

8. CRETACEOUS CALCAREOUS PLANKTON BIOSTRATIGRAPHY OF SITES 872 THROUGH 879¹

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ABSTRACT

This paper documents the distribution of calcareous nannofossils and planktonic foraminifers in Cretaceous sequences recovered at Sites 872 through 879 drilled on guyots in the central and western Pacific Ocean during Leg 144. Calcareous plankton biostratigraphy allows us to obtain important biostratigraphic age constraints for the onset, development, and demise of shallow-water sedimentation on these guyots.

Site 872 on Lo-En Guyot is the only site at which shallow-water limestones were not recovered during Leg 144. Here, the oldest sediment consists of pelagic limestone infilling fractures within the volcanic substrate. Calcareous plankton biostratigraphy constrains the age of these sediments to Coniacian to earliest Santonian (*Dicarinella concavata* planktonic foraminifer zone; CC14–CC15 nannofossil zones).

On Wodejebato Guyot (Sites 873 through 877), initiation of carbonate platform sedimentation occurred in the late Campanian (CC22 nannofossil Zone), continued during the late Campanian and Maastrichtian, and ended during the late, possibly latest, Maastrichtian. On MIT Guyot (Site 878), calcareous plankton biostratigraphy indicates that the initiation of carbonate platform sedimentation occurred in the earliest Aptian (lower part of the *Chiastocyclus litterarius* nannofossil zone before the “nannoconid crisis”). After a phreato-magmatic eruption that deposited a polymictic breccia, carbonate sedimentation resumed in the middle late Aptian (*Nannococcus truitii* Acme, *Globigerinelloides algerianus* to *Hedbergella trocoidea* planktonic foraminifer zones). Shallow-water deposition ended during the late Albian after the *Biticinella breggiensis* Zone. Carbonate platform sedimentation at Site 879 on Takuyo-Daisan Guyot began during the middle late Aptian (*N. truitii* Acme, *G. algerianus* to *H. trocoidea* planktonic foraminifer zones) and ended by late Albian time (*Rotalipora ticinensis* planktonic foraminifer zone). Shallow-water limestone at Site 879 correlates with the upper carbonate platform sequence recovered at Site 878, but its thickness is only half that of the coeval sequence deposited on MIT Guyot, suggesting the presence of hiatuses.

INTRODUCTION

Leg 144 was devoted to the exploration of five guyots in the central and western Pacific Ocean (see site map preceding title page and Table 1) to reconstruct their geologic evolution and the age of inception and demise of the shallow-water carbonate sedimentation. Ten sites were occupied and 20 holes were drilled during the cruise (Premoli Silva, Haggerty, Rack, et al., 1993).

At all the guyots, volcanic substrate is represented by basalts that constructed emergent subaerial volcanic edifices that subsequently subsided to increasing water depths. Shallow-water limestone deposited over the volcanic substratum, and pelagic foraminifer and nannofossil ooze capped the guyots during the Tertiary and Quaternary (Premoli Silva, Haggerty, Rack, et al., 1993). Drilling on Lo-En Guyot indicated subaerial flows of late shield volcanism that were submerged before the late Turonian. Shallow-water limestone of Albian age was recovered on dredges from the southern flank of Lo-En Guyot (Lincoln et al., 1993), but it was not encountered at the drilled Site 872 (Premoli Silva, Haggerty, Rack, et al., 1993; ODP Leg 144 Shipboard Scientific Party, 1993).

The Cretaceous sedimentary sequences on the explored guyots are represented by shallow-water limestone. Calcareous nannofossils and planktonic foraminifers were extensively searched at all sites to obtain biostratigraphic ages based on calcareous plankton. We describe here the Cretaceous nannofossil and planktonic foraminifer assemblages recovered at Site 872 (Lo-En Guyot), Sites 873 through 877 (Wodejebato Guyot), Site 878 (MIT Guyot), and Site 879 (Takuyo-Daisan

Guyot) and discuss the biochronostratigraphic evidence for ages of inception, deposition, and demise of shallow-water limestones.

MATERIAL AND METHODS

Very detailed sampling was performed to ensure recovery of even sparse calcareous plankton in the shallow-water limestone (Table 2). The study was based on the examination of thin sections (both calcareous nannofossils and planktonic foraminifers), smear slides (calcareous nannofossils), washed residues, and cuttings (planktonic foraminifers). Smear slides were prepared using standard techniques: raw material was permanently mounted using the Norland Optical Adhesive. In addition, although some samples were ultrasonically cleaned and centrifuged to concentrate the extremely rare nannofossils, this procedure met with little success. Selected nannofossil-bearing samples also were examined with the scanning electron microscope; however, the best results were derived from the study of smear slides and thin sections with a polarizing microscope. Semi-quantitative and quantitative study of nannofossils was performed with a polarizing microscope, at 1250× magnification.

All thin sections prepared for sedimentological and paleontological analysis on board or for shore-based paleontological study were examined for planktonic foraminifers (see Premoli Silva et al. and Arnaud-Vanneau, both in this volume). This study was integrated with that based on isolated planktonic specimens, obtained from cuttings of poorly cemented limestone, collected by a sieve as each section of the core was split.

The results of this biostratigraphic study are reported separately for each guyot.

SITE 872 (LO-EN GUYOT)

The oldest sediments recovered at Site 872 occur in cracks within the volcanic substrate. Of the guyots explored during Leg 144, Lo-En is the only one where shallow-water limestone was not recovered at the drill site. Here, in fact, pelagic limestone immediately overlies the

¹ Haggerty, J.A., Premoli Silva, I., Rack, F., and McNutt, M.K. (Eds.), 1995. *Proc. ODP, Sci. Results*, 144: College Station, TX (Ocean Drilling Program).

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Table 1. Latitude, longitude, and water depth for Sites 872 through 879.

Site	Guyot	Latitude (N)	Longitude (E)	Water depth (mbsf)
872	Lo-En	10°05.85'	162°51.96'	1084
873	Wodejebato	11°53.84'	164°55.20'	1334
874	Wodejebato	12°00.76'	164°55.22'	1374
875	Wodejebato	12°00.72'	164°56.44'	1409
876	Wodejebato	12°01.476'	164°55.90'	1399
877	Wodejebato	12°01.14'	164°55.30'	1355
878	MIT	27°19.143'	151°53.028'	1323
879	Takuyo-Daisan	34°10.46'	144°18.56'	1501

basalt and is followed by a volcanic pebble conglomerate, and foraminifer-nannofossil ooze that capped the guyot during the Tertiary and Quaternary. Calcareous nannofossil and planktonic foraminifers from the cracks in the volcanic substrate constrain the age of the oldest sediments at this site.

Calcareous Nannofossils

A few layers with moderately to poorly preserved Cretaceous nannofossils were detected in Core 144-872A-17H, which penetrated the contact between the pelagic limestone and the underlying basalt, and in Core 144-872B-4R, which recovered basalts with thin interbasalt sediment layers (Premoli Silva, Haggerty, Rack et al., 1993). Sample 144-872A-17H-CC yielded a nannofossil assemblage containing *Micula concava*, *Reinhardtites anthophorus*, *Aspidolithus parvus expansus*, *Arkangelskiella specillata*, *Stoverius biarcus*, *Stoverius coronatus*, and *Gephyrorhabdus coronadventis* (Table 3). This nanoflora is correlated with Santonian Zones CC15–17 of Sissingh (1977) (Fig. 1).

In Core 144-872B-4R, five sediment layers yielded common and moderately well preserved calcareous nannofossils (Table 3). The co-occurrence of *Lithastrinus septenarius*, *Reinhardtites anthophorus*, *Micula decussata*, and *Eiffellithus eximius* in Sample 144-872B-4R-1, 21–22 cm, indicates Zone CC15 of Sissingh (1977). Sample 144-872B-4R-1, 60–62 cm, contains frequent specimens of *Nannoconus farinacciae* along with *Lithastrinus septenarius* and, therefore, is correlated with the late Coniacian to early Santonian Zones CC14 and CC15 of Sissingh (1977) (Fig. 1). Only sparse specimens of *Eiffellithus eximius* were observed in Sample 144-872B-4R-1, 68–89 cm, which cannot be older than early Turonian based on nannofossil biostratigraphy. However, planktonic foraminifers from this interval indicate the *Dicarinella concavata* Zone of Coniacian to earliest Santonian age.

