50. PALEOBI GEOGRAPHIC EVOLUTION OF SHALLOW-WATER ORGANISMS FROM THE APTIAN TO THE EOCENE IN THE WESTERN PACIFIC

Isabella Premoli Silva,1 Alda Nicora,2 Annie Arnaud Vanneau,3 Ann F. Budd,4 Gilbert F. Camoin,5 and Jean-Pierre Masse5

ABSTRACT

Shallow-water organisms recovered from drilling four guyots in the western Pacific (from the southern Marshall Islands to the Japanese Seaamounts) allow the recognition of changes in bioprovinces through time. The Tethyan low-latitude bioprovince characterizes the early Aptian worldwide. In the late Albian, however, shallow-water floral and faunal assemblages from the drilled guyots, although predominantly composed of cosmopolitan forms, yielded few elements with an areal distribution more restricted to either the Caribbean-central American region or the Mediterranean, suggesting that two bioprovinces had already differentiated at low latitude at that time. During the late Campanian-Maastrichtian, the guyots' area was under the influence of the Caribbean bioprovince, but foraminifer assemblages also include some Mediterranean elements, suggesting that colonization occurred both westward and eastward. In the latest Paleocene-early middle Eocene, the direction of colonization reversed, with prevalent migration from the Mediterranean toward the Pacific.

INTRODUCTION

One of the objectives of Ocean Drilling Program (ODP) Legs 143 and 144 in the western Pacific was to recover shallow-water carbonate platform sediments from several guyots in two transects roughly oriented east-west (Mid-Pacific Mountains) and south-north (Marshall Islands to Japanese group) so that we could establish the evolutionary patterns of carbonate sedimentation and reconstruct the biogeographic evolution of the fossil assemblages. The aim of this paper is the preliminary analysis of Aptian to Eocene shallow-water organism paleobiogeography based on the specimens recovered from four out of five guyots drilled during Leg 144 along the south-north transect (Sites 871 through 879) (Premoli Silva, Haggerty, Rack, et al., 1995; see site map preceding title page). Primarily mid-Cretaceous shallow-water sediments were recovered at Allison and Resolution guyots during Leg 143, along with a small large-foraminifer fauna of late Campanian age from Site 869 (south of Wodejebato, Marshall Islands) (Sager, Winterer, Firth, et al., 1993). The overall mid-Cretaceous faunal and floral assemblages from the two legs are discussed by Arnaud Vanneau and Sliter (1994, 1995; also unpubl. data), whereas the upper Campanian fauna from Site 869 (Leg 143) is incorporated in the present discussion of the Marshall Islands assemblages.

Before Leg 144, the fossil record of shallow-water organisms in the western Pacific was confined to dredge-haul samples from few guyots or allochthonous material resedimented in deep-sea sites (e.g., Premoli Silva and Brusa, 1981; Grötsch et al., 1993; Lincoln et al., 1993; and references herein).

FAUNAL AND FLORAL ASSEMBLAGES

Shallow-water faunal and floral assemblages recovered during Leg 144 belong to three different ages: (1) Aptian–Albian (Site 878, MIT Guyot; and Site 879, Takuyo-Daisan Guyot) (for species descriptions and biostratigraphy, see Arnaud Vanneau and Premoli Silva, this volume, and Masse and Arnaud Vanneau, this volume); (2) late Campanian–Maastrichtian (Sites 873 through 877, Wodejebato Guyot) (for species descriptions and biostratigraphy, see Premoli Silva et al., this volume); and latest Paleocene–early middle Eocene (Site 871, Limalok Guyot) (for species descriptions and biostratigraphy, see Nicora et al., this volume). The most abundant and consistent fossil group from all ages is that of the larger benthic foraminifers. Subordinate fossil groups are rudists, corals, calcareous algae, and other bivalves and bryozoans. Estimated abundances of the various fossil groups are reported in the specialty chapters of this volume.

