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24. SEDIMENT GRAIN-SIZE CONTROL ON GAS HYDRATE PRESENCE, SITES 994, 995, AND 997[1]

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ABSTRACT

This research was designed to check the assumption of the grain-size control on a gas hydrate presence in the Blake Ridge sediments; the assumption had originated from the data gained at Deep Sea Drilling Project (DSDP) Site 533. Granulometric analysis (the combined pipette-sieve method) of the 345 sediment samples obtained after pore-water squeezing from Ocean Drilling Program (ODP) Sites 994, 995, and 997 has provided support for this assumption. The zone of negative anomalies of pore-water chlorinity, which is generally recognized to be gas hydrate bearing, is confined, as a whole, to the interval of comparatively coarse-grained sediments in each of the three site columns because content of the fine fractions <0.05, <0.01, <0.005, and <0.001 mm is lower there (although the character of this control changes from site to site). The individual chlorinity anomalies also coincide, for the most part, with relatively coarse-grained sediments.

INTRODUCTION

Examination of the world-wide data suggests that submarine gas hydrates are of migration origin and generally occur under the control of comparatively coarse-grained sediments and fractured zones (Ginsburg and Soloviev, 1988, 1997; Soloviev and Ginsburg, 1994, 1997). Their confinement to the relatively coarse-grained sediments has been inferred, in particular, from the Deep Sea Drilling Project (DSDP) results obtained from the Blake Ridge area (Figs. 1, 2), although this suggestion was not sufficiently reliable because of inadequate sampling frequency. To support this suggestion, we undertook the present study.

We have studied the granulometric composition of sediments along the columns of three Ocean Drilling Program (ODP) sites drilled during Leg 164 (Sites 994, 995, and 997 [99, 125, and 121 samples, respectively]) and compared them with the distribution of the pore-water chlorinity, which is commonly accepted as a guide to a gas hydrate content of sediments (in particular, by participants of this leg). The chlorinity data are borrowed from Paull, Matsumoto, Wallace, et al. (1996). It is important to note that the grain-size analysis was carried out on the "cakes"—the same samples that were squeezed to get pore-water samples for chemical analysis.

METHOD OF GRAIN-SIZE ANALYSIS AND RESULTS

The combined pipette-sieve method of grain-size analysis resulted in the use of 13 size fractions in this study. These fractions are the following (grain size in millimeters): >1.0, 1.0–0.63, 0.63–0.40, 0.40–0.315, 0.315–0.200, 0.200–0.160, 0.160–0.100, 0.100–0.063, 0.063–0.050, 0.050–0.010, 0.010–0.005, 0.005–0.001, and <0.001. The State USSR Standard (GOST 12536-79, 1998) provides a basis for this method.

To calculate grain-size fractions content of dry sediment, weight percent of water in the sediment sample was first determined.

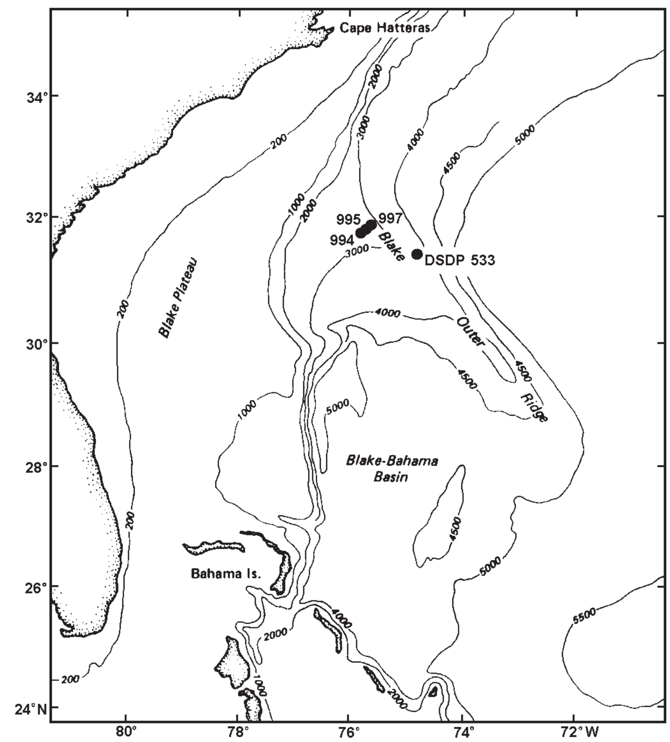

Figure 1. Location of the DSDP and ODP sites discussed herein in the Blake Outer Ridge area (after Paull, Matsumoto, Wallace, et al., 1996). Contours are in meters below sea level.

For grain-size analysis, a weighed sediment sample (20–35 g) was added to distilled water, mixed, and held for 12–15 hr. Then, according to Lapina (1974), the sample was dispersed with ultrasound (frequency 22 kHz) for 3–5 min. Thereupon the specimen was ground (by rubber pestle, without force), poured into a glass beaker, topped up to the definite level by water (with the addition of an anticoagulant [sodium phyrophosphate, 50 mL of a saturated solution per 4 L of treated suspension]), mixed again, and held at room temperature (18°–22°C). Three subsamples were taken, one after another, from a tabulated depth (7–10 cm) below the surface of suspension, at tabulated time intervals of "minute" (17–19 min), "hour" (71–78 min), and "diurnal" (21–23 hr) for subsamples representing the grain-size fraction <0.01,

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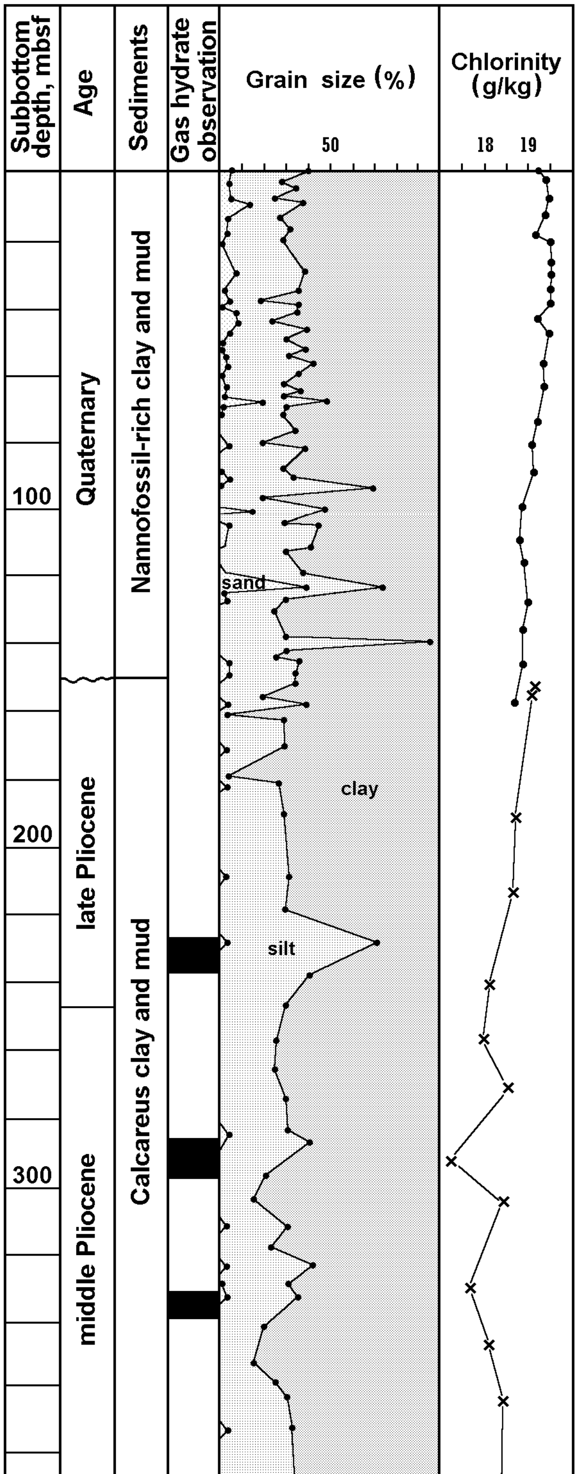

Figure 2. Gas hydrates (observed and inferred = black bars), sediment grains size, and pore-water chlorinity in the column at DSDP Site 533. After Ginsburg and Soloviev (1988; compiled using the data from Sheridan, Gradstein, et al., 1984).

<0.005, and <0.001 mm, respectively. A 25- to 30-mL pipette was used for taking these subsamples. Each subsample was transferred to a porcelain bowl, dried, and weighed. Using the data obtained and taking into account the water content of the sample (see above), the mass of three clay grain-size fractions of the sediment were calculated. Thereupon the suspension (situated in the glass beaker) was completely freed of clay particles by repeated settling and decantation (through a siphon); the duration of settling and level of decantation are tabulated in the method prescription. These operations were repeated until the layer to be decanted became transparent. The remainder of the specimen (grain-size fractions > 0.01 mm) was transferred into a porcelain bowl, dried, weighed, and sieved manually by means of a bank of woven sieves, for a period of 20 min. Each obtained fraction was weighed, and the mass of the remaining grain-size fractions was calculated.

