

### 33. SEDIMENTS AND INTERSTITIAL WATER AT SITES 582 AND 584, THE NANKAI TROUGH AND THE JAPAN TRENCH LANDWARD SLOPE<sup>1</sup>

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#### ABSTRACT

Two trenches off Japan were explored during DSDP Leg 87. One is the Nankai Trough and the other is the Japan Trench; Site 582 is located on the floor of the former and Site 584 is situated on the deep-sea terrace of the latter. Cores from Site 582 and 584 consist mainly of hemipelagic sediments and diatomaceous silts and mudstone, respectively. In this report we analyze the chemistry of the interstitial water and sediments, as well as the sediment mineralogy.

Sulfate reduction is accompanied by the production of secondary pyrite, which is rich in the sediment at both sites. Dissolved Ca concentration is relatively low and changes only slightly at both sites, probably because of the formation of carbonate with high alkalinity. Concentrations of dissolved Mg decrease with depth at Site 584. The dissolved Mg depletion probably results from the formation of Mg-rich carbonate and/or ion exchange and reaction between interstitial water and clay minerals. Higher Si/Al values are due to biogenic opal in the sediments and roughly correlate with higher values of interstitial water SiO<sub>2</sub>. Increases in dissolved Li concentrations may be related to its release from clay minerals, to advection that results from dewatering, and/or to fluid transport.

#### INTRODUCTION

The chemical composition of interstitial waters of marine sediments may be modified by many processes, particularly diagenetic reactions and diffusive and advective transport of dissolved constituents. The qualitative and quantitative estimation of the above-mentioned processes is difficult because of the complexity and variation of the reactants, the multitude of possible reactions, and the scatter of sediment physical properties data. Only Perry and others (1976) and Lawrence and others (1975) clarified the relation between interstitial water and sediments with respect to Mg, Ca, and oxygen isotope by means of the precise analysis of both phases. In addition, a few studies have been done on samples from active margins, where sediment accumulation rates are very high and many faults and fissures exist (Moore and Gieskes, 1980).

DSDP Leg 87 offered an opportunity to study the diagenesis of terrigenous sediments along an active margin. This report centers on the interstitial water chemistry of Sites 582 and 584 (Fig. 1) and incorporates information regarding sediment chemistry and mineralogy.

#### SAMPLING AND ANALYTICAL PROCEDURES

##### Sampling

Samples of interstitial water were collected at all of the Leg 87 sites by standard shipboard squeezing techniques, and several samples were collected by means of the IPOD in-hole sampler, a device that collects both water for chemical analysis in a stainless tubular coil and water for gas analysis in a connected copper coil.

<sup>1</sup> Kagami, H., Karig, D. E., Coulbourn, W. T., et al., *Init. Repts. DSDP, 87*: Washington (U.S. Govt. Printing Office).

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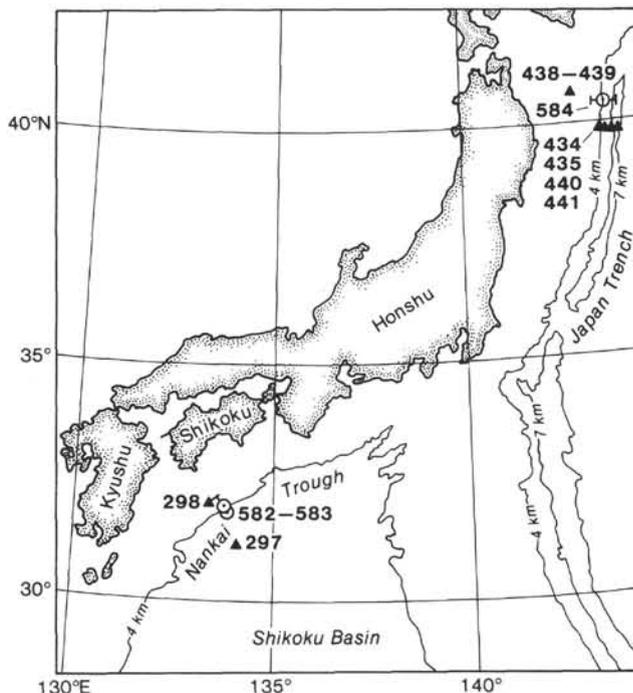


Figure 1. Location of DSDP Sites 582, 583, and 584, as well as location of earlier, related DSDP sites.

##### Analysis of Interstitial Water

Interstitial waters were obtained from the drilled hole(s) and analyzed on board for pH, alkalinity, chlorinity, and salinity. On the basis of concentrations obtained by these shipboard analyses, we decided to carry out more complicated studies on samples obtained at Sites 582 and 584.

The concentrations of Li, Na, K, Ca, and Mg were measured by a Hitachi 170-50A type atomic absorption spectrometer. All solutions were adjusted to 4000 ppm LaCl<sub>3</sub> solution to prevent interference by co-existing elements. The Na concentration was calculated from charge balances.

The colorimetric method was employed to test for silica (Matsui, 1963). Ammonium molybdate is added to the sample solution, resulting in the production of silicomolybdic acid. The color of this solution is yellow. Next, the reducing agent is added at regular intervals until molybdenum-blue appears. The concentration of silica is determined by measuring the absorbance of 800- $\mu\text{m}$  wave-length light by this blue color. The Hitachi 101 spectrophotometer was used for measurements of absorbance.

Sulfate analyses were carried out using a titration technique.

#### Analysis of Sediments

**Bulk chemistry.** The sediment samples used for chemical and mineralogical analysis are the same sediment plugs squeezed on board for interstitial water extraction. One method of analysis employs a Ion-Coupled Plasma (ICP) Emission Spectroscopy (Javrel-Ash model 975) located at Tsukuba University. In this analysis, the JB-1, JB-2, JA-1, and JG-1 (JGS standard rocks) and the G-2, AGV-1, and BCR-1 (USGS standard rocks) served as standards. In ICP analysis, 100 mg of sample powder is dissolved with 10 ml of fluoric acid and 5 ml of sulphuric acid. The solution is diluted with nitric acid and double distilled water to make a total volume of exactly 100 ml. The relative accuracy of this method is approximately 5% for each element (Notsu, 1980).

In order to normalize the variability for the nonbiogenic sediments (removing biogenic carbonate or opal), values of Mg, K, Ca, Na, and Zn are commonly reported as the atomic ratios Mg/Al, K/Al, and so forth. In addition Al should be the least mobile major element involved in any alteration or diagenetic processes.

**Mineral identification.** X-ray diffraction was used to identify the minerals existing in the starting materials and in the reaction products. We used the Rigaku Denshi diffractometer and  $\text{CuK}\alpha$  radiation.

**Identification of clay minerals.** Clay minerals in remnant sediments were concentrated by decantation in distilled water and centrifuged. These clay minerals were identified by X-ray diffraction patterns before and after treatment by ethylene-glycol.