Aptian–Albian Assemblages

Almost 700 m of lower Aptian–upper Albian carbonate platform sediments were recovered at MIT Guyot (Site 878), and 170 m, of late Aptian–late Albian age at Takuyo-Daisan Guyot (Site 879). Fourteen benthic foraminifer species, 17 species of calcareous algae, and 10 coral genera were identified altogether from the two sites (see Arnaud Vanneau and Premoli Silva, this volume, and Appendix, this chapter). The benthic foraminifer fauna is composed of common Vercorsella, Cuneolina, Orbitolina, Neozoozita, Voloshinoides?, less common tracholoids, Arenobuliminia, Coskinolinella, miliolids, and other small foraminifera. Calcareous algal assemblages are dominated by the dasycladaceans, although the most consistent species is the red alga Polystrata alba (Masse and Arnaud Vanneau, this volume).

According to Arnaud Vanneau and Premoli Silva (this volume), seven biostratigraphic assemblages can be distinguished, on the basis of benthic foraminifers, in the successions studied (Table 1). Besides the occurrences at Sites 878 and 879, Assemblage 1 of late Albian age is also present at the tops of the Resolution and Allison guyots (Leg 143) as well as in dredge hauls from the edges of MIT Guyot (Grötsch et al., 1993). A small foraminifer fauna similar to Assemblage 0 of latest Albian age, identified at the top of the platform sequence at Takuyo-Daisan, was recorded from dredges on the top of Daichi-Kashima (Shiba, 1988). Furthermore, Konishi (1989) mentioned a few calcareous algae from the same dredges at Daichi-Kashima, similar to those described from Site 879 by Masse and Arnaud Vanneau (this volume), but most of the species identified by the latter authors are reported for the first time from the Pacific region. Rare cuneoloids and orbitolinids, not specifically identified, were also recorded at Site 315 (Line Islands), Site 171 and Isakov Guyot (Mid-Paciﬁc Mountains), and Site 585 (East Mariana Basin) (Schlager...
Table 1. Aptian–Albian benthic foraminifer assemblages recorded at Sites 878 (MIT Guyot) and 879 (Takuyo-Daisan Guyot) (after Arnaud Vanneau and Premoli Silva, this volume).

<table>
<thead>
<tr>
<th>Assemblage</th>
<th>Neozazzatalia isabellae</th>
<th>Caneolina slieteri</th>
<th>Caneolina parva</th>
<th>Caneolina cf. pararia</th>
<th>Fischerina sp.</th>
<th>Trocholina altisspa</th>
<th>Paracoskinolina cf. sulcoperculina</th>
<th>Orbitolina sp.</th>
<th>Orbitolina (Conioorbitolina) cf. allemannii</th>
</tr>
</thead>
<tbody>
<tr>
<td>Assemblage 0</td>
<td>Neozazzatalia isabellae</td>
<td>Caneolina slieteri</td>
<td>Caneolina parva</td>
<td>Caneolina cf. pararia</td>
<td>Fischerina sp.</td>
<td>Trocholina altisspa</td>
<td>Paracoskinolina cf. sulcoperculina</td>
<td>Orbitolina sp.</td>
<td>Orbitolina (Conioorbitolina) cf. allemannii</td>
</tr>
<tr>
<td>Assemblage I</td>
<td>Neozazzatalia isabellae</td>
<td>Caneolina slieteri</td>
<td>Caneolina parva</td>
<td>Caneolina cf. pararia</td>
<td>Fischerina sp.</td>
<td>Trocholina altisspa</td>
<td>Paracoskinolina cf. sulcoperculina</td>
<td>Orbitolina sp.</td>
<td>Orbitolina (Conioorbitolina) cf. allemannii</td>
</tr>
<tr>
<td>Assemblage II</td>
<td>Neozazzatalia isabellae</td>
<td>Caneolina slieteri</td>
<td>Caneolina parva</td>
<td>Caneolina cf. pararia</td>
<td>Fischerina sp.</td>
<td>Trocholina altisspa</td>
<td>Paracoskinolina cf. sulcoperculina</td>
<td>Orbitolina sp.</td>
<td>Orbitolina (Conioorbitolina) cf. allemannii</td>
</tr>
<tr>
<td>Assemblage III</td>
<td>Neozazzatalia isabellae</td>
<td>Caneolina slieteri</td>
<td>Caneolina parva</td>
<td>Caneolina cf. pararia</td>
<td>Fischerina sp.</td>
<td>Trocholina altisspa</td>
<td>Paracoskinolina cf. sulcoperculina</td>
<td>Orbitolina sp.</td>
<td>Orbitolina (Conioorbitolina) cf. allemannii</td>
</tr>
<tr>
<td>Assemblage IV</td>
<td>Neozazzatalia isabellae</td>
<td>Caneolina slieteri</td>
<td>Caneolina parva</td>
<td>Caneolina cf. pararia</td>
<td>Fischerina sp.</td>
<td>Trocholina altisspa</td>
<td>Paracoskinolina cf. sulcoperculina</td>
<td>Orbitolina sp.</td>
<td>Orbitolina (Conioorbitolina) cf. allemannii</td>
</tr>
<tr>
<td>Assemblage V</td>
<td>Neozazzatalia isabellae</td>
<td>Caneolina slieteri</td>
<td>Caneolina parva</td>
<td>Caneolina cf. pararia</td>
<td>Fischerina sp.</td>
<td>Trocholina altisspa</td>
<td>Paracoskinolina cf. sulcoperculina</td>
<td>Orbitolina sp.</td>
<td>Orbitolina (Conioorbitolina) cf. allemannii</td>
</tr>
<tr>
<td>Assemblage VI</td>
<td>Neozazzatalia isabellae</td>
<td>Caneolina slieteri</td>
<td>Caneolina parva</td>
<td>Caneolina cf. pararia</td>
<td>Fischerina sp.</td>
<td>Trocholina altisspa</td>
<td>Paracoskinolina cf. sulcoperculina</td>
<td>Orbitolina sp.</td>
<td>Orbitolina (Conioorbitolina) cf. allemannii</td>
</tr>
</tbody>
</table>

