

## 10. INTERSTITIAL WATER STUDIES, LEG 48

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### ABSTRACT

Interstitial water studies on sites drilled during Leg 48 indicate that (1) complex dissolved sulfate profiles exist in those sites with rapid Quaternary sedimentation, (2) calcium and magnesium gradients in sites on the Rockall Plateau are linearly correlated and indicate the importance of reactions in the strata underlying the deepest samples (these reactions probably involve alteration reactions of volcanic debris), (3) strontium gradients reflect carbonate recrystallization processes, and (4) dissolved silica reflects the presence of biogenic silica.

### INTRODUCTION

During Leg 48, interstitial waters were extracted at all sites onboard D/V *Glomar Challenger*. The samples were analyzed onboard (J.P.) for titration alkalinity and dissolved calcium, magnesium, and chloride, and the acidified samples were further analyzed in our laboratory for potassium, silica, strontium, and sulfate (R.E.). In this report, we present the observed data, with some tentative interpretations. None of the sites drilled reached igneous basement, a fact that makes interpretation difficult, particularly since concentration gradients suggest that reactions in deeper, uncored strata may be responsible for them.

### METHODS

Analyses were carried out using the techniques described by Gieskes (1974), with some minor modifications. Data for dissolved potassium show rather large inaccuracies, due to malfunctions in our flame emission analysis system. As no consistent trends occur in dissolved potassium, this has no serious effect on our interpretations.

### RESULTS

The data are presented in Table 1 and in Figures 1 to 5.

### DISCUSSION

#### Sites 400-402 (Bay of Biscay)

Sites 400 and 402 are characterized by exceptionally high Quaternary sedimentation rates of 6 to 8 cm/1000 years. Typically, these sites indicate a maximum in alkalinity (Figure 1, Table 1) and show concentrations of dissolved calcium of less than the seawater concentration in the upper section. This is due to the precipitation of calcium carbonate resulting from the production of bicarbonate ions during the sulfate reduction process (c.f., Gieskes, 1975). Concentration gradients in calcium and magnesium are complex and do not lend themselves to ready interpretation. The data for dissolved strontium show large increases, which are related to carbonate recrystallization processes (Gieskes, 1975; Sayles and Manheim, 1975).

Of some interest are the depth distributions of dissolved sulfate. At Site 400, a clear minimum occurs in the rapidly

deposited Quaternary section, indicating almost complete depletion of dissolved sulfate. At 400 meters, a maximum occurs, followed by a gradual decrease downward. This can best be understood in terms of the continued reduction of sulfate in the deeply buried carbonaceous sediments (below 700 m). That such processes can still occur at great depth was already shown at Site 386 (Leg 43) by Miller et al. (in press). Subsequently, the rapidly deposited Quaternary section has imposed the more complex sulfate distribution. Clearly, no steady state has been reached in this site. Such complex patterns have been observed previously, e.g., in Site 241 (Gieskes, 1974) and Site 336 (Gieskes et al., 1979).

Dissolved silica data reflect mainly the presence or absence of biogenic silica.

#### Sites 403 and 404 (Rockall Plateau)

Sedimentation rates at these two sites have been less than 2.5 cm/1000 years during the last 10 million years. Consequently, sulfate depletions are moderate (Figures 2 and 3) and only slight maxima occur in the alkalinity-depth profiles. Data quality in Site 403 is superior and indicates a good linear correlation between calcium and magnesium, with  $\Delta\text{Ca}/\Delta\text{Mg} = 1.15$  (Figure 2). The concentration-depth profiles of calcium and magnesium suggest that these gradients are essentially diffusional in nature and that they are probably due to reactions occurring deeper in the site, perhaps in the underlying tuffs and volcanic sandstones. Measurements of formation factors (by electrical conductivity) would be helpful in confirming this opinion (McDuff and Gieskes, 1976).

The dissolved strontium profile shows a clear maximum at about 150 to 170 meters, i.e., in the Miocene nannochalks. Clearly, this strontium profile is related to carbonate recrystallization processes, and below 200 meters it indicates that diffusion occurs to an unidentified sink in the deeper sediments. The calcium and magnesium gradients do not appear to have any relation to the strontium profile. We submit that the concentration changes in calcium and magnesium are related to alteration reactions involving volcanic material, much in the way that has been suggested previously by Lawrence et al. (1975), Gieskes et al. (1975), and Perry et al. (1976).