### GENERAL CHARACTERISTICS OF SITES 582 AND 584

Site 582 is located on the floor of the Nankai Trough about 2 km south of the deformation front (Fig. 1). The sediments are dark olive gray and gray turbidites and hemipelagic clays and silts (Fig. 2). Coarse sand turbidites decrease in frequency with sub-bottom depth. Trench turbidites include volcanic glass, lithic fragments, heavy minerals, red chert, well-preserved mixtures of shallow and deep benthic foraminifers, and both marine and non-marine diatom assemblages. Site 582 is characterized by extremely high rates of accumulation during the Quaternary caused by the large input of continental-derived sediment. Biostratigraphic and paleomagnetic data suggest reduction of rates from near 900 m/Ma before 0.4 Ma ago or earlier to less than 300 m/Ma after 0.4 Ma (Leg 87 Scientific Party, 1983; Karig et al., 1983).

Both the turbidites and the hemipelagic sediments of the axial deposits have an organic carbon content from 0.5 to 0.7%, decreasing to less than 0.5% in the hemipelagites beneath. Hydrocarbon gases (mainly methane with very minor  $\text{CO}_2$ ,  $\text{C}_2$ ,  $\text{C}_3$ , and  $i\text{-C}_4$ , as well as traces of  $\text{H}_2\text{S}$ , isopentane, and neopentane) are present throughout the section as gas pockets. No solid gas hydrate was encountered (site chapters, Sites 582 and 584, this volume).

Site 584 is situated on the deep-sea terrace of the trench slope (Fig. 1) where 954 m of the sedimentary section were penetrated. The oldest sediment cored was middle Miocene. Four lithostratigraphic units are recognized (site chapter, Site 584, this volume). The uppermost 4 m at Hole 584 is Pleistocene sediment (0 to 4 m sub-bottom

depth). A second lithologic unit (4 to 231 m sub-bottom depth) is lower Pliocene diatomaceous mud and mudstone. A third lithologic unit (231 to 537 m sub-bottom depth) is also a diatomaceous mudstone, but is distinguished by fine sand and silt beds, seaward-dipping strata, and markedly higher induration than in the overlying sediments. The Pliocene/Miocene boundary occurs within that unit, near 564 m sub-bottom depth, but no lithologic contrast marks the boundary. A bioturbated mudstone with a much-reduced diatom content constitutes Unit 4 (Fig. 2). Rates of sediment accumulation were estimated based on selected datum levels and are highest (200 to 700 m/Ma) for the early Pliocene and latest Miocene, a 7-Ma time span (Leg 87 Scientific Party, 1983; Karig et al., 1983).

### SITE 582 RESULTS FOR INTERSTITIAL WATER AND SEDIMENT CHEMISTRY AND MINERALOGY

#### Pore-Water Chemistry

Salinity, pH, and chlorinity are nearly constant with respect to sub-bottom depth at this site (Table 1). Alkalinity reaches a maximum of 45 meq/l at 200 m sub-bottom then remains virtually constant at about 25 mmoles/l beneath 280 sub-bottom depth (Fig. 3A).

The  $\text{SO}_4$  concentration decreases to 5 mmoles/l within the upper 100 to 200 m, increases to about 25 mmoles/l to a total depth of 670 m (Fig. 3B).

The Mg concentration decreases to 42 mmoles/l within the upper 50 m of sediments, remains constant to 200 m, then decreases to a total depth of 690 m (Fig. 3B).

The dissolved Ca is constant at 5 mmoles/l, a concentration of about half that of bottom seawater (Fig. 3C).

The K concentration remains fairly constant throughout the section (Fig. 3C).

Dissolved Sr shows only a slight peak around 200 m sub-bottom and increases below 400 m sub-bottom (Fig. 3D).

Dissolved Li concentration increases slightly between the seafloor and 550 m sub-bottom in Lithologic Unit 1 and then increases rapidly below that depth in Unit 2 (Fig. 3E).

The  $\text{SiO}_2$  concentration is nearly constant throughout at about 0.6 mmoles/l (Fig. 3F).

#### Sediment Chemistry

The bulk chemistry of the remnant sediment samples from Sites 582 and 584 is presented in Table 2. At Site 582, the atomic ratios for Si/Al, Mg/Al, Na/Al, K/Al, and Li/Al remain low and fairly constant (Fig. 4). The Ca/Al and Sr/Al ratios are scattered but decrease with depth (Fig. 4C, D), and, conversely, the Zn/Al ratio increases with depth by nearly a factor of 2 (Fig. 4H).

#### Sediment Mineralogy

Smear-slide estimates for Site 582 indicate that quartz and feldspar concentrations decrease gradually with depth as clay concentrations gradually increase (Fig. 5). Clay minerals present include kaolinite, illite, and smectite. Pyrite is found in all the sections at concentrations of 2–9%.

