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**DIAGENETIC PATTERNS AND PROCESSES
WITHIN A PLEISTOCENE CONTINENTAL SLOPE
OF MIXED CARBONATE AND SILICICLASTIC LITHOLOGIES:**

**AN INVESTIGATION OF RESULTS FROM
DEEP OCEAN DRILLING OFF THE NORTHEAST AUSTRALIAN MARGIN**

By

SELMA ALPAY, B.SC.

**A thesis submitted to
the Faculty of Graduate Studies and Research
in partial fulfillment of
the requirements for the degree of**

Master of Science

Department of Earth Sciences

**Carleton University
Ottawa, Ontario.**

January 1996

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submitted by Selma Alpay, B.Sc.
in partial fulfilment of the requirements for
the degree of Master of Science

Thesis Supervisor
Chairman, Department of Earth Sciences

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Ottawa-Carleton Geoscience Centre

January 1996

ABSTRACT

Deep ocean drilling within a shelf-edge transect off northeast Australia in water depths of 210-570 m (Sites 819, 820, and 821, Ocean Drilling Program Leg 133) has penetrated 400 m of mixed carbonate and siliciclastic lithologies of Pleistocene age (<1.48 Ma).

Mineralogic, geochemical, and petrographic analyses of 592 sediment samples form the database for this investigation of diagenetic patterns and processes under burial.

Authigenic replacement dolomite forms at the expense of magnesian calcite; prolific dolomitization occurs during slow sedimentation rates near the sediment-water interface where diffusion from overlying seawater provides an additional source of Mg. Negative $\delta^{13}\text{C}$ signatures (<-12 ‰ PDB) indicate that dolomite precipitation is bacterially-mediated within the diagenetic zone of sulphate reduction.

Palisade calcite and sparry calcite burial cements (10-25 μm) are suspected to be of magnesian calcite mineralogy by palisade cement morphology, selective dolomite replacement, alteration to finer-grained, anhedral, microcrystalline calcite (5 μm), and excess abundance of magnesian calcite (as detected by XRD) for which the amount of skeletal magnesian calcite observed petrographically is inadequate.

Onset of lithification to chalk-equivalent strata occurs at greater burial depths in northeast Australia (below 93-118 m in comparison to 55-70 m in pure carbonate slopes). The

deeper first occurrence of partly lithified strata is caused by more rapid burial rates that exceed the rate of diagenesis and by the possible insulating effect of clay minerals (kaolinite or chlorite and illite) within an intergranular muddy matrix ($<2\ \mu\text{m}$) that preserves initial metastable carbonate mineralogy. Lithification is enhanced by increased carbonate contents ($>57\%$) that contain an original metastable mineralogy -- susceptible to dissolution and subsequent precipitation of stable calcite cements.

Metastable aragonite persists consistently as skeletal fragments to a burial depth of at least 400 m (generally $<20\%$ of the carbonate fraction), whereas aragonite at depths below 250 m in pure carbonate slopes may occur only locally. Metastable aragonite and magnesian calcite and their constituent trace elements are preserved in anomalously higher quantities at depth intervals of low carbonate content and increased terrigenous influx (high relative detrital quartz content). The carbonate mineral components, that include anhedral, microcrystalline calcite, form isolated, unconnected domains within a greenish, clay-bearing, muddy intergranular matrix that acts as a physical and chemical barrier to impede rapid burial diagenesis.

ACKNOWLEDGMENTS

Thanks are extended to George R. Dix of the Department of Earth Sciences, Carleton University, whose supervision introduced me to the tools of study in carbonate sedimentology and provided logistical support for the research. As a member of the thesis committee, Ken Torrance of Carleton University's Department of Geography welcomed the chance to contribute and guided my imagination to perform contortionist feats at the ionic scale. André Desrochers of the Department of Geology, University of Ottawa, served as an enthusiastic thesis committee member and presented a much-appreciated forum to observe and discuss complex diagenetic fabrics.

This investigation was supported through an operating research grant to G.R. Dix (Natural Sciences and Engineering Research Council of Canada), a student Grant-in-Aid (American Association of Petroleum Geologists), and a Graduate Student Bursary (Faculty of Graduate Studies and Research, Carleton University). Sincere appreciation is extended to the Ocean Drilling Program for granting permission to retrieve samples from the Gulf Coast Repository at Texas A&M University.

Invaluable technical support was received from several individuals in the Department of Earth Sciences at Carleton University. Ron Conlon generated hundreds of powder X-ray diffraction analyses. Peter Jones, Cheng Huang, and Lewis Ling provided expert assistance in scanning electron microscopy. Anett Briggs prepared thin sections and

assisted me to achieve a nearly unattainable polish in fine-grained lithologies. Technical contributions were made by Dan Marshall and Jim Crowley who guided me on extended tours of computer graphics and by Brad Johnson who removed the cobwebs from my memory of black and white print-making. Richard Taylor volunteered as an examining board member and turned his attention, temporarily, to burial diagenesis. Sheila Thayer and Jack Hogg have treated my concerns with remarkable sensitivity and competence.

Outside Carleton's Department of Earth Sciences, I have appreciated expert assistance from several sources. Karl Diedrich and Robert Kehle in the Department of Chemistry aptly identified and furnished equipment for laboratory experiments. Wayne England of the Department of Biology granted access to a superb darkroom. In the Department of Geology at the University of Ottawa, Natalie Morisset analyzed stable isotopes, $\delta^{13}\text{C}$ and $\delta^{18}\text{O}$, in dolomite and John Loop measured major and trace element concentrations in the bulk carbonate fraction. Keiko Hattori advised me of the available analytical techniques for troublesome fine-grained lithologies. Thin sections were prepared by Vancouver Petrographic Services. Joel Grice generously provided access and an introduction to "Imogene" for the hands-on experience of running powder XRD analysis in the Mineral Sciences Division of the Canadian Museum of Nature. Participation in the first SEPM Congress on Sedimentary Geology--Linked Earth Systems was an opportunity to have several stimulating discussions with Leslie Melim (Rosentiel School of Marine and Atmospheric Science, Division of Marine Geology and Geophysics, University of Miami) whose petrographic expertise and research have given me new insights into my own work.

To the friends I have discovered at Carleton University, among whom are Pablo Guerstein, Veronica Irigoyen, and Lizzy Ann Dunworth, I extend my gratitude for their camaraderie and support. I have gained new views on the scientific community, academia and human dignity from the people closest to me. Cathy Langill has lent me a tender understanding ear. Sue Burbidge's friendship has been a lifeline during both our joint exploits and individual thesis challenges. Marc Hinton has injected me with regular large dosages of encouragement which I have appreciated immensely. My friend, Pat Brennan, has motivated me by sharing her excitement in the personal discovery of new forays in science. I have been inspired by the extraordinary ingenuity and insight of a valued friend and colleague, David Corrigan. Drifting above Perry Reef in the Bahamas ignited a treasured friendship with Claudia Schröder-Adams who has shown exceptional sincerity and generosity; she has also availed me of her scientific expertise in micropaleontology with great enthusiasm.

Finally, I have been privileged to receive uninterrupted true confidence in my endeavours from Aysel Alpay.

"If you surprise an intruder in the act of burglarizing your home, do not panic. Remember, he is as frightened as you are. One good device is to rob *him*."

- Woody Allen -

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1. INTRODUCTION

Shallow burial diagenesis has been investigated previously in three settings of deep-water carbonate sedimentation: pelagic environments, isolated carbonate platform margins, and epicontinental margins. Samples for study were retrieved by dredging, grab sampling, submersible dives (e.g., Schlager & James, 1978), subsurface piston coring (e.g., Mullins *et al.*, 1985), and deep-ocean drilling (e.g., Deep Sea Drilling Project: Matter *et al.*, 1975, Garrison, 1981; Ocean Drilling Program: Dix & Mullins, 1988, 1992, Malone *et al.*, 1990).

In fine-grained carbonate sediments, examination of shallow burial diagenesis must consider the source of cement, the role of compaction, and the main chemical and mineralogical processes that contribute to lithification (e.g., Choquette & James, 1990). Since the original input mineralogy in pelagic carbonate sedimentation is predominantly stable calcite, burial diagenesis is not controlled by mineral solubility. However, at burial depths greater than 500 metres below sea floor (mbsf), pressure solution can enhance calcite solubility. In contrast, periplatform carbonate sediments contain an original heterogeneous mineralogy of calcite, magnesian calcite, and aragonite, each with different solubilities that contribute to diagenetic reactions under burial (Schlager & James, 1978). Large quantities of bank-derived metastable magnesian calcite and aragonite are susceptible to dissolution and reprecipitation as stable calcite cements (e.g., Schlager & James, 1978, Mullins *et al.*, 1985). Consequently, on the basis of input mineralogy, a

much greater initial 'diagenetic potential' can be anticipated in peri-platform sediments than in the pelagic realm (Schlanger & Douglas, 1974). Diagenetic potential also increases with increasing lateral proximity to the carbonate platform where abundances of metastable carbonate minerals are higher, sedimentation rates are more rapid, and the initial metastable minerals are preserved longer under rapid burial (Dix & Mullins, 1988). In both pelagic and periplatform carbonate sediments, the general sequence of lithification with increasing age and depth of burial is from ooze to chalk to limestone (unlithified to partly lithified to lithified), although anomalies occur and reversal intervals have been documented (Schlanger & Douglas, 1974).

Chemical and mineralogical evidence of contemporary diagenesis is given by changing solid-phase and pore-water Sr^{2+} concentrations (e.g., Baker *et al.*, 1982, Malone *et al.*, 1990). With increasing burial lithification, there is a decrease in solid-phase Sr^{2+} as aragonitic Sr-rich skeletal fragments dissolve and reprecipitate as Sr-poor calcite cements. An attendant rise in pore-water Sr^{2+} concentration occurs.

A composite summary of the diagenetic patterns and processes within pure carbonate slopes is compiled from previous investigations in the Maldives Archipelago, Indian Ocean, (Malone *et al.*, 1990) and in the Bahamas (e.g., Mullins *et al.*, 1988, Dix & Mullins, 1988, 1992) in Table 1.1.

Table 1.1. Diagenetic Patterns and Processes in Pure Carbonate Slopes

Diagenetic Feature	Patterns and Processes
Carbonate Mineral Distribution	<p>Metastable magnesian calcite and aragonite abundances decrease with depth; calcite abundances increase with depth. Magnesian calcite and aragonite dissolve and reprecipitate as stable calcite cements under burial.</p> <p>Magnesian calcite undergoes dissolution and conversion to calcite more rapidly with burial than does aragonite.</p> <p>Aragonite occurrence is primarily in the form of needles. It is virtually absent below 250 mbsf where isolated occurrences may only be localized.</p> <p>Diagenetic potential increases with proximity to the margin as abundances of bank-derived metastable carbonate minerals are higher, sedimentation rates are more rapid, and the metastable mineralogy is preserved at greater depths under burial.</p>
Dolomitization	<p>Pervasive authigenic dolomite has precipitated during hardground development near the sediment-water interface during periods of slow sedimentation. Its distribution is sporadic. Sources of Mg for dolomitization are diffusion from overlying seawater and dissolution of magnesian calcite.</p>
Lithification	<p>Onset of lithification to chalk occurs between 55 and 70 mbsf.</p> <p>Degree of lithification increases vertically with depth (ooze to chalk to limestone) and decreases laterally with distance from the margin.</p> <p>Increase in lithification with depth coincides with an increase in stable calcite cements. Decrease in lithification with lateral distance from the margin coincides with a decrease in the original metastable carbonate mineral input.</p>

An epicontinental slope of mixed carbonate and siliciclastic lithologies contains a more diverse original mineralogy that reflects pelagic, periplatform, and hemipelagic sedimentation (Coniglio & Dix, 1992). Initial metastable components in the carbonate fraction are expected to control mineralogic and geochemical alterations in the subsurface.

The role of the siliciclastic minerals in shallow burial diagenesis has not yet been identified, although speculation and empirical observations have been used to discuss the effects of the clay-size fraction on mass balances, dolomitization, and diffusion (Matter *et al.*, 1975; Garrison, 1981; Wei & Gartner, 1993). Swart *et al.* (1993) have initiated investigation of burial diagenesis within an epicontinental slope of mixed sediment lithology by an initial synthesis of pore-water geochemistry and subsurface mineralogy. They attribute changes in pore-water geochemical profiles to mineral authigenesis (calcite and dolomite), adsorption onto clay mineral particles (K^+), and carbonate recrystallization ($\delta^{18}O$, $\delta^{13}C$).

The primary mandate of Ocean Drilling Program (ODP) Leg 133 off the northeast Australian margin was to obtain a record of passive margin evolution and the response to sea-level changes in the late Cenozoic and Quaternary (Davies, McKenzie, & Palmer-Julson *et al.*, 1991). A secondary goal was to characterize the diagenetic history of a mixed carbonate and siliciclastic slope in contrast with that of carbonate platform margins. This study addresses the secondary mandate of ODP Leg 133 by providing a detailed investigation of spatial diagenetic patterns and processes within the northeast Australian margin. A total of 592 sediment samples, Pleistocene in age (<1.48 Ma), were analyzed. They were retrieved from a shelf-edge transect of three deep-ocean drillholes that forms the foundation of the database for this study (Sites 819, 820, and 821 of ODP Leg 133; Figures 1, 2, 3). The primary research objectives of this investigation are: to identify distribution patterns of the carbonate minerals as a result of diagenetic alteration (including dolomitization), to infer the diagenetic contribution, if any, of the siliciclastic

FIGURE 1 Map of Study Sites off the Northeast Australian Margin
Bathymetry in metres. (After Davies, McKenzie, & Palmer-Julson *et al.*, 1991).

FIGURE 2. Schematic Transect Across the Queensland Trough
(Based on seismic profiling; after Davies, McKenzie, & Palmer-Julson *et al.*, 1991).

FIGURE 3. Bathymetry of ODP Leg 133 Drill Sites 819, 820, and 821
(Location shown by square in Figure 1; bathymetry in metres; after Barton *et al.*, 1993)

minerals, to synthesize the results with existing databases from Leg 133 for a comprehensive diagenetic summary (McKenzie, Davies, & Palmer-Julson, *et al.*, 1993; Davies, McKenzie, & Palmer-Julson, *et al.*, 1991), and to compare results with those of studies from pure carbonate slopes such as in the Maldives Ridge of the Indian Ocean (Malone *et al.*, 1990) and in the northern Bahamas (Dix & Mullins, 1988, 1992).

2. STUDY SITES

2.1. GEOLOGIC HISTORY

Although Holocene development of the Great Barrier Reef is well known in northeast Australia, it represents a recent episode (0.5 to 0.8 Ma) in the history of a passive continental margin which has been forged by processes of rifting, subsidence, plate motion, sea-level variation, and plate collision since Late Cretaceous (Davies *et al.*, 1989, Davies, McKenzie, & Palmer-Julson *et al.*, 1991). Late Cretaceous and Paleocene rifting allowed the opening of the Coral Sea basin and the development of the rift trough system that includes the Queensland Trough (Figures 1, 2). Seafloor spreading is represented by shallow basement tilt blocks (≥ 2.00 s two-way travel time; Figure 2). Relics of the rifting event were structural physiographic highs on which the carbonate platforms could later develop. Clastic, fluvio-deltaic, and carbonate sedimentation during temperate conditions of the Eocene and Oligocene was followed by widespread transgressions from simultaneous subsidence and sea-level rise in Late Oligocene to Early Miocene. Although reef growth was inhibited initially by temperature and high oceanic phosphate concentrations from late Middle Eocene to middle Early Eocene, northward plate movement into the tropics allowed robust reef development by early Middle Miocene on the Queensland and Marion Plateaus and on the northern epicontinental plateau (Figures 1, 2). Reef growth on the Queensland and Marion Plateaus was restricted by Late Miocene subsidence and simultaneous sea-level fall, and, during the Pliocene, the northern

reefs were buried by progressive foreland basin development (Davies *et al.*, 1989, Davies, McKenzie, & Palmer-Julson *et al.*, 1991).

This study focuses on post-Pliocene carbonate and fluvioclastic sedimentation that is considered to occur in response to sea-level change (e.g., Davies, McKenzie, & Palmer-Julson *et al.*, 1991). During rising and high sea-level conditions, reefal and inter-reefal carbonate deposition was dominant, whereas siliciclastic deposition was restricted mostly to the inner shelf. In contrast, during falling and low sea-level conditions, increased transport of terrigenous material to the slope was manifested as terrigenous-carbonate facies couplets (e.g., Feary *et al.*, 1993). The couplets were produced by transport of (1) detrital carbonate sediments to the slope, (2) aggradation of fluvial and siliciclastic-carbonate mixtures to the middle and outer shelf, and (3) progradation of terrigenous-carbonate sand and sandy mud from shelf-edge deltas to the upper slope (Maxwell, 1968, Maxwell & Swinchatt, 1970, Hopley, 1982, Flood & Orme, 1988, Belperio & Searle, 1988, Davies *et al.*, 1991, Feary & Jarrard, 1993, Feary *et al.*, 1993, Peerdeman & Davies, 1993).

2.2. SITE LOCATIONS

Sites 819, 820, and 821 represent 3 of 16 sites drilled during ODP Leg 133 off the northeast Australian margin. These sites form the western end of a transect that extends east of Cairns from Grafton Passage in the central Great Barrier Reef and across the Queensland Trough to the Queensland Plateau near Holmes Reef (Figures 1, 2, 3). The

transect of drillholes at Sites 819-821 were selected by the ODP to investigate sedimentary facies changes that are sensitive to sea-level fluctuations. The transect also provides the foundation for a detailed study of the spatial diagenetic patterns and processes within a mixed carbonate and siliciclastic shelf-margin.

The nearest reef lies approximately 6 km west of the most proximal site, 821. Site 821 lies 2 km west of Site 820 which lies 3 km west of Site 819 (Figures 1, 2, 3). Water depths and the coordinates of each hole are given in Table 2.1. (Davies, McKenzie, & Palmer-Julson *et al.*, 1991).

TABLE 2.1. Water Depths and Coordinates of Drillholes

Hole	Water Depth (mbsl)	Coordinates
819A	565.2	16°37.439'S, 146°19.486'E
820B	279.0	16°38.219'S, 146°18.218'E
821A	212.7	16°38.793'S, 146°17.376'E

2.3. ACCUMULATION RATES

Drilling to a depth of 400 m was projected to intersect Early Pliocene sediments from previous stratigraphic interpretations (e.g., Davies *et al.*, 1989), however, shipboard data reveal that only Pleistocene sediments were recovered by drilling. Penetration reached strata of Early Pleistocene age (between 1.27 and 1.48 Ma) at the base of each drillhole. Consequently, an expanded Middle to Late Pleistocene section was retrieved (Davies &

McKenzie, 1993). Barton *et al.* (1993) supplemented existing shipboard data of Davies, McKenzie, & Palmer-Julson *et al.* (1991) and the calcareous nannofossil stratigraphy of Wei & Gartner (1993) with additional marker horizons from magnetic susceptibility stratigraphy to generate a chronology from which accumulation rates can be estimated (Table 2.2.; Figure 4). High sedimentation rates may be responsible for the underconsolidation of most of the sediments at Sites 819-821. According to Ladd *et al.* (1993), where increased lithification occurs at Site 820, it correlates with intervals of slower sedimentation. At Site 821, increased lithification coincides with recent mass-wasting and older erosional surfaces.

TABLE 2.2. Summary of Accumulation Rates

Datum	$A_{2.5c}$ (Ma)	Depth (mbsf)			Rate (cm/ka)		
		819	820	821	819	820	821
1	0.075	10	10	11	13.3	13.3	14.7
2	0.275	26.9	35.4	35.8	8.5	12.7	12.9
3	0.465	32.4	108	109.5	28.9	38.2	38.8
4	0.73	40.8	137	139.5	31.7	10.9	11.3
5	0.81	45	141	143	52.5	50.0	43.8
6	0.92	56.1	160	176.8	10.1	17.3	30.7
7	1.10	166.9	260.3	270.1	61.6	55.7	51.8
8	1.27	189.2	271.7	279.2	13.1	6.7	5.4

(Revised after Barton *et al.*, 1993; not corrected for compaction)

FIGURE 4. Accumulation Rates (cm/ka)

(Time lines, dashed lines, are from Barton *et al.*, 1993; unconformities, dotted lines, are from Feary *et al.*, 1993).

2.4. BIOSTRATIGRAPHY

Occurrences of calcareous nannofossils and planktic and benthic foraminifera provide the basis for biostratigraphy (Davies, McKenzie, & Palmer-Julson *et al.*, 1991). Benthic foraminiferal assemblages in the uppermost 120 m of Hole 819A suggest an upper bathyal paleodepth of 200-600 metres below sea level (mbsl; Alexander *et al.*, 1993). Sites 820 and 821 contain both neritic (<200 mbsl) and upper bathyal assemblages (Davies, McKenzie, & Palmer-Julson *et al.*, 1991).

A major hiatus at 32.5 mbsf at Site 819 is confirmed by condensed nannofossil strata and a slump detachment surface (Figure 4; Davies, McKenzie, & Palmer-Julson *et al.*, 1991).

Abrupt changes in foraminiferal abundances and in the ratio of planktic to benthic foraminifera (P/B) provide further evidence to mark the break in the record (Kroon *et al.*, 1993). Through a study of mineral magnetism, particle size, and carbonate content records in the uppermost 120 m of Hole 819A, Alexander *et al.* (1993) determined that at least 200 ka are missing from the marine isotopic stages. The planktic foraminiferal $\delta^{18}\text{O}$ record shows a significant change of environment before the hiatus at 41 mbsf. According to Alexander *et al.* (1993), the interval between 41 and 32.5 mbsf represents a transitional period between two different patterns of ocean circulation from Subtropical Central Water (SCW) to Antarctic Intermediate Water (AAIW) and an associated change in temperature from 18-25°C to 4.2-6°C respectively. In an investigation of the uppermost 17 m of Hole 821A and 60 m of Hole 819A, Kroon *et al.* (1993) suggest that the abundances of foraminifera and their P/B ratios are controlled by the distribution of oceanic water masses

and current velocities. They infer a shift from the Subtropic Lower Water (SLW) to AAIW at Site 819 with a concomitant decrease in bottom-water temperature from 25 to 5°C. Sea-level fluctuations could have induced a change in the vertical distribution of the prevailing water masses (Alexander *et al.*, 1993). Kroon *et al.* (1993) also point out that a shallowing of the mixing zone between SLW and AAIW is plausible within the context of a simultaneous worldwide reorganization of paleoclimate and paleoceanography.

