14. CHEMICAL AND ISOTOPIC COMPOSITION OF INTERSTITIAL WATER FROM DEEP SEA DRILLING PROJECT SITES 533 AND 534¹

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ABSTRACT

Low salinities and strong opposing fluctuations between chlorinity and interstitial water δ^{18} O and δ D characterize the region of gas-hydrate occurrence at Site 533. In addition to the hydrate recovered from 243 m sub-bottom, thin, diffuse layers of hydrate composing about 10% of the total pore space may have been cored around 290 m. Decomposition during recovery could account for the high oxygen isotope value (+2.80‰) and low chlorinity (17.21 g/kg) observed at this depth. High alkalinity and dissolved ammonia (71 meq/l and 33 mM, respectively) indicate substantial microbial activity.

Chlorinity gradually increases with depth in the 1600-m-thick sediment column at Site 534, perhaps due to deepseated alteration-hydration reactions or to the presence of nearby evaporites. $\delta^{18}O$ and δD decrease with depth and are well correlated, suggesting that a common mechanism is fractionating both.

INTRODUCTION

Site 533 is located in the vicinity of Sites 102, 103, and 104 that were drilled during DSDP Leg 11 on the Blake Outer Ridge. Seismic data obtained in this area suggested the presence of gas hydrates in the sediments (Lancelot and Ewing, 1972; Tucholke et al., 1977; Shipley et al., 1979; Dillon et al., 1980). Site 533 was thus drilled with the specific aim of testing for the presence of gas hydrates in the sediments and to carry out detailed investigations of the inorganic and organic geochemistry of these sediments and their interstitial waters. The sediments cored were middle Pliocene to Holocene gray green muds. Interstitial water was sampled to a sub-bottom depth of 400 m.

Site 534 was drilled in the Blake-Bahama Basin in order to add to information derived from coring at Site 391 (DSDP Leg 44). Interstitial water was continuously sampled from 500 to 1100 m sub-bottom depth. Sediments in this interval consisted primarily of Lower Cretaceous to Miocene chalk, carbonaceous claystone, and limestone. Because sampling of interstitial water ceased well short of the basement depth of 1635 m, interpretation of the data at Site 534 is somewhat restricted.

In this chapter, we present the data obtained both on board ship and in our home laboratories on the inorganic chemistry of the interstitial waters. Data on the carbon isotopic composition of the dissolved carbon dioxide are presented elsewhere (Claypool, this volume).

METHODS

Shore-based analyses of dissolved constituents were carried out at Scripps Institution of Oceanography according to methods described by Gieskes (1974). Stable isotope analyses for interstitial water oxygen and hydrogen were run at the Institute of Geophysics and Planetary Physics at UCLA. Oxygen was prepared from 1- to 2-ml aliquots by the standard carbon dioxide equilibration method (Epstein and Mayeda, 1953). Appropriate corrections for the isotopic contribution of tank carbon dioxide were made (Craig, 1957). Hydrogen was prepared by passing 5 μ l aliquots of water through a furnace packed with uranium turnings at 750°C (Bigeleisen et al., 1952). Analyses were run on a Varian MAT 250 stable isotope mass spectrometer. Results are expressed in del (δ) notation relative to the SMOW standard. Standard deviations determined from six replicate runs of laboratory standards are $\pm 0.10\%$ for δ^{18} O and $\pm 1.9\%$ for δ D.

RESULTS

The shipboard data and the results of this study are presented in Table 1.

Site 533

Gas hydrates were first recovered by DSDP during Legs 66 and 67 in the continental slope sediments of the Mid-America Trench (Shipley and Didyk, 1982; Aubouin, von Huene, et al., 1982). Harrison et al. (1982) and Hesse and Harrison (1981) studied the interstitial water chemistry of the sites drilled during Leg 67 and established substantial decreases in dissolved chloride along with significant increases in δ^{18} O with depth at Sites 496 and 497. These observations were explained in terms of hydrate decomposition during core recovery. Chlorinity decreases and δ^{18} O increases would occur as a result of the addition of fresh, H₂¹⁸O-enriched water from the hydrates that exclude salt and which, by comparison with ice (O'Neil, 1968; Trofimuk et al., 1974), are assumed to concentrate ¹⁸O relative to the water in which they form. The chlorinity decreases at Sites 496 and 497 were fairly uniform (Harrison et al., 1982; Hesse and Harrison, 1981), but at the hydrate-containing sites of Leg 66, decreases in chlorinity were sporadic and only occurred in hydrate-bearing zones (Gieskes, unpublished data). Similarly, chlorinity decreases were observed at Sites 102 to 104 (Sayles et al., 1972). The

¹ Sheridan, R. E., Gradstein, F. M., et al., *Init. Repts. DSDP*, 76: Washington (U.S. Govt. Printing Office).

