

49. INTERSTITIAL WATER STUDIES, LEG 80¹

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ABSTRACT

Interstitial water studies of sediments recovered during DSDP Leg 80 (Goban Spur transect) indicate a well-developed dissolved-sulfate minimum at Site 548 resulting from increased sulfate reduction in the rapidly deposited Pleistocene sediment section. Changes in the concentration of dissolved strontium at each site must be related to carbonate recrystallization processes.

INTRODUCTION

During Leg 80 of the Deep Sea Drilling Project, interstitial water samples were recovered from four drill sites along a transect across the Goban Spur (Fig. 1). In this report we present both the shipboard data and measurements made in our laboratory, as well as a brief interpretation of these data.

MATERIALS AND METHODS

Interstitial water samples were obtained using, whenever possible, the routine shipboard program of at least one sample every 50 m. Unfortunately, especially at Site 550, samples were sometimes not collected close to the bottom of the hole. As increases in calcium content with depth are often interpreted in terms of sources in the underlying basement, it is imperative to obtain samples to basement. The lack of data from such samples necessarily hampers the interpretation presented in this chapter.

Shipboard data include salinity, pH, alkalinity, and calcium, magnesium, and chloride contents. The acidified samples (alkalinity samples) were analyzed in our shore laboratory for dissolved silica, strontium, lithium, potassium, ammonia, and sulfate contents. Methods used have been described by Gieskes (1974), Gieskes and Lawrence (1976), and Gieskes et al. (1982).

RESULTS AND DISCUSSION

The data are presented in Table 1 and in Figures 2, 3, and 4.

Site 548

Site 548 (Fig. 2) is characterized by rapidly accumulated marly calcareous oozes in the upper 300 m of the sediment column (Units 1, 2, and 3). In the upper 100 m, sediment accumulation rates averaged ~55 m/m.y., and between 100 and 300 m, they ranged from 32.3 to 20.6 m/m.y. The sediment column below 300 m is marked by sedimentary unconformities interspersed with periods of rapid and slow sedimentation (see site chapter).

During the period of rapid sediment accumulation in the Pleistocene, more organic carbon must have become buried, and as a result, sulfate reduction processes in the sediment column became more important. Thus, as is typical for sites that have a rapidly deposited top section, a minimum in sulfate content is observed (Gieskes,

1983). Associated with this sulfate reduction process is the production of ammonia, which reaches a maximum concentration of ~1500 μM (Fig. 2). In the upper 100-m section, decreases in concentrations of dissolved calcium and magnesium are also observed. The decrease in calcium content can be understood in terms of carbonate precipitation. The decrease in magnesium content can be caused by removal into authigenic silicate phases or into dolomite. Circumstances for the latter process are enhanced by the low sulfate concentrations (Baker and Kastner, 1982). Alkalinity increases are relatively small (maximum increase ~15 meq dm^{-3}). Sulfate reduction produces alkalinity ($\delta\text{SO}_4 \sim 50 \text{ meq dm}^{-3}$), and the processes of calcium removal (~8 meq dm^{-3}) and magnesium removal (~26 meq dm^{-3}) cause depletions in alkalinity. This leaves a balance of ~16 meq dm^{-3} in alkalinity gain, which, when corrected for the increase in ammonia, yields ~15 meq dm^{-3} in bicarbonate produced. This is very close to the observed increase.

Data on dissolved strontium and lithium reveal well-developed maxima at ~250 m sub-bottom. The increase in concentration of strontium can be related to carbonate recrystallization reactions (Baker et al., 1982), whereas lithium could have its source either in carbonates or in siliceous sediments. Note that the zone of maximum strontium and lithium concentrations is also the zone of maximum dissolved-silica concentration, indicating the influence of biogenic silica. Gieskes (1981) hypothesized that siliceous sediments constitute the main source of lithium in DSDP interstitial waters; the hypothesis cannot be tested at this site.