Planktonic Foraminifers

Planktonic foraminifers co-occur with calcareous nannofossils in Hole 872B samples but are absent in Hole 872A. In the lower samples (144-872B-4R-1, 46–48 cm; 144-872B-4R-1, 60–62 cm, and 144-872B-4R-1, 68–71 cm), planktonic foraminifer assemblages are characterized by abundant marginotruncanids (e.g., *M. sigali*, *M. schneegansi*, *M. pseudolinneiana*, *M. coronata*) and *Heterohelix reussi*, common *Dicarinella concavata*, and rare whiteinellids and *Dicarinella primitiva*. Rare, older forms possibly attributable to *Dicarinella hagni* and *Marginotruncana marianosi* are recorded in Sample 144-872B-4R-1, 68–71 cm. The bulk of the planktonic faunas in all three layers is indicative of the *Dicarinella concavata* Zone. According to the revised calibration of Premoli Silva and Sliter (1994; see also below), this zone spans the interval from upper Turonian to lowermost Santonian; however, the most probable age for these sediments is Coniacian. The possible older forms, *D. hagni* and *M. marianosi*, become extinct in the late middle Turonian (*Marginotruncana sigali* Zone). Poor recovery and the discontinuous record make it difficult to determine whether the older aspect of the assemblage is

related to reworking or to preservation. There is evidence in favor of both hypotheses. On one hand, the occurrence of shallow-water foraminifers and other skeletal organisms within the faunal-rich pelagic sediments would support the possibility of some transport and reworking. On the other hand, owing to the poor preservation and high degree of phosphatization in the lowermost sample the older species mentioned above may be misidentified.

The topmost sample (Sample 144-872B-4R-1, 18–22 cm) yields common to abundant, rather well-preserved planktonic foraminifers. The assemblage, substantially similar to that from the previous samples, includes common marginotruncanids belonging to the same species as identified in the underlying assemblages, several *Dicarinella concavata*, *Globigerinelloides bollii*, *Heterohelix reussi*, and rare *Conusotruncana fornicata*, *Archaeoglobigerina cretacea*, *Globotruncana linneiana*, *Ventilabrella eggeri*, and *V. glabrata*. This assemblage indicates the *Dicarinella asymetrica* Zone, even in the absence of the nominate species and is probably early Santonian in age.

Other notable features of this sequence are the occurrence of several medium-sized, perfectly preserved fish teeth and abundant fecal pellets (*Favreina* sp.), and a few benthic foraminifers indicative of rather shallow-water environment in the lowermost samples.

Two species of benthic foraminifers associated with calcareous plankton are *Dictyopselloides* sp. (Samples 144-872B-4R-1, 46–48, 60–62, and 68–71 cm) and *Dorothia* sp. cf. *D. bulletta* (Sample 144-872B-4R-1, 68–71 cm). The latter species is known from the Upper Cretaceous, whereas the genus *Dictyopselloides* is known from the Santonian of France and Spain. Their occurrence is consistent with that inferred from calcareous plankton.

These benthic foraminifers, with a bathymetric range from upper to middle neritic (maximum paleodepth close to 200 m), suggest a relatively shallow paleodepth for the pelagic fracture infillings, although the possibility of post-mortem transport or reworking cannot be ruled out.

In summary, the oldest sediment preserved on Lo-En Guyot consists of Coniacian to early Santonian pelagic limestone occurring as fracture infillings and volcanic pebble conglomeratic matrix lying atop basaltic substrate. Planktonic foraminifers and, to a lesser extent, calcareous nannofossils constrain the age of this material as Coniacian to early Santonian. However, sediments as old as late middle Turonian may have been deposited on the guyot. The presence of middle neritic benthic foraminifers in the lowest deposits may indicate either a relatively shallow pelagic paleoenvironment or the transport of shallow-water material into a deeper site of deposition. The Coniacian to early Santonian fossils are extensively phosphatized, indicating an extended period of exposure on the seafloor.

SITES 873 THROUGH 877 (WODEJEBATO GUYOT)

Wodejebato Guyot formed during the Cretaceous as a volcanic edifice and platform sediments were deposited during the Late Cretaceous. The demise of the shallow-water limestone occurred during the Maastrichtian, and pelagic foraminifer and nannofossil oozes capped the guyot during the Tertiary and Quaternary (Premoli Silva, Haggerty, Rack, et al., 1993). The platform limestone of the Cretaceous sedimentary sequence at Sites 873 through 877 was extensively searched for calcareous nannofossils and planktonic foraminifers to obtain biostratigraphic ages and calibration to zonal schemes based on calcareous plankton. Calcareous nannofossils were not observed in the platform sequences recovered at Sites 875 and 876 on the outer ridge, whereas a few nannofossiliferous layers were found at the base of the shallow-water limestones at Sites 873, 874, and 877.

Planktonic foraminifers were observed at all site, with increasing abundance in both persistence of occurrence and species richness per sample, from the lagoonal Site 873 to the inner ridge Sites 874 and 877. Maximum abundance and diversity occur at the outer ridge Sites 875 and 876.

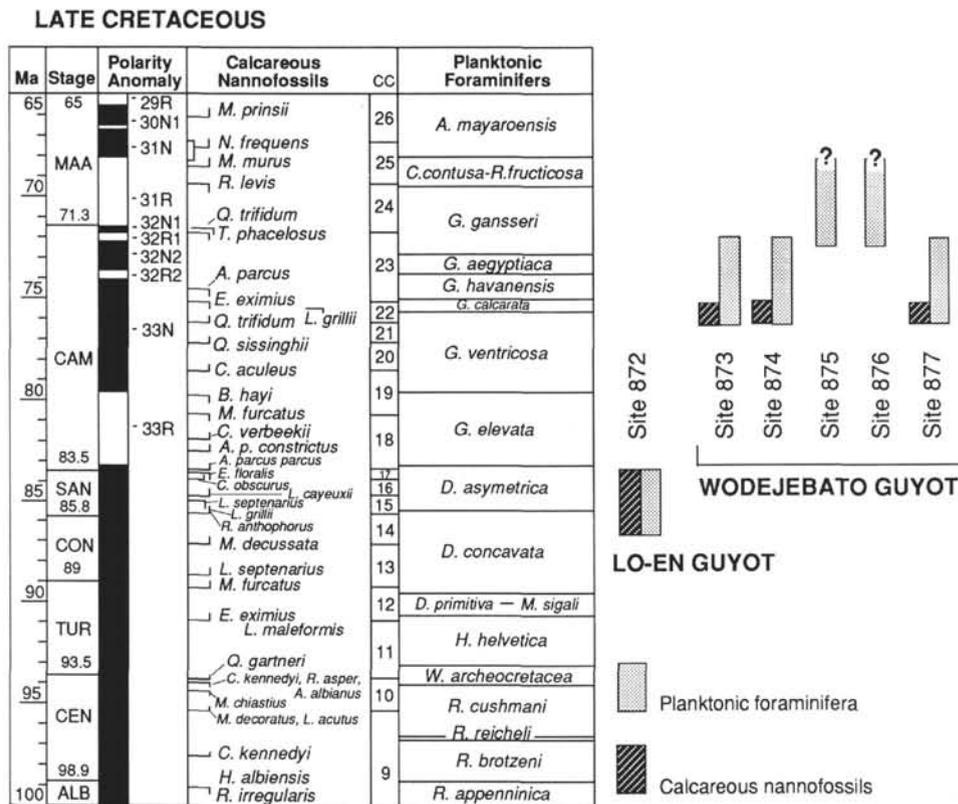


Figure 1. Updated time scale (Gradstein et al., 1994) and revised biomagnetostratigraphy for the Late Cretaceous. Biostratigraphic ages at Sites 872 through 877 are based on the occurrence of calcareous nannofossils and planktonic foraminifers in shallow-water limestone from Wodejebato Guyot (Sites 873 through 877) and in the oldest sediments infilling fractures within the volcanic substrate at Lo-En Guyot (Site 872). Age scale after Gradstein et al. (1994); nannofossil zonation of Sissingh (1977); planktonic foraminifer zonation of Premoli Silva and Sliter (1994).

