

14. DATA REPORT: GEOCHEMISTRY AND MINERALOGY OF PERIPLATFORM CARBONATE SEDIMENTS: SITES 1006, 1008, AND 1009¹

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ABSTRACT

An intensive mineralogic and geochemical investigation was conducted on sediments recovered during Ocean Drilling Program Leg 166 from the western Great Bahama Bank at Sites 1006, 1008, and 1009. Pleistocene through middle Miocene sediments recovered from Site 1006, the distal location on the Leg 166 transect, are a mixture of bank-derived and pelagic carbonates with lesser and varying amounts of siliciclastic clays. A thick sequence of Pleistocene periplatform carbonates was recovered near the platform edge at Sites 1008 and 1009. Detailed bulk mineralogic, elemental (Ca, Mg, Sr, and Na), and stable isotopic ($\delta^{18}\text{O}$ and $\delta^{13}\text{C}$) analyses of sediments are presented from a total of 317 samples from all three sites.

INTRODUCTION

Sites 1006, 1008, and 1009 are located on the western slope of the Great Bahama Bank (Fig. 1). Site 1006 ($24^{\circ}23.989'\text{N}$, $79^{\circ}27.451'\text{W}$), the most distal site in the Bahamas Transect, is situated ~ 30 km from the platform edge in 658 m of water (Eberli, Swart, Malone, et al., 1997). A 717.3-m-thick Pleistocene to middle Miocene sequence of mixed pelagic and bank-derived carbonates with varying and lesser amounts of siliciclastic, clay-sized material was recovered.

Sites 1008 and 1009 are located ~ 100 km to the south of the main Bahamas Transect (Fig. 1). Site 1009 ($23^{\circ}36.84'\text{N}$, $79^{\circ}3.00'\text{W}$) is positioned ~ 4.5 km from the platform edge in 308 m of water. Site 1008 ($23^{\circ}36.64'\text{N}$, $70^{\circ}5.01'\text{W}$) is located 2.7 km more basinward than Site 1009 in 437 m of water. Thick, expanded Pleistocene sequences of periplatform sediments were recovered at both sites. Based on shipboard biostratigraphy, the age at the base of the section at Site 1009 [226.1 meters below seafloor (mbsf)] is ~ 1.44 Ma, and a similar age is observed at the bottom of the recovered sequence (134.5 mbsf) at Site 1008 (e.g., Eberli, Swart, Malone, et al., 1997).

Periplatform sediments are important components of both modern and ancient carbonate depositional systems (McIlreath and James, 1978; Cook and Mullins, 1983; Enos and Moore, 1983). However, relative to deep-sea oozes and neritic (platform) carbonates, we know much less about the diagenesis of periplatform sediments. In this report, I document the detailed mineralogic and geochemical analyses of sediments from these three sites. Discussion and interpretation of these results will be presented in a future publication.

METHODS

Sediment samples were analyzed at a frequency of ~ 1.5 m from Sites 1008 and 1009 and ~ 10 m from Site 1006. At all three sites, selected lithified horizons were also sampled and analyzed. Before analyses, each sample was examined and classified for the relative degree of lithification. Because the sediments in the present study are not deep-sea oozes, and to be consistent with shipboard descriptions (Eberli, Swart, Malone, et al., 1997), the nongenetic descriptors—unlithified, partially lithified, and lithified—are used rather than ooze, chalk, and limestone. All 317 samples were subjected to the