Site 404, drilled near Site 403, shows similar features. We suggest that the magnesium concentration at 202 meters is in

TABLE 1  
Interstitial Water Data, Leg 48

Core-Section	Depth (m)	Na <sup>a</sup>	K <sup>a, b</sup>	Mg <sup>a</sup>	Ca <sup>a</sup>	Sr <sup>a</sup>	Cl <sup>a</sup>	SO <sub>4</sub> <sup>a</sup>	Alk <sup>c</sup>	Si <sup>d</sup>
<b>Hole 400A</b>										
2-4	90		15	35.8	3.7	.35	558		20.0	
6-2	125	464	15	45.5	5.6	.47	563	1.8	16.4	378
12-6	188	478	11	41.5	9.3	.83	572	2.9	14.0	509
18-4	242	471	16	41.6	12.6	1.06	564	11.3	10.3	
24-5	300	469	13	44.2	15.7	1.04	565	16.6	5.05	
35-2	400	470	14	43.3	21.7	1.10	572	19.3	5.87	
40-1	446	454	14	36.2	27.7	1.00	568	12.8	4.34	816
45-4	498	454	(12)	37.3	31.4	1.14	572	14.3	4.30	1230
51-5	557	452	(12)	35.9	32.9	0.87	575	12.8	2.22	
56-1	600		(21)	30.4	29.5	0.77	574		4.28	510
62-5	661	460	(12)	37.6	26.6	0.81	584	8.4	1.60	359
68-2	714		(19)	31.2	28.6	0.87	523		.82	
<b>Hole 401</b>										
1-4	6	486	15	51.3	11.0		567	27.4	4.03	184
5-4	118	484	13	47.8	15.7	0.16	571	25.3	2.24	
10-5	168	493	12	46.7	16.2	0.17	580	24.6	1.25	573
16-2	220	453	(17)	45.6	16.6	0.06	544	24.3	1.74	1090
<b>Hole 402</b>										
1-2	3	463	16	48.0	8.7	0.08	540	21.6	9.58	795
5-2	130	460	15	45.5	8.6	0.09	546	16.6	3.82	
<b>Hole 402A</b>										
1-2	140	462	13	46.3	9.8	0.18	544	19.2	4.90	
12-2	243	445	(17)	45.6	14.7	0.34	540	20.1	2.92	389
18-3	302		(17)	40.2	20.0	0.54	555		2.20	326
30-3	417		(10)	37.6	22.7	(0.78)	541		0.77	
<b>Hole 403</b>										
2-5	12	497	11	51.5	10.9	0.16	575	27.5	2.68	
7-1	53	491	13	47.5	14.8	0.32	578	24.2	2.91	558
12-6	108	499	12	43.7	18.4	0.72	586	23.8	3.38	695
18-2	159	478	14	41.0	21.3	0.83	574	20.4	3.27	
26-2	235	475	10	38.5	24.8	0.54	567	22.0	2.27	
34-4	314	481	13	33.5	30.9	0.31	584	18.8	1.30	
39-2	359	485	11	30.8	35.1	0.15	585	21.2	0.80	117
<b>Hole 404</b>										
2-4	27	493	13	49.9	11.8	0.22	576	26.1	2.02	
4-1	172	493	11	44.3	17.9	0.54	579	24.2	2.52	
7-2	202	501	11	32.9	23.2	0.63	572	25.9	2.01	697
17-3	298		13	26.7	44.1	0.23	540		0.91	65
22-4	347	410	(15)	23.8	50.4	0.06	557	17.5	0.92	137
<b>Hole 405</b>										
1-5	7	469	13	55.0	10.3	0.08	556	26.7	2.93	292
8-3	69	473	13	53.2	12.2	0.14	564	24.7	3.12	
13-3	117	486	13	51.7	13.5	0.17	575	25.8	2.59	581
16-3	145	485	12	49.4	15.4	0.22	574	25.3	2.59	700
19-3	173	486	14	48.7	15.5	(0.05)	575	25.8	1.64	
31-3	288	448	(18)	39.2	23.7	0.31	558	17.0	0.82	410
40-3	372	489	10	18.5	40.8	0.26	575	21.1	0.45	226
<b>Hole 406</b>										
1-2	3		13	52.4	10.6		560		3.93	
2-3	66	479	13	46.2	8.6	0.43	563	18.0	3.75	531
4-2	216	456	14	33.3	17.3	1.24	551	7.6	7.82	
6-1	329		12	28.1	18.0	1.27	575		3.89	902
13-4	457	513	16	20.7	23.5	1.20	588	14.7	1.65	796
20-2	521		13	19.2	25.2	1.36	584		1.91	979
29-3	608	493	13	17.4	28.3	(1.46)	575	11.7	1.94	1110
34-1	652		(8)	14.8	30.2	.62	586		0.84	

<sup>a</sup>mmoles/l.