3. ANALYTICAL TECHNIQUES

3.1. SAMPLING AND PREPARATION

Sampling of drillholes 819A, 820B, and 821A of ODP Leg 133 (Davies, McKenzie, & Palmer-Julson *et al.*, 1991) yielded 10 cm³ of bulk sediment every metre in the upper 150 metres below sea floor (mbsf). Sample spacings widened up to approximately 10 m to the base of each hole (~400 mbsf). Additional samples were taken in intervals that are characterized by abrupt changes in lithification, mineralogy, and pore-water chemistry as detected by initial shipboard analyses (Davies, McKenzie, & Palmer-Julson *et al.*, 1991). Half of each sample was preserved in cold storage; the other half was air-dried at room temperature and powdered by mortar and pestle to establish a consistent grain size of less than 200 µm.

3.2. LITHIFICATION

Degree of lithification was classified as unlithified, partly lithified, or lithified according to the ODP scheme (Davies, McKenzie & Palmer-Julson *et al.*, 1991).

3.3. CARBONATE CONTENT

Total carbonate content was measured by the "karbonat-bombe" method of Müller and Gastner (1971) whose stated accuracy is within 5% error. Empirical standard deviations of less than 2% were calculated from replicate analyses in this study.

3.4. MINERALOGY

3.4.1. BULK SAMPLE

Carbonate mineral abundances (magnesian calcite, calcite, aragonite and dolomite) in the bulk sample were determined as ratios of peak-area from powder X-ray diffractograms (Milliman, 1974) with a precision of 3% or better in replicate analyses; they are expressed as percentages of the total carbonate fraction. For the main bimodal calcite peak (centred approximately at $29.75^\circ 2\theta$), peak-area geometries were allotted to magnesian calcite and calcite according to Berner (1966); this method is expected to produce results within 5% error (Milliman, 1974), although Burton (1984) cautions that errors can be in excess of 15%. Consequently, peak-area ratios are considered to represent qualitative estimates of relative mineral abundances and serve to identify depth intervals over which mineralogic changes occur. XRD analysis was executed on glass slide mounts by a Phillips X-ray diffractometer (PW 1080 unit controlled by a PW 1710 unit) with Ni-filtered Cu-K α radiation ($\lambda = 1.5406 \text{ \AA}$) over an interval of 25 to $32^\circ 2\theta$. Quartz, a consistent constituent within the sediment samples, was used as an internal standard ($d = 3.343 \text{ \AA}$)

for evaluating peak position. The relative abundance of quartz was identified by measuring its peak-area and normalizing it to the highest peak-area for quartz within each hole respectively. MgCO_3 mole percentages in calcite were estimated from peak position according to the curve of Goldsmith *et al.* (1961). FeCO_3 content (weight %) in dolomite was estimated by comparison of d-spacings with the calibration curve of Al-Hashimi and Hemingway (1974) who demonstrate that substitution of the Fe^{2+} cation in the smaller Ca^{2+} site increases the unit cell parameters of the mineral. Since the d-spacing does not necessarily decipher Mg^{2+} from Fe^{2+} cation substitution of Ca^{2+} , the estimated percentage FeCO_3 in dolomite is used as a guide to indicate possible occurrences of ferrous-rich dolomite.

3.4.2. FINE FRACTION

After initial powdering, lithified samples were mechanically dispersed in distilled water to separate the fine interstitial material from the bulk sediment. A minimum settling time of 7 hours, 43 minutes, 48 seconds yielded samples of 2 μm size or less in the uppermost 10 cm of the water column according to Stoke's law (Stokes, 1851 as described by Galehouse, 1971). The fine fraction was pipetted from the column, separated from the water by filtration (glass Millipore® system; 0.1 μm Whatman® filter), and analyzed by XRD (full scan of 3 to 73° 2 θ) for mineralogic determination. One sample was successfully analyzed as it yielded a sufficiently large volume of the fine fraction for XRD analysis.

3.5. GEOCHEMISTRY

3.5.1. MAJOR AND TRACE ELEMENT CONCENTRATIONS

Cation concentrations (Ca^{2+} , Mg^{2+} , Ba^{2+} , Fe^{2+} , Mn^{2+} , Na^+ , Sr^{2+}) within the bulk carbonate fraction were determined by dissolving 250 to 1000 mg of the powdered sample in 8% HCl (by volume) and analyzing the resultant solution by inductively-coupled plasma atomic emission spectroscopy (ICP-AES) with the program CALCTINY. The sampling intervals for geochemical analyses are coarser (5-10 m) than those for lithification, carbonate content, and mineralogic determinations. Replicate samples of limestone standard yielded average concentrations and standard deviations given in Table 3.1. (n=14). Raw data are shown in Appendix B.

TABLE 3.1. Precision of ICP-AES Analyses of Limestone Standard

CATION	AVERAGE CONCENTRATION (ppm)	STANDARD DEVIATION
Ca^{2+}	3970	7
Mg^{2+}	21	5
Ba^{2+}	8	2
Fe^{2+}	521	206
Mn^{2+}	293	69
Na^+	164	202
Sr^{2+}	503	125

3.5.2. STABLE CARBON AND OXYGEN ISOTOPES OF DOLOMITE

Dolomite was concentrated in selected sediment samples by treatment with weak acetic acid (10% by volume) under constant stirring to promote dissolution of the remaining carbonate components (magnesian calcite, calcite, and aragonite); their dissolution was verified by XRD analysis after filtration and mounting on glass slides. CO₂ that is evolved from a reaction of the dolomite-concentrated sample with 100% phosphoric acid was analyzed on a triple collector VG SIRA mass spectrometer for stable isotopes, $\delta^{13}\text{C}$ and $\delta^{18}\text{O}$ (McCrea, 1950). The ^{18}O fractionation factor for the carbonate-H₃PO₄ reaction was $\alpha = 1.01065$ at 50 °C (Rosenbaum & Sheppard, 1986).

3.6. PETROGRAPHY

Thin sections were made from lithified sediments by epoxy impregnation under vacuum. They were subsequently polished and treated with alizarin red-S and potassium ferricyanide stains for carbonate mineral identification and qualitative estimation of ferrous iron content (Evamy, 1969; Friedman, 1971). Petrographic point-counting and visual estimation with comparison charts (Flügel, 1982) enabled both compositional classification for mixed siliciclastic and carbonate sediments according to the scheme of Mount (1985) and limestone classification for pure carbonate sediments under the scheme of Dunham (1962). An empirically-derived count of 300 points was used with less than 5% error calculated between sets of 100 points; the chosen point-count is consistent with Flügel (1982) who has recommended a minimum count of 300 to 500 points. Selected thin

sections were viewed by cathodoluminescence microscopy (ELM-2 Nuclide Luminoscope); no luminescence was observed. Despite several attempts, the fine-grained lithologies were not amenable to analysis of mineral composition by electron microprobe. However, the ultrastructure of selected bulk sediment samples was examined with a Jeol JSM 6400 scanning electron microscope under a working distance of 18 to 25 mm, voltage of 10 to 20 kV, and probe current of 10 to 12 mA.

4. RESULTS

4.1. LITHIFICATION

Although most of the sediment samples are unlithified or partly lithified, a few lithified samples were identified (Figure 5; overlap of symbols is caused by the figure scale). Stiff, unlithified sediments are distinguished from unlithified sediments by lower water contents. The degree of lithification increases with depth from unlithified to partly lithified to lithified sediments. Although the extent of lithification generally decreases with distance from the continental margin, the greatest number of lithified samples were detected at the intermediate site, 820 (Figure 5; Appendix A). The first downhole occurrences of chalk-equivalent lithification (partly lithified) are at burial depths between 93.1 mbsf at Site 819 and 118.0 mbsf at Site 820; lithification to limestone-equivalent strata (lithified) first occurs at greater depth, between 120.0 mbsf at Site 821 and 219.3 mbsf at Site 819. The sediment age where onset of partial lithification occurs is between 0.73 Ma and 0.465 Ma; lithification to limestone-equivalence occurs in sediments with age ranges of 1.48 Ma to 0.465 Ma (Figure 5).

4.2. CARBONATE CONTENT

Carbonate content within the sampled transect varies between 21.0% and 88.6% (Figure 6; Appendix A). Abrupt decreases in carbonate content characterize the upper 100 to 150 m of each site and appear to cap gradual increases. The general vertical patterns of

FIGURE 5. Degree of Lithification
 (Time lines, dashed lines, from Barton *et al.*, 1993; unconformities, dotted lines, from Feary *et al.*, 1993).

FIGURE 6. Carbonate Content (%)
 (Expressed as % of the bulk sediment; time lines, dashed lines, from Barton *et al.*, 1993; unconformities, dotted lines, from Feary *et al.*, 1993).

carbonate content variations are similar between Sites 821 and 820; Site 819 shows a distinctly different pattern.

Where partly lithified sediments are documented, they occur in bulk samples with carbonate contents greater than 29%; lithified sediments occur in bulk samples with carbonate contents in excess of 57% (Figures 7, 8, 9; Appendix A).

4.3. MINERALOGY

4.3.1. BULK SAMPLE

Abrupt increases in relative quartz content in the three drillholes overlie gradual decreases that are most apparent at Site 821 in the upper 50 m (Figure 10). The relative abundance of quartz shows an antithetic relationship with carbonate content at all sites (Figures 7, 8, 9). Documented relative quartz content represents detrital, terrigenous quartz ($d = 3.34$ Å), not biogenic silica ($d = 4.1$ Å; Williams *et al.*, 1985); biogenic silica was not evident in XRD diffractograms although it was observed by scanning electron microscopy.

The amount of aragonite decreases with depth, although it persists consistently to the base of each drillhole (~ 400 mbsf) to less than 20% of the total carbonate fraction (Figure 11). It occurs in comparable abundances across the slope (Figures 7, 8, 9).

The proportion of magnesian calcite within the carbonate fraction decreases with depth at Sites 821 and 820 (Figure 12). Occurrences below 150 mbsf are sporadic, particularly at

FIGURE 7. Lithification, Carbonate Content, and Bulk Mineralogy of Hole 819A

FIGURE 8. Lithification, Carbonate Content, and Bulk Mineralogy of Hole 820B

FIGURE 9. Lithification, Carbonate Content, and Bulk Mineralogy of Hole 821A

FIGURE 10. Relative Quartz Content
(Expressed as a ratio of the XRD peak-area normalized to the maximum peak-area for each hole respectively).

FIGURE 11. Aragonite (%)
(Expressed as % of the total bulk carbonate fraction).

FIGURE 12. Mg-Calcite (%)
(Expressed as % of the total bulk carbonate fraction).

Sites 821 and 820, where its decrease with depth is similar to that of aragonite. Although Mg-calcite abundance remains higher than 30% throughout the most distal site, 819, it is marked by sporadic intervals of sharp decreases or absences. The average composition of magnesian calcite is approximately 11 mole % MgCO_3 . Metastable carbonate mineral peaks (Mg-calcite and aragonite) are coincident with decreases in carbonate content (e.g., 213.5, 317.7, 358.8, and 387.2 mbsf in Hole 821A; Figure 9).

The quantity of calcite (average 2 mole % MgCO_3) in the carbonate fraction increases with depth consistently within the three drillholes (Figure 13). Below 150 mbsf, it is more abundant within the carbonate fraction of the two most proximal sites, 821 and 820, than at the distal site, 819. The vertical distribution of calcite is related inversely to that of magnesian calcite (Figures 7, 8, 9).

The first downhole occurrence of dolomite, in amounts >25% of the carbonate fraction, appears at shallower depths with increasing distance from the margin (65.3, 50.4 and 39.0 mbsf at Sites 821, 820, and 819, respectively; Figure 14). Its occurrence at greater depth is isolated at specific intervals that coincide with decreases in magnesian calcite (Figures 7, 8, 9). Proportions of dolomite increase in magnitude with distance from the margin (Figure 14). If cation substitution is restricted to Fe^{2+} for Ca^{2+} in stoichiometric dolomite (50 mole % Ca; 50 mole % Mg), the average composition is split either as 16 weight % FeCO_3 or, as ferrous-rich dolomite, in excess of 40 weight % FeCO_3 . The occurrence of ferroan dolomite is confirmed by stained thin section observations.

FIGURE 13. Calcite (%)
(Expressed as % of the total bulk carbonate fraction).

FIGURE 14. Dolomite (%)

(Expressed as % of the total bulk carbonate fraction; time lines, dashed lines, from Barton *et al.*, 1993; unconformities, dotted lines, from Feary *et al.*, 1993).

4.3.2. Fine Fraction

XRD analysis of the fine fraction, or muddy interstitial material, yields a mineralogy that is dominated by clay minerals and calcite. XRD analysis was performed successfully on one representative sample at 259.45 mbsf, Hole 820B. The clay minerals are dominantly kaolinite or chlorite ($d = 14.90, 7.26, 3.59 \text{ \AA}$) and illite ($d = 10.16, 4.99, 3.35 \text{ \AA}$), with possible occurrences of glauconite as a member of the illite group. Kaolinite and chlorite (particularly Fe-rich chlorite) cannot be distinguished by XRD analysis when they occur together (Grim, 1968, Hardy & Tucker, 1988). Small quantities of either glauconite or chlorite can account for the greenish colour that pervades the sediment samples. The clay minerals, except glauconite, are derived from terrigenous sources. The carbonate mineral present in the fine fraction is stable calcite ($d = 3.04 \text{ \AA}$).

4.4. GEOCHEMISTRY

4.4.1. MAJOR AND TRACE ELEMENT CONCENTRATIONS

Downhole variations of Ca and Mg/Ca within the bulk carbonate fraction are antithetic (Figures 15, 16, 17; Appendix B). Their distributions shift with changes in mineralogy (Figures 18, 19, 20). The magnitude of solid-phase Mg/Ca is proportional to the distribution of the Mg-rich phases, magnesian calcite and dolomite. Note that the sampling interval for major and trace element concentrations is coarser than that for mineralogic analyses and, therefore, do not coincide with all of the major mineralogic shifts (e.g., 221.7 mbsf, Hole 819A, Figure 18). Note also that the horizontal scales are different for each element or elemental ratio.

FIGURE 15. Bulk Carbonate Geochemistry, Hole 819A
(Ca in ppm; Mg/Ca, Fe/Ca, Mn/Ca, Na/Ca, Sr/Ca, Ba/Ca in ppm/ppm).

FIGURE 16. Bulk Carbonate Geochemistry, Hole 820B
(Ca in ppm; Mg/Ca, Fe/Ca, Mn/Ca, Na/Ca, Sr/Ca, Ba/Ca in ppm/ppm).

FIGURE 17. Bulk Carbonate Geochemistry, Hole 821A
(Ca in ppm; Mg/Ca, Fe/Ca, Mn/Ca, Na/Ca, Sr/Ca, Ba/Ca in ppm/ppm).

FIGURE 18. Mg-Bearing Carbonate Minerals (%), and Solid-Phase Ca (ppm),
Mg/Ca (ppm/ppm), Hole 819A

FIGURE 19. Mg-Bearing Carbonate Minerals (%) and Solid-Phase Ca (ppm),
Mg/Ca (ppm/ppm), Hole 820B

FIGURE 20. Mg-Bearing Carbonate Minerals (%) and Solid-Phase Ca (ppm),
Mg/Ca (ppm/ppm), Hole 821A

Fe/Ca, Mn/Ca, Na/Ca, and Ba/Ca, all prominent constituents of seawater (Brown *et al.*, 1989), share similar downhole patterns of occurrence within the three holes (Figures 15, 16, 17; Appendix B). The occurrence of Fe/Ca in relatively large quantities suggests that it has potential sources other than seawater (average seawater Fe/Ca = 4.85×10^{-6} ; Brown *et al.*, 1989). As increased dolomite abundance and occurrences of ferrous-rich dolomite coincide with both elevated and lowered bulk sediment Fe/Ca (Figures 21, 22, 23; e.g., Site 819, Figure 24), no dominant correlation can be inferred. Ba concentration in the bulk sediment of Hole 821A shows several intervals of anomalously higher concentrations that are not apparently linked to relative decreases in carbonate content (Figure 23). Solid-phase Sr slightly decreases with depth although, it does not appear to have the same dependence on carbonate content as the other trace elements (Figures 15, 16, 17). Sr persists vertically to the base of each hole as does aragonite.

There are several interesting mineralogic and geochemical correlations within intervals of low carbonate content. Figures 21, 22 and 23 illustrate these relationships with dotted lines. In general, where carbonate contents are low, the proportions of metastable carbonate minerals, aragonite and magnesian calcite, are higher and the trace element concentrations of Fe/Ca, Mn/Ca, Na/Ca, and Ba/Ca are higher. The occurrence of Mg-calcite at depth is particularly striking in Hole 821A (213.5, 317.7, 358.8 and 387.2 mbsf; Figure 23) because its appearance is in defiance of the downhole trend of decreasing abundance with depth. Aragonite shows a similar decrease with depth and isolated increases in response to carbonate content

FIGURE 21. Carbonate Content (%), Metastable Carbonates (%), and Solid-Phase Fe/Ca, Mn/Ca, Na/Ca, Ba/Ca (ppm/ppm), Hole 819A

FIGURE 22 Carbonate Content (%), Metastable Carbonates (%), and Solid-Phase Fe/Ca, Mn/Ca, Na/Ca, Ba/Ca (ppm/ppm), Hole 820B

FIGURE 23. Carbonate Content (%), Metastable Carbonates (%), and Solid-Phase Fe/Ca, Mn/Ca, Na/Ca, Ba/Ca (ppm/ppm), Hole 821A

FIGURE 24. Dolomite (%) and Solid-Phase Fe/Ca (ppm/ppm),
Hole 819A

4.4.2. STABLE CARBON AND OXYGEN ISOTOPES OF DOLOMITE

Twenty samples were selected for stable isotopic analyses of dolomite. Their signatures are characterized by some notable excursions (Figures 25, 26; Appendix B). $\delta^{18}\text{O}$ in Hole 821A is depleted in the uppermost portion (-7.86‰ PDB at 53.1 mbsf) and fluctuates between -3.04 and $+1.79\text{‰}$ with depth. $\delta^{13}\text{C}$, on the other hand, varies between -1.08 and $+1.53\text{‰}$ PDB with the exception of a strong depletion at 312.19 mbsf to -12.62‰ . In Hole 820B, $\delta^{18}\text{O}$ fluctuates between $+2.99$ and -2.78‰ mbsf whereas $\delta^{13}\text{C}$ varies between $+0.94$ and -2.36‰ . In the upper portion of Hole 819A (35-40 mbsf), $\delta^{18}\text{O}$ values lie between $+3.19$ and $+4.06\text{‰}$. The upper $\delta^{13}\text{C}$ signatures at Site 819 are strongly depleted (-24.05 to -16.3‰) in contrast with the deeper signatures that increase with depth from $+1.63$ to $+7.16\text{‰}$. A cross-plot of $\delta^{18}\text{O}$ versus $\delta^{13}\text{C}$ in the authigenic dolomites illustrates the magnitude of the isotopic excursions (Figure 27).

4.4. PETROGRAPHY

4.4.1. LITHOLOGY, STRUCTURES, AND COMPOSITION

Of 593 sediment samples, only 12 were sufficiently well-indurated for thin section preparation. Sediments with a siliciclastic fraction less than 10% are classified as dolomitic mudstones, bioclastic wackestones, and mudstones (Dunham, 1962; Appendix C). Specimens with higher proportions of siliciclastic minerals are classified as muddy allochem limestones and muddy micrites according to Mount (1985).

FIGURE 25. $\delta^{18}\text{O}$ (PDB) in Dolomite

FIGURE 26. $\delta^{13}\text{C}$ (PDB) in Dolomite

FIGURE 27. $\delta^{18}\text{O}$ (PDB) versus $\delta^{13}\text{C}$ (PDB) in Dolomite

- 819 (this study) □ 819 (Swart, 1993)
- ▲ 820 (this study) △ 820 (Swart, 1993)
- 821 (this study) ○ 821 (Swart, 1993)
- ✱ Exuma Sound (Mullins *et al.*, 1988)
- + West Florida (Mullins *et al.*, 1988)

Bioturbation structures, such as compacted burrows, appear in most of the thin sections and are evident petrographically at low magnification (e.g., Plate 1A). Compacted burrows and deformed skeletal material (e.g., Plate 1B) provide evidence for mechanical compaction under burial.

The main skeletal constituents are planktic, benthic, and agglutinated foraminifera, pteropods, coccoliths, sponge spicules, and tunicate spicules with minor occurrences of cup corals, echinoid spines, and ostracodes (e.g., Plates 1C, D, and 2B, C, D; Appendix C). Skeletal fragments also occur. Skeletal aragonite likely represents mollusc fragments (e.g., Plate 1C). Rare aragonite needles, in close association with euhedral dolomite, were observed by scanning electron microscopy. Skeletal calcite, in various stages of dissolution, cannot be identified faunally, although some precursor skeletal materials that appear as ghost skeletons can be identified by their shape. Ghost skeletons appear in specimens where pervasive replacement mineralization has destroyed pre-existing fabrics.

Detrital grains of clay minerals, such as chlorite, appear unaltered. Anhedral detrital quartz and feldspar grains, which are too small to be distinguished petrographically (up to silt-sized grains), show calcite replacement at their crystal margins. Authigenic pyrite (e.g., framboids, Plate 2A), phosphate, and glauconite occur predominantly in foraminiferal chambers although they also occur in intergranular spaces.

PLATE 1. Sediment Characteristics. A. Compacted burrow at 363.2 mbsf, Hole 820B (thin section photomicrograph, magnification: $\times 43$). B. Mechanical compaction of a planktic foraminiferal test in a dolomitized interval at 398.3 mbsf, Hole 820B (thin section photomicrograph, magnification: $\times 273$). C. Skeletal aragonite with herring-bone pattern (probable mollusc) and (below) benthic foraminifer at 123.9 mbsf, Hole 820B (thin section micrograph, magnification: $\times 273$). D. Tunicate spicule (arrow) and planktic foraminifer (f) in stiff, unlithified sediment at 137.14 mbsf, Hole 821A (scanning electron micrograph, scale: 6mm = 10 μ m).

PLATE 2. Diagenetic Features. A. Pyrite framboid in stiff, unlithified sediment at 45.97 mbsf, Hole 819A (scanning electron micrograph, scale as shown). B. Dissolution of Fe-rich organic cement of an agglutinated foraminifer (arrow) at 120.0 mbsf, Hole 821A (thin section photomicrograph, magnification: $\times 427$). C. Anhydral microcrystalline calcite (AMC) fills the void space within a pteropod cavity at 123.9 mbsf, Hole 820B (thin section photomicrograph, magnification: $\times 273$). D. Dissolving coccolith occurs at 39.97 mbsf, Hole 819A, where dolomite forms 70% of the carbonate fraction in stiff, unlithified sediment (scanning electron micrograph, scale as shown).