Calcareous Nannofossils

Nannofossils are well preserved and highly diverse (= number of species) in the basal sediments at Sites 873, 874, and 877, but abundances are extremely low. A detailed documentation including quantitative distribution of nannofloras from Wodejebato Guyot is given by Erba et al. (this volume). Our remarks here concern only the biostratigraphy (Fig. 1). Calcareous nannofossils occur only at the base of the platform sequence at Sites 873, 874, and 877 and date the onset of marine sedimentation. At Site 877, the occurrence of the marker species *Quadrum trifidum*, *Eiffellithus eximius*, and *Reinhardtites anthophorus* indicates the CC22 Zone (Sissingh, 1977) of late Campanian age. At Sites 873 and 874 nannofloral assemblages indicate a broad Campanian age, but key species with a more restricted range were not observed. However, the volcanic pedestal at all sites drilled on Wodejebato Guyot consists of magnetically reversed basalts attributed to magnetic polarity Chron 33R of early Campanian age (Premoli Silva, Haggerty, Rack, et al., 1993; Nakanishi, Gee, et al., 1992). Therefore, the oldest marine sediments at Sites 873 and 874 are datable as late Campanian. Because the nannofloral composition is very similar at Sites 873, 874, and 877, we also attribute the oldest marine sediments of Sites 873 and 874 to the CC22 Zone of Sissingh (1977) (Fig. 1).

The species *Corollithion kennedyi*, which is restricted to the Cenomanian was found at Site 877 suggesting the presence of older sediments elsewhere on Wodejebato Guyot. Other pre-Campanian species include *Axopodorhabdus albianus*, *Eprolithus floralis*, and *Rhagodiscus asper*. Evidence of reworking also is given by the occurrence of recrystallized, broken, and often phosphatized specimens of long-ranging taxa such as *Watznaueria barnesae*, *Cretarhabdus surirellus*, and *Zygodiscus erectus* (see Erba et al., this volume).

Several samples analyzed from the remainder of the platform limestone at Sites 873, 874, and 877, were barren of calcareous nannofossils.

Planktonic Foraminifers

The planktonic foraminifer assemblages are, in general, poorly diversified as was expected in such shallow-water depths of Wodejebato carbonate platform. The most consistent forms of the generally small-sized faunas are *Archaeoglobigerina*, and secondarily *Heterohelix* and *Globigerinelloides*. Keeled forms occur sporadically. The spatial and temporal distribution of planktonic foraminifers shows a clear trend. Keeled forms, known to be deeper dwelling inhabitants than the globigeriniforms (Caron and Homewood, 1983), are more abundant in the outer ridge sites. In addition, keeled forms occur in the uppermost part of the carbonate sequence at the other three sites (see Tables 4–8). Most of the identified taxa are long-ranging species, but the keeled group contains the most age-diagnostic species found on Wodejebato; the *Gansserina gansseri* group. The nominate taxon identifies the *G. gansseri* Zone, which according to the revised calibration (see Chronostratigraphy below) straddles the Campanian/Maastrichtian boundary and extends through the middle Maastrichtian. Representatives of the *Gansserina gansseri* group (e.g., *G. gansseri* and *G. wiedenmayeri*) occur at the top of the carbonate sequence at Sites 873 and 877 (Tables 4 and 8), one core above the base of the limestone unit at Site 875, and almost at the base at Site 876 (Tables 6 and 7). On the other hand, this group was not found at Site 874, which yielded the poorest and fewest planktonic assemblages (Table 5) (see also Premoli Silva et al., this volume). These occurrences suggest the top of the carbonate sequence at Sites 873 and 877, and

Table 2. Samples investigated for calcareous nannofossils listing the type of investigation, key species, and biozones.

Core, section, interval (cm)	Smear slide	Thin section	SEM	Nannofossils	Core, section, interval (cm)	Smear slide	Thin section	SEM	Nannofossils
Lo-En Guyot					1R-CC, 13-15		X		—
144-872A-17H-CC		X		CC15-17	2R-1, 20-23		X		late middle Albian
144-872B-4R-1, 0-1	X			—	3R-1, 40-46		X		late middle Albian
4R-1, 20-21	X			—	15R-CC	X			—
4R-1, 21-22	X			CC15	36M-1, 98-105	X			—
4R-1, 60-62		X		CC15	41M-1, 0-4		X		<i>N. truittii</i> Acme
4R-1, 61-62	X			CC14-15	41M-1, 4-8		X		<i>N. truittii</i> Acme
4R-1, 68-89	X			<i>E. eximius</i> + <i>M. furcatus</i>	42M-1, 5-10	X			—
5R-1, 127-128	X			<i>E. eximius</i>	42M-1, 15-20		X		—
5R-2, 12-20	X			—	42M-1, 22-25		X		—
5R-2, 44-47	X			—	44M-CC	X			—
5R-2, 96-97	X			—	45M-CC	X			—
5R-2, 122-124	X			—	50R-3 (base)	X			—
5R-4, 25-27	X			—	51R-2, 5-10		X		—
Woejebato Guyot					52R-CC	X			—
144-873A-2R-CC	X			—	53R-CC	X			—
3R-CC	X			—	63R-2, 2-4	X			—
4R-CC	X			—	62R-2, 112-113	X			—
5R-CC	X			—	62R-2, 120	X			—
6R-CC	X			—	62R-2, 130	X			—
7R-CC	X			—	62R-2, 140	X			—
8R-1, 110-116	X			—	63R-1, 0-1	X			—
8R-2, 5-8	X			—	63R-1, 6-8	X			—
8R-2, 9-12	X			—	63R-1, 10-11	X			—
9R-2, 16-22	X			<i>Prediscosphaera</i> sp.	75R-1, 141-143		X		lower <i>C. litterarius</i> Zone
11R-2, 15-16	X			—	75R-2, 0-4		X		lower <i>C. litterarius</i> Zone
11R-2, 20	X		X	—	77R-1, 28-31		X		<i>W. barnesae</i> + <i>R. irregularis</i>
11R-2, 17-22	X		X	Campanian	79R-5, 80-81	X			—
12R-CC	X			Campanian	79R-5, 100-105	X			—
144-873B-9N-CC	X			—	94R-5, 0-1	X			—
1N-CC	X			—	Takuyo-Daisan Guyot				
144-874B-21R-1, 0-1	X			—	144-879A-2R-1, 32-38		X		—
21R-1, 35-36	X			—	2R-1, 132-138		X		—
21R-1, 40-41	X			—	5R-1, 0-2	X			—
21R-1, 44-45	X		X	Campanian	15R-1, 0-3		X		—
21R-1, 148-149	X			—	16R-1, 12-13	X			—
21R-CC	X			—	16R-1, 14-15	X			—
144-875C-8M-CC	X			—	16R-1, 17-18	X			—
10M-CC	X			—	16R-1, 18-20	X			—
11M-CC	X			—	16R-1, 23-27		X		—
12M-CC	X			—	16R-1, 25-26	X			<i>N. truittii</i> Acme
13M-CC	X			—	16R-1, 27-33		X		<i>N. truittii</i> Acme
144-876A-11R-2, 13	X			—	16R-1, 37-38	X			—
11R-2, 43-44	X			—	16R-1, 44-45	X			—
11R-2, 56-62	X			—	16R-1, 60-63	X			—
14R-1, 0-1	X			—	16R-1, 68-72	X			<i>N. truittii</i> Acme
144-877A-1R-1, 140-144	X			—	16R-1, 74-77	X			—
1R-1, 144-148	X			—	16R-1, 79-84		X		—
3R-1, 29-30	X			—	16R-1, 94-96	X			—
3R-1, 93-94	X			—	16R-1, 102-103	X			—
7R-CC	X			—	16R-1, 123-125		X		—
14R-CC	X			—	16R-1, 137-145	X			—
16R-CC	X			—	17R-1, 0-5		X		—
18R-CC	X			—	17R-1, 18-19	X			—
19R-CC	X			—	17R-1, 23-24	X			—
20R-1, 16-17	X		X	Campanian	17R-1, 24-25	X			—
20R-1, 28-29	X			—	17R-1, 29-30	X			—
20R-1, 42-44	X		X	Campanian	17R-1, 36-37	X			—
20R-1, 44-45	X		X	CC22	17R-1, 50-51	X			—
20R-1, 54-55	X			—	17R-1, 57-61		X		—
20R-1, 70-71	X		X	Late Cretaceous	17R-1, 70-80	X	X	X	<i>N. truittii</i> Acme
20R-1, 81-82	X			—	17R-1, 73-74	X			<i>N. truittii</i> Acme
20R-1, 92-94	X			—	17R-1, 78-79	X			<i>W. barnesae</i>
20R-1, 101-102	X			—	17R-1, 79-80	X			—
20R-1, 102-103	X			—	17R-1, 80-83	X	X	X	<i>N. truittii</i> Acme
20R-2, 0-1	X			—	17R-1, 83-85	X			—
20R-2, 1-2	X			—	17R-1, 95-97	X			—
20R-2, 15-16	X			—	17R-1, 97-103	X	X	X	<i>N. truittii</i> Acme
20R-2, 34-35	X			—	17R-1, 109-112		X		—
20R-2, 61-62	X			—	17R-1, 119-120	X			—
20R-2, 98-99	X			—	17R-1, 133-134	X			—
MIT Guyot					17R-1, 146-147	X			—
144-878A-1R-CC, 10-12	X			—	17R-2, 25-26	X			<i>R. irregularis</i> + <i>Z. erectus</i>
					17R-2, 40-41	X			—
					17R-2, 55-56	X			—
					17R-CC	X			—
					18R-1, 4-7		X		—
					18R-1, 10-13		X		—
					18R-1, 22-26		X		—
					18R-1, 23-24	X			—
					18R-1, 30-35	X			<i>N. truittii</i> Acme
					18R-1, 31-37	X	X	X	late Aptian
					21R-1, 95-96				—