<sup>b</sup>values in brackets uncertain.

<sup>c</sup>equivalents/l.

<sup>d</sup>μmoles/l.

error, so that a reasonably simple concentration gradient results, with a linear correlation to that of calcium. Again, a maximum in dissolved strontium occurs in the dissolved strontium profile near the lower end of the Miocene carbonate sediments. We submit that, again, alterations of volcanic material in the underlying sediments are the main cause of the observed gradients in calcium and magnesium.

#### Site 405

In Site 405, the Quaternary section, i.e., the upper 40 to 50 meters, has been deposited at sedimentation rates of 2 to 3

cm/1000 years. Below this, large unconformities characterize the section, and the bulk of the recovered sediment consists of rapidly deposited early Eocene sediments, with silicified mudstones below 3000 meters. Concentration gradients in calcium and magnesium are linearly correlated, with  $\Delta Ca/\Delta Mg = 0.82$ . We suggest that the character of the gradients is, again, essentially diffusional in nature, with the slopes of the gradients increasing in the silicified section. Here again, formation factor measurements may be relevant (McDuff and Gieskes, 1976).

The dissolved strontium data show a maximum at the bottom of the carbonate sequence.

#### Site 406

Sedimentation rates in Site 406 have been high in the upper 500 meters of the sediment column. This is, again, reflected in a minimum in dissolved sulfate and a maximum in alkalinity. As is usual in such cases, the concentration gradients in calcium and magnesium are complex and difficult to interpret.

#### ACKNOWLEDGMENTS

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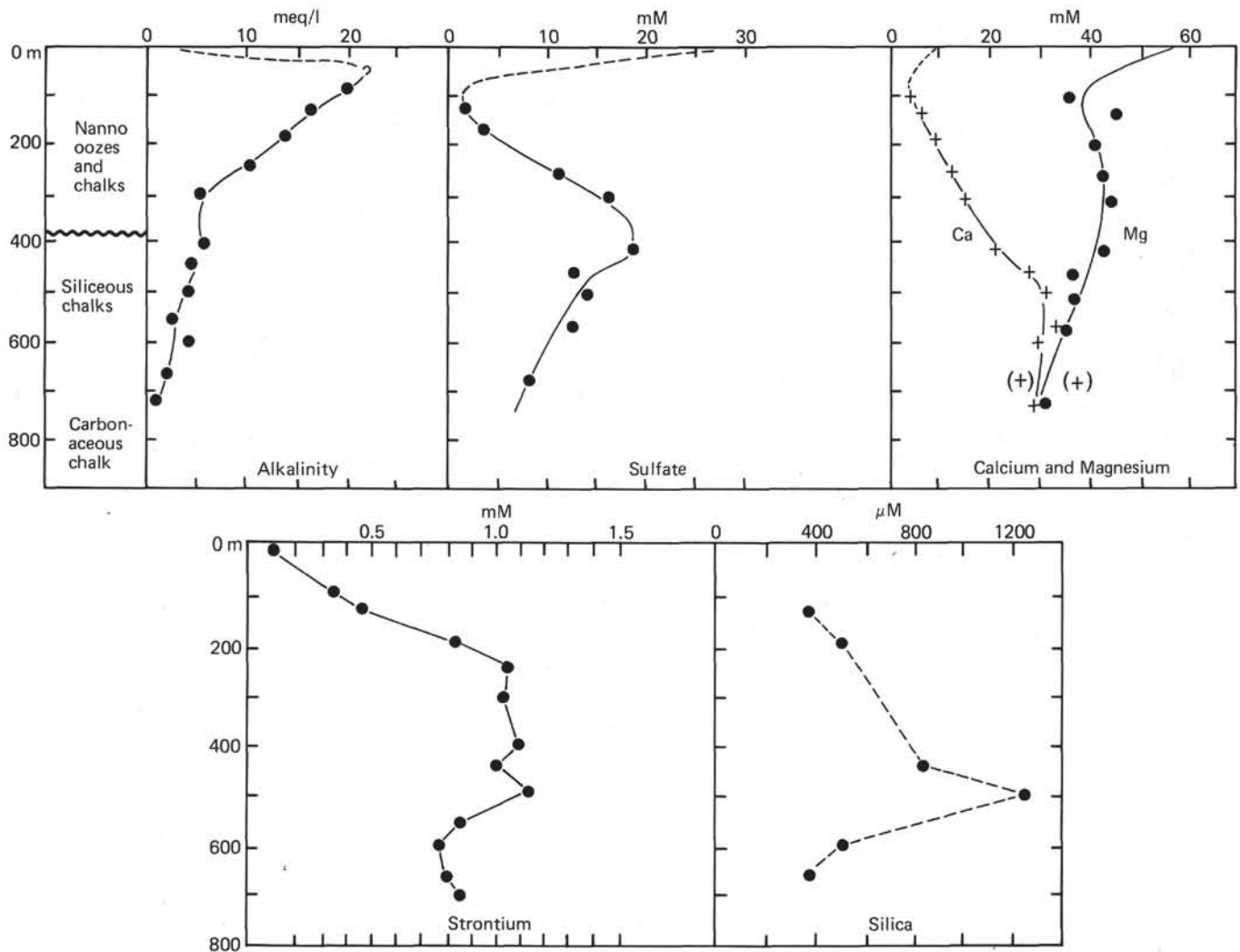


