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15. CARBONATE BIOCLASTS OF SHALLOW-WATER ORIGIN AT SITE 793[1]

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ABSTRACT

Shallow-water limestone fragments and carbonate bioclasts recovered at Site 793, Ocean Drilling Program Leg 126 are described and discussed in relation to the rifting of the Oligocene basin in the forearc of the Izu-Bonin Arc. The author suggests that there were islands with shallow-water environments on the flanks of the rift basin in its prerifting to initial rifting stage.

INTRODUCTION

Shallow-water limestone is one of the best indicators of sea-level position. Ocean Drilling Program (ODP) Leg 126 was drilled in the central part of the Izu-Bonin Arc to reveal the geologic history of both the forearc and backarc. Shallow-water limestone fragments and carbonate bioclasts were found as clastics in the sediment gravity-flow deposits in the Oligocene sequence at Site 793 in the forearc basin. This study describes these shallow-water limestone fragments and bioclasts to determine the distribution and environment of shallow-water areas around the basin in the Paleogene. Furthermore, a limestone fragment from a dredge haul of the forearc area south of the ODP sites is also described to discuss supplementally the rifting history of the basin in the forearc of the Izu-Bonin Arc.

GEOLOGIC SETTING

The Izu-Bonin Arc is an intraoceanic arc in the northwestern Pacific that has been formed since the Eocene by extensive volcanism (Honza and Tamaki, 1985). In the northern part of the Izu-Bonin forearc, two basement highs form discontinuous north-trending lines along the volcanic front. One is called a frontal-arc high (FAH), and the other an outer-arc high (OAH). The former continues to the Shin-Kurose Ridge in the north, and the latter continues to the Bonin Ridge in the south (Honza and Tamaki, 1985) (Fig. 1). The southernmost part of the FAH is represented by a seamount (Ohmachi Seamount) near the junction between the Nishinoshima Trough and the Sofugan Tectonic Line (Fig. 1). Beyond the Sofugan Tectonic Line, which separates the northern and southern parts of this arc (Yuasa, 1985), the FAH cannot be recognized in the seismic records, but frontal volcanoes continue southward between the Bonin and the Nishinoshima troughs (Yuasa et al., 1982).

Between the two basement highs, there is a forearc basin that is a rift basin with a Paleogene volcanic basement, as interpreted from the multichannel seismic survey and confirmed with the drilling results of Leg 126 (Leg 126 Shipboard Scientific Party, 1989; Taylor, Fujioka, et al., 1990). During Leg 126, three sites were successfully drilled in the forearc basin. Site 793 is situated in the central to outer part of the forearc basin, and Site 792 is located near the frontal-arc high (Fig. 1). The stratigraphic successions of these forearc sites are similar to each other; the lower part of the Oligocene sequence consists mainly of sediment gravity-flow deposits with a high sedimentation rate, whereas the upper part consists of pelagic nannofossil chalk with a low sedimentation rate (Taylor, Fujioka, et al., 1990, pp. 407–413).

SAMPLE DESCRIPTION AND MICROSCOPIC OBSERVATION

Nine rock specimens from Site 793 and one rock sample from a dredge haul were used in this study. Sampling horizons, visual descriptions, and microscopic observations of the samples are as follows. Folk's (1962) classification of limestone types is adopted. The age assignments of larger foraminifers are based on the summary of Hashimoto and Matsumaru (1984) for southeast Asia.

Site 793

Limestone fragments and carbonate bioclasts occur in the lower part of the Oligocene sequence of Unit V of Site 793, from Section 126-793B-63R-3 to Core 126-793B-77R (1182–1326 mbsf) (Taylor, Fujioka, et al., 1990, pp. 315–403) (Fig. 2).

Sample 126-793B-63R-3, 6–8 and 55–57 cm

These two samples are medium-grained sandstone taken from a thick, greenish black to dark greenish gray (5GY2/1–5GY4/1) sandstone bed 152 cm thick. This bed consists of well-laminated calcareous coarse- to medium-grained sandstone. Bioclasts are composed of highly fragmental larger benthic foraminifers, encrusting coralline algae, and bryozoans. Lens-shaped larger foraminifers occur in this sandstone and are arranged parallel to the lamina (Plate 1, Fig. 1). Sand grains of volcanic rocks include reddish brown ones, probably epiclastic.