4.5.2. DOLOMITE

Authigenic dolomite (<1 μm to 10 μm) precipitates as intergranular and intragranular void-fill, pore-lining, and replacement mineralization. It occurs occasionally as ferroan dolomite, as identified by its blue stain in thin section. As intergranular precipitation occurs, crystal growth incorporates the surrounding sediment into the dolomite rhomb (Plate 3A, B). Replacement and pore-lining dolomite appear in close association with intergranular and intragranular sparry calcite cements (Plate 3C, D). Intragranular dolomite grows as pristine euhedral crystals, apparently from the inside of the test walls toward the centre of the skeletal cavity, until crystal coalescence occludes pore spaces (Plate 4). Where replacement dolomitization is pervasive (e.g., 221.7 mbsf, Hole 819A), it can be fabric-destructive. Traces of the original biogenic sediment components can be observed by skeletal fragments, ghost skeletons and skeletal chambers that have not been fully occluded (e.g., Plate 5).

4.5.3. CALCITE CEMENTS

Calcite cements form in three distinct types: intragranular palisade calcite (~ 25 μm), intergranular and intragranular sparry calcite (20 μm), and anhedral microcrystalline calcite (AMC; 5 μm). In most cases, AMC cement occurs with palisade and sparry calcite cements.

Intragranular palisade calcite cement growth begins on the inside of the test wall and accretes concentrically inward to the centre of the skeletal cavity (Plate 6; Schroeder,

PLATE 3. Intergranular, Replacement, and Pore-Lining Dolomite. A. A single euhedral dolomite rhomb has precipitated on a skeletal fragment in stiff, unlithified sediment at 131.13 mbsf, Hole 821A (scanning electron micrograph, scale: 6.8 mm = 1 μ m). B. Intergranular dolomite rhomb with a coccolith in the background in stiff, unlithified sediment at 39.97 mbsf, Hole 819A (scanning electron micrograph, scale bar = 1 μ m). C. Dolomite occurs as white euhedral rhombs that selectively replace intergranular and intragranular sparry calcite cements at 363.2 mbsf, Hole 820B (thin section photomicrograph, magnification: $\times 427$). D. Pore-lining dolomite has precipitated inside a planktic foraminiferal test wall at 363.2 mbsf, Hole 820B; it appears to replace the void-fill sparry calcite cement (thin section photomicrograph, magnification: $\times 427$).

PLATE 4. Intragranular Dolomite. A. Intragranular dolomite precipitates as euhedral rhombs on the inside of a planktic foraminiferal test wall in stiff, unlithified sediment at 45.97 mbsf, Hole 819A (scanning electron micrograph, scale as shown). B. Continued precipitation of dolomite rhombs occludes intragranular pore space within a planktic foraminiferal cavity in partly lithified sediment at 107.05 mbsf, Hole 819A (scanning electron micrograph, scale as shown). C. Coalescing intragranular dolomite rhombs occlude porosity in partly lithified sediment at 107.05 mbsf, Hole 819A (scanning electron micrograph, scale as shown).

PLATE 5. Fabric-Destructive Dolomite. A. An example (for comparison) of an undolomitized, eye-shaped foraminifer that has been infilled with sparry calcite cement at 150.7 mbsf, Hole 820B (thin section photomicrograph, magnification: $\times 427$). B. An example (for comparison) of an undolomitized, round, planktic foraminifer. Palisade calcite cement fill appears to have undergone alteration to AMC cement at crystal margins and terminations, 123.9 mbsf, Hole 820B (thin section photomicrograph, magnification: $\times 427$). C. The outlines of eye-shaped and round planktic foraminifera, similar to those in A and B, are identifiable although pervasive dolomitization (77% of the carbonate fraction) begins to occlude their chambers at 221.7 mbsf, Hole 819A (thin section photomicrograph, magnification: $\times 427$).

PLATE 6. Palisade Calcite Cement Growth. A. Early palisade cement with euhedral terminations suggests concentric growth that is initiated from the inside of a planktic foraminiferal test wall at 150.7 mbsf, Hole 820B (thin section photomicrograph, magnification: $\times 427$) B. Continued palisade cement growth begins to occlude porosity at 123.9 mbsf, Hole 820B (thin section photomicrograph, magnification: $\times 427$). C. Porosity occlusion by palisade calcite cement growth within a planktic foraminifer in stiff, unlithified sediment at 305.52 mbsf, Hole 819A (scanning electron micrograph, scale as shown). D. Sweeping extinction of pore-occluding palisade cement is in optical continuity with the test wall at 372.4 mbsf, Hole 820B (thin section photomicrograph under polarized light, magnification: $\times 273$).

1972, Lighty, 1985). Under polarized light, palisade calcite cement displays sweeping extinction that is in optical continuity with the test (Plate 6D). In one instance (259.5 mbsf, Hole 820B), palisade cement replaces the host skeletal wall (Plate 7A). It also occurs with AMC at its crystal margins and terminations (Plate 7B) and in a zoned pattern with AMC cement (Plate 7C). In some cases, AMC cement completely fills intragranular spaces without any evidence of palisade cement (Plate 8A). Evidence of degradation of palisade calcite cement is shown by scanning electron microscopy after the test wall has dissolved. The remaining palisade cement occurs in close association with probable replacement dolomite (Plate 8B, C).

Intergranular sparry calcite occurs at 363.2 mbsf in Hole 820B as ferroan calcite (Plate 3C). Its heterogeneous distribution within the thin section matches the patchy morphology of bioturbation and burrowing structures. Original intragranular sparry calcite cement can be recognized after test dissolution by its shape that resembles the outline of the host skeletal chamber (Plate 9). It commonly occurs with slight deviations in its original outline that are bordered by AMC (Plate 9B, C). Test dissolution is also closely associated with AMC (Plate 10). Intergranular and intragranular AMC forms isolated domains within an intergranular muddy matrix (Plate 10C; Appendix C).

4.5.3 INTERGRANULAR MATRIX

Scanning electron microscopy shows a general heterogeneous grouping of carbonate components and clay minerals. Clay minerals often enclose the carbonate sediment

PLATE 7. Features of Palisade Calcite Cement. A. Palisade calcite cement actually replaces the planktic foraminiferal test wall (arrow) at 259.5 mbsf, Hole 820B (thin section photomicrograph, magnification: $\times 427$). B. Palisade calcite cement occurs with AMC cement at its crystal margins and terminations, 225.7 mbsf, Hole 820B (thin section photomicrograph, magnification: $\times 427$). C. Intragranular palisade calcite cement occurs with AMC cement at 150.7 mbsf, Hole 820B (thin section photomicrograph, magnification: $\times 273$).

PLATE 8. Degradation of Test Walls. A. Intragranular AMC cement within a planktic foraminifera whose test wall undergoes dissolution at 150.7 mbsf, Hole 820B (thin section photomicrograph, magnification: $\times 273$). Where dissolution has occurred, intergranular AMC cement is abundant. **B.** Palisade calcite cement persists after test dissolution and begins to decompose itself in stiff, unlithified sediment at 39.97 mbsf, Hole 819A (scanning electron micrograph, scale: $8.8\text{mm} = 1\mu\text{m}$). **C.** Remnants of palisade calcite cement are incorporated with other carbonate components (e.g., dolomite rhombs) to weld together in stiff, unlithified sediment at 305.52 mbsf, Hole 819A (scanning electron micrograph, scale bar = $10\mu\text{m}$).

PLATE 9. Possible Alteration of Intragranular Calcite Cement. A. The test wall of an eye-shaped foraminifer dissolves; intragranular sparry calcite cement occurs with AMC cement (far right) at 225.7 mbsf, Hole 820B (thin section photomicrograph, magnification: $\times 427$). **B. and C.** Although the foraminiferal tests have dissolved, intragranular sparry calcite cements can be recognized by their outlines that resemble foraminiferal chambers; they occur with AMC cement at their margins (arrows) at 225.7 mbsf, Hole 820B (thin section photomicrographs, magnification: $\times 427$).

PLATE 10. Test Dissolution as a Source of Anhedral Microcrystalline Calcite.
Dissolution of skeletal calcite and reprecipitation as AMC cement occurs at A. 120.0 mbsf, Hole 821A (thin section photomicrograph, magnification: $\times 273$), B. 280.5 mbsf, Hole 820B (thin section photomicrograph, magnification: $\times 273$), and C. 120.0 mbsf, Hole 821A (thin section photomicrograph, magnification: $\times 427$). Note that, for B, AMC cement also occurs with intragranular sparry calcite cement.

constituents and are arranged in a tight, enveloping configuration (Plate 11A, B). The greenish, muddy intergranular matrix ($<2\ \mu\text{m}$) pervades the lithified sediment samples and isolates the carbonate components, including AMC, to create unconnected carbonate domains (e.g., Plate 11C).

PLATE 11. Clay Minerals. A. A tubular clay mineral surrounds the carbonate components (e.g., dolomite rhomb in the upper left corner) in partly lithified sediment at 107.05 mbsf, Hole 819A (scanning electron micrograph, scale as shown). B. Clay minerals are heterogeneously distributed in partly lithified sediment at 289.75 mbsf, Hole 820B (scanning electron micrograph, 8.5mm = 1 μ m). C. All of the sediment components, including AMC, are engulfed in a greenish, muddy intergranular matrix (arrow) at 120.0 mbsf, Hole 821A (thin section photomicrograph, magnification: $\times 427$).

5. DISCUSSION

5.1. RESPONSE OF SEDIMENTATION TO SEA-LEVEL CHANGE

The apparent correlation of relative rates of sediment accumulation within equivalent time ranges across the slope suggests that there is some lateral consistency in sedimentation patterns with the possible exception of isolated erosional events (e.g., at 32.5 mbsf, Site 819; Figure 4). Erosional surfaces were defined by reary *et al.* (1993) and, coupled with high-amplitude continuous reflectors, they mark seismic sequence boundaries across the slope.

Within each time interval, carbonate contents display similar variations in each drillhole that are likely controlled by sea-level change (Figure 6). The antithetic relationship between relative quartz content and carbonate content (Figures 7, 8, 9) supports the likelihood of sea-level control on sedimentation patterns. Since only detrital quartz is indicated by XRD analysis, depth intervals of low carbonate contents may be used as indicators of high terrigenous influxes during sea-level rise when wave action at the shoreline induces lateral transport across the slope. Collision of the Indian-Australian Plate with Papua-New Guinea may generate a source of detrital quartz to the study area that is transported by ocean current dynamics; it is likely not significant in contrast with its potential contribution to hemipelagic sedimentation in rift troughs. At Site 823 in the Queensland Trough (Figure 2), however, Watts *et al.* (1993) suggest that the dominant control of terrigenous and carbonate sedimentation during the Pleistocene is sea-level

change. As depths that correspond to high terrigenous influxes indicate sea-level rise, in turn, they can be used as proxies for intervals with greater abundances of the clay-size fraction, or terrigenously-derived, clay-bearing, muddy intergranular matrix.

The lateral and vertical relationship of terrigenous quartz and carbonate content to sea-level change is consistent with Feary & Jarrard (1993) whose study of downhole logging at Site 820 suggests that, within the sedimentary cycles or terrigenous-carbonate facies couplets in both the lower progradational and the upper aggradational sequences, intervals of increased terrigenous influx mark relative rises in sea-level. Small variations in carbonate content in isolated intervals may be a consequence of the terrigenous-carbonate facies couplets (Figure 6).

The data in this study show a distinct drop in carbonate content (Figure 6) at the hiatus that Alexander *et al.* (1993) identified at 32.5 mbsf, Site 819, by their detailed carbonate content records. Alone, the carbonate content data of this study could not adequately detect the hiatus without the corroboration of additional evidence (e.g., Davies, McKenzie, & Palmer-Julson *et al.*, 1991, Kroon *et al.*, 1993).

5.2. ONSET OF LITHIFICATION

Despite the observation of Ladd *et al.* (1993) that increased lithification occurs at erosional surfaces, there is no evidence in this study to show a link between erosional boundaries and degree of lithification (Figure 5). There is some evidence that slower rates

of sedimentation may generate zones of greater lithification (Figures 4, 5) but that does not rule out the possibility that, in a period of high average accumulation rate, undetected short-lived periods of slow sedimentation could have been conducive to lithification.

The occurrence of limestone-equivalent strata within intervals of higher carbonate content than at chalk-equivalent or ooze-equivalent occurrences suggests that carbonate constituents enhance the extent of sediment lithification (Figures 7, 8, 9). Dissolution of metastable aragonite and magnesian calcite and subsequent reprecipitation as stable calcite cements can increase the potential for lithification.

Onset of lithification within sediments of a mixed carbonate and siliciclastic slope occurs at greater burial depths than in periplatform carbonate environments. Chalk-equivalent strata is first encountered vertically between 93.1 and 118.0 mbsf in northeast Australia (Figure 5). In contrast, the first appearances of chalk in the Maldives Ridge in the Indian Ocean occurs at 70 mbsf (Malone *et al.*, 1990) and in Exuma Sound in the Bahamas at 55 mbsf (Dix & Mullins, 1988). Although this comparison can be made in terms of burial depth, there are perhaps more significant differences in age and sedimentation rate.

Chalks appear in sediments of 2.3 Ma age in the Maldives Ridge (Malone *et al.*, 1990) and in Pliocene (5.1 to 2 Ma) sediments in Exuma Sound (Dix & Mullins, 1988), whereas their first occurrence in northeast Australia is in much younger sediments between 0.73 and 0.465 Ma (Figure 5). Higher accumulation rates bury the original heterogeneous mineralogy to greater depths more rapidly and preserves the metastable constituents

longer. Consequently, if the rate of burial is greater than the rate of diagenesis, the first downhole occurrence of chalk-equivalent strata is expected to be deeper. Onset of lithification at greater burial depths in northeast Australia than in pure carbonate slopes remains an important result that could suggest an impediment to burial diagenesis that is inherent in the siliciclastic fraction of mixed sediment lithologies.

5.3. PERSISTENCE OF ARAGONITE

Sr is readily incorporated into the crystal structure of both biogenic and inorganic aragonite (Morse & Mackenzie, 1990). The decreasing aragonite and Sr contents with depth are consistent with an increase in diagenetic neomorphism of aragonite to stable calcite (e.g., Kinsman, 1969; Figures 11, 15, 16, 17). Indeed, calcite increases with depth as a possible product of aragonite solid-state recrystallization (Figure 13). Pore-water Sr^{2+} concentrations increase with depth at Sites 821 and 820 (and up to 200 mbsf at Site 819; Davies, McKenzie, & Palmer-Julson *et al.*, 1991) to demonstrate current diagenetic alteration of aragonite; as aragonite dissolves, it releases Sr^{2+} into the pore-water and reprecipitates as Sr-poor stable calcite (Baker *et al.*, 1982)

In isolated carbonate platform margins, the disappearance of aragonite is evident. In the Maldives Ridge, where aragonite is dominantly in the form of aragonite needles, its abundance is significantly reduced by 155 mbsf and disappears by 250 mbsf (6 Ma; Malone *et al.*, 1990). In Little Bahama Bank, aragonite, also mostly as needles,

disappears by 100 mbsf (late Miocene); its occurrence at greater depths is isolated (Dix & Mullins, 1992). Skeletal aragonite, as probable mollusc fragments, is the dominant form to be observed petrographically in Sites 819-820 during this study, although Swart (1993) has reported the occurrence of aragonite needles in Hole 821A. Aragonite needles, such as those documented in pure carbonate slopes, are more susceptible to dissolution than skeletal aragonite by virtue of their larger surface areas (e.g., Walter, 1985). Since aragonite is dominantly in the form of skeletal aragonite, its dissolution may be inhibited kinetically by its microstructure (e.g., Dix & Mullins, 1988). Nonetheless, as a metastable mineral, dissolution of aragonite, regardless of microstructure, is thermodynamically favoured.

Aragonite persistence with depth has also been documented within the western margin of the Great Bahama Banks (677 mbsf, late Neogene; Melim *et al.*, in press). Its occurrence at depth (e.g., 367 mbsf) is in the form of peloids whose organic sheaths can act as kinetic barriers that preserve the original mineralogy (L.A. Melim, pers. comm.). Early compaction of peloidal grainstones to wackestones created a low permeability zone that Melim *et al.* (in press) view as an effective seal of the peloidal interval to inhibit aragonite dissolution. In northeast Australia, there is no physical evidence of anomalous compaction. However, aragonitic components occur within a clay-rich intergranular muddy matrix. Its presence may impede aragonite dissolution as a kinetic barrier, analogous to peloidal organic sheaths in the Great Bahama Banks, and as an impermeable barrier, analogous to the compacted peloidal interval of Melim *et al.* (in press).

5.4. DOLOMITIZATION

Euhedral rhombs suggest that dolomitization is authigenic. It appears at shallower depths with increasing distance from the margin (Figure 14), possibly in response to the shallowing diagenetic zone of sulphate reduction from 150 to 55 to 16 mbsf at Sites 821, 820, and 819, respectively (as seen from pore-water SO_4^{2-} profiles in Davies, McKenzie, & Palmer-Julson *et al.*, 1991). Sulphate is a suspected inhibitor of dolomite precipitation (e.g., Morrow & Ricketts, 1988).

The antithetic relationship between dolomite and magnesian calcite shows that a possible source of Mg for dolomitization is magnesian calcite (Figures 18, 19, 20). Similarly, the antithetic relationship between solid-phase Ca and Mg/Ca suggests strong replacement of Mg for Ca in the crystal lattices of either of the Mg-bearing carbonate minerals, Mg-calcite or dolomite. Petrographic evidence that selective dolomite replacement of intergranular and intragranular sparry calcite cements (Plate 3 C, D) raises questions about the composition of the sparry calcite -- it is likely magnesian calcite, although compositional analysis by electron microprobe was unsuccessful because of its ineffectiveness with fine grain sizes. The possibility of Mg-rich sparry calcite cements is confirmed by preferential dolomite replacement of sparry calcite in the presence of planktic foraminifera of low Mg content. The probable driving force for dolomite to replace magnesian calcite cement is a source of Mg.

PM-1 3½"x4" PHOTOGRAPHIC MICROCOPY TARGET
NBS 1010a ANSI/ISO #2 EQUIVALENT

PRECISIONSM RESOLUTION TARGETS

Although Kahle (1965) suggests that clay minerals can play a role as Mg-donors or catalysts in the precipitation of dolomite, there is no mineralogic or petrographic evidence to support the hypothesis in northeast Australia. Detrital clay particles are unaltered. Dolomite growth is not preferentially initiated within the clay-rich muddy intergranular matrix. However, where dolomitization is pervasive, the role of the clay fraction cannot be evaluated.

An example of pervasive replacement dolomite at 221.7 mbsf, Hole 819A (Figure 7; Plate 5C) shows that increased dolomite abundance corresponds to decreases in percentages of the other carbonate minerals, an abrupt increase in carbonate content, and a sudden increase in lithification. A magnesium balance calculation (Appendix D) shows that the source of Mg must exceed what is available from Mg-rich calcite cements or skeletal magnesian calcite (e.g., benthic foraminifera; Scholle, 1978). In this case, where accumulation rates are relatively slow (5.4 cm/ka; Table 3.2.), Mg diffusion from overlying seawater to the shallow subsurface can provide the source for dolomitization and can lead to hardground development, as hypothesized for carbonate platforms (e.g., Swart & Guzikowski, 1988, Melim *et al.*, in press). Within 10 m below the major hiatus at 32.5 mbsf, Site 819, a sharp increase in dolomite abundance is observed (Figure 14). Although there is some correlation between erosional surfaces and increases in dolomite abundances beneath them within about 10 m, it does not preclude the possibility that dolomite could have precipitated by Mg diffusion from seawater during periods of slower sedimentation that cannot be documented by bulk accumulation rates (Figure 4).

Shallow, positive $\delta^{18}\text{O}$ signatures in Hole 819A (3.19-4.06 ‰ PDB, 35-40 mbsf; Figure 22) may represent a decrease in temperature when dolomite precipitated under the influence of Antarctic Intermediate Water (AAIW, $\sim 5^\circ\text{C}$); the sampled sediments lie within the transition zone from Subtropical Central or Lower Water ($\sim 25^\circ\text{C}$) to AAIW (41 to 32.5 mbsf; Alexander *et al.*, 1993, Kroon *et al.*, 1993). The same three samples show strong anomalous depletion in ^{13}C ($\delta^{13}\text{C} = -16$ to -24 ‰) that suggests precipitation in the diagenetic zone of sulphate reduction (<16 mbsf at Site 819; Davies, McKenzie, & Palmer-Julson *et al.*, 1991). Other negative excursions in $\delta^{13}\text{C}$ (e.g., -12.62 ‰ at 312.2 mbsf, Hole 821A) may represent local bacterially-mediated diagenesis. Otherwise, $\delta^{13}\text{C}$ values appear to be inherited from the signatures of the precursor CaCO_3 that dolomite replaces. There is also no accounting for the possible fractionation effects of incorporating Fe into the dolomite crystal lattice (e.g., Irwin *et al.*, 1977). Swart (1993) does not discuss any manifestation of the well-developed diagenetic zones of sulphate reduction and methanogenesis in his study of stable carbon isotope signatures in dolomite (ODP Leg 133, Sites 819-822; Figure 27); he attributed their small variations to the high percentage of CaCO_3 in the sediments that effectively buffers the influx of CO_2 by organic carbon diagenesis. He also suggests that the stable isotopic composition of dolomite does not represent conditions at the time of precipitation, but merely reflects current pore-water chemistry with which it continues to equilibrate. The strong depletions in $\delta^{13}\text{C}$ at shallow depths in Hole 819A in this study indicate that dolomite has precipitated within the zone of sulphate reduction (e.g., Irwin *et al.*, 1977, Veizer, 1983, Hill, 1990,

Tucker & Wright, 1990). At intervals where $\delta^{13}\text{C}$ does not vary, its original signature may have been obliterated by an on-going process of equilibration with pore-waters as suggested by Swart (1993). Variations in the stable isotopic compositions of known deep-water dolomites from isolated carbonate margins in Exuma Sound and West Florida Slope are more restricted than those found in this study (Figure 27; Mullins *et al.*, 1988). Sun (1994) also summarizes isotopic compositions of shallow-water dolomite that fall in a more narrow range than those of this study ($\delta^{18}\text{O}$ between +2 and +5 ‰ PDB and $\delta^{13}\text{C}$ between +1.5 and +5 ‰ PDB).