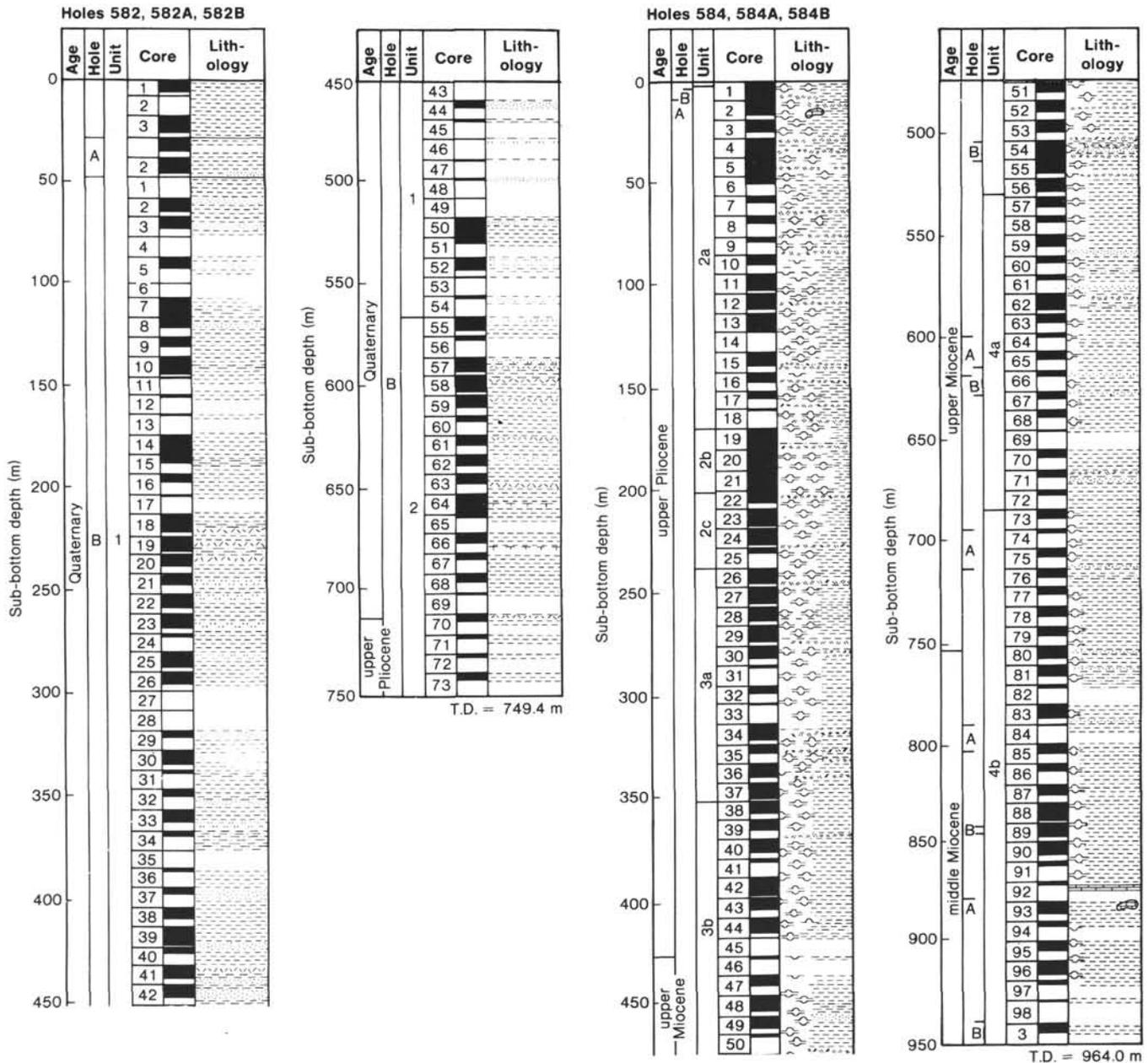


Figure 2. Lithology columns, Sites 582 and 584. For key to lithologic symbols, see Explanatory Notes chapter (this volume). T. D. = total depth.

Biogenic silica in the form of diatoms, sponge spicules, radiolarians, and silicoflagellates is scarce at Site 582, as is calcium carbonate in the form of foraminifers and calcareous nannofossils.

**SITE 584 RESULTS FOR INTERSTITIAL WATER AND SEDIMENT CHEMISTRY AND MINERALOGY**

**Pore-Water Chemistry**

From 0 to 260 m sub-bottom depth, the pH increases slightly, from 7.27 to 7.80, but is fairly constant below 260 m (Table 1). Cl does not differ significantly from seawater concentrations. The alkalinity varies between 4 and 23 meq/l (Fig. 6A), reaching a maximum value at

300 m sub-bottom depth (site chapter, Site 584, this volume).

The SO<sub>4</sub> concentration decreases gradually to 4 mmoles/l at a depth of 400 m (Fig. 6B). The Mg concentration is relatively high and constant at more than 50 mmoles/l in the upper 150 m of sediment, but then shows a slight decrease to about 48 mmoles/l by 250 m and a steady decrease to 25 mmoles/l at 594 m sub-bottom (Fig. 6B).

Dissolved Ca increases slightly from 10 to 12 mmoles/l in the upper 100 m of sediments, but decreases to 7 mmoles/l downhole to a depth of 300 m and remains relatively constant at 8 mmoles/l from 450 to 594 m (Fig. 6C). The dissolved K decreases from 13 to 10 mmoles/l with a nearly constant gradient (Fig. 6C).

Table 1. Interstitial water data, Leg 87.

Core-Section (interval in cm)	Sub-bottom depth (m)	pH	Salinity (‰)	Chlorinity (‰)	Alkalinity (meq/l)	Mg	Ca	Sr	Na	K	Li	SO <sub>4</sub>	Silica
<b>Hole 582</b>													
1-3, 143-150	4.5	7.79	33.80	19.78	21.12	48.03	6.92	0.07	481.12	13.36	0.01	12.73	0.63
3-5, 120-130	26.9	7.19	33.00	19.99	16.26	42.91	5.65	0.07	494.14	12.95	0.01	12.13	0.66
<b>Hole 582A</b>													
1-5, 0-10	35.1	7.50	33.60	19.78	19.53	42.07	4.98	0.08	481.67	12.25	0.01	5.36	0.60
2-5, 0-10	44.8	7.71	33.80	19.07	24.64	43.20	4.75	0.08	465.53	11.78	0.01	5.41	0.60
<b>Hole 582B</b>													
2-2, 140-150	61.2	7.81	33.80	19.58	28.33	43.21	4.46	0.08	483.69	12.69	0.01	5.62	0.55
14-5, 138-150	181.5	7.98	34.60	19.68	45.62	46.39	5.14	0.09	484.61	12.88	0.01	0.00	0.43
18-5, 140-150	217.0	7.78	34.10	19.37	36.43	45.02	7.69	0.09	477.29	12.40	0.01	6.25	0.55
23-1, 140-150	252.2	7.86	33.60	19.34	23.48	40.56	6.39	0.08	477.38	11.91	0.01	7.18	0.54
30-5, 138-150	335.4	7.85	33.00	19.10	20.36	34.68	5.11	0.07	475.49	11.60	0.01	3.85	0.61
33-4, 140-150	362.5	7.95	32.20	18.89	20.21	36.34	5.65	0.07	369.92	11.69	0.02	6.35	0.47
38-3, 140-150	408.3	7.76	33.80	19.10	20.08	36.55	4.81	0.07	485.02	11.15	0.01	10.10	0.60
50-3, 135-150	522.3	7.89	33.60	19.07	21.34	28.26	7.61	0.08	496.98	10.97	0.02	10.31	0.60
54-2, 135-150	559.3	7.91	33.30	19.37	25.36	28.63	5.75	0.09	517.22	12.21	0.03	13.33	0.59
66-2, 135-150	674.8	7.64	33.00	18.04	18.00	25.17	9.23	0.11	489.76	11.81	0.04	21.86	0.68
61-2, 135-150	626.7	7.70	33.30	19.20	20.62	27.81	6.47	0.11	536.41	13.00	0.05	28.00	0.67
<b>Hole 584</b>													
1-4, 140-150	4.0	7.27	36.30	19.14	3.72	52.64	10.67	0.08	457.77	13.18	0.02	27.07	0.85
2-3, 140-150	14.8	7.42	35.50	18.58	3.64	51.15	10.46	0.08	445.17	13.10	0.02	26.96	0.92
3-3, 140-150	24.5	7.63	36.60	19.31	4.97	52.06	10.97	0.08	462.93	13.59	0.02	26.55	1.13
5-5, 140-150	46.3	7.41	36.50	20.01	5.61	52.75	11.58	0.08	481.88	13.06	0.02	26.86	0.99
6-2, 140-150	51.2	7.57	35.80	19.61	5.96	52.50	11.62	0.08	473.25	13.25	0.02	27.90	0.94
7-1, 140-150	59.3	7.38	35.50	19.34	5.85	52.18	11.58	0.08	461.89	11.89	0.02	25.05	0.52
9-1, 140-150	78.5	7.39	35.80	19.44	6.59	52.27	11.45	0.08	465.33	12.38	0.02	25.19	0.80
10-3, 140-150	91.0	7.61	35.80	19.48	7.56	51.82	11.85	0.08	466.65	12.86	0.02	24.99	0.89
12-5, 140-150	113.0	7.51	35.50	19.41	7.60	50.89	11.27	0.08	466.23	12.76	0.02	24.19	0.93
16-2, 135-150	147.0	7.52	35.80	19.21	10.33	52.13	11.44	0.08	449.89	11.43	0.03	18.22	0.84
19-6, 135-150	182.1	7.50	34.60	19.31	11.96	50.57	9.34	0.07	456.93	11.36	0.02	15.82	1.02
22-3, 135-150	206.6	7.58	34.40	19.44	14.53	48.97	8.47	0.08	468.62	10.85	0.03	15.82	1.05
27-4, 135-150	255.8	7.79	34.60	19.78	20.35	48.43	6.16	0.08	478.15	9.53	0.03	9.37	0.49
32-2, 135-150	300.3	7.74	33.60	19.31	23.64	42.36	5.56	0.06	486.54	10.00	0.03	12.10	1.00
37-5, 135-150	352.6	7.70	33.00	19.17	19.93	37.18	5.64	0.07	473.05	10.83	0.05	4.50	0.99
42-4, 135-150	398.9	7.74	32.40	18.91	19.98	33.37	5.97	0.10	472.34	10.69	0.07	4.27	0.78
47-3, 135-150	445.5	7.80	33.00	19.01	21.79	29.39	7.15	0.14	474.13	10.51	0.09	0.00	0.77
51-2, 135-150	482.3	7.63	33.00	19.31	19.67	29.51	6.64	0.09	481.69	10.16	0.08	0.00	0.77
57-3, 135-150	541.1	7.71	33.00	19.21	19.87	27.33	5.92	0.09	485.05	9.99	0.09	0.00	0.56
62-1, 135-150	590.1	7.90	33.00	19.17	18.14	23.51	6.46	0.10	488.62	10.09	0.09	0.00	0.74