The results of grain-size analysis of all 375 samples from Sites 994, 995, and 997 are presented in Tables 1–3, respectively. Seventeen samples were analyzed a second time. These results (provided in Table 4) show that the accuracy of determination of the isolated grain-size fractions, particularly the fine ones, is rather low; however, the discrepancy becomes essentially less important when considering fractions jointly (Table 5).

DISCUSSION

The distribution of all measured grain-size fractions with depth is diagrammed in Figures 3–5 along with the pore-water chlorinity. Inspection of Figures 3–5 points to the fact that the depth intervals, which encompass the chlorinity anomalies, are confined to the depth intervals where comparatively coarse-grained sediments occur. Two grain-size horizons bounding the zone of lowered pore-water chlorinity anomalies are clearly recognized in the column of Site 994 at depths in the regions of 250 and 400 mbsf (Fig. 3). The sediments in these horizons are enriched by particles >0.05, >0.01, >0.005, and >0.001 mm, compared to adjacent depths; the extent of the enrichment peaks are at approximately 2%, 10%, 12%–15%, and 8%–10%, respectively, which is distinctly larger than the upper 95% confidence limit of the standard deviation of the accuracy of our grain-size analysis (see Table 5). Similar horizons are more distinctly pronounced in the column of Site 995 (Fig. 4). In addition, the entire interval bounded by these horizons differs noticeably in this column from the underlying and overlying sediments by a rather high content of the fractions >0.005 and >0.001 mm. These two horizons do not stand out in the column at Site 997 (Fig. 5), but the entire interval under discussion is clearly discerned there by frequent interlayers characterized by a rather high content of the fractions >0.005 and >0.001 mm.

Individual chlorinity anomalies, which are attributed to gas hydrate–presence in situ, are also often, but not universally, controlled by rather coarse-grained sediments. Of a list of 61 of the most prominent anomalies in all three studied columns, 44 (77%) are more or less evidently confined to such sediments. Figure 6 provides an example of these anomalies.

CONCLUSIONS

This investigation has corroborated the grain-size control hypothesis on gas hydrate distribution along sediment columns. This control is observed in each of the three studied columns at the medium scale (the entire zone of chlorinity anomalies is controlled by a comparatively coarse-grained horizon), but manifests itself variously. In the column at Site 994, the gas hydrate–bearing zone is limited by coarse-grained sediments on the inside (at the top and bottom), but in the column at Site 997, this zone is discerned by relatively coarse-grained interlayers, and both these features are combined in the column at Site 995. It is important to note that Site 995 is located between Sites 994 and 997. The grain-size control on the gas hydrate distribution is also detected at the detail scale (at the level of individual sample) with some degree of certainty: 77% of individual chlorinity anomalies are confined to comparatively coarse-grained sediments.

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Table 1. Sediment grain-size analysis results and pore-water chlorinity, Site 994.

Core, section, interval (cm)	Depth (mbsf)	Sediment grain-size distribution (%)													Chlorinity (mM)
		>1.00	1.0-0.63	0.63-0.40	0.40-0.315	0.315-0.2	0.20-0.16	0.16-0.10	0.1-0.063	0.063-0.05	0.05-0.01	0.01-0.005	0.005-0.001	<0.001	
164-994C-															
4H-2, 145-150	26.35	0.0	0.0	0.0	0.0	0.0	0.0	0.3	0.3	0.6	16.0	17.1	22.7	42.9	554
4H-4, 140-145	29.30	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.2	0.3	10.8	16.8	44.8	26.9	549
5H-2, 140-150	35.85	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.3	1.3	29.6	18.7	27.2	22.5	554
5H-5, 145-150	40.35	0.0	0.0	0.0	0.0	0.0	0.2	0.2	0.3	0.7	14.6	15.6	21.7	46.7	551
6H-4, 145-150	48.05	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.4	10.2	11.2	30.8	47.0	552
7H-4, 145-150	57.85	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.2	0.8	11.5	12.7	33.9	40.8	549
8H-5, 140-150	68.80	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.8	13.2	19.4	30.1	36.1	545
10H-2, 140-150	74.80	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.6	16.8	17.4	40.8	24.2	545
11H-2, 140-150	84.30	0.8	0.0	0.0	0.2	0.0	0.0	0.2	0.0	0.4	10.9	24.5	27.1	36.0	544
12H-2, 140-150	93.50	0.0	0.0	0.0	0.0	0.0	0.0	0.3	0.2	0.6	15.6	13.7	34.8	34.6	541
13H-2, 140-150	103.30	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.6	15.6	17.3	41.8	24.1	535
14H-5, 140-150	117.30	0.0	0.0	0.0	0.0	0.0	0.0	0.3	0.2	1.0	15.9	19.6	31.9	31.0	537
15H-6, 145-150	127.68	0.0	0.0	0.0	0.0	0.0	0.2	0.8	0.4	2.7	18.0	12.3	41.6	23.9	—
16H-2, 145-150	131.85	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.2	1.2	19.9	17.5	42.7	18.3	534
17H-3, 145-150	142.85	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.8	13.7	15.9	48.2	21.1	529
20X-3, 145-150	162.85	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.4	16.8	19.2	40.3	23.3	523
21X-4, 145-150	170.75	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.4	16.0	70.6	7.6	5.4	523
22X-5, 140-150	180.80	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.4	13.9	16.6	43.7	25.4	524
23X-3, 135-150	188.35	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.4	14.1	14.9	45.4	25.2	516
24X-1, 135-145	194.95	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.4	15.2	15.3	43.0	25.7	520
25X-4, 140-150	209.20	0.0	0.0	0.0	0.2	0.0	0.2	0.2	0.0	0.4	12.0	15.1	40.7	30.9	499
26X-2, 140-150	215.80	0.0	0.0	0.0	0.2	0.0	0.0	0.2	0.0	0.5	11.6	15.6	45.7	26.2	513
29X-2, 45-50	234.05	0.0	0.0	0.0	0.0	0.0	0.0	0.3	0.0	0.5	13.3	13.5	46.3	25.9	509
30X-2, 140-150	244.70	0.0	0.0	0.0	0.2	0.0	0.0	0.2	0.0	0.5	15.8	17.7	48.2	17.4	486
31X-6, 67-72	259.47	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.0	0.4	16.5	19.3	37.5	25.9	478
32X-1, 130-140	262.20	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.0	0.4	12.1	16.8	36.1	34.2	508
33X-2, 140-150	273.29	0.0	0.0	0.2	0.2	0.0	0.0	0.2	0.0	0.2	11.9	18.4	32.4	36.5	506
35X-2, 143-153	291.90	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.0	0.4	9.7	9.3	45.8	34.3	481
36P-1, 0-23	299.40	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.0	0.2	10.8	16.8	37.3	34.6	—
38X-1, 145-150	310.45	0.0	0.0	0.0	0.2	0.0	0.0	0.2	0.0	0.2	12.8	20.3	53.7	12.3	502
39X-1, 93-98	319.53	0.0	0.0	0.0	0.2	0.0	0.0	0.0	0.0	0.5	13.0	12.6	46.4	27.0	503
40X-4, 24-30	333.00	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.0	0.4	13.5	17.5	34.5	33.6	507
41X-3, 122-132	341.67	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2	14.0	17.8	39.0	28.8	489
42X-3, 140-150	352.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2	12.7	18.1	41.1	27.7	504
43X-2, 135-150	359.53	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2	12.5	4.0	43.9	39.1	495
44X-1, 135-150	368.20	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3	12.6	18.1	32.8	36.2	509
46X-2, 135-150	379.36	0.0	0.0	0.0	0.2	0.0	0.0	0.2	0.0	0.4	9.3	14.5	43.4	32.0	495
47X-4, 130-145	391.90	0.0	0.0	0.0	0.2	0.0	0.0	0.2	0.0	0.2	9.7	24.0	32.9	31.5	447
49X-5, 135-150	402.67	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2	12.0	16.0	34.0	37.6	508
50X-2, 102-112	407.72	0.0	0.0	0.0	0.2	0.0	0.0	0.0	0.0	0.4	14.3	14.7	35.9	34.2	450
51X-1, 140-150	416.20	0.0	0.0	0.0	0.2	0.0	0.0	0.2	0.0	0.2	12.2	10.8	45.4	30.8	486
52X-2, 137-147	427.37	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2	11.4	14.1	42.4	31.7	498
54X-3, 140-150	439.50	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2	12.0	13.1	41.5	33.0	507
56X-2, 135-150	456.25	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3	12.7	16.0	30.9	40.0	509
57X-1, 111-126	464.11	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3	13.8	16.6	37.6	31.7	510
58X-1, 135-150	473.95	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.4	13.3	19.6	39.2	27.5	509
59X-3, 135-150	485.93	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2	13.6	27.5	27.7	31.0	512
61X-2, 135-150	495.75	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.0	0.2	16.0	22.1	32.1	29.4	514
62X-2, 135-150	504.35	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.4	14.2	22.3	39.0	24.1	512
63X-4, 140-155	516.03	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.4	16.9	21.3	24.8	36.2	512
64X-3, 135-150	525.10	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.4	19.7	25.4	21.6	32.9	511
65X-3, 135-150	535.00	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.0	0.4	16.4	21.4	29.6	31.8	511
67X-4, 118-128	546.63	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2	15.1	22.4	35.3	26.9	510
68X-5, 135-150	556.15	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2	17.0	21.7	36.6	24.5	514
69X-4, 135-150	565.06	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.3	15.6	20.5	40.5	22.8	514
71X-2, 135-150	572.75	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.4	11.7	23.8	38.7	25.3	511

Table 1 (continued).