Increased concentrations of dissolved calcium (and decreased concentrations of magnesium) below ~300 m sub-bottom could be the results of reactions taking place in lower unsampled sediments.

Site 549

Sediments cored at Site 549 (Fig. 3) are characterized by slow sediment accumulation rates in the upper 100 m and a number of unconformities at greater depths.

As is typical at slow accumulation rates, decreases in dissolved-sulfate content are small, as a result of both the diminished process of bacterial sulfate reduction and the increased supply of dissolved sulfate by diffusion from the overlying ocean. Alkalinity increases are likewise very small.

¹ Graciansky, P. C. de, Poag, C. W., et al., *Init. Repts. DSDP, 80*: Washington (U. S. Govt. Printing Office).

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A small maximum in calcium concentration occurs at ~200 m sub-bottom, and magnesium uptake is limited to the upper 200 m of the sediment column. It is not certain whether the decrease in magnesium content is related to carbonate reactions; a closer investigation of the carbonate phases is needed (Renard, this vol.). It is important to note, however, that the maximum strontium concentration occurs at ~200 m sub-bottom. This indicates that at this level carbonate recrystallization reactions are occurring. The source of lithium is again difficult to identify, because the dissolved-silica concentration also has a maximum in these horizons (see the Site 548 chapter).

The concentration of dissolved potassium decreases throughout the cored section, and appears to have a sink at greater depths.

Site 550

Site 550 (Fig. 4) is generally characterized by low sediment accumulation rates. Unfortunately, no sediments were recovered in the upper 100 m, so that a small minimum in the sulfate concentration may occur but will go undetected in that section.

The main source of dissolved calcium and the sink for magnesium are located in the deeper unsampled section, and perhaps lie in the underlying basalts.

The dissolved-strontium profile again reflects carbonate recrystallization reactions, with the strontium concentration reaching quite high values (~850 μM).

ACKNOWLEDGMENTS

This work was supported by Grants NSF OCE80-23966 and 82-18539.

The authors gratefully acknowledge the shipboard chemical work by Mr. David Ripley.

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Date of Initial Receipt: July 26, 1983

