

32. EARLY CRETACEOUS SHALLOW-WATER BENTHIC FORAMINIFERS AND FECAL PELLETS FROM LEG 143 COMPARED WITH COEVAL FAUNAS FROM THE PACIFIC BASIN, CENTRAL AMERICA, AND THE TETHYS¹

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ABSTRACT

Early Cretaceous shallow-water benthic foraminifers and fecal pellets were recovered from Allison and Resolution guyots in the western Mid-Pacific Mountains (MPM) during Ocean Drilling Program Leg 143. These faunas are used to date the carbonate platform owing to the near absence of other microfossils. Four sites contained the Early Cretaceous assemblages: Site 865 on Allison Guyot, and Sites 866, 867, and 868, which were drilled as part of a transect across the perimeter of Resolution Guyot.

Of these sites, Site 866, located about 1.5 km inward from the perimeter mound on Resolution Guyot, provided the most complete record of carbonate sedimentation because drilling penetrated about 1600 m of Hauterivian to late Albian shallow-water carbonate rocks capped by a thin veneer of Maastrichtian to Pliocene pelagic sediments before encountering basalt. The Hauterivian age of the basal limestone pre-dates the clastic limestone of Barremian age from Deep Sea Drilling Project Site 463 in the MPM and thus represents the oldest shallow-water carbonate rocks yet recovered from the Pacific Basin.

Forty-four species of benthic foraminifers, including the new species *Nezzazata isabellae* and *Vercorsella wintereri*, and three species of fecal pellets are grouped into five biostratigraphically significant assemblages: Assemblage I = late Albian, Assemblage II = middle(?) to late Albian(?), Assemblage III = late Aptian(?) to early Albian(?), Assemblage IV = Barremian to early Aptian, and Assemblage V = Hauterivian. This biostratigraphic succession served as the standard for dating and comparing the Aptian(?) to Albian sequence at Site 865 and the Albian sediments at Sites 867/868, as well as the Aptian-to-Albian shallow-water sequences drilled during Leg 144.

Although sparse, the Hauterivian to Aptian assemblages represent a mixture of species known from the northern and southern margins of the Tethys. Further, the stratigraphic succession of the Pacific species is the same as that in Tethyan sequences. Late Aptian to Albian assemblages are distinguished by an influx of species from Mexico and Venezuela associated with a Tethyan fauna.

Based on the benthic faunas, three major paleoenvironments corresponding to the development of the platform are recognized at Site 866: (1) sandy, normal-marine conditions in the Hauterivian, (2) restricted lagoonal conditions with stromatolites during the Barremian to early Aptian, and (3) muddy facies with sponges and normal-marine lagoonal conditions during the late Aptian and Albian.

INTRODUCTION

Early Cretaceous benthic foraminifers were recovered from shallow-water limestone drilled in the western Mid-Pacific Mountains (MPM) at Allison Guyot (Site 865) and Resolution Guyot (Sites 866 and 867/868) during Leg 143 (Fig. 1). The MPM comprise several broad plateaus surmounted by flat-topped seamounts or "guyots" of known Cretaceous age (Hamilton, 1956; Heezen et al., 1973; Matthews et al., 1974). Drilling during Leg 143 was conducted to determine the history of Cretaceous volcanism and subsequent carbonate platform development for guyots in the western central Pacific Ocean. Accordingly, Resolution Guyot, a multiple-reentry site, was drilled to extend through the carbonate cap and into the volcanic pedestal, whereas Allison Guyot, a single-bit site, was drilled into the cap.

Site 865 is located on the summit of Allison Guyot in the central MPM at 18°26.41'N, 179°33.34'W and a water depth of 1518.4 mbsf. About 731 m of Lower Cretaceous shallow-water limestone was drilled before basalt sills were encountered in the lowest 33 m of Hole 865A.

The remaining three sites were drilled on Resolution Guyot in the western MPM as part of a transect across the perimeter of a MPM guyot. Site 866 was located on the northern rim of the summit about 1.5 km inward from the perimeter mound at 21°19.95'N, 174°18.84'E at a water depth of 1361.8 mbsf so as to penetrate lagoonal facies.

About 1600 m of Lower Cretaceous shallow-water limestone resting on basalt was drilled in Hole 866A; drilling extended 124 m farther into the basalt. Sites 867 and 868, located about 2 km northward of Site 866 and only about 400 m apart, were positioned for drilling into the summit of the perimeter mound (Site 867) and a lower terrace outside the mound (Site 868). Site 867, drilled at 21°20.96'N, 174°18.58'E at a water depth of 1352 mbsf, penetrated about 77 m of Lower Cretaceous shallow-water limestone. At Site 868, located at 21°21.17'N, 174°18.56'E and a water depth of 1385 mbsf, only about 17 m of Lower Cretaceous shallow-water limestone was penetrated.

Most of the biostratigraphy of the Lower Cretaceous shallow-water carbonates recovered from Leg 143 is based on benthic foraminifers owing to the near absence of planktonic foraminifers, calcareous nannofossils, and palynomorphs. Rudist bivalves represent an important biostratigraphic component of the biologic assemblage from Leg 143, but their occurrence is surprisingly rare and patchy at Allison and Resolution guyots and consists mostly of fragmental debris (see Masse and Swinburn, this volume). Accordingly, we present here the distribution and taxonomy of the biostratigraphically important Early Cretaceous benthic foraminifers and fecal pellets recovered, discuss the interpretation of their ages, and draw comparisons among these species, many of which are new or are previously undescribed from the Pacific Basin, and comparable species from well-known assemblages elsewhere. Our study focuses on Sites 865 and 866, the latter representing the oldest and most complete record from Leg 143 and, indeed, the oldest shallow-water carbonates yet recovered from the Pacific Basin. The stratigraphic distribution of benthic foraminifers and fecal pellets in Holes 865A and 866A is shown in Tables 1 and 2; most species are illustrated in Plates 1 through 5.

¹ Winterer, E.L., Sager, W.W., Firth, J.V., and Sinton, J.M. (Eds.), 1995. *Proc. ODP, Sci. Results*, 143: College Station, TX (Ocean Drilling Program).

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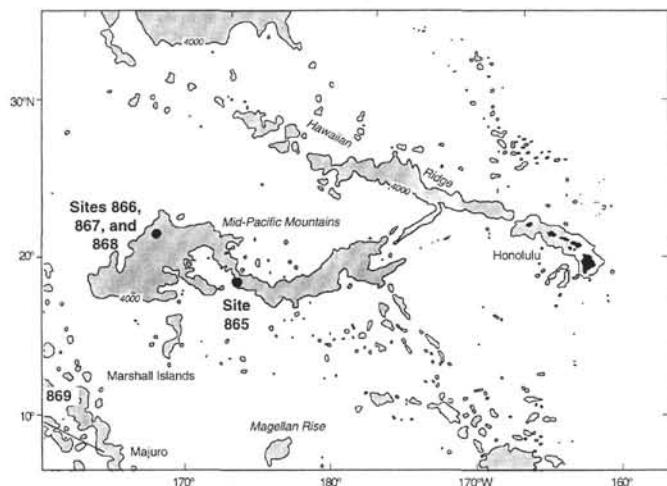


Figure 1. Location of Leg 143 drill sites in the Mid-Pacific Mountains, western central Pacific Ocean Basin. Shaded areas are shallower than 4 km.

METHODS

More than 600 samples from Leg 143 were examined in thin sections cut perpendicular to bedding where possible. In addition, specimens were isolated from limestone using a complex technique that involves impregnating specimens with sodium sulfate in a vacuum bell jar and successively freezing and heating the limestone in a thermocryostat. Freed specimens were examined in oriented thin sections or as whole specimens. Sampling was based on sediment type or the microscopic examination of the core. For the turbiditic sediments at Site 869, the emphasis was placed on sampling coarser layers, such as at the bases of graded beds, and in volcanoclastic breccias, fine conglomerates, and coarse sands.

The stratigraphic distribution of benthic foraminifers and fecal pellets in Tables 1 and 2 is shown according to the following scale for standard thin sections (about 20 × 30 cm):

VA = very abundant (>10 specimens for large foraminifers and >20 for small foraminifers),

A = abundant (6–10 specimens for large foraminifers and 10–20 for small foraminifers),

C = common (3–5 specimens for large foraminifers and 3–10 for small foraminifers),

F = few (2 specimens for both large and small foraminifers), and

R = rare (single specimens for both large and small foraminifers).

Figures 2 and 3 display the distribution of key species after the examination of more than 600 thin sections from the Leg 143 collections of ODP and those of the participating scientists.

Sample notation follows the standard ODP format, given as drilling leg followed by site, core, core type (R = rotary), section, and interval (centimeters below top of section). The abbreviation "CC" refers to a core-catcher sample taken from the bottom of the cored interval.

BIOSTRATIGRAPHY

The biostratigraphy used to date the succession of Early Cretaceous benthic foraminifers from Leg 143 is based primarily on the results of the Working Group on Benthic Foraminifera, IGCP Project No. 262, "Tethyan Cretaceous Correlation," chaired by A. Arnaud-Vanneau, and on previous European publications (e.g., Schroeder and Neumann, 1985). A stratigraphic distribution chart that summarizes the results of Project 262 was prepared by about 40 specialists from 14 countries. This collaboration clarified the stratigraphic distribution of the most important age-diagnostic benthic foraminifers from a broad geographic area, which includes the northern margin of the Tethys from

the Crimea to Mexico; the Adriatic area from Greece, Albania, Croatia, Slovenia, and Italy; and the southern margin of the Tethys from the Middle East to Morocco. The distribution chart will soon be published in the final report of Project 262. Substage age correlations of the benthic succession in carbonate platform deposits are based, when possible, on ammonites in the Lower Cretaceous sequence (e.g., Hoedemaeker et al., 1993) and pelagic foraminifers in the Upper Cretaceous sequence that were introduced during marine intercalations.

Age-diagnostic Faunal Assemblages

We distinguish five microfaunal assemblages that enable us to date the Hauterivian to Albian sequence of shallow-water carbonate rocks from Hole 866A (Fig. 2). This biostratigraphic succession provides the standard with which we date the younger assemblages from Hole 865A (Fig. 3).

Assemblage I: *Nezzazata* sp. A, *Nezzazata isabellea* n. sp., *Cuneolina parva*, C. sp. cf. *C. pavonia*, *Pseudonummoloculina* sp. X, *Trocholina* sp. cf. *T. lenticularis*, T. sp. cf. *T. odukpaniensis*, and *Barkerina* sp. cf. *B. barkerensis* (see Tables 1 and 2; systematic descriptions below).

Stratigraphic distribution: From Samples 143-866A-3R-CC to -15R-CC and from Samples 143-865A-17X-CC to -44R-CC.

Age: Large cuneolinids such as *Cuneolina parva* and *Cuneolina pavonia* range from the late Albian to Cenomanian, according to the authors who participated in the IGCP Working Group on Benthic Foraminifera. In addition, *Cuneolina* sp. cf. *C. pavonia* ranges from the uppermost middle Albian to the lower Cenomanian in Mexico, as shown in Figure 4. The range of *Trocholina lenticularis* is from the upper Albian to the lower Cenomanian(?) in the Middle East (Henson, 1947). Only *Barkerina barkerensis* typically is restricted to the middle Albian, but the specimens from Hole 865A are too sparse and poorly sectioned to confirm the identification. Thus, in the absence of older age indicators, we suggest that this assemblage belongs to the late Albian.

Assemblage II: *Nezzazata isabellea* n. sp., *Cuneolina* sp. A, orbitolinid A, orbitolinid B, *Paracoskinolina* sp. cf. *P. sunnilandensis*, *Neoiragia*(?) sp., *Arenobulimina* sp. cf. *A. chapmani*, *Vercorsella* sp. cf. *V. arenata*, V. sp. cf. *V. scarsellai*, *Voloshinoides* sp. A, *Pseudonummoloculina* sp., and a few, uncertain specimens of *Cuneolina parva* and C. sp. cf. *C. pavonia*.

Stratigraphic distribution: From Samples 143-866A-15R-CC to -57R-1 and from Samples 143-865A-45R-CC to -86R-1.

Age: The lower part of this assemblage is characterized by the occurrence of orbitolinids. *Paracoskinolina sunnilandensis* reported from the Albian of Texas, Mexico, and Venezuela (Maync, 1955) ranges from the middle to the upper Albian in Mexico (Fig. 4). The genus *Neoiragia* is typical of the upper Albian in Europe, but very small forms are reported in the Albian (middle?) of Spain (E. Caus, pers. comm., 1993). This assemblage is considered to be of middle(?) to late(?) Albian age.

Assemblage III: *Vercorsella* sp. cf. *V. immaturata*, *Nezzazata isabellea* n. sp., N. sp. B, *Arenobulimina* sp. A, and *Buccicrenata hedbergi*.

Stratigraphic distribution: From Samples 143-866A-57R-1 to -57R-82R-1 and from Samples 143-865A-86R-1 to -91R-3.

Age: *Nezzazata* sp. B and *Arenobulimina* sp. A are found in the upper Aptian of the Aquitaine Basin (N'Da, 1984) and in upper lower Albian to lowermost middle Albian sediments of Mexico (Ortuño Arzate et al., 1989; Scott and Gonzalez-Leon, 1991; and Fig. 4). *Buccicrenata hedbergi* has been described from the Aptian to Albian of Venezuela by Maync (1953). We suggest that this assemblage indicates a late Aptian(?) to early Albian(?) age.

Assemblage IV: *Protopenneroplis* sp., *Nezzazata*(?) sp. C., *Falsurgonina*(?) sp., and *Neotrocholina* sp. cf. *N. friburgensis*.

Stratigraphic distribution: From Samples 143-866A-82R-1 to -129R-6.

Table 1. Stratigraphic distribution of Early Cretaceous benthic foraminifers and fecal pellets from Hole 866A.

Age	Core, section, interval (cm)	Species	
		late Albian?	late Albian?
late Albian to middle Albian	2R-2, 7-8		
	7R-CC, 14-15		
	15R-CC, 13-14		
	25R-1, 50-52		
	29R-CC, 21-24		
	31R-1, 35-37		
	35R-1, 88-90		
	36R-1, 43-44		
	38R-1, 23-24		
	44R-CC, 26-27		
	45R-CC, 23-25		
	46R-1, 104-106		
	46R-2, 41-43		
	47R-1, 92-94		
	48R-1, 30-32		
	49R-1, 8-8		
	50R-CC, 5-7		
	51R-1, 31-33		
	53R-1, 53-56		
	56R-CC, 15-16		
	58R-1, 21-23		
	59R-1, 52-53		
	61R-1, 119-120		
	62R-1, 73-76		
	63R-1, 136-138		
	64R-1, 18-20		
	65R-1, 101-102		
	66R-1, 88-91		
Barremian to early Aptian	70R-2, 67-69		
	71R-1, 43-45		
	71R-1, 64-67		
	73R-1, 88-89		
	74R-2, 56-59		
	75R-3, 113-115		
	77R-1, 91-93		
	79R-4, 11-13		
	80R-1, 22-23		
	81R-3, 73-75		
	82R-1, 74-46		
	83R-1, 36-42		
	85R-2, 29-33		
	86R-1, 134-136		
	87R-1, 77-79		
	88R-1, 77-79		
	89R-2, 22-23		
	91R-1, 41-42		
	94R-1, 80-81		
	96R-1, 4-6		
	98R-1, 125-126		
	99R-1, 8-10		
	100R-1, 25-26		
	102R-2, 59-64		
	103R-1, 33-34		
	108R-1, 42-44		
	109R-2, 26-28		
	110R-1, 126-128		
	111R-1, 27-28		
	112R-1, 31-32		
	115R-1, 22-26		
	117R-2, 29-31		
	118R-2, 41-43		
	119R-1, 18-19		
	120R-1, 39-41		
	121R-3, 19-20		
	122R-1, 67-69		
	123R-1, 43-45		
	125R-2, 70-72		
	126R-1, 79-80		
	128R-1, 90-92		
	129R-1, 90-92		
	130R-1, 69-73		
	131R-1, 92-94		
	132R-1, 55-58		
	133R-2, 94-97		
	136R-1, 1-3		
	137R-1, 42-44		
	138R-1, 10-13		
	139R-1, 41-43		
Hauterivian	142R-1, 26-27		
	143R-1, 24-27		
	144R-1, 137-140		
	145R-2, 49-50		
	146R-1, 100-102		
	147R-1, 23-25		
	148R-1, 121-122		
	152R-1, 10-12		
	153R-1, 116-118		
	154R-1, 51-52		
	155R-1, 119-122		
	157R-1, 11-14		
	158R-1, 84-86		
	159R-2, 18-20		
	160R-1, 26-28		
	165R-2, 118-120		
	166R-1, 97-100		
	167R-2, 7-9		
	168R-1, 24-25		
	169R-3, 17-18		
	170R-3, 106-108		
	171R-1, 21-24		

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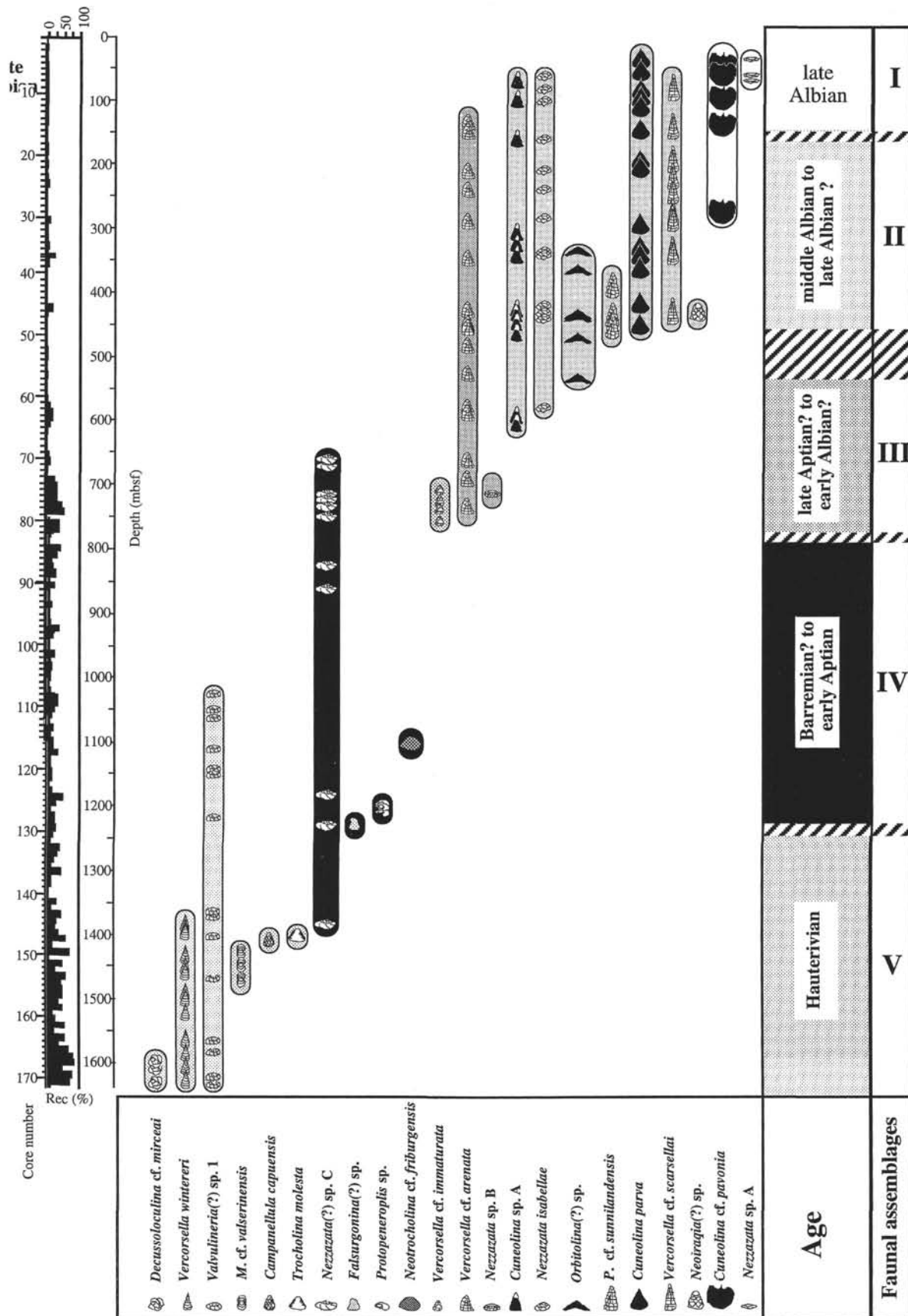


Figure 2. Distribution of the most important Early Cretaceous benthic foraminifers from Hole 866A. Foraminiferal illustration shows occurrence.