Core, section, interval (cm)	Depth (mbsf)	Sediment grain-size distribution (%)													Chlorinity (mM)
		>1.00	1.0-0.63	0.63-0.40	0.40-0.315	0.315-0.2	0.20-0.16	0.16-0.10	0.1-0.063	0.063-0.05	0.05-0.01	0.01-0.005	0.005-0.001	<0.001	
72X-1, 135-150	579.85	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.0	0.4	11.5	22.7	41.4	23.6	512
73X-3, 42-57	591.52	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.4	9.9	14.3	47.9	27.5	511
74X-2, 135-150	599.39	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2	13.8	18.1	42.1	25.6	516
75X-4, 135-150	613.05	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.4	15.7	12.3	41.2	30.5	518
76X-5, 135-150	624.35	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3	15.0	17.7	46.9	20.1	523
77X-2, 88-108	628.50	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.7	15.8	19.5	36.4	27.3	523
78X-2, 130-150	639.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2	11.4	19.4	35.1	33.8	515
79X-6, 118-133	653.10	0.0	0.0	0.0	0.0	0.0	0.0	0.4	0.0	1.2	23.8	65.5	8.8	0.3	525
80X-5, 135-150	661.76	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2	9.4	18.5	41.9	30.0	521
81X-4, 135-150	669.69	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2	10.5	20.7	41.1	27.6	520
83X-2, 135-150	686.53	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.4	13.2	20.4	40.2	25.9	519
84X-2, 135-150	696.60	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.4	13.4	18.0	34.9	33.2	518
164-994D-															
2X-1, 140-150	243.20	0.0	0.0	0.0	0.2	0.2	0.2	0.2	0.0	0.3	19.8	20.6	41.1	17.4	502
2X-2, 140-150	244.70	0.0	0.0	0.0	0.0	0.2	0.2	0.8	0.0	0.8	19.6	19.4	30.2	28.8	511
2X-3, 140-150	246.20	0.0	0.0	0.0	0.0	0.0	0.0	0.4	0.0	1.1	31.2	19.4	23.2	24.7	515
2X-4, 140-150	247.70	0.0	0.0	0.0	0.0	0.0	0.0	0.4	0.0	0.7	22.1	17.9	30.9	28.0	478
3X-1, 135-150	252.80	0.0	0.0	0.0	0.0	0.0	0.0	0.3	0.0	0.6	13.8	15.2	38.7	31.3	511
3X-2, 135-150	254.25	0.0	0.0	0.0	0.0	0.0	0.0	0.4	0.0	0.4	19.3	19.8	34.2	25.9	495
3X-3, 135-150	255.75	0.0	0.0	0.0	0.0	0.0	0.0	0.4	0.0	0.7	19.1	20.1	34.4	25.3	508
3X-4, 135-150	257.25	0.0	0.0	0.0	0.0	0.0	0.0	0.4	0.0	0.8	18.3	19.3	37.4	23.8	510
3X-5, 140-150	258.80	0.0	0.0	0.0	0.0	0.0	0.0	0.4	0.0	0.7	17.3	19.2	35.7	26.7	516
4X-3, 135-150	264.61	0.0	0.0	0.0	0.0	0.0	0.0	0.3	0.0	0.3	13.2	18.7	34.2	33.3	497
4X-4, 135-150	266.11	0.0	0.0	0.0	0.0	0.2	0.2	0.4	0.0	0.7	13.6	17.9	35.7	31.3	503
5X-1, 135-150	271.95	0.0	0.0	0.0	0.0	0.2	0.4	0.7	0.0	0.7	19.0	11.6	44.0	23.2	512
5X-2, 135-150	273.45	0.7	0.2	0.2	0.2	0.2	0.2	0.3	0.0	0.3	7.5	11.8	44.0	34.3	507
5X-3, 135-150	274.95	0.0	0.0	0.0	0.0	0.0	0.2	0.4	0.0	0.4	10.0	17.8	30.8	40.3	515
5X-4, 135-150	276.45	0.0	0.0	0.0	0.0	0.0	0.0	0.4	0.0	0.4	11.3	19.8	37.6	30.5	510
6X-1, 135-150	378.05	0.0	0.2	0.0	0.2	0.2	0.0	0.2	0.0	0.3	13.6	18.6	42.2	24.5	502
6X-2, 135-150	379.55	0.0	0.0	0.0	0.2	0.0	0.0	0.2	0.2	0.4	9.9	17.7	53.0	18.4	498
6X-3, 135-150	381.05	0.0	0.0	0.0	0.2	0.0	0.0	0.2	0.2	0.4	12.8	21.8	43.5	20.8	504
6X-4, 135-150	382.55	0.0	0.0	0.0	0.2	0.0	0.0	0.2	0.2	0.4	13.5	22.8	38.0	24.6	506
7X-2, 135-150	387.86	0.0	0.0	0.0	0.2	0.0	0.0	0.2	0.2	0.4	11.5	23.6	49.2	14.5	441
7X-3, 120-135	389.21	0.0	0.0	0.2	0.2	0.0	0.0	0.2	0.2	0.4	13.8	18.2	47.1	19.7	508
7X-4, 135-150	390.71	0.0	0.0	0.0	0.2	0.0	0.0	0.2	0.0	0.4	12.1	18.9	43.4	24.8	505
8X-1, 135-150	397.15	0.0	0.0	0.0	0.0	0.0	0.2	0.4	0.0	0.2	10.5	18.9	43.9	25.9	504
8X-2, 135-150	398.65	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.2	0.4	13.4	19.2	47.0	19.6	458
8X-3, 135-150	400.15	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.2	0.4	12.8	18.8	43.3	24.3	502
8X-4, 135-150	401.65	0.0	0.0	0.0	0.2	0.0	0.0	0.2	0.2	0.4	15.2	20.7	41.1	21.8	510
9X-1, 135-150	406.75	0.0	0.0	0.0	0.2	0.0	0.0	0.2	0.0	0.2	21.1	20.1	37.1	20.9	467
9X-2, 135-150	408.25	0.0	0.0	0.0	0.2	0.0	0.0	0.2	0.2	0.4	17.4	24.0	35.7	21.9	502
9X-3, 135-150	409.75	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.2	0.4	16.7	14.9	48.4	19.2	489
9X-4, 135-150	411.25	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.2	0.4	15.3	23.5	38.6	21.8	486
9X-5, 135-150	412.75	0.0	0.0	0.0	0.2	0.0	0.0	0.2	0.2	0.4	15.6	17.5	44.5	21.3	507

Note: Pore-water chlorinity data from Paull, Matsumoto, Wallace, et al. (1996). — = no data.

Table 2. Sediment grain-size analysis results and pore-water chlorinity, Site 995.