Figure 1. Interstitial water data, Site 400.

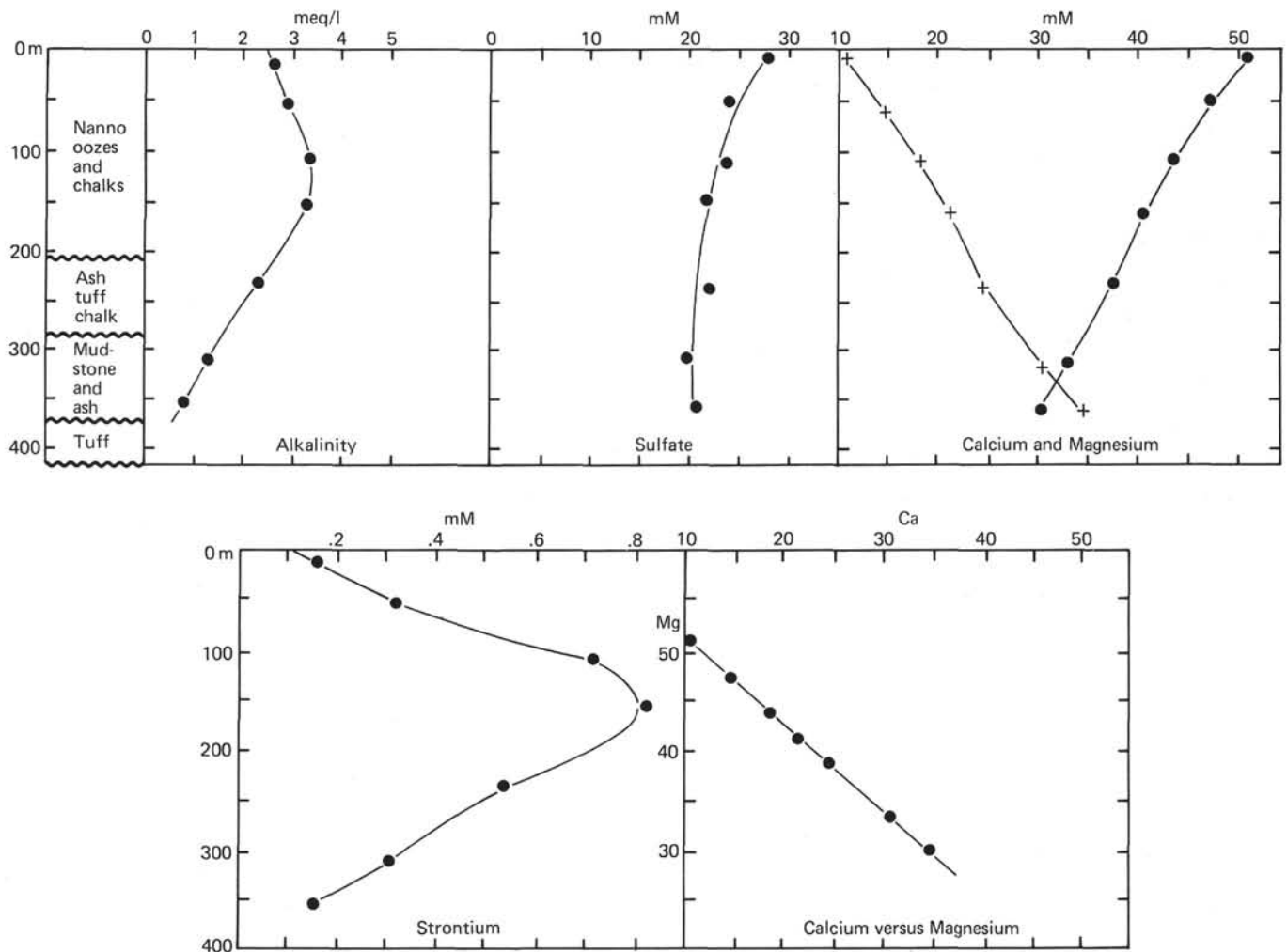


Figure 2. Interstitial water data, Site 403.