Note: pH, salinity, chlorinity, and alkalinity data are from site chapters for Sites 582 and 584, this volume. Concentrations of elements and silica are in mmol/L.

Dissolved Sr remains constant in the upper 200 m of sediments, reaches a minimum concentration at about 300 m, then increases to 594 m (Fig. 6D).

The dissolved Li concentration is low and relatively constant at 0.02 mmol/L in the upper 300 m of sediment, but then increases steadily to about 0.08 mmol/L by 450 m, remaining nearly constant at this concentration to a total depth of 594 m (Fig. 6E).

Although dissolved silica analyses show a scatter around 0.8 mmol/L, there is an overall decrease with depth (Fig. 6F).

### Sediment Chemistry

Sediments remain low and nearly constant in their Mg/Al, and Sr/Al ratios throughout the entire sediment sequence (Fig. 7E, 7D). Si/Al, Ca/Al, Na/Al and K/Al ratios generally decrease with depth (Fig. 7A, 7C, 7E, 7F). Li/Al ratios are scattered (Fig. 7G), and Zn/Al ra-

tios increase with depth by nearly a factor of 3 (Fig. 7H). Other elements show no marked depth-related trends.

### Sediment Mineralogy

Smear-slide observations indicate that diatom concentrations are high (60%) in the upper 200 m of the sediments, but decrease gradually to 10% at total depth (Fig. 8).

Other biogenic silica microfossils (such as sponge spicules, radiolarians, and silicoflagellates) are common at Site 584, but biogenic carbonate is scarce.

Quartz and feldspar concentrations gradually increase with depth to 30%. Also, clay concentrations gradually increase, despite considerable scatter within the data. Clay minerals present include kaolinite, illite, and smectite.

Although pyrite and other opaque minerals are found in all the sections, the pyrite concentration is variable from 1 to 6%.

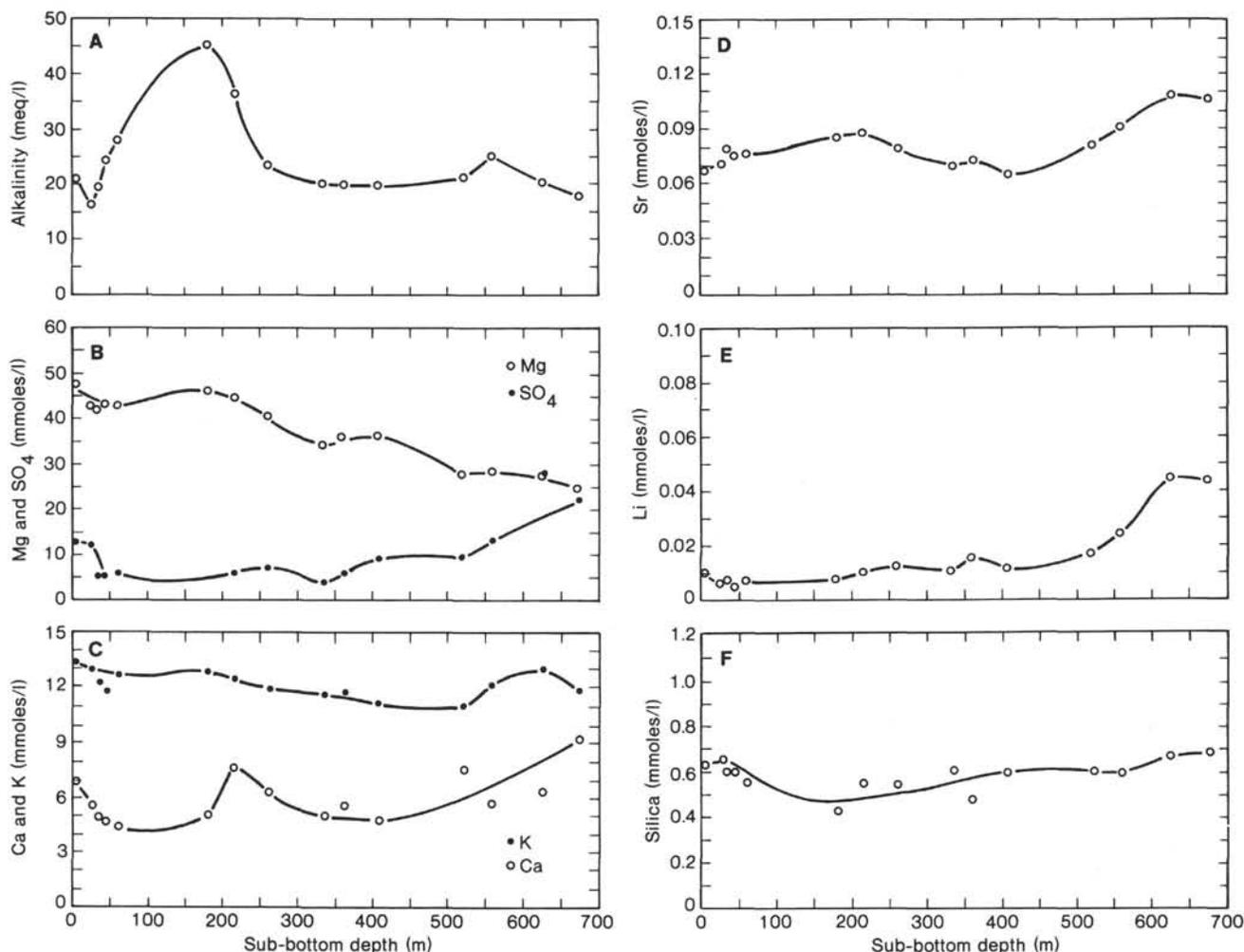


Figure 3. Site 582 interstitial water chemistry. Alkalinity data are from on-board analyses (site chapter, Site 582, this volume). Labels A-F are for text references.

## DISCUSSION

### Site 582

Sulfate reduction is accompanied by the production of secondary pyrite at low temperature, probably owing to reduced sulfur and ferrous iron formation during the production of biogenic methane. The sediments have an organic content between 0.5 and 0.7% and hydrocarbon gases, mainly methane with very minor  $\text{CO}_2$ ,  $\text{C}_2$ , and  $\text{C}_3$ , and traces of  $\text{H}_2\text{S}$  are present (site chapter, Site 582, this volume). Pyrite occurring in cores below the sulfate-reducing zone are probably relicts of a time when those strata were within 300 m of the seafloor.