Core, section, interval (cm)	Depth (mbsf)	Sediment grain-size distribution (%)													Chlorinity (mM)
		>1.00	1.0-0.63	0.63-0.40	0.40-0.315	0.315-0.2	0.20-0.16	0.16-0.10	0.1-0.063	0.063-0.05	0.05-0.01	0.01-0.005	0.005-0.001	<0.001	
164-995A-															
1H-1, 145-152	1.45	0.0	0.0	0.0	0.2	0.2	0.2	0.8	0.2	2.3	26.6	20.2	23.3	25.7	555
2H-1, 145-150	3.15	0.0	0.0	0.0	0.2	0.2	0.2	1.1	0.2	4.2	23.6	22.3	28.6	19.0	557
2H-2, 145-150	4.70	0.0	0.0	0.0	0.2	0.2	0.2	0.8	0.0	1.2	18.1	20.6	30.4	28.1	559
2H-3, 145-150	6.25	0.0	0.0	0.0	0.2	0.2	0.2	1.1	0.0	1.1	13.1	13.4	31.2	39.4	561
2H-4, 145-150	7.80	0.0	0.0	0.0	0.2	0.2	0.4	0.9	0.0	1.3	12.0	13.7	38.5	32.9	559
2H-6, 0-5	9.45	0.0	0.0	0.0	0.2	0.2	0.2	0.4	0.2	3.0	16.9	16.1	39.5	23.4	560
3H-1, 153-158	12.73	0.0	0.0	0.0	0.2	0.2	0.2	1.1	0.2	4.4	22.9	18.0	30.4	22.0	562
3H-2, 153-158	14.28	0.0	0.0	0.0	0.2	0.2	0.2	0.2	0.0	0.4	10.9	21.3	35.5	31.0	562
3H-3, 145-150	15.75	0.0	0.0	0.0	0.2	0.2	0.2	0.2	0.0	0.4	11.2	13.1	44.0	30.4	563
3H-4, 145-150	17.25	0.0	0.0	0.0	0.0	0.0	0.0	0.5	0.0	0.5	11.9	17.5	43.6	26.0	562
3H-5, 145-150	18.75	0.0	0.0	0.0	0.0	0.0	0.0	0.4	0.0	0.4	12.7	19.1	42.8	24.5	559
3H-6, 145-150	20.25	0.0	0.0	0.0	0.0	0.0	0.0	0.5	0.0	0.5	13.8	7.7	43.4	34.1	561
4H-1, 145-150	22.15	0.4	0.0	0.0	0.2	0.2	0.2	0.7	0.0	2.2	21.7	18.9	36.1	19.2	563
4H-2, 145-150	23.65	0.0	0.0	0.0	0.0	0.0	0.2	0.4	0.0	0.8	16.7	22.6	34.1	25.2	560
4H-3, 145-150	25.15	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.0	0.4	15.0	17.3	34.1	32.9	561
4H-4, 145-150	26.65	0.0	0.0	0.0	0.0	0.0	0.0	0.4	0.0	0.7	12.9	1.4	53.3	31.3	556
4H-5, 145-150	28.15	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.0	0.5	8.0	15.9	58.9	16.3	556
4H-6, 35-40	28.55	0.0	0.0	0.0	0.0	0.0	0.0	0.3	0.0	0.7	15.3	19.8	54.5	9.0	557
5H-5, 145-150	37.65	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.0	0.4	14.8	22.6	25.3	36.5	553
6H-5, 140-150	47.10	0.0	0.0	0.0	0.0	0.0	0.0	0.4	0.0	0.8	14.4	18.8	36.0	29.4	546
7H-5, 145-150	56.60	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.0	0.7	9.3	13.6	38.9	37.1	544
8H-5, 140-150	66.10	0.0	0.0	0.0	0.2	0.0	0.0	0.2	0.0	0.2	15.3	18.1	37.9	28.0	544
9P-1, 35-50	68.55	0.0	0.0	0.0	0.2	0.2	0.2	0.4	0.2	0.9	12.2	23.4	39.4	22.8	—
10H-3, 140-150	73.60	0.0	0.0	0.0	0.2	0.2	0.4	0.8	0.0	1.2	12.9	18.8	38.5	27.0	541
11H-3, 59-69	82.29	0.4	0.2	0.2	0.2	0.2	0.2	0.2	0.0	0.2	7.0	16.3	35.4	39.2	538
12H-6, 140-150	96.08	0.0	0.0	0.0	0.2	0.2	0.2	0.2	0.0	0.4	19.6	7.7	42.3	29.3	532
13H-5, 140-150	105.10	0.0	0.0	0.0	0.0	0.2	0.2	0.4	0.0	0.8	15.4	7.4	50.7	24.9	532
14H-4, 140-150	113.10	0.0	0.0	0.0	0.2	0.2	0.2	1.1	0.2	0.8	12.4	8.7	45.1	31.2	531

Table 2 (continued).