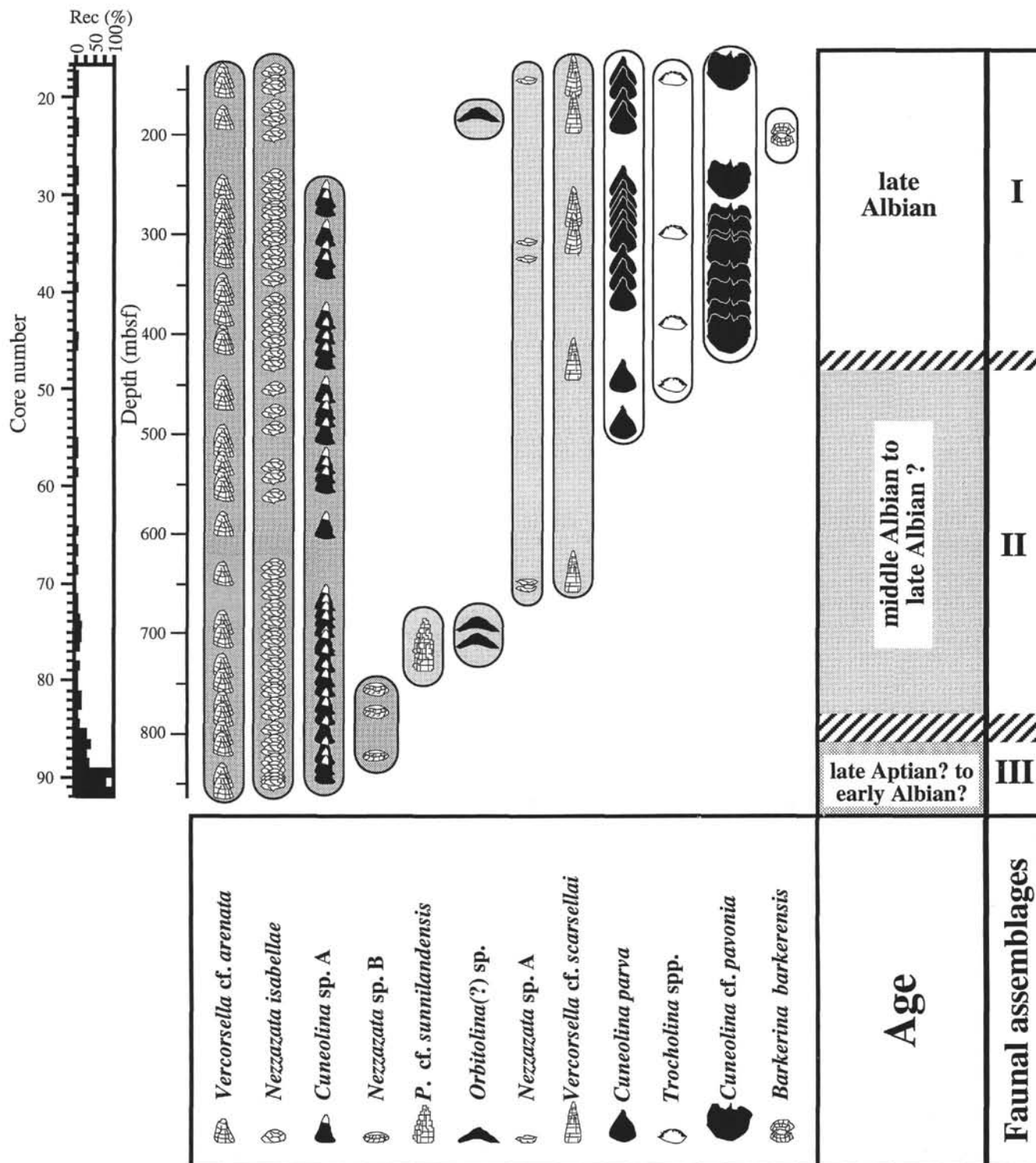


Figure 3. Distribution of the most important Early Cretaceous benthic foraminifers from Hole 865A.

Age: *Protopeneroplis* sp. and *Falsurgonina*(?) sp. are found only in the lower part of this interval. The genus *Protopeneroplis* is typical of the Berriasian to Valanginian interval and generally is thought not to occur younger than the Hauterivian (Bucur, 1993). However, it may occur in the Barremian of Italy (M. Chiocchini, pers. comm., 1992). The genus *Falsurgonina* ranges from the Hauterivian(?) to the lower Aptian in France (Arnaud-Vanneau, 1980), whereas *Neotrocholina friburgensis* typically ranges from the latest Barremian to the

earliest Aptian (Arnaud-Vanneau, 1980). This faunal assemblage thus suggests a Barremian to early Aptian age.

Assemblage V: *Campanellula capuensis*, *Melathrokerion* sp. cf. *M. valserinensis*, *Valvulineria*(?) sp. 1, *Decussoloculina* sp. cf. *D. mirceai*, *Vercorsella wintereri* n. sp., and *Favreina* sp. cf. *F. prusensis*.

Stratigraphic distribution: From Samples 143-866A-129R-6 to -171R-1.

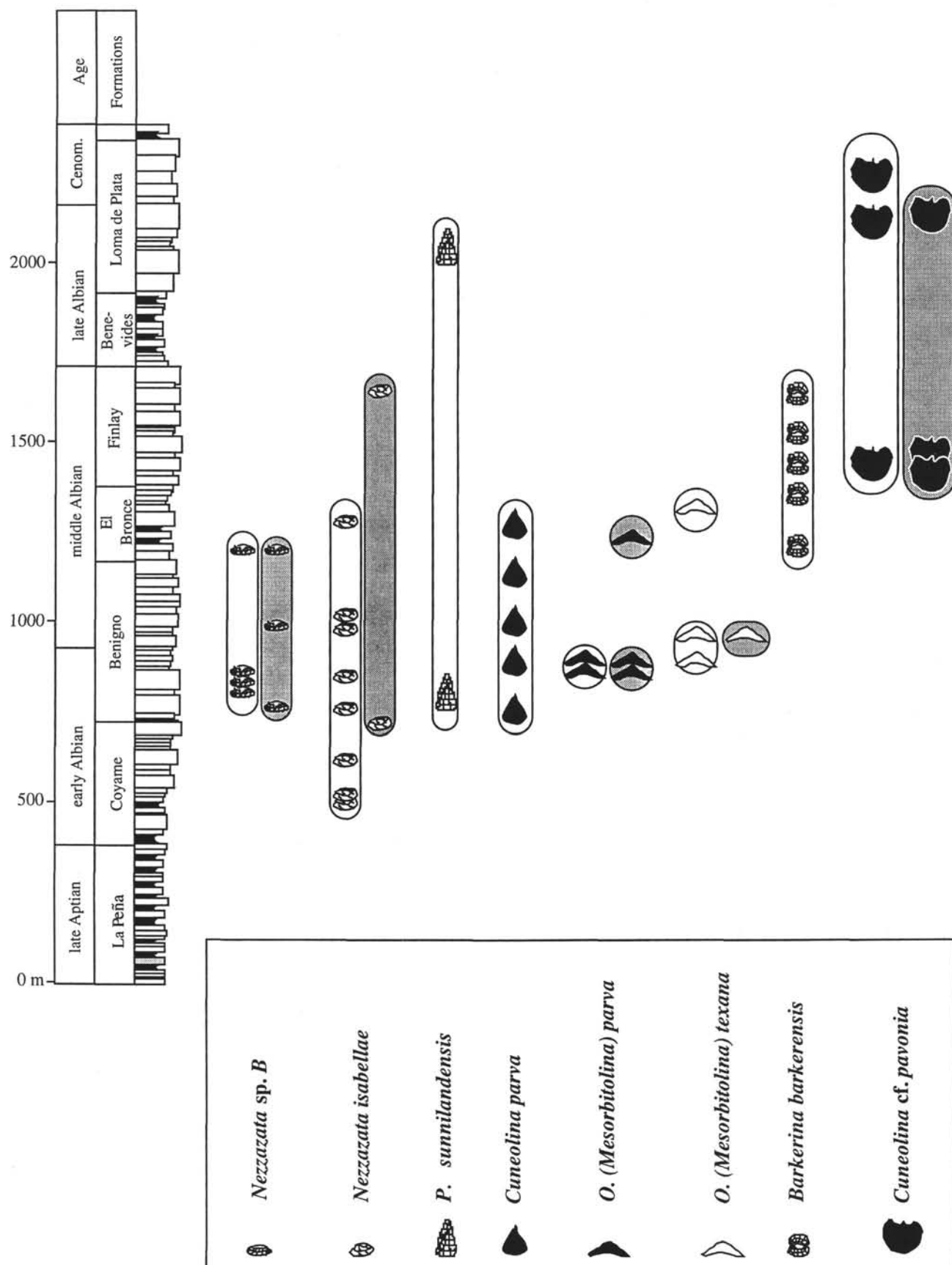


Figure 4. Distribution of Albian benthic foraminifers from two sections in the Chihuahua Basin, Mexico (modified from Ortuño Arzate et al., 1989): Cuchillo Parado (shown in white) and Sierra Boquilla (shown in gray). The lithology shown is from the Cuchillo Parado section.

Age: This assemblage is characterized by the presence of *Vercorsella wintereri* n. sp. and *Valvulineria*(?) sp. 1. Within the primary assemblage, we distinguish two secondary assemblages. The lower secondary assemblage (from Samples 143-866A-167R-2 to -171R-1) contains specimens provisionally referred to *Decussoloculina mirceai* that originally was described from the Berriasian to Valanginian of Romania by Neagu (1984). The upper secondary assemblage (from Samples 143-886A-129R-6 to -167R-2) contains *Campanellula capuensis*, the index species for the upper Hauterivian along the southern margin of the Tethys (Chiocchini and Mancinelli, 1977; Luperto Sinni and Masse, 1986; Fig. 5), *Favreina prusensis*, described from the Tithonian of Turkey (Paréjas, 1948), and specimens of *Melathrokerion* sp. cf. *M. valserinensis* that are the same size as specimens from the Hauterivian of Slovenia (Arnaud-Vanneau, H. Arnaud, and M. Cousin, unpub. data, 1994). The fact that *Decussoloculina* sp. cf. *D. mirceai* is found only at the bottom of the primary assemblage and *Campanellula capuensis* only at the top may indicate that the Hauterivian section is complete or nearly so.

In summary, the benthic foraminifers and fecal pellets from Leg 143 date the carbonate platform in the MPM as Early Cretaceous (Hauterivian to Albian) in age. Only Site 866 on Resolution Guyot has a thick carbonate section resting on basalt where the age of the oldest carbonate deposits is Hauterivian. At the other sites, the age of the oldest carbonate sedimentary rocks recovered is younger and probably Albian at Sites 867/868 and possibly late Aptian at the bottom of Hole 865A, where the limestone is intruded by one or more basalt sills. In contrast, the youngest shallow-water carbonate rocks at all sites are represented by faunas of assemblage I, which suggests that the demise of platform sedimentation was more or less coeval during the late Albian (see Sliter, this volume).

PREVIOUS RECORD FROM THE PACIFIC OCEAN BASIN

The Cretaceous age of many seamounts and guyots in the northwest Pacific, which stretch from the Japanese group through the Marcus-Wake chain to the MPM, was established since the 1950s largely through dredge hauls (e.g., Hamilton, 1956; Tsuchi and Kagami, 1967; Matthews et al., 1974; Ladd et al., 1974) and later through drilling (e.g., Winterer et al., 1973; Heezen et al., 1973; Thiede et al., 1981). Paleontologic ages from the dredges, based primarily on macrofaunal debris, identified a general Barremian to Albian age for the shallow-water carbonate rocks. Results from drilling provided age control based on microfossils for the overlying pelagic carbonate materials. Within this record, information regarding Early Cretaceous benthic foraminifers was mostly limited to rare specimens from the Cuneolinidae (*Cuneolina*, *Vercorsella*, *Sabaudia*), the Orbitolininae (*Conicorbitolina*, *Neoiragia*, *Orbitolina*), and *Trocholina*. Identifications often were limited to genera and precise descriptions are lacking.

Dredges from Daiichi Kashima Seamount recovered benthic foraminifers dated as Early to middle Cretaceous (Research Group for Daiichi Kashima Seamount, 1976; Shiba, 1988; Konishi, 1989). Specimens attributed to *Orbitolina lenticularis* (Blumenbach) by Shiba (1988) probably are *Conicorbitolina* sp., and the forms referred to *Cuneolina laurentii* are probably *Cuneolina parva*.

Fragments of "*Orbitolina*" were dredged from Isakov Guyot (Heezen et al., 1973) and found reworked in upper Oligocene sediments from Site 462 in the Nauru Basin (Premoli Silva and Brusa, 1981). Reworked specimens of *Cuneolina* are reported from Cenomanian strata at Site 171 on Horizon Guyot and from Campanian sediments at Site 315 in the Line Islands by Premoli Silva and Brusa (1981).

Recent dredging from Lo-En Guyot in the Marshall Islands recovered forms attributed to *Sabaudia* associated with the planktonic foraminifer *Favusella washitensis* (Lincoln et al., 1993). Recent reports by Schlager and Philip (1990), Grötsch (1991), Grötsch and Flügel (1992), and Grötsch et al. (1993) on dredged material from Charlie Johnson, Isakov, MIT, Woods Hole, and Allison guyots indi-

cated a late Albian age for sediments recovered based on an assemblage of planktonic and benthic foraminifers. Benthic species described include *Orbitolina* (*Mesorbitolina*) *parva* and *Cuneolina pavonia*, indicating a late Aptian to late Albian age.

However, the specimens in dredged material from MIT Guyot referred by Grötsch (1991, pl. 19, figs. 3–9) to *Cuneolina pavonia* probably represent forms we attribute to *Cuneolina parva* and *Cuneolina* sp. cf. *C. pavonia*. These species are components of Assemblage I and suggest that the same assemblage exists at MIT Guyot, if not throughout the northwest Pacific Ocean. The association of these species with planktonic foraminifers from the latest Albian planktonic foraminifer *Rotalipora appenninica* Zone by Grötsch (1991), Grötsch and Flügel (1992), and Grötsch et al. (1993) confirms the late Albian age of the benthic assemblage.

Finally, Lower Cretaceous sediments with orbitolinids and other larger foraminifers are known along the western margin of the Pacific Ocean from Japan to Borneo (e.g., Matsumaru et al., 1976; Hashimoto and Matsumaru, 1984; and references therein). These faunas have affinities to species from the two margins of the Tethys as well as from the Pacific Basin and thus are important for interpreting paleogeographic pathways.

COMPARISON WITH OTHER AREAS

Central America

Early Cretaceous benthic foraminifers are well known and described in detail from the eastern margin of the Pacific Ocean and the Caribbean (e.g., the Aptian to Albian of Mexico and Venezuela). For comparison, we have selected two Albian to lower Cenomanian sections from the Chihuahua Basin of Mexico at Cuchillo Parado and Sierra Boquilla (Fig. 4) that previously were studied by Ortuño Arzate et al. (1989).

In the Chihuahua Basin, the carbonate platform deposits are represented by a 7000-m-thick unit that extends from the middle lower Albian to the lower Cenomanian. We have no data concerning Aptian sediments in this region. The stratigraphic distribution of benthic foraminifers, such as *Orbitolina* (*Mesorbitolina*) *texana*, and *Barkerina barkerensis*, are similar in the Chihuahua Basin and in the Lampazos area studied by Scott and Gonzalez-Leon (1991). *Orbitolina* (*Mesorbitolina*) *texana* ranges from the uppermost Aptian to the middle Albian in the Lampazos area. *Barkerina barkerensis* is considered as a middle Albian species, as shown in Figure 4.

In 1989, Ortuño Arzate et al. did not identify species of *Nezzazata* and *Cuneolina*. However, about 100 specimens of these two genera have now been photographed and identified (AAV), and their distribution is shown in Figure 4. *Cuneolina parva* ranges from the lowermost Albian to the middle Albian. Specimens referred to *Cuneolina* sp. cf. *C. pavonia* range from the uppermost middle Albian to the lower Cenomanian. In the uppermost middle Albian, *Cuneolina* sp. cf. *C. pavonia* is associated with forms assigned to *Barkerina* sp. cf. *B. barkerensis* and *Cuneolina parva*. This assemblage is similar to assemblage I from Allison and Resolution guyots.

In the Chihuahua Basin, orbitolinids are abundant in the uppermost lower Albian and the lower middle Albian in association with *Paracoskinolina sunnilandensis*. The same association is found in Assemblage II at Site 866 on Resolution Guyot. Other species in this assemblage, however, such as *Cuneolina* sp. A, *Vercorsella* sp. cf. *V. scarsellai*, and *Neoiragia*(?) sp., have not been identified in Mexico. *Nezzazata* sp. B also is associated with these species, unlike in the Pacific sequences of Leg 143 where it is restricted to the older Assemblage III. Further, *Nezzazata isabellae* n. sp. has a long range in Mexico extending from the lower to middle Albian.

In summary, many of the species identified from the Pacific guyots show the same stratigraphic distribution in Mexico. Well-known Central American species such as *Paracoskinolina walnutensis*, *Coskinolinoides texanus*, and *Nummuloculina heimi* are, as yet, unknown in the Pacific Basin. In contrast, species of *Neoiragia* and

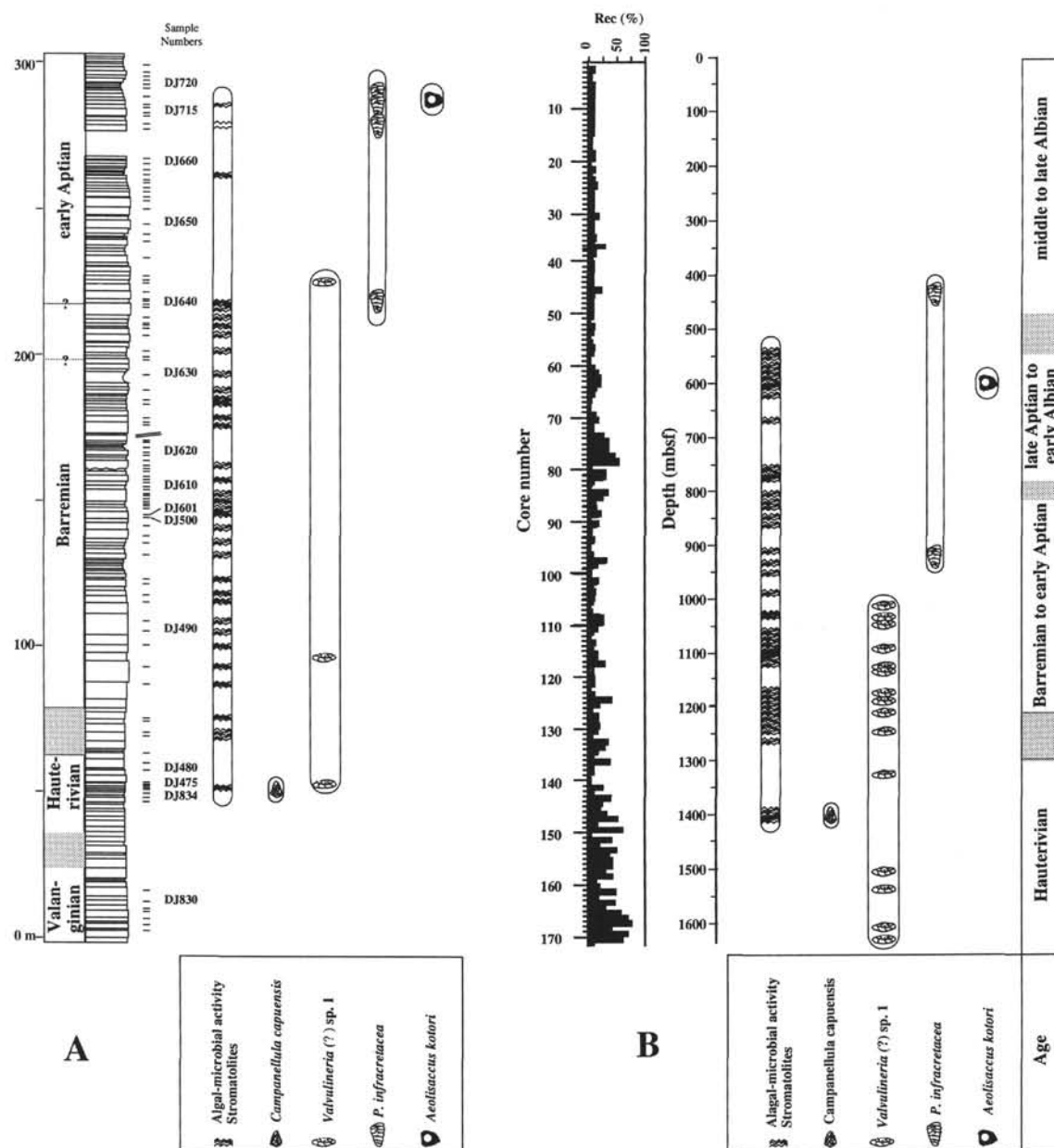


Figure 5. Distribution of Early Cretaceous benthic foraminifers from the Fara Martino section (A) of central Italy (after Arnaud-Vanneau and Arnaud, 1988), originally located on the southern margin of the Tethys, compared to the distribution at Site 866 (B).