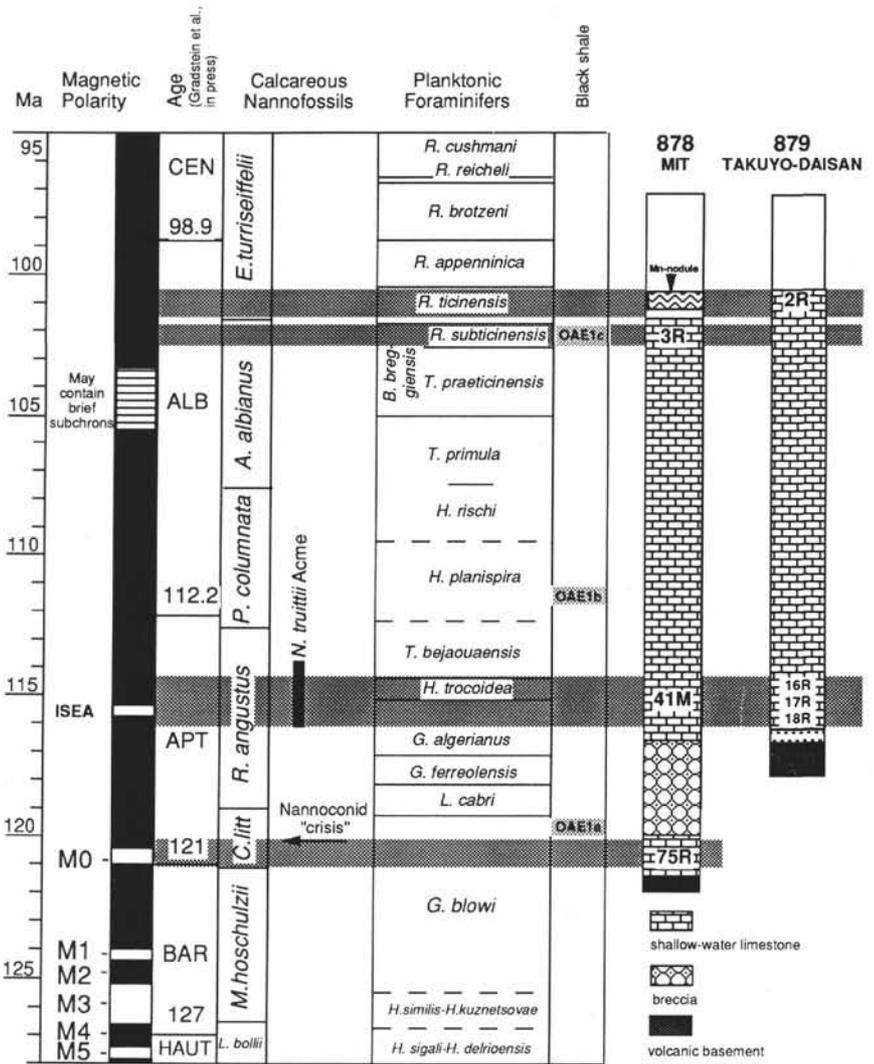


Figure 2. Age of Aptian to Albian calcareous plankton (shaded) recovered from shallow-water carbonate platform sediments at Site 878 (MIT Guyot) and at Site 879 (Takuyo-Daisan Guyot). Age scale and magnetostratigraphy after Gradstein et al (1994); nannofossil zonation of Thierstein (1973, 1976), Roth (1978), and Erba (1994); planktonic foraminifer zonation of Premoli Silva and Sliter (1994).

observed in both samples include *Watznaueria barnesae*, *Cyclagelosphaera margerelii*, *Rucinolithus irregularis*, *Rucinolithus terebrodentarius*, *Eprolithus floralis*, *Nannoconus steinmannii*, *Nannoconus inconspicuus*, and *Nannoconus bucheri*. The occurrence of *Eprolithus floralis* and the absence of younger marker species indicate the *Rhagodiscus angustus* Zone of late Aptian age. More precisely, the relative dominance of *Nannoconus truittii* suggests the *Nannoconus truittii* Acme of middle late Aptian age (Fig. 2) (Mutterlose, 1989, 1991; Erba, 1994).

In the upper shallow-water limestone, calcareous nannofossils occur in two samples, and assemblages are characterized by very low abundance and poor preservation. Sample 144-878A-3R-1, 40–46 cm, contains sparse *Watznaueria barnesae*, *Rucinolithus irregularis*, small *Eiffellithus* spp., and *Pervilithus varius*. A similar assemblage in Sample 144-878A-2R-1, 20–23 cm, yielded *Watznaueria barnesae*, *Watznaueria supracretacea*, *Rucinolithus irregularis*, *Rucinolithus terebrodentarius*, *Eprolithus floralis*, small *Eiffellithus* spp., and *Braarudosphaera stenorhetha*. The co-occurrence of *Rucinolithus irregularis* and small *Eiffellithus* spp. suggests that Cores 144-878A-2R and -3R are correlative with the early late Albian part of the *Axopodorhabdus albianus* Zone, immediately preceding the first occurrence of *Eiffellithus turriseiffelii* and also with the *Biticinella breggiensis* planktonic foraminifer zone. Similar assemblages were recorded in the Tethys (Erba, 1988), Pacific and Indian Oceans (Bralower, 1993; Bralower et al., 1993). This age assignment is corroborated by the occurrence of rare specimens of *Pervilithus varius*

that were reported from coeval intervals in Tethyan sections (Erba, 1988), and by the presence of *Braarudosphaera stenorhetha*, which is restricted to the middle to late Albian (Perch-Nielsen, 1985).

Planktonic Foraminifers

A few layers belonging to both the upper and lower platform limestone yielded generally rare, poorly preserved planktonic foraminifers. They may occur more frequently than plotted in Fig. 2, but we disregarded all specimens in which the calcitic wall was not at least partially visible in thin section.

The lowermost Sample 144-878A-77R-1, 28–31 cm, yielded several specimens, mainly hedbergellids. Most are coated with a micritic, occasionally sparry, film. The species identified include common *Hedbergella delrioensis*, very rare *H. excelsa*, possible *H. aptiana*, and *Globigerinelloides ferreolensis*. Their average size is around 250 µm. A single specimen, tentatively referred to *G. ferreolensis* was observed in Samples 144-878A-75R-2, 0–4 cm, and -75R-1, 0–4 cm, respectively, whereas Sample 144-878A-75R-1, 141–143 cm, yielded more numerous planktonic foraminifers. In the latter, however, nondiagnostic sections predominate and only *Hedbergella delrioensis* was identified confidently.

A small planktonic foraminifer fauna occurs in Sample 144-878A-41M-1, 4–8 cm. This includes single specimens of *Hedbergella similis*, *H. trocoidea*, *H. delrioensis*, and *Globigerinelloides barri* in addition to a few unidentifiable specimens.

Table 4. Range chart of planktonic foraminifers in the shallow-water sediments recovered at Site 873 (Wodejebato Guyot), late Campanian–Maastrichtian.

