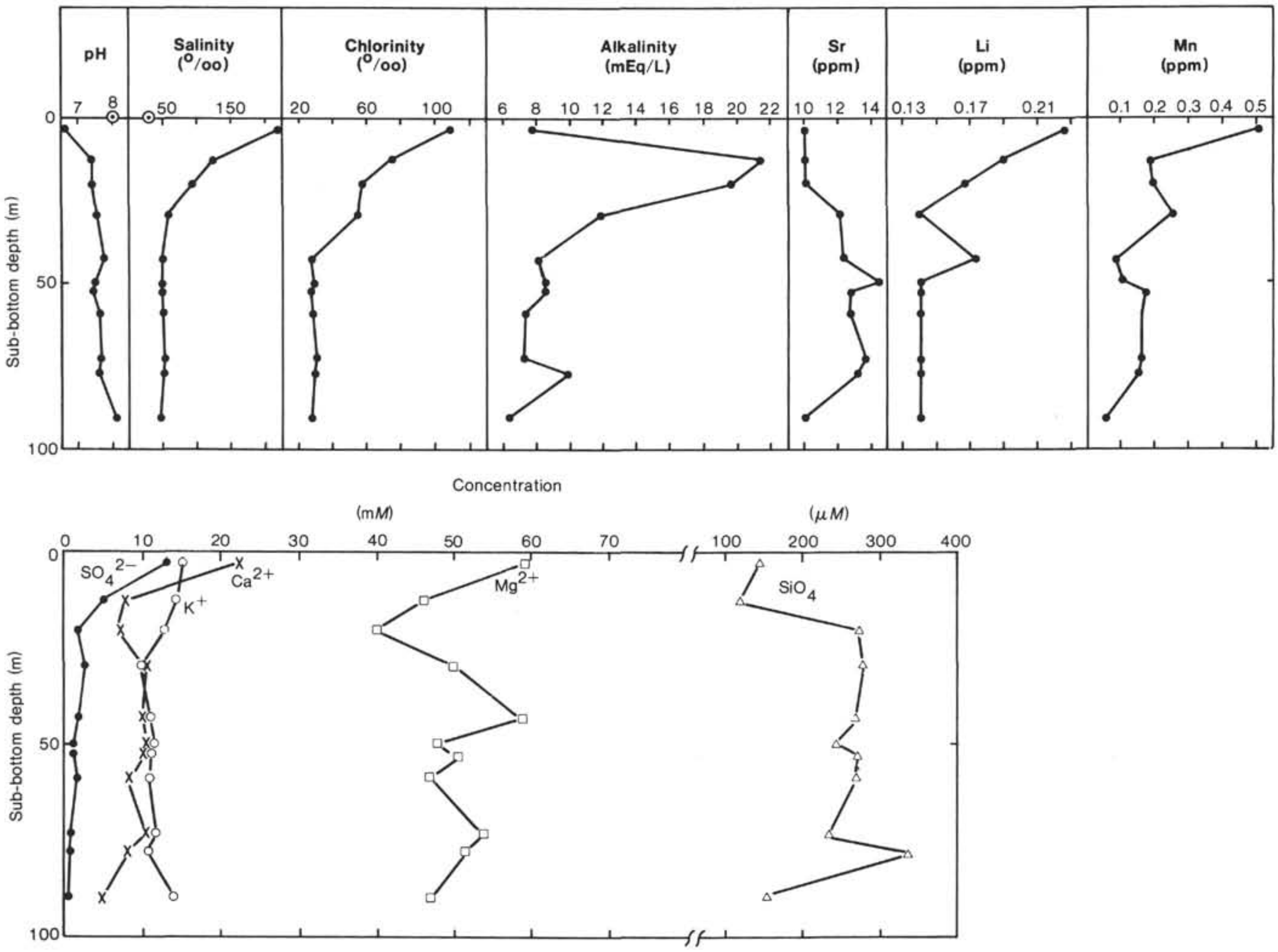

Figure 11. Interstitial water chemistry at Site 618. Data given in Table 1. ⊙ = surface seawater.