Date of Acceptance: November 30, 1983

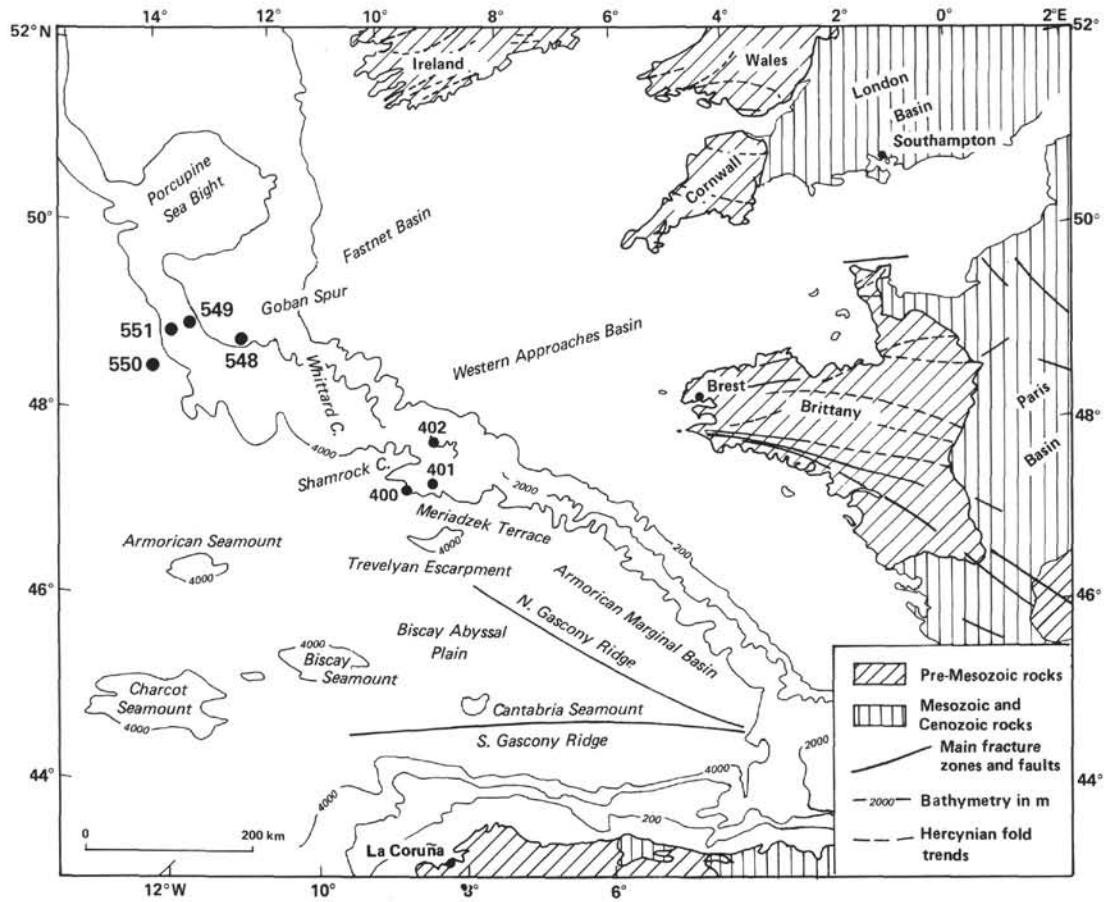


Figure 1. Study area of Leg 80, Goban Spur.

Table 1. Analyses of interstitial water samples, Leg 80.