Site 873	<i>Margino truncana pseudolinneana</i>	<i>Globigerinelloides prairiehillensis</i>	<i>Archaeoglobigerina</i> sp.	<i>Hedbergella</i> sp. cf. <i>H. planispira</i>	<i>Globigerinelloides</i> sp.	<i>Archaeoglobigerina blowi</i>	<i>Archaeoglobigerina cretacea</i>	<i>Heierohelix</i> sp.	<i>Globigerinelloides subcarinatus</i>	<i>Heterohelix globulosa</i>	<i>Globigerinelloides alvarezii</i>	<i>Gonasserina wiedenmayeri</i>	<i>Hedbergella</i> sp.	<i>Globotruncana ventricosa</i>
Core, section, interval (cm)														
Hole 873B														
8N-1, 4-8	.	.	1	.	.	.	.	1	.	.	.	.	.	.
8N-1, 56-57	.	.	1	.	.	.	.	1	.	.	.	.	.	.
8N-1, 130-132	2	.	.	.	.	.	.
8N-2, 71-73	?
8N-2, 77-79	3	.	.	.	.	1	.
8N-CC	1
9N-1, 130-135	1	.	.	.	.	.	1
Hole 873A														
3R-1, 3-6	1	.	.	.	.	.	.	.	.
4R-1, 16-20	.	.	?
5R-1, 13-18	.	.	1	.	.	.	.	.	.	.	.	1?	.	.
5R-1, 41-46	?	.	1	.	.	.	.	.	.
5R-1, 104-107	.	.	.	1	.	.	.	?	.	.	.	.	.	.
6R-1, 11-18	.	1	1	.	.	.	.	1	.	.	1	1	.	.
7R-1, 7-9	.	.	1	.	.	.	.	1	.	.	.	.	.	.
7R-1, 16-20	.	.	1	.	.	.	.	.	.	.	.	.	.	.
7R-1, 30-34	.	.	1	.	.	.	.	.	.	.	.	.	.	.
7R-2, 0-4	.	.	1	.	.	.	.	.	.	.	.	.	.	.
8R-1, 54-57	1	.	.	.	.
8R-2, 0-3	.	.	1	.	.	.	.	.	.	.	.	.	.	.
8R-2, 20-23	1	.	.	.	.	.	.	.
9R-1, 78-81	1	1	.	.	.	.	.	.	.
9R-1, 119-123	1	.	.	.	.	.
9R-1, 142-146	.	.	vr	.	.	.	.	.	.	.	.	.	.	.
9R-2, 0-3	.	.	1	.	.	.	.	2	.	.	.	.	.	.
10R-1, 46-50	1	.	.	.	1	1	1	.	.	.	.	.	.	.
10R-1, 116-118	.	.	1	.	.	.	.	.	.	.	.	.	.	.
11R-2, 0-3	1	1	1	.	.	.	.	.	.	.	.	.	.	.

Note: Estimated abundance given as # = number of specimens and vr = very rare.

Very rare, poorly preserved planktonic foraminifers were observed in Sample 144-878A-26M-1, 4–12 cm. Only two specimens could be confidently identified as *Hedbergella delrioensis* and *Ticinella roberti*, respectively.

A single specimen of *Hedbergella delrioensis* and a possible early form of *Rotalipora subticinensis* were observed in Sample 144-878A-3R-1, 40–46 cm. Sparse, small-sized planktonic foraminifers occur in Sample 144-878A-1R-CC, 13–15 cm (Fig. 2), where the species identified include single specimens of *Hedbergella delrioensis*, *H. simplex*, and *Globigerinelloides ultramicrus*.

The planktonic foraminifer assemblages at Site 878, although poorly diversified, contain a few age-diagnostic species. In particular, (1) *Hedbergella excelsa* and the possible *H. aptiana*, from the lowermost assemblage, do not range above the lower Aptian (Longoria, 1974; Banner and Desai, 1988). The mean sizes of all the individuals, not exceeding 250 µm, also are characteristic of lower Aptian assemblages (see Tornaghi et al., 1989). (2) The occurrence of *Globigerinelloides barri* and *Hedbergella trocoidea* dates Sample 144-878A-41M-1, 4–8 cm, and, thus the initiation of the upper carbonate plat-

Table 5. Range chart of planktonic foraminifers in the shallow-water sediments recovered at Site 874 (Wodejebato Guyot), late Campanian–Maastrichtian.

Site 874	<i>Globotruncana bulloides</i>	<i>Heterohelix</i> sp.	<i>Pseudotextularia</i> sp.	<i>Globigerinelloides messinae</i>	<i>Archaeoglobigerina</i> sp.	<i>Globigerinelloides alvarezii</i>	<i>Globigerinelloides subcarinatus</i>	<i>Heterohelix globulosa</i>	<i>Hedbergella monmouthensis</i>	<i>Hedbergella holmdelensis</i>	<i>Globotruncana</i> sp.	<i>Heterohelix striata</i>	<i>Rugoglobigerina</i> sp.	<i>Hedbergella</i> sp.
Core, section, interval (cm)														
Hole 874A														
1R-2, 16-22	.	?	.	.	1	.	.	.	.	.	.	.	.	.
Hole 874B														
2R-1, 19-21	.	?	.	.	F	.	.	.	.	.	.	.	.	.
2R-1, 67-69	.	.	.	.	.	.	.	.	.	.	.	.	.	?
2R-1, 84-87	.	.	.	.	.	.	.	.	.	.	.	.	.	?
2R-1, 126-130	.	.	.	.	.	.	.	.	.	.	.	.	?	.
3R-1, 114-118 inf.	.	.	.	1	1	.	.	C	C	F	?	.	.	.
10R-1, 5-7	.	1	.	.	1	1	1	.	.	.	.	.	.	.
11R-1, 1-3	.	vr	.	1	.	.	.	.	.	.	.	.	.	.
16R-1, 10-12	.	vr	.	.	.	.	.	.	.	.	.	.	.	.
19R-1, 7-10	.	1	.	.	.	.	.	.	.	.	.	.	.	.
19R-1, 11-13	cf 1	1	.	.	.	.	.	.	.	.	.	.	.	.
19R-1, 120-125	.	vr	?	.	.	.	.	.	.	.	.	.	.	.

Notes: Estimated abundance given as # = number of specimens, vr = very rare, F = few, and C = common. "cf" = uncertain identification, and "inf." = pelagic infilling.

form, as late Aptian and possibly as middle late Aptian. This age determination is based primarily on the stratigraphic range of *G. barri*, that is known from the base of the *Globigerinelloides algerianus* Zone to the middle of the *Hedbergella trocoidea* Zone (Sigal, 1977). (3) *Ticinella roberti* is known to range from uppermost Aptian to upper Albian (Caron, 1985), but its distribution is not continuous, as it disappeared in the lower Albian and reappeared in the lower upper Albian *Biticinella breggiensis* Zone. We interpret its occurrence in Sample 144-878A-26M-1, 4–12 cm, as representing the upper part of its total range, in agreement with the Albian age inferred from the associated shallow-water benthic assemblage. (4) The tentative identification of *Rotalipora subticinensis*, although primitive in morphology, is diagnostic of the nominal upper subzone of the *Biticinella breggiensis* Zone. Sample 144-878A-3R-1, 40–46 cm, thus, is possibly dated as late Albian.

In summary (Fig. 2), calcareous nannofossils and planktonic foraminifers indicate that (1) the initiation of carbonate platform sedimentation occurred in the earliest Aptian (lower part of the *C. litterarius* Zone before the "nannoconid crisis"), (2) the deposition of the polymictic breccia is constrained to the "middle" Aptian, (3) carbonate sedimentation resumed after the phreato-magmatic eruption, in the middle late Aptian (*N. truitii* Acme, *G. algerianus* to *H. trocoidea* Zones), and (3) carbonate sedimentation ended during the late Albian after the *Biticinella breggiensis* Zone. This interpretation is consistent with the occurrence of *Planomalina praebuxtorfi*, a short-ranging species that straddles the *Rotalipora ticinensis*/*Rotalipora appenninica* zonal boundary, in the overlying manganese nodules (Fig. 2) (see Watkins et al., this volume).

SITE 879 (TAKUYO-DAISAN GUYOT)

Site 879 was drilled on the eastern margin of Takuyo-Daisan Guyot and penetrated a middle Cretaceous carbonate platform overlying the volcanic substrate. No pelagic cap was recovered at this site. Both

Table 6. Range chart of planktonic foraminifers in the shallow-water sediments recovered at Site 875 (Wodejebato Guyot), *Gansserina gansseri* Zone, Maastrichtian.

