Davies, P. J., McKenzie, J. A., Palmer-Julson, A., et al., 1991
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3. PRINCIPAL RESULTS AND SUMMARY[1]

Shipboard Scientific Party[2]

INTRODUCTION

The 9300-km^2 northeastern Australian margin represents the largest area of neritic carbonate deposition currently on Earth (Fig. 1). As explained in the "Introduction" chapter (this volume), its tectonic setting on a young passive margin proximal to major depocenters makes it of immense scientific interest as an analog for similar associations that have occurred repeatedly throughout geological time. The overall objectives of Leg 133 were (1) to define the evolution of these platforms, including their relationships to adjoining basins, and (2) to understand the effects of climate and sea level on their development in space and time. While achieving these objectives, more than 5.5 km of core was recovered from 36 holes at 16 sites (811–826) during a 68-day cruise out of Guam, U.S.A., from 4 August to 11 October 1990. A total of 51 days were spent on the site, while 12 days were spent in transit and 5 days in port.

Specific scientific objectives of Leg 133 were to define the following:

1. Sedimentary response to changes in global sea levels in the late Cenozoic and, in particular, the Quaternary.
2. Influences of paleochemistry, paleoclimate, and paleoceanography on the initiation, growth, and demise of carbonate platforms, including the Great Barrier Reef.

Secondary objectives included investigations of the following:

1. Variations in slope-to-basin stratigraphy and facies on both sides of rift basins.
2. Diagenetic history and processes that are operating on pure carbonate and mixed carbonate/siliciclastic margins.

This chapter provides a summary of drilling results from each site (see Figs. 2 and 3). Coring statistics for Leg 133 appear in Table 1.

SITES 811/825

Site 811 (proposed Site NEA-8) is located on the western margin of Queensland Plateau, 3.5 nmi east of Holmes Reef. The site was intended to sample a periplatform sequence on the Queensland Plateau and to determine sea levels and climatic signals for comparison with Sites 819 through 821 (proposed Sites NEA-1 through NEA-3).

Site 825 was a reoccupation of Site 811 in an attempt to reach our basement objective and to recover additional sediments from poorly recovered intervals at Site 811.

[1] Davies, P. J., McKenzie, J. A., Palmer-Julson, A., et al., 1991. *Proc. ODP, Init. Repts.*, 133: College Station, TX (Ocean Drilling Program).

[2] Shipboard Scientific Party is as given in list of participants preceding the contents.

Results

Drilling at Site 811 penetrated a 392.5-m-thick sequence of calcareous (99% $CaCO_3$) early-middle Eocene to Pleistocene platform-top sediments. On the basis of benthic foraminifer assemblages, the depositional site was estimated as at middle bathyal paleobathymetric depth (600–1000 m) for at least the last 10 m.y. Below 200 mbsf, reworking and redeposition of shallower-water deposits are indicated by the occurrence of larger benthic foraminifers. Below 270 mbsf, redeposited skeletal grains document the transition to a neritic environment, possibly fore- or back-reef. Sedimentation rates for the upper 270 mbsf were relatively low for a carbonate platform environment and ranged between 1.5 and 3 cm/k.y. Variations in the rate can be attributed to varying amounts of bank-derived carbonate detritus and to removal of finer fractions by winnowing.

Six major lithologic units were recovered:

1. *Unit I* (0–33.15 mbsf; upper Pleistocene to upper Pliocene, 1.8–2.5 Ma): foraminifer oozes with nannofossils and nannofossil oozes with foraminifers, intercalated with redeposited shallow-water carbonate sediments composed of unlithified bioclastic packstones with nannofossils and lithoclastic rudstones.
2. *Unit II* (33.15–147.5 mbsf; upper Pliocene to upper Miocene, 2.4–8.75 Ma): homogeneous nannofossil oozes with foraminifers to foraminifer oozes with nannofossils.
3. *Unit III* (147.5–269.5; upper to middle Miocene, 8.75–12.5 Ma): periplatform oozes and chalks, which alternate with numerous 10- to 70-cm-thick bioclastic foraminifer wackestone, packstone, lithoclast floatstone, and rudstone layers; these commonly fine upward.
4. *Unit IV* (269.5–356.3 mbsf; middle to lower Miocene, 12.5–[?]Ma): redeposited sand and rubble package containing mostly skeletal grains, such as coral debris, alcyonarian spicules, mollusk fragments, small and larger benthic foraminifers (amphisteginids, miliolids, textularians), echinoids, crustaceans, bryozoans, and red algae.
5. *Unit V* (356.3–365.9 mbsf; upper Oligocene, [?] Ma): a unit having poor recovery of unlithified to well-cemented, fine-grained skeletal packstone that contains abundant planktonic foraminifers in a micritic matrix composed of silt-sized bioclastic particles.
6. *Unit VI* (365.9–392.5 mbsf; lower to middle Eocene): a pebble of shallow-water limestone was recovered from this interval; it may represent the sedimentary cover overlying basement at this site.

Hole 825A was washed to 200 mbsf after the retrieval of a 4.5-m APC mud-line core. APC/XCB drilling then penetrated to 381.5 mbsf, followed by RCB drilling of Hole 825B between 379.5 and 466.3 mbsf, with basement contact at ~453 mbsf.

The continental basement is a possible quartz-feldspar-mafic(?) metasediment or metavolcanic rock. Accurate identification of the rock type will require shore-based analysis of