5.5. CEMENTATION

The development of intragranular palisade calcite cement is well documented in Plate 6 where its initial growth begins on the inside of the test wall and continues concentrically inward to the centre of the skeletal cavity and occludes porosity. Its sweeping extinction under polarized light provides further evidence that the test must form the substrate from which crystal growth is initiated and continues radially inward (Plate 6D). Its occurrence with AMC at crystal margins and terminations (Plates 5B, 7B) raises questions. What is perceived as AMC at the crystal margins and terminations may in fact be end-on views of three dimensional palisade calcite cement. However, end-on views at the crystal terminations are probable; at crystal margins, they are less likely. It is possible that palisade calcite cement alters to AMC. Interestingly, this hypothesis is in direct conflict with Ostwald ripening because it implies a decrease in grain size by alteration. Ostwald ripening suggests a thermodynamic drive for neomorphism to the most stable form (i.e.

lowest Gibbs free surface energy), which has the lowest surface area. and, therefore a larger grain size (Morse & Mackenzie, 1990). The alteration of palisade calcite cement to AMC in these examples may not be a transformation of polymorphs, but recrystallization of magnesian calcite to stable AMC. This notion is supported by the preferential replacement by dolomite of probable Mg-rich void-fill cements that could have originated as palisade Mg-calcite cement. Schroeder (1972) determined the mineralogy of palisade cements in precipitated crusts and cores of Recent Bermuda reefs to be magnesian calcite by XRD and electron microprobe analyses. In the southeast Florida shelf, Lighty (1985) also found Mg-calcite palisade cements that radiate outward from an algal filament substrate within skeletal cavities.

The zoned pattern of intragranular palisade calcite cement with AMC cement (Plate 7C) is more ambiguous. Does the palisade cement recrystallize as AMC or does the reverse occur? When AMC cement completely fills intragranular spaces without evidence of palisade cement, it may represent total alteration of palisade cement to AMC, or it may be a precursor to sparry calcite precipitation (Plate 8A). Nonetheless, degradation of palisade calcite cement has been documented, particularly after the test wall has dissolved (Plates 8B, C).

Bioturbation, in one thin section (Hole 820B, 363.2 mbsf), may have created zones of increased permeability for intergranular ferroan sparry calcite to precipitate (Plate 3C). Its

distribution matches the general petrographic morphology of bioturbation structures at low magnification (e.g., Plate 1A).

Although test dissolution is prolific, original intragranular sparry calcite cement can be identified from the shape of the host skeletal chamber (Plate 9). Deviations in its original shape are margined by AMC cement to suggest alteration from a larger grain size (Mg-calcite) to a smaller grain size (AMC; Plate 9B, C). Sparry calcite cement is likely Mg-rich in composition and recrystallizes into a stable calcite form as AMC. Since dolomite selectively replaces sparry calcite cements (inter- and intragranular), they probably contain >4 mole % MgCO_3 .

Test dissolution appears to lead to reprecipitation as AMC cement (Plate 10). Plate 10B illustrates a case where, not only does the test dissolve and reprecipitate as AMC, but also the intragranular sparry calcite appears to be undergoing a similar process of recrystallization to AMC.

The downhole increase in stable calcite that coincides with downhole decreases in magnesian calcite (Figures 7, 8, 9) is in accord with the petrographic observations of increasing AMC with depth by thin section analysis and scanning electron microscopy. Since the observed proportion of Mg-rich skeletal material appears inadequate to account for all of the magnesian calcite, it is also probable that at least a fraction of the palisade and sparry calcite cements contain Mg, particularly at Site 819 where Mg-calcite persists

with depth (Figure 12). With burial depth, Mg-calcite cements recrystallize to form AMC. Although AMC stains a darker pink than either the palisade or sparry calcite cements, it is likely caused by stain retention of its finer grain size and not by Fe content. There is no correlation between solid-phase Fe and calcite occurrences downhole (Figures 13, 15, 16, 17). AMC likely represents the most stable form of calcite cement.

Intergranular and intragranular AMC cement remains as unconnected realms within an intergranular muddy matrix; it either displaces or replaces the interstitial clay-rich material (Plate 10C; Appendix C). In pure carbonate slopes, AMC also occurs, but since the intergranular muddy matrix does not exist, AMC is free to coalesce and form a more cohesive, pervasive cement.

5.6. POTENTIAL ROLE OF CLAY MINERALS

Since carbonate and quartz contents appear to reflect relative sea-level change, depth intervals of low carbonate contents may be used as indicators of high terrigenous influxes and greater proportions of the clay-bearing interstitial material.

The trace element concentrations (Fe/Ca, Mn/Ca, Na/Ca, and Ba/Ca) are higher where the metastable carbonate minerals are more abundant (Figures 21, 22, 23). Since Mg-calcite, aragonite, dolomite, and, to a lesser degree, calcite incorporate Fe, Mn, Na, and Ba into their crystal lattices, their repartitioning with diagenesis is of great interest as mineral dissolution and reprecipitation occurs with depth (e.g., Veizer, 1983). In this case, it is

apparent that the strongest correlation between mineralogic and trace element trends occurs between magnesian calcite and Fe/Ca, Mn/Ca, Na/Ca, and Ba/Ca. The vertical behaviour of any of these trace elements can stand as a proxy for Mg-calcite abundance. Although XRD analyses have not distinguished the Mg-calcite peak either because of overlap with the calcite peak or because of potentially large errors in peak-area analysis, the presence of trace elements can indicate its probable presence downhole (e.g. at 271.7 mbsf, Hole 821A; Figure 21).

Fe, Mn, Na, and Ba are relatively common as cations in seawater (Brown *et al.*, 1989). However, Fe occurs in larger concentrations than might be expected from seawater and could have other sources. Fe that is loosely bound on clay-mineral surfaces may be mobilized into the carbonate fraction from iron oxides within the terrigenous muds. Another potential source of Fe is the organic cement of agglutinated foraminifera, which are subject to becoming unstable at depth and dissolving (Plate 2B; Sidner & McKee, 1976, Schröder-Adams & McNeil, in press). Once iron is liberated either from the clay minerals or from dissolution of agglutinated foraminifera, below the zone of sulphate reduction, it will tend to precipitate as FeS₂, pyrite. Euhedral pyrite and pyrite framboids are evident in thin section observations (e.g., Plate 2A) and occur with ferroan dolomite as also observed at Site 823 downslope of the transect in this study (Figure 2; Dix, 1995). At least a portion of the solid-phase Fe is taken up in ferroan dolomite (marked in Figures 21-24).

The potential role of the clay minerals is one of diagenetic impedance. Since metastable minerals occur at intervals of low carbonate contents, they likely occur at intervals of higher clay content that is associated with the fine interstitial materials. Chamley *et al.* (1993) have determined from selected surficial samples at Sites 819-821 that the dominant clay mineralogy in order of abundance is smectite, kaolinite, and illite with minor quantities of chlorite. The muddy intergranular matrix, that was identified to consist of kaolinite or chlorite and illite in this study, represents a fine fraction of low permeability that can serve as both a physical barrier and a chemical barrier to dissolution of metastable carbonates.

Under scanning electron microscopy, the clay minerals are arranged in a heterogeneous configuration that encompasses and engulfs the carbonate components (Plate 11A, B). The heterogeneous grouping of sediment constituents could be caused by the uneven distribution of negatively-charged clay minerals. Thin section analysis shows that the clay-rich intergranular matrix isolates unconnected domains of skeletal calcites, aragonites, intergranular and intragranular cements, and AMC (Plate 11C). The presence of the intergranular matrix, either by virtue of its fine grain size or by its clay mineral content, likely impedes diagenetic reactions, allows the isolated preservation of metastable carbonate minerals at depth, impedes dissolution of skeletal aragonite, and restricts rapid lithification.

6. CONCLUSIONS

Patterns of carbonate mineral distribution within a slope of mixed carbonate and siliciclastic lithologies off the northeast Australian margin are comparable to spatial trends within pure carbonate slopes. Abundances of metastable magnesian calcite and aragonite decrease with depth; stable calcite abundances increase with depth. Authigenic dolomite occurs sporadically at intervals that, in many cases, correlate with depths above which are known erosional surfaces. The degree of lithification increases with depth and decreases with distance from the margin.

Diagenetic processes in the carbonate fraction of mixed sediments are also similar to those of isolated carbonate platform margins. Metastable aragonite and magnesian calcite dissolve and reprecipitate as stable, anhedral microcrystalline calcite with depth. Formation of authigenic replacement dolomite is at the expense of magnesian calcite. Pervasive dolomitization near the sediment-water interface is linked to slow sedimentation rates during which the necessary Mg supply is likely diffused from overlying seawater. In northeast Australia, however, $\delta^{13}\text{C}$ evidence indicates that its precipitation occurs within the diagenetic zone of sulphate reduction.

One of the major differences between the slope of mixed sediment lithology and slopes of isolated carbonate platform margins is the Pleistocene sea-level control of the original input mineralogy that represents pelagic, periplatform, and hemipelagic sedimentation.

During sea-level rise, terrigenous influx is increased as shoreline wave action allows lateral transport of sediment from the continent. The siliciclastic fraction appears to inhibit diagenetic reactions within the carbonate minerals. Low carbonate contents (< 57 %) that coincide with high terrigenous influxes are not conducive to complete lithification. Onset of lithification appears at greater burial depths in the mixed carbonate and siliciclastic slope (93 to 118 mbsf) when compared with the first occurrences of chalk-equivalents and chalks in pure carbonate slopes (55 to 70 mbsf). Increased burial rates of metastable carbonates in northeast Australia preserve them at greater depths than in carbonate platform margins and impedes their dissolution and reprecipitation as calcite cements to maintain a high diagenetic potential. Skeletal aragonite and its main constituent trace element ratio, Sr/Ca, persist with depth to the base of the drillholes despite the thermodynamic drive to dissolve. Metastable magnesian calcite and its solid-phase trace element ratios, Fe/Ca, Mn/Ca, Na/Ca, and Ba/Ca, are preserved in anomalously larger quantities in isolated intervals that correspond with depths of low carbonate contents, and, presumably, depths of high clay contents. Carbonate components, such as anhedral microcrystalline calcite, remain isolated within an intergranular muddy matrix that contains clay minerals (kaolinite or chlorite and illite). The matrix material physically and chemically inhibits connections between carbonate domains and impedes cementation. The intergranular matrix is likely responsible for the persistence of aragonite and the isolated preservation of metastable carbonate minerals and their trace elements at depth. Consequently, zones of greater diagenetic potential can be correlated with intervals of

high terrigenous influxes in the continental slope of mixed carbonate and siliciclastic lithologies.

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APPENDIX A

LITHIFICATION, CARBONATE CONTENT, AND MINERALOGY

TABLE A.1 Lithification, Carbonate Content, and Bulk Mineralogy of Hole 819A

Core-Sxn	Interval	Depth (mbsf)	Lithification	Carbonate Content (%)	Relative Quartz	Aragonite (%)	Mg-Calcite (%)	Calcite (%)	Dolomite (%)
1-1	98-100	0.98	unlithified	67.0	0.1269	23	41	35	0
1-2	46-48	1.96	unlithified	57.8	0.1827	25	42	33	0
1-2	141-143	2.91	unlithified	49.2	0.1946	20	42	37	0
1-3	99-101	3.99	unlithified	34.9	0.3257	23	43	34	0
1-4	46-48	4.96	unlithified	35.6	0.3257	20	43	36	0
1-4	138-140	5.88	unlithified	36.8	0.2263	18	47	35	0
1-5	98-100	6.98	unlithified	71.0	0.1100	10	53	37	0
1-6	44-46	7.94	unlithified	67.6	0.0964	17	48	35	0
2-1	66-68	9.16	unlithified	57.1	0.1794	18	54	27	0
2-2	20-22	10.2	unlithified	38.6	0.2919	22	47	31	0
2-2	120-122	11.2	unlithified	47.2	0.2094	21	44	35	0
2-3	66-68	12.16	unlithified	38.5	0.2834	17	55	28	0
2-4	21-23	13.21	unlithified	55.0	0.1980	23	38	39	1
2-4	116-118	14.16	unlithified	50.0	0.3731	18	43	39	0
2-5	66-68	15.16	unlithified	66.7	0.0914	18	47	34	1
2-5	141-143	15.91	unlithified	71.0	0.1142	21	41	38	0
2-6	98-100	16.98	unlithified	70.5	0.1396	25	40	35	1
2-7	51-53	18.01	unlithified	67.0	0.0948	24	44	33	0
3-1	88-90	18.88	unlithified	62.5	0.2030	27	41	32	0
3-2	39-41	19.89	unlithified	68.8	0.1954	26	39	32	4
3-2	139-141	20.89	unlithified	50.7	0.4146	24	45	31	0
3-3	87-89	21.87	unlithified	42.0	0.5072	23	46	32	0
3-4	39-41	22.89	unlithified	37.9	0.5491	21	51	29	1
3-4	139-141	23.89	unlithified	31.0	0.5770	23	49	27	0
3-5	93-95	24.93	unlithified	32.3	0.8003	17	25	58	0
3-6	39-41	25.89	unlithified	59.9	0.3304	29	32	36	3
3-6	136-138	26.8	unlithified	72.7	0.2792	21	45	34	1
4-1	73-75	28.23	unlithified	30.9	0.4907	23	49	28	0
4-2	17-19	29.17	unlithified	70.7	0.2453	18	39	43	1
4-2	120-122	30.2	unlithified	69.3	0.1777	21	38	42	0
4-3	73-75	31.23	unlithified	66.7	0.3862	21	38	40	1

TABLE A 1 Lithification, Carbonate Content, and Bulk Mineralogy of Hole 819A (cont)

Core-Sxn	Interval	Depth (mbsf)	Lithification	Carbonate Content (%)	Relative Quartz	Aragonite (%)	Mg-Calcite (%)	Calcite (%)	Dolomite (%)
4-4	22-24	32.2	unlithified	67.2	0.1396	22	37	40	1
4-4	121-123	33.21	unlithified	24.2	0.5533	33	44	23	0
4-5	73-75	34.23	unlithified	40.3	0.6853	24	41	35	1
4-6	22-24	35.22	unlithified	50.5	0.5626	18	35	30	17
4-6	121-123	36.21	unlithified	45.9	0.5939	19	43	31	7
4-7	67-69	37.17	unlithified	52.5	0.4949	22	38	27	14
5-1	98-100	37.98	unlithified	51.6	0.3955	21	40	31	8
5-2	54-56	39.04	stiff, unlithified	60.6	0.4188	18	13	16	53
5-2	147-149	39.97	stiff, unlithified	64.8	0.4416	16	0	14	70
5-3	101-103	41.01	unlithified	52.5	0.5351	22	47	31	1
5-4	54-56	42.04	unlithified	47.3	0.4924	20	37	32	11
5-4	146-148	42.96	unlithified	54.5	0.5816	22	40	35	2
5-5	99-101	43.99	unlithified	56.9	0.4048	17	40	40	2
5-6	54-56	45.04	unlithified	60.5	0.3858	17	30	49	4
5-6	147-149	45.97	unlithified	51.3	0.3299	19	35	46	0
6-1	24-26	46.74	unlithified	46.4	0.5685	24	40	36	0
6-1	126-128	47.76	unlithified	47.7	0.4932	18	38	44	0
6-2	74-76	48.74	unlithified	48.3	0.4281	19	41	40	0
6-3	25-27	49.75	unlithified	51.7	0.4010	20	39	37	3
6-3	132-134	50.82	unlithified	64.4	0.3706	23	15	51	11
6-4	70-72	51.7	unlithified	67.2	0.3046	26	15	49	10
6-5	25-27	52.75	unlithified	68.4	0.3934	23	16	54	7
6-5	132-134	53.82	unlithified	71.3	0.3147	25	8	56	11
6-6	72-74	54.72	unlithified	72.3	0.2386	25	9	47	19
7-1	53-55	56.53	stiff, unlithified	69.6	0.3080	29	0	61	10
7-1	146-148	57.46	stiff, unlithified	68.3	0.3215	30	0	57	13
7-2	98-100	58.48	unlithified	62.0	0.4264	29	18	41	12
7-3	54-56	59.54	stiff, unlithified	66.2	0.5165	25	16	54	4
7-3	143-145	60.43	unlithified	62.3	0.3553	25	23	49	3
7-4	98-100	61.48	unlithified	64.1	0.2885	25	25	47	2
7-5	56-58	62.56	unlithified	58.5	0.3397	18	41	39	2

TABLE A 1 Lithification, Carbonate Content, and Bulk Mineralogy of Hole 819A (cont.)

Core-Sxn	Interval	Depth (mbsf)	Lithification	Carbonate Content (%)	Relative Quartz	Aragonite (%)	Mg-Calcite (%)	Calcite (%)	Dolomite (%)
7-6	6-8	63.56	unlithified	56.1	0.4619	25	27	46	2
7-6	109-111	64.59	unlithified	50.9	0.5072	26	31	43	1
7-7	83-85	65.83	unlithified	53.9	0.4746	26	33	41	0
8-2	54-56	66.6	unlithified	48.9	0.6684	22	41	37	0
8-2	145-147	67.57	unlithified	37.8	1.0000	23	44	30	3
8-3	97-99	68.59	unlithified	52.8	0.6193	22	43	34	1
8-4	61-63	69.73	unlithified	51.7	0.7809	19	46	35	0
8-4	146-148	70.58	unlithified	46.8	0.5444	21	43	36	0
8-5	98-100	71.6	unlithified	49.6	0.5127	19	47	34	0
8-6	59-61	72.71	unlithified	50.7	0.5491	22	46	32	0
8-6	144-146	73.56	unlithified	47.5	0.6396	18	47	34	0
8-7	94-96	74.56	unlithified	45.5	0.5330	18	47	35	1
8-8	49-51	74.11	stiff, unlithified	50.7	0.4264	17	50	32	1
9-2	4-6	75.39	unlithified	42.9	0.5884	19	42	38	0
9-2	102-104	76.37	unlithified	41.5	0.5719	24	39	37	1
9-3	53-55	77.38	unlithified	40.9	0.5939	17	41	42	0
9-4	3-5	78.38	unlithified	45.3	0.5381	23	39	38	0
9-4	106-108	79.14	unlithified	37.0	0.6819	24	38	39	0
9-5	57-59	80.42	unlithified	63.0	0.2792	24	34	42	1
9-6	3-5	81.38	unlithified	64.1	0.3629	25	14	56	3
9-6	113-115	82.48	stiff, unlithified	66.8	0.3397	23	14	60	3
9-7	60-62	83.45	unlithified	64.2	0.3118	25	0	70	5
9-8	3-5	84.38	unlithified	56.9	0.2893	22	0	72	6
10-2	6-8	84.96	unlithified	54.6	0.4234	21	18	57	5
10-2	107-109	85.97	unlithified	55.0	0.5723	23	35	40	2
10-3	65-67	87.05	unlithified	50.8	0.5668	21	41	38	1
10-4	6-8	87.96	unlithified	55.1	0.7064	22	47	31	1
10-4	107-109	88.97	unlithified	41.1	0.9404	24	43	33	0
10-5	68-70	90.08	unlithified	37.4	0.9953	22	45	33	0
10-6	5-7	90.95	unlithified	45.0	0.5838	24	43	33	0
10-6	107-109	91.97	stiff, unlithified	41.4	0.5584	23	41	36	1

TABLE A 1 Lithification, Carbonate Content, and Bulk Mineralogy of Hole 819A (cont)

Core-Sxn	Interval	Depth (mbsf)	Lithification	Carbonate Content (%)	Relative Quartz	Aragonite (%)	Mg-Calcite (%)	Calcite (%)	Dolomite (%)
10-7	68-70	92.43	unlithified	47.1	0.4839	20	43	37	0
10-8	3-5	93.08	partly lithified	47.3	0.5118	21	43	36	0
11-2	6-8	94.38	unlithified	43.2	0.5330	21	44	35	0
11-2	102-104	95.34	unlithified	57.2	0.3858	24	37	39	0
11-3	66-68	96.48	stiff, unlithified	59.0	0.3354	22	40	39	0
11-4	6-8	97.38	stiff, unlithified	51.3	0.3443	20	41	39	0
11-4	104-106	98.36	stiff, unlithified	57.2	0.3046	23	39	38	0
11-5	51-53	99.33	stiff, unlithified	61.3	0.3443	23	38	39	0
11-6	5-7	100.37	stiff, unlithified	65.2	0.3384	23	41	36	0
11-6	105-107	101.37	stiff, unlithified	65.3	0.3071	19	41	40	0
11-7	60-62	102.42	stiff, unlithified	65.2	0.3443	21	36	44	0
11-8	4-6	103.36	partly lithified	63.4	0.4281	23	41	36	0
12-3	55-57	107.05	stiff, unlithified	74.5	0.3299	17	21	36	27
12-3	65-67	107.15	unlithified	65.3	0.4112	27	23	44	6
13-7	55-57	119.63	unlithified	56.7	0.5491	22	40	38	0
14-4	105-107	126.05	stiff, unlithified	53.5	0.5305	23	41	36	0
15-4	95-97	128.45	unlithified	68.2	0.3249	21	26	48	5
16-4	81-83	134.8	stiff, unlithified	73.3	0.3350	24	11	54	11
16-8	10-12	140.09	unlithified	52.5	0.4213	19	45	36	0
18-1	40-42	150.1	stiff, unlithified	57.4	0.2893	22	0	73	5
18-4	48-50	154.68	stiff, unlithified	71.8	0.1946	18	0	67	15
19-3	67-69	163.07	unlithified	67.3	0.2623	21	34	44	1
19-3	76-78	163.16	unlithified	31.0	0.9569	21	37	37	4
20-1	82-84	169.92	partly lithified	69.3	0.4226	17	0	65	17
20-5	10-12	175.2	partly lithified	79.2	0.2115	10	0	49	41
21-1	3-5	178.83	stiff, unlithified	63.4	0.3304	21	0	35	45
23-5	56-58	204.66	stiff, unlithified	32.8	0.7910	17	41	42	1
24-4	58-60	212.48	stiff, unlithified	39.6	0.5127	16	40	42	2
25-2	83-85	219.33	lithified	57.8	0.4112	19	19	63	1
26-1	1-3	221.71	partly lithified	85.3	0.1396	6	0	17	77
27-4	65-67	231.45	partly lithified	52.0	0.4569	19	37	44	0

TABLE A I Lithification, Carbonate Content, and Bulk Mineralogy of Hole 819A (cont.)