and Premoli Silva, 1981; Moberly, Schlanger, et al., 1986). These records indicate that a similar shallow-water foraminifer assemblage was widespread in the Pacific, at least in the late Albian.

Faunal and Floral Biogeographic Affinities

The foraminifer assemblages identified at Sites 878 and 879 include a mixture of species well known along the Arabo-African Tethyan margin, such as Prachrysalidina sp. cf. P. infracretacea and Trocholina altisspa, as well as Pseudonummuloculina aurigerica, Coskinolinella navarrensis, Coskinolinella daquini, and Fischerina? carinata from the European margin (Arnaud Vanneau and Sliter, 1994). There are also species first described from the American region such as Orbitolina (Mesorbitolina) texana oculata, Paracoskinolina sp. cf. P. sulcoperculina, and probably Orbitolina (Mesorbitolina) sp. cf. O. (M.) plevia, but these species have a worldwide distribution (i.e., they are cosmopolitan; Arnaud Vanneau and Sliter, 1994). Moreover, several specimens of Distefanella mooretownensis, Distefanella sp., Plagiopychus aff. fragilis, P. aff. minor, and antilocaprinids (Antilocaprina sp.) (see Appendix; see also Camoin et al., this volume). A few corals were also recorded, but their poor preservation prevented identification.

At the outer ridge sites (875 and 876), the pseudorbitoidids are present only as reworked elements within an assemblage dominated by sulcoperculids and Astororbis, associated in the lower half of the sequence, at least at Site 875, with common Omphaloclycus macroporus. Astororbis is consistently present and abundant up to the top of the sequence, whereas sulcoperculids are absent in the uppermost 25 m of the carbonate platform at Site 875 and in the upper 90 m at Site 876. Rare possible Lepidorbitoides were also found in the middle part of the Site 875 sequence. Accompanying calcareous algae, corallinealgae and Pohystrata alba, are abundant but frequently fragmented. Rudists are common components of the bioclasts, but they are present only as fragments, whereas corals are rare.