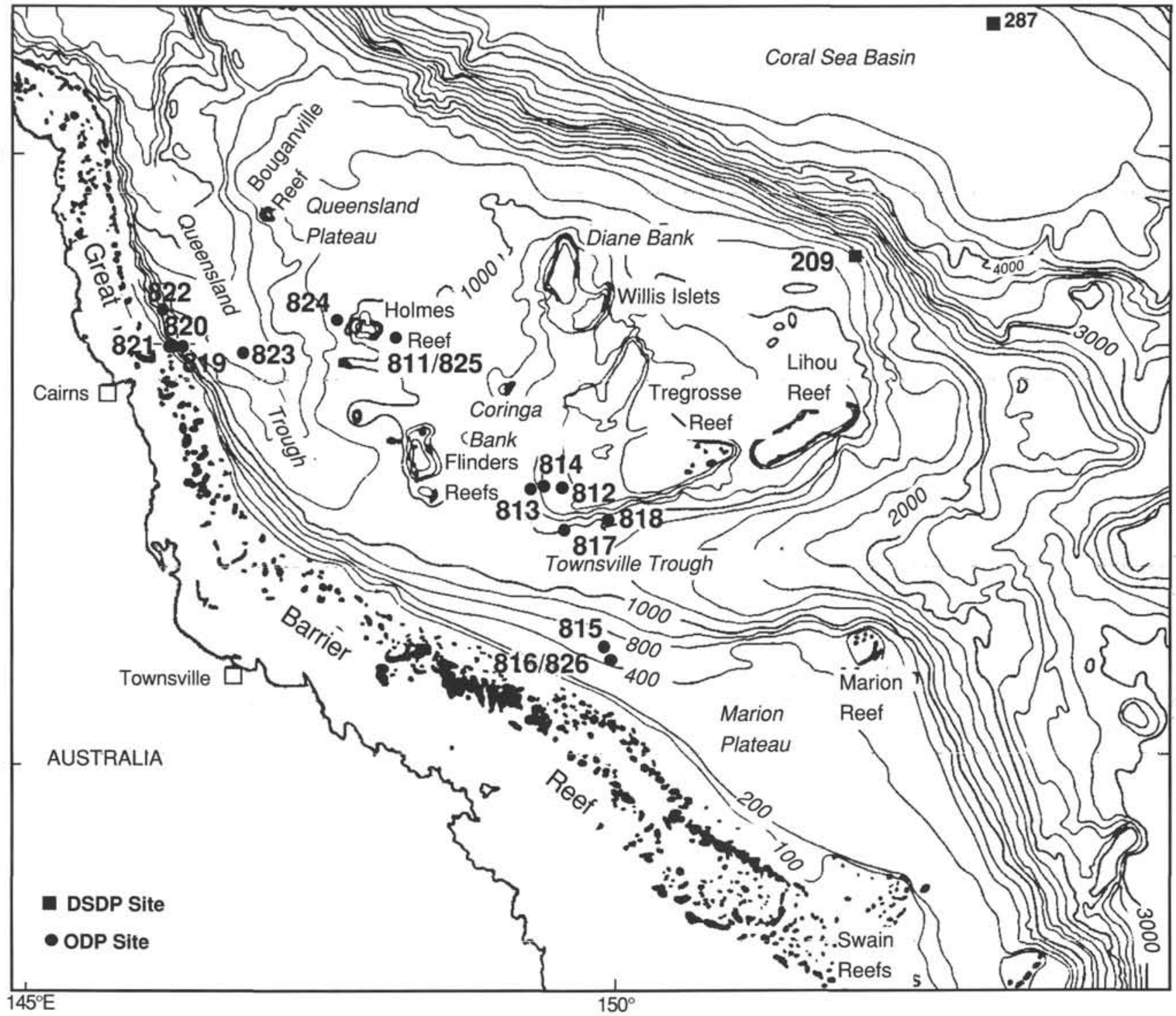

Figure 1. Map of northeast Australian margin showing Leg 133 drill sites. Bathymetry in meters.

thin sections. The age of the bioclastic grainstone and rudstone representing the inner-shelf facies that transgressed over the basement cannot be determined precisely, but sparse coccoliths indicate a range from middle Eocene to early Miocene. An age interpretation based on the abundant larger benthic foraminifers obtained in Hole 825B will be forthcoming after shore-based analyses of thin sections.

Five lithologic units (possibly six, based on the recovery of a single pebble dated as early to middle Eocene) were defined for the Site 811 sedimentary sequence. The sediments recovered at Site 825 correspond to these units in part; however, with the deeper penetration, Hole 825B extended below the level of the lowest Unit VI section defined at Site 811. Therefore, the same unit designations were used for Site 825 sediments, with a redefinition of Unit VI on the basis of better recovery and an additional Unit VII to include the basement rock. Note that Units II and V, recognized at Site 811, were not recovered at Site 825. These lithologic units are defined as follows:

1. *Unit I* (0–4.5 mbsf; upper Pleistocene): nannofossil foraminifer micritic ooze with interbeds of thin foraminifer pteropod packstone layers, which have been interpreted as calciturbidites. These sediments correlate with the Pleistocene periplatform ooze of Subunit IA at Site 811.

2. No sediments from Site 811 *Unit II* were cored at Site 825.

3. *Unit III* (200.0–276.4 mbsf; middle Miocene): white micritic ooze and chalk with nannofossils and foraminifers alternating with white unlithified to partially lithified bioclastic packstone and floatstone, similar to the series of deep-water periplatform ooze and chalk alternating with gravity-flow deposits recovered at Site 811 in the same depth interval.

4. *Unit IV* (305.4–315.0 mbsf; upper lower Miocene): white lithified bioclastic packstone with foraminifers and yellow indurated bioclastic rudstone with larger benthic foraminifers, coralline algae, and coral molds, as observed at Site 811.

5. No sediments from Site 811 *Unit V* were recovered at Site 825.

6. *Unit VI* (408.4–453 mbsf; middle Eocene to lower Miocene, probably upper Oligocene): white and pale yellow to yellow, alternating with more pinkish levels, indurated, well-sorted bioclastic grainstone and rudstone. The dominant bioclasts are coralline algae, echinoids, mollusks, and small

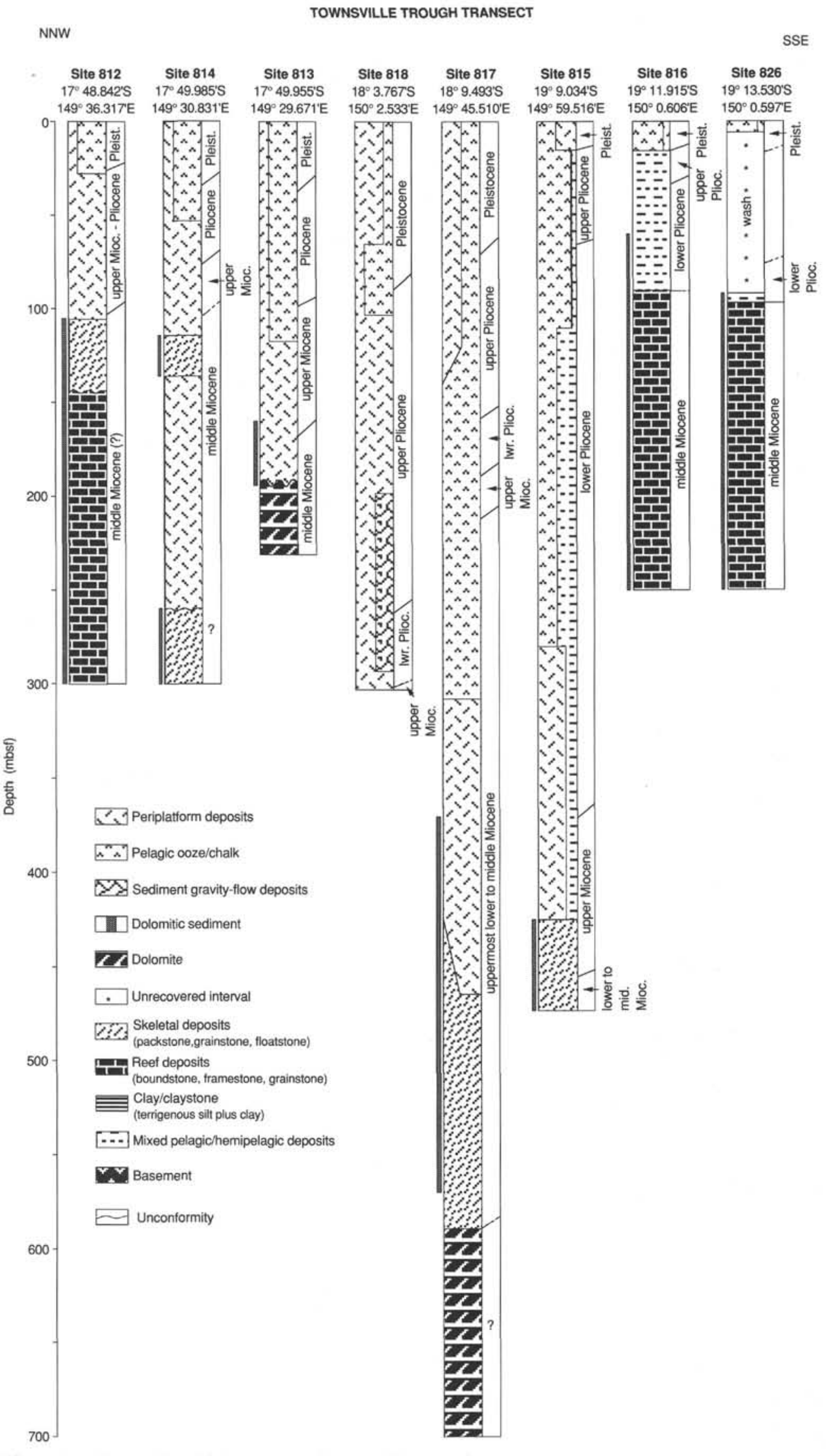

Figure 2. Lithostratigraphic summary of Townsville Trough transect.