Trocholina exist on the guyots and have never been reported from the Americas. The distribution of Albian species, however, is similar between the guyots and Mexico, except for *Nezzazata* sp. B, which is associated with younger species in Mexico.

Tethys

For a comparative Hauterivian to Aptian section from the Tethys, we have selected the Fara San Marino section in central Italy, studied by Arnaud-Vanneau and Arnaud (1988), that is similar to Site 866 in depositional facies and species content (Fig. 5). At Fara San Marino, the Hauterivian to lower Aptian carbonate platform sequence is 300 m thick and was originally located on the southern margin of the Tethys. Facies are mostly restricted marine and display algal-microbial layers and numerous stromatolites. In Italy, the restricted facies extend south to Gargano, where the same stratigraphic interval is

referred to as the "membre loféritique" by Luperto Sinni and Masse (1986) owing to the numerous stromatolites.

The Pacific sediments from Site 866 also indicate the development of stromatolites and algal-microbial layers during this time interval. More importantly, the stratigraphic distribution of key species is similar between the Italian and Pacific sites. Further, the Pacific biostratigraphic interpretations are in general accord with the strontium-isotope stratigraphy of Jenkyns et al. (this volume). The stratigraphic position of *Campanellula capuensis* is constrained to the uppermost Hauterivian in Italy (Chiocchini and Mancinelli, 1977; Luperto Sinni and Masse, 1986), and the distribution apparently is similar at Site 866. *Valvulineria (?)* sp. 1 ranges from the Hauterivian to the lower Aptian in the two sections. *Praechrysalidina infractureacea* ranges from the Aptian to the Albian. *Aeolisaccus kotori*, confined to the southern margin of the Tethys, also ranges from the Aptian to the Albian but was identified only in the Albian at Resolution Guyot.

Three other species characterize the Hauterivian to lower Aptian interval at Site 866: *Falsurgonina* sp., and specimens referred to *Neotrocholina* sp. cf. *N. friburgensis*, and *Decussoloculina* sp. cf. *D. mirceai*. These species are not shown in Figure 5 as the type specimens are restricted to the northern margin of the Tethys. *Falsurgonia* ranges from the Hauterivian to the Barremian and *Neotrocholina friburgensis* is known from the Barremian to the basal part of the lower Aptian. *Decussoloculina* sp. cf. *D. mirceai* from the Pacific is similar in morphology to the type species described from Romania.

In summary, benthic foraminifers from the Hauterivian to Aptian interval in the Pacific display the same evolutionary succession as do those from the carbonate platform on the southern margin of the Tethys in Italy. The stratigraphic distribution of species is the same, with the addition of species from the northern Tethys during the Barremian and early Aptian.

Biogeographic Conclusions

All the Early Cretaceous benthic foraminifers identified from Allison and Resolution guyots are known from the margins of the Tethys, except for the new species *Vercorsella wintereri* n. sp., *Cuneolina* sp. A, and a presumed new orbitolinid genus and species. The minute size of both *Vercorsella wintereri* n. sp. and *Cuneolina* sp. A may explain their apparent absence in earlier studies, and the identification of the new orbitolinid requires oriented thin sections across the embryonic apparatus of isolated specimens to confirm its identification. For these reasons, we are not sure that true endemic shallow-water species existed in the Early Cretaceous Pacific Ocean.

The Hauterivian to Aptian benthic foraminifer assemblages from Leg 143 contain a mixture of species known from the northern and southern margins of the Tethys, as shown in Figure 6. The Hauterivian sediments of the Pacific atolls are characterized by the diagnostic species *Campanellula capuensis*, which is restricted to the southern margin of the Tethys. However, we also identified specimens resembling *Decussoloculina mirceai*, which is a species described from the northern margin of the Tethys.

The Barremian to lower Aptian sequence displays a mixed fauna having restricted northern taxa, such as *Falsurgonia*, and specimens tentatively assigned to *Neotrocholina friburgensis*, which occur together with restricted southern species such as *Praechrysalidina cretacea* and *Aeolisaccus katori*.

The upper Aptian to Albian sequence includes typical American faunas that were introduced for the first time following the opening of the central Atlantic Ocean. These faunas include: (1) southern margin species such as *Praechrysalidina infractetacea* and forms resembling *Trocholina lenticularis* (known from the Middle East); (2) the northern-margin taxa *Iraqia*(?); and (3) species from Central America such as *Paracoskinolina sunnilandensis*, and specimens tentatively referred to *Barkerina barkerensis*, and *Cuneolina pavonia*, the latter specimens resembling the form referred to as *C. waltheri* by Scott and Gonzalez-Leon (1991). Furthermore, *Barkerina barkerensis* and *Cuneolina pavonia* are also known from Europe.

The degree of mixing of benthic species known from the two margins of the Tethys in the faunas from the central Pacific Ocean is unusual and important to biogeographic considerations. Similar faunal mixing is known in regions from the southern margin of the Tethys located in the Adriatic area (Slovenia, Croatia) that paleogeographically were close to the northern margin of the Tethys during the Early Cretaceous (Fig. 6). Other than these examples, however, no other such biogeographically mixed Early Cretaceous benthic faunas are known.

DEPOSITIONAL ENVIRONMENTS

In the following discussion, we consider the benthic foraminifers together with other biogenic and lithogenic constituents in the samples collected to determine the succession of environments that occurred during the depositional history of the carbonate platforms. The posi-

tions of the sites on Resolution and Allison guyots relative to the margin of the platform are important for explaining the types of environments that are represented on each guyot. However, the most important factor is the age of the sediments and the types of species that existed at that time. We begin our discussion with the thick sequence at Site 866 and then consider the sequence at Site 865. The distribution of biogenic constituents at each site is shown in Tables 3 and 4.

Site 866 (Resolution Guyot)

Two major environments are represented in the Hauterivian section at Site 866. From Samples 143-866A-171R-1, 21–24 cm, to -154R-1, 51–52 cm, environments with normal salinity and normal oxygenation are suggested by the presence of a few nodosariidae, *Marsonella*, and bryozoans (Table 3). The interval is represented by oolitic and/or oncolithic sand and the sparse microfauna includes small biserial benthic foraminifers such as *Vercorsella wintereri* n. sp. (common), *Valvulineria*(?) sp. 1 (rare to few), and *Belorussiella* (rare to few). Miliolids are missing.

During deposition of Samples 143-866A-153R-1, 116–118 cm, to -132R-1, 55–58 cm, environments were muddy and the microfauna includes *Istrilocolina* and ostracodes with more restricted-marine intervals represented by evidence of algal-microbial activity. The presence of miliolids, textulariids, *Vercorsella wintereri* n. sp., and *Valvulineria*(?) sp. 1 indicate that lagoonal conditions existed between periods of restricted-marine conditions.

Environments during the Barremian to lower Aptian interval, from Samples 143-866A-131R-1, 92–94 cm, to -88R-1, 77–79 cm, were mostly dominated by strong algal-microbial activity and the development of stromatolites. Except for ostracodes and *Istrilocolina*, the microfauna is rare. The widespread algal-microbial activity that characterized this period is of special interest. In today's oceans, it is difficult to imagine such restricted-marine environments with below-normal salinity and oxygen values so close to the margin of a relatively small Pacific island.

During the late Aptian to early Albian, conditions became increasingly closer to normal marine. Three types of environments are distinguished. From Samples 143-866A-87R-1, 77–79 cm, to -79R-4, 11–13 cm, the presence of *Marsonella* and *Belorussiella* identify normal-marine conditions. From Samples 143-866A-77R-1, 91–93 cm, to -73R-1, 88–89 cm, the environment approached reefal conditions. Fragments of corals, echinoids, calcareous sponges, *Polystrata alba*, and large dasyclads are present, and, as is usual in this kind of environment, the foraminiferal fauna is sparse and only specimens of *Vercorsella* sp. cf. *V. immaturata* are common. Still, the environment is not truly reefal as reefal material is rare. Finally, in the uppermost part of this interval, from Samples 143-866A-71R-1, 64–67 cm, to -58R-1, 21–23 cm, restricted-marine environments reappear including evidence of algal-microbial activity and stromatolites.

During the middle to late Albian, restricted-marine environments disappeared and facies were mostly muddy with abundant, large sponge spicules. From Samples 143-866A-56R-CC, 21–23 cm, to -2R-2, 7–8 cm, normal-lagoon environments are present with an upward increase in *Cuneolina*, *Vercorsella*, and miliolids which are present throughout and are sometimes abundant. *Nezzazata* also is present and the microfauna is increasingly diverse, with up to 20 species identified.

Site 865 (Allison Guyot)

More than 700 m of upper Aptian to Albian shallow-water carbonate rocks was recovered at Site 865. The facies mostly are lagoonal, muddy, and rich in large sponge spicules (Table 4). A relationship exists between the density of sponge spicules and the abundance of benthic foraminifers. When spicules are abundant, foraminifers are rare and vice versa.

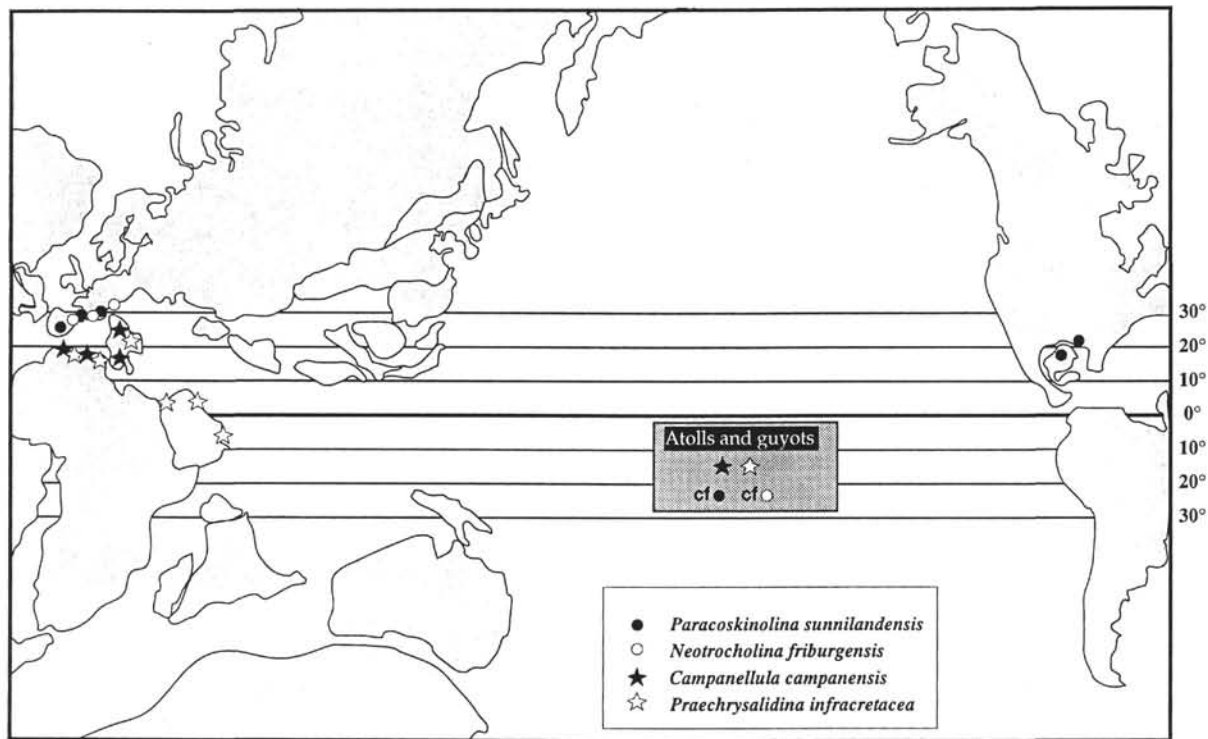


Figure 6. Paleogeographic distribution of selected benthic foraminifers during the Early Cretaceous. Map from Terra Mobilis (Scotese and Denham, 1987).

Three types of depositional environments are identified. From Samples 143-865A-94R-3, 123–124 cm, to -91R-3, 89–93 cm, the environment represents the first deposition of carbonate materials on the guyot during a transgression. The microfacies contains a mixture of volcanic debris, clay, wood fragments, and worn small benthic foraminifers. In this assemblage, only large foraminifers such as *Buccicrenata hegbergi* with an agglutinated test and fragments of arthropods seem autochthonous. The environment probably was very shallow.

From Samples 143-865A-90R-1, 45–47 cm, to -81R-1, 53–60 cm, the sediment contains less clay, and small-sized benthic foraminifers are abundant, especially *Nezzazata isabellae* n. sp. Benthic foraminifers are diverse, with 13 species identified, whereas large sponge spicules are few to common. Lagoonal environments and low-energy muddy facies are interpreted for sediments from Samples 143-865A-80R-1, 32–38 cm, to -44R-CC, 14–16 cm. The biofacies consists of abundant to very abundant sponge spicules and a low-diversity benthic foraminifer assemblage limited mostly to abundant miliolids and *Nezzazata isabellae* n. sp.

The interval from Samples 143-865A-43R-CC, 1–2 cm, to -17X-CC, 34–36 cm, contains normal-marine biofacies with increasingly abundant benthic foraminifers. As at Site 866, microfaunas are dominated by *Cuneolina*, *Vercorsella*, and miliolids with less abundant nezzazatids. The diversity increases upsection; however, only 18 species were identified at Site 865.

In summary, three major depositional environments were identified in the Lower Cretaceous shallow-water carbonate sequence from Leg 143. The first, which can be found in the Hauterivian at the base of the carbonate sequence at Site 866, corresponds to a sandy environment with normal-marine salinity and oxygen conditions. During this time, Resolution Guyot probably was an island that lacked a true lagoon and protected environments. The latter is suggested by the absence of a true muddy facies.

Noticeably restricted-lagoonal conditions occurred during the Barremian to early Aptian with the development of strong algal-microbial activity and stromatolites. Carbonate productivity of microbial origin quickly extended to sea level, and the sedimentation

represents a type of “catch up” series (James and Macintyre, 1985). It is interesting to note a similar period of strong microbial activity during the Barremian to early Aptian in central Italy. At that time, the platform sequence in Italy was at a paleolatitude of about 15°N, whereas Resolution Guyot was 18°S. This, albeit limited, comparison perhaps identifies a paleolatitudinal core interval favorable to the development of microbial activity.

Late Aptian to Albian depositional environments were similar at Sites 866 and 865 and are characterized by muddy facies, large sponge spicules, and normal-marine lagoonal conditions. No evidence of restricted-marine conditions was found throughout the interval. Carbonate sedimentation was in a “keep up” mode, with the rate of production matching the rate of rise in sea level. During this time, the guyots were located near the paleoequator, and the benthic foraminifer faunas were relatively abundant and diversified.

CONCLUSIONS

The results from Leg 143 provided important new information on the biogeography of Early Cretaceous benthic foraminifers and the history of carbonate platform sedimentation in the central Pacific Ocean, chief of which was the discovery of the oldest carbonate platform yet known from the Pacific, the Hauterivian at Resolution Guyot. Demise of the carbonate platform at both Allison and Resolution guyots, and perhaps elsewhere in the Pacific, took place more or less at the same time during the late Albian (Sliter, this volume).

Within the Hauterivian to Albian sequence at Site 866, five age-diagnostic faunal assemblages are identified:

Assemblage I: *Nezzazata* sp. A., *N. isabellae* n. sp., *Cuneolina parva*, C. sp. cf. *C. pavonia*, *Pseudonummoloculina* sp. X, *Trocholina* sp. cf. *T. lenticularis*, T. sp. cf. *T. odukpaniensis*, and *Barkerina* sp. cf. *B. barkerensis* of late Albian age.

Assemblage II: *Nezzazata isabellae* n. sp., *Cuneolina* sp. A, orbitolinid A, orbitolinid B, *Paracoskinolina* sp. cf. *P. sunnilandensis*, *Neoiragia*(?) sp., *Arenobulimina* sp. cf. *A. chapmani*, *Vercorsella* sp.

Table 3. Ecologic distribution of Early Cretaceous biogenic material from Hole 866A.

Core, section, interval (cm)	Bioclasts														Environments
	Ammonites	Planktonic foraminifers	Bryozoans	Nodularia	Murchisonella	Corals	Polystrophia alba	Attached foraminifers	Large diacyclids	Calcareous sponges	Large sponge spicules	Ophiolids	Rudist fragments	Baculites irregularis	
2R-2, 7-8															
7R-CC, 14-15															
15R-CC, 13-14															
25R-1, 50-52															
29R-CC, 21-24															
31R-1, 35-37															
35R-1, 98-99															
36R-1, 43-44															
38R-1, 23-24															
44R-CC, 26-27															
45R-CC, 23-25															
46R-1, 104-106															
46R-2, 41-43															
47R-1, 32-34															
48R-1, 30-32															
49R-1, 6-8															
50R-CC, 6-7															
51R-1, 31-33															
53R-1, 53-56															
56R-CC, 15-16															
58R-1, 21-23															
59R-1, 52-53															
61R-1, 119-120															
62R-1, 73-76															
63R-1, 136-138															
64R-1, 18-20															
65R-1, 101-102															
66R-1, 89-91															
70R-2, 87-89															
71R-1, 43-45															
71R-1, 64-67															
73R-1, 88-89															
74R-2, 56-59															
75R-3, 113-115															
77R-1, 91-93															
79R-4, 11-13															
80R-1, 22-23															
81R-3, 73-75															
82R-1, 74-76															
83R-1, 39-42															
85R-2, 29-33															
86R-1, 134-136															
87R-1, 77-79															
88R-1, 77-79															
89R-2, 22-23															
91R-1, 41-42															
94R-1, 80-81															
96R-1, 4-6															
98R-1, 125-126															
99R-1, 8-10															
100R-1, 25-26															
102R-2, 59-64															
103R-1, 33-34															
108R-1, 42-44															
109R-2, 26-28															
110R-1, 126-128															
111R-1, 27-28															
112R-1, 31-32															
115R-1, 22-26															
117R-2, 29-31															
118R-2, 41-43															
119R-1, 18-19															
120R-1, 39-41															
121R-1, 18-20															
122R-1, 67-69															
123R-1, 43-45															
125R-2, 70-72															
126R-1, 79-80															
128R-1, 90-92															
129R-1, 90-92															
130R-1, 69-73															
131R-1, 92-94															
132R-1, 55-58															
133R-2, 94-97															
136R-1, 1-3															
137R-1, 42-44															
138R-1, 10-13															
139R-1, 41-43															
142R-1, 26-27															
143R-1, 24-27															
144R-1, 137-140															
145R-2, 49-50															
146R-1, 100-102															
147R-1, 23-25															
148R-1, 121-122															
152R-1, 10-12															
153R-1, 116-118															
154R-1, 51-52															
155R-1, 119-122															
157R-1, 11-14															
158R-1, 84-86															
159R-2, 18-20															
160R-1, 26-28															
165R-2, 118-120															
166R-1, 97-100															
167R-2, 7-9															
168R-1, 24-25															
169R-3, 17-18															
170R-3, 106-108															
171R-1, 21-24															
Environments	Normal marine ← → Restricted														

Table 4. Ecologic distribution of Early Cretaceous biogenic material from Hole 865A.