Some elements of these assemblages (e.g., rudists, sulcoperculids, Astororbis, and a few Orbitoides sp.) were identified in the dredge haul from the southern slope of Wodejebato Guyot (Lincoln et al., 1993). Moreover, several specimens of Pseudorbitoides trechmanni along with a possible Vaughanina were recovered in the volcaniclastic sediments at the apron Site 869 drilled in the abyssal plain south of Wodejebato Guyot (Sager, Winterer, Firth, et al., 1993; Erba et al., this volume).
were recorded from Papua Pseudorbitoides macroporus together with recovered in an analogous setting along the Line Islands chain at Sites sp. (close to and rare Orbitoides and Orbitoides Pseudor- Caribbean-central American bioprovince (Table 3). In fact, presently western Pacific sites and locations are elements typical of the nal assemblages recovered from Wodejebato Guyot and other cur-

Faulnal Flora

The main components of the late Campanian–Maastrichtian faunal assemblages recovered from Wodejebato Guyot and other currently western Pacific sites and locations are elements typical of the Caribbean–central American bioprovince (Table 3). In fact, Pseudorbitoides, Vaughanina, Asterorbis, and Sulcoperculina, conspicuous faunal elements of this bioprovince, are unknown in the Medi-

denean taxa

Table 2. Aptian–Albian benthic foraminifers and calcareous algae from Sites 878 (MIT Guyot) and 879 (Takuyo-Daisan Guyot), arranged according to bioprovincial affinities (after Arnaud Vanneau and Premoli Silva, and Mas e and Arnaud Vanneau, both this volume).

<table>
<thead>
<tr>
<th>Ages</th>
<th>Cosmopolitan taxa</th>
<th>Mediterranean taxa</th>
<th>Caribbean taxa</th>
</tr>
</thead>
<tbody>
<tr>
<td>late Albian</td>
<td>Canelinea parva</td>
<td>Fischerina? crinitata</td>
<td>Parachetetes aswapassit</td>
</tr>
<tr>
<td></td>
<td>Canelinea cf. parva</td>
<td>Teoconulina altispira</td>
<td>Neomeris creatula</td>
</tr>
<tr>
<td></td>
<td>Paracondroconulina cf. smallulataeformis</td>
<td>Triploporella aff. steinianus</td>
<td>Cylindroporella cl. barnesi</td>
</tr>
<tr>
<td></td>
<td>Polyspira alta</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Santitrypa somalic</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Aptian–Albian</td>
<td>Orbitoides (Mesorbitoides) tetusa oculata</td>
<td>Pseudochrysalina cf. infraceracea</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Orbitolina (Mesorbitoides) periva</td>
<td>Pseudonummoloculina aurigera</td>
<td></td>
</tr>
<tr>
<td>early Aptian</td>
<td></td>
<td>Coskinolinella navarrowens</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Coskinolinella dagani</td>
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<tr>
<td></td>
<td></td>
<td>Salpingoporella cf. melitbergii</td>
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<td></td>
<td></td>
<td>Salpingoporella cf. melitae</td>
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<tr>
<td></td>
<td></td>
<td>Aeroporella rodericola</td>
<td></td>
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<td></td>
<td></td>
<td>Mentella etricz</td>
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</tr>
</tbody>
</table>

ments of the coarser layers within deep-sea host deposits (Premoli Silva and Brusa, 1981). The same benthic foraminifers were also recovered in an analogous setting along the Line Islands chain at Sites 165, 315, and 316 (Beckmann, 1976; Premoli Silva and Brusa, 1981).

The only species never found at any other deep-sea site except Wodejebato are Omphaloclycus macroporus and Orbitoides sp. However, representatives of the genus Orbitoides and Omphaloclycus macroporus together with Pseudorbitoides were recorded from Papua (Glaessner, 1960). Moreover, these taxa along with Lepidorbitoides and a possible Asterorbis (Sulcoperculina in Hashimoto et al., 1978) were described by Hashimoto et al. (1978) from a sandstone conglomerate cropping out in central Luzon (Philippines).

Largest Benthic Foraminifers

Almost 290 m of shallow-water carbonate deposits were recovered at Site 871 (Limalok Guyot). These are mainly of early to early Middle Eocene age, with the lowermost layers belonging to the latest Paleocene. Larger benthic foraminifers are the most important fossil group. Calcareous algal assemblages are dominated by either encrusting or branched coralineaceans, associated with common Polystersa alba especially in the colonizing community. Other identified algae are rare Cymopolia, Salpingoporella, Halimeda, and Thaumatoporella. Rare corals and bivalves were also recorded (see Nicora et al., this volume).