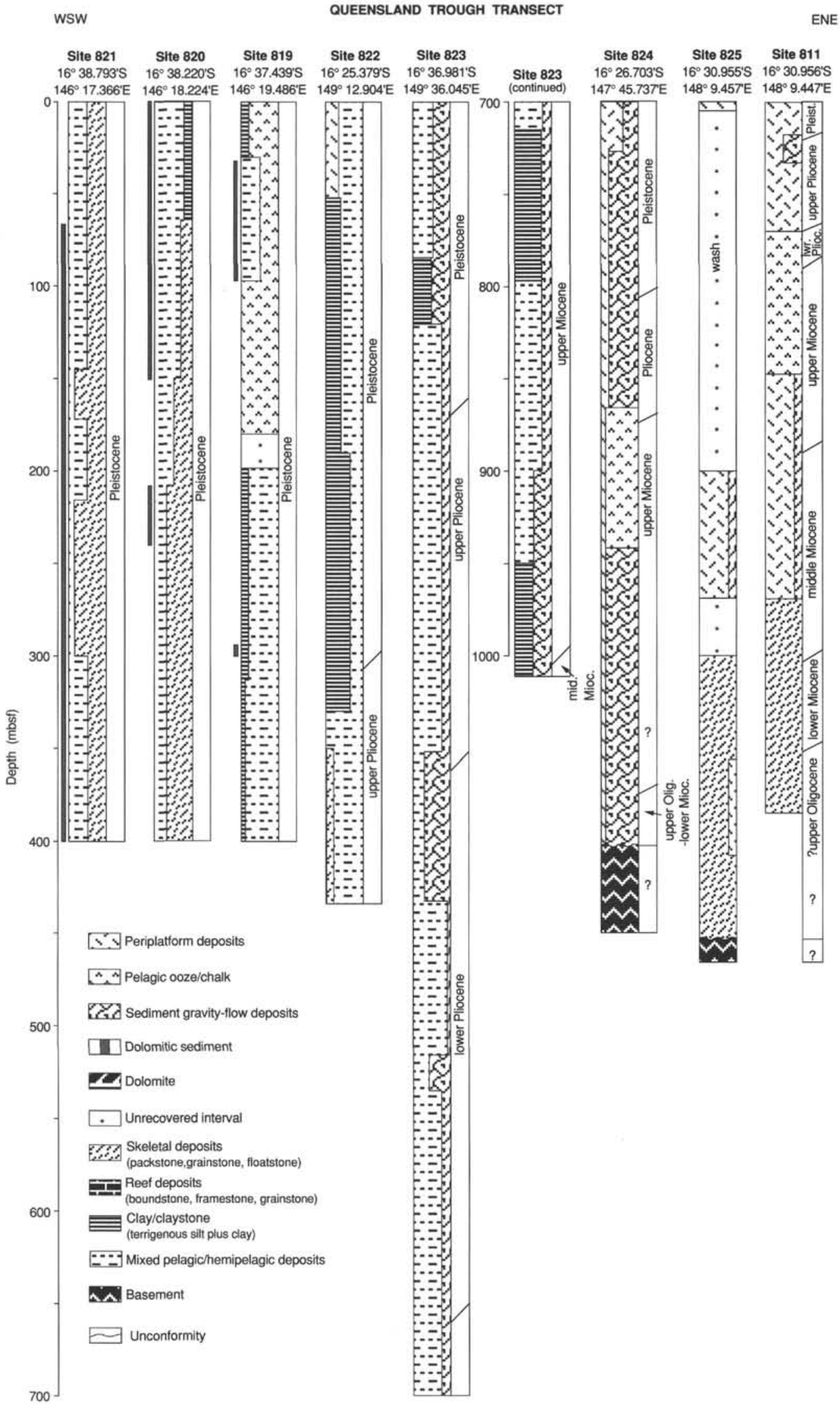

Figure 3. Lithostratigraphic summary of Queensland Trough transect.

Table 1. Coring statistics for Leg 133.

Hole	Dates occupied (1990)	Latitude	Longitude	Water depth (m)	Penetr. (m)	Number of cores	Interval cored (m)	Length recov. (m)	Recovery (%)
811A	17 Aug.–17 Aug.	16°30.977′S	148°9.436′E	937.1	213.6	23	214.5	213.2	99.4
811B	17 Aug.–19 Aug.	16°30.948′S	148°9.454′E	937.0	392.5	24	199.3	15.5	7.8
811C	20 Aug.–20 Aug.	16°30.942′S	148°9.451′E	936.8	55.2	6	55.2	55.3	100.1
812A	20 Aug.–21 Aug.	17°48.841′S	149°36.313′E	461.6	189.9	22	189.9	40.7	21.4
812B	22 Aug.–23 Aug.	17°48.842′S	149°36.306′E	461.6	300.0	18	149.2	8.5	5.7
812C	26 Aug.–27 Aug.	17°48.842′S	149°36.331′E	461.9	137.8	16	137.8	114.1	82.8
813A	24 Aug.–24 Aug.	17°49.959′S	149°29.669′E	539.1	231.5	26	231.6	199.4	86.1
813B	24 Aug.–25 Aug.	17°49.951′S	148°29.673′E	538.9	190.0	21	190.0	196.2	103.2
814A	25 Aug.–26 Aug.	17°49.985′S	149°30.831′E	520.4	300.0	33	300.0	162.4	54.1
815A	27 Aug.–30 Aug.	19°9.034′S	149°59.508′E	465.5	473.5	51	473.5	416.2	87.9
815B	30 Aug.–31 Aug.	19°9.034′S	149°59.524′E	465.9	36.4	4	36.4	37.8	103.8
816A	31 Aug.–31 Aug.	19°11.924′S	150°0.608′E	437.8	111.5	15	111.5	97.5	87.5
816B	31 Aug.–1 Sept.	19°11.911′S	150°0.601′E	437.8	77.2	9	77.2	10.5	13.6
816C	1 Sept.–2 Sept.	19°11.911′S	150°0.608′E	437.8	250.0	13	109.6	11.3	10.3
817A	3 Sept.–4 Sept.	18°9.496′S	149°45.494′E	1016.6	330.7	35	330.7	280.4	84.8
817B	4 Sept.–4 Sept.	18°9.487′S	149°45.505′E	1015.7	204.0	22	204.0	211.1	103.5
817C	4 Sept.–4 Sept.	18°9.489′S	149°45.534′E	1016.1	27.2	3	27.2	27.3	100.2
817D	4 Sept.–8 Sept.	18°9.499′S	149°45.509′E	1015.8	700.0	47	430.0	22.2	5.2
818A	8 Sept.–8 Sept.	18°3.767′S	150°2.533′E	748.7	9.6	1	9.5	9.6	101.0
818B	8 Sept.–9 Sept.	18°3.767′S	150°2.533′E	744.8	302.9	32	302.9	314.6	103.9
819A	9 Sept.–12 Sept.	16°37.439′S	146°19.486′E	565.2	400.0	44	400.0	339.5	84.9
820A	12 Sept.–12 Sept.	16°38.221′S	146°18.229′E	278.0	144.3	17	144.3	146.1	101.3
820B	12 Sept.–14 Sept.	16°38.219′S	146°18.218′E	279.0	400.0	44	400.0	324.9	81.2
821A	15 Sept.–16 Sept.	16°38.793′S	146°17.376′E	212.8	400.0	43	400.0	382.9	95.7
821B	16 Sept.–17 Sept.	16°38.794′S	146°17.366′E	211.3	165.9	20	165.9	167.4	100.9
822A	17 Sept.–20 Sept.	16°25.379′S	149°12.904′E	955.2	433.9	47	433.9	387.5	89.3
823A	21 Sept.–21 Sept.	16°36.981′S	146°47.037′E	1638.4	119.8	13	119.8	123.7	103.3
823B	21 Sept.–26 Sept.	16°36.982′S	146°47.053′E	1637.9	805.4	84	805.4	754.7	93.7
823C	26 Sept.–30 Sept.	16°36.983′S	146°47.066′E	1637.8	1,011.0	24	227.0	186.1	82.0
824A	1 Oct.–3 Oct.	16°26.704′S	147°45.737′E	1000.4	377.3	36	327.3	129.7	39.6
824B	3 Oct.–3 Oct.	16°26.703′S	147°45.720′E	1001.9	52.5	6	52.5	53.3	101.5
824C	3 Oct.–4 Oct.	16°26.705′S	147°45.753′E	1000.3	183.2	19	183.2	3.2	1.7
824D	4 Oct.–6 Oct.	16°26.690′S	147°45.753′E	1001.9	96.5	10	96.5	1.1	1.1
825A	6 Oct.–7 Oct.	16°30.948′S	148°9.458′E	939.4	381.5	23	186.0	54.4	29.2
825B	7 Oct.–8 Oct.	16°30.961′S	148°9.457′E	939.3	466.3	10	86.8	3.0	3.5
826A	8 Oct.–10 Oct.	19°13.530′S	150°0.597′E	425.3	250.0	18	156.5	7.1	4.5
		Leg 133 totals			10,221.1	879	7,965.1	55,105.5	69.2

branching corals. Primary intergranular porosity is well preserved, with only minimum moldic porosity. The interpreted depositional environment is temperate-to-subtropical waters on the inner neritic shelf. These sediments probably represent the transgressive facies overlying continental basement.