Core, section, interval (cm)	Bioclasts														Environments
	Planorbic foraminifera	Spirulina sp.	Bryozoans	Nodosariidae	Marsosinella	Coral	Large disjuncts	Calcareous sponges	Large sponge spicules	Orbitolids	Rudist fragments	Bacella irregularis	Verruculoidae	Echinoids	
17X-CC, 34-36				R					VA						
18R-CC, 15-16					R				VA						
19R-CC, 3-4									VA						
21R-CC, 0-1									VA						
22R-CC, 2-3									F						
24R-CC, 5-6									F						
26R-CC, 12-13									F						
28R-1, 120-121	12								VA						
29R-CC, 2-3									C						
30R-CC, 5-6					R				F						
31R-CC, 2-3									F						
32R-CC, 0-1									F						
33R-CC, 4-5	12								VA						
34R-1, 0-1									VA						
34R-1, 15-16	12								F						
34R-1, 40-42									F						
34R-1, 67-68									F						
34R-1, 85-86									F						
34R-1, 124-125									F						
34R-1, 140-141									VA						
35R-CC, 0-1									VA						
36R-CC, 0-1									C						
36R-CC, 8-9									C						
36R-CC, 17-18									C						
37R-CC, 1-5									F						
39R-CC, 15-16									F						
39R-CC, 41-42									F						
40R-CC, 8-11									F						
40R-CC, 13-16									F						
41R-CC, 26-28									F						
42R-CC, 2-4									F						
43R-CC, 1-2	12								F						
44R-CC, 14-16									VA						
45R-CC, 19-21									F						
46R-CC, 0-3									C						
47R-CC, 1-3									C						
50R-CC, 15-17	12								C						
51R-CC, 11-13									C						
52R-CC, 1-5									C						
54R-CC, 3-5									C						
55R-CC, 2-5									C						
57R-CC, 0-3	12								VA						
58R-CC, 14-16									VA						
59R-CC, 4-6									VA						
60R-CC, 11-13									F						
61R-CC, 8-9									F						
64R-CC, 10-13									VA						
66R-CC, 9-11									F						
68R-CC, 1-3									C						
69R-CC, 21-22									C						
70R-CC, 1-3									C						
71R-CC, 11-13									C						
72R-CC, 14-17	12								C						
73R-1, 9-10	12								C						
74R-1, 48-50									C						
74R-1, 84-86									F						
75R-1, 2-3									A						
75R-1, 47-48	22								C						
76R-1, 22-23									C						
76R-1, 82-83									R						
77R-CC, 2-3									F						
78R-1, 84-85									F						
79R-1, 13-14									F						
80R-1, 32-38	1								C						
81R-1, 53-60									C						
82R-1, 59-60	12								A						
83R-CC, 1-2									C						
84R-1, 75-81									C						
85R-1, 104-105									F						
85R-2, 73-74									VA						
86R-1, 34-37									VA						
86R-2, 116-117									C						
87R-2, 32-34									C						
88R-1, 13-15									C						
89R-5, 1-4									C						
90R-1, 45-47	12								F						
91R-3, 89-93									C						
92R-3, 63-67	12								F						
94R-3, 123-124									F						
Environments	Normal marine ← → Restricted														

cf. *V. arenata*, *V. sp.* cf. *V. scarsellai*, and *Voloshinoides sp.* A. of middle(?) to late(?) Albian age.

Assemblage III: *Vercorsella sp.* cf. *V. immaturata*, *Nezzazata isabellae* n. sp., *N. sp.* B, *Arenobulimina sp.* A, and *Buccicrenata hedbergi* of late Aptian(?) to early Albian(?) age.

Assemblage IV: *Protopenneroplis sp.*, *Nezzazata(?) sp.* C., *Falsurgonina(?) sp.*, and *Neotrocholina sp.* cf. *N. friburgensis* of Barremian to early Aptian age.

Assemblage V: *Campanellula capuensis*, *Melathrokerion sp.* cf. *M. valserinensis*, *Valvulineria(?) sp.* 1, *Decussoloculina sp.* cf. *D. mirceai*, *Vercorsella wintereri* n. sp., and *Favreina sp.* cf. *F. prusensis* of Hauterivian age.

The Leg 143 microfauna is neither abundant nor diverse. Minimum abundance was found in the Hauterivian sequence, the maximum in the Albian. The evolutionary succession of the microfauna is the same as that described for faunas from the Tethys by Arnaud-Vanneau (1986). During the Hauterivian, the microfauna is sparse and of low diversity. After the Barremian, the number of genera and species increases upsection to the Albian. Nevertheless, the Pacific faunas are the least diverse of the faunas studied. This may be attributed to the paleogeographic position near the paleoequator and/or to the geographic isolation in the vast Cretaceous Pacific Ocean. Still, 44 species of Early Cretaceous benthic foraminifers and three species of fecal pellets were identified and described.

The benthic foraminifer fauna from the Hauterivian to lower Aptian sequence at Site 866 is identical to that observed in the Tethys. There was no apparent barrier to migration of the benthic faunas throughout the tropical oceans. The appearance of typical American species in the upper Aptian to Albian sequence demonstrates that a certain isolation existed at that time between Europe and Africa on the one hand, and the Americas on the other. The Pacific region, however, was not affected by the isolation and continued to receive migrating microfaunas from all sources.

One aim of Leg 143 was to identify the oldest atoll and reef facies of the Pacific Ocean. It is now clear that reefs did not exist in the Early Cretaceous Pacific Ocean as they do today. Only a few fragments from possible patch reefs were recovered and are represented by corals, calcareous sponges, attached foraminifers, and algae.

Three major types of depositional environments were identified that correspond to three steps of platform development. The first corresponds to the initial development of the platform during the Hauterivian. At that time, there probably was no lagoon and Resolution Guyot was a sandy island. The second step corresponds to the development of a true lagoon during the Barremian to early Aptian. The lagoon was restricted to normal-marine flow, contained stromatolites, and was filled with carbonate particles of microbial origin.

The final step during the late Aptian and Albian corresponds to the development of muddy lagoonal environments with numerous sponges and a more or less normal salinity. Although the biofacies indicates increasingly normal-marine conditions, the presence of incipient calcitization and desiccation cracks in the lithologic sequence provides continued, though diminishing, evidence of subaerial emergence (Sager, Winterer, Firth, et al., 1993). The latest Albian samples at both Sites 865 and 866 consist of wackestone with the typical cuneolinid-miliolid assemblage that characterizes the sequence. Nothing in the biofacies adjacent to the upper contact of the shallow-water limestone foretells the future demise of the platform.

SYSTEMATIC DESCRIPTIONS

Here, we describe the biostratigraphically important Early Cretaceous benthic foraminifers and fecal pellets identified in our post-cruise analysis. Forty-four species of benthic foraminifers and three species of fecal pellets are described and illustrated to provide a solid taxonomic basis for future studies in the Pacific Basin (see Pls. 1 through 5; Appendix). The synonymic list is reduced to the original description of each species followed by the principal revisions, and previous references in the Pacific area. For the most part, we have followed the taxonomic classification of Loeblich and Tappan (1988).

Many of the following species identifications are associated with the abbreviation "cf.". We use this abbreviation to indicate probable similarity. Although the scarcity of specimens, poor preservation, and nondiagnostic thin sections often prevent exact identification, we fully expect that identity would be established if adequate material were available for study. Thus, although we treat the identifications as complete in reference to stratigraphic and geographic distribution, we apply a conservative nomenclature pending further study of this first, and important, discovery from the Pacific Ocean.

Order FORAMINIFERIDA Eichwald, 1830
Family HAPLOPHRAGMOIDIDAE Maync, 1952
Genus *DEBARINA* Fourcade, Raoult and Vila, 1972

Debarina sp. cf. *D. hahounerensis* Fourcade, Raoult, and Vila, 1972
(Pl. 1, Figs. 1, 2)

Description. Test planispiral, partially involute, slightly compressed. Protoconch small, globular, followed by three or four whorls of subrectangular chambers in axial section, with up to 12 chambers per whorl. Plane of coiling in initial whorl is more or less perpendicular to the plane of subsequent whorls (Pl. 1, Fig. 2). Wall calcareous, microgranular. Aperture a row of rounded pores at base of apertural face.

Remarks. About 20 specimens were observed in thin section. These Pacific forms are smaller and more compressed than the type specimens of *Debarina hahounerensis*.

Age and occurrence. Late Aptian to Albian, from Sections 143-865A-82R-2 to -57R-1 and 143-866A-66R-1 to -6R-CC.

Known range. Late Barremian to Albian

Geographic distribution. Originally described from the Aptian of Algeria, this species is widespread along the margins of the Tethys.

Family CHARENTIIDAE Neumann, 1965
Genus *MELATHROKERION* Brönnimann and Conrad, 1967

Melathrokerion sp. cf. *M. valserinensis* Brönnimann and Conrad, 1967
(Pl. 1, Figs. 3, 4)

Description. Test nautiloid, planispiral, involute. Protoconch globular, followed by two or three whorls of globular chambers. Wall agglutinated, microgranular, thick, with septa that thin rapidly from the wall to the aperture (Pl. 1, Fig. 3), later striated by narrow canaliculi. Aperture large, areal, crescentic.

Remarks. About 10 specimens were observed in thin section. The Pacific specimens are smaller and more compressed than the type specimens, but similar forms are known from the Hauterivian of Slovenia.

Age and occurrence. Probable Hauterivian, from Samples 143-866A-154R-1, 110-112 cm; -153R-2, 20-22 cm; -152R-1, 4-5 cm; and -149R-1, 91-93 cm.

Known range. Barremian to early Aptian.

Geographic distribution. This species is known from the northern margin of the Tethys in Spain, France, and Switzerland and was originally described from the Barremian to lower Aptian of the French Alps.

Family CYCLAMMINIDAE Marie, 1941
Subfamily BUCCICRENATINAE Loeblich and Tappan, 1985
Genus *BUCCICRENATA* Loeblich and Tappan, 1949

Buccicrenata hedbergi (Maync)
(Pl. 1, Fig. 5)

Pseudocyclammina hedbergi Maync, 1953, pp. 101-102, pl. 16, figs. 1-8.

Description. Test planispiral, involute, slightly compressed. Protoconch globular with four chambers in the spire. Chambers increase rapidly in size, separated by depressed sutures. Wall agglutinated of coarse calcareous particles, alveolar. Aperture an areal slit.

Remarks. Six specimens were observed in thin section.

Age and occurrence. Albian to late Aptian(?), from Samples 143-865A-89R-5, 1-4 cm, and -89R-4, 72-75 cm.

Known range. Berriasian to Albian.

Geographic distribution. This species was described from the Aptian to Albian of Venezuela and is widely known from the margins of the Tethys.

Family BARKERINIDAE Frizzell and Schwartz, 1950
Genus *BARKERINA* Frizzell and Schwartz, 1950

Barkerina sp. cf. *B. barkerensis* Frizzell and Schwartz, 1950
(Pl. 1, Fig. 6)

Description. Test globular, planispiral, involute. Low and broad chamber subdivided by transverse partitions. Wall microgranular. Aperture a row of arched openings at the base of apertural face.

Remarks. Two specimens, observed in subaxial and tangential thin sections, resemble *Barkerina barkerensis*. Although transverse partitions are clearly visible in the tangential section (Pl. 1, Fig. 6), the specimens are too sparse and too poorly cut to confirm the identification.

Age and occurrence. Albian, from Sample 143-865A-24R-CC, 5–6 cm.

Known range. Albian (middle).

Geographic distribution. Originally described from the Albian of Texas, *Barkerina barkerensis* also is found in Mexico and Venezuela.

Family SPIROPLECTAMMINIDAE Cushman, 1927
Subfamily SPIROPLECTAMMININAE Cushman, 1927
Genus AMMOBACULOIDES Plummer, 1932

Ammobaculoides sp.
(Pl. 1, Fig. 7)

Description. Test small, elongate, slightly compressed (maximum height, 0.2 mm). Protoconch small, rounded, followed by 11 to 12 chambers in a planispiral coil, later biserial with three or four rows of chambers. Wall agglutinated. Aperture a slit at base of final chamber.

Remarks. Three specimens were observed in subaxial sections.

Age and occurrence. Probable Hauterivian, from Sample 143-866A-146R-1, 111–114 cm.

Subfamily NOVALESIIINAE Loeblich and Tappan, 1984
Genus NOVALESIA Magniez, 1974

Novallesia angulosa (Magniez)
(Pl. 1, Figs. 9–11)

Spiroplectamminoides angulosus nov. gen., nov. sp., Magniez, 1972, pp. 189–190, pl. 2, figs. 1–11a, pl. 5, figs. 1b–7, text-fig. 4.

Description. Test elongate (maximum height, 0.65 mm), triangular in axial section with an acute apical angle of about 15°. Early stage planispiral with a protoconch followed by a few chambers (Pl. 1, Fig. 9), later biserial with a maximum of eight rows of chambers. Chambers subdivided by thin radial beams (Pl. 1, Fig. 11). Wall agglutinated. Aperture a low interiomarginal slit.

Remarks. Six specimens were observed in axial and subaxial sections and are identical to the type specimens.

Age and occurrence. Albian, from Samples 143-865A-59R-CC, 4–6 cm, -47R-1, 92–94 cm, -46R-CC, 0–3 cm, -44R-CC, 15–16 cm, 143-866A-47R-1, 70–72 cm, and 143-866B-8R-2, 20–21 cm.

Known range. Late Aptian (Gargasian) to Albian.

Geographic distribution. This species, described from the Albian of the Pyrenees, is known from France and Spain.

Novallesia producta (Magniez)
(Pl. 1, Fig. 8)

Spiroplectamminoides productus nov. gen., nov. sp., Magniez, 1972, pp. 181, 185, 186, 189, pl. 1, figs. 1a–13b, pl. 4, figs. 1b, 2, 3, 4b, 5, 6b, 7b, 8–12.

Description. Test small, elongate (maximum height, 0.30 mm), triangular in axial section, early stage planispiral with a protoconch partly surrounded by four chambers, later biserial with a maximum of eight rows of chambers. Chambers subdivided by two to four thin radial beams. Wall agglutinated. Aperture a low interiomarginal slit.

Remarks. Fourteen specimens were observed in axial and subaxial sections. The Pacific specimens, although similar in morphology to the type species, are smaller and have fewer chambers.

Age and occurrence. Probably Hauterivian, from Samples 143-866A-156R-1, 81–85 cm; -155R-1, 119–122 cm; -154R-2, 119–121 cm; -153R-2, 20–22 cm; -152R-1, 4–5 cm; -150R-3, 66–69 cm; and -143R-1, 24–27 cm.

Known range. Hauterivian to Cenomanian.

Geographic distribution. This species was originally described from the Albian of the Pyrenees and is widespread along the margins of the Tethys.

Family VERNEULINIDAE Cushman, 1911
Subfamily VERNEULINOIDINAE Suleymanov, 1973
Genus BELORUSSELLA Akimets, 1958

Belorussella textilarioides (Reuss)
(Pl. 1, Figs. 19, 20)

Bolivina textilarioides Reuss, 1863, pl. 10, fig. 1.

Description. Test small, elongate, compressed perpendicular to the plane of biseriality, ovate in section, with a maximum height of 0.35 mm and a maximum diameter of 0.15 mm; apical angle varies from 18° to 22° in axial section perpendicular to the plane of biseriality; initial triserial stage very small, followed by elongate biserial stage with chambers increasing rapidly in height. Sutures oblique and depressed (Pl. 1, Fig. 19). Wall finely agglutinated. Aperture an elongate slit in plane of symmetry extending to apex from base of final chamber, with an internal tooth plate that forms an alternating siphon extending to previous apertures (Pl. 1, Figs. 19, 20).

Remarks. About seven specimens were observed in thin section. The Pacific forms are smaller than the type specimens, but similar forms are found in the Valanginian to Hauterivian of Italy and Slovenia.

Age and occurrence. Hauterivian to Barremian, from Samples 143-866A-160R-1, 26–28 cm; -129R-6, 13–15 cm; -125R-3, 19–21 cm; and -125R-1, 141–145 cm.

Known range. Hauterivian to early Aptian.

Geographic distribution. This species, described from the Cretaceous of Austria, is recorded throughout the Tethys.

Family TROCHAMMINIDAE Saidova, 1981
Genus CAMPANELLULA De Castro, 1964

Campanellula capuensis De Castro, 1964
(Pl. 1, Fig. 12)

Campanellula capuensis De Castro, 1964, pp. 59–60, pls. 1–6.

Description. Test small, conical, with a flat to slightly concave base, trochoid with four or more chambers per whorl, height 0.2 mm, diameter 0.15 mm. Chambers triangular and densely packed in tangential section. Intracamer suture depressed and form an acute angle to the axis of coiling. Wall agglutinated, of microgranular calcite. Aperture of pores at margin of septa.

Remarks. Specimens of *Campanellula capuensis* in the present material are rare and limited to two thin sections: one tangential and one transverse oblique. These sections, however, are characteristic of the species, and the thickness and size of the test are identical to typical specimens from the southern margin of the Tethys.

Age and occurrence. Hauterivian, probably late Hauterivian, from Samples 143-866A-147R-1, 95–97 cm; and -147R-1, 23–25 cm.

Known range. Late Hauterivian.

Geographic distribution. This species, described from the Hauterivian of Italy, previously was known only from the southern margin of the Tethys in Italy, Croatia, Slovenia, North Africa, and southern Spain.

Family ATAXOPHRAGMIIDAE Schwager, 1877
Subfamily ATAXOPHRAGMIINAE Schwager, 1877
Genus ARENOBULIMINA Cushman, 1927

Arenobulimina sp. cf. *A. chapmani* Cushman, 1936
(Pl. 1, Figs. 15, 16)

Agglutinerende Foraminifere, Grötsch, 1991, pl. 14, figs. 10–12.
Textulariid foraminifera, Grötsch and Flügel, 1992, pl. 33, figs. 5, 6.

Description. Test conical, trochospiral, broad (maximum height, 0.45 mm, maximum diameter, 0.42 mm) with a wide umbilicus (Pl. 1, Figs. 15–18). Chambers inflated, increasing rapidly in size and number with up to five in the early stage and seven in the later stage, separated by depressed sutures. Wall agglutinated, thick, microgranular calcareous. Aperture at base of apertural face, obscured.

Remarks. About 35 specimens were observed in thin section. The Pacific specimens differ from typical *Arenobulimina chapmani* in being smaller and having an agglutinated calcareous test. *Arenobulimina chapmani* previously was identified from whole specimens; it is difficult, therefore, to compare the morphology to specimens in thin section. Nevertheless, the present specimens tentatively are attributed to *Arenobulimina chapmani* as the overall morphology, number of chambers in the final whorl, and umbilical characteristics are similar.