Remarkable among the larger benthic foraminifers is the presence of abundant Alveolina, which include Alveolina (Glomodelina) sp., A. (Alveolina) ilerdensis, A. (A.) pinguis, and flosculine alveol-

Largest Benthic Foraminifers

A large assemblage with common Nummulites, discozyclinids, asterocyclinids, and a single specimen of a poorly preserved Alveolina of early Eocene age was recovered from Site 462 drilled in the Nauru Basin (Premoli Silva and Brusa, 1981). As for the Cretaceous assemblage, these shallow-water forms are present at different stratigraphic levels as allochthonous elements of the coarser layers within deep-sea host deposits. Identified species are Nummulites permutatus and Assilina leymeriei of latest Eocene age, and Nummulites buri
galenis, N.usta, and N. ortulaires of middle to late Eocene age. These forms were not encountered in the cores from Limalok Guyot, and in our opinion, their absence is probably related to the restricted environment characterizing the lagoonal setting at that time, which was unsuitable for nummulitids.

In addition, Hashimoto et al. (1978) identified Assilina sp. and Ranikothalia bernadezi from the same sandstone conglomerate cropping out in central Luzon (Philippines), which yielded the Late Cretaceous benthic foraminifers described above. Again, these forms are missing at Limalok. Eocene shallow-water organisms, comparable with those recovered at Limalok Guyot, occur as far east as the Line Islands and Tuamotu (see Premoli Silva and Brusa, 1981). How-
ever, the foraminifer assemblages in these areas are predominantly composed of discocyclinids and asterocyclinids, whereas nummulitids and alveolinids are missing. Only from later in the Eocene a single species of *Nummulites* (close to *N. variolarius*) was recorded by Beckmann (1976) from Tuamotu (Site 318).

**Faunal and Floral Biogeographic Affinities**

The principal components of the benthic foraminifer faunas recovered from lower and lower middle Eocene shallow-water sediments at Limalok Guyot are alveolinids, nummulitids, asterocyclinids, and discocyclinids (Table 3). The first two fossil groups are known to typify Tethyan assemblages in the Eocene, and their areal distribution, at least at the generic level, extended toward the east as far as the Indo-Pacific margin (Adams, 1973; Hottinger, 1971, 1973). Several species of *Nummulites* and especially *Alveolina*, identified at Limalok or in the Nauru Basin, were described from the Mediterranean area (Hottinger, 1960; Schaub, 1981). At first sight, the *Alveolina*-bearing layers recovered at Limalok (Premoli Silva, Haggerty, Rack, et al., 1993, p. 56, fig. 13) exhibit a remarkable similarity with some horizons cropping out at Tremp (Spain), the stratotype of the Ilerdian stage (see Hottinger, 1960). The other groups, asterocyclinids and discocyclinids, include numerous *Asterocyclina* and less common *Discocyclina*. These two genera are cosmopolitan but exhibit some provinciality at the specific level. Although both genera are presently under revision, we could confidently identify *Discocyclina Barkeri* at the base of the platform sequence in association with poorly preserved alveolinids. This species was described from the Caribbean (Ellis and Messina, 1967). A second Caribbean species, *Coleoceras elongatus*, was observed in the upper part of the Limalok platform sequence associated with *Nummulites laevigatus*.

**DISCUSSION**

Taking into consideration the overall poor recovery obtained by drilling shallow-water carbonate sequences at Limalok, Wodejebato, MIT, and Takuyo-Daisan guyots during Leg 144, the faunas and floras of these guyots are rather rich in species as well as individuals in all the stratigraphic intervals. However, the species richness recorded from these guyots, even if supplemented with the record from redeposited material of nearby locations, cannot compare with the species diversity observed in coeval carbonate platforms cropping out on land, where lateral as well as vertical distributions could be studied in detail. Even at Wodejebato, the five sites, drilled ad hoc, represent a discrete sampling of a few centimeters compared with tens to hundreds of meters in the land-based sequences. Because of this overall poor sampling, the faunal and floral collections associated gathered great importance, allowing us to tentatively reconstruct the bioprovincial evolution.