Sample 126-793B-65R-2, 90–91 cm

Sample 126-793B-65R-2, 90–91 cm, was taken from the central part of a thick, greenish black (5GY2/1), sandy granule conglomerate bed. An inflated, lens-shaped, larger foraminifer (*Eulepidina* sp.) is the only bioclast in this sample (Plate 1, Fig. 2).

Sample 126-793B-74R-4, 22–24 cm, and -74R-6, 118–120 cm

These two samples were taken from one thick greenish black (5GY2/1) debris-flow deposit (granule conglomerates) containing large mud intraclasts. Sample 126-793B-74R-4, 22–24 cm, yields larger foraminifers, *Biplanispira mirabilis* (Umbgrove) (Plate 1, Fig. 4) and *Pellatispira rutteni* Umbgrove, which assign this sample a late Eocene age (K. Matsumaru, pers. comm., 1990) (Hashimoto and Matsumaru, 1984). It also contains fragments of light gray, biomicrite that includes many miliolid foraminifers as well as fragments of articulate coralline algae (Plate 1, Fig. 3). Sample 126-793B-74R-6, 118–120 cm, was taken from the sandy granule conglomerate and includes a pebble-sized fragment of biosparite with benthic foraminifers and articulate coralline algae.

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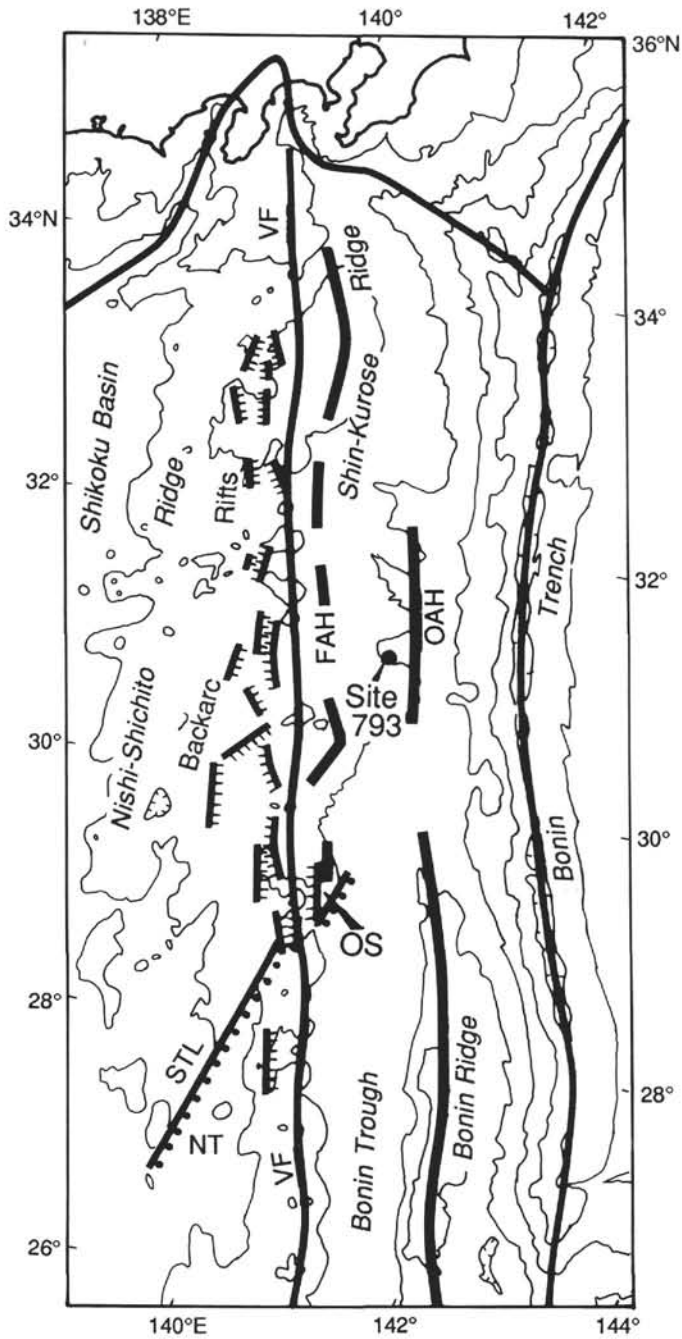

Figure 1. Geologic structures of the Izu-Bonin Arc compiled from Honza and Tamaki (1985), Yuasa (1985), and Leg 126 Scientific Drilling Party (1989). FAH = frontal-arc high, OAH = outer-arc high, VF = volcanic front, OS = Ohmachi Seamount, NT = Nishinoshima Trough, and STL = Sofugan Tectonic Line.