Table 1. Interstitial water chemistry, Leg 76, Holes 533, 533A, and 534A.

Sample (interval in cm)	Sub-bottom depth (m)	pН	Alk (meq/l)	S (g/kg)	Ca (mM)	Mg (mM)	Cl (g/kg)	Sr (µM)	LI (µM)	К (µМ)	SO4 (mM)	NH4 (μM)	Si (µM)	δ ¹⁸ O (‰)	δD (‰)
Hole 533															
1-1, 135–140 2-1, 75–80	1 3	7.39	8.49 11.88	35.04 34.76	8.67 7.27	56.7 47.2	19.31 19.43	72.2 57.0	34 31	11.07 8.85	23.9 18.8	488 798	422 581	-0.14 +0.09	-4.9 -3.3
6-2, 145-150 7-2, 145-150	14	7.62	24.61	33.17	2.32	40.8	19.46	44.5	20 25	11.21	-	1880	394 462	-0.13 + 0.02	-1.3 -2.1
8-1, 140-145	22 28	7.67	26.52 26.69	33.28 33.22	2.22	41.7	19.53 19.53	45.5	21 21	11.73	2.6	2355 2892	520 663	+0.22+0.25	-2.2
10-2, 140-145	32 37	8.13	25.55	33.22 33.44	1.37	38.6	19.53	25.6	24 29	11.9 10.83	1.1	3380 3482	371 611	-0.02 + 0.48	+0.3 - 0.5
12-1, 140-145	40 46	7.59	25.02	33.35	1.89	39.3 37.5	19.55	25.6	28 29	10.74	1.3	39.42 4224	576 384	+0.27	-4.4 -1.8
14-1, 145-150	48	7.88	24.64	33.39	2.04	36.6	19.50	44.8	29 24	11.5	-	4096 5120	442 326	-0.24 + 0.14	-3.3 -3.2
18-1, 140–150 20-2, 140–150	65 76	8.00	25.61	33.11	1.91	38.9	19.41	45.5	18	10.83	-	5200 5427	481 576	-0.72 -0.19	-1.9 -2.7
22-1, 140-150 22-1, 140-150	83	7.83	23.02	32.78	1.74	32.3	19.24	44.8	40	13.49	-	6195	512 570	+0.18 +0.17	-3.2
26-2, 0-10 28-2, 140-150	101	7.74	22.39	32.51	1.89	27.8	18.90	41.1	28	11.77	1.1	6904 7378	435	-0.21 + 0.35	-3.7
30-1, 140-150 32-2, 140-150	119	7.82	25.55	32.62	2.28	25.3	18.93	64.0 44.8	45 50	12.20	2.9	8140 9057	570 518	-0.19 -0.29	-6.6 -5.1
34-1, 140-150 37-1, 140-150	137 148	7.93 7.85	27.20 27.07	32.78 32.78	1.43 1.34	22.9 22.8	18.91 18.88	57.2 57.2	56 64	14.11 13.78	1.2 1.0	9326 9807	488 384	-0.19 -0.24	-4.9
40-1, 140-150 Hole 533A	160	7.95	32.82	32.89	1.87	22.7	18.74	68.0	82	8.84	-	11,000	592	-0.66	- 3.9
3-2, 140-150	155	7.54	26.79	33.83	3.76	28.7	19.21	84.5	92	11.4	<2	7384	813	-0.31	-6.0
4-2, 140-150 8-2, 140-150	193	7.45	35.24 68.63	33.72 34.10	3.69	28.4	19.07	68.0 60.2	189	14.5	<2	16,600	1041	-0.02 -0.45	-9.2
10-6, 5-15	243	7.54	48.34	34.43	5.06	27.9	18.65	121.6	302	14.9	<2	19,900	1352	-1.88	- 18.9
16-4, 135-145	272	7.20	56.00	34.38	4.53	25.0	17.95	56.0	105	9.9	~2	14,900	848	-0.55	- 12.8
20-2, 140-150	307	7.55	48.16	31.57	3.21 4.74	22.1	17.21	53.2	219	12.9	~2	19,200	702	-0.54	- 10.0
22-6, 135-145 24-5, 140-150	332 349	7.51	42.40	32.29	3.43	19.9	17.66	/3.0 99.0	471	18.8	<2	33,200	1117	+0.06	-10.3