High alkalinities are accompanied by low concentrations of dissolved sulfate and calcium at Site 582, suggesting precipitation of calcium carbonate in relation to sulfate reduction.

Pore-water concentrations of dissolved Mg decrease by a factor of 0.85 within the first 4.5 m below the seawater/sediment interface and then decrease by a factor of 0.5 to a depth of 680 m. Although this trend must be explained in terms of interstitial water interaction with sediments, the Mg/Al in sediments is quite constant. Evi-

dently, no large quantity of Mg ions is added to the sediment phase. Probably the sediments of Unit 1 at Site 582 are so young (Quaternary) that the interstitial water has not yet reacted with the sediments.

Dissolved K does not indicate a sink in the section, also probably a result of incomplete reaction with these relatively young sediments.

### Site 584

Sediments from Sites 438, 439, 440, and 441 of Leg 57 have an average organic carbon content of about 0.8% (Rullkötter et al., 1980; Sato, 1980). Despite the lack of Leg 87 shipboard analyses of organic carbon, the sediments at Site 584 are estimated to have high organic carbon content. Sulfate reduction is accompanied by the production of pyrite and a large increase in alkalinity, which is responsible for the precipitation of calcium carbonate, as reflected in a minimum dissolution calcium at about 300 m.

There are one or more possible reasons for the increase in dissolved Sr with depth: (1) carbonate recrystallization processes; (2) alteration of volcanic matter; and (3) ion exchange and reaction between the intersti-

Table 2. Chemical analyses of sediments, Sites 582 and 584.

Core-Section (interval in cm)	SiO <sub>2</sub>	Al <sub>2</sub> O <sub>3</sub>	FeO*	MgO	CaO	Na <sub>2</sub> O	K <sub>2</sub> O	TiO <sub>2</sub>	P <sub>2</sub> O <sub>5</sub>	MnO	Li	Sr	Co	Ni	Zn	LOI
<b>Hole 582</b>																
1-3, 143-150	59.59	16.13	6.08	2.92	1.41	3.49	2.88	0.72	0.13	0.09	77.0	149	13.01	47.29	50.33	6.56
3-5, 120-130	61.39	15.20	5.61	2.46	1.92	3.10	2.82	0.68	0.14	0.10	61.4	168	16.24	44.98	66.32	6.58
<b>Hole 582A</b>																
1-5, 0-10	67.61	13.77	4.51	1.97	1.95	2.75	2.51	0.56	0.10	0.09	52.7	176	9.97	25.57	53.95	4.18
2-5, 0-10	59.80	16.08	6.14	2.72	1.84	2.92	2.94	0.74	0.15	0.10	68.0	162	17.29	50.89	65.48	6.57
<b>Hole 582B</b>																
2-2, 140-150	59.05	16.09	6.32	2.72	2.23	2.89	2.91	0.74	0.15	0.11	66.0	174	18.31	48.03	60.96	6.80
14-5, 138-150	57.90	16.33	6.69	3.00	2.35	2.98	2.75	0.74	0.18	0.10	74.9	190	21.45	51.89	83.99	6.98
18-5, 140-150	58.85	15.81	6.20	2.66	2.52	2.99	2.62	0.71	0.17	0.10	53.7	196	16.34	44.19	73.00	7.36
23-1, 140-150	60.97	16.32	5.98	2.56	1.32	2.92	2.93	0.71	0.14	0.08	61.8	153	16.50	48.26	77.46	6.05
30-5, 138-150	60.11	15.78	6.00	2.51	2.03	2.77	2.83	0.72	0.15	0.10	60.4	165	16.08	52.33	73.93	7.01
33-4, 140-150	65.95	14.35	4.81	2.03	2.30	3.02	2.34	0.57	0.11	0.08	41.0	191	11.48	45.16	57.03	4.45
50-3, 135-150	62.28	16.10	5.94	2.62	1.21	2.85	2.90	0.76	0.15	0.09	58.3	147	17.34	53.20	121.78	5.10
54-2, 135-150	61.18	16.33	7.23	2.94	0.98	2.85	2.97	0.74	0.12	0.10	61.5	140	19.38	48.77	102.22	4.55
66-2, 135-150	59.57	16.84	6.46	2.84	1.77	2.50	2.99	0.76	0.11	0.10	71.0	156	18.37	56.42	114.62	6.06
<b>Hole 584</b>																
1-4, 140-150	66.29	8.57	3.05	1.40	3.93	2.96	1.59	0.32	0.06	0.04	48.6	182	5.96	26.30	19.58	11.79
2-3, 140-150	70.42	7.76	2.83	0.99	2.39	2.93	1.50	0.26	0.03	0.04	45.2	133	3.73	26.83	18.40	10.86
3-3, 140-150	71.78	7.78	2.79	1.26	0.99	3.03	1.31	0.29	0.02	0.04	34.0	100	4.57	24.33	21.04	10.72
5-5, 140-150	68.71	6.99	2.41	1.11	0.64	2.86	1.22	0.24	0.01	0.03	34.4	85	0.72	20.88	15.46	15.77
6-2, 140-150	66.25	10.54	4.41	1.17	2.57	3.17	1.11	0.36	0.04	0.06	29.8	124	5.83	19.43	26.34	10.31
7-1, 140-150	71.21	7.83	2.56	1.20	0.70	3.28	1.55	0.27	0.02	0.04	44.2	86	0.86	23.25	19.69	11.34
9-1, 140-150	72.44	7.05	2.42	1.21	0.63	3.04	1.31	0.26	0.01	0.03	44.0	86	2.68	21.50	15.94	11.61
10-3, 140-150	68.81	9.42	3.49	1.55	1.20	3.04	1.58	0.38	0.04	0.04	40.7	115	7.16	30.58	26.24	10.46
12-5, 140-150	68.74	8.69	3.20	1.51	0.99	2.86	1.62	0.34	0.04	0.04	43.2	100	8.50	36.88	32.47	11.97
16-2, 135-150	71.89	6.83	2.65	1.13	0.73	2.94	1.58	0.23	0.02	0.03	47.5	78	5.65	25.38	24.91	11.98
19-6, 135-150	71.99	6.24	2.25	1.10	1.50	2.66	1.37	0.21	0.02	0.03	53.3	102	6.15	31.11	17.05	12.63
22-3, 135-150	71.81	6.40	2.26	1.10	1.02	2.69	1.40	0.22	0.01	0.03	52.8	91	6.26	27.38	21.08	13.07
27-4, 135-150	74.62	6.57	2.44	1.05	0.72	2.50	1.28	0.22	0.02	0.03	40.4	82	4.70	26.38	15.98	10.55
32-2, 135-150	69.79	9.79	3.68	1.65	0.78	2.86	1.49	0.39	0.04	0.05	37.2	106	6.30	30.46	33.03	9.48
37-5, 135-150	67.10	11.30	4.24	1.92	0.96	2.97	1.83	0.45	0.05	0.05	43.2	121	9.55	51.62	53.77	9.11
42-4, 135-150	66.32	11.77	4.60	1.97	0.82	3.01	1.94	0.49	0.06	0.16	49.4	122	9.30	49.62	58.60	8.85
47-3, 135-150	69.17	10.52	4.05	1.75	0.53	2.80	1.80	0.42	0.04	0.05	52.8	102	9.47	33.87	45.62	8.88
51-2, 135-150	66.78	12.24	4.74	2.30	0.89	2.86	1.92	0.58	0.07	0.06	47.2	129	11.55	41.00	71.43	7.56
57-3, 135-150	65.81	12.80	5.31	2.51	1.14	2.78	1.94	0.62	0.07	0.06	55.2	141	8.54	33.57	73.25	6.96
62-1, 135-150	63.51	14.37	6.05	2.79	1.46	3.06	2.13	0.72	0.11	0.10	54.1	160	19.02	75.19	85.85	5.69