Sample 126-793B-75R-2, 41–42 and 86–87 cm; -75R-3, 14–15 cm; and -77R-5, 43–45 cm

These four samples were taken from a thick greenish black (5GY2/1), debris-flow deposit (conglomerate). Sample 126-793B-75R-2, 41–42 cm, includes two fragments of encrusting coralline algae with encrusting benthic foraminifers (Plate 1, Fig. 5). Sample 126-793B-75R-2, 86–87 cm, contains a fragment of biomicrite that includes benthic and planktonic foraminifers, ostracodes, and encrusting coralline algae.

Sample 126-793B-75R-3, 14–15 cm, is taken from the basal part of the debris-flow deposit; it includes a fragment of biosparite with a

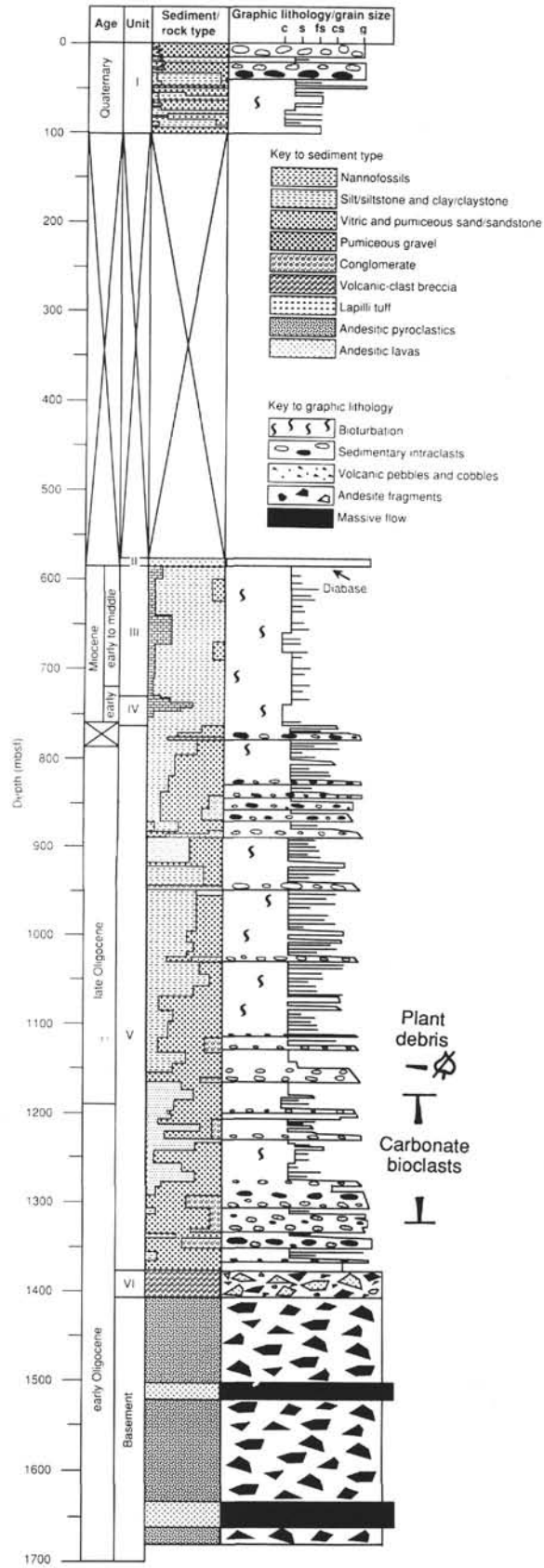

Figure 2. Columnar section of the stratigraphic sequence at Site 793 (Taylor, Fujioka, et al., 1990, pp. 410–411). c = claystone, s = siltstone, fs = fine-grained sandstone, cs = coarse-grained sandstone, and g = conglomerate.