Age and occurrence. Albian, from Samples 143-865A-87R-2, 32–34 cm; -86R-1, 16–20 cm; -85R-2, 41–42 cm; -82R-1, 70–71 cm; -82R-1, 59–60 cm; -81R-1, 53–60 cm; -69R-CC, 21–22 cm; -58R-CC, 14–16 cm; 143-866A-46R-1, 85–87 cm; -39R-1, 77–78 cm; and -31R-1, 92–94 cm.

Geographic distribution. This species was described from the Albian of Great Britain.

Arenobulimina cochleata Arnaud-Vanneau, 1980
(Pl. 1, Figs. 13, 14)

Arenobulimina cochleata Arnaud-Vanneau, 1980, pp. 446–450, pl. 53, figs. 4–10, pl. 81, figs. 9–21, text-figs. 166, 167.

Description. Test small, conical, trochospiral (maximum height, 0.55 mm; maximum diameter, 0.40 mm). Chambers inflated, progressively enlarging in size, four to five in the final whorl, and separated by depressed sutures. Umbilicus medium in size (Pl. 1, Fig. 13). Wall agglutinated, thick, microgranular calcareous. Aperture at base of apertural face but obscured.

Remarks. Five specimens observed in thin section are identical in overall morphology to the figured types.

Age and occurrence. Hauterivian to early Aptian(?), from Samples 143-866A-147R-1, 23–25 cm; -144R-1, 137–140 cm; -119R-1, 18–19 cm; and -102R-1, 59–64 cm.

Known range. Hauterivian to Aptian.

Geographic distribution. This species, described from the lower Aptian of Vercors, France, is known from the margins of the Tethys in Switzerland, France, and Spain on the north, and from the Middle East and Italy on the south.

Arenobulimina sp. A
(Pl. 1, Figs. 21–23)

Description. Test minute, conical, trochospiral (maximum height, 0.14 mm; maximum diameter, 0.10 mm), with a small umbilicus (Pl. 1, Figs. 22, 23). Chambers increase progressively in size with six to seven in the final whorl, separated by depressed sutures. Wall agglutinated, thin, microgranular calcareous. Aperture at base of apertural face.

Remarks. About 10 specimens were observed in thin section that are smaller than previously described species of *Arenobulimina*.

Age and occurrence. Early Albian(?) or late Aptian(?), limited to the earliest carbonate deposits of Hole 865A from Samples 143-865A-90R-1, 61–62 cm; -90R-1, 45–47 cm; -90R-1, 21–22 cm; and -90R-1, 13–14 cm.

Genus *PRAECHRYSLIDINA* Luperto Sinni, 1979

Praechrysalidina infractetacea Luperto Sinni, 1979
(Pl. 2, Fig. 1)

Praechrysalidina infractetacea Luperto Sinni, 1979, pp. 6–16, pl. 1, figs. 1–9, pl. 2, figs. 1–8, pl. 3, figs. 1–6.

Description. Test high trochospiral, conical, triserial throughout (maximum height, 1.15 mm) with chambers that increase rapidly in size. Sutures depressed. Wall agglutinated, thick, microgranular calcareous. Aperture a slit at base of a cribrate apertural plate.

Remarks. Four specimens were observed in thin section. Fine striae perpendicular to the test surface that typify the species were not identified in the Pacific specimens.

Age and occurrence. Albian, from Samples 143-866A-47R-1, 94–96 cm; -42R-CC, 15–16 cm; -36R-1, 54–56 cm; and 143-865A-86R-1, 34–37 cm.

Known range. Valanginian(?), Aptian to Albian.

Geographic distribution. Originally described in Italy, this species is known from the Middle East to North Africa along the southern margin of the Tethys.

Subfamily GLOBOTEXTULARIIDAE Cushman, 1927
Genus *VOLOSHINOIDES* Barnard and Banner, 1980

Voloshinoides(?) sp. A
(Pl. 2, Figs. 2–4)

Description. Test conical, enrolled in high trochospire (maximum height, 0.55 mm). Chambers four or five per whorl in the early stage and fewer in the later stage, subdivided by radial beams. Wall agglutinated, microgranular. Aperture obscured.

Remarks. Nine specimens were observed in thin section. The presence of rafters is not perfectly clear in the Pacific specimens; thus, assignment to this genus is uncertain. If rafters are truly lacking, then these specimens belong to the genus *Hagenowina*.

Age and occurrence. Albian, from Samples 143-865A-75R-1, 47–48 cm; -74R-1, 48–50 cm; -73R-1, 9–10 cm; -51R-CC, 11–13 cm; -34R-1, 101–102 cm; 143-866A-36R-1, 2–4 cm; and 143-866B-4M-1, 30–32 cm.

Voloshinoides(?) sp. B
(Pl. 2, Fig. 5)

Description. Test small, conical, trochospirally enrolled (maximum height, 0.30 mm). Chambers decrease in number from three to two per whorl, subdivided by two to three radial beams.

Remarks. The two specimens observed in thin section differ from species A in their smaller size, fewer initial chambers per whorl, and fewer beams subdividing the chambers.

Age and occurrence. Probable Barremian, from Sample 143-866A-129R-1, 52–54 cm.

Family NEZZAZATIDAE Hamaoui and Saint-Marc, 1970
Subfamily NEZZAZATINAE Hamaoui and Saint-Marc, 1970
Genus *NEZZAZATA* Omara, 1956

Nezzazata isabellae Arnaud-Vanneau and Sliter, n. sp.
(Fig. 7; Pl. 2, Figs. 11–24).

Description. Test has a low trochospiral, biconvex, spiral side more convex than umbilical side, periphery rounded, umbilicus closed (maximum height, 0.14 mm; maximum diameter, 0.20 mm). Protoconch rounded, at apex of the dorsal face, followed by two to three whorls of up to 12 chambers per whorl, separated by slightly depressed sutures. Variation in test size and chamber number in the final whorl may result from dimorphism. Wall of microgranular calcite, imperforate. Aperture extends from the umbilicus to the periphery, then bends parallel to the peripheral margin, with an apertural tooth and tooth plate that extends back in the direction of the previous aperture.

Remarks. More than 100 specimens were observed in thin section and as isolated specimens. Comparison of the present specimens to previously described species shows distinct differences. Nine species of *Nezzazata* are described from the Cenomanian to the Turonian: *N. simplex* Omara, *N. gyra* (Smout), *N. conica* (Smout), *N. depressa* (Smout), *N. convexa* (Smout), *N. perforata* (Smout), *N. glomerulata* (Smout), *N. calcarata* (Smout), and *N. cenomana* Wasfi and Hataba. All the species described by Smout are larger in size than *N. isabellae* (two to three times larger), differ in shape, and have a very well-developed tooth plate that extends to the previous aperture. *Nezzazata cenomana* is somewhat bigger than *N. isabellae*, but differs in having a concave umbilical side. The Hauterivian species *Nezzazata simplex germanica* Omara and Strauch is poorly described and may be incorrectly assigned to *Nezzazata*. Thus, *Nezzazata isabellae* probably represents one of the oldest species belonging to the genus.

Depository. National Museum of Natural History, Washington, D.C.

Holotype. USNM 483970, axial thin section (Pl. 2, Fig. 11).

Type locality. Allison Guyot, Sample 143-865A-87R-1, 32–34 cm.

Age and occurrence. (Late?) Aptian to early Albian, from Samples 143-865A-90R-1, 62–63 cm; -90R-1, 61–62 cm; -90R-1, 45–47 cm; -90R-1, 44–45 cm; -90R-1, 13–14 cm; -88R-1, 13–15 cm; -87R-1, 92–95 cm; -87R-1, 63–66 cm; -87R-1, 32–34 cm; -86R-2, 116–117 cm; -86R-1, 16–20 cm; -75R-1, 2–3 cm; -17X-CC, 34–35 cm; 143-866A-35R-1, 88–90 cm; and -30R-CC, 0–1 cm.

Derivatio nominis. The species is dedicated to Professor Isabella Premoli Silva, University of Milano, Italy, co-chief of Leg 144.

Nezzazata sp. A
(Pl. 2, Figs. 8–10)

Description. Test a low trochospiral, slightly biconvex, umbilicus closed, periphery acute (maximum height, 0.12 mm; maximum diameter, 0.25 mm). Protoconch obscured, followed by a minimum of two whorls of chambers with up to seven chambers per whorl, separated by slightly depressed sutures (Pl. 2, Fig. 10). Aperture having a tooth plate that extends in the direction of the previous aperture.

Remarks. About 10 specimens were observed in thin section that differ from *N. isabellae* in being somewhat larger and having an acute periphery.

Age and occurrence. Late Albian, from Samples 143-865A-34R-1, 85–86 cm; 143-866A-8R-CC, 12–13 cm; -4M-1, 30–32 cm; and 143-866B-4R-1, 2–4 cm.

Nezzazata sp. B
(Pl. 2, Figs. 8–10)

Description. Test small, a low trochospiral, spiral side more convex than umbilical side, periphery rounded, umbilicus closed (maximum height, 0.10 mm; maximum diameter, 0.18 mm). Protoconch rounded, followed by three whorls of chambers, with 10 chambers visible per whorl that increase very gradually in size, separated by slightly depressed sutures (Pl. 2, Fig. 25).

Remarks. About 15 specimens were observed in thin section. *Nezzazata* sp. B is one of the smaller forms of *Nezzazata*. Despite the small size, chambers are numerous and increase slowly in size. The same species is also known from the upper Aptian of the Aquitaine Basin and in the lower to middle(?) Albian of Mexico and Venezuela (AAV, pers. observ., 1982, 1992, 1994).

Age and occurrence. Late Aptian(?) to early Albian(?), from Samples 143-865A-88R-1, 13–15 cm; -87R-2, 32–34 cm; and 143-866A-76R-3, 10–15 cm.

Nezzazata(?) sp. C
(Pl. 2, Figs. 6, 7)

Description. Test a low trochospiral, spiral side more convex than umbilical side, periphery rounded, umbilicus closed (maximum height, 0.20 mm; maximum diameter, 0.35 mm). Protoconch rounded, followed by three whorls of chambers with nine chambers visible per whorl that increase rapidly in size, separated by slightly depressed sutures (Pl. 2, Fig. 7). Apertural tooth plate indistinct.

Remarks. About 35 specimens observed in thin section are tentatively assigned to the genus *Nezzazata* owing to the lack of a clearly defined tooth plate. These specimens are larger and have chambers that increase more rapidly in size than younger nezzazatids found at Sites 865 and 866. Similar specimens from the Barremian to Aptian of France and Spain have been referred to *Valvulineria(?)* sp. 2 (Arnaud-Vanneau, 1980).

Age and occurrence. Hauterivian(?) to Aptian, from Samples 143-866A-152R-2, 105–107 cm; -147R-1, 23–25 cm; -145R-2, 49–50 cm; -144R-2, 37–40 cm; -143R-3, 11–13 cm; -129R-1, 52–54 cm; -125R-1, 19–21 cm; -79R-3, 114–116 cm; -78R-3, 90–91 cm; -76R-3, 10–15 cm; -75R-2, 1–3 cm; -72R-7, 113–115 cm; and -71R-2, 37–41 cm.

Valvulineria Cushman, 1926

Remarks. We tentatively place the following specimens in the genus *Valvulineria* on the basis of the shape of the test, although they differ in having a microgranular, imperforate wall and an aperture consisting of a slit at the base of the apertural face.

Valvulineria(?) sp. 1, Arnaud-Vanneau, 1980
(Pl. 2, Figs. 27–30)

Description. Test small, trochospiral, biconvex, spiral side more convex than the umbilical side, umbilicus closed (maximum height, 0.11 mm; maximum diameter, 0.20 mm). Protoconch rounded, at apex of the trochospire, followed by three whorls of chambers with up to eight chambers per whorl that increase gradually in size. Apertural tooth plate indistinct.

Remarks. About 60 specimens were observed in thin section that closely resemble species of *Nezzazata* in their test shape and size, chamber arrangement, and wall structure. The absence of a visible tooth plate, however, prevents assignment to this genus and is the reason why we tentatively assign these numerous specimens to the genus *Valvulineria*.

Age and occurrence. Hauterivian to Barremian, from Samples 143-866A-171R-1, 21–24 cm; -170R-4, 138–139 cm; -166R-1, 97–100 cm; -154R-1, 51–52 cm; -147R-2, 123–124 cm; -147R-1, 23–25 cm; -146R-1, 111–114 cm; -145R-1, 18–20 cm; and -144R-1, 137–140 cm.

Known range. Valanginian to early Aptian.

Geographic distribution. This widespread species was first identified in the Barremian of Vercors, France.

Family CUNEOLINIDAE Saidova, 1981

Subfamily SABAUDIINAE Brönnimann, Decrouez, and Zaninetti, 1983

Genus *SABAUDIA* Charollais and Brönnimann, 1965

Sabaudia minuta (Hofker Jr.)
(Pl. 1, Figs. 24, 25)

Textulariella minuta n. sp., Hofker Jr., 1965, pp. 186–187, pl. 3, figs. 5–6, pl. 4, figs. 1–9.

Sabaudia minuta (Hofker Jr.); Charollais and Brönnimann, 1965, pp. 620–621, pl. 1, figs. 1–6, text-fig. 4

Sabaudia minuta (Hofker Jr.); Arnaud-Vanneau and Chiocchini, 1985, pp. 29–32, pl. 10, figs. 1–14, text-fig. 4

Description. Test a small high cone with flattened base (maximum height, 0.20 mm; maximum diameter, 0.20 mm). Apical angle varies from 17° to 20° in axial section parallel to the plane of biseriality. Initial trochospiral stage formed by a rounded protoconch and two to three small chambers with a microgranular wall covered by a thick yellow calcitic layer (Pl. 1, Fig. 25), followed by later biserial stage with up to five chambers, each subdivided by radial beams (Pl. 1, Fig. 24). Horizontal rafters are not present. Wall of biserial stage agglutinated, microgranular. Aperture an interiomarginal slit.

Remarks. Eight specimens were observed in thin section.

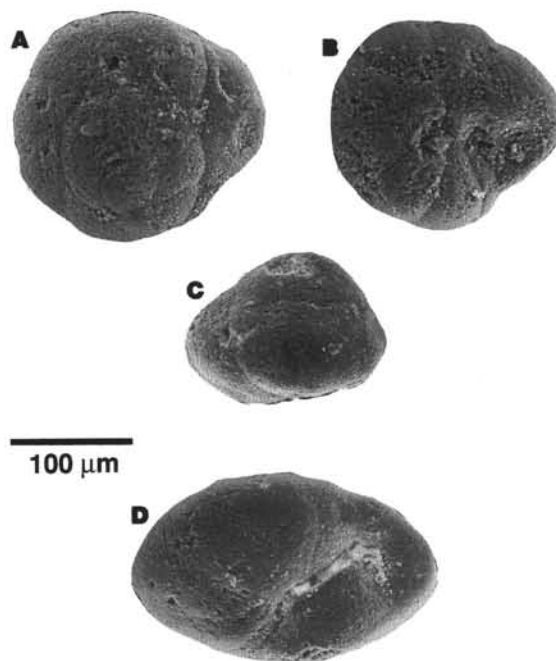


Figure 7. *Nezzazata isabellae* Arnaud-Vanneau and Sliter, n. sp. A. Dorsal view. B. Ventral view. C. Lateral view. D. Apertural view. Figures 7A through 7C from Sample 143-865A-90R-1, 45–47 cm, and Figure 7D from Sample 143-865A-88R-1, 36–38 cm.

Age and occurrence. Albian, from Samples 143-865A-87R-2, 32–34 cm, and -86R-1, 16–20 cm.

Known range. Valanginian to Cenomanian.

Geographic distribution. The species is widespread along the margins of the Tethys.

Subfamily CUNEOLININAE Saidova, 1981

Genus *VERCORSELLA* Arnaud-Vanneau, 1980, emend.

New emendation. The genus *Vercorsella* is recognized by the elongate, flaring test that is somewhat laterally compressed parallel to the plane of biseriality. The embryonic apparatus is composed of a globular protoconch followed by an undivided deutoconch. The protoconch, deutoconch, and the next one or two chambers form a short trochospiral stage followed by a more prominent biserial stage. Chambers in the biserial stage are divided by radial beams that increase in number in successive chambers. Horizontal rafters may appear in the later chambers. The test wall is agglutinated and microgranular. The aperture consists of a row of rectangular pores at the base of the septal face.

We distinguish *Cuneolina* from *Vercorsella* by its keriothecal test and subdivided deutoconch.

Vercorsella sp. cf. *V. arenata* Arnaud-Vanneau, 1980
(Pl. 3, Figs. 5–9)

Description. Test small, conical (maximum height, 0.60 mm; maximum diameter, 0.30 mm) with an apical angle that varies from 25° to 30° in axial section parallel to the plane of biseriality. Initial trochospiral stage consists of rounded protoconch, small deutoconch, and one or two chambers (Pl. 3, Figs. 5, 6), followed by biserial stage with up to six chambers that are slightly compressed parallel to the plane of biseriality and subdivided by four to five radial beams that extend from the outer wall toward the plane of biseriality. Horizontal rafters are not present. Wall of biserial stage microgranular. Aperture a row of three or four rectangular pores.

Remarks. About 40 specimens were observed as isolated specimens and in both oriented and random thin sections. The Pacific specimens differ from typical *Vercorsella arenata* in being smaller, less compressed, and having

fewer vertical partitions in chambers of the biserial stage. The test is microgranular only and not arenaceous.

Age and occurrence. Aptian to Albian, common in Sections 143-865A-89R-1 to -75R-1, and Sections 143-866A-77R-3 to -4R-1.

Known range. Barremian to Albian.

Geographic distribution. Although known from the margins of the Tethys, the species occurs predominantly along the northern margin in Romania, Switzerland, France, and Spain.

Vercorsella sp. cf. *V. immaturata* He, 1982
(Pl. 2, Figs. 31–34)

Description. Test small, conical (maximum height, 0.35 mm; maximum diameter, 0.18 mm), apical angle varies from 18° to 30° in axial section parallel to the plane of biseriality. Embryonic apparatus formed by rounded protoconch and small deuteroconch (Pl. 2, Fig. 31). Initial trochospiral stage not observed. Biserial stage with up to nine rows of chambers that are slightly compressed parallel to the plane of biseriality and divided by two or three short radial beams that extend less than halfway to the plane of biseriality and are thinner toward the center. Horizontal rafters are not present. Wall microgranular.

Remarks. About 30 specimens were observed in thin section. The Pacific specimens differ from typical *Vercorsella immaturata* in having a more acute apical angle, and fewer and shorter radial beams in the chambers of the biserial stage.

Age and occurrence. Late(?) Aptian, from Samples 143-866A-78R-3, 90–91 cm; -76R-3, 10–15 cm; -75R-3, 113–115 cm; and -75R-2, 1–3 cm.

Known range. Aptian to Albian.

Geographic distribution. The species previously was restricted to Xizang, Tibet.

Vercorsella sp. cf. *V. scarsellai* De Castro, 1963
(Pl. 3, Figs. 1–4)

Description. Test small, elongate, conical (maximum height, 1.05 mm; maximum diameter, 0.3 mm), apical angle varies from 15° to 28° in axial section parallel to the plane of biseriality. Initial trochospiral stage consists of a rounded protoconch, a small deuteroconch, and one chamber (Pl. 3, Fig. 1), followed by a biserial stage with up to eight chambers, slightly compressed parallel to the plane of biseriality and divided by a maximum of four radial beams. Horizontal rafters are lacking. Wall microgranular. Aperture a row of rectangular pores at base of septal face.

Remarks. About 30 specimens were observed in thin section. The Pacific specimens differ from typical *Vercorsella scarsellai* in being smaller and having fewer chambers and fewer but thicker radial beams.

Age and occurrence. Albian, from Section 143-865A-89R-6 to -47R-CC and Section 143-866A-47R-1 to -15R-CC.

Known range. Barremian to Albian.