Note: SiO<sub>2</sub>, Al<sub>2</sub>O<sub>3</sub>, FeO\*, MgO, CaO, Na<sub>2</sub>O, K<sub>2</sub>O, TiO<sub>2</sub>, and P<sub>2</sub>O<sub>5</sub> concentrations are expressed in %; other concentrations are in ppm. \* indicates that total iron is expressed as FeO\*. LOI is loss on ignition (i.e., loss on heating to 1000°C).

tial water and clay minerals. Although it is difficult to speculate about the processes because of the absence of Sr isotope data at this time, we postulate that the Sr source is associated with the recrystallization reactions. The reason is that the dissolved Ca profile, like the Sr profile, shows a minimum at 300 m sub-bottom. In contrast, the alkalinity profile shows a maximum at the same depth.

Dissolved Mg appears to be consumed throughout the sediment column during diagenesis. Identification of newly formed silicate minerals is hampered, however, because of dilution by similar detrital minerals. At Site 584 detrital materials are relatively fresh and authigenic calcitic and dolomitic concretions occur (Matsumoto et al., this volume).

Usually decreases in dissolved Mg are associated with the alteration of volcanic matter in pelagic sediments (Perry et al., 1976). In a continental margin setting, however, where rapid accumulation rates and high organic carbon contents lead to very high alkalinity values, carbonate precipitation and dolomitization may be the cause of the observed magnesium depletions. But Mg-rich and

Fe-rich carbonate concretions are found in discreet depth intervals. Another possibility is that dissolved Mg depletion results from ion exchange and reaction between interstitial water and clay minerals.

The distribution of pore-water Na values is reflected in the sediment chemistry. Dissolved Na concentrations increase with depth, whereas the Na/Al ratio decreases in the sediment column. Despite no clear evidence, the formation of secondary minerals probably controls this trend.

## RELATIONS BETWEEN INTERSTITIAL WATER AND SEDIMENTS

### Dissolved Silica Content

Dissolved silica analyses for Site 584 are scattered around 0.8 mmoles/l, a typical value for sediment containing both clay minerals and biogenic silica. Diatom frustules occur throughout, even at 590 m (the deepest interstitial water sample). We found no secondary silica minerals at this site, perhaps because of the low geothermal gradient.

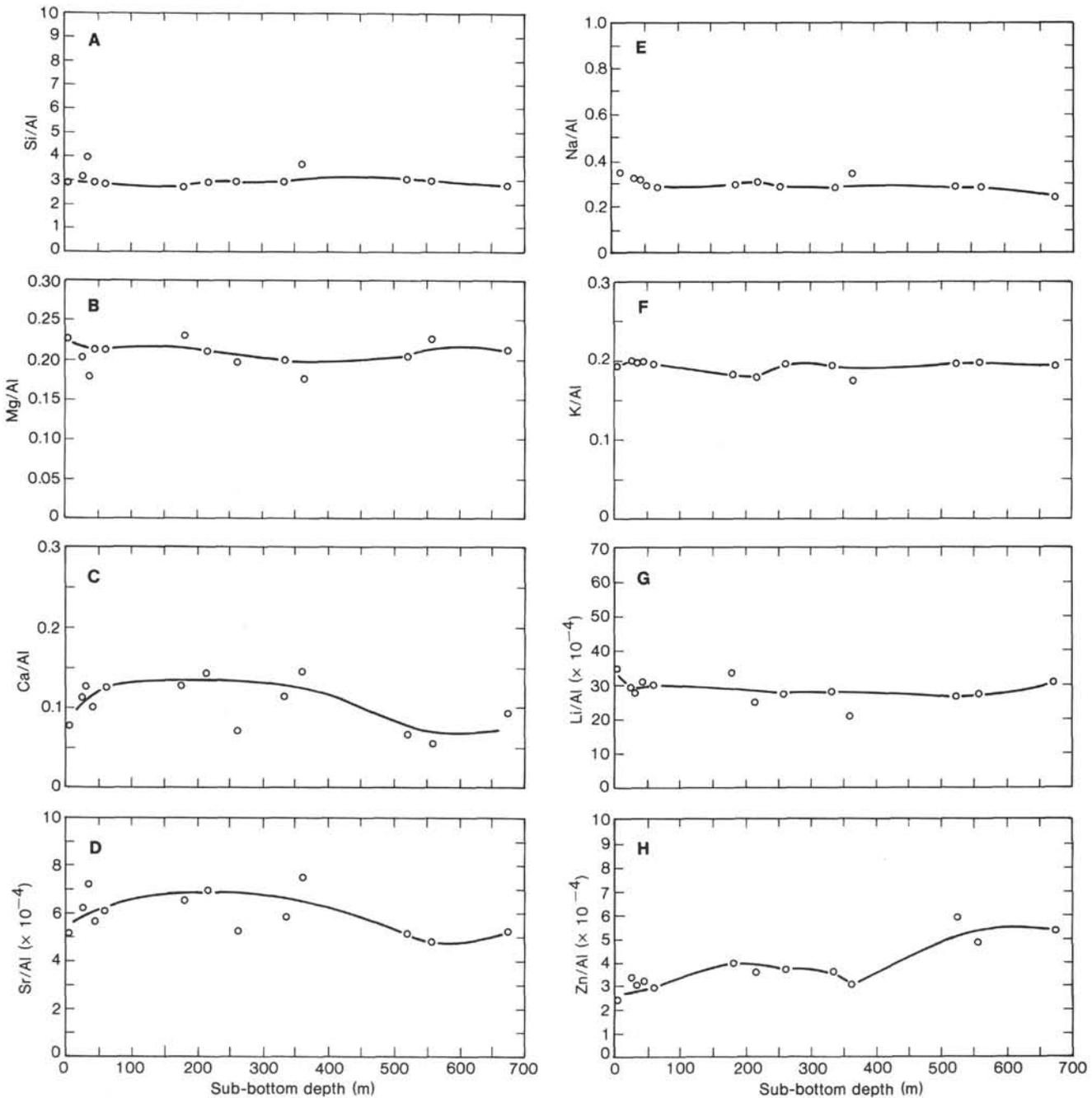


Figure 4. Site 582 sediment chemistry. Labels A-H are for text references.

Dissolved silica concentration increases slightly with depth at Site 582. Its average is 0.6 mmoles/l, less than that at Site 584. The sediments at Site 582 mainly consist of clay minerals, quartz, and feldspar and contain little or no biogenic opal. In general, quartz and feldspar resist diagenesis, and the dissolution of opaline silica exceeds the dissolution of clay minerals. Probably the difference in mineral composition at these sites arises from initial disparate silica concentrations between each location.