15-mm diameter. Larger foraminifers, encrusting benthic foraminifers, and encrusting and articulate coralline algae are constituents of the bioclasts in this sample.

Sample 126-793B-77R-5, 43–45 cm, is a greenish black (5GY2/1), pebbly sandstone from the debris-flow deposit; it includes a pebble-sized fragment of pelmicrite that includes encrusting coralline algae.

Sample D731

Sample D731 was taken from a dredge haul situated on the western slope of the Ohmachi Seamount (D731; 29°09′N, 140°43′E, 2640 m in water depth) (Fig. 1) during the GH85-2 Cruise of the Geological Survey of Japan. Several cobble- to pebble-sized rock fragments were taken, and one sample (D731-7) is a calcareous sandstone that contains pebble-sized gravels of clinopyroxene-orthopyroxene andesite and includes larger benthic foraminifers (Plate 1, Fig. 6). Moreover, free specimens of larger foraminifers were found in the sands of a cylinder dredge. These larger foraminifers are *Biplanispira mirabilis* (Umbgrove) and *Asterocyclina* sp., which assign a late Eocene age to this sample. The calcareous sandstone includes encrusting and articulate coralline algae, echinoid spines, and bryozoans besides larger foraminifers. Sample D731 includes andesitic gravels, one of which has a K-Ar age of 31.9 ± 1.2 and 33.6 ± 1.2 Ma (Yuasa et al., 1988).

DISCUSSION

Limestone fragments and carbonate bioclasts were found in the Oligocene sequence at Site 793 in the forearc basin. The bioclasts include larger benthic foraminifers, smaller benthic and planktonic foraminifers, and calcareous algae, which were originally deposited in a shallow-water environment <200 m in depth. All limestone fragments and calcareous bioclasts were found in the sediment gravity-flow deposits in the sequence. The paleocurrents of the sediment gravity-flow deposits of Site 793 were examined by means of the grain orientations, which suggest that a supply area existed northnorthwest of this site (Hiscott et al., this volume). Benthic foraminifer data from the muddy sediments intercalated in the sediment gravity-flow deposits in the lower part of the Oligocene sequence show that a deep-water environment existed, probably below the calcium carbonate compensation depth (CCD) (Kaiho, this volume). These data indicate that the carbonate materials were deposited through sediment gravity flow from the basin margins, where the shallow-water environment was present. Based on biostratigraphic and magnetostratigraphic age data, an early Oligocene age has been assigned, and the larger foraminifers from the sediment gravity-flow deposits are Oligocene species, except for two Eocene species in Sample 126-793B-74R-4, 22–24 cm (K. Matsumaru, pers. comm., 1990). The sediment gravity-flow deposits, including the carbonate bioclasts of a shallow-water origin, were deposited in the Oligocene. The source of the carbonate bioclasts was mainly a shallower part of the basin margins as well as pre-existing Eocene limestone in part. The carbonate bioclasts of Site 793 suggest that a shallow-water environment was present from the late Eocene to the Oligocene.

In addition, Samples 126-793B-59R-3, 130 cm and -59R-4, 120 cm, yielded wood fragments, suggesting the presence of a land area that supplied clastic grains into the forearc basin (Taylor, Fujioka, et al., 1990, pp. 315–403). This horizon is just above the sequence with calcareous bioclasts (Fig. 2). Moreover, epiclastic volcanic debris with a reddish color occurred in the Unit V sequence of Site 793 (Taylor, Fujioka, et al., 1990, pp. 315–403). Consequently, these data show the presence of a land area around the forearc basin as a sediment source during the deposition of the lower part of Unit V of Site 793 in the initial stage of the rift sedimentation.

Nummulites boninensis Hanzawa, which is middle Eocene in age, occurs on Hahajima, one of the Bonin Islands. The Eocene sequence of Hahajima is composed of volcanic rocks (lava and pyroclastic rocks), sandstones, and limestones; and the uppermost Eocene sequence is composed of *Pellatispira* limestone (Ujiie and Matsumaru, 1977). Minamizaki limestone of the Chichijima Island yields larger foraminifers of an Oligocene-Miocene age. In the northern part of the arc, the present outer-arc area, probably a northern extension of that of the Bonin Ridge area, had been already sunk below the sea level at the initial stage of the Oligocene rift basin (Kaiho, this volume).