Geographic distribution. The species is known from the southern margin of the Tethys in Italy, Croatia, Slovenia, North Africa, and the Middle East.

Vercorsella wintereri Arnaud-Vanneau and Sliter, n. sp.
(Pl. 3, Figs. 10–17)

Description. Test minute, conical (maximum height, 0.30 mm; maximum diameter, 0.15 mm), apical angle varies from 20° to 30° in axial section parallel to the plane of biseriality. Initial trochospiral stage indistinct, protoconch very small (20 µm), deuteroconch about half the size of the protoconch (Pl. 3, Fig. 12), followed by biserial stage with up to eight chambers. Chambers either not compressed or slightly compressed perpendicular to the plane of biseriality, subdivided by up to five very short radial beams that extend nearly to the outer wall (Pl. 3, Figs. 16, 17). Horizontal rafters are not present. Wall microgranular. Aperture indistinct.

Remarks. About 70 specimens were observed in thin section. *Vercorsella wintereri* is the only species assigned to the genus that either lacks compression of the chambers in the biserial stage or shows compression perpendicular to the plane of biseriality. In addition, this species has the shortest radial beams yet described, which makes identification difficult in axial sections and requires further examination in subaxial, tangential, or radial sections.

Depository. National Museum of Natural History, Washington, D.C.

Holotype. USNM 483971, subaxial section (Pl. 3, Fig. 10).

Type locality. Resolution Guyot, Sample 143-866A-153R-2, 20–22 cm.

Age and occurrence. Hauterivian, from Samples 143-866A-171R-1, 21–40 cm; -170R-4, 138–139 cm; -170R-1, 44–45 cm; -169R-3, 17–18 cm; -169R-2, 113–114 cm; -167R-2, 7–9 cm; -167R-1, 30–32 cm; -166R-1, 11–10 cm; -164R-2, 140–143 cm; -160R-1, 26–28 cm; -157R-3, 72–74 cm; -157R-2,

84–86 cm; -157R-1, 11–14 cm; -156R-1, 81–85 cm; -155R-1, 119–122 cm; -154R-2, 119–121 cm; -153R-2, 20–22 cm; -152R-2, 105–107 cm; and -150R-3, 66–69 cm.

Derivatio nominis. The species is dedicated to Professor Jerry Winterer, Scripps Institution of Oceanography, and co-chief of Leg 143.

Genus *CUNEOLINA* d'Orbigny, 1839, emend.

New emendation. Test free, somewhat compressed parallel to the plane of biseriality and conical to flabelliform. The embryonic apparatus consists of a globular to oval protoconch covered by a deuteroconch that is divided by beams and rafters. The following biserial stage consists of broad, low chambers that are divided by radial beams extending from the outer wall toward the plane of biseriality and, sometimes, by horizontal rafters. The wall is agglutinated or microgranular and keriothecal. The aperture consists of a row of pores at the base of the septal face.

Cuneolina sp. cf. *C. pavonia* d'Orbigny, 1846
(Pl. 4, Figs. 1–5)

Cuneolina pavonia d'Orbigny; Grötsch, 1991, pl. 19, fig. 5.

Description. Test compressed, flabelliform (maximum height, 1.8 mm; maximum diameter, 0.4 mm), with a small initial trochospiral stage followed by a larger biserial stage. Chambers broad, divided by numerous radial beams that thin toward the plane of biseriality and two to three transverse rafters, interior divided into network of rectangular chamberlets close to the outer wall. Wall keriothecal microgranular, with very small, tubular alveoles.

Remarks. About 15 specimens were observed in mostly tangential or transverse thin sections. We attribute these large specimens with a very large embryonic apparatus divided by many beams and rafters to this species (Pl. 4, Figs. 4, 5). The Pacific specimens are smaller and have a thinner, less agglutinated wall than typical *Cuneolina pavonia* and may represent another species. However, without whole specimens and more definitive thin sections, we presently cannot distinguish these specimens from *Cuneolina pavonia*.

Age and occurrence. Late Albian, from Samples 143-865A-29R-CC, 2–3 cm; 143-866A-15R-CC, 13–14 cm; -9R-CC, 1–2 cm; -6R-CC, 17–19 cm; 143-866B-10R-CC, 41–43 cm; -7R-CC, 6–9 cm; -5M-CC, 39–41 cm; and 143-867B-13R-CC, 20–22 cm.

Known range. Albian to Santonian.

Geographic distribution. The species is known along the southern margin of the Tethys in the Middle East, Egypt, Greece, Italy, Albania, Yugoslavia, and North Africa, and from the northern margin in France and Spain.

Cuneolina parva Henson, 1948
(Pl. 4, Figs. 6–9)

Cuneolina pavonia var. *parva* var. nov. Henson, 1948, pp. 624–627, pl. XIV, figs. 1–6, pl. XVII, figs. 7–12, pl. XVIII, figs. 12–14.

?*Cuneolina laurentii* Sartoni and Crescenti; Shiba, 1988, pl. 7, figs. 25–28.

Cuneolina pavonia d'Orbigny; Grötsch, 1991, pl. 19, figs. 3, 4?, 6–8.

Description. Test compressed, conical to flabelliform (maximum height, 1.3 mm; maximum diameter, 0.9 mm). Embryonic apparatus composed of a large, oval, protoconch covered by a deuteroconch divided by beams and rafters, followed by a broad, low, biserial stage with up to 12 chambers. Chambers compressed parallel to the plane of biseriality and divided by radial beams and one or two transverse rafters that produce a rectangular network of chamberlets. Wall keriothecal, microgranular, and composed of small, tubular alveoles. Aperture a row of rectangular pores at base of septal face.

Remarks. The Pacific taxon, represented by about 20 specimens examined whole and in thin section, is similar to the types of *Cuneolina parva* described from the Santonian of Egypt. The published age of the type locality, however, is incorrect and, instead, probably is Albian (A.I. Kenawi, pers. comm., 1991).

Age and occurrence. Late(?) Albian, from Samples 143-865A-34R-CC, 15–16 cm; -34R-1, 118–119 cm; -34R-1, 101–102 cm; -34R-1, 85–86 cm; -31R-CC, 2–3 cm; -29R-CC, 2–3 cm; -19R-CC, 3–4 cm; 143-866A-20R-CC, 3–4 cm; -17R-CC, 2–3 cm; -15R-CC, 2–3 cm; -12R-CC, 2–3 cm; -11R-CC, 3–4 cm; 143-866B-5M-1, 5–7 cm; -4M-1, 30–32 cm; and 143-868B-1R-2, 15–17 cm.

Known range. Albian to Cenomanian, Santonian(?).

Geographic distribution. The species is mostly known from the southern margin of the Tethys in the Middle East, Egypt, Greece, Italy, Albania, Yugoslavia, and North Africa, and from the northern margin in France and Spain.

Cuneolina sp. A
(Pl. 4, Figs. 10, 11)

Description. Test small, slightly compressed, conical (maximum height, 0.65 mm; maximum diameter, 0.35 mm). Embryonic apparatus formed by a

small, oval protoconch, slightly tilted, and a deuteroconch divided by a few rafters and beams, followed by short biserial stage with up to five or six chambers slightly compressed parallel to the plane of biseriality. Chambers divided by radial beams that thin toward the center, horizontal rafters lacking. Wall keriothecal, microgranular, with very small, tubular alveoles. Aperture a row of elongate pores at base of septal face.

Remarks. About 20 to 30 specimens of this apparently new species were observed whole and as oriented and random thin sections. The Pacific form is the smallest cuneolinid described and probably the oldest. The conical test is triangular and never flabelliform as are *Cuneolina parva* or *Cuneolina pavonia*. The deuteroconch displays only a few beams and rafters, and sometimes only one is visible in thin section. Chambers are divided by only radial beams, and the specimens lack the horizontal rafters.

Age and occurrence. Albian, common from Sections 143-865A-88R-1 to -17X, and Sections 143-866A-45R-CC to -11R-CC.

Family ORBITOLINIDAE Martin, 1890
Subfamily DICTYOCONINAE Moullade, 1965
Genus *Paracoskinolina* Moullade, 1965

Paracoskinolina sp. cf. *P. sunnilandensis* (Maync)
(Pl. 4, Figs. 14–16)

Coskinolina sunnilandensis Maync, 1955, pp. 106, pl. 16, fig. 1.

Description. Test small, high conical (apical angle from 35° to 40°), with a flat base (maximum height, 0.7 mm; maximum diameter, 0.5 mm). Embryonic apparatus indistinct. Chamber margin divided by radial beams that thicken slightly toward center of test; transverse rafters lacking. Central zone divided by pillars that appear continuous from one chamber to the next (Pl. 4, Fig. 14).

Remarks. The Pacific specimens, represented by 15 thin sections, differ from typical representatives of *Paracoskinolina sunnilandensis* in their small size, high conical test, and reduced central zone. The general arrangement of the beams and pillars, however, is similar to the type specimens but critical thin sections are unavailable to confirm this assignment.

Age and occurrence. Middle to late Albian(?), from Samples 143-865A-77R-CC, 2–3 cm; -76R-1, 78–79 cm; 143-866A-47R-1, 94–96 cm; -47R-1, 70–75 cm; -47R-1, 66–68 cm; -46R-1, 104–109 cm; and -39R-1, 77–78 cm.

Known range. Hauterivian to Albian.

Geographic distribution. Originally described from the Albian of Florida, this species is known from the northern margin of the Tethys in France, and Switzerland, and from Texas, Mexico, and Venezuela.

Genus *FALSURGONINA* Arnaud-Vanneau and Argot, 1973

Falsurgonina(?) sp.
(Pl. 3, Fig. 18)

Description. Test small, high conical, base slightly concave (height, 0.2 mm; diameter, 0.2 mm). Protoconch globular, followed by small trochospiral stage. Radial zone broad, lacking horizontal rafters, central zone reduced. Only sparse radial partitions exist, probably produced by invaginations of the chamber floor.

Remarks. Only one specimen was observed in axial section.

Age and occurrence. Probable Barremian, from Sample 143-866A-129R-6, 13–15 cm.

Known range of genus. Hauterivian(?) to lower Aptian.

Geographic distribution. Previously restricted to the northern margin of the Tethys in France and Spain.

Subfamily ORBITOLININAE Martin, 1890
Genus *NEOIRAQIA* Danilova, 1963

Neoiraqia(?) sp.
(Pl. 4, Fig. 10)

Description. Test small, high conical, base flat (height, 0.3 mm; diameter, 0.35 mm). Embryonic apparatus with globular protoconch capped by a deuteroconch, divided by a few beams and rafters, later chambers complete. Narrow radial zone, darker than central zone, divided by radial beams and horizontal rafters. Central zone in axial sections displays regular alternation of partitions that do not thicken at the base.

Remarks. Only two specimens were observed in thin section.

Age and occurrence. Middle(?) to late Albian, from Sample 143-866A-46R-1, 104–106 cm.

Known range of genus. Late Albian to Cenomanian.

Geographic distribution. The genus is known from the southern margin of the Tethys in the Middle East, Greece, Italy, Albania, and Yugoslavia and from the northern margin in France, Spain, and Portugal. Small-sized *Neoiraqia*(?) similar to the Pacific specimens are known from the late Albian(?) of Spain, but as yet have not been described (AAV and E. Caus, pers. observ., 1990).

Orbitolinid A
(Pl. 3, Figs. 19, 20)

Description. Test large, low conical (apical angle from 100° to 135°), base convex to concave (maximum height, 1.80 mm; maximum diameter, 4.60 mm). Embryonic apparatus composed of rounded protoconch (0.80 mm) surrounded laterally, more or less completely, by deuteroconch divided by beams and rafters producing polygonal network. Beams and rafters form small alveoles perpendicular to the wall of deuteroconch that open toward the protoconch (Pl. 3, Fig. 20), followed by two or three semilunar chambers that form short trochospire. Chambers bilobate, arranged symmetrically on both sides of protoconch. Later chambers display radial zone divided by two orders of radial beams and by horizontal rafters that produce rectangular chamberlets. First-order radial beams do not alternate between chambers. Radial zone divided by radial zigzag partitions that thicken and become triangular in axial or subaxial sections; partitions alternate regularly from one chamber to the next in contrast to first-order beams of the radial zone.

Remarks. About 20 specimens were observed whole and in oriented and random thin sections that apparently represent a new orbitolinid genus and species. Two morphologic characteristics distinguish this taxon from other genera in the subfamily: (1) the morphology of the embryonic apparatus consists of a protoconch and a deuteroconch, followed by bilobate chambers that form a short trochospire; and (2) the absence of alternating first-order radial beams in the marginal zone contrast with the complete alternation of radial partitions in the central zone.

Age and occurrence. Probable Albian (middle to late?), from Sample 143-866A-47R-1, 60–72 cm.

Orbitolinid B

Remarks. About 15 specimens of orbitolinids observed in subaxial, tangential and oblique thin sections were not assigned to genus or species owing to the poor quality of the material. Nevertheless, these occurrences are of interest as the stratigraphic distribution of orbitolinids is limited.

Age and occurrence. Probable Albian (middle to late?), from Samples 143-865A-74R-1, 84–86 cm; -71R-1, 84–86 cm; 143-866A-57R-1, 80–82 cm; -46R-2, 14–16 cm; -39R-1, 23–24 cm; -35R-1, 129–130 cm; and -35R-1, 88–90 cm.

Family INVOLUTINIDAE Bütschli, 1880
Genus *TROCHOLINA* Paalzow, 1922

Trocholina sp. cf. *T. lenticularis* Henson, 1947
(Pl. 5, Fig. 1)

Description. Test low conical (apical angle, 130°; diameter, 1.2 mm), protoconch indistinct, sections of the following tubular second chamber are triangular in the figured subaxial section and strongly eroded, umbilical side slightly convex. Wall calcareous, very thin, eroded in figured specimen.

Remarks. A single specimen was observed in thin section that is similar in morphology and size to specimens of *Trocholina lenticularis* illustrated by Arnaud-Vanneau, Boisseau, and Darsac (1988, pl. 6, figs. 22–27). The poor preservation of the recovered specimen and the lack of additional material, however, prevent definitive assignment to this species.

Age and occurrence. Late(?) Albian, from Sample 143-865A-51R-CC, 11–13 cm.

Known range. Late Albian to early Cenomanian.

Geographic distribution. This species previously was restricted to the southern margin of the Tethys in the Middle East.

Trocholina molesta Gorbachik, 1959
(Pl. 5, Fig. 6)

Trocholina molesta Gorbachik, 1959, pp. 79–91, pl. 4, figs. 1–2.

Trocholina molesta Gorbachik; Arnaud-Vanneau, Boisseau, and Darsac, 1988, p. 359, fig. 3, pl. 6, figs. 11–21.

Description. Test small, low conical (apical angle, 110°; diameter, 0.4 mm), protoconch indistinct, tubular second chamber showing four whorls,

umbilical side slightly convex. Wall calcareous, outer wall moderately thick, partly eroded in figured specimen.

Remarks. A single specimen observed in thin section is similar in morphology and size to typical specimens of *Trocholina molesta*.

Age and occurrence. Probable Hauterivian, from Sample 143-866A-147R-1, 23–25 cm.

Known range. Tithonian to Barremian.

Geographic distribution. This species, described from the Berriasian of the Crimea, is known along the northern margin of the Tethys from the Crimea to Spain.

Trocholina sp. cf. *T. odukpaniensis* Dessauvage, 1968
(Pl. 5, Fig. 7)

Description. Test small, low conical (apical angle, 95° to 110°; maximum diameter, 0.7 mm), eroded. Protoconch indistinct, tubular second chamber with four whorls visible, subaxial section of tubular chamber shows triangular section that bends slightly toward umbilical side, umbilical side flat to slightly convex.

Remarks. Two specimens were observed in thin section that are similar in morphology, although smaller, to specimens of *Trocholina odukpaniensis*. These specimens may represent juveniles; however, with the present limited material, we cannot confirm the identification.

Age and occurrence. Late Albian, from Samples 143-865A-34R-1, 40–42 cm, and -15R-CC, 15–16 cm.

Known range. Late Albian to early Cenomanian.

Geographic distribution. This species was described from the upper Albian to lower Cenomanian of Nigeria and is reported from the margins of the Tethys.

Genus *NEOTROCHOLINA* Reichel, 1956

Neotrocholina sp. cf. *N. friburgensis* Guillaume and Reichel, 1957
(Pl. 5, Figs. 2, 3)

Description. Test conical (apical angle, about 90°; maximum diameter, 0.62 mm) with a thick yellow calcitic crust. Protoconch indistinct. Second chamber tubular, broad, triangular in subaxial section (Pl. 5, Fig. 2), trochospirally enrolled in four whorls parallel to the flat umbilical side.

Remarks. Five specimens were observed in thin section. The Pacific specimens are smaller than typical *Neotrocholina friburgensis* and have a flat umbilical side. Comparable specimens are known from the Barremian of France (Arnaud-Vanneau, 1980).

Age and occurrence. Barremian, from Sample 143-866A-115R-1, 22–26 cm.

Known range. Late Barremian to the base of the early Aptian.

Geographic distribution. The species was originally described from Switzerland and is also found in France and Romania.

Neotrocholina sp. cf. *N. infragranulata* Noth, 1951
(Pl. 5, Figs. 4, 5)

Description. Test low conical (apical angle from 125° to 135°; maximum diameter, 0.40 mm) with a thick yellow calcitic crust (Pl. 5, Fig. 5). Protoconch indistinct. Second chamber tubular, triangular in subaxial section with a small acute angle toward the center of the test (Pl. 5, Fig. 4), trochospirally enrolled in four whorls. Umbilical side flat, with characteristic marginal ridge and numerous small pillars (Pl. 5, Fig. 5).

Remarks. Four specimens were observed in thin section that closely resemble *Neotrocholina infragranulata*. The paucity of thin sections, however, prevented us from confirming our identification of this species, which originally was described from whole specimens.

Age and occurrence. Hauterivian to Barremian, from Samples 143-866A-157R-1, 11–14 cm; -156R-1, 81–85 cm; -115R-1, 22–26 cm; and -112R-1, 67–69 cm.

Known range. Hauterivian to Barremian.

Geographic distribution. This widespread species was originally described from the Hauterivian of Austria.

Family VENTROLAMINIDAE Weynschenck, 1950
Genus *PROTOPENEROPLIS* Weynschenck, 1950

Protopeneroplis sp.
(Pl. 5, Figs. 8–10)

Description. Test low trochospiral, lenticular, planoconvex to biconvex, spiral side more convex than umbilical side, periphery subacute (maximum

height, 0.30 mm; maximum diameter, 0.45 mm). Chambers in minimum of two whorls. Sutures probably pustulate or ornamented (Pl. 5, Fig. 10). Wall calcareous and composed of two layers: a microgranular inner layer and a hyaline outer layer that increases in thickness toward the initial chamber. Thickening on spiral side forms calcitic button visible in axial or subaxial section (Pl. 5, Fig. 10); surface ornamentation indistinct. Aperture indistinct.

Remarks. Seven specimens were observed in thin section that are the same size as *Protopeneroplis ultragranulata* Gorbachik from the Berriasian of the Crimea, but differ in being less ornamented.

Age and occurrence. Probable Barremian, from Samples 143-866A-127R-1, 25–27 cm; -126R-1, 70–72 cm; -125R-3, 19–21 cm; -125R-2, 70–72 cm; and -125R-1, 143–145 cm.

Family HAUERINIDAE Schwager, 1876
Subfamily SIPHONAPERTINAE Saidova 1975
Genus *RUMANOLOCLINA* Neagu, 1984

Rumanoloculina sp. cf. *R. minima* Tappan, 1943
(Pl. 5, Fig. 12)

Description. Test globular. Chambers with floors, in milioline arrangement, forming successive Y-shaped cycles 90° apart, separated by depressed sutures, five chambers visible externally. Wall calcareous, imperforate, porcelaneous. Aperture indistinct.

Remarks. About 20 specimens were observed in thin section that precluded the determination of the surface ornamentation.