Core-Sxn	Interval	Depth (mbsf)	Lithification	Carbonate Content (%)	Relative Quartz	Aragonite (%)	Mg-Calcite (%)	Calcite (%)	Dolomite (%)
28-2	30-32	237.8	stiff, unlithified	38.6	0.6819	21	34	44	0
29-1	27-29	245.87	partly lithified	31.8	0.6049	15	38	47	1
29-4	106-108	251.16	partly lithified	44.4	0.5025	15	40	42	2
30-2	51-53	257.31	partly lithified	53.7	0.3536	17	39	41	3
					0.3025	17	43	38	2
					0.4019	15	42	40	3
					0.7716	20	40	39	2
					0.6193	16	41	41	2
					0.3071	16	45	36	2
					0.2411	18	41	39	3
					0.3536	14	43	40	3
					0.2792	17	42	39	2
					0.2792	18	43	37	2
				mean:	0.5228	16.8	41.9	39	2.4
				variance:	0.3934	2.84	2.99	2.67	0.27
				stdev:	0.4873	1.69	1.73	1.63	0.52
31-2	91-93	267.31	partly lithified	61.8	0.4467	14	46	41	1
32-3	77-79	278.27	partly lithified	51.7	0.4569	18	17	61	1
33-3	66-68	287.86	partly lithified	29.0	0.4416	14	38	41	6
34-1	54-56	294.44	partly lithified	33.8	0.3350	18	34	42	6
35-1	3-5	303.53	stiff, unlithified	60.0	0.4213	15	35	50	1
35-2	52-54	305.52	stiff, unlithified	67.7	0.4146	13	0	67	20
35-3	100-102	307.5	partly lithified	62.0	0.0525	18	17	63	1
35-4	144-146	309.44	stiff, unlithified	61.8	0.0523	15	32	53	0
35-6	51-53	311.51	partly lithified	25.8	0.0218	15	34	51	0
36-4	80-82	317.99	partly lithified	44.6	0.0377	15	29	54	3
37-4	80-82	328.2	partly lithified	49.9	0.0422	18	32	48	2
38-2	90-92	334.54	partly lithified	44.7	0.0378	16	34	50	0
39-6	68-70	350.38	partly lithified	44.4	0.0376	17	38	42	3
40-7	73-75	360.13	stiff, unlithified	46.6	0.0394	16	37	45	2
41-6	78-80	368.83	partly lithified	52.2	0.0442	15	42	42	1

TABLE A 1 Lithification, Carbonate Content, and Bulk Mineralogy of Hole 819A (cont)

Core-Sxn	Interval	Depth (mbsf)	Lithification	Carbonate Content (%)	Relative Quartz	Aragonite (%)	Mg-Calcite (%)	Calcite (%)	Dolomite (%)
42-3	83-85	374.63	partly lithified	58.3	0.0493	13	0	86	1
43-6	86-88	387.56	partly lithified	50.1	0.0424	12	35	53	0
44-7	58-60	398.21	stiff, unlithified	42.7	0.0361	18	35	48	1

TABLE A.2. Lithification, Carbonate Content, and Bulk Mineralogy of Hole 820B

Core- Section	Interval	Depth (mbsf)	Lithification	Carbonate Content (%)	Relative Quartz	Aragonite (%)	Mg-Calcite (%)	Calcite (%)	Dolomite (%)
1-1	6-8	0.06	unlithified	73.3	0.2036	26	46	29	0
1-1	106-108	1.06	unlithified	68.7	0.0815	23	48	29	0
1-2	56-58	2.06	unlithified	69.3	0.2324	24	45	31	1
1-3	6-8	3.06	unlithified	64.1	0.1833	26	46	29	1
1-3	106-108	4.06	unlithified	47.9	0.2480	21	52	27	0
1-4	57-59	5.07	unlithified	57.5	0.3782	25	43	32	0
1-5	5-7	6.05	unlithified	45.8	0.3782	28	45	27	0
1-5	107-109	7.07	unlithified	64.7	0.1273	12	56	31	1
1-6	46-48	7.96	unlithified	76.3	0.0851	20	46	34	1
2-1	14-16	8.34	unlithified	62.7	0.1673	20	48	33	0
2-1	119-121	9.39	unlithified	45.7	0.4000	24	46	31	0
2-2	69-71	10.39	unlithified	53.1	0.2960	21	46	33	0
2-3	16-18	11.36	unlithified	45.7	0.1705	22	55	23	0
2-3	120-122	12.4	unlithified	49.2	0.2280	20	47	34	0
2-4	69-71	13.39	unlithified	49.4	0.1782	17	49	34	0
2-5	14-16	14.34	unlithified	64.1	0.0902	19	46	35	0
2-5	117-119	15.37	unlithified	66.4	0.0851	23	44	34	0
2-6	68-70	16.38	unlithified	71.5	0.1105	22	45	33	1
2-7	16-18	17.36	unlithified	77.7	0.1018	23	45	32	1
3-1	15-17	17.85	unlithified	84.6	0.1236	22	46	32	1
3-1	115-117	18.85	unlithified	75.7	0.0902	23	48	29	1
3-2	65-67	19.85	unlithified	67.6	0.0982	19	49	32	0
3-3	15-17	20.85	unlithified	69.9	0.0764	19	51	31	0
3-3	115-117	21.85	unlithified	76.8	0.1015	19	44	34	3
3-4	65-67	22.85	unlithified	63.8	0.0982	24	45	31	1
3-5	16-18	23.86	unlithified	67.3	0.0916	22	43	36	1
3-5	119-121	24.89	unlithified	67.6	0.1400	26	42	32	0
3-6	66-68	25.86	unlithified	69.2	0.1200	23	41	36	0
3-7	14-16	26.84	unlithified	77.1	0.1407	26	37	33	5
4-1	2-4	27.22	unlithified	61.5	0.2909	21	44	29	6
4-1	102-104	28.22	unlithified	50.1	0.6280	22	47	30	0

TABLE A 2 Lithification, Carbonate Content, and Bulk Mineralogy of Hole 820B (cont)

Core- Section	Interval	Depth (mbsf)	Lithification	Carbonate Content (%)	Relative Quartz	Aragonite (%)	Mg-Calcite (%)	Calcite (%)	Dolomite (%)
4-2	53-55	29.23	unlithified	38.5	0.4327	17	58	25	1
4-3	3-5	30.23	unlithified	38.4	0.3200	25	54	18	2
4-3	103-105	31.23	unlithified	57.7	0.3382	17	53	27	2
4-4	44-46	32.14	unlithified	61.4	0.4364	18	44	38	1
4-5	15-17	33.35	unlithified	80.8	0.1200	18	45	30	7
4-5	102-104	34.22	unlithified	65.2	0.1564	23	39	33	4
4-6	62-64	35.32	unlithified	73.1	0.1345	21	41	33	4
4-7	16-18	36.36	stiff, unlithified	72.5	0.1491	24	31	37	8
5-1	20-22	36.9	unlithified	78.8	0.1273	22	30	42	5
5-1	120-122	37.9	unlithified	72.7	0.1200	23	31	40	6
5-2	68-70	38.88	unlithified	65.4	0.1865	25	39	30	6
5-3	19-21	39.89	unlithified	66.8	0.1702	22	46	30	3
5-3	119-121	40.89	stiff, unlithified	75.0	0.1473	23	41	32	4
5-4	66-68	41.86	unlithified	72.3	0.0884	21	42	32	5
5-5	18-20	42.88	stiff, unlithified	67.9	0.1080	24	36	36	4
5-5	121-123	43.91	unlithified	57.0	0.1418	24	38	33	5
5-6	71-73	44.91	unlithified	56.3	0.2640	23	37	36	4
5-7	23-25	45.93	unlithified	53.2	0.1702	22	42	31	4
6-1	15-17	46.35	unlithified	49.7	0.2800	26	36	34	4
6-1	115-117	47.35	unlithified	56.9	0.2444	26	40	31	3
6-2	64-66	48.34	unlithified	54.4	0.2880	23	43	34	0
6-3	17-19	49.37	unlithified	47.4	0.3011	22	46	32	0
6-3	120-122	50.4	unlithified	75.3	0.1345	22	31	26	22
6-4	66-68	51.36	unlithified	73.9	0.2182	22	50	29	0
6-5	16-18	52.36	unlithified	66.0	0.1927	22	46	32	0
6-5	121-123	53.41	unlithified	53.0	0.1964	25	44	31	0
6-6	66-68	54.36	unlithified	59.3	0.1600	20	36	34	10
6-7	15-17	55.35	unlithified	56.8	0.2280	22	35	37	6
7-1	53-55	56.23	unlithified	66.0	0.1091	17	23	43	17
7-1	145-147	57.15	unlithified	56.7	0.1789	18	22	49	11
7-2	99-101	58.19	unlithified	60.5	0.2109	20	17	38	24

TABLE A 2 Lithification, Carbonate Content, and Bulk Mineralogy of Hole 820B (cont.)

Core- Section	Interval	Depth (mbsf)	Lithification	Carbonate Content (%)	Relative Quartz	Aragonite (%)	Mg-Calcite (%)	Calcite (%)	Dolomite (%)
7-3	53-55	59.23	unlithified	61.2	0.2073	21	43	36	0
7-3	144-146	60.14	unlithified	40.7	0.3636	20	50	31	0
7-4	100-102	61.2	unlithified	36.4	0.3080	21	47	31	0
7-5	54-56	62.24	unlithified	54.3	0.2662	27	51	22	0
7-5	144-145	63.14	unlithified	69.3	0.3535	31	46	23	1
7-6	100-102	64.2	unlithified	60.0	0.3025	20	46	32	2
7-7	53-55	65.23	unlithified	66.2	0.4764	21	46	33	1
8-1	20-22	65.4	stiff, unlithified	61.9	0.1796	30	37	33	1
8-1	120-122	66.4	stiff, unlithified	72.3	0.1600	27	21	32	19
8-2	70-72	67.4	unlithified	71.5	0.1080	23	22	44	10
8-3	20-22	68.4	unlithified	69.5	0.1636	27	21	46	7
8-3	121-123	69.41	stiff, unlithified	73.0	0.2545	26	28	41	4
8-4	70-72	70.4	unlithified	61.7	0.2600	25	40	33	2
8-5	20-22	71.4	unlithified	62.9	0.3898	25	42	33	1
8-5	125-127	72.45	unlithified	63.9	0.1418	25	46	29	0
8-6	72-74	73.42	unlithified	57.8	0.3273	29	41	29	0
8-7	15-17	74.35	unlithified	58.0	0.2436	26	44	30	0
9-1	32-34	75.02	stiff, unlithified	69.3	0.1320	20	44	33	4
9-1	132-134	76.02	unlithified	60.3	0.2160	24	43	33	0
9-2	82-84	77.02	unlithified	50.0	0.1640	16	43	41	0
9-3	33-35	78.03	unlithified	52.2	0.3240	21	46	33	0
9-3	136-138	79.06	stiff, unlithified	71.2	0.1193	23	38	39	0
9-4	101-103	80.21	unlithified	62.1	0.1865	26	42	31	0
9-5	31-33	81.01	stiff, unlithified	69.2	0.1055	20	33	42	4
9-5	139-141	82.09	stiff, unlithified	69.9	0.1120	25	13	50	12
9-6	86-88	83.06	unlithified	75.0	0.1400	26	1	60	14
9-7	30-32	84	unlithified	81.6	0.0727	24	0	61	16
10-1	3-5	84.23	unlithified	75.0	0.0880	24	0	62	13
10-1	102-104	85.22	stiff, unlithified	79.4	0.1720	31	0	58	12
10-2	54-56	86.24	stiff, unlithified	65.4	0.1709	31	1	62	7
10-3	3-5	87.23	unlithified	57.4	0.2480	28	28	45	1

TABLE A 2 Lithification, Carbonate Content, and Bulk Mineralogy of Hole 820B (cont)

Core- Section	Interval	Depth (mbsf)	Lithification	Carbonate Content (%)	Relative Quartz	Aragonite (%)	Mg-Calcite (%)	Calcite (%)	Dolomite (%)
10-3	103-105	88.23	stiff, unlithified	63.5	0.1160	33	6	51	10
10-4	56-58	89.26	unlithified	73.0	0.1360	29	0	61	10
10-5	3-5	90.23	stiff, unlithified	75.0	0.2269	28	1	58	14
10-5	105-107	91.25	stiff, unlithified	62.9	0.2280	32	10	51	8
10-6	61-63	92.31	stiff, unlithified	61.5	0.2320	25	21	53	2
10-7	4-6	93.24	unlithified	70.4	0.1891	24	20	53	3
11-1	29-31	93.99	unlithified	71.2	0.1345	32	1	55	13
11-1	133-135	95.03	unlithified	66.3	0.1920	32	16	44	9
11-2	79-81	95.99	stiff, unlithified	73.9	0.0764	23	22	45	9
11-3	28-30	96.98	stiff, unlithified	74.0	0.1018	24	24	46	6
11-3	134-136	98.04	stiff, unlithified	68.1	0.1345	26	24	45	4
11-4	78-80	98.98	stiff, unlithified	76.0	0.0873	24	19	48	8
11-5	28-30	99.98	stiff, unlithified	64.3	0.0949	27	14	50	9
11-5	136-138	101.06	stiff, unlithified	74.0	0.1091	28	11	47	14
11-6	81-83	102.01	stiff, unlithified	76.0	0.1160	22	15	51	11
11-7	27-29	102.97	unlithified	76.0	0.1091	24	35	35	6
12-1	19-21	103.39	unlithified	81.9	0.0873	21	0	70	9
12-1	119-121	104.39	unlithified	72.0	0.1309	28	0	56	17
12-2	69-71	105.39	stiff, unlithified	76.1	0.1160	29	1	62	9
12-3	19-21	106.39	stiff, unlithified	78.0	0.1000	26	0	60	13
12-3	118-120	107.38	stiff, unlithified	80.1	0.1178	27	0	61	11
12-4	67-69	108.37	stiff, unlithified	76.0	0.1018	25	0	66	9
12-5	16-18	109.36	stiff, unlithified	70.4	0.1236	30	0	63	8
12-5	119-121	110.39	stiff, unlithified	70.0	0.1280	28	0	61	11
12-6	68-70	111.38	stiff, unlithified	74.4	0.1200	28	0	64	8
12-7	16-18	112.36	stiff, unlithified	74.0	0.1353	28	0	62	10
13-1	19-21	112.89	stiff, unlithified	72.5	0.1105	29	0	61	10
13-1	119-121	113.89	stiff, unlithified	74.0	0.1491	26	19	50	5
13-2	71-73	114.91	stiff, unlithified	70.2	0.1455	22	34	40	4
13-3	19-21	115.89	stiff, unlithified	57.7	0.3760	25	43	32	0
13-3	118-120	116.88	stiff, unlithified	58.4	0.3215	24	44	32	1

TABLE A 2 Lithification, Carbonate Content, and Bulk Mineralogy of Hole 820B (cont.)

Core- Section	Interval	Depth (mbsf)	Lithification	Carbonate Content (%)	Relative Quartz	Aragonite (%)	Mg-Calcite (%)	Calcite (%)	Dolomite (%)
13-4	75-77	117.95	partly lithified	79.5	0.1505	25	0	63	12
13-5	18-20	118.88	unlithified	79.8	0.1222	21	0	67	12
13-5	115-117	119.85	partly lithified	87.3	0.0320	15	0	70	15
13-6	75-77	120.95	unlithified	79.6	0.0785	19	0	62	19
13-7	19-21	121.89	stiff, unlithified	77.2	0.1491	24	0	65	12
14-1	20-22	122.4	unlithified	62.0	0.5367	32	14	45	9
14-1	118-120	123.38	unlithified	51.4	0.6036	26	43	31	0
14-2	24-26	123.94	lithified	77.4	0.1491	21	0	71	8
14-2	71-73	124.41	partly lithified	86.8	0.1236	19	0	73	8
14-3	18-20	125.38	stiff, unlithified	77.3	0.1658	23	0	66	10
14-3	116-118	126.36	stiff, unlithified	72.9	0.1600	22	0	68	9
14-4	69-71	127.39	stiff, unlithified	73.4	0.1818	24	0	69	7
14-5	18-20	128.38	stiff, unlithified	70.9	0.1898	24	0	67	9
14-5	117-119	129.37	stiff, unlithified	71.4	0.2000	20	0	69	10
14-6	72-74	130.42	unlithified	70.7	0.3055	23	0	66	11
14-7	20-22	131.4	stiff, unlithified	71.3	0.2356	23	0	68	9
15-1	20-22	131.9	unlithified	62.9	0.2218	28	0	61	11
15-1	117-119	132.87	stiff, unlithified	71.2	0.2182	25	0	66	9
15-2	70-72	133.9	stiff, unlithified	70.6	0.2240	22	0	66	12
15-3	18-20	134.88	stiff, unlithified	71.2	0.2360	19	0	73	7
15-3	118-120	135.88	unlithified	68.6	0.2480	26	0	64	10
15-4	71-73	136.91	stiff, unlithified	61.5	0.3127	20	0	67	13
15-5	19-21	137.89	unlithified	62.7	0.3240	23	0	68	10
15-5	116-118	138.86	unlithified	59.6	0.3731	23	0	64	13
15-6	71-73	139.91	stiff, unlithified	54.9	0.4640	22	0	63	15
15-7	17-19	140.87	stiff, unlithified	53.8	0.3927	27	0	54	20
16-1	15-17	141.35	unlithified	51.0	0.4945	29	0	53	19
16-1	132-134	142.52	stiff, unlithified	65.4	0.3382	14	0	86	1
16-2	69-71	143.39	unlithified	43.1	0.8596	44	10	46	0
16-3	2-4	144.22	unlithified	53.8	0.4276	23	0	63	14
17-1	4-6	150.74	lithified	72.5	0.1927	12	0	85	3

TABLE A 2 Lithification, Carbonate Content, and Bulk Mineralogy of Hole 820B (cont)

Core- Section	Interval	Depth (mbsf)	Lithification	Carbonate Content (%)	Relative Quartz	Aragonite (%)	Mg-Calcite (%)	Calcite (%)	Dolomite (%)
17-1	15-17	150.85	unlithified	55.8	0.6476	24	0	25	51
17-1	116-118	151.86	unlithified	49.0	0.5978	33	0	53	14
17-2	61-63	152.81	stfri, unlithified	50.0	0.4844	24	0	47	29
17-3	13-15	153.83	stfri, unlithified	43.1	0.7331	26	26	41	8
17-3	114-116	154.84	stfri, unlithified	38.5	0.7375	26	39	35	0
17-4	71-73	155.91	stfri, unlithified	39.2	0.4960	24	41	35	0
17-5	10-12	156.8	partly lithified	38.5	0.4400	20	46	33	0
18-2	80-82	162.5	unlithified	47.4	0.3640	21	47	32	0
18-5	93-95	167.13	stfri, unlithified	69.4	0.3160	21	0	44	34
19-2	53-55	167.23	unlithified	84.8	0.1236	8	0	79	13
20-2	80-82	177.1	stfri, unlithified	40.5	0.6000	28	35	37	0
20-3	95-97	178.75	unlithified	55.2	0.6480	24	0	76	1
20-5	7-9	180.87	unlithified	75.3	0.2836	15	0	66	19
20-5	121-123	182.01	stfri, unlithified	74.7	0.1891	13	0	69	18
20-6	68-70	182.98	stfri, unlithified	69.5	0.1818	17	0	70	13
20-7	10-12	183.9	partly lithified	72.6	0.2109	16	0	73	11
21-1	10-12	184.2	partly lithified	67.7	0.1840	12	0	76	12
21-1	114-116	185.24	partly lithified	76.4	0.7280	17	0	72	11
21-2	57-59	186.17	partly lithified	73.5	0.2000	15	0	72	14
21-3	17-19	187.27	stfri, unlithified	68.5	0.2313	19	0	69	12
21-3	116-118	188.26	stfri, unlithified	65.8	0.2255	20	0	67	13
21-4	58-60	189.18	stfri, unlithified	60.5	0.3855	25	0	66	9
21-5	14-16	190.24	stfri, unlithified	60.1	0.3273	22	0	67	11
21-5	114-116	191.24	stfri, unlithified	52.6	0.5164	22	0	74	4
21-6	59-61	192.19	stfri, unlithified	42.7	0.4756	22	0	57	1
21-7	10-12	193.2	stfri, unlithified	40.9	0.5040	27	26	47	0
22-1	10-12	193.8	unlithified	35.0	0.5520	28	38	34	1
22-1	108-110	194.78	unlithified	35.0	0.7280	26	36	37	0
22-2	59-61	195.79	unlithified	31.0	0.5629	27	40	33	0
22-3	11-13	196.81	unlithified	33.0	0.6240	27	35	38	0
22-3	109-111	197.79	unlithified	32.9	0.5804	28	35	37	0

TABLE A 2. Lithification, Carbonate Content, and Bulk Mineralogy of Hole 820B (cont)

Core- Section	Interval	Depth (mbsf)	Lithification	Carbonate Content (%)	Relative Quartz	Aragonite (%)	Mg-Calcite (%)	Calcite (%)	Dolomite (%)
22-4	60-62	198.8	unlithified	31.1	0.6640	22	40	38	0
22-5	10-12	199.8	unlithified	31.0	0.5320	25	37	39	0
22-5	109-111	200.79	unlithified	31.1	0.9338	25	35	40	0
22-6	63-65	201.83	unlithified	27.0	1.0000	24	38	38	0
23-1	16-18	203.56	unlithified	58.3	0.5040	20	0	66	14
23-1	133-135	204.73	stiff, unlithified	57.8	0.3560	22	0	67	12
23-2	67-69	205.57	unlithified	52.4	0.4800	22	0	67	11
23-5	78-80	210.18	partly lithified	77.0	0.1040	11	0	79	9
24-1	59-61	213.39	partly lithified	81.6	0.1320	11	0	80	9
24-6	50-52	220.8	stiff, unlithified	69.3	0.2051	19	0	71	10
25-3	24-26	225.74	lithified	86.4	0.1418	8	0	84	8
26-1	34-36	232.44	unlithified	57.8	0.4669	20	0	66	14
27-1	113-115	242.93	unlithified	69.7	0.3142	12	0	78	10
28-3	64-66	254.74	stiff, unlithified	70.8	0.2800	9	0	74	16
28-6	85-87	259.45	lithified	62.1	0.3520	7	0	85	8
29-2	33-35	262.63	partly lithified	82.8	0.1898	3	0	83	14
30-1	56-58	270.96	lithified	73.9	0.1882	10	0	82	9
31-1	38-40	280.48	lithified	61.2	0.4713	7	0	89	3
32-1	5-7	289.75	partly lithified	76.0	0.1309	2	0	93	5
33-1	98-100	300.38	stiff, unlithified	56.0	0.3760	15	18	66	1
33-2	53-55	301.43	stiff, unlithified	39.5	0.5080	23	41	36	1
33-3	12-14	302.52	stiff, unlithified	42.5	0.4920	22	38	41	1
33-3	100-102	303.4	stiff, unlithified	39.6	0.5760	21	37	42	0
33-4	48-50	304.38	partly lithified	42.5	0.4760	19	39	42	0
33-4	138-140	305.28	stiff, unlithified	39.7	0.5673	22	39	33	1
33-5	100-102	306.4	stiff, unlithified	40.6	0.5498	24	45	31	1
33-6	11-13	307.01	stiff, unlithified	39.7	0.7069	22	42	36	1
34-1	20-22	309.3	stiff, unlithified	58.2	0.4200	12	1	84	5
35-1	2-4	318.82	partly lithified	71.9	0.1840	7	0	79	14
35-1	102-104	319.82	partly lithified	73.7	0.2240	8	0	84	7
35-2	50-52	320.8	partly lithified	63.8	0.2705	12	0	75	12