Figure 1 outlines the areal distribution at a global scale of the faunal and floral assemblages in early Aptian, late Albian, late Campanian–Maastrichtian, and early–middle Eocene age intervals of platform growth on the Pacific guyots. According to the paleolatitudes reconstructed during Leg 144 (see Larson et al., this volume), the guyots studied were all located in the Southern Hemisphere around 10°S at the time of the inception of carbonate deposition.

As previously described, the Aptian and most Albian assemblages are largely composed of taxa diffused along both margins of the Tethyan Ocean, which extended from Central America as far east as eastern Asia at that time (Carnin et al., 1993; Masse et al., 1992a, 1992b, 1993a, 1993b). The fossil record from the guyots drilled during Leg 144 indicates that the Tethyan bioprovince may have extended eastward to include the central Pacific area. Apparently, no endemic species were present at that time. From the late Albian onward, a discrete bioprovince started to differentiate in the Caribbean–central American region from the main Tethyan early Aptian bioprovince (see e.g., Skelton, 1988; Masse et al., 1993b). In the late Albian, the shallow-water assemblages here studied predominantly consist of cosmopolitan species or with Tethyan affinity, but they also comprise some dasycladacean algae recorded only from the Caribbean–central American region. This finding is consistent with the rudist record from the Mid-Pacific Mountains (Leg 143), which indicates that some endemic was acquired by this group in late Albian time (see Swinburne and Masse, 1995). This suggests that the Pacific guyots were located on an area of overlap of the two bioprovinces, the old Tethyan and the new differentiating Caribbean one.

By Campanian–Maastrichtian time, the Tethyan and Caribbean bioprovinces were well established at low latitudes, possibly further divided into a few subprovinces (e.g., Dilley, 1971, 1973; Van Gorsel, 1978). A Tethyan assemblage outlined the Tethyan bioprovince that extended from the Atlantic European margin (on the west) to southeast Asia (on the east). The Caribbean bioprovince was located in the Caribbean–central American area. Cosmopolitan species (i.e., species common to both bioprovinces) were represented by *Orbitoides* and *Omphalocyclus* (Van Gorsel, 1978).

The central Pacific benthic foraminifer assemblage was strongly dominated by Caribbean taxa such as pseudorbitoidids, *Asterorbis*, and sulcoperculids. These occur in association with rudists, known exclusively from the Caribbean, and with a few cosmopolitan *Orbitoides* and *Omphalocyclus*, which apparently exhibit a more stratigraphically limited distribution. However, some Mediterranean elements such as *Dicyclina*, *Vidalina hispanica*, and *Idalina antiqua* (see Loeblich and Tappan, 1988), were also recorded in the lagoonal facies
at Wodejebato, and possible *Lepidorbinioides* were found at Site 875. The presence of Mediterranean elements within a predominantly Caribbean assemblage suggests that either these elements are essentially cosmopolitan and so far were never recognized from the Caribbean region or the Pacific guyots were located on the crossroad between the two bioprovinces. The first hypothesis would argue for the Caribbean bioprovince to have been extended to the west to include the central Pacific region, whereas the second hypothesis favors the identification of a new bioprovince or subprovince characterized by elements from both Mediterranean and Caribbean bioprovinces.

It is worth mentioning that some rudist taxa with Caribbean-central American affinities (i.e., *Torreites* and *Thyrastylor*) have been recorded as far west as Iran and Oman around the eastern Tethyan ocean (Skelton and Wright, 1987; Skelton, 1988) (see Fig. 1).