Sample (interval in cm)	Sub-bottom depth (m)	pH	Alk (meq dm ⁻³)	S (g/kg)	Ca (mM)	Mg (mM)	Cl (g/kg)	Sr (μM)	Li (μM)	K (mM)	SO ₄ (mM)	NH ₄ (μM)	Si (μM)
Hole 548													
2-6, 145-150	13	7.26	11.59	34.9	5.4	50.3	19.41	84.8	31.6	11.0	16.5	1039	378
7-5, 145-150	59	7.14	13.95	33.8	6.1	41.1	19.48	174.0	89.6	11.0	1.2	1508	632
15-4, 140-150	106	6.92	17.13	34.1	6.6	41.5	19.37	559.3	249.9	10.5	—	719.9	606
20-2, 140-150	139	6.82	16.98	33.8	9.1	40.5	19.41	458.2	238.0	9.9	2.4	1440	821
25-1, 138-150	163	6.82	15.93	33.8	10.7	38.8	19.44	531.0	253.7	9.9	2.4	1534	867
30-3, 141-150	191	6.81	15.54	33.8	12.0	38.3	19.44	567.5	269.1	9.8	4.7	678.6	824
Hole 548A													
4-5, 140-150	242	6.69	11.19	35.2	13.3	38.0	19.41	615.9	282.5	11.9	4.5	1288	1050
9-2, 135-150	285	6.81	9.04	34.9	14.5	39.1	19.41	638.4	285.6	11.7	15.7	1014	1040
15-3, 135-150	343	6.90	6.82	34.9	15.8	40.3	19.48	539.0	285.5	10.5	19.7	660.0	583
18-1, 143-150	369	7.13	6.55	36.0	16.4	40.3	19.48	518.4	243.0	9.6	20.5	653.4	631
23-3, 140-150	419	7.20	5.74	34.6	19.1	40.6	18.56	—	—	—	—	—	—
29-3, 135-150	477	6.96	3.25	35.5	21.8	38.2	19.37	381.6	196.1	9.4	24.2	315.9	227
Hole 549													
1-4, 145-150	6	7.49	3.41	35.2	10.5	51.5	19.14	94.5	33.0	13.5	28.6	0	2
4-5, 140-150	225	7.01	5.34	36.3	21.1	43.4	19.44	307.8	135.0	10.1	25.9	0	945
14-4, 140-150	318	—	—	35.5	—	—	—	—	—	—	—	—	—
20-4, 135-150	375	—	—	34.6	21.4	41.1	19.37	—	—	—	—	—	—
25-1, 135-150	419	7.11	4.36	36.6	20.0	42.7	19.41	280.9	111.3	9.4	24.2	0	588
28-2, 135-150	449	7.30	3.63	35.5	18.8	43.9	19.34	224.7	90.1	9.3	25.4	0	561
53-2, 140-150	677	7.35	2.52	35.8	18.3	45.9	19.34	114.4	78.0	9.2	27.6	0	348
56-3, 140-150	707	—	—	35.8	20.8	42.5	19.27	—	—	—	—	—	—
61-3, 134-150	751	7.56	1.70	36.0	20.7	44.5	19.51	152.3	78.8	8.4	—	0	157
75-1, 143-150	818	—	—	36.3	21.2	44.0	19.48	—	—	—	—	—	—
85-1, 135-150	890	7.35	1.20	36.0	21.2	45.1	19.48	116.5	67.6	7.9	25.7	0	161
90-1, 127-150	930	—	—	36.3	—	—	—	—	—	—	—	—	—
Hole 549A													
1-3, 140-150	5	7.20	3.78	36.0	10.2	53.3	19.20	95.4	31.8	11.6	30.2	0	190
5-4, 140-150	43	7.19	4.47	36.3	12.2	50.8	19.41	145.2	53.0	12.2	25.9	0	620
9-5, 140-150	82	7.10	4.63	36.0	14.3	50.0	19.44	180.2	68.9	11.0	26.6	0	604
12-2, 140-150	106	7.11	4.70	36.0	16.1	48.3	19.51	212.0	84.8	11.0	27.9	0	678
24-1, 140-150	134	7.07	5.22	36.8	16.8	47.6	19.58	248.2	91.0	11.2	25.6	0	770
Hole 550													
3-2, 110-120	112	7.13	4.51	35.5	14.5	45.9	19.48	680.5	111.3	10.7	21.7	296.8	524
8-3, 140-150	161	7.06	4.25	35.8	17.1	45.9	19.48	901.0	143.1	9.0	24.2	328.6	238
14-2, 140-150	217	7.12	3.08	35.8	19.5	44.7	19.65	903.0	168.0	9.7	—	278.3	225
19-1, 140-150	263	7.00	3.35	35.8	22.0	43.6	19.78	950.3	189.0	9.4	22.05	157.5	320
24-4, 140-150	315	—	—	34.1	29.2	41.2	18.83	—	—	—	—	—	—
29-5, 135-150	364	7.04	1.98	35.8	36.4	36.5	19.58	824.0	200.9	7.1	—	123.6	314
34-3, 135-150	408	—	—	34.1	41.4	32.3	18.53	—	—	—	—	—	—
39-4, 135-150	457	6.75	1.91	36.3	49.8	30.8	19.95	956.8	228.8	7.0	17.7	114.4	514
Hole 551													
1-2, 140-150	3	7.43	3.64	35.8	10.6	52.4	19.21	95.4	31.8	11.2	30.2	0	0
2-2, 140-150	107	7.47	2.86	36.0	10.9	52.9	19.31	—	—	—	—	—	—