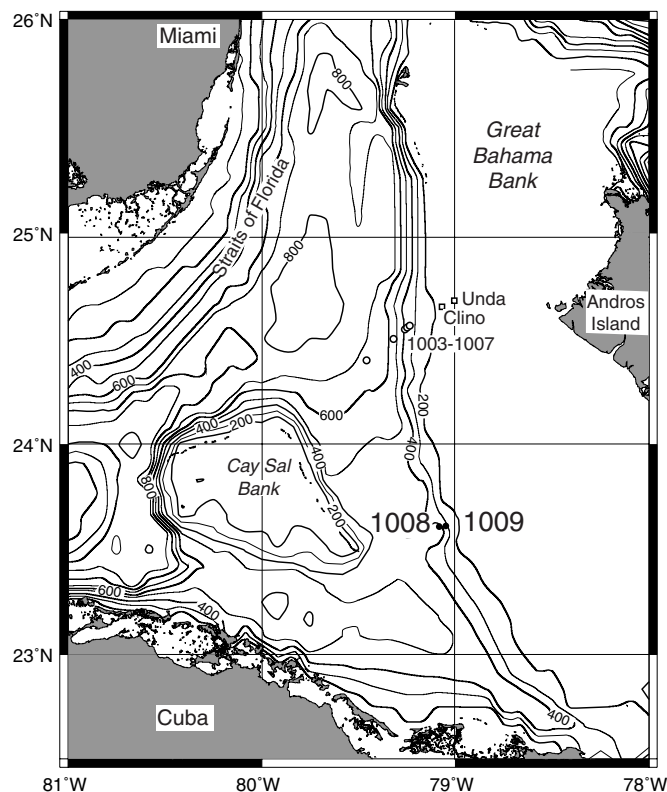


Figure 1. Location of sites drilled during Leg 166. Sites utilized in this report are highlighted in larger, bold type; bathymetry is shown in meters.

same cleaning and analytical procedures. The outer edge of the sample was scraped away to avoid any contamination obtained during sampling, and then approximately 1 g of bulk sediment was rinsed twice in deionized water, centrifuged and decanted, and dried overnight at 60°C . Lithified samples were crushed prior to rinsing.

A portion of each sample was analyzed by powder X-ray diffraction (XRD) using $\text{CuK}\alpha$ radiation on a Rigaku D-Max 111V-B X-ray diffractometer equipped with a graphite monochromator. Samples were ground in acetone, then smear-mounted onto glass plates and step-scanned from 20° – 80° 2θ , collecting data every 0.03° 2θ at 2 s/step. Quantitative proportions of aragonite, high-Mg calcite (HMC), low-Mg calcite (LMC), and dolomite (normalized to 100% carbon-

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ate) were determined by Rietveld refinement of XRD patterns (Rietveld, 1969; Post and Bish, 1989; Bish and Post, 1993). Reported accuracy of the method for carbonate minerals is better than $\pm 3\%$ (Bish and Post, 1993; Reid et al., 1992). Replicate analyses indicate that the precision is better than 1% when the phase is present in quantities >40 wt%. Precision subsequently decreases with decreasing weight percent. In addition to the chemical analyses described below, Mg content of HMC and dolomite was determined from the $d_{(10.4)}$ shift using the idealized curve of Goldsmith and Graf (1958) after correcting for specimen displacement by Rietveld refinement. Precision determined from replicates is ± 0.3 mol% Mg.

Each sample was analyzed for stable oxygen and carbon isotopic ratios. Approximately 120 mg of powdered sample was reacted in "100%" phosphoric acid at 70°C in an online, automated Kiel device coupled to a Finnigan MAT 251 stable isotope-ratio mass spectrometer. The carbonate standard NBS-19 ($\delta^{13}\text{C} = 1.95\text{‰}$, $\delta^{18}\text{O} = -2.20\text{‰}$) was used to calibrate to the Peedee belemnite (PDB) standard. Repeated analyses of NBS-19 yielded reproducibility of better than 0.1‰ for $\delta^{18}\text{O}$ and $\delta^{13}\text{C}$ ($N = 34$).