7. *Unit VII* (453–466.3 mbsf; age unknown): the basement rock is dark gray, poorly foliated, well-lithified, fine-grained quartz-feldspar-mafic(?) metasediment(?) or metavolcanic(?) containing more coarsely crystalline zones of quartz and feldspar. Thin discontinuous quartz or feldspar veinlets are present, and disseminated pyrite is common.

SITE 812

Site 812 (proposed Site NEA-10A/1) is located on the southern margin of Queensland Plateau, between the Flinders and Tregrosse reefs. This site represents the lagoonal-bank end-member of a three-site transect (together with Sites 813 and 814) intended for studying facies distribution in response to changes in sea level across a platform-slope transition in a pure carbonate system.

Results

Drilling penetrated a 300-m-thick sequence of platform-top sediments (average 97% $CaCO_3$) that ranged in age from middle Miocene to Pleistocene. Benthic foraminifers indicate deepening from a neritic setting (0–200 m) in the late Miocene to early Pliocene to upper bathyal (200–600 m) during the late Pliocene and Pleistocene. Middle Miocene sedimentation occurred in a shallow-water, lagoonal, or back-reef environment.

Latest Pliocene and Pleistocene sedimentation rates are slightly more than 1 cm/k.y., whereas early Pliocene rates were ~0.5 cm/k.y. A hardground or condensed horizon separating lower Pliocene (Hole 812A) or uppermost upper Miocene (Hole 812C) from the overlying upper Pliocene sediments is consistent with that interpretation. Shipboard paleomagnetic studies revealed a good reversal stratigraphy downward into the upper Pliocene and recorded the top of the Olduvai event (1.88 Ma) above the hardground.

Three major lithologic units were recovered and are described as follows:

1. *Unit I* (0–27.9 mbsf; upper Pliocene to Pleistocene): Unit I contains white foraminiferal oozes with pteropods and bioclasts that consist of fine-grained planktonic foraminiferal debris and bryozoan particles.

2. *Unit II* (27.9–141.6 mbsf; upper Pliocene to middle or lower upper Miocene): micritic chalks, variably containing foraminifers and nannofossils; bryozoan mollusk floatstones; dolomitic packstones. A 1.5-m-thick, white to light gray,

dolomitized limestone hardground with a condensed upper surface separates Unit I from Unit II. The capping surface is composed of light reddish brown to brownish fine laminations, presumably iron oxides and phosphate coatings. The degree of induration decreases downward from lithified grainstone to unlithified packstone.

3. *Unit III* (141.6–300.0 mbsf; middle Miocene?): based on downhole logs, the contact between Unit II and Unit III is sharp, with marked increases in resistivity, velocity, and uranium content between 141 and 145 mbsf; dolomitized coralline algal packstones, bioclastic floatstones and wackestones, and coralline algal rudstones.

SITE 813

Site 813 (proposed Site NEA-10A/3), together with Sites 812 and 814, is located on the southwestern edge of the extensive Tregrosse/Lihou/Coringa Bank complex. Site 813 represents the most distal part of an aggradational/progradational sequence.

Results

Double-APC coring penetrated a 231.5-m-thick sequence of middle Miocene to Pleistocene drowned platform sediments (average >95% $CaCO_3$). Benthic foraminifers indicate a water depth that increased from shallow neritic (0–100 m) in the middle Miocene to upper bathyal (200–600 m) during the late Pliocene and Pleistocene.

Sedimentation rate in the upper Pliocene to Pleistocene interval was 2.2 cm/k.y., which succeeded an early Pliocene rate of ~1.2 cm/k.y. Latest late Miocene sedimentation rates were 3 cm/k.y. Nannofossil foraminiferal oozes of Unit II were deposited during the earliest late Pliocene to late Miocene and are distinguished from the overlying and underlying oozes by the inclusion of iron-stained and/or phosphatized particles. In addition, a major change in physical properties (e.g., lower velocity and increased porosity and water content) occur between 64.2 and 102.4 mbsf, encompassing most of Unit II. These properties suggest that these fines may have been winnowed away, leaving behind coarser-grained, more porous sediments. Concentration of iron-stained and phosphatized reworked particles in these oozes requires a source area wherein these chemical alterations occurred, possibly associated with the contemporaneous condensed sequence recovered at nearby Site 814.

Five major lithologic units were recovered:

1. *Unit I* (0–76.8 mbsf; Pleistocene to Pliocene): homogeneous, micritic, foraminifer to foraminifer-nannofossil ooze with bioclasts. High nannofossil content (50%–80%) is consistent with predominantly pelagic origin for the ooze, but variable degrees of induration suggest that the flux of metastable bank-derived carbonates–having a greater diagenetic potential–was not constant.

2. *Unit II* (76.8–117 mbsf; Pliocene-upper Miocene): nannofossil foraminiferal ooze with micrite. The upper boundary is marked by salmon-colored foraminifer ooze containing reddish-brown to reddish-yellow, presumably iron-stained, particles mixed with *in-situ* foraminifers, bioclasts, and grains of indeterminant origin. In the lower part of the unit, the ooze is characterized by the presence of dark grains that are phosphatized benthic foraminifers.

3. *Unit III* (117–160 mbsf; upper Miocene): bioclastic foraminiferal ooze with micrite and nannofossils ("periplatform ooze"); this unit differs from overlying units in having reduced nannofossil content (~20%–30%) in the fine fraction, which suggests a larger influx of bank-derived metastable carbonate.

4. *Unit IV* (160–~195 mbsf; upper Miocene–middle Miocene): dolomitized semilithified to lithified foraminiferal micritic chalks that contain bioclasts interbedded with dolomitized unlithified to semilithified micritic foraminiferal ooze with bioclasts and nannofossils. The basal 3 m contains dolomitized bioclastic nannofossil chalk that is interbedded with dolomitic foraminiferal rudstone and packstone.

5. *Unit V* (~195–231.5 mbsf; middle Miocene or older?): poor recovery in this interval yielded fragments of dolomitized skeletal grainstones and microcrystalline dolomite, including calcareous algae and foraminifers, suggesting a shallow neritic environment (10–50 m) adjacent to or on a carbonate bank.

SITE 814

Site 814 (proposed Site NEA-10A/2) is located on the southwestern edge of the extensive Tregrosse/Lihou/Coringa Bank complex. This site is in front of a carbonate bank and represents the proximal transition between the lagoonal-bank (Site 812) and the distal parts (Site 813) of an aggradational/progradational sequence.

Results

Drilling penetrated a 300-m-thick sequence of middle Miocene (or older) to Pleistocene platform-slope sediments (average 96% $CaCO_3$). Benthic foraminifers indicate deepening from shallow neritic (0–100 m) in the middle Miocene to upper bathyal (200–600 m) during the late Pliocene–Pleistocene. The late Pleistocene sedimentation rate was 2.4 cm/k.y., whereas the late Pliocene–early Pleistocene rate was ~1.2 cm/k.y. The late Miocene–early Pliocene either is missing or corresponds to a time of reduced sedimentation. The middle Miocene sedimentation rate was estimated as ~1.4 cm/k.y.

