

### 33. BENTHIC FORAMINIFERS AND PALEOBATHYMETRY OF BARROW GROUP (BERRIASIAN-VALANGINIAN) DELTAIC SEQUENCES, SITES 762 AND 763, NORTHWEST SHELF, AUSTRALIA<sup>1</sup>

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#### ABSTRACT

Micropaleontological analysis of the Barrow Group of Sites 762 and 763 has been undertaken with a view to determining the stratigraphic age and depositional environment of the unit. The stratigraphic age of the unit is Berriasian-Valanginian at both sites, in line with palynological findings. The unit is interpreted as having been deposited in a marine deltaic environment. Paleobathymetry at Site 763 (proximal) and Site 762 (distal) is interpreted as having been of the order of 100 m and 200–500 m, respectively. Paleontological evidence for the presence of deep-water submarine fans at Site 763 is lacking. The paleobathymetric significance of the observed variations in the benthic foraminiferal populations at Site 763 remains unclear.

#### INTRODUCTION

The main reason for drilling on the Exmouth Plateau during Ocean Drilling Program (ODP) Leg 122 was to increase regional geological knowledge by comparing and contrasting the latest Jurassic–earliest Cretaceous sedimentary histories at Sites 762 and 763 (Fig. 1). Site 763 appeared on seismic evidence to have been at that time proximal and Site 762 distal to a terrigenous sediment source from a hinterland to the south (Fig. 2). The main aim of the present work was to determine the depth of depositional environment of the Barrow Group (Valanginian-Berriasian unit on Fig. 2) at Sites 762 and 763. A secondary aim was to confirm the palynologically determined Berriasian–early Valanginian stratigraphic age of the unit. The systematic micropaleontology that underpins the stratigraphic and paleobathymetric interpretation is outlined in Appendix A. Studied samples are listed in Appendix B.

#### Previous Work

Tait (1985) has mapped the former Barrow Group delta in the study area. According to his interpretation, it was confined by a system of transforms and spreading axes to the west and by the Flinders Fault to the east and was fed by sediment from the southwest which was channelled to the northeast. It prograded until starved of sediment and formed a final east-west-trending arcuate front which appears to pass between the locations of Site 763 to the south and Site 762 to the north. The topsets and foresets of the southern area were assigned to the Flacourt Formation and the bottomsets of the northern area to the Malouet Formation. The succeeding unit is the Muderong Shale.

#### STRATIGRAPHY

The distributions of microfossils in the Barrow Group of Sites 762 and 763 are given on Tables 1 and 2, respectively. The known stratigraphic ranges of selected key species are given on Figure 3, which is compiled from various published

and unpublished sources. These species, and the absence of older or younger species, indicate a Berriasian-Valanginian age. Palynostratigraphic analyses indicate a Berriasian–early Valanginian age (Brenner, chapter 23, this volume).

#### PALEOBATHYMETRY OF SITE 763

The distribution of microfossils in the Barrow Group of Site 763 is given on Table 2.

#### Indications of a Deltaic Environment

The foraminiferal suborder ratio (Fig. 4) reveals a dominance of agglutinated Textulariina and calcareous Rotaliina and an absence of porcelaneous Miliolina (which latter feature may simply reflect the poorly advanced state of evolution and dispersal of the Miliolina in the Early Cretaceous). Analogy with modern microfaunas suggests a hyposaline marsh, lagoonal or estuarine or normal marine deltaic environment (Murray, 1973; Boltovskoy and Wright, 1976). The low abundance and dominance and moderately high-diversity values (Fig. 5) are further suggestive of a normal marine deltaic environment.

A more proximal setting can also be ruled out on account of the dissimilarity of the fauna as compared to those of the well-documented sub-environments of the modern Mahakam Delta Plain (van Gorsel, 1988) and Mississippi Delta Plain and active birdfoot (Phleger, 1954, 1955, 1960; Hiltermann and Tüxen, 1978; Haman, 1983; Hiltermann and Haman, 1985). These are characterized by the agglutinating foraminifers *Ammoastuta*, *Ammoscalaria*, *Ammotium*, *Arenoparrella*, *Miliammina*, *Polysaccammina*, *Tiptotrocha*, and *Trochamminita*. Many of these genera are restricted to the Cenozoic, but *Ammoastuta* and *Miliammina* are also regarded as indicators of marginal marine environments in the middle part of the Cretaceous (Luger, 1988).