For major and minor elemental compositions, ~50 mg of each sample was leached for 30 min in 25 ml of 1M acetic acid buffered with 1M ammonium acetate (pH of ~5). The buffered acetic acid was chosen to minimize contamination from noncarbonate phases. The leachate was centrifuged, decanted, and stored in HDPE bottles for analyses. After appropriate dilution, the solutions were analyzed for Ca, Mg, Sr, and Na by flame atomic absorption spectroscopy using a Perkin-Elmer Model 603 spectrophotometer. Standardization was achieved with SPEX plasma grade standards, coupled with the following internal check standards: reagent grade calcium carbonate, NBS-1C, and two previously well-characterized periplatform carbonate sediment samples from the Maldives (Malone et al., 1990; Malone, unpubl. data). Replicate analyses of samples yielded the following mean relative error for the entire procedure: <1% for mol% CaCO_3 , 3% for mol% MgCO_3 , 3% for Na, and 2% for Sr.

RESULTS

Bulk mineralogic and geochemical data have been compiled for Sites 1006, 1008, and 1009 in Tables 1, 2, and 3, respectively. In addition to the data, the ODP sample identifier, depth (in mbsf), and degree of lithification (as defined above) of each sample analyzed are also tabulated. In Tables 2 and 3, the shipboard lithologic classification (Eberli, Swart, Malone, et al., 1997) of each sample is listed. Data are depicted graphically vs. depth in Figures 2 through 5.

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Table 3 (continued).

Core, section, interval (cm)	Depth (mbsf)	Shipboard lithology	Degree of lithification	Aragonite (wt%)	LMC (wt%)	HMC (wt%)	Dolomite (wt%)	mol% Mg		CaCO ₃ (mol%)	MgCO ₃ (mol%)	Mg (ppm)	Na (ppm)	Sr (ppm)	$\delta^{13}\text{C}$ PDB	$\delta^{18}\text{O}$ PDB
								HMC (XRD)	Dolomite (XRD)							
25X-6, 29-31	197.19	pl bio wack	PL	65.3	5.9	28.8	0	11.9		95.93	2.2	5,348	1945	8,877	4.96	0.99
25X-7, 29-31	198.69	pl bio mud-wack	PL	69.0	7.4	23.6	0	11.1		96.00	2.1	5,125	1934	9,101	4.88	0.79
26X-1, 29-31	198.79	pl pel bio wack	PL	68.6	7.4	24.0	0	11.1		95.88	2.1	5,208	1985	9,662	4.93	0.83
26X-2, 29-31	200.29	pl bio wack	PL	69.2	8.7	22.1	0	11.2		95.53	2.5	6,030	1994	9,722	4.94	0.66
26X-3, 29-31	201.79	pl bio wack	PL	70.4	9.4	20.2	0	10.6		95.72	2.3	5,464	2135	9,593	4.99	0.76
26X-4, 29-31	203.29	pl bio wack	PL	71.1	10.2	18.7	0	11.8		95.55	2.4	5,724	2169	9,961	4.84	0.57
26X-5, 29-31	204.79	pl bio wack	PL	72.1	10.8	17.1	0	11.0		95.41	2.4	5,732	2438	10,173	4.92	0.56
27X-1, 29-31	207.89	pl bio wack	PL	67.4	11.2	21.4	0	11.2		95.57	2.5	6,085	1960	9,323	4.81	0.80
27X-2, 29-31	209.39	pl bio wack	PL	70.9	10.0	19.1	0	11.3		95.70	2.3	5,592	1943	10,023	4.81	0.63
27X-3, 29-31	210.89	pl wack mud	PL	71.3	12.6	16.1	0	11.5		95.43	2.5	6,029	2128	10,079	4.79	0.75
27X-4, 29-31	212.39	pl bio mud-wack	PL	73.0	11.5	15.5	0	11.6		95.45	2.3	5,664	2433	10,050	4.90	0.55
27X-5, 29-31	213.89	pl bio mud wack	PL	72.1	10.6	17.3	0	11.4		95.73	2.3	5,564	1942	9,879	5.01	0.85
27X-6, 29-31	215.39	pl bio mud wack	PL	75.9	13.2	10.9	0	11.8		95.48	2.4	5,793	2129	10,493	4.93	0.52
27X-7, 29-31	216.89	pl bio mud	PL	78.2	10.6	11.2	0	11.7		95.87	2.0	4,858	2158	10,297	4.96	0.51
28X-1, 29-31	216.99	pl wack	PL	71.0	4.0	24.4	0.6	11.8	46.6	96.20	2.0	4,761	1802	9,128	4.97	0.96
28X-2, 29-31	218.49	pl wack	PL	69.5	4.4	23.8	2.3	10.3	41.6	95.32	2.7	6,597	2084	9,166	4.95	0.91
28X-3, 29-31	219.99	pl bio wack	PL	50.9	14.8	29.9	4.4	12.1	42.3	92.60	5.8	14,147	1847	7,073	4.16	1.00
28X-4, 29-31	221.49	pl pel mud wack	PL	77.8	3.1	17.3	1.8	11.3	41.6	95.66	2.2	5,256	2233	10,397	5.01	0.39
28X-5, 29-31	222.99	pl bio mud wack	PL	81.5	4.5	12.9	1.1	12.8	45.4	95.57	2.1	5,200	2363	10,916	4.92	0.43