Five major lithologic units were recovered and are described as follows:

1. *Unit I* (0-56.8 mbsf; Pleistocene to upper lower Pliocene): nannofossil foraminiferal ooze intercalated with foraminiferal packstone.

2. *Unit II* (56.8–66.5 mbsf; Pliocene near the lower/upper Pliocene contact) well-lithified, yellow-to-white, foraminiferal micritic limestone containing fish teeth and phosphate grains that have been capped by a hardground surface coated with an iron-rich crust. The surface has been bored and filled by several generations of cement. Moldic and vuggy porosity occurs, in addition to scattered silt-sized dolomite crystals and grains. Coring recovered only 0.6 m of limestone, but downhole logging suggested that Unit II is ~8 m thick, while the degree of induration decreases downward.

3. *Unit III* (66.5–136.0 mbsf; [?]lower Pliocene to middle to [?]late Miocene): micritic ooze to bioclastic packstone.

4. *Unit IV* (136.0–263.9 mbsf; middle Miocene or older): dolomitized bioclastic packstone, calcareous ooze, partially lithified mudstone, and partially lithified lithoclastic floatstone.

5. *Unit V* (263.9–300.0 mbsf; middle Miocene or older): yellowish-brown to pale brown, dolomitized lithified packstone of sucrosic dolomite with high intergranular porosity. Dolomitization has obliterated the original fabric and texture.

SITE 815

Site 815 (proposed Site NEA-14), located along the southern margin of Townsville Trough, ~3 km north and in front of the northwestern edge of Marion Plateau, was intended (1) to establish the composition and age of the fore-reef and overlying sediments, and (2) to establish the cause and timing of platform demise. Other objectives were to investigate paleoclimatic history and facies response to climatic variation and initiation of boundary-current activity.

Results

Drilling penetrated a 473.5-m-thick sequence of sediments that consist of 416 m of uppermost Miocene–Pleistocene hemipelagic sediments overlying lower-middle to upper Miocene shelf carbonates. Uppermost Miocene benthic foraminifers indicate outer neritic water depths (100–200 m), but redeposited reefal taxa occur. Site 815 deepened to upper bathyal (200–600 m) during hemipelagic sedimentation. Late Pliocene–Pleistocene sedimentation rates were 1.7 to 3.2 cm/k.y., but increased 10-fold during the early Pliocene, with rates up to 32.4 cm/k.y. between 3.51 and 4.24 Ma. The ~275-m-thick lower Pliocene section should provide high-resolution biostratigraphy.

Six major lithologic units were recovered and are defined as follows:

1. *Unit I* (0–73.3 mbsf; Pleistocene to lower upper Pliocene): foraminifer nannofossil to nannofossil foraminifer ooze, with nannofossil content of 20% to 30%.
2. *Unit II* (73.3–280.5 mbsf; lower Pliocene): greenish-gray to gray, slightly bioturbated nannofossil oozes to unlithified nannofossil mixed sediment.
3. *Unit III* (280.5–348.4 mbsf; lower Pliocene): greenish-gray to gray foraminifer nannofossil and nannofossil foraminifer chalks that are distinguished by increases in degree of induration and contorted and folded bedding. The nannofossil content is up to 80%.
4. *Unit IV* (348.4–425.3 mbsf; upper upper Miocene to lower lower Pliocene): greenish-gray foraminifer nannofossil and nannofossil foraminifer chalks with an increased number of burrows that have been preserved as sedimentary structures. Larger burrows appear to become more numerous with depth; recognized trace fossils include *Chondrites, Zoophycos, Planolites,* and possibly *Scoyenia*. Nannofossil content ranges from 35% to 50%.
5. *Unit V* (425.3–444.5 mbsf; upper middle to upper Miocene): pale brown dolomitized lithified foraminifer packstones with bioclasts and minor chalk. Trace fossils are abundant in the upper part of the unit, but become less common with depth. Between Units V and VI (444.5–454.2 mbsf), nothing was recovered, while downhole logging did not reach this level.
6. *Unit VI* (454.2–463.8 mbsf; uppermost lower Miocene to lower middle Miocene): poorly recovered dolomitized large benthic foraminifer rudstones to floatstones within a planktonic foraminifer packstone.

SITE 816

Site 816 (proposed Site NEA-13) is located on the northwestern corner of Marion Plateau. This site was intended to determine (1) the nature, age, and cause(s) for the demise of known carbonate buildups and (2) the minimum position and timing of the middle Miocene decline in sea level.

Results

Drilling penetrated a 250-m-thick sequence of sediments composed of a 90-m-thick unit of lower Pliocene–Pleistocene hemipelagic sediments overlying shallow-water (<5 m), earliest Pliocene or older, lithified carbonates. Shallow-water bioassemblages are chlorozoan, which is indicative of warm surface waters. Within hemipelagic sediments, benthic foraminifers indicate upper bathyal depths (200–600 m). The late Pleistocene sedimentation rate was low (0.5 cm/k.y.), whereas late Pliocene rates (2 cm/k.y.) were normal for a pelagic setting. Sediments from the top 31 m of Hole 816A are magnetically reversed, indicating that most of the Brunhe and perhaps part of the Matuyama magnetic zones are missing. This might account for the low Pleistocene sedimentation rate. As at Site 815, the early Pliocene sedimentation rate increased dramatically.

Three major lithologic units were recovered and are distinguished as follows:

1. *Unit I* (0–93 mbsf; Pleistocene to lower Pliocene): light gray foraminifer nannofossil ooze that grades downward into olive green nannofossil clayey ooze with dolomite and foraminifers.
2. *Unit II* (93–163.7 mbsf; middle Miocene): partially dolomitized rhodolith-bearing bioclastic floatstone and rudstone. Spheroidal to discoidal rhodoliths have been cemented within a matrix consisting of coarse angular fragments of mollusks, coralline algae, coral, *Halimeda,* bryozoans, echinoid spines, and lithoclasts. Moldic and intraparticle porosity is well developed, and geopetal fabrics partially fill some cavities.
3. *Unit III* (163.7-250.0 mbsf; middle Miocene): Unit III consists of dolomitized coralline algal and coral (including *Porites* and *Acropora*) boundstone and framestone with white rhodoliths of up to 5 cm in diameter. Minor bioclasts include fragments of coralline algae, mollusks, rare *Halimeda,* and coral. Moldic and intraparticle porosities are well developed.

SITE 817

Site 817 (proposed Site NEA-11), located on the lower slope of Queensland Plateau southwest of the Tregrosse/ Lihou/ Coringa bank complex, was intended to obtain stratigraphic and age data for interpreting event stratigraphy on the northern side of Townsville Trough.

Results

Drilling penetrated 700 m of upper lower Miocene to Pleistocene, carbonate platform slope sediments. The sequence contains a record of the varying fluxes of platform-derived vs. pelagic-derived carbonate sediments to the slope. The latest early Miocene to middle Miocene and the early late Pliocene to Pleistocene were periods when platform-derived material dominated. During the late middle Miocene to early late Pliocene, the Queensland Plateau was apparently drowned, and pelagic flux dominated.

The nature of the platform-derived sediments deposited at Site 817 varied with time; during the middle Miocene, bioclastic debris accumulated on the slope, whereas only periplatform ooze reached the site during the Pliocene to Pleistocene. Apparently, the slope was immediately adjacent to a producing carbonate platform margin during the middle Miocene. During the Pliocene to Pleistocene, carbonate production had stepped back to the present position of the Tregrosse/Lihou/ Coringa bank complex, which enabled only fine-grained material to reach the preexisting slope.