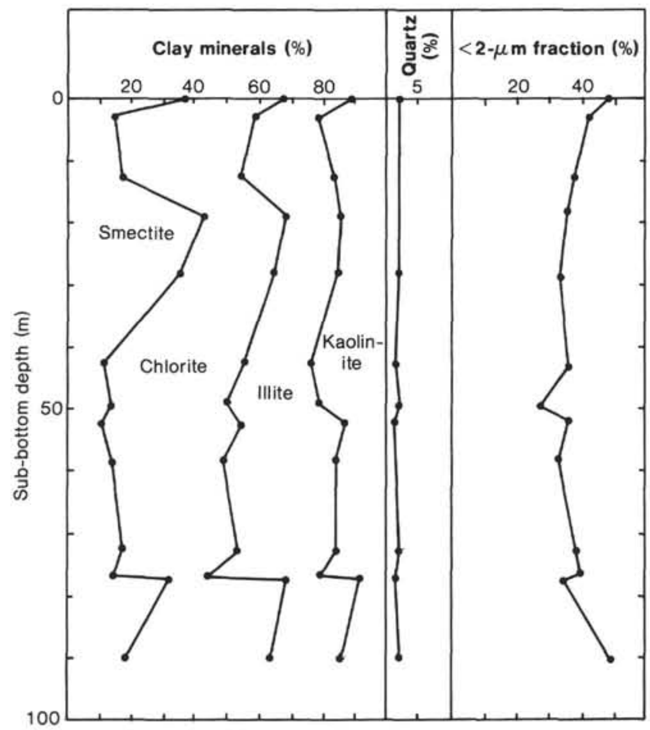

Figure 12. Clay mineral composition and quartz and clay content at Site 618.