29-3, 140-150	396	7.24	41.03	33.33	5.09	20.5	18.34	99.0 93.6	263	12.5	<2	29,000	706	+0.06	-9.5
Hole 534A															
3-2, 135–145 7-2, 140–150	558 596	7.15 7.02	8.81 8.11	34.27 34.87	15.2 17.5	34.6 34.3	20.7 20.11	1919 1866	_	9.10 8.7	7.3 6.3	1836 2156	840 941	-1.80 - 2.20	-9.4 -11.9
10-3, 105–120 14-2, 135–150	617 653	7.01 7.08	8.91 7.35	34.49 34.38	18.9 20.6	32.6 33.1	20.31 20.4	1737 1606	Ξ	8.3 3.3	6.3	2150 1650	846 847	-2.20 - 1.82	-11.7 -11.5
20-2, 135–150 24-2, 135–150	708 744	7.27 7.47	3.94 3.25	34.43 33.55	25.4 28.3	34.4 34.0	20.20 19.42	968 932	-	4.9 3.5	6.7	1236 541	834 273	-2.32 -2.41	-12.0 -12.9
27-1, 140–150 29-2, 135–150	766 786	8.23 8.24	2.10 2.60	32.62 35.31	26.8 29.1	31.4 35.2	18.83 20.19	1102 1217	Ξ	3.6 5.1	8.5	707 790	73 78	-2.39 - 1.98	-11.4 -8.7
32-1, 132-150 34-1, 105-120	813 832	7.61 8.10	2.29 2.30	36.30 33.80	31.2 31.5	38.6 33.2	20.53 19.62	1238 1300	_	3.1 3.7	15.5	624 478	130 78	-1.52 - 2.67	-6.6 -16.4
36-2, 135-150 38-4, 135-150	853 875	8.05 8.09	2.19 1.77	35.83 36.71	33.5 34.1	34.4 38.1	20.91 20.57	1388 1414	_	2.8 3.9	6.8 14.6	540 478	88 78	-2.83 -1.85	-14.5 -7.1
41-4, 135-150 43-1, 135-150	902 915	8.42 7.70	1.25 0.94	34.21 37.02	34.9 36.6	35.0 36.6	19.67 21.29	1581 1581	_	3.2 4.1	9.4 10.2	478 499	88 109	-3.87 -2.83	-13.6 -13.8
45-2, 135–150 49-2, 140–150	935 966	7.47	0.77	37.02 37.51	36.7 39.5	36.2 37.1	21.49 21.69	1501	Ξ	3.5		_	102	-2.86 -3.01	-12.8 -15.5
52-1, 0-15 56-1, 140-150	990 1028	7.43	0.33	37.51 37.51	43.6 47.6	36.5 37.0	21.56 21.61	1918	—	3.9	7.6	489		-2.84 -2.10	-17.4 -10.3
58-2, 135-150 61-2, 127-142	1047 1074	_	_	37.45 39.22	56.3 63.1	36.5 35.3	21.87 22.37	1890 2510	_	2.4 2.8	_	520 500	75 80	-2.80	-12.7 -14.6
63-2, 105-120 64-4, 135-150	1092 1104	_	_	39.33 39.33	63.8 64.4	36.0 35.1	22.37 21.86	1970	_	1.3	8.2	520	80	-5.78 -2.53	-14.1 -15.4
94-3, 0-15 100-3, 135-150	1357 1405	_	_	-	=	_	_	_	Ξ			=	Ξ	-2.97 -3.43	-15.1 - 17.0

Note: - indicates no data available.

concentration-depth profiles of chloride in these sites are presented in Figure 1. Lancelot and Ewing (1972) suggest that gas hydrates on the Blake Outer Ridge may decompose below a sub-bottom depth of ~ 600 m, that is, below the bottom simulating reflector (BSR). The chlorinity data suggest that this depth horizon may, in fact, be located somewhat deeper at this site.