Three major lithologic units were recovered and are defined as follows:

1. *Unit I* (0–200.8 mbsf; Pleistocene to upper Miocene): strongly bioturbated micritic ooze with foraminifers and nannofossils (0–120 mbsf) that grades into nannofossil ooze with foraminifers and micrite (120–200.8 mbsf). Soft-sediment deformation (i.e., slump folds) occurs at several points.
2. *Unit II* (200.8–426.7 mbsf; upper Miocene to middle Miocene): a possible unconformity, distinguished by a transition from ooze to chalk, separates Units I and II. Unit II contains micritic chalk, nannofossil chalk with foraminifers,

micrite, sponge spicules and radiolarians, and micritic chalk with foraminifers and bioclasts.

3. *Unit III* (426.7–700.0 mbsf; uppermost lower [?]Miocene or older): the contact between Units II and III is gradational and conformable; it has been arbitrarily placed where coarse-grained bioclasts first appear. Unit III is characterized by relatively coarse-grained bioclastic limestone and dolomite.

SITE 818

Site 818 (proposed Site NEA-9A), located on a gently inclined, upper-slope terrace of the Queensland Plateau, southwest of the Tregrosse/Lihou/Coringa bank complex, was selected for penetrating a uniquely thick pile of upper Neogene sediments to determine their composition and origin.

Results

APC drilling recovered 303 m of lower Pliocene to Pleistocene, periplatform sediments. Benthic foraminifers indicate middle bathyal paleodepths (600–1000 m). The occurrence of platform-derived carbonate throughout implies transport from Queensland Plateau since the early Pliocene, but varying fluxes may be associated with changes in bank productivity and/or the amount of redeposition at the site. Compared with sedimentation rates for the past 1.5 m.y. (5.7 cm/k.y.), two previous periods exhibit significantly different carbonate accumulation rates: 2.4 cm/k.y. between 1.5 and 2.42 Ma, and 42 cm/k.y. between 2.42 and 2.6 Ma.

Two major lithologic units were recovered and are described as follows:

1. *Unit I* (0–293.4 mbsf; Pleistocene to lower Pliocene): homogeneous periplatform oozes composed of varying proportions of micrite and nannofossils with minor amounts of bioclasts, foraminifers, and pteropods.

2. *Unit II* (293.4–302.9 mbsf; upper Miocene): well-indurated calcareous chalk with bioclasts and foraminifers.

SITE 819

Site 819 (proposed Site NEA-3) occurs in Grafton Passage on the continental slope east of Cairns, defining the deeper-water end of a shelf-edge transect (with Sites 820 and 821) that was aimed at defining relationships between changes in sea level, sedimentary sequences, seismic geometries, and, in particular, the response of a developing slope sequence to rapid changes in global sea levels. Objectives were to determine (1) the nature of the progradational and aggradational units beneath the upper slope terrace and (2) the age and origin of eight observed seismic sequences.

Results

APC/XCB coring to 400 mbsf recovered 84.9% of an expanded Pleistocene section that spanned <1.48 m.y. Preservation of nannofossils was excellent, although preservation of planktonic foraminifers is facies specific, with light-colored intervals that contain abundant foraminifers. Benthic foraminifers indicate upper bathyal water depths throughout, but sediment studies suggest depth variations controlled by changes in sea level and fluvial contributions. A hiatus occurs between 275 and 465 k.y. Sedimentation rates vary in relation to lithologic changes: 10 to 11 cm/k.y. for the late Pleistocene, 6 cm/k.y. from 0.93 to 0.465 k.y., and 42.4 cm/k.y. during the middle Pleistocene (1.27–0.93 Ma). Between 1.27 Ma and the base of Hole 819A (<1.48 Ma), sedimentation rate is ~87 cm/k.y. Calculation of sedimentation rates and definition of sedimentary units were complicated by slumping at 32.5 and 75 mbsf and a slump detachment surface at ~190 m, observed in seismic data.

Five major lithologic units were recognized and are defined as follows:

1. *Unit I* (0–32.5 mbsf; upper Pleistocene): rhythmically interbedded couplets of clay- and carbonate-rich clayey pteropod ooze.

2. *Unit II* (32.5–97.0 mbsf; Pleistocene): five rhythmic couplets of silty stringers toward the base that grade upward into dolomitized clayey nannofossil oozes.

3. *Unit III* (97.0–179.7 mbsf; Pleistocene): rhythmically interbedded bioclastic and micritic oozes. An unrecovered interval between Units III and IV occurs at 179.7-198.1 mbsf.

4. *Unit IV* (198.1–313.2 mbsf; Pleistocene): bioclastic wackestones and nannofossil clayey oozes with quartz and silt stringers. Although higher percentages of quartz silt and sand characterize the unit as a whole, these are best seen near the base, where three upward-coarsening packages occur.

5. *Unit V* (313.2–400 mbsf; Pleistocene): relatively homogeneous clayey chalk at the base, micritic clayey chalks in the middle, and clayey bioclastic nannofossil chalks in the uppermost part. Quartz is most dominant in the middle micritic part.

SITE 820

Site 820 (proposed Site NEA-2) occurs in 278 m of water in Grafton Passage, the central site in the upper continental slope transect. Objectives included determining the composition and origin of prograding and aggrading units beneath the outer upper slope. In conjunction with Site 821, Site 820 allowed us to calibrate abrupt seismic facies changes.

Results

Hole 820A was APC/VPC cored to 144.3 mbsf and had 100% recovery. Hole 820B was APC cored to 160.2 mbsf, and XCB cored to 400 mbsf; recovery overall was 81.2%. The section to 400 mbsf is an expanded Pleistocene interval; nannofossil and planktonic foraminifer data suggest that the section is fairly complete and has an age range at the bottom of the hole from 1.27 to 1.48 Ma. Nannofossil preservation is related to subtle lithologic changes and is good in the upper 100 mbsf, moderate to poor between 100 and 300 mbsf, and improves again below 300 mbsf. Preservation of planktonic foraminifers is related to lithologic variability. Benthic foraminifers suggest that sediments above 150 mbsf were deposited in an upper bathyal environment and that sediments below 150 mbsf were deposited in upper bathyal to outer neritic water depths. Sedimentation rates at Site 820 compare with those at Site 819: 41.1 cm/k.y. for the middle Pleistocene; 8.2 cm/k.y. for the latest middle Pleistocene; 35 cm/k.y. for the earliest late Pleistocene; and 10 to 11 cm/k.y. for the latest Pleistocene.

Three major lithologic units were recognized and are distinguished as follows:

1. *Unit I* (0–150.7 mbsf; Pleistocene): very fine-grained wackestones and mudstones that have been interbedded with bioclastic packstones; generally finer than underlying sediments. Bioturbation is pervasive. Dolomite increases gradually with depth.

2. *Unit II* (150.7–208.1 mbsf; Pleistocene): a mixture of bioclastic packstones, bioclastic clayey mixed sediments, and silty claystones; represents the transition from coarser Unit III to finer Unit I.

3. *Unit III* (208.1–400 mbsf; Pleistocene): bioclastic packstones with interbedded, finer-grained calcareous mudstones (some laminated) and mixed sediments. Five cycles were recognized, each representing upward-coarsening from calcareous mudstone with bioclasts and nannofossils up to me-

dium-to-fine, calcareous chalky packstone containing quartz, feldspar, nannofossils, and clay. Dolomite (maximum = 17.4%, at 224.4 mbsf) is present within the top three cycles.

SITE 821

Site 821 (proposed Site NEA-1) occurs in Grafton Passage, where it defines a shallow end-member of the shelf-edge transect. Objectives were to determine the age and facies of the most proximal portions of the aggradational and progradational units immediately in front of the present day Great Barrier Reef and the sea-level signal of the prograding and aggrading units beneath the uppermost slope terrace.