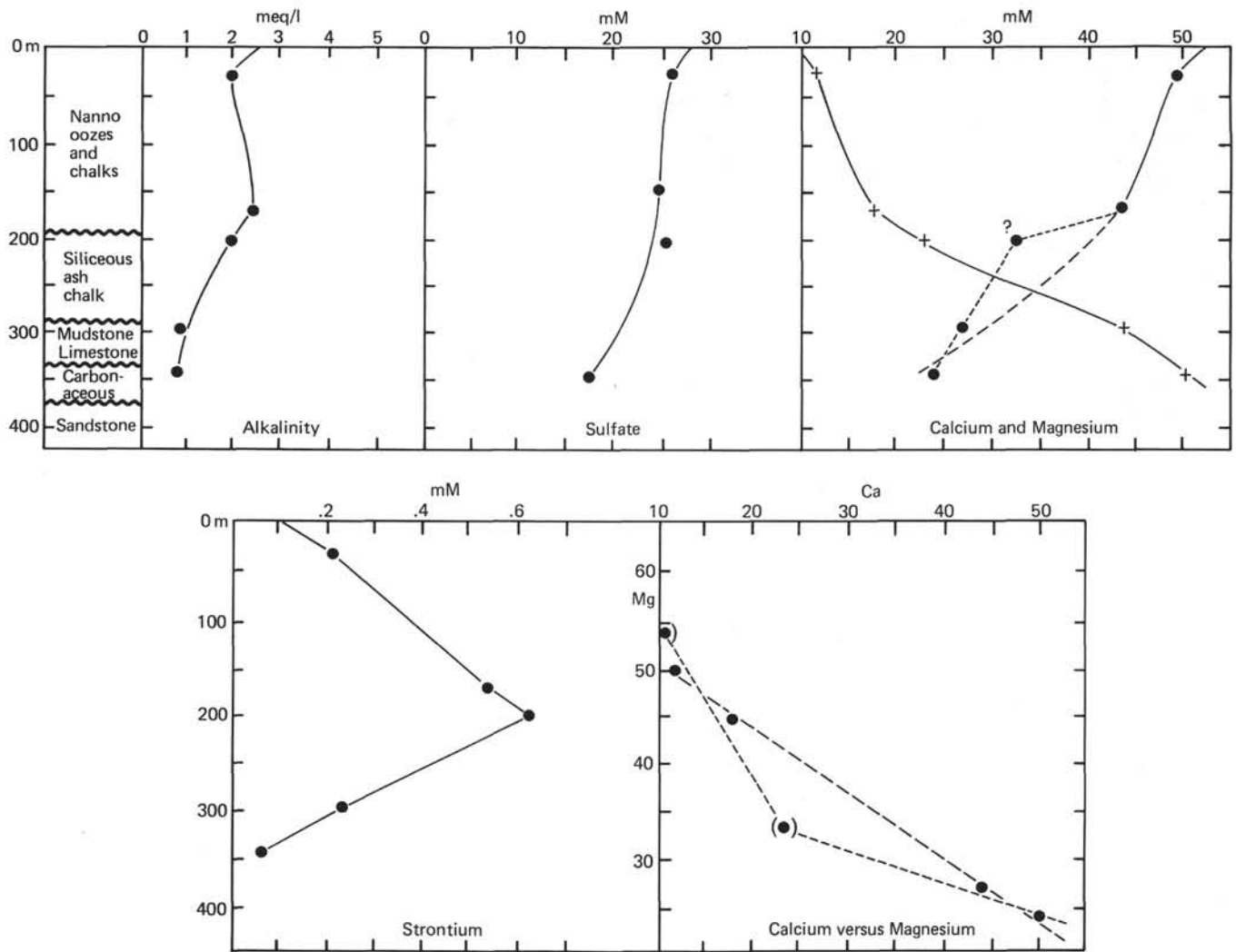


Figure 3. Interstitial water data, Site 404.