Figures 2 and 3 illustrate the shipboard and shorebased data for dissolved species at Site 533. Again, a gradual decrease in chlorinity is observed in Hole 533 (Fig. 2), whereas the deeper horizons cored in Hole 533A (Fig. 3) show a rather complex pattern in chlorinity. The latter pattern is mimicked to a certain extent by the concentration depth profiles of dissolved ammonia, magnesium, lithium, and perhaps potassium. Whether these jagged profiles are the result of dilution caused by hydrate decomposition cannot be fully ascertained, but data for dissolved constituents of the intersitial fluids suggest that this is indeed the case.

Sulfate depletion is essentially complete below 20 m (Fig. 2), and ammonia concentrations gradually increase with depth to concentrations as high as 30 mM at ~ 400 m sub-bottom. Such observations are typical at sites where extensive methane production occurs (Gieskes et al., 1982; Harrison et al., 1982). Dissolved calcium remains low throughout the drilled section of Site 533. Dissolved magnesium decreases with depth, but it is difficult to pinpoint reactions responsible for these decreases. The data on dissolved strontium are puzzling. They appear too low and scattered, and we suspect that the data are not reliable. To some extent, this statement also applies to the data on dissolved potassium.

Figure 4 shows the depth profiles of δ^{18} O and δ D for Site 533 (Holes 533 and 533A combined). Large fluctuations in the depth ranging from 160 to 360 m sub-bottom add further support to the hypothesis of hydrate decomposition during core recovery. Section 533A-18-6 (294 m) shows both the lowest observed chlorinity



Figure 1. Chlorinity data for Sites 102, 103, and 104, DSDP Leg 11 (Sayles et al., 1972).

(17.21 g/kg) and the highest observed isotopic composition (+2.80% and +0.0% for δ^{18} O and δ D, respectively). As Hesse and Harrison (1981) have noted, it is difficult to explain positive oxygen isotope compositions of such a magnitude by a mechanism other than hydrate decomposition. Figure 5 presents a simple model illustrating the effect of an isolated gas-hydrate layer on the local pore water chemistry from the time of hydrate crystallization to the time of decomposition during coring operations. Assuming that solutes move by diffusion only and that the hydrate concentrates the heavier isotopes, we expect to observe low chlorinities and high δ^{18} O and δ D marking the horizon where the hydrate existed. Moreover, we would expect to see diffusion-related deflections above and below the hydrate layer with high chlorinities and low δ^{18} O and δ D. Just this pattern of behavior is observed between 260 and 320 m when chlorinity and δ^{18} O are plotted side by side in Figure 6. A hydrate-bearing region may, therefore, have existed around 290 m sub-bottom prior to coring operations. Hydrate may also have been present at ~260 m sub-bottom. It is interesting to note, however, that although a small piece of hydrate was recovered at 243 m sub-bottom, no chlorinity and isotope "fingerprint" was observed. The lack of a fingerpoint may indicate that the hydrate bed cored was small and isolated. The lack of recovery at 290 m sub-bottom, on the other hand, suggests that whereas the total amount of hydrate present was substantial (10% of the pore space by shipboard estimation), the hydrate probably existed in very thin, diffuse layers that decomposed quickly.

It is clear that this interpretation does not explain all the fluctuations in Figure 6. From 160 to 240 m sub-bottom, chlorinity and δ^{18} O both decrease, showing a positive rather than a negative correlation. Indeed, a plot of δ D against chlorinity for Site 533 also shows a weak but positive correlation that would not be expected for hydrate formation or decomposition (Fig. 7). One possible explanation is an infiltration of low-chlorinity, isotopically light water from elsewhere. Gieskes (1981) cited an example of fresh water imprints on hemipalagic sediments as far as 200 mi. from land. Such an hypothesis at Site 533 seems extremely unlikely, however, in view of the lack of sandy beds that could act as aquifers and the distance of this site from the mainland (~300 mi.). Other explanations are not readily apparent.

Site 534

Figure 8 presents concentration depth profiles of shipboard and shore-based data for dissolved species at Site 534. Data for alkalinity, calcium, and magnesium indicate that Site 534 is a representative continuation of Site 391. Below 500 m, little change occurs in dissolved magnesium, but dissolved calcium increases gradually with depth, indicating a source in the deeper sections.