Results

Hole 821A was APC cored to 145.9 mbsf and XCB cored to 400 mbsf, with an average recovery of 95%; Hole 821B was APC cored to 165.9 mbsf with 100% recovery. As at Sites 819 and 820, the section to 400 mbsf at Site 821 is an expanded Pleistocene section. Calcareous nannofossils indicate an age of 1.27 to 1.48 Ma for its base. Preservation of planktonic foraminifers and nannofossils varies from near-pristine in clayey intervals to overgrown in sandy intervals. Benthic foraminifers indicate a depth range of neritic to upper bathyal. Variations in sedimentation rates at Site 821 are similar to those at Site 820: middle Pleistocene rates of 28.2 cm/k.y. are succeeded by 12.2 cm/k.y. between 0.930 and 0.465 Ma, 49.2 cm/k.y. in the succeeding 0.190 m.y., and 10.2 cm/k.y. from 0.275 Ma to the present. The locus of increased sedimentation had shifted from Site 820 to Site 821 by the late Pleistocene, coincident with the aggradation phase of sedimentation.

Five major lithologic units were recognized and are described as follows:

1. *Unit I* (0–145.5 mbsf; Holocene to upper Pleistocene; age, <0.456 Ma): mixed sediments of siliceous and bioclastic components, calcareous silts and clays, bioclastic and nannofossil oozes and chalks, bioclastic packstones, and *Halimeda* rudstones. With the exception of the uppermost part, this unit is a series of rapidly deposited aggradational packages.
2. *Unit II* (145.5–172.0 mbsf; age, >0.465 to <0.93 Ma; upper Pleistocene): at the base is an upward-fining, siliciclastic-dominated packstone; at the top is a glauconitic and siliciclastic, lithified mudstone, perhaps representing a hardground.
3. *Unit III* (172.0–215.0 mbsf; age, >0.93 to 1.27 Ma; lower Pleistocene): dolomitized bioclastic wackestone/chalk and bioclastic packstone.
4. *Unit IV* (215.8–298.8 mbsf; age, >0.93 to ~1.27 Ma; lower Pleistocene): thickly bedded dolomitized chalk and bioclastic packstones and wackestones.
5. *Unit V* (298.8–400.0 mbsf; lower Pleistocene): dolomitized bioclastic packstones and chalky mixed sediments, interbedded with less calcareous sandy, silty, and clayey mudstones.

SITE 822

Site 822 (proposed Site NEA-4) occurs at the foot of the slope east of the Great Barrier Reef offshore Cairns, northeast of the Grafton Passage transect. Drilling was aimed at determining the age and facies of a lower-slope fan in front of today's Great Barrier Reef; additional objectives were to define lower-slope fan processes and to understand the signatures in sea level that have been preserved in the lower-slope facies.

Results

Hole 822A was APC cored to 95.9 mbsf and XCB cored to 433.9 mbsf; recovery was 89.3%. The section comprises Pleistocene to Pliocene (>2.6 Ma) hemipelagic sediments, with a hiatus between 275 and 465 k.y. Benthic foraminifers indicate deposition within middle bathyal depths. Sedimentation rates are highly variable: 36 to 42 cm/k.y. between 0.93 and 1.48 Ma and 16 cm/k.y. between 1.88 and 2.6 Ma. The lowest rates (4.0 cm/k.y.) occur at the base of the section, with relatively low rates (8–12 cm/k.y.) above the 930-k.y. level. High sedimentation rates may be coincident with global highstands of sea level.

Sediments are mainly muds that contain varying amounts of carbonate ooze and terrigenous clays, with lesser bioclastic and terrigenous (mostly quartz) sand and silt. The sequence is distinctly cyclical, as seen in variations in color and composition related to the proportions of carbonate and terrigenous sediments.

Two major lithologic units were recognized and are described as follows:

1. *Unit I* (0–52.9 mbsf; age, 0 to <0.93 Ma; Pleistocene): bioclastic ooze with nannofossils and micrite.
2. *Unit II* (52.9–433.9 mbsf; age, 0.465 to >2.6 Ma; Pleistocene to Pliocene): clayey calcareous mixed sediment containing terrigenous clay that has been interbedded with clayey nannofossil ooze. Claystones dominate the middle part of the unit, whereas bioclastic sediments become more important downward.

SITE 823

Site 823 (proposed Site NEA-5) is located in the central-western Queensland Trough, toward the deepest part of the basin. This location was selected to recover basinal material for paleoceanographic studies and for correlation with the drill sites on the Australian continental margin to the Queensland Plateau transect. Specific objectives for this site included obtaining a complete basinal section for paleoceanographic history and correlation of basin-fill response between the continental margin and the Queensland Plateau.

Results

APC/XCB/RCB drilling penetrated a 1011.0-m-thick sequence of uppermost middle Miocene to Pleistocene hemipelagic to pelagic sediments interbedded with numerous gravity-flow deposits that were interpreted as turbidites, debris flows, and slumps; recovery was 92%. Benthic foraminifers indicate lower bathyal paleodepths (1000–2000 m). More than 1800 gravity-flow deposits were recognized; chronological integrity of microfossil biostratigraphy was maintained, indicating nearly contemporaneous deposition of redeposited material.

Seven major lithologic units were recovered and are defined as follows:

1. *Unit I* (0–120.7 mbsf; Pleistocene): pelagic to hemipelagic ooze interbedded with redeposited layers, which were interpreted as turbidites and debris flows.
2. *Unit II* (120.7–352.75 mbsf; upper Pliocene): nannofossil ooze with clay and bioclasts interbedded with lithoclastic rudstone, which were interpreted as debris flows, and bioclastic and skeletal packstones showing normal grading and abrupt basal contacts, which are indicative of turbidites.
3. *Unit III* (352.75–535.7 mbsf; lower Pliocene): nannofossil chalk with bioclasts and foraminifers or quartz, clayey nannofossil mixed sediment, and dolomitic nannofossil chalk with clay intermixed with lithoclastic rudstone, conglomerate, and mixed sediment, which has been interpreted as debris flows and slumps; nannofossil siltstone with bioclasts, calcite, and pyrite, gray nannofossil chalk, nannofossil chalk with micrite, and mixed sediments; mud clasts in a matrix of mixed

sediment with micrite separated by an interval of relatively undeformed nannofossil chalk.

4. *Unit IV* (535.7–715.0 mbsf; lower Pliocene to upper Miocene): foraminifer nannofossil chalk, nannofossil mixed sediment to chalk with foraminifers and bioclasts becoming clayey nannofossil chalk with foraminifers, bioclasts and/or quartz, nannofossil chalk with clay or foraminifer nannofossil clayey chalk with depth; characterized by large-scale slump features. Bioclastic foraminifer packstone layers, showing graded bedding indicative of turbidites, are sometimes found inverted within slumps. Microfaults are associated with some slumps. Clasts and matrix in lithoclast rudstones, interpreted as debris flows, are cut by *Chondrites* and *Zoophycos*, indicating post-depositional bioturbation. The base is a debris flow.

5. *Unit V* (715.0–795.7 mbsf; lower Pleistocene to upper Miocene): nannofossil mixed sediment to nannofossil claystone. Nannofossil chalk is present, although less abundant than in overlying Unit IV. Unit V contains a few foraminifer skeletal packstone layers that have been interpreted as turbidites. Laminations occur in the transitions from darker to lighter colored mixed sediments.

6. *Unit VI* (795.7–899.1 mbsf; upper Miocene): Unit VI is distinguished by distinctive color oscillations that are produced by alternations of white to light gray, strongly bioturbated nannofossil chalk to mixed sediment, limestone, and clayey nannofossil chalk with dark greenish-gray nannofossil mixed sediment and claystone. Interbedded layers of partially graded lithified calcareous grainstone with siliciclastics and traces of glauconite and skeletal packstone, both of which were interpreted as turbidites, are dark greenish-gray. Multiple generations of microfaults and large-scale slump folds are present. Lithoclastic rudstone and floatstone, interpreted as debris flows, are common. In fact, Units VI and VII together contain ~50% of the total number of debris flows observed in the entire Site 823 sequence.