Core, section, interval (cm)	Depth (mbsf)	Sediment grain-size distribution (%) >1.00	1.0-0.63	0.63-0.40	0.40-0.315	0.315-0.2	0.20-0.16	0.16-0.10	0.1-0.063	0.063-0.05	0.05-0.01	0.01-0.005	0.005-0.001	<0.001	Chlorinity (mM)
15H-4, 140-150	122.60	0.0	0.0	0.0	0.0	0.0	0.2	0.4	0.0	0.8	14.2	17.2	43.6	23.4	527
16H-6, 140-150	133.98	0.0	0.0	0.0	0.2	0.2	0.2	0.4	0.0	0.4	14.7	18.6	40.6	24.6	525
17H-5, 140-150	143.10	0.0	0.0	0.0	0.2	0.2	0.2	0.4	0.0	1.2	13.8	17.6	45.9	20.3	523
18P-1, 47-61	145.67	0.0	0.0	0.0	0.0	0.2	0.2	0.9	0.0	1.3	15.8	22.2	45.7	13.7	—
19H-6, 64-74	153.72	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.0	0.5	19.3	17.7	42.5	19.9	525
21X-1, 135-150	166.55	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.0	0.6	20.2	33.9	37.7	7.4	520
21X-3, 135-150	169.55	0.0	0.0	0.0	0.0	0.0	0.2	0.2	0.0	0.3	16.4	24.3	47.4	11.2	522
22X-2, 135-150	177.65	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.2	0.4	19.7	24.9	37.0	17.7	520
22X-4, 135-150	180.65	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.2	0.3	17.2	18.9	46.3	16.8	522
23X-2, 135-150	187.25	0.0	0.0	0.0	0.2	0.0	0.2	0.2	0.2	0.3	15.0	20.7	50.7	12.7	519
23X-4, 135-150	190.25	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.2	0.4	15.2	20.8	54.2	9.0	517
24X-1, 135-150	195.35	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.2	0.3	16.2	38.7	37.5	6.9	503
25X-1, 135-150	205.05	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.0	0.5	14.6	18.8	55.3	10.6	513
25X-3, 135-150	208.05	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.0	0.5	18.8	28.9	45.3	6.4	508
27P-1, 28-42	223.18	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.2	1.2	20.7	23.2	43.1	11.5	—
28X-3, 135-150	228.25	0.0	0.0	0.0	0.2	0.0	0.3	0.5	0.0	0.7	14.7	68.3	11.2	4.1	510
28X-5, 135-150	231.25	0.2	0.0	0.0	0.2	0.2	0.0	0.3	0.0	0.3	13.1	28.9	50.1	6.5	508
30X-2, 68-82	244.88	0.0	0.0	0.0	0.0	0.0	0.0	0.4	0.0	0.7	21.0	19.6	48.4	9.9	464
30X-4, 85-100	247.74	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.2	0.7	22.5	21.5	47.1	7.8	489
31X-2, 135-150	255.15	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.0	0.7	17.8	17.3	46.2	17.6	496
31X-2, 128-143	259.65	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.0	0.9	16.0	45.2	29.1	8.6	505
32X-1, 118-133	263.08	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.0	0.6	17.8	25.3	49.8	6.4	505
33X-1, 135-150	272.85	0.0	0.0	0.0	0.0	0.0	0.0	0.4	0.0	1.3	18.0	49.5	24.4	6.4	509
33X-4, 88-103	276.78	0.0	0.0	0.0	0.0	0.0	0.0	1.2	0.0	2.0	25.9	58.3	7.0	5.6	502
34X-1, 106-121	282.16	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.0	1.1	25.0	32.9	15.7	24.9	502
35X-1 130-150	292.00	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.0	0.4	11.8	20.9	58.7	7.9	504
35X-3, 130-150	295.00	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.0	0.7	16.1	55.7	22.9	4.3	505
36P-1, 9-24	300.39	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.0	0.7	10.8	86.1	1.0	1.0	—
40X-2, 65-95	330.99	0.0	0.0	0.0	0.0	0.0	0.0	0.4	0.0	0.4	16.5	71.2	8.3	3.2	493
41X-2, 0-20	340.40	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.0	0.8	17.5	70.8	7.3	3.2	500
42X-1, 130-150	349.90	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.0	0.7	18.9	71.1	1.6	7.2	486
42X-3, 130-150	352.90	0.0	0.0	0.0	0.0	0.0	0.0	0.4	0.0	0.7	19.2	70.6	6.1	2.9	504
43X-1, 130-150	359.50	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.0	0.6	17.4	70.1	3.5	8.3	488
43X-5, 19-39	364.39	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.0	0.4	15.7	73.4	8.4	1.7	503
44X-1, 130-150	369.20	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.0	0.4	17.7	74.7	4.8	2.0	487
45P-1, 13-33	377.63	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.0	0.3	14.0	62.9	17.3	5.1	—
46X-3, 130-150	382.39	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.0	0.4	15.7	4.6	77.9	0.9	509
46X-5, 122-142	385.31	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.0	0.7	15.5	77.7	3.9	1.9	496
47X-2, 130-150	389.90	0.0	0.0	0.0	0.0	0.0	0.0	0.4	0.0	0.7	18.8	37.9	15.2	27.1	489
47X-4, 130-150	392.90	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.0	0.7	15.8	76.6	4.5	2.1	493
48P-1, 0-23	396.80	0.0	0.0	0.0	0.0	0.0	0.0	0.4	0.0	0.9	14.2	50.7	33.2	0.6	—
49X-2, 130-150	400.60	0.0	0.0	0.0	0.0	0.0	0.0	0.4	0.0	0.8	16.9	67.1	8.4	6.4	482
49X-4, 130-150	403.60	0.0	0.0	0.0	0.0	0.0	0.0	0.4	0.0	0.8	12.8	75.0	2.3	8.8	504
50X-2, 130-150	409.20	0.0	0.0	0.0	0.0	0.0	0.0	0.4	0.0	0.4	16.3	77.5	0.7	4.7	483
50X-5, 130-150	413.70	0.0	0.0	0.0	0.2	0.0	0.0	0.2	0.0	0.4	11.2	33.9	34.0	20.1	502
51X-2, 130-150	418.80	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.0	0.2	12.1	16.7	45.7	25.2	439
51X-5, 44-64	422.44	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.0	0.2	10.5	20.7	41.2	27.1	491
53X-2, 130-150	429.40	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.0	0.2	12.8	24.0	37.8	25.0	481
53X-5, 130-150	433.90	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.0	0.6	11.1	20.7	45.5	21.9	480
54X-2, 130-150	438.00	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.0	0.2	13.9	33.9	34.4	17.4	480
54X-5, 100-120	442.20	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.0	0.2	16.1	16.9	35.8	30.7	501
55X-1, 130-150	446.20	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.0	0.2	13.9	18.2	47.9	19.6	503
56X-1, 130-150	455.80	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.0	0.2	12.8	22.1	43.0	21.8	505
56X-3, 61-81	458.11	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.0	0.2	11.0	16.7	49.2	22.8	507
57X-1, 82-102	465.02	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2	12.3	15.1	53.2	19.2	510
58X-2, 130-150	475.46	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2	12.1	18.1	45.5	24.1	511
58X-4, 130-150	477.94	0.0	0.0	0.0	0.2	0.2	0.2	0.6	0.4	0.4	13.4	20.4	28.2	36.0	513
59X-2, 130-150	486.30	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.2	0.2	10.4	40.9	6.0	41.9	510
61X-6, 9-39	500.34	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.4	17.4	23.8	18.4	39.8	516
62X-3, 117-137	506.61	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.2	12.1	34.9	16.6	36.0	511
63X-3, 130-150	515.55	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.2	0.4	11.6	15.2	32.2	40.2	509
64X-4, 130-150	527.80	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.4	15.8	19.9	28.8	34.7	509
65X-2, 130-150	534.40	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.0	0.2	15.3	21.7	28.3	34.3	513
67X-2, 130-150	553.60	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.4	13.7	26.7	22.2	37.1	509
68X-3, 130-150	564.70	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.0	0.2	11.7	82.8	2.0	3.1	510
69X-1, 130-150	571.30	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.4	12.9	30.2	19.6	36.9	514
71X-4, 130-150	585.64	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.2	0.4	13.7	33.3	16.1	36.0	513
72X-1, 110-131	590.30	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.4	16.6	30.4	19.0	33.6	511
73X-2, 53-78	600.07	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2	14.2	30.3	21.5	33.6	511
74X-2, 101-121	610.91	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.2	0.4	14.5	20.8	28.6	35.3	515
75X-4, 130-150	623.80	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.0	0.4	12.5	38.2	14.6	33.8	510
76X-2, 0-32	629.10	0.0	0.0	0.0	0.0	0.2	0.2	0.2	0.2	0.4	12.0	28.3	21.6	36.7	514
77X-3, 130-150	640.32	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.4	12.2	23.9	25.7	37.9	513
78X-1, 105-125	647.95	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2	12.5	28.3	25.0	34.0	512
79X-2, 130-150	658.62	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.4	9.2	30.1	22.1	38.0	511
80X-3, 130-150	669.95	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.2	12.3	28.6	24.1	34.7	513
81X-5, 130-150	683.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.4	12.0	63.8	7.3	16.6	512
82X-5, 47-73	690.85	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.4	14.1	31.9	24.2	29.4	514
83X-7, 0-20	703.80	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.0	0.6	10.1	24.6	29.5	35.0	513
164-995B-															
6X-1, 120-150	245.80	0.0	0.0	0.0	0.0	0.1	0.1	0.1	0.4	0.5	23.3	16.9	33.9	24.7	454
7P-1, 57-77	309.07	0.0	0.0	0.0	0.0	0.1	0.5	0.9	0.9	3.8	31.5	14.0	25.2	23.2	—
8X-2, 120-150	312.08	0.0	0.0	0.0	0.0	0.1	0.1	0.2	0.6	1.3	26.7	17.6	30.9	22.6	503
8X-3, 135-150	313.73	0.0	0.0	0.1	0.1	0.2	0.2	0.3	0.5	1.0	15.7	15.4	43.8	22.8	473
8X-4, 135-150	315.23	0.0	0.0	0.0	0.1	0.5	0.8	2.5	1.0	4.0	23.5	9.5	38.2	19.8	511
8X-5, 135-150	316.73	0.0	0.0	0.0	0.1	0.1	0.1	1.8	0.8	2.2	22.6	16.7	33.5	22.2	497

Table 2 (continued).

Core, section, interval (cm)	Depth (mbsf)	Sediment grain-size distribution (%) >1.00	1.0-0.63	0.63-0.40	0.40-0.315	0.315-0.2	0.20-0.16	0.16-0.10	0.1-0.063	0.063-0.05	0.05-0.01	0.01-0.005	0.005-0.001	<0.001	Chlorinity (mM)
10P-1, 43-56	319.53	0.0	0.0	0.0	0.0	0.9	1.3	5.8	2.7	5.8	31.5	31.9	11.8	8.3	—
11X-1, 130-150	411.30	0.0	0.0	0.0	0.0	0.2	0.2	3.0	1.0	4.0	30.0	15.8	26.2	19.5	468
11X-2, 120-150	412.70	0.0	0.0	0.0	0.1	0.2	0.4	2.0	1.2	4.0	24.6	16.9	24.5	26.1	505
11X-4, 10-30	414.46	0.0	0.0	0.0	0.0	0.1	0.2	0.7	0.5	1.4	21.5	16.9	39.4	19.3	444
12X-1, 120-150	419.00	0.0	0.0	0.0	0.1	0.2	0.2	1.4	0.5	4.8	31.4	16.2	26.7	18.6	481
12X-2, 121-141	420.51	0.0	0.0	0.0	0.0	0.1	0.1	0.8	0.5	2.8	27.2	14.9	32.4	21.2	489
13X-1, 130-150	428.70	0.0	0.0	0.0	0.0	0.2	0.2	1.9	0.5	1.9	28.2	9.8	40.9	16.4	489
13X-2, 120-150	430.10	0.0	0.0	0.1	0.1	0.4	0.4	3.6	1.4	3.1	31.1	20.1	23.1	16.8	502
15X-1, 130-150	447.90	0.0	0.0	0.1	0.1	0.1	0.4	2.0	0.5	2.5	30.5	19.0	25.1	19.9	500
15X-2, 111-116	449.21	0.0	0.0	0.1	0.1	0.9	0.9	3.6	1.8	8.0	36.5	16.0	20.0	12.3	498
15X-3, 120-150	450.80	0.0	0.0	0.1	0.1	0.9	0.8	2.6	0.9	2.6	31.1	29.3	17.6	14.0	500
15X-4, 130-150	452.40	0.0	0.0	0.0	0.0	0.1	0.1	0.5	0.3	0.2	20.9	26.2	33.4	18.2	501

Note: Pore-water chlorinity data from Paull, Matsumoto, Wallace, et al. (1996). — = no data.

Table 3. Sediment grain-size analysis results and pore-water chlorinity, Site 997.