Dissolved silica data indicate a sharp decrease below 750 m, that is, below Unit IV. Concentrations in Unit V (carbonaceous claystones) are very low. The boundary between Units IV and V (Fig. 8) is also marked by a minimum in dissolved strontium. Presumably, strontium is produced by recrystallization of carbonates in the



Figure 2. Interstitial water chemistry, Hole 533. (Lithology: Unit I-nannofossil marl and silty nannofossil clays [Holocene-Pleistocene].)

chalks above 500 m, and in the limestones of Unit VI (Fig. 8). Alkalinity values decrease rapidly below 700 m, probably as a result of reactions taking place in Unit V. Dissolved potassium clearly indicates a sink for this element in the claystone of Unit V.

Of interest is the gradual increase in dissolved chloride with depth (Fig. 8). Superimposed on this are very sharp decreases in Unit V. Data on dissolved calcium and magnesium do not suggest that these results are due to seawater contamination. Another possibility is that slight contamination may have occurred because of inadequate drying of the squeezing apparatus. Of some interest, however, is the shipboard observation that zones of low porosity in Unit V correspond to the low chlorinity values. At this stage it is not clear what may have caused the chlorinity anomalies. There is little doubt, however, that chloride concentrations do increase with depth, perhaps related to alteration and/or hydration reactions taking place in deeper, unsampled sediment sections or to the presence of nearby evaporites.

Interstitial water oxygen and hydrogen isotope depth profiles for Site 534 are shown in Figure 9. Except for sharp negative deflections in δ^{18} O at 900 m and 1090 m sub-bottom depth, the two profiles match closely. Both show slight decreases with depth, -1.6%/km for δ^{18} O and about -7%/km for δ D. The strong fluctuations between 750 and 950 m sub-bottom (carbonaceous claystone unit) appear to mimic variations in chlorinity and sediment porosity in the same interval and may be related to them. The sharp negative deflection in δ^{18} O observed at 1090 m (534A-63-2, -5.78%) does not correlate with δ D or chlorinity. Calcium, however, shows a steep gradient between 950 and 1050 m sub-bottom, which may indicate a source near 1100 m. Strontium shows a local maximum here and potassium has a sink near (or perhaps below) 1100 m. Taken together, these observations suggest that some sort of sediment alteration may be occurring around 1090 m that escaped shipboard notice.

As has been noted in the previous discussion, oxygen and hydrogen isotopic compositions generally vary together at Sites 533 and 534. A plot of δD against $\delta^{18}O$ illustrates this more clearly (Fig. 10). Deeper, older sediments are generally more depleted in interstitial water ¹⁸O and D. A least-squares fit of the data from Hole 534A gives the relation:

$\delta D = 4.2 \ \delta^{18}O - 2.3$

with a correlation coefficient of 0.78. Although the coefficient is not very high, the linear model actually fits quite well, because the residual variance of δD values about the regression line is fully accounted for by the analytical precision of measurement. Section 534A-63-2 ($\delta^{18}O = -5.78\%$) was not used to calculate the line, because it lies far from the main cluster of points and may be unreliable. The regression line passes quite close to SMOW standard values and, in fact, fits isotope data from the upper (nonhydrate-bearing) sediments of



Figure 3. Interstitial water chemistry, Hole 533A. (Lithology: Unit I—nannofossil marl and silty nannofossil clays [Holocene-Pleistocene]; Unit II—medium to dark greenish gray silty nannofossil clays [middle to late Pliocene]).



Figure 4. Oxygen and hydrogen stable isotopic composition of interstitial water from Site 533 (• = Hole 533; + = Hole 533A).

Hole 533 reasonably well. For reasons that are not clear (perhaps related to the presence of gas hydrate), the data from Hole 533A all fall below the line, toward higher δ^{18} O or lower δ D values. A weaker but similar correlation was observed by Lawrence and Gieskes

(1981) when they plotted all the available $\delta^{18}O$ and δD measurements for interstitial waters at previous DSDP sites.

The reasons for the depth-related depletions in interstitial water deuterium and ¹⁸O at Site 534 are difficult



Figure 5. Model for the influence of a hypothetical, isolated gas-hydrate bed on the chlorinity and isotopic composition of surrounding interstitial water. (Frames 1-5 depict chlorinity and isotope composition profiles in the same sedimentary interval from the time of hydrate crystallization to the time of hydrate decomposition during core recovery. 1. Before hydrate crystallization; 2. immediately after rapid hydrate crystallization; 3. just before drilling [the profiles in 3 assume that interstitial water species move predominately by diffusion]; 4. after complete hydrate decomposition during coring operations [the arrows show the locations of shipboard sampling for interstitial water]; 5. shipboard reconstruction of chlorinity and isotope composition profiles.)

to identify. Fractionation of the interstitial water isotopes could conceivably have occurred during shipboard squeezing, because unusually high pressures were required to recover samples from the deeper cores (Coplen and Hanshaw, 1973). Further research could readily evaluate this hypothesis. In the case that the observed isotopic trends are not a squeezing artifact, several explanations are possible.