A more distal submarine fan setting also appears unlikely on paleontological evidence, although interpreted fan deposits have been identified between Cores 122-763C-5R and 122-763B-52X. "Flysch-type" (see, for instance, Kaminski et al., 1988) benthic and bathypelagic foraminifers are absent (though, again, this may be due to evolutionary rather than environmental effects). However, the recovery of the nasseline radiolarian *Eucyrtis?* in Core 122-763C-5R may indicate deep water. Modern nasselines are bathypelagic and most

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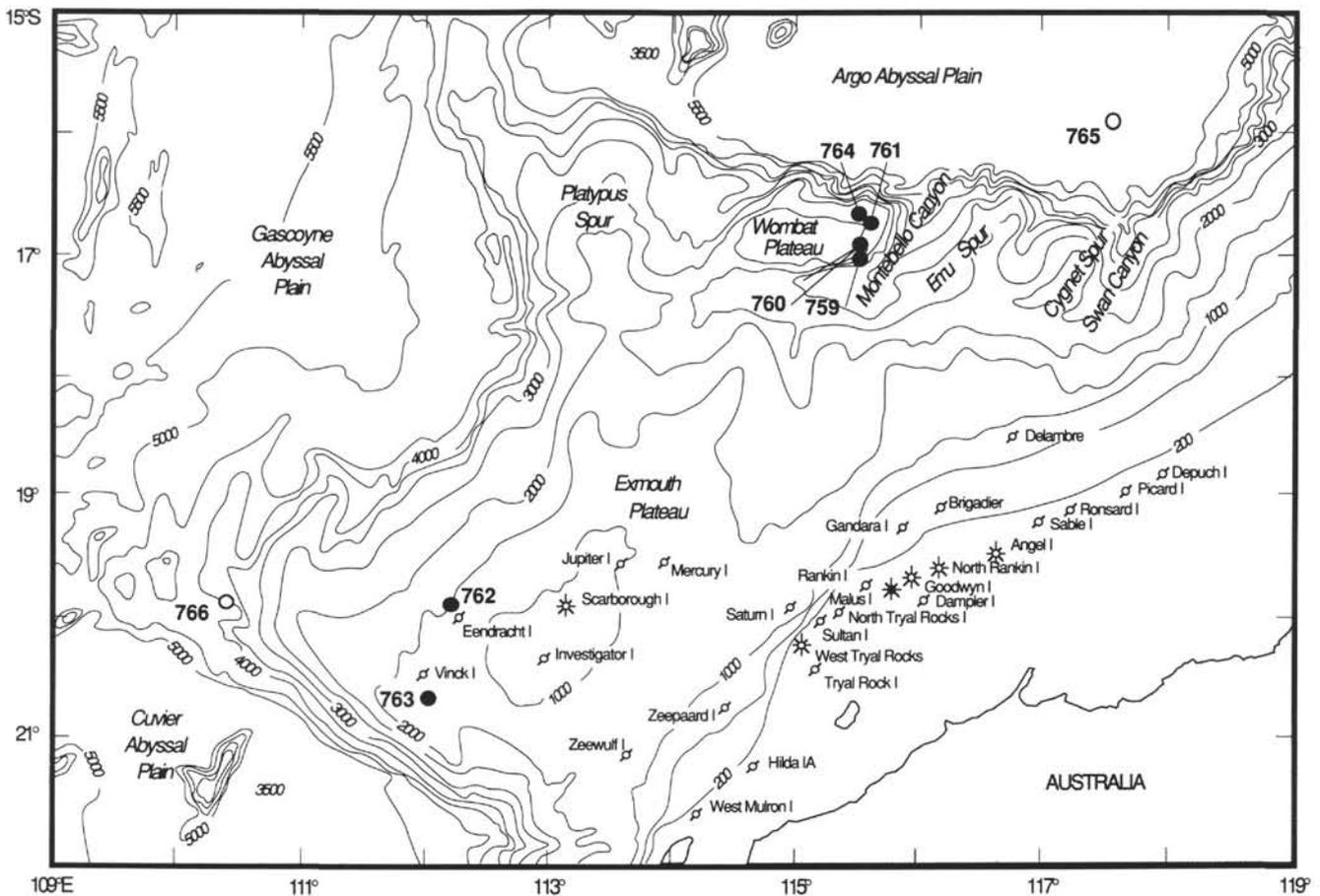


Figure 1. Location map, Sites 762 and 763, Exmouth Plateau, Northwest Shelf, Australia. Closed circles indicate Leg 122 sites, open circles are Leg 123 sites, and other symbols are commercial wells.