TABLE A 2 Lithification, Carbonate Content, and Bulk Mineralogy of Hole 820B (cont)

Core- Section	Interval	Depth (mbsf)	Lithification	Carbonate Content (%)	Relative Quartz	Aragonite (%)	Mg- Calcite (%)	Calcite (%)	Dolomite (%)
36-1	39-41	328.89	stiff, unlithified	65.8	0.3491	11	0	72	17
36-6	77-79	336.77	stiff, unlithified	47.7	0.4364	16	32	50	1
37-3	94-96	342.14	stiff, unlithified	38.7	0.6676	14	40	46	0
38-2	92-94	350.32	partly lithified	41.7	0.4844	13	44	39	4
39-3	22-24	360.72	unlithified	73.5	0.1891	6	0	77	16
40-1	54-56	363.24	lithified	79.3	0.1702	12	0	47	40
41-4	78-80	372.38	lithified	77.2	0.1855	4	0	85	11
42-3	128-130	380.98	partly lithified	73.2	0.2480	6	0	78	16
43-CC	19-21	386.59	partly lithified	57.9	0.4655	19	0	80	1
44-1	72-74	396.72	partly lithified	49.4	0.4080	28	0	72	1
44-2	75-77	398.25	lithified	73.2	0.3200	4	0	23	73

TABLE A 3. Lithification, Carbonate Content, and Bulk Mineralogy of Hole 821A

Core- Section	Interval	Depth (mbsf)	Lithification	Carbonate Content (%)	Relative Quartz	Aragonite (%)	Mg-Calcite (%)	Calcite (%)	Dolomite (%)
1-1	72-74	0.72	unlithified	69.8	0.0659	25	45	30	1
1-2	12-14	1.62	unlithified	67.7	0.0709	25	46	29	1
1-2	108-110	2.58	unlithified	65.6	0.1334	26	42	32	1
1-3	73-75	3.73	unlithified	65.6	0.1263	24	43	33	1
2-1	17-19	4.57	unlithified	63.5	0.1747	26	45	29	1
2-1	114-116	5.54	unlithified	52.9	0.2253	26	48	26	0
2-2	63-65	6.53	unlithified	51.0	0.2360	29	47	24	0
2-3	17-19	7.57	unlithified	49.0	0.2434	27	45	28	0
2-3	101-103	8.41	unlithified	52.9	0.1784	27	50	23	0
2-4	55-57	9.45	unlithified	35.3	0.9375	4	64	32	1
2-5	23-25	10.63	unlithified	49.0	0.2797	22	50	28	0
2-5	100-102	11.40	unlithified	41.2	0.2267	27	44	29	0
2-6	70-72	12.60	unlithified	45.1	0.1689	26	49	25	0
2-7	11-13	13.51	unlithified	43.1	0.2323	21	53	26	1
3-1	17-19	14.07	unlithified	45.1	0.2378	24	48	28	0
3-1	128-130	15.18	unlithified	53.8	0.1472	21	46	32	0
3-2	61-63	16.01	unlithified	61.2	0.1189	18	50	32	0
3-3	17-19	17.07	unlithified	82.7	0.0486	21	42	37	1
3-3	128-130	18.18	unlithified	72.5	0.0410	24	46	30	1
3-4	61-63	19.01	unlithified	75.0	0.0625	21	48	31	1
3-5	16-18	20.06	unlithified	70.7	0.0578	21	43	36	1
3-5	102-104	20.92	unlithified	67.3	0.0380	21	38	41	1
3-6	61-63	22.01	unlithified	67.1	0.0794	23	42	36	1
3-7	14-16	23.04	unlithified	69.2	0.0257	22	44	35	1
4-1	20-22	23.60	unlithified	65.4	0.0660	22	41	37	0
4-1	124-126	24.64	unlithified	71.2	0.0557	25	46	29	1
4-2	72-74	25.62	unlithified	74.9	0.0417	24	42	33	2
4-3	20-22	26.60	unlithified	65.4	0.1267	24	45	28	2
4-3	123-125	27.63	unlithified	60.0	0.1041	22	47	26	5
4-4	73-75	28.63	unlithified	50.0	0.2111	24	51	25	1
4-5	20-22	29.60	unlithified	50.7	0.1524	20	56	24	1

TABLE A 3 Lithification, Carbonate Content, and Bulk Mineralogy of Hole 821A (cont)

Core- Section	Interval	Depth (mbsf)	Lithification	Carbonate Content (%)	Relative Quartz	Aragonite (%)	Mg-Calcite (%)	Calcite (%)	Dolomite (%)
4-5	122-124	30.62	unlithified	44.2	0.1541	24	53	22	0
4-6	72-74	31.62	unlithified	41.4	0.1672	19	57	23	0
4-7	22-24	32.62	unlithified	36.5	0.2044	26	50	24	0
5-1	25-27	33.15	unlithified	54.6	0.1047	14	61	25	0
5-1	124-126	34.14	unlithified	53.7	0.2657	21	60	20	0
5-2	71-73	35.11	unlithified	21.0	1.0000	1	58	42	0
5-3	10-12	36.00	unlithified	42.1	0.2600	14	49	37	1
5-3	113-115	37.03	unlithified	72.4	0.0869	16	53	31	0
5-4	72-74	38.12	unlithified	83.9	0.0262	12	58	30	1
5-5	16-18	39.06	stiff, unlithified	76.2	0.0215	15	35	38	12
5-5	125-127	40.15	stiff, unlithified	78.0	0.0401	24	32	32	12
5-6	74-76	41.14	stiff, unlithified	76.2	0.0365	18	27	48	7
5-7	22-24	42.12	stiff, unlithified	72.1	0.0395	19	33	43	6
6-1	20-22	42.60	unlithified	74.3	0.0311	14	36	42	7
6-1	124-126	43.64	stiff, unlithified	73.8	0.0350	19	40	37	4
6-2	67-69	44.57	stiff, unlithified	72.3	0.0385	17	40	39	5
6-3	19-21	45.59	stiff, unlithified	66.1	0.0405	16	42	35	7
6-3	125-127	46.65	stiff, unlithified	68.6	0.0372	19	38	38	6
6-4	66-68	47.56	unlithified	62.2	0.0743	18	40	39	2
6-5	16-18	48.56	unlithified	64.8	0.0625	22	32	43	3
6-5	106-108	49.46	unlithified	58.3	0.0456	21	43	36	1
6-6	68-70	50.58	unlithified	51.4	0.0892	17	45	33	0
6-7	15-17	51.11	unlithified	46.9	0.1153	23	43	33	0
7-1	20-22	52.10	unlithified	55.2	0.0836	20	47	32	0
7-1	123-125	53.13	unlithified	65.3	0.0688	18	19	33	30
7-2	65-67	54.05	unlithified	57.9	0.0971	24	48	24	4
7-3	16-18	55.06	unlithified	78.7	0.0270	15	34	39	12
7-3	127-129	56.17	unlithified	69.6	0.0642	20	33	43	4
7-4	65-67	57.05	unlithified	63.3	0.0798	23	25	43	9
7-5	21-23	58.11	unlithified	65.9	0.0704	22	11	50	17
7-5	126-128	59.16	unlithified	51.7	0.0958	22	14	45	19

TABLE A 3 Lithification, Carbonate Content, and Bulk Mineralogy of Hole 821A (cont)

Core- Section	Interval	Depth (mbsf)	Lithification	Carbonate Content (%)	Relative Quartz	Aragonite (%)	Mg-Calcite (%)	Calcite (%)	Dolomite (%)
7-6	68-70	60.08	unlithified	64.1	0.0532	18	14	54	14
7-7	19-21	61.09	unlithified	55.5	0.1651	20	40	36	4
8-1	20-22	61.60	unlithified	46.7	0.1412	20	52	28	0
8-1	124-126	62.64	unlithified	40.2	0.1338	21	53	26	0
8-2	72-74	63.62	unlithified	41.0	0.1356	20	56	24	0
8-3	20-22	64.60	unlithified	38.2	0.1338	13	61	26	0
8-3	127-129	65.67	stiff, unlithified	68.7	0.1014	22	48	30	0
8-4	71-73	66.61	unlithified	68.7	0.0797	21	53	26	0
8-5	21-23	67.61	stiff, unlithified	63.0	0.0929	19	38	24	18
8-5	125-127	68.65	stiff, unlithified	64.6	0.0932	23	35	27	14
8-6	71-73	69.61	stiff, unlithified	59.0	0.0943	20	33	40	6
8-7	21-23	70.61	stiff, unlithified	45.8	0.0760	19	44	32	5
9-1	20-22	71.10	stiff, unlithified	57.2	0.0743	16	22	54	8
9-1	125-127	72.15	stiff, unlithified	78.8	0.0236	17	0	72	12
9-2	74-76	73.14	unlithified	86.8	0.0284	18	0	71	11
9-3	21-23	74.11	stiff, unlithified	84.6	0.0738	20	0	72	8
9-3	125-127	75.15	stiff, unlithified	78.7	0.0449	22	0	70	9
9-4	72-74	76.12	stiff, unlithified	71.2	0.0395	21	0	68	10
9-5	20-22	77.10	stiff, unlithified	78.5	0.0389	24	0	65	11
9-5	105-107	77.95	stiff, unlithified	75.0	0.0502	19	0	70	11
9-6	66-68	79.06	stiff, unlithified	72.5	0.0481	24	0	67	9
9-7	15-17	80.05	stiff, unlithified	75.0	0.0473	23	0	65	12
10-1	46-48	80.86	stiff, unlithified	66.4	0.0608	20	0	66	14
10-1	141-143	81.81	stiff, unlithified	69.2	0.0481	15	0	68	17
10-2	96-98	82.86	stiff, unlithified	64.3	0.1064	25	1	66	9
10-3	44-46	83.84	stiff, unlithified	55.8	0.1014	21	1	64	15
10-3	140-142	84.80	stiff, unlithified	62.2	0.0574	21	0	68	11
10-4	95-97	85.85	stiff, unlithified	69.2	0.0456	14	0	62	24
10-5	44-46	86.84	stiff, unlithified	66.0	0.0481	9	0	37	54
10-5	135-137	87.75	stiff, unlithified	55.8	0.1345	14	28	57	2
10-6	94-96	88.84	stiff, unlithified	46.4	0.1470	19	48	29	4

TABLE A 3 Lithification, Carbonate Content, and Bulk Mineralogy of Hole 821A (cont)

Core- Section	Interval	Depth (mbsf)	Lithification	Carbonate Content (%)	Relative Quartz	Aragonite (%)	Mg Calcite (%)	Calcite (%)	Dolomite (%)
10-7	54-56	89.94	stiff, unlithified	63.5	0.0574	16	58	26	0
11-1	52-54	90.42	unlithified	77.2	0.0632	18	54	27	0
11-2	5-7	91.45	stiff, unlithified	71.3	0.1284	18	40	38	5
11-2	105-107	92.45	stiff, unlithified	67.3	0.1059	18	39	27	16
11-3	51-53	93.41	stiff, unlithified	57.9	0.1274	25	41	30	4
11-4	2-4	94.24	stiff, unlithified	58.0	0.0966	19	42	34	5
11-4	107-109	95.47	stiff, unlithified	63.8	0.0845	28	37	29	6
11-5	51-53	96.41	stiff, unlithified	69.8	0.0688	19	0	47	34
11-6	4-6	97.44	stiff, unlithified	87.2	0.0135	12	0	64	24
11-6	107-109	98.47	unlithified	83.6	0.0244	14	0	68	18
11-7	55-57	99.45	stiff, unlithified	79.5	0.0253	14	0	63	23
12-1	21-23	99.61	unlithified	54.6	0.0706	23	1	65	11
12-1	123-125	100.63	stiff, unlithified	75.8	0.0595	20	0	63	17
12-2	66-68	101.56	stiff, unlithified	78.2	0.0324	20	0	57	22
12-3	20-22	102.60	stiff, unlithified	70.1	0.0855	23	0	50	27
12-3	123-125	103.63	stiff, unlithified	64.6	0.0985	29	0	59	12
12-4	67-69	104.57	partly lithified	80.0	0.0706	23	1	65	12
12-5	20-22	105.60	stiff, unlithified	76.6	0.0405	20	25	49	5
12-5	113-115	106.53	stiff, unlithified	87.9	0.0204	21	0	66	13
12-6	68-70	107.58	stiff, unlithified	76.8	0.0507	19	0	60	21
12-7	22-24	108.62	stiff, unlithified	74.3	0.0649	23	0	59	18
13-1	20-22	109.10	stiff, unlithified	80.9	0.0524	21	0	57	22
13-1	124-126	110.14	stiff, unlithified	76.0	0.0980	12	0	67	21
13-2	67-69	111.07	stiff, unlithified	76.9	0.0845	25	0	59	15
13-3	20-22	112.10	stiff, unlithified	74.0	0.0446	23	0	49	28
13-3	124-126	113.14	stiff, unlithified	81.1	0.0486	32	0	53	15
13-4	67-69	114.07	stiff, unlithified	78.0	0.0456	31	0	55	14
13-5	22-24	115.12	partly lithified	81.2	0.0186	16	0	54	30
13-5	124-126	116.14	stiff, unlithified	82.0	0.0243	16	0	52	32
13-6	72-74	117.12	partly lithified	87.5	0.0137	16	0	62	22
13-7	25-27	118.15	stiff, unlithified	82.0	0.0253	20	0	58	22

TABLE A.3. Lithification, Carbonate Content, and Bulk Mineralogy of Hole 821A (cont.)

Core- Section	Interval	Depth (mbsf)	Lithification	Carbonate Content (%)	Relative Quartz	Aragonite (%)	Mg-Calcite (%)	Calcite (%)	Dolomite (%)
14-1	21-23	118.61	unlithified	71.3	0.0557	23	0	51	26
14-1	126-128	119.66	stiff, unlithified	82.0	0.0316	20	0	65	15
14-2	14-16	120.04	lithified	87.8	0.0203	16	0	75	10
14-2	64-66	120.54	stiff, unlithified	84.0	0.0650	16	0	72	12
14-3	19-21	121.59	partly lithified	83.8	0.0490	16	0	74	10
14-3	130-132	122.70	stiff, unlithified	84.0	0.0507	15	0	71	15
14-4	64-66	123.54	stiff, unlithified	84.0	0.0243	12	0	65	23
14-5	15-17	124.55	stiff, unlithified	88.0	0.0253	16	0	71	13
14-5	129-131	125.69	stiff, unlithified	88.2	0.0446	15	0	69	16
14-6	63-65	126.53	stiff, unlithified	84.0	0.2054	17	0	68	16
14-7	13-15	127.53	partly lithified	82.2	0.0198	17	0	67	17
15-1	22-24	128.12	stiff, unlithified	82.1	0.0507	24	0	63	12
15-1	127-129	129.17	stiff, unlithified	77.9	0.0389	22	0	59	19
15-2	74-76	130.14	stiff, unlithified	79.8	0.0372	15	0	57	29
15-3	23-25	131.13	stiff, unlithified	77.8	0.0574	20	0	58	16
15-3	136-138	132.26	partly lithified	77.6	0.0539	22	0	62	16
15-4	95-97	133.35	partly lithified	77.6	0.0385	21	0	49	30
15-5	8-10	133.98	stiff, unlithified	77.5	0.0539	25	0	51	24
15-5	95-97	134.85	partly lithified	83.6	0.0929	18	0	77	5
15-6	106-108	136.46	stiff, unlithified	65.1	0.1691	21	46	31	2
15-7	24-26	137.14	stiff, unlithified	65.1	0.0836	26	41	27	5
16-1	1-3	137.41	lithified	81.2	0.0688	16	10	72	3
16-1	104-106	138.44	lithified	71.1	0.0456	17	0	47	37
16-2	53-55	139.43	stiff, unlithified	72.9	0.0557	25	0	67	9
16-3	11-13	140.51	unlithified	74.9	0.0929	17	20	32	30
16-3	106-108	141.46	partly lithified	80.8	0.0524	15	32	39	14
16-4	55-57	142.45	partly lithified	82.9	0.0500	6	42	52	1
16-5	22-24	143.62	partly lithified	76.6	0.0456	14	0	76	10
17-1	12-14	146.02	stiff, unlithified	66.6	0.0948	25	0	60	15
17-1	107-109	146.97	stiff, unlithified	56.4	0.1041	15	0	68	17
17-2	62-64	148.02	stiff, unlithified	60.4	0.1431	22	0	59	19

TABLE A 3. Lithification, Carbonate Content, and Bulk Mineralogy of Hole 821A (cont.)

Core- Section	Interval	Depth (mbst)	Lithification	Carbonate Content (%)	Relative Quartz	Aragonite (%)	Mg-Calcite (%)	Calcite (%)	Dolomite (%)
17-3	10-12	149.00	stiff, unlithified	68.1	0.1233	18	0	81	1
17-3	103-105	149.93	partly lithified	81.7	0.0380	14	0	70	16
17-4	64-66	151.04	partly lithified	76.2	0.0608	11	0	72	16
17-5	16-18	152.06	stiff, unlithified	73.6	0.0775	20	0	65	15
17-5	108-110	152.98	partly lithified	72.3	0.0410	18	0	69	13
17-6	73-75	154.13	stiff, unlithified	69.5	0.0985	31	0	50	19
17-7	10-12	155.00	stiff, unlithified	64.3	0.1216	21	0	63	17
18-1	17-19	155.77	partly lithified	79.3	0.0426	13	0	78	9
18-1	127-129	156.87	partly lithified	88.5	0.0502	8	0	79	14
18-2	63-65	157.73	partly lithified	81.2	0.0274	5	0	77	18
18-3	16-18	158.76	stiff, unlithified	60.4	0.1059	17	0	63	20
18-3	130-132	159.90	stiff, unlithified	75.1	0.1267	18	0	70	12
18-4	67-69	160.77	partly lithified	76.5	0.0676	15	0	73	12
18-6	84-86	163.94	stiff, unlithified	67.1	0.3284	11	0	75	14
19-1	94-96	166.14	stiff, unlithified	60.4	0.1988	22	0	69	10
19-5	51-53	171.71	stiff, unlithified	65.0	0.2267	16	0	77	8
20-1	16-18	175.06	partly lithified	70.9	0.1914	14	0	53	33
20-5	104-106	181.94	stiff, unlithified	62.5	0.1115	21	0	74	5
21-6	81-83	192.91	stiff, unlithified	55.0	0.2601	25	0	65	10
22-6	62-64	202.02	partly lithified	73.7	0.1115	20	0	69	11
23-3	76-78	207.26	stiff, unlithified	61.2	0.1486	22	0	70	7
24-1	72-74	213.52	unlithified	31.8	0.3698	28	35	37	0
24-5	82-84	219.62	partly lithified	88.6	0.0439	7	0	84	9
25-1	106-108	223.56	partly lithified	73.6	0.1245	12	0	78	10
25-4	63-65	227.63	stiff, unlithified	74.6	0.0818	13	0	74	13
26-2	127-129	234.97	stiff, unlithified	67.7	0.0895	8	0	60	32
26-6	133-135	241.03	partly lithified	62.7	0.1909	11	0	75	13
27-1	21-23	242.01	stiff, unlithified	59.9	0.1703	18	0	48	34
27-3	129-131	246.09	stiff, unlithified	64.4	0.1297	14	0	86	1
27-6	50-52	249.80	stiff, unlithified	69.5	0.0818	11	0	73	16
28-1	42-44	251.82	partly lithified	70.1	0.1081	9	0	78	13

TABLE A.3 Lithification, Carbonate Content, and Bulk Mineralogy of Hole 821A (cont.)