In early and early-middle Eocene time, the guyots' assemblages were dominated by Tethyan elements such as alveolinids and nummulitids, which are missing in the Caribbean. The very few *Nummulites* recorded in the latter region belong to different species. Asterocyclinids and discoxydids in the Eocene assemblage may be representatives of the cosmopolitan group, but their evolution is still so poorly known that further interpretations are totally premature. It is certain, however, that *Discocyclina barkeri* and *Coleciconus elongatus* of the Caribbean bioprovince occur in association with the Tethyan fauna. During the early-middle Eocene, we are confronted with a situation similar to that of Campanian-Maastrichtian period, except that it is the Tethyan bioprovince which may have been extended eastward to include the central Pacific. Yet again, the identification of a central Pacific subprovince cannot be ruled out.

**CONCLUSIONS**

Shallow-water organisms recovered by drilling the guyots in the western Pacific provide information on the distribution of larger foraminifers, rudists, corals, and calcareous algae, and have greatly increased our knowledge about the Cretaceous and Early Tertiary bioprovinces. The oldest records, of early Aptian age, confirm the cosmopolitan Tethyan character of the low-latitude foraminifer and rudist assemblages associated with carbonate platforms. Contrary to expectation, also calcareous algae and especially dasycladaceans show a much wider geographical distribution.

By late Albian time, the high level of endemism characterizing the Caribbean bioprovince, probably related to the wider Atlantic acting as a significant barrier to dispersal of most sensitive shallow-water organisms (see discussion in Skelton, 1988), also started to affect the guyots' region as supported by the record of dasycladaceans of Caribbean affinity and endemic rudists from the drill holes. This means that a dispersal route in a westward direction was activated from the Caribbean as far as the central Pacific region by that time (Fig. 1).

During the late Campanian-Maastrichtian, shallow-water organisms (foraminifers and rudists) of the central Pacific display great...
affinities with the Caribbean–central American bioprovince, although associated with some Mediterranean elements. Based on the presence of Lepidorbitoides, now questioned, Premoli Silva and Brusa (1981) suggested that a new bioprovince was distinguishable in the central Pacific, characterized by the association of Caribbean and Mediterranean elements. The occurrence of elements from both bioprovinces may be explained by assuming that the direction of migration toward the guyots' region was predominantly from the west, although a minor migration from the east might have existed. It is well known that shallow-water faunas and floras cannot easily migrate across a large, deep ocean, such as the present eastern Pacific, which would act as a barrier.

Schlanger et al. (1981), based on a still preliminary plate reconstruction, suggested that at first the Caribbean Plate was probably located much more to the west than its present position, which would place it closer to the guyots' region; and, second, a number of shallow “stepping stones” existed between the Caribbean area and the guyots studied. Because the intraplate volcanism that created Wodejebato Guyot was a widespread phenomenon of the Pacific Plate, edifices rising from the seafloor to reach the photic zone were probably numerous in the Late Cretaceous (see Lincoln et al., 1993). This interpretation was followed and further supported by Skelton and Wright (1987) and Skelton (1988) for explaining the disjunct distribution of Mediterranean rudists in the Caribbean and eastern Tethys (Iran, Oman). Camoin et al. (1993) reemphasize the function of the general oceanic surface circulation in the dispersal of shallow-water organisms. The main Pacific equatorial current system flowing from east to west could have easily dispersed the shallow-water organisms, originated in the Caribbean region, across the central Pacific towards the eastern Tethys. On the other hand, the recent numerical ocean circulation model (Barron and Peterson, 1989) shows that a clockwise gyre-type circulation existed between Eurasia and Africa, which probably produced a flow toward the east facilitating the eastward dispersal of the Tethyan elements toward the central Pacific. This eastward migration could have occurred because some “stepping stones” (i.e., island arcs, small continental blocks, etc.) were probably available at that time between India and Eurasia and in the western Pacific.

During the Early Tertiary, the direction of the main faunal migration, and thus of colonization, was reversed with respect to Late Cretaceous time, from west to east, the latter dispersal direction prevailing at the present time. This shift can be explained by the growth, since Late Cretaceous time, of the large, deep eastern Pacific Basin, which led initially to an increasingly difficult migration and eventual cessation of colonization from the east. On the other hand, this shift coincides with a time with a major tectonic reorganization in the southeastern Asian region, with the possible formation of new “stepping stones” on the western side of the Pacific favoring colonization from the Mediterranean toward the central Pacific.