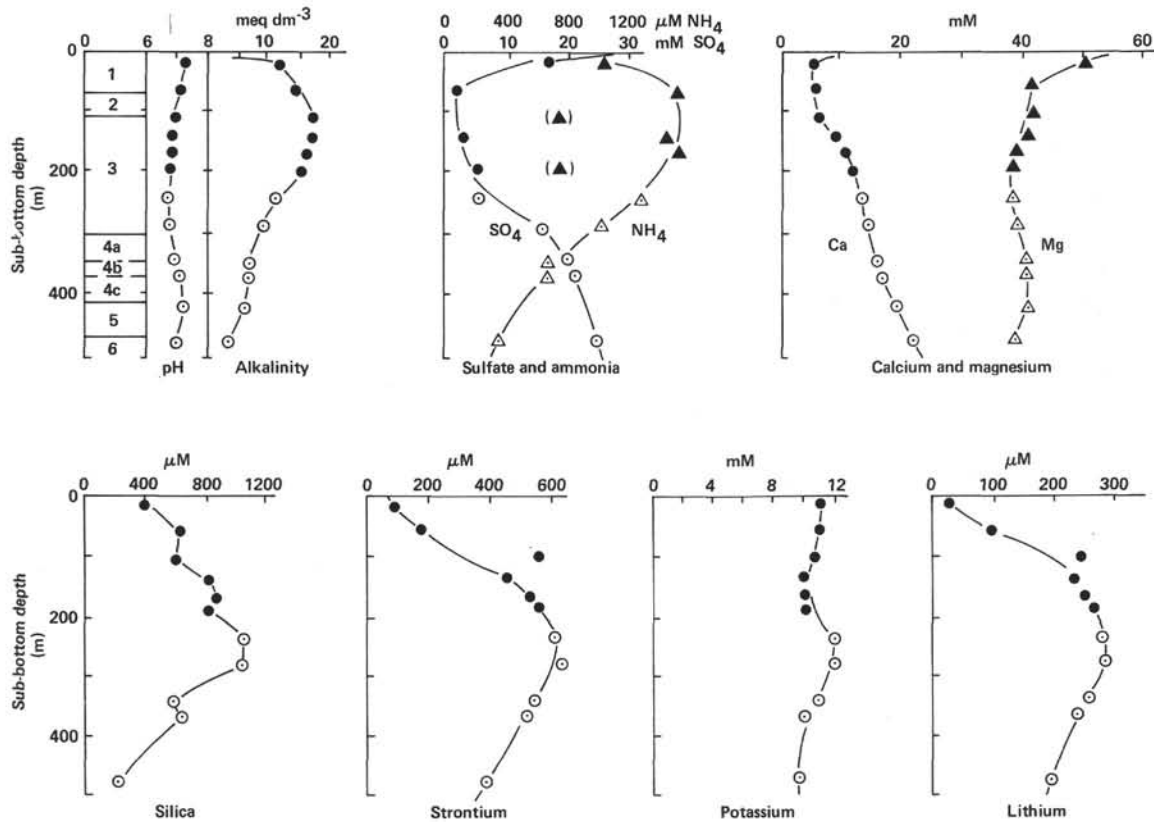


Figure 2. Interstitial water chemistry, Site 548. Lithology: Unit 1: alternating marly calcareous ooze and nannofossil ooze (Pleistocene); Unit 2: reddish clay, grayish clay, foraminifer-nannofossil oozes (lower Pleistocene); Unit 3: homogeneous bioturbated nannofossil oozes and chalks (108-211 m sub-bottom), interbedded with turbiditic siltstones (205-305 m sub-bottom) (upper Pleistocene to upper Miocene); Subunit 4a: foraminifer-nannofossil chalks (lower Miocene-upper Oligocene); Subunit 4b: foraminifer-nannofossil chalks (lower Oligocene-middle Miocene); Subunit 4c: same as 4b; Unit 5: marly nannofossil chalk (lower Eocene); Unit 6: foraminifer-nannofossil chalk (Danian-upper Campanian). Data in parentheses: questionable. Closed symbols = Hole 548. Open symbols = Hole 548A.