Core- Section	Interval	Depth (mbsf)	Lithification	Carbonate Content (%)	Relative Quartz	Aragonite (%)	Mg-Calcite (%)	Calcite (%)	Dolomite (%)
28-6	63-65	259.53	partly lithified	61.8	0.2081	9	0	78	13
29-2	62-64	263.22	partly lithified	77.8	0.0799	8	0	75	17
29-6	45-47	269.05	partly lithified	67.5	0.1166	9	0	75	15
30-1	87-89	271.67	partly lithified	62.1	0.1579	10	0	82	8
30-7	6-8	279.86	partly lithified	73.2	0.1034	4	0	84	12
31-1	20-22	280.60	partly lithified	73.5	0.1096	5	0	82	13
31-2	83-85	282.73	stiff, unlithified	53.9	0.1877	17	0	59	25
31-3	129-131	284.69	partly lithified	67.6	0.1334	6	0	83	11
31-CC	33-35	287.86	partly lithified	58.1	0.1932	7	0	80	13
32-CC	14-16	290.24	stiff, unlithified	55.8	0.2007	14	0	84	2
33-1	28-30	299.98	stiff, unlithified	67.9	0.1133	7	0	73	21
33-2	129-131	302.34	partly lithified	67.3	0.1429	6	0	83	11
33-4	2-4	304.07	partly lithified	66.2	0.1282	10	0	84	6
33-6	80-82	307.85	stiff, unlithified	69.2	0.1096	7	0	83	9
34-1	22-24	309.62	stiff, unlithified	59.1	0.1571	7	0	93	1
34-2	129-131	312.19	stiff, unlithified	39.1	0.2358	10	14	21	55
34-6	76-78	317.66	stiff, unlithified	52.8	0.1319	16	42	42	1
35-4	68-70	324.18	stiff, unlithified	48.7	0.1598	17	0	75	7
36-3	85-87	331.61	stiff, unlithified	56.6	0.1412	9	0	75	15
36-5	119-121	334.95	stiff, unlithified	62.2	0.1718	7	0	68	25
37-3	98-100	342.28	lithified	87.7	0.0297	1	0	86	13
37-6	88-90	346.68	partly lithified	69.9	0.1262	4	0	84	12
38-2	112-114	350.52	partly lithified	58.4	0.3176	8	0	77	15
39-1	130-132	358.80	partly lithified	32.8	0.2473	27	43	30	0
39-6	68-70	365.68	partly lithified	64.0	0.0806	7	0	87	6
40-3	82-84	371.02	partly lithified	57.8	0.0882	11	0	89	0
41-1	79-81	377.59	stiff, unlithified	50.4	0.2061	17	0	67	16
41-6	16-18	384.46	partly lithified	59.5	0.1267	12	0	69	19
42-1	80-82	387.20	partly lithified	32.9	0.2137	17	27	56	0
42-6	63-65	394.53	partly lithified	74.7	0.1486	4	0	80	17
43-3	74-76	399.84	stiff, unlithified	65.7	0.0654	1	0	82	17

APPENDIX B

GEOCHEMISTRY

TABLE B.1. Carbonate Fraction Bulk Geochemistry, Hole 819A

Cora- Section	Interval	Depth (mbaf)	Ca (ppm)	Mg (ppm)	Ba (ppm)	Fe (ppm)	Mn (ppm)	Na (ppm)	Sr (ppm)
1	98-100	0.98	383975	11446	12	1346	100	8371	2264
1	138-140	5.88	382474	12519	13	2136	125	8796	1992
2-2	120-122	11.2	380938	13616	16	7940	229	7751	2077
2-6	98-100	16.98	380562	13884	10	1967	90	5629	2795
3-1	88-90	18.88	376290	16936	21	6139	121	7326	3037
3-2	39-41	19.89	373095	19218	12	3645	126	6534	3194
3-2	139-141	20.89	377011	16421	12	4963	207	8056	2851
3-3	87-89	21.87	373733	18762	14	9251	381	10515	2374
3-4	39-41	22.89	369841	21542	16	9658	541	11685	2179
3-4	139-141	23.89	371062	20670	18	11850	587	13986	2109
3-5	93-95	24.93	382811	12278	19	13455	201	10236	1589
3-6	39-41	25.89	384758	10887	12	3789	98	5844	2946
3-6	136-138	26.8	380268	14094	8	2846	84	5136	2694
4-3	73-75	31.23	383578	11730	8	3976	106	6667	2621
4-5	73-75	34.23	377366	16167	12	7503	213	6707	2207
4-6	22-24	35.22	367992	22863	11	6112	185	5199	2457
4-6	121-123	36.21	366738	23758	11	6995	206	5318	2191
4-7	67-69	37.17	371709	20208	13	9692	251	6426	2307
5-1	98-100	37.98	374019	18558	11	6362	188	5989	2560
5-2	54-56	39.04	334727	46623	8	4831	156	4530	1903
5-2	147-149	39.97	321461	56099	9	5408	154	3898	1651
5-3	101-103	41.01	378410	15422	11	7357	195	6573	2758
5-6	54-56	45.04	377516	18080	9	5304	136	4558	2324
6-3	132-134	50.82	374514	18205	9	5629	113	4743	2526
7-1	53-55	56.53	376811	16564	7	3441	74	4216	2693
7-3	143-145	60.43	380258	14101	9	5404	112	4906	2843
7-7	83-85	65.83	382511	12492	11	7465	174	6070	2622
8-4	146-148	70.58	379032	14977	11	9162	225	5845	2350
9-2	4-6	75.39	378788	15152	12	13123	285	6844	2258
9-5	57-59	80.42	381315	13347	9	5260	131	5538	2747
10-2	107-109	85.97	380367	14023	8	5527	155	5075	2684
10-5	68-70	90.08	378244	15540	13	13766	320	7816	2194
11-2	102-104	95.34	378722	15198	10	8215	177	6266	2667
11-6	5-7	100.37	380664	13812	9	5237	119	5362	2984
11-8	4-6	103.36	380404	13997	9	5560	119	5269	2999
12-3	55-57	107.05	364416	25417	6	3992	87	2686	1789
12-3	65-67	107.15	379050	14964	7	4673	91	4651	2868
13-7	55-57	119.63	385485	10368	4	15	108	5533	2245
14-4	105-107	126.05	383277	11945	14	19	132	4325	2532
15-4	95-97	128.45	386442	9684	8	3	70	5544	2372
16-4	81-83	134.8	378215	15561	6	2811	91	3887	2838
18-1	40-42	150.1	376947	9324	8	2298	121	5557	2848
18-4	48-50	154.68	375501	17499	6	1350	69	3915	2495
19-3	67-69	163.07	384951	10749	7	1475	90	5044	2970
19-3	76-78	163.1	380890	13650	9	10090	309	9416	2305
20-1	82-84	169.92	372162	19885	6	2774	79	4539	2434
20-5	10-12	175.2	327901	51499	5	3158	67	3031	1490
21-1	3-5	178.83	333558	47459	7	4780	109	4458	2034
23-5	56-58	204.66	375744	17326	13	11980	327	8631	2062
25-2	83-85	219.33	379008	14994	13	9485	217	8125	2178
27-4	65-67	231.45	383505	11782	7	3972	115	5215	2306
28-2	30-32	237.8	381119	13486	11	7922	245	7176	2157

TABLE B.1. Carbonate Fraction Bulk Geochemistry, Hole 819A (cont.)

Core- Section	Interval	Depth (mbef)	Ca (ppm)	Mg (ppm)	Ba (ppm)	Fe (ppm)	Mn (ppm)	Na (ppm)	Sr (ppm)
29-1	27-29	245.87	377373	16162	15	15305	368	9297	1944
29-4	106-108	251.16	381095	13504	10	8777	212	6455	2066
30-2	51-53	257.31	382353	12605	9	8025	195	5260	2268
31-2	91-93	267.31	381374	13305	8	4011	116	4866	2443
32-3	77-79	278.27	377906	15781	9	3737	122	4560	2101
33-3	66-68	287.86	371608	20280	17	21050	503	10722	1823
34-1	54-56	294.44	378445	15396	16	19160	453	9163	1980
35-1	3-5	303.53	383857	11531	9	3321	132	4478	2299
35-2	52-54	305.52	360065	28525	20	5946	114	3423	1703
35-3	100-102	307.5	384675	10947	16	5284	115	4197	2208
36-4	80-82	317.99	373895	18789	20	17272	270	6694	2041
38-2	90-92	334.54	376932	16477	19	13536	260	6397	2195
40-7	73-75	360.13	375097	17788	19	14311	239	6317	2148
42-3	83-85	374.63	386667	9524	13	6939	130	4255	1920
44-7	58-60	398.21	376841	16542	22	15789	318	6889	2052

TABLE B.2. Carbonate Fraction Bulk Geochemistry, Hole 820B

Core- Section	Interval	Depth (mbaf)	Ca (ppm)	Mg (ppm)	Ba (ppm)	Fe (ppm)	Mn (ppm)	Na (ppm)	Sr (ppm)
1-1	6-8	0.06	377100	16400	10	5423	128	6412	3280
1-4	57-59	5.07	374500	18200	13	10672	306	9559	2629
2-2	69-71	10.39	373500	18900	11	10757	229	8576	2336
2-5	117-119	15.37	376900	16500	10	6694	124	6623	2742
3-3	15-17	20.85	375300	17700	9	5441	100	5798	3031
3-6	66-68	25.86	375900	17200	10	5643	122	6003	3253
4-3	3-5	30.23	369500	21800	15	15292	465	10167	2328
4-6	62-64	35.32	376700	16600	8	4667	92	5292	3130
5-3	119-121	40.89	378400	15400	9	3669	86	5332	3408
5-7	23-25	45.93	373800	18700	13	10605	216	8300	2815
6-3	17-19	49.37	376800	16600	12	9826	291	8301	2894
6-3	120-122	50.4	364700	25200	7	3823	164	4982	3130
6-4	66-68	51.36	377900	15800	7	3040	81	5205	3151
7-1	145-147	57.15	372100	20000	16	6733	197	6434	2828
7-2	99-101	58.19	360300	28400	12	6506	239	6269	2824
7-3	53-55	59.23	374100	18500	22	7212	279	7203	3269
7-7	53-55	65.23	378000	15700	11	6203	136	5789	2864
8-4	70-72	70.4	378600	15300	11	5584	158	6016	3133
9-1	32-34	75.02	370500	21100	15	6109	154	6854	3720
9-3	136-138	79.06	379000	15000	12	4387	109	4689	3176
9-4	101-103	80.21	379600	14600	14	6736	148	6550	3062
9-5	31-33	81.01	376000	17100	15	5381	134	5786	3360
9-5	139-141	82.09	370300	21200	12	5833	143	6248	3707
10-1	102-104	85.22	377400	16200	11	4259	109	4826	3714
10-5	3-5	90.23	372900	19400	10	4288	124	4786	3403
11-1	133-135	95.03	367500	23200	14	6269	149	7055	4397
11-5	28-30	99.98	375000	17800	13	5393	118	5273	4811
11-5	136-138	101.06	366700	23800	13	4696	130	6027	4624
11-6	81-83	102.01	369500	21800	12	4661	142	5725	4300
12-2	69-71	105.39	367800	23000	12	5424	116	6788	4757
12-5	119-121	110.39	371700	20200	12	6135	122	5754	3837
13-3	19-21	115.89	374200	18500	13	6367	145	6069	3859
13-5	115-117	119.85	374400	18300	9	2333	88	4461	3221
13-6	75-77	120.95	373800	18700	12	3062	94	4473	3348
13-7	19-21	121.89	378300	15500	11	4033	121	4261	3326
14-1	118-120	123.38	374600	18200	13	4056	91	4575	3542
14-6	72-74	130.42	381400	13300	13	5219	114	4388	2721
15-3	118-120	135.88	380300	14100	11	7025	125	4902	2653
15-7	17-19	140.87	366600	23900	16	8463	174	5623	2900
16-2	69-71	143.39	383700	11600	18	12625	286	8898	3412
16-3	2-4	144.22	377700	15900	17	7442	196	6086	2666
17-1	4-6	150.74	382200	12700	16	4687	340	2997	2738
17-1	15-17	150.85	346400	38300	14	7676	226	5911	2734
17-1	116-118	151.86	376200	17000	15	9431	237	6974	3352
17-2	61-63	152.81	372700	19500	15	7674	257	6282	2884
17-4	71-73	155.91	375400	17600	40	14101	361	9210	2800
18-2	80-82	162.5	374100	18500	20	16725	324	9859	3129
18-5	93-95	167.13	335500	46100	13	7243	193	5574	3419
19-2	53-55	167.23	371500	20300	10	2726	77	3589	2459
20-5	7-9	170.87	367900	22900	14	4393	105	5072	2656
21-1	114-116	185.24	370100	21300	16	5026	120	4683	2972
21-5	14-16	190.24	377700	15900	15	7209	196	4787	3098

TABLE B.2. Carbonate Fraction Bulk Geochemistry, Hole 820B (cont.)

Core- Section	Interval	Depth (mbsf)	Ca (ppm)	Mg (ppm)	Ba (ppm)	Fe (ppm)	Mn (ppm)	Na (ppm)	Sr (ppm)
22-2	59-61	195.79	374000	18600	26	21686	479	13167	3234
22-5	109-111	200.79	374400	18300	26	23004	411	12275	2810
23-5	78-80	210.18	373700	18800	11	3836	100	3908	3197
25-3	24-26	225.74	375100	17800	10	3238	167	2314	2862
27-1	113-115	242.93	373100	19200	13	5615	123	4907	3078
28-3	64-66	254.74	365500	24700	13	7420	228	4308	4054
28-6	85-87	259.45	374900	17900	15	7715	543	3788	4700
30-1	56-58	270.96	380500	13900	12	4178	138	2957	2786
32-1	5-7	289.75	385400	10400	9	3886	137	2611	2142
33-1	98-100	300.37	383500	11800	16	9300	284	4964	3451
33-4	138-140	305.28	378100	15600	23	16047	276	9258	2422
34-1	20-22	309.3	377500	16100	17	11514	329	6089	4070
35-2	50-52	320.8	372600	19600	13	7891	141	6001	2826
36-6	77-79	336.77	379800	14500	18	11353	234	7519	2836
37-3	94-96	342.14	372400	19700	24	20853	444	10870	2659
38-2	92-94	350.32	373800	18700	23	20517	363	8905	2298
39-3	22-24	360.72	368900	22200	12	7128	208	3330	3445
41-4	78-80	372.38	363900	25800	11	4993	148	3003	2758
43-CC	19-21	386.59	387900	8700	17	8339	205	5151	3317
44-1	72-74	396.72	386100	9900	18	12116	207	7166	2854
44-2	75-77	398.25	295000	75000	11	10815	170	2981	1152

TABLE B.3. Carbonate Fraction Bulk Geochemistry, Hole 821A

Core- Section	Interval	Depth (mbsf)	Ca (ppm)	Mg (ppm)	Ba (ppm)	Fe (ppm)	Mn (ppm)	Na (ppm)	Sr (ppm)
1-1	72-74	0.72	367138	23473	13	5445	151	8319	4280
2-1	114-116	5.54	372306	19762	21	4260	277	9930	3831
2-5	23-25	10.63	364819	25130	12	8777	302	10474	3233
3-1	128-130	15.18	363279	26229	12	5712	25	11858	3783
3-5	16-18	20.06	368429	22551	12	2642	108	7735	4703
4-2	72-74	25.62	367989	22865	11	2651	146	7496	4702
4-5	122-124	30.62	369654	21676	11	5851	430	10618	3520
5-2	71-73	35.11	371771	20164	10	14200	278	9935	1981
5-5	125-127	40.15	368733	22334	8	1876	88	5456	4430
6-3	19-21	45.59	366952	23606	10	2864	123	7123	4502
6-6	68-70	50.58	370078	21373	11	4794	276	10593	4063
6-7	15-17	51.11	369176	22017	16	8805	208	8526	3139
7-1	20-22	52.10	373573	18876	15	4407	251	9007	3943
7-1	123-125	53.13	365827	24409	10	3142	226	6969	3604
7-2	65-67	54.05	368717	22345	12	3734	294	8857	4753
7-5	126-128	59.16	368744	22326	10	3929	262	8598	4104
8-3	20-22	64.60	371864	20097	11	6504	501	12708	3554
8-7	21-23	70.61	371469	20380	10	5151	233	8403	3864
9-3	125-127	75.15	371368	20451	9	1892	103	5738	4623
9-7	15-17	80.05	369915	21490	9	2392	121	6897	4487
10-4	95-97	85.85	367672	23092	66	3593	192	6473	4111
10-5	44-46	86.84	353473	33234	8	3190	195	5811	3290
10-5	135-137	87.75	379331	14764	11	3940	326	7831	4407
11-2	5-7	91.45	370190	21293	18	3604	163	6890	4718
11-4	107-109	95.47	372289	19793	10	3222	163	7917	4581
11-5	51-53	96.41	366307	24066	15	3038	125	6365	3940
11-6	4-6	97.44	359425	28982	9	1522	89	5175	4144
11-6	107-109	98.47	396074	2805	25	669	385	125	680
11-7	55-57	99.45	367195	23432	8	1962	97	5086	3762
12-1	21-23	99.61	368380	22586	9	2171	126	5630	4177
12-1	123-125	100.63	371185	20582	9	2936	122	5338	4290
12-2	66-68	101.56	365203	24855	10	2685	117	5949	4535
12-3	20-22	102.60	373257	19102	10	3804	168	5926	4529
12-3	123-125	103.63	379226	14839	10	3788	222	6217	4637
12-7	22-24	108.62	368800	22286	12	2437	104	6109	4730
13-4	67-69	114.07	374644	18111	10	2572	97	5771	5407
13-5	22-24	115.12	370504	21068	9	2191	89	5585	5085
13-5	124-126	116.14	370497	21074	15	1994	86	4659	4354
13-6	72-74	117.12	365543	24612	9	2105	104	5211	4664
13-7	25-27	118.15	381290	13364	12	4704	264	8724	3990
14-1	21-23	118.61	379287	14795	11	2825	119	6864	5453
14-1	126-128	119.66	368532	22477	10	2910	107	5740	5446
14-2	14-16	120.04	377834	15833	8	3129	98	4262	4640
14-3	130-132	122.70	368719	22343	8	1995	107	4591	3988
14-4	64-66	123.54	369808	21566	9	2024	96	4930	4101
14-5	15-17	124.55	372435	19689	8	1738	93	4054	3937
15-2	74-76	130.14	368085	22797	36	2412	123	5178	4536
15-4	95-97	133.35	366239	24115	102	2334	129	5897	5316
16-3	11-13	140.51	359616	28846	12	2972	101	5822	6003
17-1	107-109	146.97	376904	16497	14	4297	278	6332	4875
17-4	64-66	151.04	364379	25444	8	2831	111	4935	3943
18-1	17-19	155.77	376299	16930	9	2883	114	4947	4313

TABLE B.3. Carbonate Fraction Bulk Geochemistry, Hole 821A (cont)

Core- Section	Interval	Depth (mbaf)	Ca (ppm)	Mg (ppm)	Ba (ppm)	Fe (ppm)	Mn (ppm)	Na (ppm)	Sr (ppm)
18-4	87-89	160.77	376241	16971	10	4109	170	5487	4489
20-1	16-18	175.06	346826	37982	9	5124	218	5020	3288
20-5	104-106	181.94	382831	12284	12	5602	261	6684	4463
22-6	62-64	202.02	371173	20591	11	4086	166	5315	3750
24-5	82-84	219.62	371917	20059	13	2129	100	4058	3227
25-4	63-65	227.63	370113	21348	32	4071	136	4909	3832
26-2	127-129	234.97	353642	33113	10	3787	164	3971	2403
26-6	133-135	241.03	381507	13209	13	5450	202	3197	2716
27-1	21-23	242.01	369282	21942	12	6327	180	4157	2662
27-3	129-131	246.09	387530	8907	11	7388	192	4933	3116
27-6	50-52	249.80	374662	18098	10	4472	102	4032	2290
28-6	63-65	259.53	379214	14847	38	6666	138	3632	2299
29-2	62-64	263.22	372160	19886	10	3677	87	3118	2014
29-6	45-47	269.05	376763	16598	13	5327	116	3390	2532
30-1	87-89	271.67	384371	11164	14	12734	333	3484	2810
30-7	6-8	279.86	374730	18050	60	3720	119	2305	1715
31-1	20-22	280.60	374890	17936	12	4526	128	4019	2400
31-2	83-85	282.73	359272	29091	19	11744	241	6695	2600
31-CC	33-35	287.86	375622	17413	19	8200	282	4528	2629
32-CC	14-16	290.24	382651	12392	22	11757	301	5783	3252
33-1	28-30	299.98	366944	23612	16	6744	148	5534	2424
33-2	129-131	302.34	370646	20967	14	7372	162	4769	2690
33-4	2-4	304.07	374470	18235	16	7937	172	4057	2750
33-6	80-82	307.85	381404	13283	19	8075	230	4253	2930
34-1	22-24	309.62	382644	12397	19	11191	352	7191	3998
34-2	129-131	312.19	345770	38736	26	20392	734	8302	2144
34-6	76-78	317.66	373178	19158	26	16831	319	8085	2610
36-3	85-87	331.61	368140	22757	30	8979	209	4866	2031
37-3	98-100	342.28	360616	28131	11	5409	232	1507	1997
38-2	112-114	350.52	372901	19356	27	9729	214	4290	2272
39-6	68-70	365.68	380871	13664	23	10503	229	4758	2997
41-6	16-18	384.46	374416	18274	28	10117	274	4411	2880
43-3	74-76	399.84	374019	18558	24	8324	235	3811	2950

TABLE B.4. Replicate ICP-AES Analyses of Limestone Standard

	Ca (ppm)	Mg (ppm)	Ba (ppm)	Fe (ppm)	Mn (ppm)	Na (ppm)	Sr (ppm)
	3974400	18285	7	326	239	79	401
	3974186	18438	6	300	250	67	405
	3973494	18933	5	263	253	97	436
	3975063	17812	6	337	243	69	434
	3975201	17714	5	333	243	65	434
	3976075	17089	10	380	236	140	412
	3974785	18010	10	697	246	853	426
	3964783	25155	7	770	336	179	563
	3973618	18844	10	409	237	173	412
	3973928	18623	5	883	266	98	397
	3961413	27562	11	564	388	111	691
	3956020	31414	9	706	429	125	746
	3963429	26122	8	672	371	137	642
	3964901	25071	8	649	369	106	638
mean	3970093	21362	8	521	293	164	503
st.dev.	6537	4669	2	206	69	202	125

TABLE B.5. Stable Isotopes in Dolomite, Hole 819A

Core- Section	Interval (cm)	Depth (mbsf)	O-18 (PDB)	C-13 (PDB)
4-6	22-24	35.22	4.06	-16.3
5-2	54-56	39.04	3.19	-20.16
5-2	147-149	39.97	3.57	-24.05
12-3	55-57	107.05	1.93	1.63
20-5	10-12	175.20	1.86	2.58
21-1	3-5	178.83	3.09	5.11
26-1	1-3	221.71	3.09	7.16

TABLE B.6. Stable Isotopes in Dolomite, Hole 820B

Core- Section	Interval (cm)	Depth (mbsf)	O-18 (PDB)	C-13 (PDB)
6-3	120-122	50.40	2.99	-2.36
13-6	75-77	120.95	-2.78	-0.99
17-1	15-17	150.85	1.18	-1.83
18-5	93-95	167.13	1.26	0.94

TABLE B.7. Stable Isotopes in Dolomite, Hole 821A

Core- Section	Interval (cm)	Depth (mbsf)	O-18 (PDB)	C-13 (PDB)
7-1	123-125	53.13	-7.86	-1.08
10-5	44-46	86.84	-2.15	-0.3
11-5	51-53	96.41	-3.04	0.69
14-4	64-66	123.51	-2.37	1.53
20-1	16-18	175.06	1.79	0.48
26-2	127-129	234.97	1.73	0.65
27-1	21-23	242.01	1.47	-0.54
34-2	129-131	312.19	0.01	-12.62
43-3	74-76	399.84	-0.31	-0.86

APPENDIX C

PETROGRAPHY

TABLE C.1. Thin Section Summary, Hole 819A 221.7 mbsf

Structures: bioturbation

Visual Estimates:

	Components	%	Characteristics
skeletal	foraminifera	10	fragmented & whole, 60-120 um
	phosphatic grains & bioclasts	5	fragmented, 30-80 um
detrital	clay mineral grains (chlorite)	trace	50 um
	quartz/feldspar	5	carbonate replacement, 70 um
authigenic	pyrite	2	framboids
	dolomite	75	euhedral, <10 um
	phosphorite	2	
porosity		1	

Classification: Dolomitic Mudstone (Dunham, 1962)

Point-Count Summary: (modal composition based on total mineralogy)

	Component	%
skeletal	planktic foraminifer	1.0
	benthic foraminifer	1.3
	skeletal calcite	4.7
	ghost skeleton	6.7
	phosphatic bioclast	0.3
	phosphatic grain	3.3
detrital	feldspar/quartz	5.3
	chlorite	0.3
authigenic	replacement dolomite	68.7
	pyrite	5.3
porosity	intragranular	0.3
	indeterminate	1.7

Classification: Dolomitic Mudstone (Dunham, 1962)

Comments:

Fabric-destructive replacement dolomitization; ghost and relic skeletal material; partial porosity occlusion of foraminiferal chambers and intergranular pore spaces.