Age and occurrence. Albian, from Samples 143-866A-47R-1, 66–68 cm; -46R-2, 14–16 cm; -46R-1, 85–87 cm; -45R-CC, 23–25 cm; -37R-1, 77–78 cm; and -35R-1, 88–90 cm.

Known range. Aptian to Albian.

Geographic distribution. This species was described from the Albian of Texas and is found along the margins of the Tethys.

Rumanoloculina robusta (Neagu)
(Pl. 5, Figs. 14 and 16)

Quineloculina robusta Neagu, 1968, p. 566, pl. 1, figs. 8–17, pl. 7, figs. 1–3.
Rumanoloculina robusta Neagu, 1986, p. 315, pl. 7, figs. 23–25, pl. 8, figs. 30–38, text-fig. 2.

Description. Test large, globular. Chambers quineloculine in arrangement, forming successive Y-shaped cycles less than 90° apart, with floors, five chambers visible externally, three on one side, two on the opposite, separated by strongly depressed sutures. Wall calcareous, imperforate, porcelaneous. Aperture indistinct.

Remarks. About 20 specimens were observed in thin section.

Age and occurrence. Barremian to early Aptian, from Samples 143-866A-126R-1, 79–80 cm; -78R-3, 90–91 cm; -77R-3, 117–122 cm; -77R-1, 91–93 cm; -71R-2, 37–41 cm; -70R-2, 21–23 cm; and -68R-CC, 5–7 cm.

Known range. Berriasian to early Aptian.

Geographic distribution. This species, described from the Barremian of Romania, is known along the margins of the Tethys

Genus *ISTRILOCLINA* Neagu, 1984

Istriloculina sp. cf. *I. elliptica* (Iovcheva)
(Pl. 5, Figs. 13, 15, 17, 18)

Pyrgo elliptique Iovcheva, 1962, pp. 52, pl. 2, fig. 7.

Description. Test elongate, ovate, thin. Chambers arrangement Y-shaped, without floors, three chambers are visible externally, two chambers on one side, and one on the opposite, separated by slightly depressed sutures. Wall very thin, calcareous, imperforate, porcelaneous. Aperture indistinct.

Remarks. More than 30 specimens observed in thin section are smaller than the type specimens of *Istriloculina elliptica*. Species of *Istriloculina* are widespread in restricted Cretaceous environments and are generally attributed to the genus *Pseudotriloculina* Cherif, 1970 (e.g., Arnaud-Vanneau, 1980). This taxonomic placement is incorrect, however, and the Cretaceous forms are now assigned to *Istriloculina*, which was subsequently described by Neagu in 1984.

Age and occurrence. Hauterivian(?) to Barremian, from Samples 143-866A-147R-1, 23–25 cm; -126R-1, 79–80 cm; -111R-1, 121–122 cm; -91R-1, 73–74 cm; -89R-1, 81–82 cm; -78R-3, 90–91 cm; and -77R-3, 117–122 cm.

Known range. Hauterivian to early Aptian.

Geographic distribution. *Istriloculina elliptica* was described from the Aptian of Bulgaria and is found along the margins of the Tethys.

Genus *DECUSSOLOCULINA* Neagu, 1984

Decussoloculina sp. cf. *D. mirceai* Neagu, 1984
(Pl. 5, Fig. 19)

Description. Test minute, elliptical. Chambers initially in milioline arrangement, then form X-shaped pattern, without floors, separated by depressed sutures. Axial thin sections show external spiral disposition of chambers on opposite sides. Wall calcareous, imperforate, porcelaneous. Aperture indistinct.

Remarks. Three small specimens observed in thin section probably represent juvenile forms. As a result, we are unsure of the correct taxonomic placement of these rare Pacific forms.

Age and occurrence. Probable Hauterivian, from Sample 143-866A-171R-1, 21–24 cm.

Known range. Late Berriasian to Valanginian.

Geographic distribution. This species, described from the Valanginian of Romania, is found along the northern margin of the Tethys in Switzerland, France and Spain.

Subfamily SIGMOILINITINAE Luczkowska, 1974
Genus *PSEUDONUMMOLOCULINA* Calvez, 1988

Pseudonummoloculina sp.
(Pl. 5, Fig. 11)

Description. Test discoidal. Protoconch surrounded entirely by flexostyle canal, followed by milioline stage, then becomes nearly planispiral, final whorl with two chambers. Wall calcareous, porcelaneous. Aperture probably areal.

Remarks. A single specimen was observed in thin section. The genus *Pseudonummoloculina* is represented by three species: *P. aurigerica* Calvez from the early to middle Albian of the Pyrenees, France; *P. heimi* (Bonet) from the Albian to Cenomanian of Mexico; and *P. robusta* (Torre) from the Senonian of Italy. The Pacific pseudonummoloculinid is a very small form and apparently represents a juvenile test intermediate in morphology between *P. aurigerica* and *P. heimi*. Without adult specimens, we lack the evidence for further taxonomic placement.

Age and occurrence. Albian, from Sample 143-866A-46R-1, 104–106 cm.

Class CRUSTACEA Pennant, 1777
Order DECAPODA Latreille, 1803
Superfamily THALASSINOIDEA Latreille, 1831
Family CALLIANASSIDAE Dana, 1852
Genus *FAVREINA* Brönnimann, 1955
Favreina sp. cf. *F. prusensis* (Paréjas)
(Pl. 5, Fig. 20)

Coprolithus prusensis Paréjas, 1948, pp. 515–519, figs. 36–42.

Description. Small cylindrical coprolites (diameter, about 0.6 mm). Circular cross section displays up to 94 small canals, circular in section, that form an outer arc and two inner arcs roughly parallel to the outer arc on both sides of the pellet.

Remarks. Three specimens were observed in thin section. The Pacific material is not well preserved and somewhat resembles *Favreina prusensis* in size. Confirmation of this identification, however, awaits a more complete description of the pattern formed by the canals in the type specimens of *F. prusensis*.

Age and occurrence. Probable Hauterivian, from Sample 143-866A-146R-1, 111–114 cm.

Known range. Portlandian.

Geographic distribution. The species was originally described from Turkey.

Family AXIIDAE Huxley, 1879
Genus *PALAXIUS* Brönnimann and Norton, 1960
Palaxius salataensis Senowbari-Daryan and Grötsch, 1992
(Fig. 8)

Description. Elongate coprolites (diameter, 0.25–0.30 mm). Transverse section shows up to four crescent-shaped canals, poorly developed, arranged in two bilaterally symmetric groups.

Remarks. Six specimens were observed.

Age and occurrence. Albian, from Sample 143-866A-46R-2, 41–43 cm.

Known range of genus. Probably Albian.

Geographic distribution. Dredge sample from MIT Guyot.

Palaxius sp. A
(Pl. 5, Figs. 21, 22)

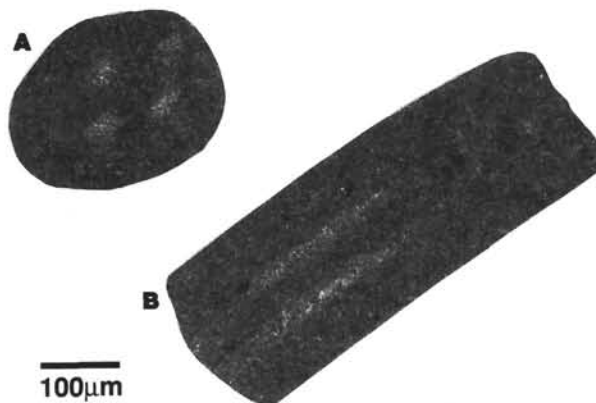


Figure 8. *Palaxius salataensis* Senowbari-Daryan and Grötsch, 1992. A. Transverse section. B. Axial section. Figures 8A and 8B from Sample 143-866A-46R-2, 41–43 cm.

Description. Elongate coprolites (diameter, 0.4–0.45 mm). Transverse section shows up to four strongly curved, crescent-shaped canals with enlarged tips. Canals usually open toward the center of the pellet.

Remarks. Twelve specimens were observed in thin section that apparently represent a new Pacific species of *Palaxius*, with canals bigger and more crescent-shaped than in *Palaxius salataensis*.

Age and occurrence. Late Aptian(?) to early Albian(?), from Sample 143-865A-87R-2, 102–104 cm.

ACKNOWLEDGMENTS

We thank ODP and the co-chiefs of Legs 143 and 144 for the opportunity to exchange and discuss information from both cruises. In addition, WVS gratefully acknowledges AVA for willingly sharing her knowledge of Early Cretaceous benthic foraminifers and for the pleasant collaboration that resulted from her accepting the considerable biostratigraphic obligations from Leg 143. We thank the ODP curators and H. Arnaud, Y. Iryu, J. Mütterlose, U. Röhl, and A. Strasser for the exchange of thin sections. J.A. Barron, A. Farinacci, B.L. Murchey, and M. Simmons reviewed the manuscript and we appreciate their helpful comments and suggestions. Eleanor V. Kohnen is acknowledged for her assistance in preparing the manuscript.

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Date of initial receipt: 2 June 1994

Date of acceptance: 1 September 1994

Ms 143SR-252

APPENDIX

Faunal Reference List

- Ammobaculoides* sp.
- Arenobulimina* sp. cf. *A. chapmani* Cushman
- Arenobulimina cochleata* Arnaud-Vanneau
- Arenobulimina* sp. A
- Barkerina* sp. cf. *B. barkerensis* Frizzell and Schwartz
- Belorussiella textularioides* (Reuss) (= *Bolivina textularioides* Reuss)
- Buccicrenata hedbergi* (Maync) (= *Pseudocyclammina hedbergi* Maync)
- Campanellula capuensis* De Castro
- Cuneolina parva* Henson
- Cuneolina* sp. cf. *C. pavonia* d'Orbigny
- Cuneolina* sp. A
- Debarina* sp. cf. *D. hahounerensis* Fourcade, Raoult, and Vila
- Decussoloculina* sp. cf. *D. mirceai* Neagu
- Falsurgonina*(?) sp.
- Favreina* sp. cf. *F. prusensis* (Paréjas) (= *Coprolithus prusensis* Paréjas)
- Istrilocolina* sp. cf. *I. elliptica* (Iovcheva) (= *Pyrgo elliptique* Iovcheva)
- Melathrokerion* sp. cf. *M. valserinensis* Brönnimann and Conrad
- Neoiragia*(?) sp.
- Neotrocholina* sp. cf. *N. friburgensis* Guillaume and Reichel
- Neotrocholina* sp. cf. *N. infragranulata* Noth
- Nezzazata isabellae* Arnaud-Vanneau and Sliter, n. sp.
- Nezzazata* sp. A
- Nezzazata* sp. B
- Nezzazata*(?) sp. C
- Novallesia angulosa* (Magniez) (= *Spiroplectamminoides angulosus* Magniez)
- Novallesia producta* (Magniez) (= *Spiroplectamminoides productus* Magniez)
- Orbitolinid A
- Orbitolinid B
- Palaxius salataensis* Senowbari-Daryan and Grötsch
- Palaxius* sp. A
- Paracoskinolina* sp. cf. *P. sunnilandensis* (Maync) (= *Coskinolina sunnilandensis* Maync)
- Praechrysalidina infracretacea* Luperto Sinni
- Protopeneroplis* sp.
- Pseudonummoloculina* sp.
- Rumanoloculina* sp. cf. *R. minima* Tappan
- Rumanoloculina robusta* (Neagu) (= *Quinqueloculina robusta* Neagu)
- Sabaudia minuta* (Hofker Jr.) (= *Textulariella minuta* Hofker Jr.)
- Trocholina* sp. cf. *T. lenticularis* Henson
- Trocholina molesta* Gorbachik
- Trocholina* sp. cf. *T. odukpaniensis* Dessauvage
- Valvulineria*(?) sp. 1
- Vercorsella* sp. cf. *V. arenata* Arnaud-Vanneau
- Vercorsella* sp. cf. *V. immaturata* He
- Vercorsella* sp. cf. *V. scarsellai* De Castro
- Vercorsella wintereri* Arnaud-Vanneau and Sliter, n. sp.
- Voloshinoides*(?) sp. A
- Voloshinoides*(?) sp. B

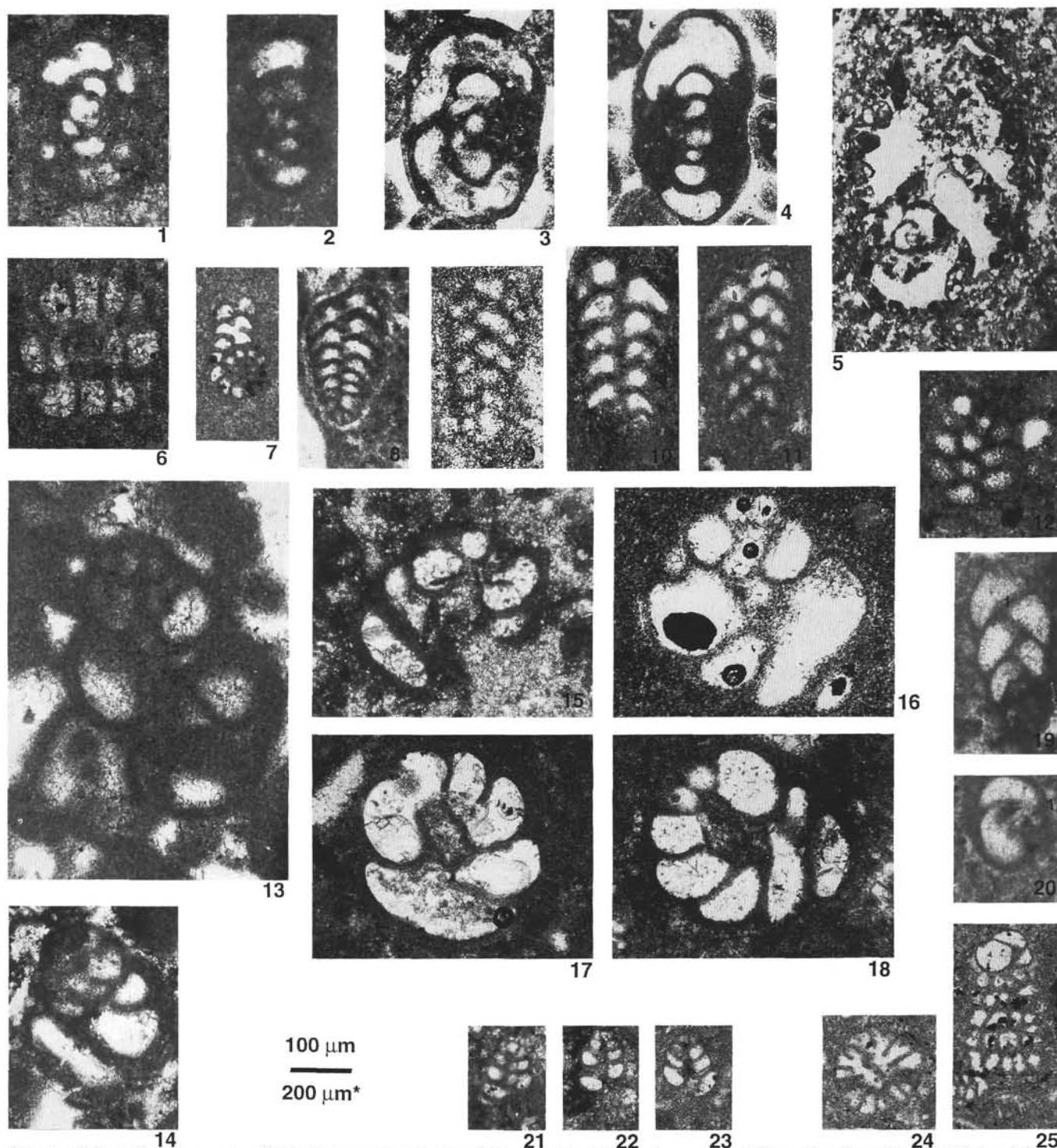


Plate 1. Thin-section micrographs of Early Cretaceous benthic foraminifera from Leg 143. Specimen scale = 100 μ m; *specimens in Figures 3, 4, and 5 = 200 μ m. **1, 2.** *Debarina* sp. cf. *D. hahounerensis*; (1) Sample 143-865A-57R-1, 45–48 cm; (2) Sample 143-866A-46R-1, 62–63 cm. **3, 4.** *Melathrokerion* sp. cf. *M. valserinensis*; (3) Sample 143-866A-149R-1, 91–93 cm; (4) Sample 143-866A-153R-2, 20–22 cm. **5.** *Buccicrenata hedbergi*, Sample 143-865A-89R-5, 1–4 cm. **6.** *Barkerina* sp. cf. *B. barkerensis*, Sample 143-865A-24R-CC, 5–6 cm. **7.** *Ammobaculoides* sp., Sample 143-866A-146R-1, 111–114 cm. **8.** *Novallesia producta*, Sample 143-866A-154R-2, 119–121 cm. **9–11.** *Novallesia angulosa*; (9) Sample 143-866B-8R-2, 20–21 cm; (10) Sample 143-865A-59R-CC, 4–6 cm; (11) Sample 143-865A-44R-CC, 15–16 cm. **12.** *Campanellula capuensis*, Sample 143-866A-147R-1, 23–25 cm. **13, 14.** *Arenobulimina cochleata*; (13) Sample 143-866A-119R-1, 18–19 cm; (14) Sample 143-866A-102R-1, 59–64 cm. **15–18.** *Arenobulimina* sp. cf. *A. chapmani*; (15) Sample 143-865A-86R-1, 16–20 cm; (16) Sample 143-866A-31R-1, 92–94 cm; (17) Sample 143-866A-85R-2, 41–42 cm; (18) Sample 143-866A-81R-1, 53–60 cm. **19, 20.** *Belorussiella* sp. cf. *B. textilarioides*, Sample 143-866A-160R-1, 26–28 cm. **21–23.** *Arenobulimina* sp. A; (21, 22) Sample 143-865A-90R-1, 45–47 cm; (23) Sample 143-865A-90R-1, 13–14 cm. **24, 25.** *Sabaudia minuta*, Sample 143-865A-87R-2, 32–34 cm.