In pelagic sediments, decreases in δ^{18} O are usually accompanied by enrichments in dissolved calcium (Lawrence and Gieskes, 1981; Gieskes, 1981). This is attributed to the alteration of volcanic ash and basalt to smectite and other phases (Lawrence et al., 1975; Perry et al., 1976; Lawrence and Gieskes, 1981). The decrease in δ D expected for this reaction is minimal, however (Lawrence and Gieskes, 1981), and cannot account for the ~18% deuterium depletion observed at this site. The possibility also exists that the isotope profiles reflect, in part, a change in the isotopic composition of



Figure 6. Expanded profiles of chlorinity (dashed line) and δ^{18} O (solid line) in interstitial waters from Hole 533A.



Figure 7. Plot of δD against chlorinity for interstitial waters from Site 533 (\odot = Hole 533, \triangle = Hole 533A).

the ocean. Some uncertainty exists regarding the isotopic composition of seawater in the geologic past. A strong case has, however, been made for the buffering of the seawater oxygen isotope ratio to within 1‰ of its present value (Muehlenbachs and Clayton, 1976; Gregory and Taylor, 1981). According to this model, the ocean is buffered by interaction with new crust generated at mid-ocean spreading centers. This would impose serious constraints on any hypothesis requiring significant variations in δ^{18} O of paleo-ocean water through time. Lawrence and Gieskes (1981) proposed that substantial alteration of basalts is occurring in crustal layer II in the presence of low δ D paleo-ocean water. This scenario would provide ¹⁸O- and D-depleted waters that



Figure 8. Interstitial water chemistry, Site 391 (O) and Site 534 (•) (except where otherwise indicated). (Lithology units: I—silty clay, some nannofossil-foraminifer ooze [Quaternary]; IIa—calcareous silt [upper Miocene]; IIb—chalk, clayclast, and marls [middle Miocene]; IIc—radiolarian mudstone [middle Miocene]; IId—intraclastic chalk limestone [middle-lower Miocene]; IIe—mudstones alternating with chalk [lower Miocene]; III—chalk-mudstone [lower Miocene]; IV—zeolitic mudstone, sandstone, porcellanite [upper Eocene]; V—black green carbonaceous claystone [Maestrichtian-Aptian]; and VI—calcareous claystone, chalk [Barremian-Hauterivian].)



Figure 9. Oxygen and hydrogen stable isotopic composition of interstitial water from Site 534.

could diffuse into the overlying layer I sediments, thereby causing the observed trends. Whether this mechanism could create an isotopic gradient throughout the 1600 m of sediment present at Site 534 is doubtful. It is clear that the reason(s) for the depletions in interstitial water δD and $\delta^{18}O$ at Site 534 are not presently understood. The results of this study do, however, appear to impose one constraint. The observed correlation between δD and $\delta^{18}O$ suggests that a common mechanism is responsible for both depletions.



Figure 10. Plot of δD against δ¹⁸O for interstitial waters from Holes 533 (☉), 533A (△), and Hole 534A (⊡). (See text for the discussion of the regression line.)

CONCLUSIONS

The principal observations at Site 533 are low salinities together with strong fluctuations in chlorinity, δ^{18} O, and δ D in the main zone of biogenic methane formation. This behavior can be understood, at least in part, in terms of hydrate decomposition during core retrieval. Poor hydrate recovery and the sharp and jagged nature of the chlorinity and isotope profiles indicate that the hydrate probably exists only in thin, diffuse layers that decompose quickly during coring operations.

Of great interest at Site 534 is the gradual increase in chlorinity and decrease in $\delta^{18}O$ and δD with depth. The increases in dissolved chloride may be related to alteration and/or hydration reactions taking place in the deeper unsampled sections or perhaps to the presence of nearby evaporites. Good correlation between $\delta^{18}O$ and δD values in this core indicates the same mechanism is probably responsible for depletions in both ¹⁸O and D.

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