Notes: HMC = high-Mg calcite, LMC = low-Mg calcite, XRD = X-ray diffraction, PDB = Peedee belemnite standard. Shipboard lithologic descriptions are abbreviations of the Dunham classification (Eberli, Swart, Malone, et al., 1997): ul = unlithified, pl = partially lithified, pel = peloidal, bio = bioclastic, wack = wackestone, pack = packstone, mud = mudstone; forams = foraminifers, nannos = nannofossils. Degree of lithification column abbreviations: PL = partially lithified, LITH = lithified, unmarked areas = unlithified. ND = not determined. See text for method of lithification classification.

This table also appears on the volume CD-ROM.

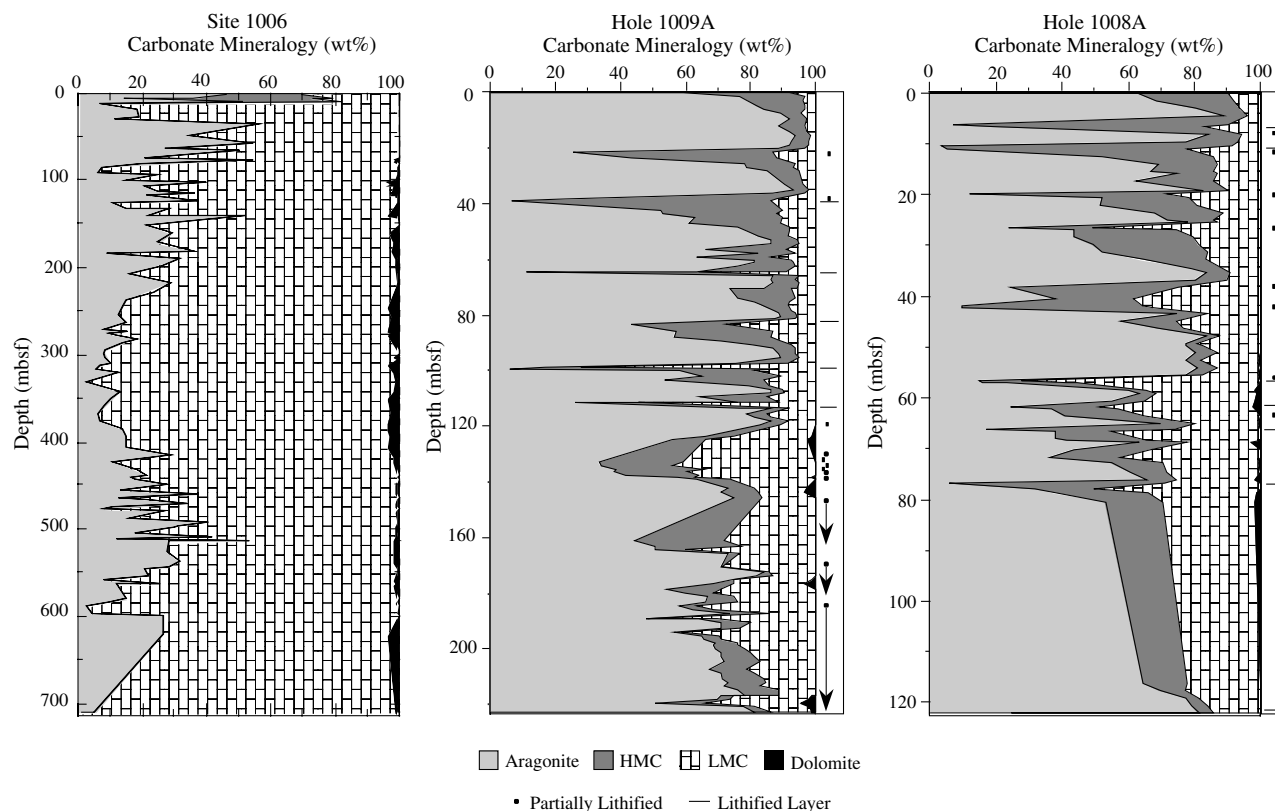


Figure 2. Bulk, cumulative carbonate mineralogy vs. depth. Relative degree of lithification is also shown for Holes 1009A and 1008A.

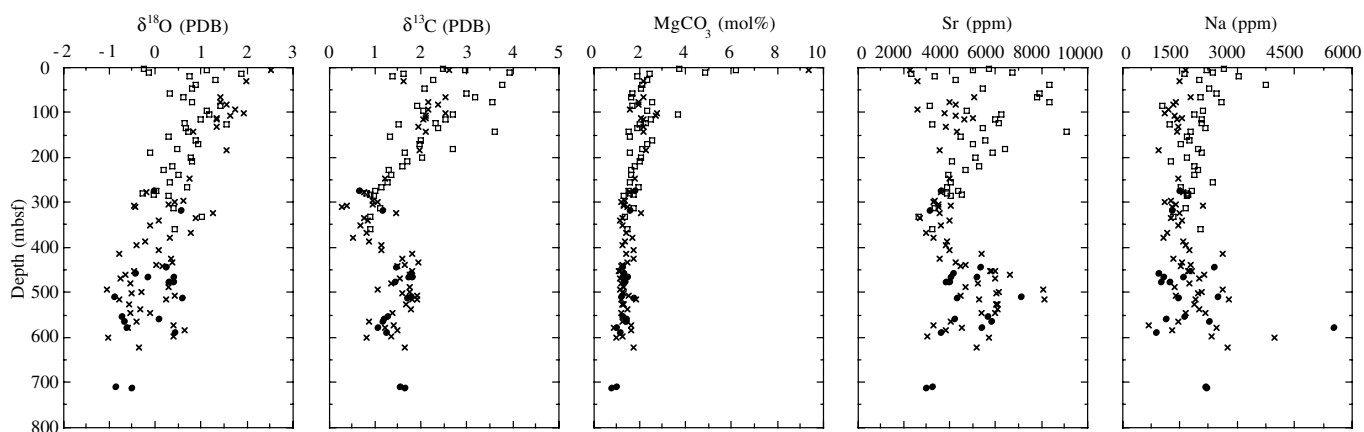


Figure 3. Geochemical data from Site 1006 vs. depth. Open squares = unlithified, crosses = partially lithified, and solid circles = lithified, PDB = Peedee belemnite standard.