Core, section, interval (cm)	Depth (mbsf)	Sediment grain-size distribution (%) >1.00	1.0-0.63	0.63-0.40	0.40-0.315	0.315-0.2	0.20-0.16	0.16-0.10	0.1-0.063	0.063-0.05	0.05-0.01	0.01-0.005	0.005-0.001	<0.001	Chlorinity (mM)
164S-997A-															
1H-1, 145-150	1.45	0.0	0.0	0.0	0.2	0.2	0.5	1.0	1.0	4.4	20.4	15.1	30.0	27.3	559
1H-2, 120-125	2.70	0.0	0.0	0.0	0.0	0.0	0.0	0.3	0.3	0.7	12.2	58.3	7.2	20.8	558
2H-1, 140-150	4.30	0.0	0.0	0.0	0.2	0.2	0.2	0.4	0.8	4.5	20.7	32.7	13.4	26.8	562
2H-2, 140-150	5.80	0.0	0.0	0.0	0.2	0.2	0.2	0.4	0.8	5.4	28.4	19.4	30.1	14.8	560
2H-3, 140-150	7.30	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.2	0.2	10.9	6.4	48.5	33.3	560
2H-4, 140-150	8.80	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.2	11.1	9.6	37.1	41.7	561
2H-5, 140-150	10.30	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.4	11.1	4.7	49.2	34.6	562
2H-6, 140-150	11.80	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.4	0.4	14.4	21.2	40.5	23.1	561
3H-1, 140-150	13.80	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.4	14.6	84.0	0.5	0.5	561
3H-2, 140-150	15.30	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.2	11.2	12.7	40.9	34.8	561
3H-3, 140-150	16.80	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.2	1.2	15.4	12.8	39.9	30.4	562
3H-4, 140-150	18.30	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.2	0.7	17.5	20.0	36.5	24.8	560
3H-5, 140-150	19.80	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.2	0.4	15.0	11.1	51.1	22.1	559
3H-6, 140-150	21.30	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.4	0.9	20.4	26.0	25.0	26.9	561
4H-1, 140-150	23.30	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.4	0.4	16.5	18.7	37.6	25.9	559
4H-2, 140-150	24.80	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.4	0.9	16.3	4.8	48.5	28.7	557
4H-3, 140-150	26.30	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.4	8.8	7.9	55.8	27.2	557
4H-4, 140-150	27.80	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.4	7.4	10.3	44.1	37.7	557
4H-5, 140-150	29.30	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.4	3.2	25.0	22.4	39.1	9.5	552
4H-6, 140-150	30.80	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.4	0.8	31.6	22.2	40.0	5.0	550
5H-2, 140-150	34.30	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.0	0.4	11.0	16.4	51.5	20.3	550
6H-2, 140-150	43.80	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.4	4.6	11.8	39.6	43.5	545
7H-1, 140-150	51.80	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.4	12.7	10.0	54.8	22.1	543
8H-2, 140-150	55.80	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.4	14.1	28.8	43.8	12.8	543
9H-2, 140-150	64.30	0.0	0.0	0.0	0.2	0.0	0.0	0.2	0.4	0.4	8.5	11.3	35.6	43.3	542
10H-6, 140-150	79.65	0.0	0.0	0.0	0.2	0.0	0.0	0.2	0.4	0.4	15.9	16.1	36.9	29.8	538
11H-2, 140-150	83.30	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.4	9.7	20.3	39.5	30.2	537
12H-2, 140-150	92.80	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.4	0.4	16.4	19.2	42.3	21.2	535
13H-4, 140-150	104.38	0.0	0.0	0.0	0.0	0.0	0.0	0.3	0.2	0.8	16.8	23.0	32.4	26.5	533
14H-3, 140-150	112.13	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.4	0.4	16.5	14.2	40.9	27.2	534
15H-2, 140-150	121.30	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.2	0.4	9.8	11.4	47.8	30.1	528
15H-5, 140-150	125.80	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.2	0.4	13.7	17.4	42.1	25.8	530
16H-2, 140-150	130.80	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.0	0.4	15.2	19.9	27.9	36.2	526
16H-5, 140-150	135.30	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.2	0.8	16.8	16.9	38.4	26.7	527
17H-2, 140-150	140.30	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.4	15.0	19.4	43.8	21.4	527
17H-5, 140-150	144.70	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.4	15.4	31.7	29.1	23.4	527
18P-1, 25-39	147.15	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.6	15.7	12.5	37.9	33.3	—
19H-4, 135-150	153.08	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.9	12.6	8.1	40.6	37.7	523
19H-6, 135-150	156.08	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2	14.6	11.6	46.2	27.1	523
20H-1, 135-150	158.75	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.4	12.0	17.6	39.7	30.3	522
20H-4, 135-150	163.25	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.4	17.6	19.6	43.1	19.3	524
21X-1, 135-150	168.25	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.0	0.4	15.1	10.2	36.6	37.5	519
21X-2, 135-150	169.75	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.4	13.8	15.3	31.9	38.5	522
2X-6, 125-140	180.84	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.2	0.4	13.8	15.1	26.2	44.1	—
25P-1, 8-28	202.48	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.4	16.6	16.2	22.0	44.7	497
25P-1, 64-74	203.04	0.0	0.0	0.0	0.2	0.0	0.0	0.2	0.0	0.8	14.0	15.4	31.3	38.0	503
26X-1, 135-150	204.75	0.0	0.0	0.0	0.2	0.0	0.0	0.2	0.0	0.2	8.3	12.9	33.1	45.1	515
26X-4, 135-150	209.25	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.2	14.7	13.2	27.8	43.9	511
27X-1, 130-150	213.30	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2	12.7	12.5	31.2	43.4	515
27X-5, 130-150	218.94	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.0	1.2	22.5	14.3	26.2	35.4	—
28X-1, 130-150	222.90	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.2	0.4	15.0	11.0	27.1	46.1	511
30X-1, 130-150	233.60	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.0	0.8	16.1	5.8	44.2	32.8	501
31X-1, 130-150	242.20	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.0	0.9	17.2	13.3	33.5	34.6	499
31X-4, 130-150	246.70	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.2	0.8	20.2	14.2	27.2	37.3	474
32X-3, 130-150	254.80	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2	12.0	23.5	36.9	27.4	458
32X-4, 0-20	255.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.4	12.1	28.3	38.1	21.1	504
32X-4, 70-90	255.70	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.0	0.2	14.2	28.4	35.5	21.5	500
32X-5, 130-150	257.80	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.4	15.6	22.8	23.0	37.8	487
34X-2, 123-143	263.83	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.0	0.2	11.5	26.8	30.6	30.7	500
34X-4, 130-150	266.83	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.0	0.2	9.7	15.8	39.9	34.2	512
35X-2, 130-150	272.20	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.2	0.2	13.6	18.1	40.0	27.5	468
35X-4, 130-150	275.20	0.0	0.0	0.0	0.2	0.0	0.0	0.2	0.0	0.4	12.0	15.1	35.1	36.9	469

Table 3 (continued).