As previously stated, the distribution of  $\text{SiO}_2$  in the interstitial water is reflected in the sediment chemistry of the two sites. Higher Si/Al values in the sediment are

roughly correlated with higher values of interstitial water  $\text{SiO}_2$  at Site 584 (Fig. 9), suggesting that the presence of biogenic opal is probably responsible for higher dissolved silica in interstitial water.

#### Dissolved Lithium Content

The profiles of dissolved Li at Sites 582 and 584 are of interest; they show 3 zones (compare Fig. 3E, 6E, and 10). The Li concentrations increase gradually in Zone 1, then more sharply (by a factor of 5) in Zone 2. In Zone 3 the dissolved Li concentrations are high and remain fairly constant. The distribution of interstitial water Li values are not reflected in sediment chemistry (Figs. 5,

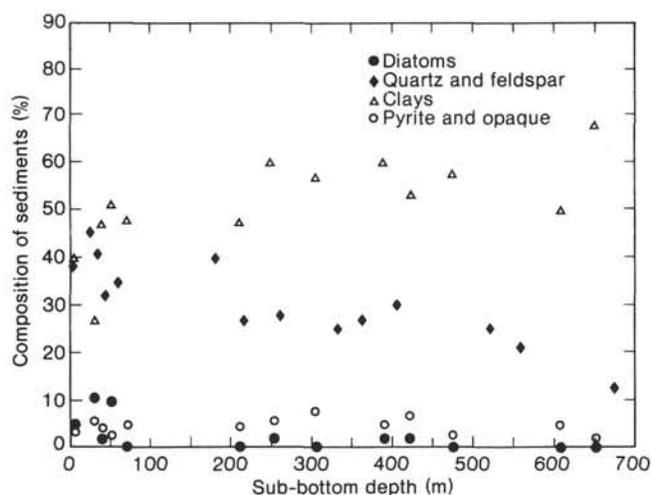


Figure 5. Site 582 sediment composition with depth.

and 7). Although increases in dissolved Li concentrations may be related to its release from clay minerals, there is another related possibility. Dewatering structures are observed below Unit 4 at Site 584 (site chapter Site 584, this volume). At Site 582 dewatering veinlets are not common, but faults and fissures exist and their permeability is much lower than that of normal sediments. The high and constant Li concentrations may be related to advection that results from dewatering processes and fluid transport (Kinoshita et al., this volume).

#### SUMMARY AND CONCLUSIONS

Both the Nankai Trough and the Japan Trench were explored during Leg 87. Site 582 is on the floor of the Nankai Trough and Site 584 is situated on the deep-sea terrace of the Japan Trench. Our investigation of the chemistry of the interstitial water and sediments, as well as the sediment mineralogy, reveals that:

1. Sulfate reduction is accompanied by the production of secondary pyrite, which is rich in the sedimentary column at both sites.

2. Dissolved Ca concentrations are relatively low and change slightly at both sites, probably because of the formation of carbonate with high alkalinity.

3. Concentrations of dissolved Mg decrease with depth at Site 584. Dissolved Mg depletion probably results from the formation of Mg-rich carbonate and/or ion exchange and reaction between interstitial water and clay minerals.

4. Higher Si/Al values caused by biogenic opal in the sediments correlate roughly with higher values of interstitial water SiO<sub>2</sub>.

5. Increases in dissolved Li concentrations may be related to its release from clay minerals and/or to advection that results from dewatering processes and/or fluid transport.

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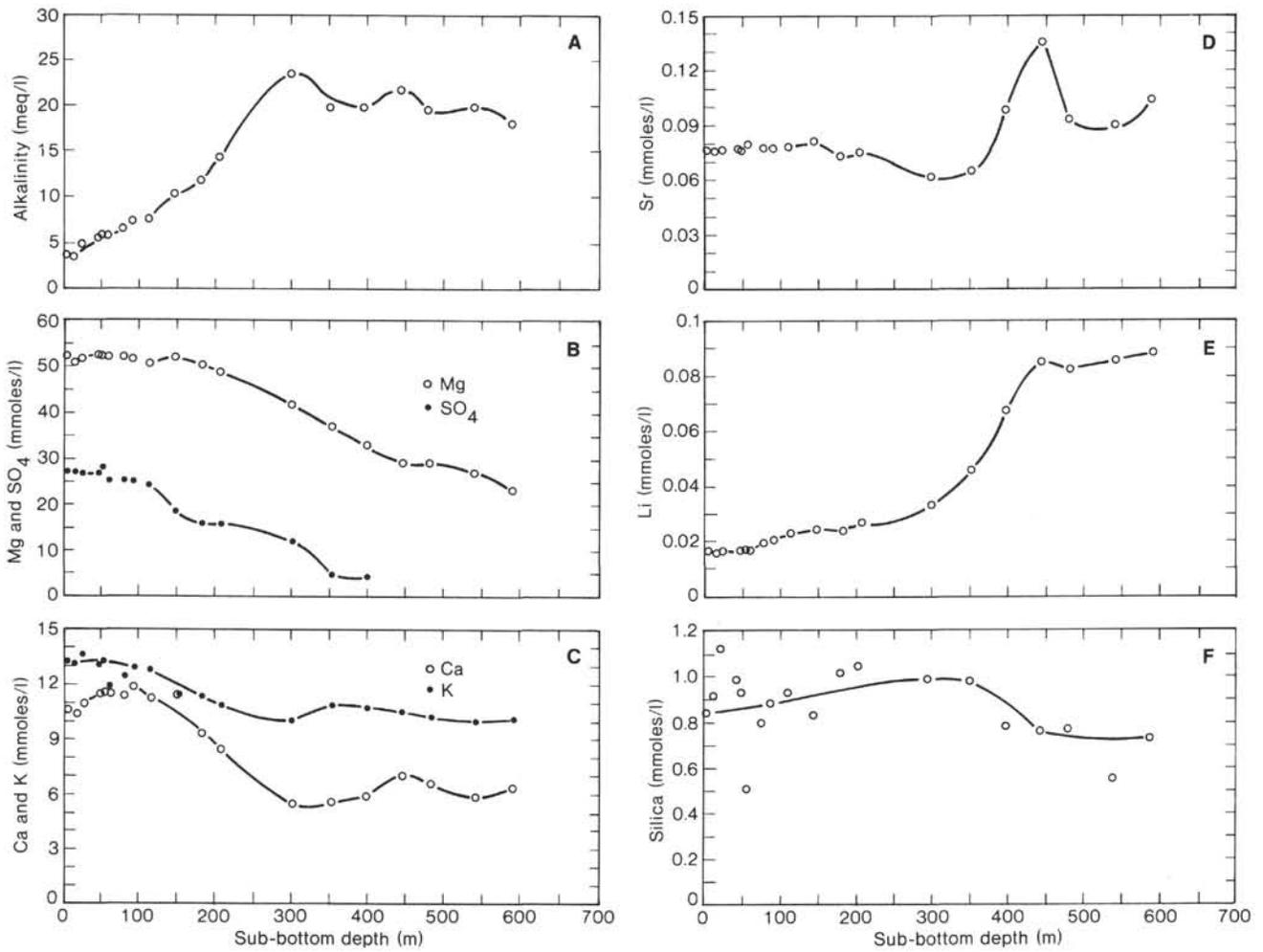


Figure 6. Site 584 interstitial water chemistry. Alkalinity data are from on-board analyses (site chapters, Sites 582 and 584, this volume). Labels A-F are for text references.