Hole 875C	<i>Heterohelix</i> sp.	<i>Globotruncana arca</i>	<i>Globotruncana</i> sp.	<i>Gansserina wiedenmayeri</i>	<i>Archaeoglobigerina blowi</i>	<i>Globotruncana bulloides</i>	<i>Rugoglobigerina hexacamerata</i>	<i>Globotruncana ventricosa</i>	<i>Gansserina gansseri</i>	<i>Archaeoglobigerina cretacea</i>	<i>Rugoglobigerina</i> sp.	<i>Globigerinelloides alvarezii</i>	<i>Hedbergella</i> sp.	<i>Rugoglobigerina rugosa</i>	<i>Pseudoguembelina costulata</i>	<i>Globigerinelloides massinae</i>	<i>Heterohelix globulosa</i>	<i>Globotruncana lapparentii</i>	<i>Archaeoglobigerina</i> sp.	<i>Contusotruncana plummerae</i>	<i>Globotruncana siuariformis</i>	<i>Globigerinelloides prairiellensis</i>	<i>Globotruncana orientalis</i>	<i>Heterohelix punctulata</i>	<i>Globotruncana rosetta</i>	<i>Rugoglobigerina rotundata</i>	<i>Rugoglobigerina macrocephala</i>	<i>Globotruncana pettersi</i>	<i>Pseudotextularia elegans</i>	<i>Globigerinelloides</i> sp.						
1M-1, 0-2	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
1M-1, 34-36	1	.	.	.	.	.	.	.	.	.	1	.	.	.	.	.	.	.	.	1	.	.	.	.	.	.	.	.	.	.	1	1	.		
2M-1, 61-64	1	.	.	.	.	.	.	.	.	.	1	.	.	.	.	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.
4M-1, 2-5	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.	cf	.	.	.	.	.	.	.
5M-1, 131-136	.	.	.	?	.	.	.	.	.	.	.	.	.	1	1	1	.	.	.	.	.	.	.	1	.	.	.	.	.	.	.	.	.
6M-1, 93-94	.	.	.	.	1	.	.	.	.	.	.	.	.	1	.	.	.	.	.	.	.	.	.	1	.	.	.	.	.	?	.	.	.
7M-1, 29-30	.	.	.	.	.	.	1	.	1	.	.	.	.	1	1	.	1	.	.	.	.	.	.	.	.	.	.	?	1	.	.	.	.
7M-1, 30-36	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.	.	.	.	.	.	.	.	.
8M-1, 18-19	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.	.	.	.	.	1	.	.	.	.	.	.	.	.	.	.
9M-1, 0-4	1	.	.	.	.	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.	1	.	.	.	.	1	.	.	.	.	.	.	.	.
9M-1, 0-7	.	1	.	.	1	.	.	.	1	.	.	.	.	1	.	.	.	.	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.
9M-1, 29-31	R	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
10M-1, 122-125	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.
10M-2, 94-96	.	.	.	.	.	.	1	.	.	1	.	.	.	.	.	.	1	.	.	.	.	.	.	.	cf	.	.	.	.	.	.	.	.	.	.
11M-1, 68-71	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
11M-1, 121-124	.	.	.	.	.	.	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.
11M-2, 61-64	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	R	.	R	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
11M-3, 49-54	.	.	.	.	1	.	1	.	.	.	.	.	.	.	.	.	1	.	.	.	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.
11M-3, 93-97	.	vr	.	.	1	.	.	1	1	.	1	.	.	.	.	C	.	.	.	.	.	1	1	.	.	.	.	.	.	.	.	.	.	.	.
12M-1, 30-34	F	.	.	.	cf	.	.	.	.	.	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
12M-1, 131-135	1	1
12M-1 (cuttings)	.	cf	.	.	R	1	.	.	.	.	.	.	.	.	.	.	.	.	1	.	cf	.	.	.	.	.	.	.	.	.	.	.	.	.	.
13M-1, 24-26	1
13M-1, 67-72	.	1	F	.	.	1	.	F	F	1	.	?	1	1	F	1	1	F	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
13M-1, 68-73	.	.	.	F	C	C	.	.	.	C	C	F	C
13M-1, 123-130	1	1
13M-1, 125-129	.	2	.	.	.	2	F	F	F
13M-2, 61-64	.	.	R	R	1
14M-1, 15-17	1
14M-1, 50-53	?	?
14M-1, 59-62	?

Notes: Estimated abundance given as # = number of specimens, vr = very rare, R = rare, F = few, and C = common. "cf" = uncertain identification.

calcareous nannofloras and planktonic foraminifers were encountered in the oldest sediments overlying basalts and provide a precise biostratigraphic age for the inception of marine sedimentation.

Calcareous Nannofossils

At Site 879, calcareous nannofossils were extensively sought in smear slides and thin sections from the upper and lower parts of the shallow-water sequence (Table 10). A few nannofossiliferous layers occur in Cores 144-879A-16R, -17R, and -18R, from the oldest sediments above the volcanic substrate. The best nannofossil assemblages are in Samples 144-879A-17R-1, 70-80, 73-74, 80-83, and 97-103 cm, which contain *Eprolithus floralis*, *Watznaueria barnesae*, *Watznaueria britannica*, *Micranolithus hoschulzii*, *Zygodiscus erectus*, *Vagalapilla stradneri*, *Biscutum constans*, *Diazomolithus lehmanii*, *Microstaurus chiastius*, *Lithraphidites carniolensis*, *Discorhabdus rotatorius*, *Braarudosphaera africana*, *Nannoconus truittii*, *Rucinolithus irregularis*, *Rucinolithus terebrodentarius*, *Rhagodiscus asper*, *Rhagodiscus angustus*, and *Markalius circumradiatus*. The occurrence of *Eprolithus floralis* without younger marker species indicates the upper Aptian *Rhagodiscus angustus* Zone. The relative dominance of *Nannoconus truittii* in all these sample indicate that Core 144-879A-17R is correlative with the middle late Aptian *N. truittii*

Acme. Similar, although depauperate, nannofloras occur in Samples 144-879A-18R-1, 30-35 and 31-37 cm; these are consequently attributed to the *N. truittii* Acme. Most samples from Core 144-879A-16R lack calcareous nannofossils. Sparse specimens of *Nannoconus truittii*, *Watznaueria barnesae*, *Rucinolithus irregularis*, and *Eprolithus floralis* were recorded in Samples 144-879A-16R-1, 25-26, 27-33, and 68-72 cm. Again, although a precise age assignment is biased by the paucity of nannofossils, the relative dominance of *Nannoconus truittii* suggests that the middle upper Aptian *N. truittii* Acme may extend to Core 144-879A-16R (Fig. 2).

Calcareous nannofossils were not observed in any samples investigated from the upper shallow-water limestone at Site 879.

Planktonic Foraminifers

Planktonic foraminifers occur in several layers in the lowermost cores and close to the top of the platform sequence. They are very rare to rare, except in two samples from Sections 144-879A-18R-1 and -16R-1, where modest numbers occur. Preservation is poor overall.

The lowermost Sample 144-879A-18R-1, 22-26 cm, yielded few specimens mainly attributed to small, indeterminate hedbergellid cross sections. Two specimens are attributed to *Hedbergella planispira* and the *H. trocoidea* group, respectively.

Table 7. Range chart of planktonic foraminifers in the shallow-water sediments recovered at Site 876 (Wodejebato Guyot), *Gansserina gansseri* Zone, Maastrichtian.