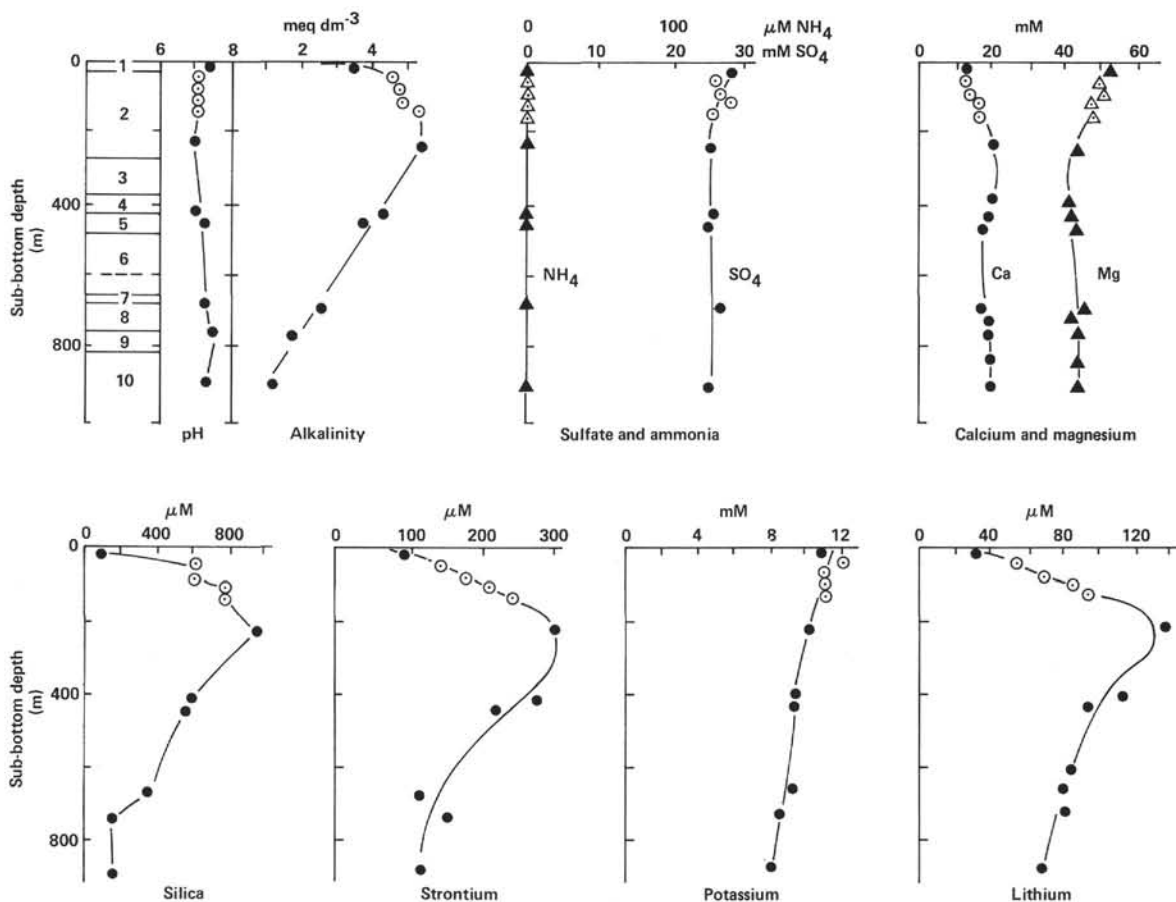


Figure 3. Interstitial water chemistry, Site 549. Lithology: Unit 1: marly, calcareous nannofossil–foraminifer oozes (Quaternary); Unit 2: nannofossil chalk (upper Miocene–lower Eocene); Unit 3: marly nannofossil chalks (lower Eocene–upper Paleocene); Unit 4: nannofossil chalk (Maestrichtian–Coniacian); Unit 5: nannofossil chalk (Coniacian–lower middle Cenomanian); Unit 6: calcareous siltstone (middle–lower Albian); Unit 7: red sandy dolomite (~lower Albian); Unit 8: calcareous and sandy calcareous mudstones (lower–upper Barremian); Unit 9: grainstones (lower Barremian); Unit 10: mudstones (lower Barremian–Hauterivian[?]). Closed symbols = Hole 549. Open symbols = Hole 549A.