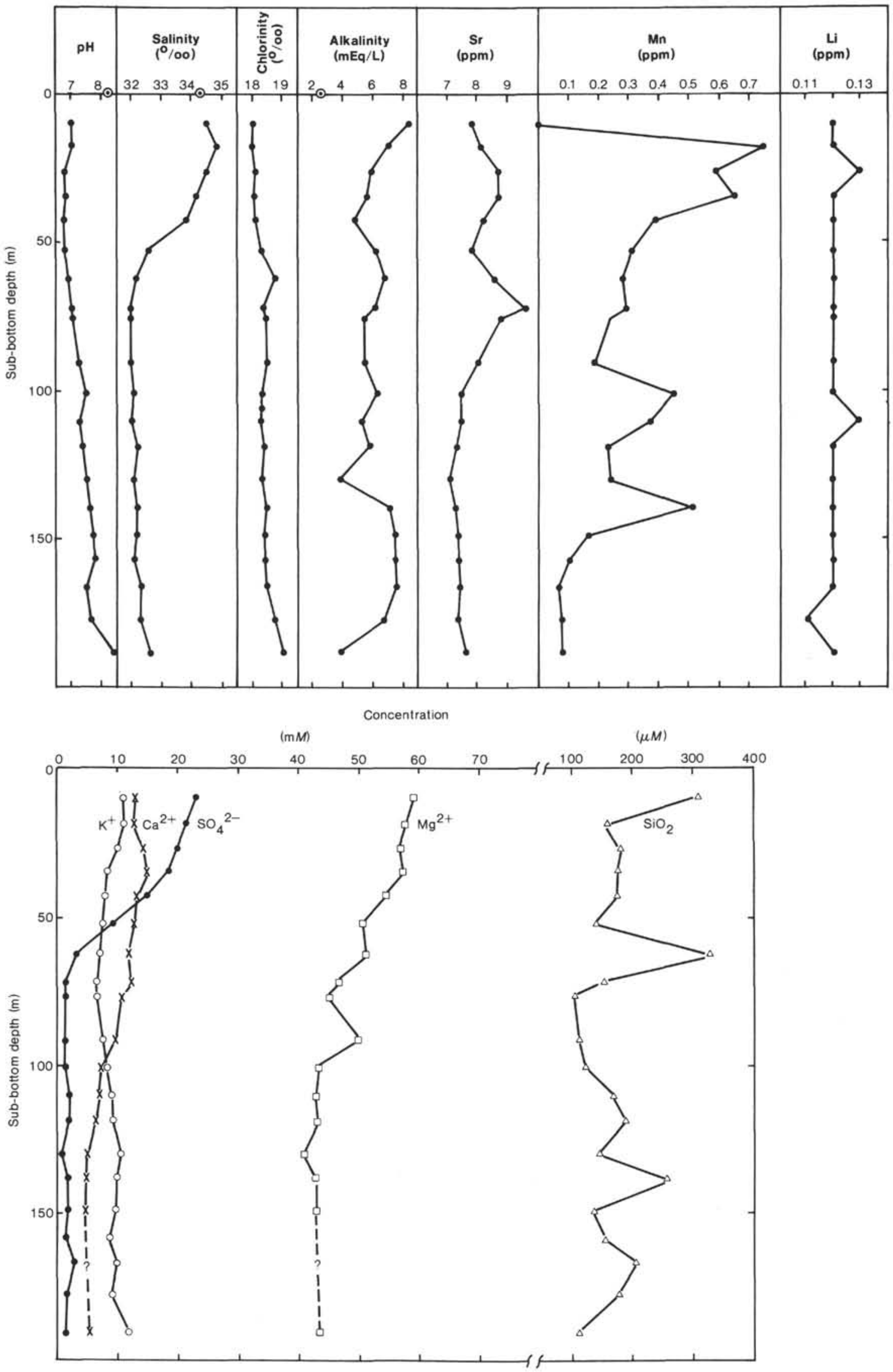

Figure 13. Interstitial water chemistry at Site 619. Data given in Table 1. ⊙ = surface seawater.

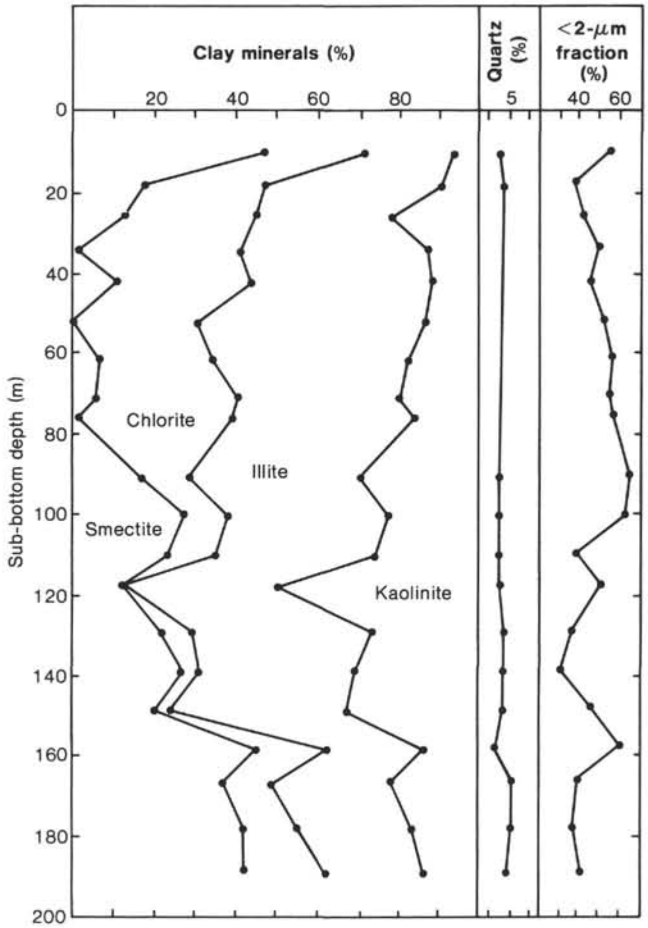

Figure 14. Clay mineral composition and clay and quartz content at Site 619.