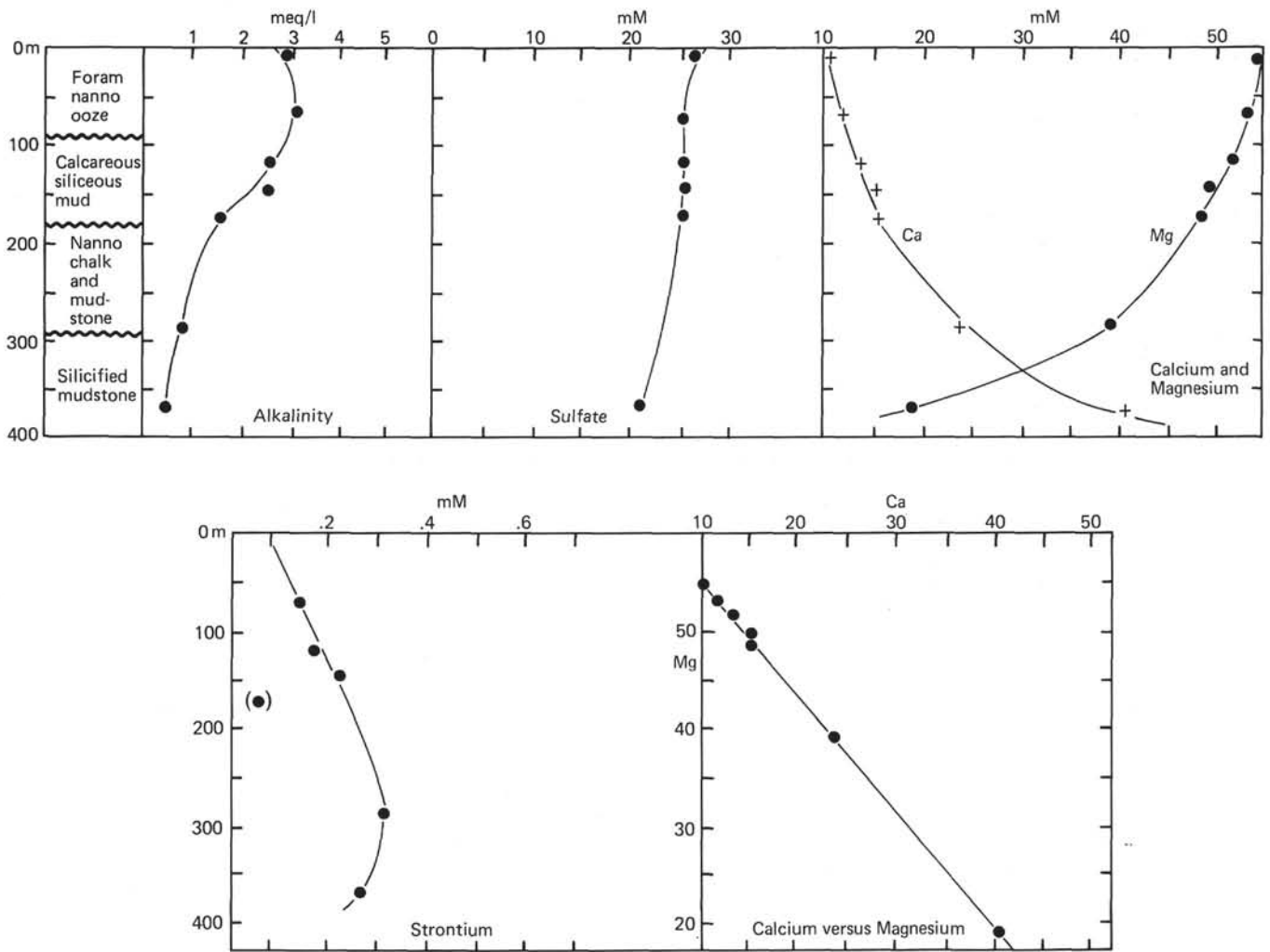


Figure 4. Interstitial water data, Site 405.