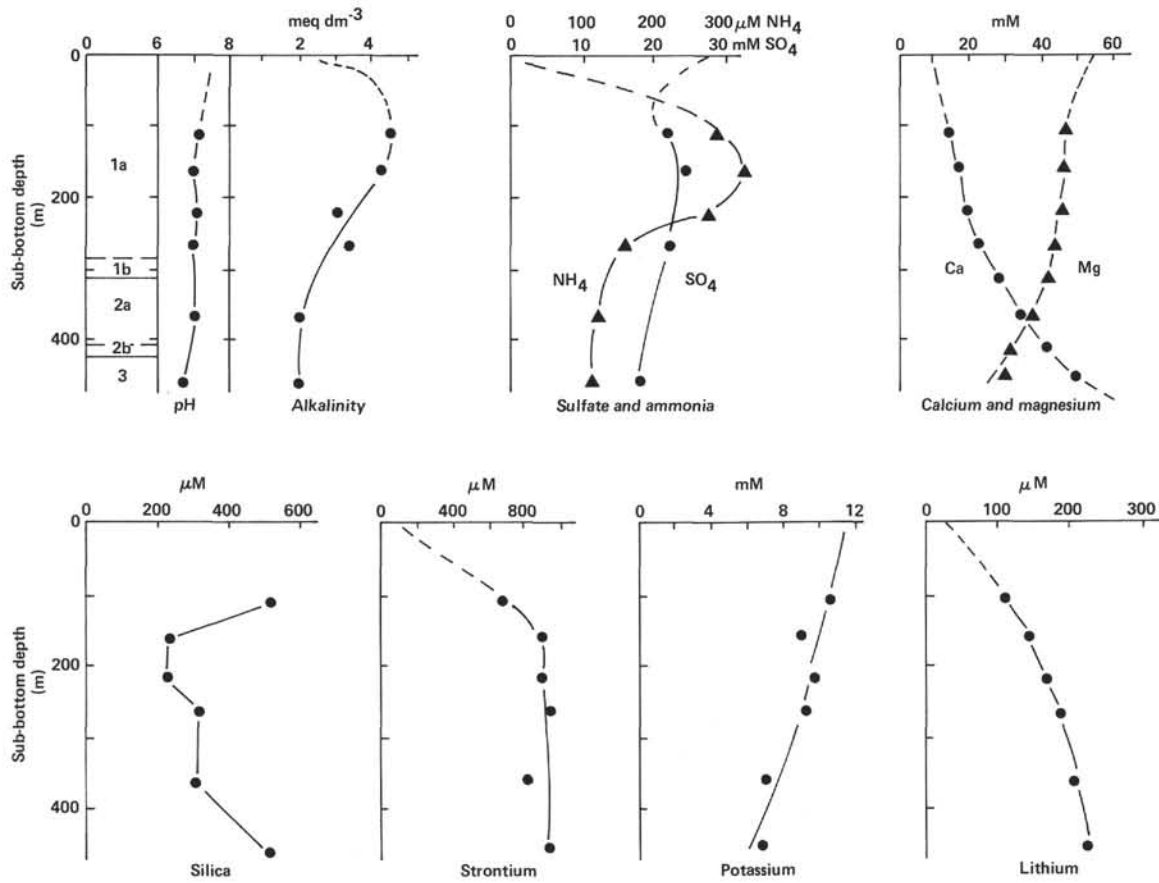


Figure 4. Interstitial water chemistry, Site 550. Subunit 1a: nannofossil oozes and chinks (Pliocene-lower middle Miocene); Subunit 1b: chinks and mudstones (siliceous) (lower middle Miocene-middle/upper Oligocene); Subunit 2a: marly nannofossil chalk (middle-lower Eocene); Subunit 2b: siliceous nannofossil chinks and mudstones (upper Paleocene); Unit 3: chinks (upper Paleocene-Maestrichtian)—basalt at 685 m sub-bottom. Dashed line denotes uncertain fairing.