Hole 876A	<i>Globotruncana arca</i>	<i>Globotruncana ventricosa</i>	<i>Gansserina gansseri</i>	<i>Rugoglobigerina rugosa</i>	<i>Conostrotruncana plummerae</i>	<i>Heterohelix punctulata</i>	<i>Globotruncana aegyptiaca</i>	<i>Globotruncana lincolni</i>	<i>Gansserina wiedenmayeri</i>	<i>Heterohelix</i> sp.	<i>Pseudostatalaria elegans</i>	<i>Archaeoglobigerina cretacea</i>	<i>Archaeoglobigerina blowi</i>	<i>Heterohelix globulosa</i>	<i>Globotruncana stansiformis</i>	<i>Archaeoglobigerina</i> sp.	<i>Pseudoglobobulina escolata</i>	<i>Pseudostatalaria</i> sp.	<i>Globotruncana bulboides</i>	<i>Globigerinelloides algerianus</i>	
1R-1, 17-21	1	.	.	.	.	.	.	.	.	.	.	.	.
1R-1, 43-48	1	F	.	1	.	.	.	.	.	.	1	.	1
1R-1, 71-76	1	.	.	.	.	.	.	.	.	.	.	.	.
2R-1, 39-45	1	.	.	.	.	.	.	.	.	.	.	.	.
4R-1, 69-76	1	.	.	.	.	.	.	.	.	.	.	.	.
5R-1, 17-18	F	.	.	.	.	.	1	1	.	.	.	.	.
5R-2, 18-24	1	.	1	.	.	.	.	1	.	?	.	.	.
5R-3, 0-6	.	.	.	1	.	.	.	.	1	1	.	.	.	.	.	.	.	.	.	.	.
7R-1, 17-23	.	.	.	1	.	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.
7R-1, 130-136	1	1	1	.	.	.	.	1	.	.	1	1	1
8R-1, 56-60	1	.	.	.	.	.	.	.	.	.	.	.	.
9R-1, 10-14	.	.	1?	.	.	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.
10R-1, 27-32	1	1	.	.	.	.	.	.	.	.	.	.	.
11R-1, 58-59	1	.	.	.	.	.
11R-1, 115-117	?	1	.	.	.
11R-1, 131-135	1	.	.	.	.	.	.	.	.	.	.	.	.
11R-2, 43-46	?
11R-2, 71-73	1	1	1	.	.	.	.	.	.	.	.	.	.
12R-1, 21-24	1	1	1	.	.	.	.	1	1	.	.	.	.
13R-1, 22-26	1	1	.	.	1	1	1	1	.	.	.	.	.
13R-1, 88-92	1	1	.	.	.	.	.	.	.	.	.	.	.
13R-1 (cuttings)	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
14R-1, 48-52	.	1	.	.	.	.	.	.	1	1	1	1	1	1	1	1	1	1	1	1	1
14R-1, 77-79	1	.	.	.	.	.	.	.	.	.	.	.	.
14R-1 (cuttings)	R	C	1	C	1	1	R	1	.	.	.	.	.	.	.	.	.	.	.	.	.

Notes: Estimated abundance given as # = number of specimens, R = rare, F = few, and C = common.

A possible *Globigerinelloides algerianus* and *Hedbergella delrioensis* occur in Sample 144-879A-18R-1, 10–13 cm, along with other rare unidentifiable forms. Single, dubious specimens of *Globigerinelloides*, *Hedbergella*, and lagenids were observed in Sample 144-879A-18R-1, 4–7 cm. Very rare indeterminate planktonic foraminifers also occur in Samples 144-879A-17R-1, 109–112 and 0–5 cm.

One of the very rare specimens observed in Sample 144-879A-16R-1, 123–125 cm, possesses large kidney-shaped chambers in cross-section and may be attributable either to *Globigerinelloides barri* or to *H. trocoidea*. The latter species, larger than 300 μm in size, also was identified in Sample 144-879A-16R-1, 79–84 cm, along with a *Globigerinelloides*, possibly *G. ferreolensis*. In the richest assemblage from Sample 144-879A-16R-1, 27–33 cm, on the contrary, nondiagnostic cross-sections prevented identification of any specimen at the specific level; most were attributed to hedbergellids.

Finally, a large specimen (>500 μm) with an acute, possibly keeled, margin, a long, slightly convex spiral side, chambers that gradually increase in size, and a large umbilicus was recorded in Sample 144-879A-2R-1, 132–138 cm, is tentatively referred to *Rotalipora ticinensis*. A second specimen somewhat resembles *Ticinella raynaudi*, and a third belongs to the genus *Hedbergella*.

Planktonic foraminifer assemblages from the lower cores (144-879A-18R to -16R), although at low abundance and diversity, appear homogeneous. The occurrence of forms attributed to *H. trocoidea*, *G. ferreolensis*, and possibly to *G. algerianus* and *G. barri* would indicate the *Globigerinelloides algerianus* Zone and constrain the age of the lowermost interval to the middle late Aptian (Figure 2). The presence of *R. ticinensis* in Sample 144-879A-2R-1, 132–138 cm, if correct, would indicate the late Albian *Rotalipora ticinensis* Zone (Fig. 2).

In summary, calcareous nannofossils and planktonic foraminifers suggest that the initiation of carbonate platform sedimentation at Site 879 occurred during the middle late Aptian (*N. truitii* Acme, *G.*

Table 8. Range chart of planktonic foraminifers in the shallow-water sediments recovered at Site 877 (Wodejebato Guyot), late Campanian–Maastrichtian.

Hole 877A	<i>Globotruncana bulboides</i>	<i>Archaeoglobigerina</i> sp.	<i>Globotruncana</i> sp. cf. <i>G. arca</i>	<i>Pseudoglobobulina</i> sp.	<i>Rugoglobigerina</i> sp.	<i>Archaeoglobigerina cretacea</i>	<i>Globotruncana</i> sp.	<i>Heterohelix</i> sp.	<i>Rugoglobigerina rugosa</i>	<i>Archaeoglobigerina blowi</i>	<i>Globigerinelloides</i> sp.	<i>Pseudostatalaria</i> sp.	<i>Gansserina wiedenmayeri</i>	<i>Gansserina gansseri</i>	<i>Pseudostatalaria elegans</i>	<i>Globotruncana ventricosa</i>
Core, section, interval (cm)																
1R-1, 8-10	.	.	.	.	.	.	.	.	.	.	.	.	.	.	cf	1
1R-2, 42-46	1	1	.	.	.	.	.	.	.	.	.	.	?	.	.	.
2R-1, 53-55	.	1	.	.	.	.	.	?	.	.	.	1	.	.	.	.
3R-1, 130-133	.	.	.	.	?	.	.	.	.	.	.	1	.	.	.	.
4R-2, 18-21	.	.	.	.	.	.	.	1	.	.	1	.	.	.	.	.
4R-3, 13-17	.	.	.	.	.	.	.	1	.	.	1	.	.	.	.	.
5R-1, 8-4	.	.	.	.	.	.	.	?	.	.	.	.	.	.	.	.
7R-1, 88-91	.	.	.	.	.	.	.	1	.	.	1	.	.	.	.	.
7R-2, 109-120	.	?	.	.	.	.	.	.	1	1	.	.	.	.	.	.
10R-1, 3-10	.	.	.	.	.	R	.	.	.	.	.	.	.	.	.	.
18R-1, 25-28	.	1	.	.	.	C	1	1	.	.	.	.	.	.	.	.
18R-1, 70-74	1	1	.	.	?	1	.	.	.	.	.	.	.	.	.	.
19R-1, 27-30	.	?	.	?	?	.	.	.	.	.	.	.	.	.	.	.
20R-1, 0-7	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.
20R-1, 61-63	vr	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.

Notes: Estimated abundance given as # = number of specimens, vr = very rare, R = rare, and C = common. "cf" = uncertain identification.

algerianus to *H. trocoidea* Zones) and ended by late Albian (*R. ticinensis* Zone). The shallow-water limestone at Site 879 is correlative with the upper platform sequence recovered in Hole 878A. The poor recovery in the middle part of the cored sequence at Site 879 prevents the identification of possible hiatuses. In fact, the carbonate sequence at this site is only half the thickness of that deposited at Site 878 on MIT Guyot during the late Aptian to late Albian interval.

CRETACEOUS CALCAREOUS PLANKTON BIOSTRATIGRAPHY AND CHRONOSTRATIGRAPHY

Cretaceous stratigraphy currently is being revised to improve the correlation between chronostratigraphy and biomagnetostratigraphy, using data from sections in Tunisia, Spain, northern Germany, and North America. These sections provide ammonite control for calcareous plankton biostratigraphy and/or magnetostratigraphy. This revision has also recalibrated the Late Cretaceous stage boundaries with respect to magnetic polarity chronozones and/or calcareous plankton biozones (Premoli Silva and Sliter, 1994). Moreover, a revised time scale has been proposed (Gradstein et al., 1994) with updated absolute ages for Mesozoic stage boundaries. Figure 1 illustrates the revised geochronology and biomagnetostratigraphy of the Late Cretaceous and the stratigraphic position of the calcareous plankton-bearing intervals at Sites 872 to 877.

We continue to equate the base of the *Rotalipora brotzeni* Zone with the Albian/Cenomanian boundary (e.g., Sigal, 1977; Porthault, 1978) as there is little macropaleontologic data and no nannofossil events at this boundary. Further, both stages fall in the Cretaceous Normal Polarity Superchron. The Cenomanian/Turonian boundary falls within the *Whiteinella archaeocretacea* Zone (Elder and Kirkland, 1985; Leckie, 1985; Robazynski, 1989); the first occurrence of the calcareous nannofossil *Quadrum gartneri* shortly precedes this boundary. The *Helvetoglobotruncana helvetica* Zone begins in the lowermost Turonian and extends to the upper half of the middle Turonian (Robazynski et al., 1990). The *Marginotruncana sigali* Zone is con-

Table 10. Range chart of calcareous nannofossils in the shallow-water limestones recovered at Site 879 (Takuyo-Daisan Guyot).