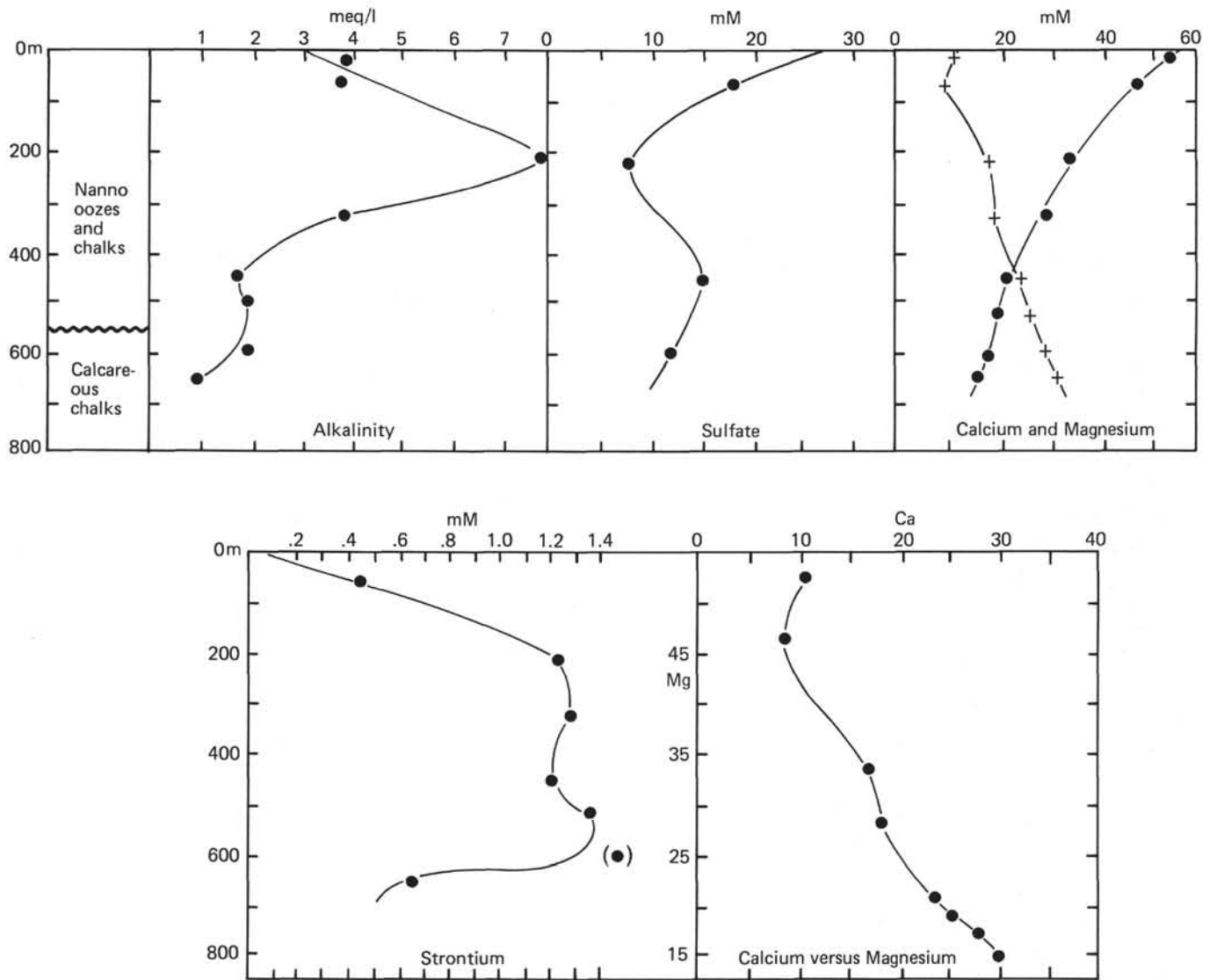


Figure 5. Interstitial water data, Site 406.