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APPENDIX

List of Preliminary Identifications of Corals from Leg 144
(by Ann E Budd)

Site 878, MIT Guyot

Lithologic Unit II (Albian to ?Aptian): Sample 144-878A-18R-1, 29–31 cm: solitary, east of base, number of costae = 22, corallite diameter (cd) = 55 mm, strong synapticulae

Genus: ??Aenigmis or Trochosomilla

Range and geographic distribution: Jurassic–Cretaceous; Europe, Africa, Texas

Sample 144-878A-31M-1, 20-22 cm: solitary, worn surface of calice, cd = 12 mm, number of septa (ns) = 12, distinctive septal arrangement, thick septa, lamellar columella.

Genus: ??Torrasomilla or Adkinsella

Range and geographic distribution: early Cretaceous; Texas

Lithologic Unit V (early Aptian):

Sample 144-878A-73R-1, 9–13 cm (thin section): thick, vesicular wall, corals in clusters, cd = 5 mm, ns > 12, recrystallized

Genus: ??Mitredendron

Range and geographic distribution: Jurassic–Cretaceous; Europe

Sample 144-878A-73R-1, 23-25 cm: east, intratenticucular budding, cd = 3–4 mm (min), plocoid, synapticulae

Genus: ??Owladastrea

Range and geographic distribution: Jurassic–Cretaceous; Europe, Africa, Asia, West Indies, Texas

Sample 144-878A-73R-1, 49–52 cm (thin section): cerioid, strong wall, intratenticucular budding, ns = 20–30, cd = 3.3 mm

Genus: ??latomastrea

Range and geographic distribution: Jurassic–Cretaceous; Europe, Africa, Texas

Sample 144-878A-76R-1, 69–73 cm (thin section): cerioid or plocoid, ?syn- napticulae, strong columella, ns = 12, cd = 1.2 mm

Genus: ??Heliocena

Range and geographic distribution: Jurassic–Cretaceous; Europe

Sample 144-878A-76R-1, 100–106 cm (thin section): plocoid, strong columella, ns = 24, cd = 1.5 mm, extensive coenosmum with synapticulae

Genus: ??Actinarius

Range and geographic distribution: Cretaceous–Oligocene; Europe, North America, West Indies, East Indies, Africa

Sample 144-878A-76R-1, 106–111 cm (thin section): plocoid, strong columella, ns = 12, cd = 1.5 mm, extensive coenosmum with synapticulae

Genus: ??Actinarius

Range and geographic distribution: Cretaceous–Oligocene; Europe, North America, West Indies, East Indies, Africa

Site 879, Takuyo-Daisan Guyot (late Albian to Aptian)

Sample 144-879A-2R-2, 35–45 cm (thin section): cerioid to plocoid, trabecular columella, ns = 24, cd = 1.2 mm

Genus: ??Monstrastrea or Columnocena

Range and geographic distribution: Jurassic–Holocene; Europe, West Indies, Texas, Indo-Pacific

Sample 144-879A-10R-1, 0–6 cm (thin section):

A: cerioid, cd = 4 mm, ns = 30–40

Genus: ??Sidastrea

Range and geographic distribution: Cretaceous–Holocene; Europe, West Indies, North America, Indo-Pacific

B: plocoid, ns = 30, cd = 2 mm

Genus: ??Diplastrea

Range and geographic distribution: Cretaceous–Holocene; Europe, West Indies, North America, Indo-Pacific

C: ??Actinarios

Range and geographic distribution: Cretaceous–Oligocene; Europe, North America, West Indies, East Indies, Africa

List of Rudists from Sites 874 and 877, Wodejebato Guyot
(by Gilbert F. Camoin and Jean Philip in Camoin et al., this volume)

Radiolitids: Distefanella mooretowensis, Distefanella sp.
Plagiopychids: Microploc ropa sp., Callocochne orcatt, Callocochne sp., Plagiopychus aff. fragili, P. aff. minor
Antiliocaprinos: Antillocaprina sp.

Occurrence. Campanian–Maastrichtian strata from Jamaica, Mexico, Cuba, and California.