Core, section interval (cm)	Total abundance	Preservation	<i>Watznaueria barnesae</i>	<i>Rhagodiscus angustus</i>	<i>Biscutum constans</i>	<i>Braarudosphaera africana</i>	<i>Rhagodiscus asper</i>	<i>Rucinolithus terebrentarius</i>	<i>Cretarhabdus surirellus</i>	<i>Conusphaera mex. mexicana</i>	<i>Eprolithus floralis</i>	<i>Nannocoelus</i> spp.	<i>Discorhabdus rotatorius</i>	<i>Nannocoelus truitii</i>	<i>Rucinolithus irregularis</i>	<i>Watznaueria britannica</i>	<i>Markalius circumradiatus</i>	<i>Micrantholithus hoschulzii</i>	<i>Zygodiscus erectus</i>	<i>Vagalapilla siradneri</i>	<i>Diazomatolithus lehmani</i>	<i>Microstaurus chiasius</i>	<i>Lithraphidites carniolensis</i>	<i>Glaukolithus diplogrammus</i>	Nannofossil zone	Age
879A-2R-1, 32-38	B	-	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
2R-1, 132-138	B	-	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
5R-1, 0-2	B	-	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
15R-1, 0-3	B	-	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
16R-1, 12-13	B	-	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
16R-1, 14-15	B	-	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
16R-1, 17-18	B	-	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
16R-1, 18-20	B	-	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
16R-1, 23-27	B	-	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
16R-1, 25-26	F	M	R	.	.	.	.	R	.	.	.	.	RF	R	.	.	.	.	.	.	.	.	.	.	.
16R-1, 27-33	F	M	R	.	.	.	.	R	.	R	.	.	F	R	.	.	.	.	.	.	.	.	.	.	.
16R-1, 37-38	B	-	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
16R-1, 44-45	B	-	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
16R-1, 60-63	B	-	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
16R-1, 68-72	F	M	R	.	R	.	.	.	.	.	.	.	RF	.	.	.	.	.	.	.	.	.	.	.	.
16R-1, 74-77	B	-	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
16R-1, 79-84	B	-	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
16R-1, 94-96	B	-	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
16R-1, 102-103	B	-	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
16R-1, 123-125	B	-	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
16R-1, 137-145	B	-	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
17R-1, 0-5	B	-	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
17R-1, 18-19	B	-	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
17R-1, 23-24	B	-	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
17R-1, 24-25	B	-	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
17R-1, 29-30	B	-	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
17R-1, 36-37	B	-	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
17R-1, 50-51	B	-	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
17R-1, 57-61	B	-	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
17R-1, 70-80	C	M	R	R	.	R	.	.	.	R	.	R	F	R	R	R	R	.	.	.	.	.	.	.	.
17R-1, 73-74	C	M	F	cf.	R	R	R	R	.	R	F	R	F	F	.	.	.	.	R	R	R	R	R	.	.
17R-1, 78-79	RR	P	RR	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
17R-1, 79-80	B	-	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
17R-1, 80-83	F	M	R	.	R	.	.	.	.	F	.	F	.	.	.	.	.	.	R	.	.	.	.	.	.
17R-1, 83-85	B	-	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
17R-1, 95-97	B	-	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
17R-1, 97-103	C	M	R	.	R	R	R	R	.	R	F	.	F	R	.	.	.	R	.	.	.	.	.	.	.
17R-1, 109-112	B	-	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
17R-1, 119-120	B	-	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
17R-1, 133-134	B	-	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
17R-1, 146-147	B	-	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
17R-2, 25-26	RR	P	.	.	.	.	.	.	.	.	.	.	.	R	.	.	.	R	.	.	.	.	.	.	.
17R-2, 40-41	B	-	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
17R-2, 55-56	B	-	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
17R-CC	B	-	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
18R-1, 4-7	B	-	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
18R-1, 10-13	B	-	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
18R-1, 22-26	B	-	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
18R-1, 23-24	B	-	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
18R-1, 30-35	F	M	R	.	R	.	.	.	.	R	F	.	R	R	R	.	.	.	.	.	.	.	.	R	.
18R-1, 31-37	R	P	R	R	R	R	R	R	R	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
21R-1, 95-96	B	-	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.

Note: Shaded areas are barren of nannofossils. Estimates of the total nannofossil abundance are given as C (common) = 1%–10% of all particles, F (few) = 0.1%–1% of all particles, R (rare) = <0.1% of all particles, and RR (extremely rare) = <0.01% of all particles. Estimates of preservation are given as M (moderate) = most specimens display moderate overgrowth/dissolution, and species identification is usually not impaired; and P (poor) = most specimens display significant amounts of overgrowth/dissolution, and species identification is sometimes impaired. Estimates of the relative abundance of nannofossil species are given as F (few) = one specimen per 2–10 fields of view, R (rare) = one specimen per 11–100 fields of view, and RR (extremely rare) = one specimen per >100 fields of view.

For sites drilled during Leg 144, some of the preliminary age assignments in Premoli Silva, Haggerty, Rack, et al. (1993) based on calcareous plankton from Upper Cretaceous sediments must be revised.

At Site 872 (Lo-En Guyot) the pelagic limestone infilling fractures in the basaltic substrate are attributed to the planktonic foraminifer *D. asymmetrica* and *D. concavata* zones and to the nannofossil Zones CC14–CC17. The oldest biostratigraphic age of these sediments is late Coniacian to earliest Santonian (*D. concavata* planktonic foraminifer zone; CC14–CC15 nannofossil Zones).

The oldest marine sediments on Wodejebato Guyot originally were dated as latest Campanian, but now are attributed to the middle late Campanian (Fig. 1). In fact, the nannofossil Zone CC22 of Sissingh (1977) recognized in Core 144-877A-20R is now revised to a middle late Campanian age.

CONCLUSIONS

Detailed investigation of calcareous plankton in samples from Cretaceous carbonate platform sequences at Sites 872, 873, 874, 875, 876, 877, 878, and 879 resulted in important biostratigraphic age constraints for the onset, development, and demise of shallow-water sedimentation on Cretaceous guyots in the central and western Pacific Ocean.

On Wodejebato Guyot planktonic foraminifers are scattered throughout the shallow-water sequences at Sites 873 through 877. However, calcareous nannofossils were observed only at Sites 873, 874, and 877, where they occur exclusively in the oldest marine sediments immediately overlying the volcanic substratum. Calcareous plankton biostratigraphy indicates that the initiation of carbonate platform sedimentation occurred in the late Campanian (CC22 Zone of Sissingh, 1977), continued during the late Campanian and Maastrichtian, and ended during the latest Maastrichtian.

On MIT Guyot (Site 878) calcareous nannofossils and planktonic foraminifers are present at various levels in the shallow-water limestone sequence. They indicate that the initiation of carbonate platform sedimentation occurred in the earliest Aptian (lower part of the *C. litterarius* Zone before the "nannoconid crisis"). After the phreatomagmatic eruption that deposited a polymictic breccia, carbonate sedimentation resumed in the middle late Aptian (*N. truitii* Acme, *G. algerianus* to *H. trocoidea* Zones). Shallow-water deposition ended during the late Albian after the *Biticinella breggiensis* Zone. This interpretation is consistent with the occurrence of *Planomalina praebuxtorfi*, a species with a very short range that straddles the *Rotalipora ticinensis/Rotalipora appenninica* zonal boundary, in the overlying manganese nodules (see Watkins et al., this volume).

Based on calcareous plankton biostratigraphy, the initiation of carbonate platform sedimentation at Site 879 occurred during the middle late Aptian (*N. truitii* Acme, *G. algerianus* to *H. trocoidea* Zones) and ended by the late Albian (*R. ticinensis* Zone). The shallow-water limestone at Site 879 correlates with the upper platform sequence recovered in Hole 878A. The thickness of the carbonate sequence at this site is only half of that deposited at Site 878 on MIT Guyot during the late Aptian to late Albian interval suggesting possible hiatuses.

Lo-En (Site 872) is the only guyot where shallow-water limestone was not recovered during Leg 144. Here, the oldest sediments consist of pelagic limestones infilling fractures within the volcanic substrate. Calcareous plankton biostratigraphy constrains the age of these sediments to late Coniacian to earliest Santonian (*D. concavata* planktonic foraminifer zone; CC14–CC15 nannofossil zones).

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