A sample from the Ohmachi Seamount includes late Eocene larger foraminifers and demonstrates the presence of a shallow-water environment in the late Eocene age in the frontal-arc high area. The age assignment determined from the larger foraminifers and the K-Ar age of the andesite in this sample suggest that the larger foraminifers are reworked from the Eocene strata to the Oligocene one, although larger foraminifers are well preserved.

CONCLUSIONS

The occurrence of carbonate bioclasts in the Oligocene sequence indicates that a shallow-water environment (i.e., an island) was present in the Paleogene arc-high areas of the flanks of the forearc basin in the prerifting to initial rifting stage in the late Eocene to early Oligocene. Frontal-arc-high islands were eroded in the initial stage of the rift sedimentation and sank below the sea surface in late Oligocene time, as evidenced from the very low pelagic sedimentation rate in this arc from the latest Oligocene through the early Miocene.

ACKNOWLEDGMENTS

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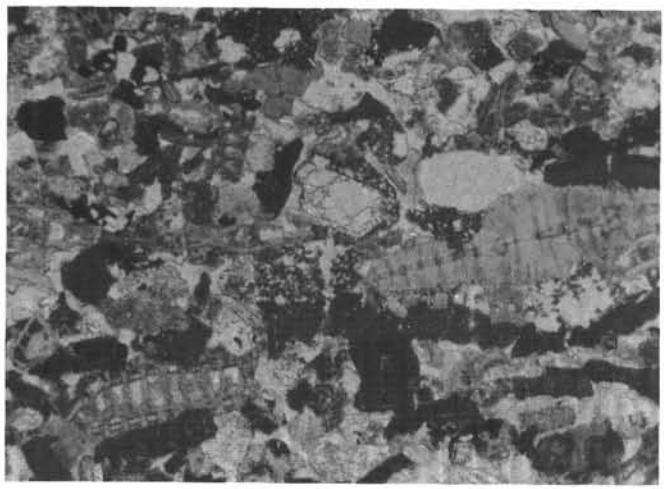

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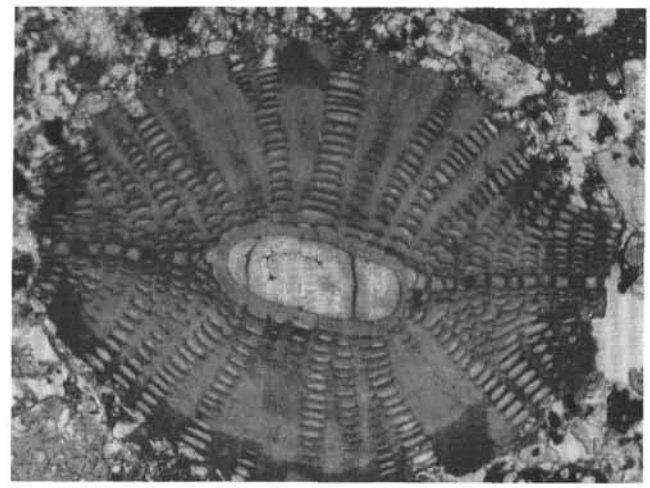

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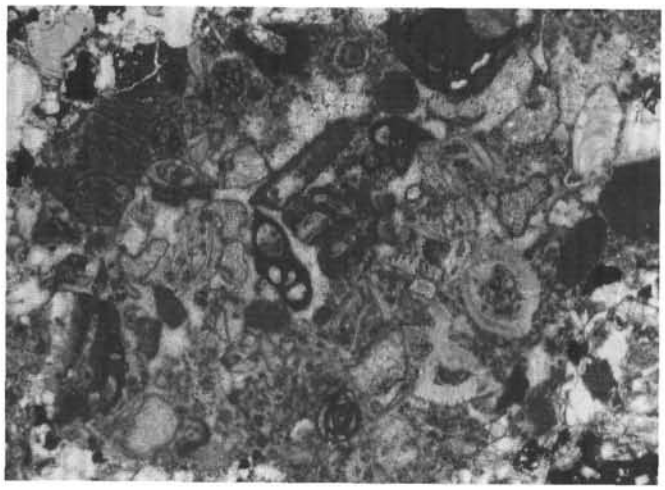