TABLE C.2. Thin Section Summary, Hole 820B 123.9 mbsf

Visual Estimates:

	Components	%	Characteristics
skeletal	foraminifera	10	fragmented & whole, 160 um
	agglutinated foraminifera	1	300 um
	skeletal calcite	2	fragmented, 40 um
	pteropod	1	1.3-2.3 mm
	skeletal aragonite	5	fragmented, 300 um - 1.3 mm
	phosphatic grains	5	fragmented, 40-80 um
detrital	quartz/feldspar	6	carbonate replacement, 65 um
	chlorite	1	80 um
matrix	muddy intergranular matrix	35	<2 um
cement	AMC	20	inter/intragranular, 5 um
	sparry calcite	5	sweeping extinction; intragranular, 20 um
	palisade calcite	1	30 um
authigenic	pyrite	5	framboids
	glauconite	1	
	phosphorite	1	
porosity		1	intragranular

Classification: Bioclastic Wackestone (Dunham, 1962)

Point-Count Summary: (modal composition based on total mineralogy)

	Component	%
skeletal	planktic foraminifer	6.3
	benthic foraminifer	3.3
	agglutinated foraminifer	0.3
	pteropod	1.3
	ostracode	0.3
	skeletal calcite	10.0
	skeletal aragonite	2.3
	ghost skeleton	0.3
	phosphatic grain	2.7
	glauconitized grain	0.3
detrital	feldspar/quartz	5.0
matrix	intergranular matrix	37.7
cement	AMC	20.3
	sparry calcite cement	1.0
authigenic	pyrite	2.0
	phosphorite	0.7
	glauconite	1.7
	calcite replacement (qtz/fspar)	2.7
porosity	intragranular	1.3

Classification: Bioclastic Wackestone (Dunham, 1962)

Comments:

Partial intragranular fill by palisade and sparry calcite cement; test dissolution; anhedral microcrystalline calcite cement occurs as isolated domains within a muddy, intergranular matrix; in situ phosphatization and pyritization within foraminiferal chambers.

TABLE C.3. Thin Section Summary, Hole 820B 150.7 mbsf

Visual Estimates:

	Components	%	Characteristics
skeletal	foraminifera	15	100-400 um
	agglutinated foraminifera	<1	400 um
	skeletal calcite	10	60 um
	pteropod	1	1.5 mm
	phosphatic bioclasts	5	fragmented, 120 um
detrital	quartz/feldspar	15	carbonate replacement, 70 um
matrix	muddy intergranular matrix	20	< 2 um
cement	AMC	20	inter/intragranular, 5 um
	sparry calcite	5	sweeping extinction; intragranular, 20 um
	palisade calcite	<1	30 um
authigenic	pyrite	5	framboids
	glauconite	1	
	phosphorite	1	
porosity		1	intragranular

Classification: Muddy Allochem Limestone (Mount, 1985)

Point-Count Summary: (modal composition based on total mineralogy)

	Component	%
skeletal	planktic foraminifer	2.0
	benthic foraminifer	3.3
	agglutinated foraminifer	0.3
	pteropod	1.7
	cup coral	1.0
	skeletal calcite	11.3
	skeletal aragonite	1.7
	phosphatic grain	1.7
	phosphatic bioclast	0.3
	glauconitized grain	0.3
detrital	feldspar/quartz	4.7
	chlorite	1.3
matrix	intergranular matrix	27.3
cement	AMC	31.7
	sparry calcite	4.7
	palisade calcite	0.3
authigenic	pyrite	1.7
	phosphorite	1.3
	calcite replacement (qtz/fspar)	5.0

Classification: Bioclastic Wackestone (Dunham, 1962)

Comments:

Test dissolution; possible alteration of intragranular sparry calcite cement; anhedral microcrystalline calcite cement occurs as isolated domains within a muddy, intergranular matrix; in situ phosphatization and pyritization within foraminiferal chambers.

TABLE C.4. Thin Section Summary, Hole 820B 225.7 mbsf

Structures: bioturbation

Visual Estimates:

	Components	%	Characteristics
skeletal	foraminifera	10	fragmented & whole, 120 um
	skeletal calcite	10	fragmented, 80 um
	skeletal aragonite	2	fragmented, 80 um
	phosphatic bioclasts	2	fragmented, 80 um
detrital	quartz/feldspar	4	carbonate replacement, 70 um
	clay	<1	65 um
matrix	muddy intergranular matrix	35	< 2 um
cement	AMC	20	inter/intragranular, 5 um
	sparry calcite	5	sweeping extinction; intragranular, 20 um
	palisade calcite	1	30 um
authigenic	dolomite	5	< 10 um
	pyrite	1	framboids
	glauconite	1	
porosity		1	intragranular

Classification: Bioclastic Wackestone (Dunham, 1962)

Point-Count Summary: (modal composition based on total mineralogy)

	Component	%
skeletal	planktic foraminifer	1.3
	benthic foraminifer	2.7
	ghost skeleton	1.0
	skeletal calcite	12.3
	skeletal aragonite	1.3
	phosphatic grain	4.0
	phosphatic bioclast	1.3
	glauconitized grain	0.3
detrital	feldspar/quartz	2.7
matrix	intergranular matrix	34.0
cement	AMC	27.7
	sparry calcite	7.7
authigenic	replacement dolomite	1.3
	pyrite	0.7
	glauconite	0.3
	calcite replacement (qtz/fspar)	1.0
porosity	indeterminate	0.3

Classification: Bioclastic Wackestone (Dunham, 1962)

Comments:

Test dissolution; anhedral microcrystalline calcite cement occurs as isolated domains within a muddy, intergranular matrix; in situ phosphatization and pyritization within foraminiferal chambers; replacement dolomite.

TABLE C.5. Thin Section Summary, Hole 820B 259.5 mbsf

Visual Estimates:

	Components	%	Characteristics
skeletal	foraminifera	10	fragmented & whole, 160 um
	skeletal calcite	2	fragmented, 80 um
	skeletal aragonite	2	fragmented, 120-400 um
	phosphatic bioclasts	5	fragmented, 40 um
	glauconitized bioclasts	1	foraminiferal chambers, 40 um
detrital	quartz/feldspar	10	carbonate replacement at margins, 80 um
	clay	2	55 um
matrix	muddy intergranular matrix	37	< 2 um
cement	AMC	20	inter/intragranular, 5 um
	sparry calcite	5	sweeping extinction; intragranular, 20 um
authigenic	dolomite	1	replacement, < 10 um
	pyrite	2	framboids
	phosphorite	1	
	glauconite	1	
porosity		1	intragranular

Classification: Muddy Micrite (Mount, 1985)

Point-Count Summary: (modal composition based on total mineralogy)

	Component	%
skeletal	planktic foraminifer	1.7
	benthic foraminifer	1.7
	pteropod	1.0
	ghost skeleton	2.0
	skeletal calcite	6.3
	skeletal aragonite	0.7
	phosphatic grain	2.7
	phosphatic bioclast	1.0
	glauconitized grain	0.3
detrital	feldspar/quartz	8.0
	chlorite	1.0
matrix	intergranular matrix	39.7
cement	AMC	16.7
	sparry calcite	5.3
authigenic	replacement dolomite	1.0
	pyrite	4.0
	phosphorite	0.7
	calcite replacement (qtz/fspar)	5.7

Classification: Bioclastic Wackestone (Dunham, 1962)

Comments:

Test dissolution: anhedral microcrystalline calcite cement occurs as isolated domains within a muddy, intergranular matrix; in situ phosphatization, glauconitization, and pyritization within foraminiferal chambers; replacement dolomite.

TABLE C.6. Thin Section Summary, Hole 820B 280.5 mbsf

Structures: bioturbation			
Visual Estimates:			
	Components	%	Characteristics
skeletal	foraminifera	10	whole, 50-600 um
	skeletal calcite	5	fragmented, 100 um
	skeletal aragonite	1	fragmented, 100 um
	glauconitized bioclasts	1	fragmented, 65 um
	phosphatic bioclasts	2	fragmented, 115 um
	echinoid spine	< 1	1.3 mm
detrital	quartz/feldspar	15	carbonate replacement, 80 um
	clays	< 1	65 um
matrix	muddy intergranular matrix	29	< 2 um
cement	AMC	25	inter/intragranular, 5 um
	sparry calcite	5	sweeping extinction; intragranular, 20 um
authigenic	dolomite	< 1	replacement < 10 um
	pyrite	5	framboids
porosity		1	intragranular

Classification: Muddy Allochem Limestone (Mount, 1985)

Point-Count Summary: (modal composition based on total mineralogy)

	Component	%
skeletal	planktic foraminifer	0.7
	benthic foraminifer	2.3
	skeletal calcite	6.0
	skeletal aragonite	0.7
	phosphatic grain	1.3
	phosphatic bioclast	2.3
detrital	feldspar/quartz	7.0
	chlorite	1.0
matrix	intergranular matrix	33.3
cement	AMC	30.7
	sparry calcite	3.3
authigenic	pyrite	2.3
	phosphorite	0.3
	calcite replacement (qtz/fspar)	9.0

Classification: Bioclastic Mudstone (Dunham, 1962)

Comments:

Test dissolution; possible alteration of intragranular sparry calcite cement; anhedral microcrystalline calcite cement occurs as isolated domains within a muddy, intergranular matrix; in situ phosphatization and pyritization within foraminiferal chambers.

TABLE C.7. Thin Section Summary, Hole 820B 363.2 mbsf

Structures: bioturbation with Fe-rich margin

Visual Estimates:

	Components	%	Characteristics
skeletal	foraminifera	5	fragmented & whole, 80 um
	skeletal calcite	5	fragmented, 120 um
	pteropod	5	120 um
	skeletal aragonite	5	fragmented, 65 um
	phosphatic bioclasts	5	fragmented, 60 um
detrital	quartz/feldspar	5	carbonate replacement, 100 um
	clay	1	80 um
matrix	muddy intergranular matrix	25	< 2 um
cement	AMC	20	inter/intragranular, 5 um
	sparry calcite	5	sweeping extinction; intragranular, 20 um
authigenic	dolomite	15	replacement, < 10 um
	ferroan dolomite	5	replacement, < 10 um
	pyrite	2	framboids
	glauconite	1	
porosity		1	intragranular

Classification: Bioclastic Wackestone (Dunham, 1962)

Point-Count Summary: (modal composition based on total mineralogy)

	Component	%
skeletal	benthic foraminifer	1.0
	ghost skeleton	0.3
	skeletal calcite	3.7
	skeletal aragonite	0.3
	phosphatic grain	1.7
	glauconitized grain	0.3
detrital	feldspar/quartz	2.7
matrix	intergranular matrix	29.0
cement	AMC	23.7
	sparry calcite	19.7
authigenic	replacement dolomite	8.7
	pyrite	1.3
	phosphorite	1.0
	glauconite	0.3
	calcite replacement (qtz/fspar)	5.7
porosity	intragranular	0.3

Classification: Bioclastic Mudstone (Dunham, 1962)

Comments:

Test dissolution; anhedral microcrystalline calcite cement occurs as isolated domains within a muddy, intergranular matrix; in situ pyritization within foraminiferal chambers; replacement dolomite and ferroan dolomite.

TABLE C.8. Thin Section Summary, Hole 820B 372.4 mbsf

Structures: bioturbation

Visual Estimates:

	Components	%	Characteristics
skeletal	foraminifera	1	fragmented & whole, 80 um
	skeletal calcite	5	fragmented, 65 um
	pteropod	3	65 um
	skeletal aragonite	5	fragmented, 60 um
	glauconitic bioclasts	<1	40 um
	phosphatic bioclasts	2	fragmented, 50 um
detrital	quartz/feldspar	20	carbonate replacement, 70 um
matrix	muddy intergranular mat	x 20	< 2 um
cement	AMC	20	inter/intragranular, 5 um
	sparry calcite	10	sweeping extinction; intragranular, 20 um
authigenic	dolomite	1	replacement, < 10 um
	pyrite	3	framboids
	phosphorite	<1	
porosity		1	intragranular

Classification: Muddy Allochem Limestone (Mount, 1985)

Point-Count Summary: (modal composition based on total mineralogy)

	Component	%
skeletal	planktic foraminifer	0.7
	benthic foraminifer	0.7
	ghost skeleton	0.3
	skeletal calcite	1.7
	phosphatic grain	1.3
	glauconitized grain	0.3
detrital	feldspar/quartz	4.7
matrix	intergranular matrix	34.3
cement	AMC	23.0
	sparry calcite	21.0
authigenic	replacement dolomite	0.7
	pyrite	2.7
	phosphorite	0.3
	calcite replacement (qtz/fspar)	8.3

Classification: Mudstone (Dunham, 1962)

Comments:

Test dissolution; anhedral microcrystalline calcite cement occurs as isolated domains within a muddy, intergranular matrix; in situ phosphatization and pyritization within foraminiferal chambers; rare replacement dolomite.

TABLE C.9. Thin Section Summary, Hole 820B 398.3 mbsf

Visual Estimates:

	Components	%	Characteristics
skeletal	foraminifera	10	fragmented & whole, 125 um
	skeletal calcite	5	fragmented, 120 um
	skeletal aragonite	1	fragmented, 120 um
	phosphatic bioclasts	5	fragmented, 80 um
detrital	quartz/feldspar	5	carbonate replacement, 80 um
	chlorite	<1	90 um
matrix	muddy intergranular matrix	10	< 2 um
authigenic	ferroan dolomite	56	acts as cement, < 10 um
	pyrite	5	framboids
	glauconite	<1	
	phosphorite	1	
porosity		2	intragranular

Classification: Dolomitic Mudstone (Dunham, 1962)

Point-Count Summary: (modal composition based on total mineralogy)

	Component	%
skeletal	planktic foraminifer	2.0
	benthic foraminifer	4.0
	ghost skeleton	6.7
	skeletal calcite	4.3
	phosphatic grain	1.3
detrital	feldspar/quartz	7.7
matrix	intergranular matrix	13.7
authigenic	ferroan dolomite	50.7
	pyrite	3.0
	calcite replacement (qtz/fspar	6.0
porosity	intragranular	0.7

Classification: Dolomitic Mudstone (Dunham, 1962)

Comments:

Ferroan dolomite replacement is fabric-destructive; test dissolution; ghost skeletal material.

TABLE C.10. Thin Section Summary, Hole 821A 120 0 mbsf

Visual Estimates:

	Components	%	Characteristics
skeletal	foraminifera	5	fragmented & whole, 195 um
	agglutinated foraminifera	2	400 um
	skeletal calcite	5	fragmented, 95 um
	pteropod	1	fragmented, 750 um
	echinoid spine	1	750 um
	skeletal aragonite	5	fragmented, 155 um
	phosphatic bioclasts	5	fragmented, 65 um
detrital	quartz/feldspar	5	carbonate replacement, 80 um
matrix	muddy intergranular matrix	20	< 2 um
cement	AMC	40	inter/intragranular, 5 um
	sparry calcite	5	sweeping extinction; intragranular, 20 um
	palisade calcite	1	25 um
authigenic	dolomite	1	replacement, < 10 um
	pyrite	1	framboids
	glauconite	1	
	phosphorite	1	
porosity		1	intragranular

Classification: Bioclastic Wackestone (Dunham, 1962)

Point-Count Summary: (modal composition based on total mineralogy)

	Component	%
skeletal	planktic foraminifer	2.0
	benthic foraminifer	2.7
	pteropod	0.3
	skeletal calcite	8.3
	skeletal aragonite	1.7
	phosphatic grain	1.0
	phosphatic bioclast	1.7
	glauconitized grain	1.7
detrital	feldspar/quartz	1.0
matrix	intergranular matrix	19.7
cement	AMC	41.7
	sparry calcite	11.0
authigenic	replacement dolomite	0.7
	pyrite	1.3
	phosphorite	1.7
	calcite replacement (qtz/fspar	3.0
	intragranular porosity	1.0

Classification: Bioclastic Wackestone (Dunham, 1962)

Comments:

Partial intragranular fill by palisade and sparry calcite cement; test dissolution; anhedral microcrystalline calcite cement occurs as isolated domains within a muddy, intergranular matrix; in situ phosphatization and pyritization within foraminiferal chambers; rare replacement dolomite.

TABLE C.11 Thin Section Summary, Hole 821A 137.4 mbsf

Visual Estimates:

	Components	%	Characteristics
skeletal	foraminifera	4	fragmented & whole, 120 um
	agglutinated foraminifera	1	315 um
	skeletal calcite	10	fragmented, 50 um
	pteropod	1	80 um - 2 mm
	skeletal aragonite	1	fragmented, 80 um
	glauconitized bioclasts	1	80 um
	phosphatic bioclasts	2	fragmented, 95 um
detrital	quartz/feldspar	10	carbonate replacement, 90 um
matrix	muddy intergranular matrix	15	< 2 um
cement	AMC	35	inter/intragranular, 5 um
	sparry calcite	15	sweeping extinction; intragranular, 20 um
	palisade calcite	1	25 um
authigenic	pyrite	1	framboids
	glauconite	1	
	phosphorite	1	
porosity		1	intragranular

Classification: Muddy Micrite (Mount, 1985)

Point-Count Summary: (modal composition based on total mineralogy)

	Component	%
skeletal	planktic foraminifer	0.6
	benthic foraminifer	0.3
	ghost skeleton	0.3
	skeletal calcite	9.0
	skeletal aragonite	0.3
	phosphatic grain	2.0
	phosphatic bioclast	1.0
detrital	feldspar/quartz	3.3
matrix	intergranular matrix	11.7
cement	AMC	39.7
	sparry calcite cement	21.7
authigenic	pyrite	2.7
	phosphorite	0.3
	calcite replacement (qtz/fspar)	7.0

Classification: Bioclastic Mudstone (Dunham, 1962)

Comments:

Partial intragranular fill by palisade and sparry calcite cement; test dissolution; anhedral microcrystalline calcite cement occurs as isolated domains within a muddy, intergranular matrix; in situ phosphatization and pyritization within foraminiferal chambers; in situ glauconitization crosses grain boundaries.

TABLE C.12. Thin Section Summary, Hole 821A 342.3 mbsf

Structures: bioturbation

Visual Estimates:

	Components	%	Characteristics
skeletal	foraminifera	5	fragmented & whole, 120 um
	ostracode	1	80 um
	skeletal calcite	2	fragmented, 65 um
	skeletal aragonite	1	fragmented, 133 um
	phosphatic bioclasts	2	fragmented, 70 um
detrital	quartz/feldspar	5	carbonate replacement, 65 um
	chlorite	1	65 um
matrix	muddy intergranular matrix	30	< 2 um
cement	AMC	5	inter/intragranular, 5 um
	sparry calcite	20	sweeping extinction; intragranular, 20 um
authigenic	dolomite	30	replacement, < 10 um
	pyrite	5	framboids
	glauconite	1	
porosity		1	intragranular

Classification: Mudstone (Dunham, 1962)

Point-Count Summary: (modal composition based on total mineralogy)

	Component	%
skeletal	planktic foraminifer	3.0
	benthic foraminifer	2.3
	pteropod	0.3
	ghost skeleton	0.3
	skeletal calcite	4.7
	phosphatic grain	0.3
	phosphatic bioclast	1.3
	glauconitized grain	1.0
detrital	feldspar/quartz	2.0
matrix	intergranular matrix	12.0
cement	AMC	14.0
	sparry calcite	36.0
authigenic	replacement dolomite	19.7
	pyrite	1.7
porosity	intragranular	0.3

Classification: Mudstone (Dunham, 1962)

Comments:

Partial intragranular fill by sparry calcite cement; test dissolution; anhedral microcrystalline calcite cement occurs as isolated domains within a muddy, intergranular matrix; in situ pyritization within foraminiferal chambers.

APPENDIX D

Mg BALANCE CALCULATION

Mg BALANCE CALCULATION

How much magnesium is available in the original Mg-calcite input in 1 g of sediment?

Assume 11 mole % MgCO_3 in magnesian calcite (average composition).

Assume 70% carbonate content of which 50% is Mg-calcite.

$$\frac{0.11 \text{ mole MgCO}_3 \cdot 84.3 \text{ g MgCO}_3}{\text{mole}(\text{Mg}_{0.11}\text{Ca}_{0.89})\text{CO}_3} \cdot \frac{\text{mole MgCO}_3}{97.7 \text{ g}(\text{Mg}_{0.11}\text{Ca}_{0.89})\text{CO}_3} \cdot 0.5 \times 0.7 \cdot \frac{24.3 \text{ g Mg}}{84.3 \text{ g MgCO}_3} = 0.00958 \text{ mole Mg}$$

or 958 ppm Mg is made available by dissolution of magnesian calcite.

How much magnesium is necessary to precipitate dolomite in 1 g of sediment?

Assume stoichiometric dolomite with 50 mole % MgCO_3 .

Assume 85.3% carbonate content of which 77% is dolomite (e.g., 221.7 mbsf, Hole 819A).

$$\frac{0.5 \text{ mole MgCO}_3 \cdot 84.3 \text{ g MgCO}_3}{\text{mole}(\text{Mg}_{0.5}\text{Ca}_{0.5})\text{CO}_3} \cdot \frac{\text{mole MgCO}_3}{92.2 \text{ g}(\text{Mg}_{0.5}\text{Ca}_{0.5})\text{CO}_3} \cdot 0.77 \times 0.853 \cdot \frac{24.3 \text{ g Mg}}{84.3 \text{ g MgCO}_3} = 0.08655 \text{ mole Mg}$$

or 8655 ppm Mg is required to precipitate dolomite.

Since more Mg is required to precipitate dolomite than can be available from magnesian calcite dissolution, there must be another Mg source (e.g., seawater 1.29×10^3 ppm; Brown *et al.*, 1989).

END

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