Core, section, interval (cm)	Depth (mbsf)	Sediment grain-size distribution (%)													Chlorinity (mM)
		>1.00	1.0-0.63	0.63-0.40	0.40-0.315	0.315-0.2	0.20-0.16	0.16-0.10	0.1-0.063	0.063-0.05	0.05-0.01	0.01-0.005	0.005-0.001	<0.001	
36X-2, 125-150	280.80	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.0	0.2	12.4	14.6	46.7	26.0	504
36X-4, 125-150	283.80	0.0	0.0	0.0	0.0	0.0	0.0	0.4	0.0	0.4	12.3	19.2	47.4	20.2	508
37X-1, 125-150	290.15	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.0	0.8	13.4	21.1	43.8	20.5	498
37X-5, 125-150	296.15	0.0	0.0	0.0	0.0	0.0	0.0	0.4	0.0	0.4	9.1	43.1	28.7	18.3	487
38X-2, 125-150	301.25	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.0	0.4	12.6	17.5	42.9	26.2	502
38X-4, 125-150	304.25	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2	13.8	17.6	30.5	38.0	508
39X-2, 125-150	310.85	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.4	12.3	10.2	60.1	16.9	506
39X-5, 125-150	315.35	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.0	0.6	15.2	15.8	47.6	20.6	505
41X-2, 130-150	321.50	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.4	12.1	20.7	49.2	17.7	503
41X-4, 130-150	324.50	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.4	11.6	20.7	53.3	13.9	481
42X-2, 88-113	329.78	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.0	0.2	13.0	32.8	29.8	24.0	506
43X-1, 130-150	338.24	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.4	13.9	11.2	58.6	15.9	490
43X-4, 78-98	341.62	0.0	0.0	0.0	0.0	0.0	0.0	0.4	0.2	0.4	17.6	21.3	50.8	9.1	500
44X-1, 125-150	347.95	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.4	14.5	22.7	45.4	17.1	505
44X-5, 125-150	353.95	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.4	14.0	14.3	38.7	32.6	504
46X-5, 125-150	372.90	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.4	16.3	21.4	43.7	18.2	496
47X-1, 125-150	376.52	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.8	12.9	11.5	60.4	14.4	470
47X-4, 0-23	379.77	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.0	0.4	12.1	23.2	32.5	31.5	504
48X-2, 125-150	388.05	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2	13.1	15.5	57.9	13.4	—
48X-5, 125-150	392.55	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.4	15.6	47.6	17.0	19.4	—
50X-2, 79-104	398.19	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.4	14.1	23.9	33.2	28.4	477
52X-1, 125-150	406.75	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.4	12.8	34.2	43.4	9.2	460
52X-4, 125-150	411.25	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.0	0.6	13.9	19.5	41.9	24.0	490
54X-2, 125-150	426.13	0.0	0.0	0.0	0.2	0.0	0.0	0.2	0.2	0.4	12.8	15.8	50.4	19.8	478
54X-4, 125-150	429.13	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.0	0.4	13.5	27.7	41.3	16.6	493
55P-1, 10-34	433.40	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2	11.1	25.9	29.3	33.2	444
164-997B-															
1X-1, 125-150	319.75	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.2	13.4	9.3	30.1	46.8	502
2X-1, 130-150	329.35	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3	11.4	12.7	36.2	39.4	391
3X-3, 125-150	341.67	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.2	12.8	14.7	32.0	40.1	483
4X-2, 44-69	415.25	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.4	14.2	13.6	19.6	52.1	496
5X-2, 125-150	426.31	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2	11.5	16.0	21.5	50.8	491
8X-2, 125-150	445.75	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.4	14.4	14.8	23.2	47.2	503
8X-6, 125-150	451.65	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.0	0.2	13.8	8.2	43.0	34.5	410
11X-3, 125-150	467.45	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.0	0.2	11.8	10.3	35.8	41.7	512
12X-2, 125-150	473.86	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2	13.9	15.7	35.4	34.8	512
13X-2, 125-150	484.25	0.0	0.0	0.0	0.2	0.0	0.0	0.2	0.0	0.8	13.9	17.4	35.6	31.8	516
14X-2, 96-121	493.56	0.0	0.0	0.0	0.2	0.0	0.0	0.2	0.0	0.4	13.5	18.2	39.6	27.9	514
16X-4, 125-150	507.55	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.4	14.2	23.8	38.1	23.5	518
17X-1, 125-150	511.65	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.0	0.4	16.0	19.5	32.8	31.0	515
18X-2, 125-150	522.75	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.0	0.4	11.7	15.2	38.7	33.6	513
19X-2, 125-150	532.35	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2	12.9	79.1	3.6	4.0	510
20X-3, 125-150	543.45	0.0	0.0	0.0	0.2	0.0	0.0	0.2	0.0	0.4	14.8	19.6	35.9	28.9	511
22X-3, 125-150	554.05	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.0	0.2	11.0	23.2	33.5	31.9	512
23X-4, 125-150	564.15	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.0	0.4	13.6	21.4	33.2	30.9	512
24X-3, 125-150	572.25	0.0	0.0	0.0	0.2	0.0	0.0	0.2	0.0	0.4	11.4	15.7	39.2	32.8	513
26X-3, 125-150	582.85	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.0	0.7	13.4	3.8	50.6	31.1	513
27X-4, 125-150	593.05	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.4	13.6	23.9	34.1	28.0	510
28X-2, 125-150	598.20	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.4	10.6	19.4	37.0	32.6	512
29X-4, 125-150	612.25	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.0	0.2	9.5	19.6	37.4	33.1	513
30X-2, 125-150	618.85	0.0	0.0	0.0	0.2	0.0	0.0	0.2	0.0	0.2	11.6	16.7	41.6	29.3	511
31X-3, 125-150	629.88	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.0	0.4	9.7	14.6	42.6	32.3	514
33X-5, 125-150	642.72	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.4	10.0	20.0	33.7	36.0	513
35X-5, 125-150	659.95	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.0	0.3	9.0	15.7	32.9	41.7	514
37X-4, 125-150	670.85	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.8	14.3	20.5	31.0	33.0	512
38X-2, 125-150	676.55	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.0	0.7	17.4	15.3	32.2	34.0	514
39X-3, 125-150	687.65	0.0	0.0	0.0	0.2	0.0	0.0	0.2	0.0	0.2	10.6	18.0	35.1	35.6	512
42X-4, 0-25	706.17	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.0	0.4	14.1	22.5	34.4	28.3	513
43X-3, 125-150	716.45	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2	11.2	22.6	37.2	28.7	508
45X-4, 125-150	728.41	0.0	0.0	0.0	0.2	0.0	0.0	0.2	0.0	0.4	15.3	23.7	31.9	28.3	511

Note: Pore-water chlorinity data after Paull, Matsumoto, Wallace, et al. (1996). — = no data.

Table 4. Grain-size check analysis results.

Core, section, interval (cm)	Depth (mbsf)	Sediment grain-size distribution (%) >1.00	1.0-0.63	0.63-0.40	0.40-0.315	0.315-0.2	0.20-0.16	0.16-0.10	0.1-0.063	0.063-0.05	0.05-0.01	0.01-0.005	0.005-0.001	<0.001
164-995A-														
22X-2, 135-150	177.65	0.0	0.3	0.3	0.3	0.3	0.0	0.5	0.2	0.8	25.6	28.0	29.0	14.5
22X-4, 135-150	180.65	0.0	0.0	0.2	0.2	0.2	0.2	0.2	0.2	0.4	19.1	21.6	36.7	21.0
23X-2, 135-150	187.25	0.0	0.2	0.2	0.5	0.2	0.2	0.2	0.2	1.0	19.4	21.9	38.2	17.6
23X-4, 135-150	190.25	0.0	0.0	0.2	0.2	0.0	0.1	0.4	0.2	0.8	22.4	28.1	31.6	15.9
24X-1, 135-150	195.35	0.0	0.0	0.2	0.2	0.0	0.2	0.8	0.2	0.8	23.2	27.8	30.7	15.9
25X-1, 135-150	205.05	0.0	0.0	0.2	0.2	0.2	0.0	0.4	0.2	0.8	17.6	30.3	33.6	16.5
25X-3, 135-150	208.05	0.0	0.2	0.2	0.2	0.2	0.0	0.2	0.2	0.8	16.4	28.8	40.1	12.7
28X-5, 135-150	231.25	0.0	0.0	0.2	0.2	0.2	0.0	0.5	0.2	0.5	10.5	33.7	38.9	15.0
30X-2, 68-82	244.88	0.0	0.0	0.0	0.2	0.2	0.2	0.4	0.8	1.6	36.4	22.0	23.5	14.5
31X-2, 135-150	255.15	0.0	0.0	0.0	0.7	0.3	0.3	0.3	0.3	0.7	15.9	32.1	42.3	7.0
31X-5, 128-143	259.65	0.0	0.0	0.0	0.5	0.2	0.2	0.2	0.2	0.5	23.1	30.8	40.0	4.2
164-994D-														
3X-1, 135-150	252.80	0.0	0.0	0.0	0.0	0.0	0.0	0.3	0.0	0.6	14.5	23.1	39.4	22.0
4X-4, 135-150	266.11	0.0	0.0	0.0	0.0	0.2	0.2	0.4	0.0	0.4	15.3	17.0	36.2	30.3
6X-4, 135-150	382.55	0.0	0.0	0.0	0.2	0.0	0.0	0.2	0.2	0.4	14.0	25.5	39.7	19.7
7X-4, 135-150	390.71	0.0	0.0	0.0	0.2	0.0	0.0	0.2	0.0	0.4	12.5	20.2	49.7	16.8
9X-4, 135-150	411.25	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.2	0.4	15.4	19.0	42.5	22.3
9X-5, 135-150	412.75	0.0	0.0	0.0	0.2	0.0	0.0	0.2	0.2	0.4	15.2	17.6	43.3	22.9