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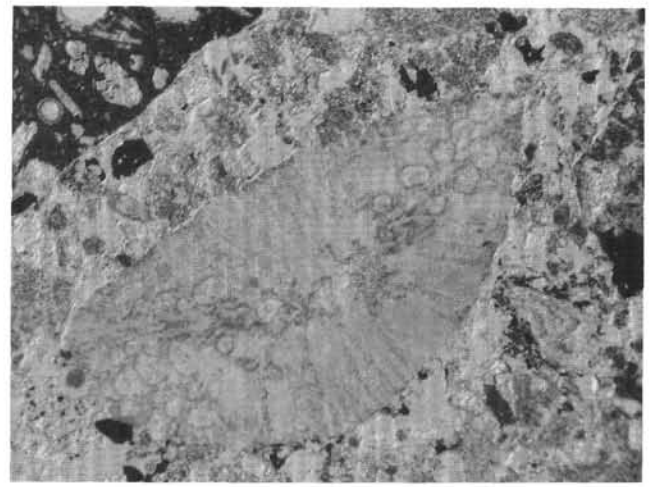

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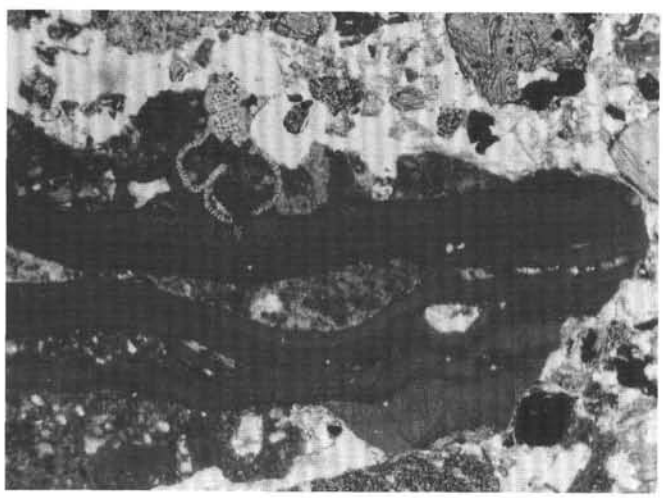

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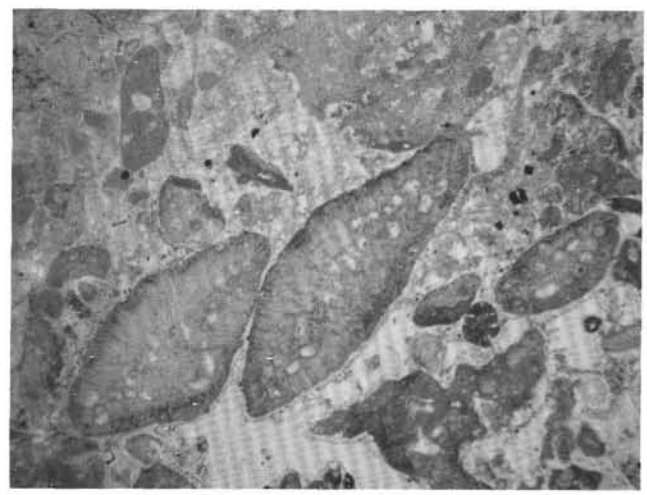

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Plate 1. Photomicrographs of thin sections of limestone and carbonate bioclasts at Site 793 and in dredge Sample D731. Scale bars = 1 mm. **1.** Calcareous sandstone including fragments of larger foraminifers and encrusting coralline algae (Sample 126-793B-63R-3, 6–8 cm). **2.** A single specimen of a larger foraminifer (*Eulepidina* sp.) in sandstone (Sample 126-793B-65R-2, 90–91 cm). **3.** A fragment of biomicrite that includes miliolid benthic foraminifers and articulate coralline algae (Sample 126-793B-74R-4, 22–24 cm). **4.** A single specimen of *Biplanisipira mirabilis* (Umbgrove) in sandstone (Sample 126-793B-74R-4, 22–24 cm). **5.** A fragment of encrusting coralline algae (Sample 126-793B-75R-2, 41–42 cm). **6.** Calcareous sandstone including *Biplanisipira mirabilis* (Umbgrove) (Sample D731-7).