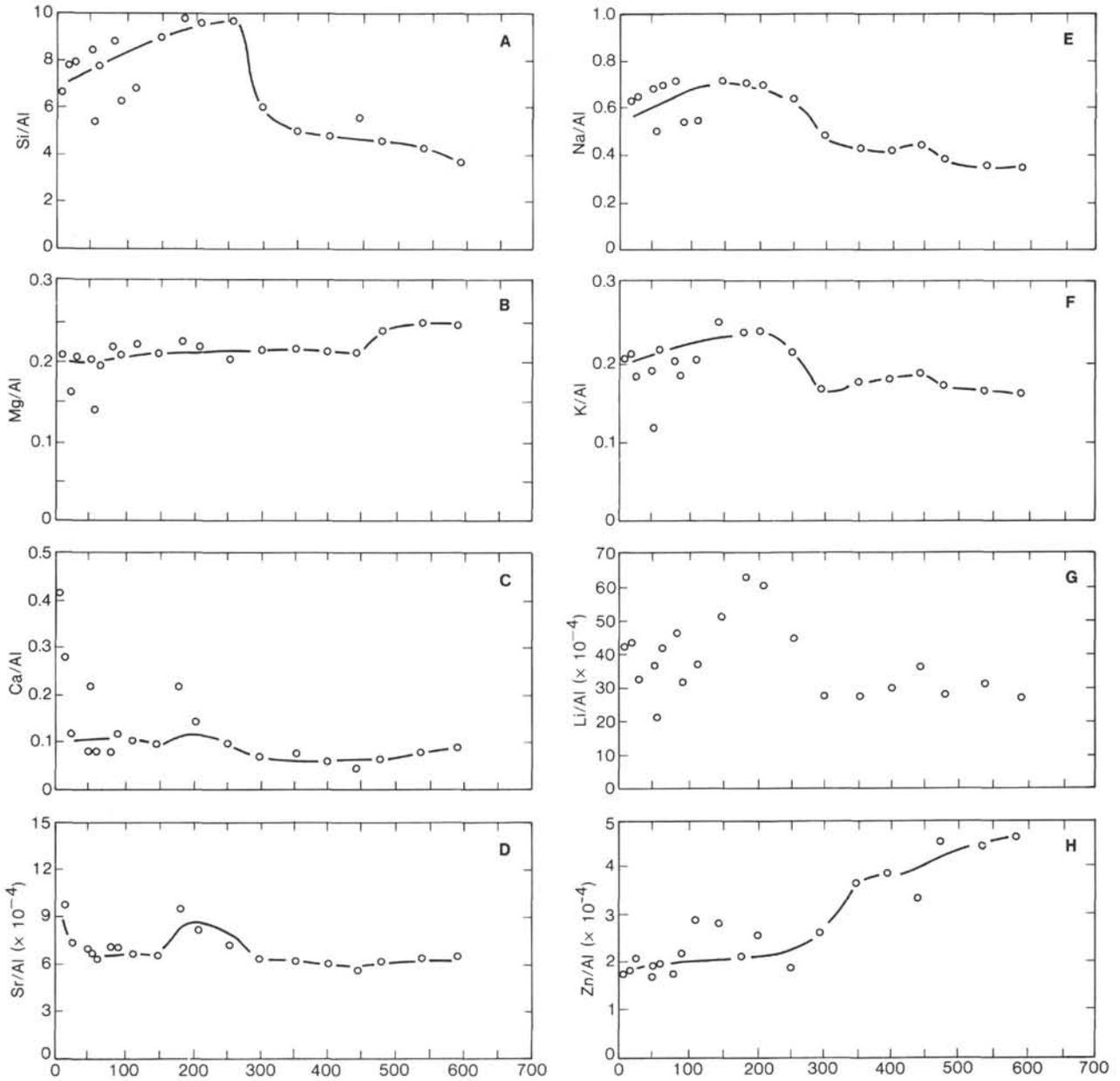


Figure 7. Site 584 sediment chemistry. Labels A-H are for text references.

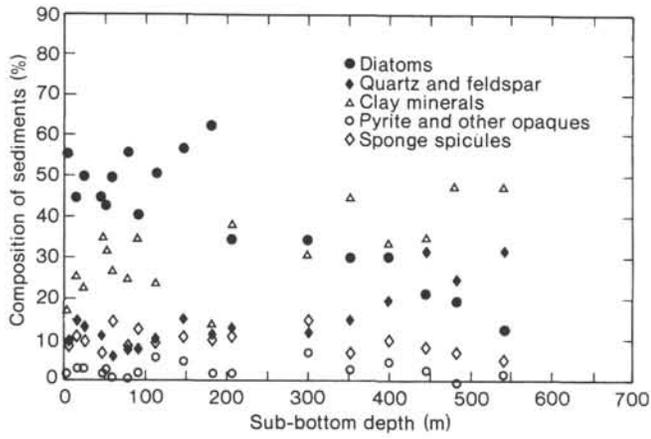


Figure 8. Site 584 sediment composition with depth.

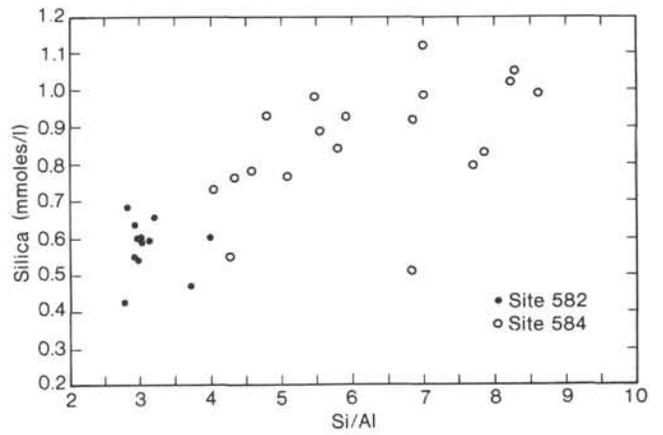


Figure 9. Relation between silica in interstitial water and Si/Al ratio in sediments.

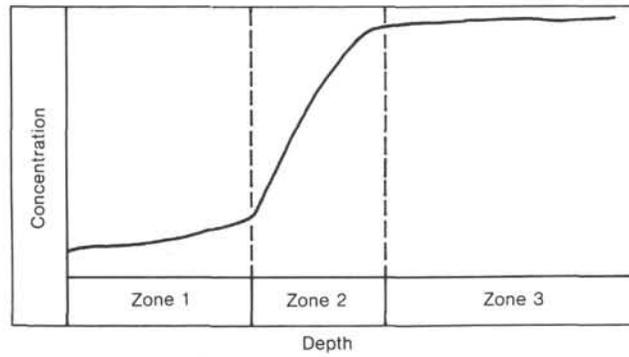


Figure 10. Schematic diagram of dissolved Li concentrations with depth.