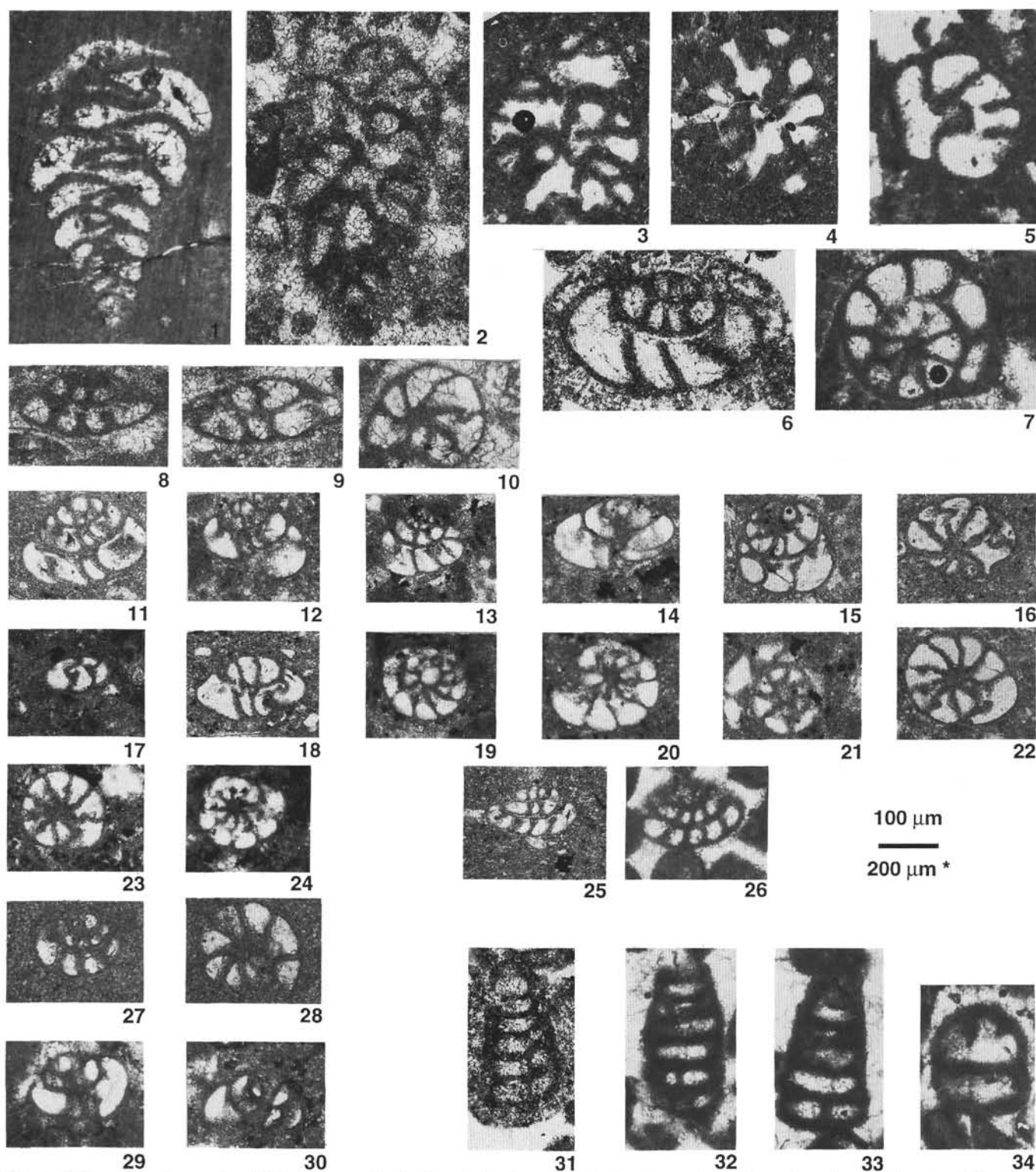


Plate 2. Thin-section micrographs of Early Cretaceous benthic foraminifers from Leg 143. Specimen scale = 100 μ m; *specimen in Figure 1 = 200 μ m. **1.** *Praechrysalidina infracretacea*, Sample 143-866A-47R-1, 94–96 cm. **2–4.** *Voloshinoides*(?) sp. A; (2) Sample 143-865A-34R-1, 101–102 cm; (3) Sample 143-865A-73R-1, 9–10 cm; (4) Sample 143-865A-74R-1, 48–50 cm. **5.** *Voloshinoides*(?) sp. B, Sample 143-866A-129R-1, 52–54 cm. **6, 7.** *Nezzazata*(?) sp. C; (6) Sample 143-866A-78R-3, 90–91 cm; (7) Sample 143-866A-79R-3, 114–116 cm. **8–10.** *Nezzazata* sp. A, Sample 143-865A-34R-1, 85–86 cm. **11–24.** *Nezzazata isabellae* n. sp.; (11) holotype; (16, 18) Sample 143-865A-87R-1, 32–34 cm; (12, 17) Sample 143-865A-90R-1, 13–14 cm; (13, 23, 24) Sample 143-865A-90R-1, 45–47 cm; (14, 19, 20, 21) Sample 143-865A-90R-1, 44–45 cm; (15, 22) Sample 143-865A-90R-1, 62–63 cm. **25, 26.** *Nezzazata* sp. B; (25) Sample 143-865A-88R-1, 13–15 cm; (26) Sample 143-866A-76R-3, 10–15 cm. **27–30.** *Valvulineria*(?) sp. 1; (27, 28) Sample 143-866A-146R-1, 111–114 cm; (29) Sample 143-866A-147R-1, 23–25 cm; (30) Sample 143-866A-170R-4, 138–139 cm. **31–34.** *Vercorsella* sp. cf. *V. immaturata*; (31) Sample 143-866A-78R-3, 90–91 cm; (32–34) Sample 143-866A-76R-3, 10–15 cm.

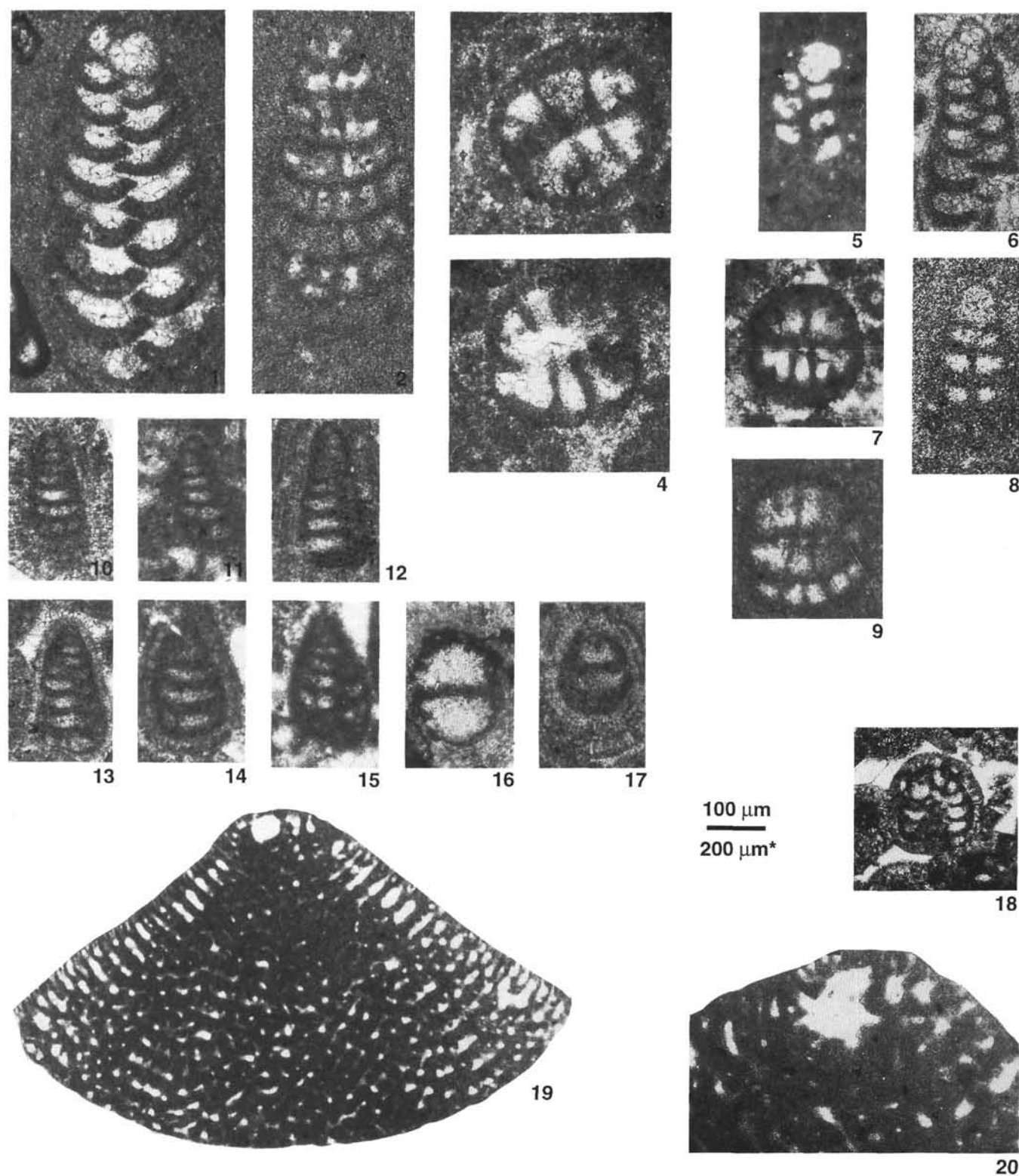


Plate 3. Thin-section micrographs of Early Cretaceous benthic foraminifers from Leg 143. Specimen scale = 100 mm; *specimen in Figure 19 = 200 mm. **1-4.** *Vercorsella* sp. cf. *V. scarsellai*; (1) Sample 143-865A-87R-1, 63-66 cm; (2) Sample 143-865A-69R-CC, 21-22 cm; (3, 4) Sample 143-866A-47R-1, 66-68 cm. **5-9.** *Vercorsella* sp. cf. *V. arenata*; (5) Sample 143-865A-79R-1, 27-28 cm; (6) Sample 143-865A-34R-1, 118-119 cm; (7) Sample 143-865A-89R-6, 28-32 cm; (8) Sample 143-866A-46R-2, 14-16 cm; (9) Sample 143-866A-46R-2, 41-43 cm. **10-17.** *Vercorsella wintereri* n. sp.; (10) holotype, Sample 143-866A-153R-2, 20-22 cm; (11-13, 17) Sample 143-866A-166R-1, 97-100 cm; (14) Sample 143-866A-166R-1, 98-100 cm; (15) Sample 143-866A-157R-2, 84-86 cm; (16) Sample 143-866A-169R-3, 17-18 cm. **18.** *Falsurgonina*(?) sp., Sample 143-866A-129R-6, 13-15 cm. **19, 20.** Orbitolinid A; (19, 20) Sample 143-866A-47R-1, 60-70 cm.

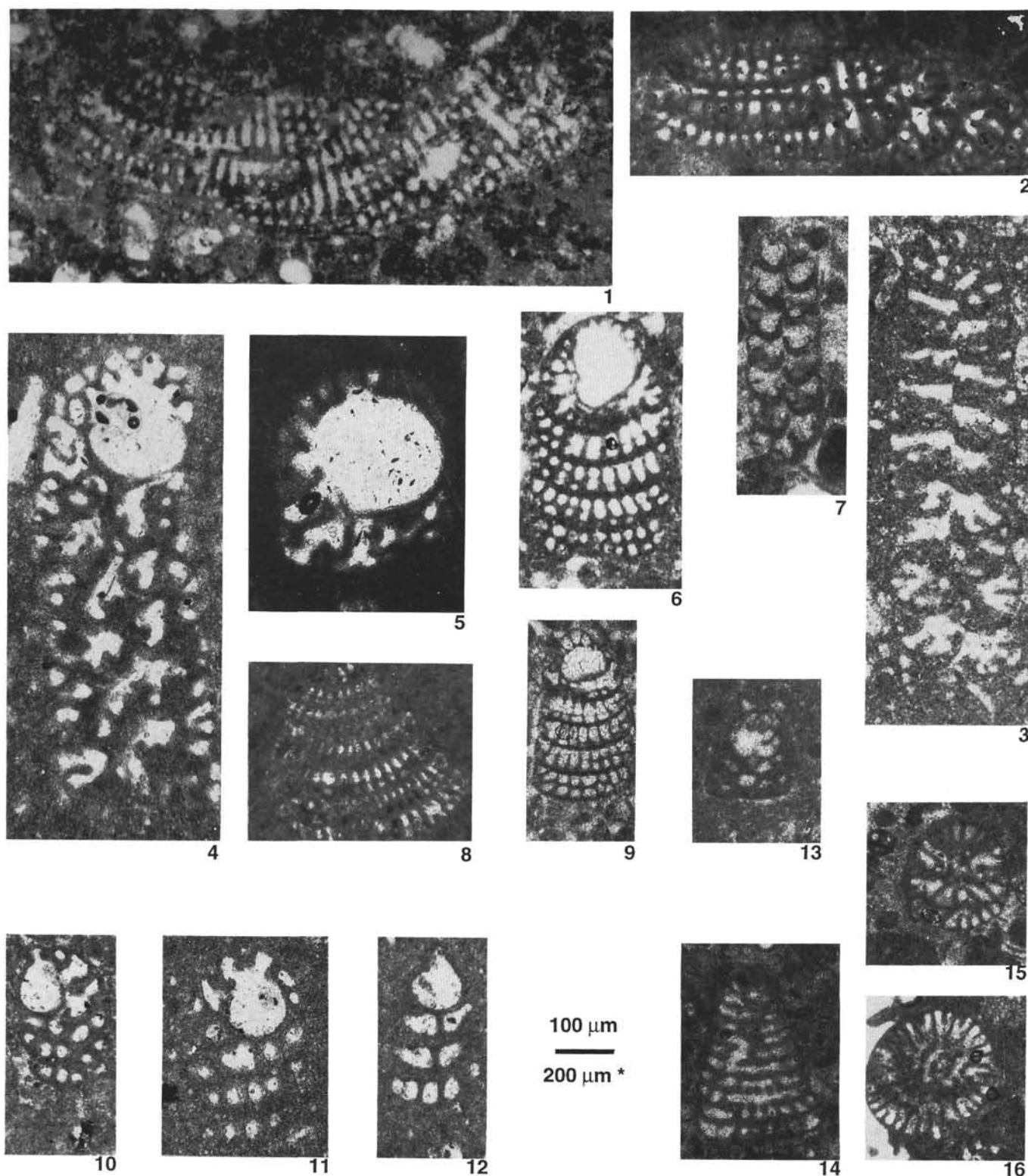


Plate 4. Thin-section micrographs of Early Cretaceous benthic foraminifers from Leg 143. Specimen scale = 100 mm; *specimens in Figures 1-3, 6-9, and 13-16 = 200 mm. **1-5.** *Cuneolina* sp. cf. *C. pavonia*; (1) Sample 143-866A-15R-CC, 13-14 cm; (2) Sample 143-866A-15R-CC, 2-3 cm; (3) Sample 143-867B-13R-1, 20-22 cm; (4) Sample 143-865A-29R-CC, 2-3 cm; (5) Sample 143-865A-5M-1, 5-7 cm. **6-9.** *Cuneolina parva*; (6) Sample 143-866A-31R-1, 35-37 cm; (7) Sample 143-865A-34R-1, 101-102 cm; (8) Sample 143-866A-20R-CC, 3-4 cm; (9) Sample 143-865A-34R-1, 101-103 cm. **10-12.** *Cuneolina* sp. A; (10) Sample 143-865A-88R-1, 13-15 cm; (11) Sample 143-865A-71R-1, 48-50 cm; (12) Sample 143-865A-75R-1, 2-3 cm. **13.** *Neoiraqia*(?) sp., Sample 143-866A-46R-1, 104-106 cm. **14-16.** *Paracoskinolina* sp. cf. *P. sunnilandensis*; (14, 15) Sample 143-866A-47R-1, 66-68 cm; (16) Sample 143-866A-39R-1, 77-78 cm.

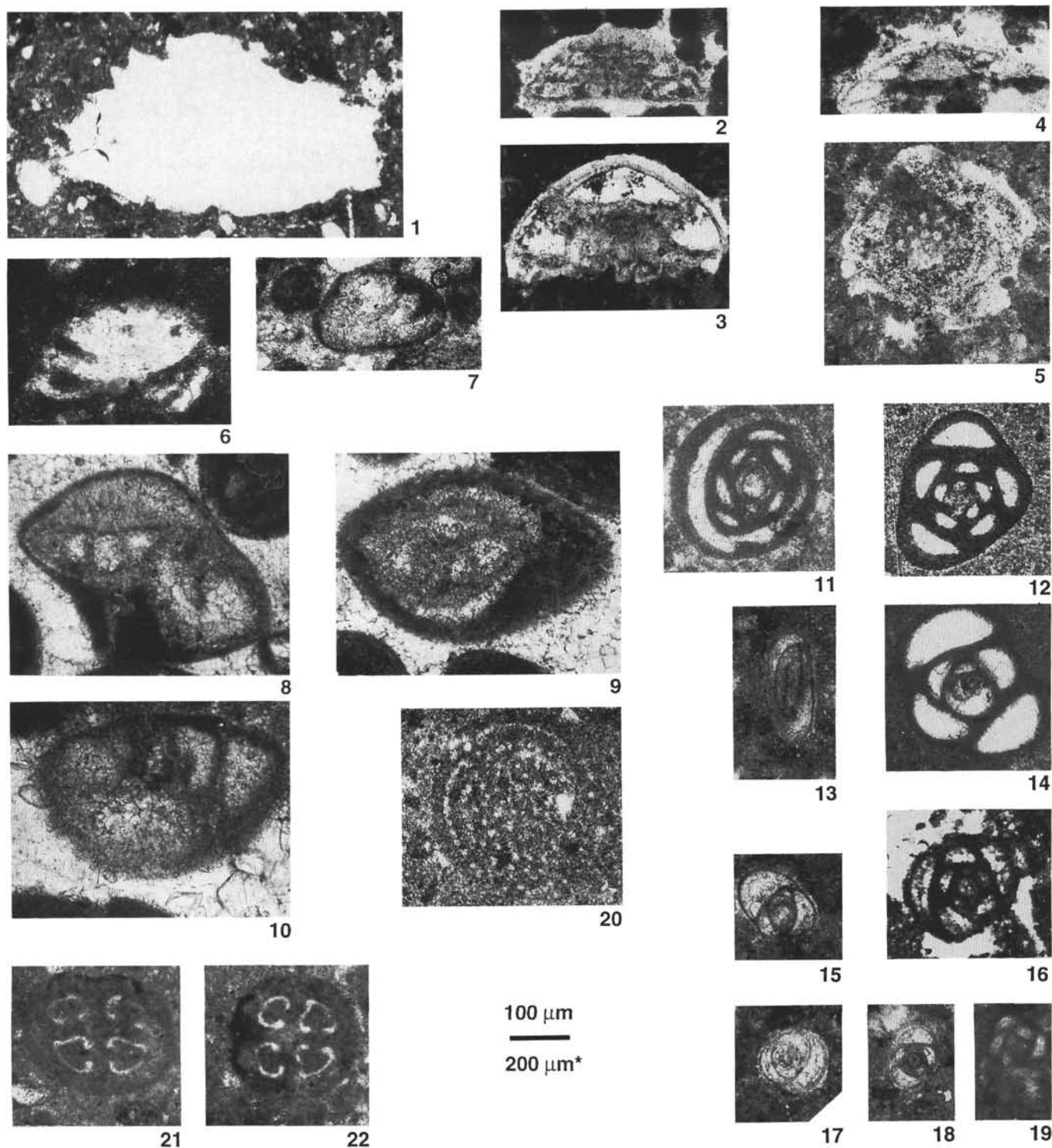


Plate 5. Thin-section micrographs of Early Cretaceous benthic foraminifers from Leg 143. Specimen scale = 100 μm ; *specimens in Figures 1–3 and 6 = 200 μm . 1. *Trocholina* sp. cf. *T. lenticularis*, Sample 143-865A-51R-CC, 11–13 cm. 2, 3. *Neotrocholina* sp. cf. *N. friburgensis*; (2, 3) Sample 143-866A-115R-1, 22–26 cm. 4, 5. *Neotrocholina* sp. cf. *N. infragranulata*; (4) Sample 143-866A-115R-1, 22–26 cm; (5) Sample 143-866A-112R-1, 118–119 cm. 6. *Trocholina molesta*, Sample 143-866A-147R-1, 23–25 cm. 7. *Trocholina* sp. cf. *T. odukpaniensis*, Sample 143-866A-34R-1, 40–42 cm. 8–10. *Protopenneroplis* sp.; (8, 9) Sample 143-866A-127R-1, 25–27 cm; (10) Sample 143-866A-125R-1, 143–145 cm. 11. *Pseudonummoloculina* sp., Sample 143-866A-46R-1, 104–106 cm. 12. *Rumanoloculina* sp. cf. *R. minima*, Sample 143-866A-46R-1, 85–87 cm. 13, 15, 17, 18. *Istriloculina* sp. cf. *I. elliptica*, Sample 143-866A-147R-1, 23–25 cm. 14, 16. *Rumanoloculina robusta*; (14) Sample 143-866A-126R-1, 79–80 cm; (16) Sample 143-866A-70R-2, 21–23 cm. 19. *Decussoloculina* sp. cf. *D. mirceai*, Sample 143-866A-171R-1, 21–24 cm. 20. *Favreina* sp. cf. *F. prusensis*, Sample 143-866A-146R-1, 111–114 cm. 21, 22. *Palaxius* sp. A, Sample 143-865A-87R-2, 102–104 cm.