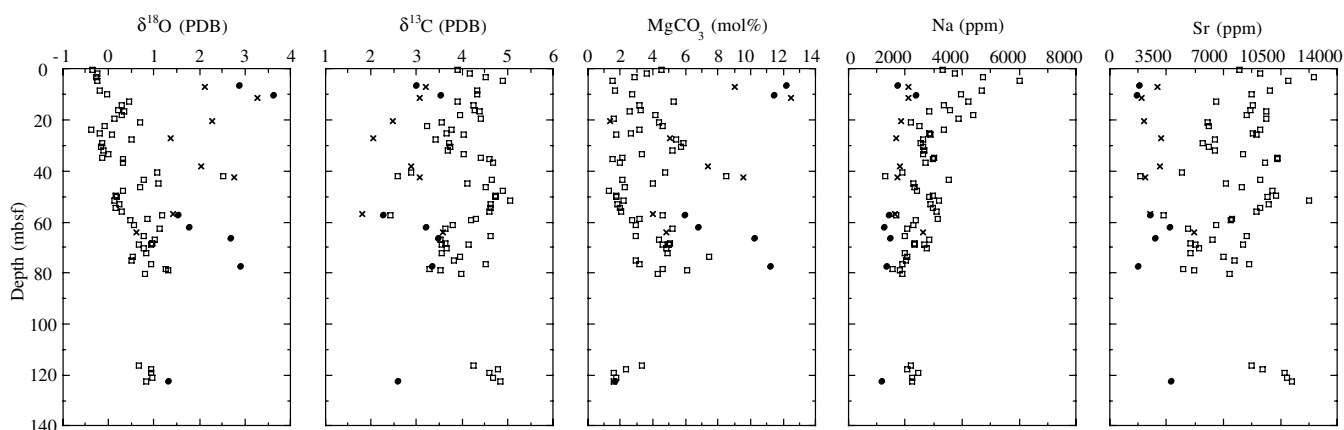


Figure 4. Geochemical data from Site 1008 vs. depth. Open squares = unlithified, crosses = partially lithified, and solid circles = lithified, PDB = Peedee belemnite standard.

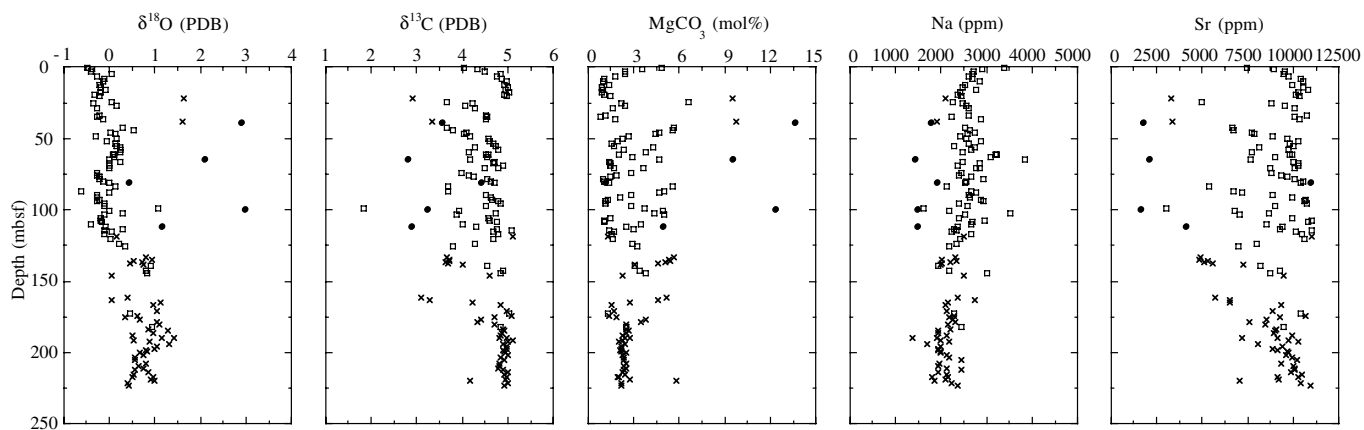


Figure 5. Geochemical data from Site 1009 vs. depth. Open squares = unlithified, crosses = partially lithified, and solid circles = lithified, PDB = Peedee belemnite standard.