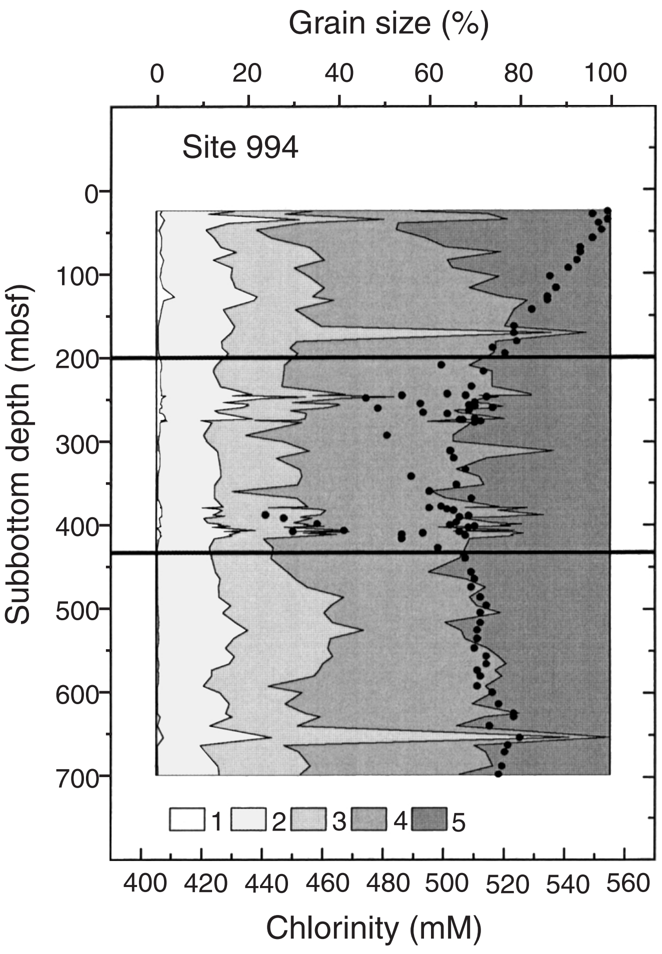

Figure 3. Sediment grain-size distribution (lines) and pore-water chlorinity (solid circles; after Paull, Matsumoto, Wallace, et al., 1996) in the column at ODP Site 994. Grain-size fractions in millimeters: 1 = >0.05; 2 = 0.05–0.01; 3 = 0.01–0.005; 4 = 0.005–0.001; 5 = <0.001. Bold lines limit the gas hydrate zone.

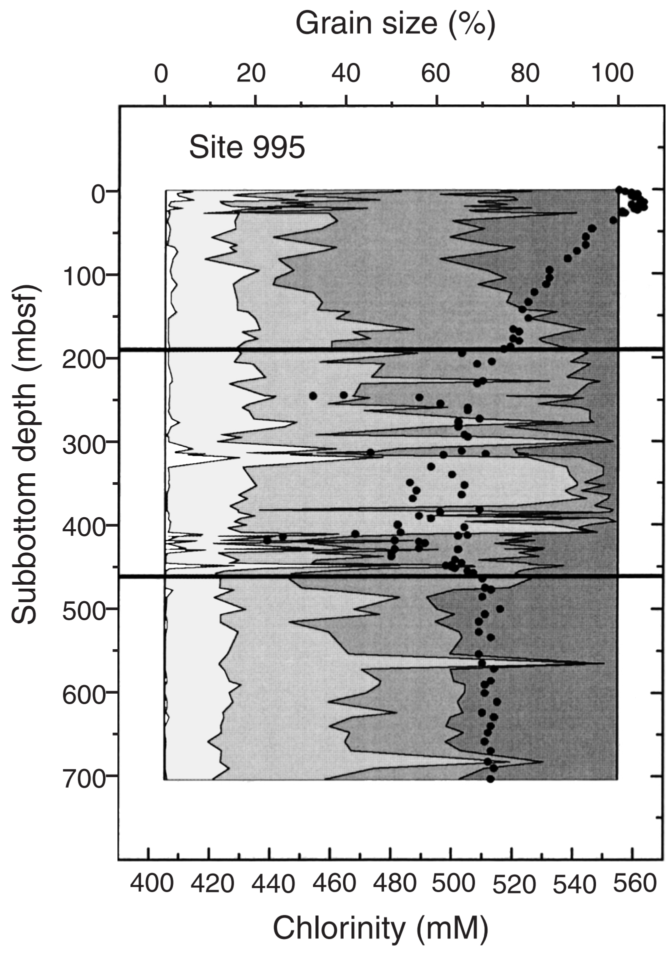

Figure 4. Sediment grain-size distribution and pore-water chlorinity in the column at ODP Site 995. See Figure 3 for symbol definition.

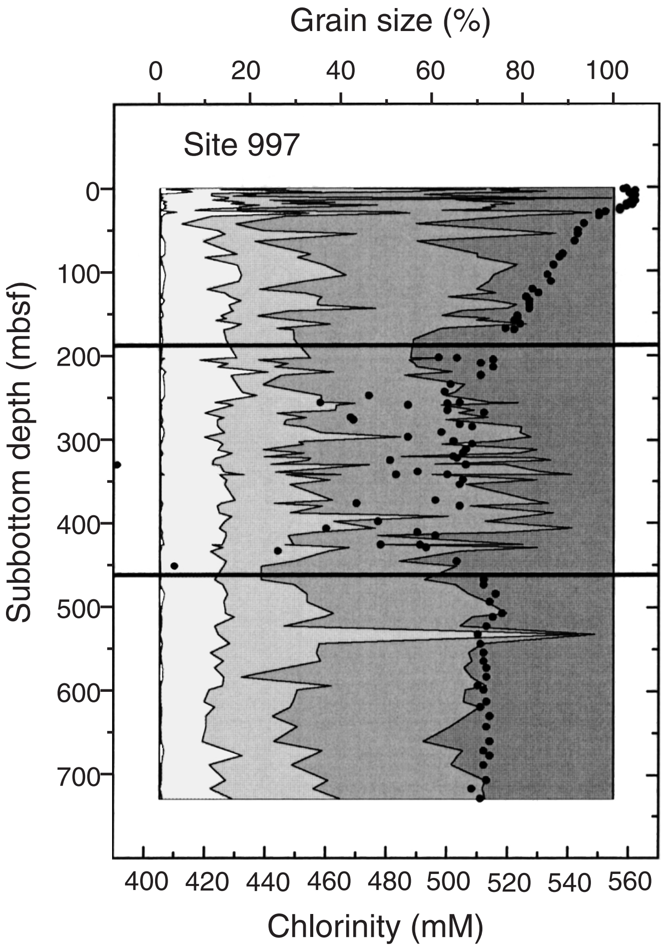

Figure 5. Sediment grain-size distribution and pore-water chlorinity in the column at ODP Site 997. See Figure 3 for symbol definition.

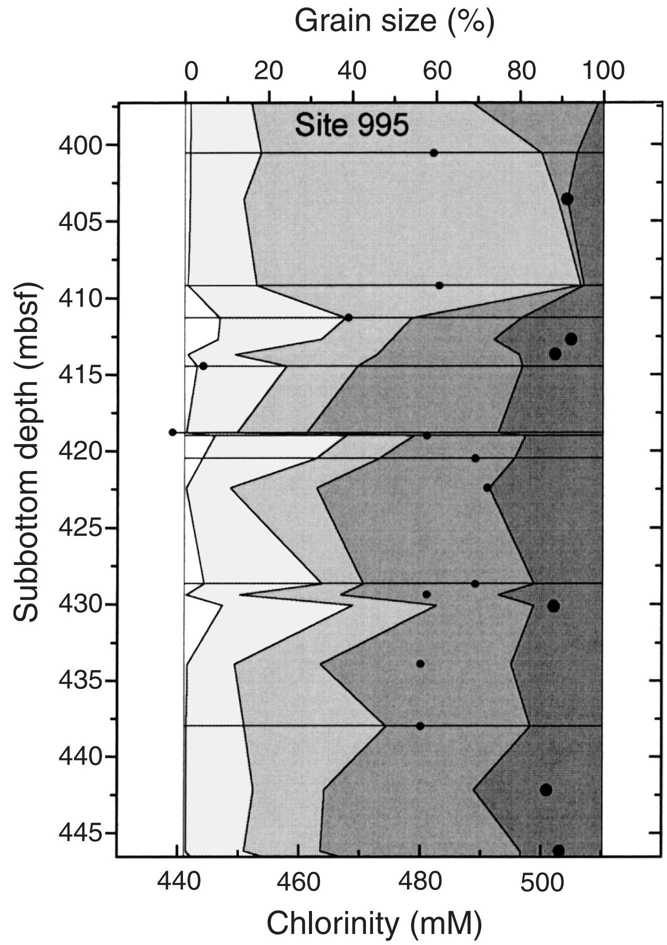

Figure 6. Sediment grain-size distribution and pore-water chlorinity in the lower part of the zone of local chlorinity anomalies in the column at ODP Site 995. Large circles = background chlorinity values; small circles = local anomalous values. Anomalous values confined to relatively coarse-grained sediments are identified by horizontal lines. See Figure 3 for other symbols.

Table 5. Reproducibility of grain-size results calculated from 17 repeated analyses.

	Grain-size fractions							
Reproducibility characteristics:	<0.001	0.001-0.005	0.005-0.01	0.01-0.05	0.05-0.063	<0.005	<0.01	<0.05
Standard deviation (σ):	4.4	8.2	5.1	2.7	0.3	6.6	4.4	0.9
95% confidence range of σ:	3.3-6.3	6.2-12.3	3.8-7.6	2.0-4.0	0.2-0.45	5.0-9.9	3.3-6.6	0.7-1.4