7. *Unit VII* (899.1–1011.0 mbsf; upper to middle Miocene): Unit VII is defined by the occurrence of shallow-water, platform-derived pebbles and clasts within lithoclastic rudstones, interpreted as debris flows. These pebbles and clasts contain coralline algae, large benthic foraminifers, coral fragments, and dolostone fragments. Sediments include nannofossil chalk with clay, foraminifers, and bioclasts; clayey nannofossil mixed sediments; and nannofossil claystone. Increases in the amount of clay, siliciclastics, and traces of glauconite give the sediments a dark gray color. Medium sand- to silt-sized gray bioclastic packstone and quartz foraminifer packstone layers with well-defined upward-fining sequences have been interpreted as turbidites.

SITE 824

Site 824 (proposed Site NEA-6) lies on the western slope of Queensland Plateau west of Holmes Reef. Our main objective here was to understand processes along the eastern margin of the Queensland Trough by obtaining as complete a section as possible of Paleogene sediments and the basement onto which they have transgressed.

Results

At this site, four holes were drilled to a total depth of 431 mbsf: Hole 824A was drilled with APC/XCB tools after washing down to 50 mbsf; In Hole 824B, we used APC coring to recover the top 50 mbsf, and in Holes 824C and 824D, we used RCB coring to recover the sections below 300 mbsf, including the basement. The odd sequence of drilling defined above was a result of the shortage of core liners aboard the vessel. Recovery averaged 28.4% for Site 824.

Sediments range in age from late Pleistocene to late Oligocene–early Miocene. Basement is probably Paleozoic(?). Benthic foraminifers indicate middle bathyal deposition. Sedimentation rates were apparently highest in the late Pleistocene. Thereafter, rates decreased to 12.9 cm/k.y. by 2.4 Ma, before increasing again to 22 to 30 cm/k.y. for the section down to 11 Ma.

These sediments are pure carbonates that were deposited as nannofossil oozes and allochthonous packstones and rudstones composed of mollusks, bryozoans, corals, and coralline algae.

Seven major lithostratigraphic units were recovered and are distinguished as follows:

1. *Unit I* (0–105 mbsf; Pleistocene): two cycles of upward-fining bioclastic packstones and rudstones; alternating pelagic oozes and chalks occur in the upper part.

2. *Unit II* (105–135.5 mbsf; Pliocene): pelagic calcareous mudstones with varying amounts of nannofossils, micrite, and shallow-water-derived bioclasts and upward-fining packstones, which are thickest in the middle of the unit.

3. *Unit III* (135.5–166 mbsf; Pliocene): white to dark gray, densely cemented, bioclastic rudstones and packstones. Large fragments of corals, coralline algae, and whole rhodoliths occur in a sand-sized bioclastic matrix.

4. *Unit IV* (166–242.3 mbsf; middle to upper Miocene): white to light gray nannofossil ooze and chalks having varying amounts of bioclasts, micrite, and calcite. Layers of fine-to-medium bioclastic packstones with nannofossils and micrite occur throughout and contain abundant shallow-water components; the degree of lithification varies with depth.

5. *Unit V* (242.3–338.7 mbsf; upper to middle Miocene or older): the upper half of the unit is composed of interbedded white foraminifer chalk and allochthonous shallow-water-derived mollusks, corals, coralline algae, rhodoliths, *Halimeda,* and benthic reef foraminifers. The shallow-water sediments exhibit upward-fining, grading, and moldic porosity. The lower half of the unit is composed of dense skeletal packstone and rudstones made up of branching corals, mollusks, echinoids, and benthic foraminifers.

6. *Unit VI* (338.7–401.9 mbsf; Miocene to upper Oligocene): white bryozoan-dominated bioclastic rudstone with poorly preserved coralline and large foraminifer fragments and ahermatypic(?) corals, all of which have been recrystallized and cemented. The base of the unit is a dark yellowish-brown to gray, poorly sorted quartz bioclastic sandstone in a mud matrix. Identifiable carbonate grains are bryozoans and larger foraminifers (*Operculina* and *Assilina*). Milky to clear rounded and angular quartz are common, along with reworked black phyllite clasts.

7. *Unit VII* (401.9–431 mbsf; age unknown): deeply weathered orange to brown regolith overlying black to dark gray phyllite and schists with quartzitic lenses and a light gray to green finely crystalline metavolcanic rock.

SITE 826

Site 826 (near proposed Site NEA-13) is located on the northwestern margin of Marion Plateau, in a position ~1.5 nmi south of Site 816. The location defines a lagoonal site immediately behind the Miocene(?) barrier reef drilled at Site 816. Our drilling objective was not to establish the stratigraphy at the site, but to penetrate postulated lagoonal sequences so as to obtain faunas we could use to date Sites 816 and 826. After establishing the mud line, we washed the hole to 98.5 mbsf. Thereafter, the hole was rotary-cored to a depth of 250 mbsf.

Results

Sediments recovered at Site 826 included muds immediately above the lagoonal sequence at 98.5 mbsf and dolomitized skeletal packstones, rudstones, and minor boundstones between 98.5 mbsf and termination depth.

Two lithostratigraphic units were identified as follows:

1. *Unit I* (0–98 mbsf; [?]Pliocene to Pleistocene): This unit, recovered only in the upper two cores, is the same as Unit I at Site 816.
2. *Unit II* (98–250 mbsf; middle Miocene?): the unit is composed of partially to completely dolomitized bioclastic rudstone and minor coralgal boundstone. Benthic foraminifers are common in some sections, so that accurate dates should be obtained from shore-based studies of these sediments. Such dates will have a substantial impact on our interpretations at Site 816, and the middle Miocene sea-level history on the Marion Plateau.

DISCUSSION

Although shipboard results remain preliminary, drilling during Leg 133 provided valuable, and sometimes surprising, new information about the evolution of carbonate-platform environments. Combining lithostratigraphic, chemostratigraphic, magnetostratigraphic, and biostratigraphic analyses to estimate the timing of events, we have interpreted a Cenozoic record of environmental change on the northeast Australian margin. This record tentatively can be used to differentiate between the influences of fluctuations in sea level, tectonic subsidence, terrigenous flux, paleoclimate, and paleoceanography on the development of carbonate platforms, as suggested by previous studies.

Our interpretation of shipboard results indicates that carbonate sedimentation on the Queensland Plateau was initiated during the early middle Eocene, when the seas transgressed across the metasedimentary continental basement. Temperate faunas inhabited the local seas during the latest Oligocene, but by the latest early Miocene, tropical fauna dominated the Queensland and Marion plateaus. The transition from temperate to tropical waters reflects the northward movement of the Australian Plate combined with the initiation of the southward flow of tropical waters from the equatorial Pacific. During the early middle Miocene, tropical waters supported robust reefal growth that gradually declined during the late middle Miocene, possibly in conjunction with paleoenvironmental changes that were induced by the steady decrease in eustatic sea level during this period.

Carbonate production on the shallow-water banks diminished dramatically in the late Miocene in response to global climatic deterioration, which was accelerated by a seasonal influx of colder waters into this tropical environment, and continued decreases in eustatic sea level. The banks apparently were unable to respond to climatic amelioration during the earliest Pliocene. A pulse of more rapid subsidence on the Queensland Plateau, in combination with rising eustatic sea level, may have essentially drowned these banks. Conditions stabilized during the late early Pliocene, when the carbonate banks were rejuvenated and remained more or less productive until the present. This renewed bank production, however, was on a much reduced scale compared with that of the flourishing reefs and banks of the early to middle Miocene, and has barely been able to keep up with continued subsidence. However, carbonate banks of the Marion Plateau have never recovered from being suffocated by increased terrigenous influx. Initiation of reef growth on the Great Barrier Reef is even younger, beginning at about 1 m.y. ago.

Our initial results from drilling and shipboard studies remain preliminary and attempts to relate the causes and consequences of the interpreted environmental changes recognized in the sediment record must await further results obtained from shore-based studies. New information toward resolving enigmatic problems surrounding the development of carbonate platforms will undoubtedly evolve from these studies.

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