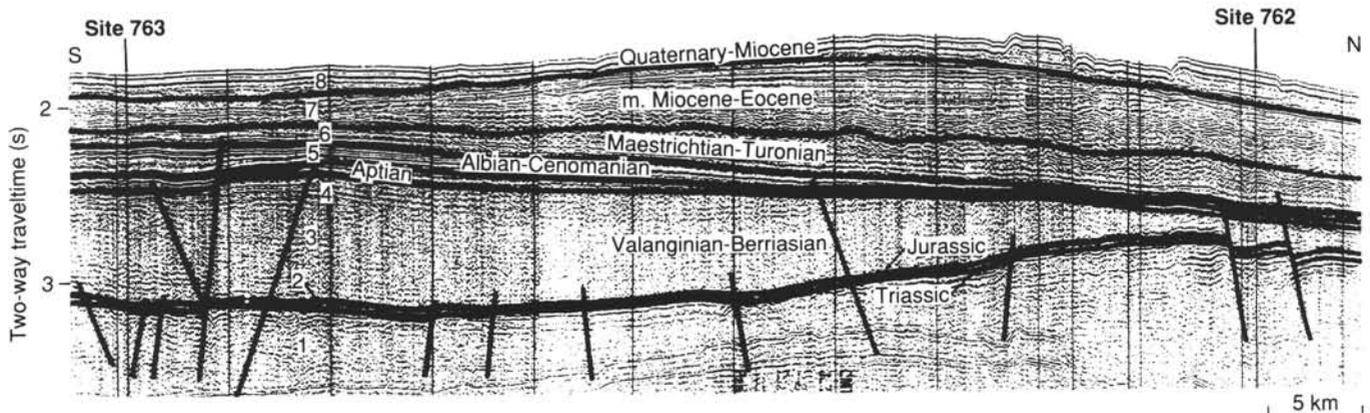


Figure 2. Interpreted seismic section through Sites 762 and 763. Note pronounced thinning of Valanginian-Berriasian (Barrow Group) from south to north.

common in live form in the water column between depths of 200 to more than 2000 m (their bell-like morphology probably represents an adaptation to life in areas of oceanic upwelling) and dead in underlying sediments. Latest Jurassic to earliest Cretaceous forms were probably also oceanic in their ecological preferences (Dyer and Copestake, 1989).

The precise placement within the delta-fan system is difficult to determine. However, foraminiferal assemblages from Site 763 are similar to the so-called "Ammodiscus" or "Ammodiscus-Dentalina" assemblages described by Nagy

(1985a, 1985b) from the Jurassic Dunlin and Brent Formation deltaics of the Statfjord area of the northern North Sea (analogous in terms of extratropical latitude and probably climate and offshore energy if not necessarily in terms of sediment supply and morphology). These indicate delta top and proximal deltaic marine settings, respectively, characterized by high clastic sediment input (Fig. 6). Similar assemblages also occur in the Paleocene-Eocene Moray Group deltaics of the central North Sea (authors' unpublished observations).

**Table 1. Distribution of microfossils in the Barrow Group (Berriasian-Valanginian), Site 762.**

91X	90X	89X	88X	87X	86X	85X	84X	83X	82X	81X	Core No.
											Microfossils
		p	p						p		<i>Bathysiphon</i> sp.
		p									Ammodiscidae Indet.
									p		<i>Haplophragmoides</i> sp.
p											<i>Textularia</i> sp. 1
p											<i>P. kummi</i>
p											Lituolacea Indet.
p	p		p								<i>L. ex gr. muensteri</i>
				p							<i>S. valanginiana</i>
p											Nodosariidae Indet.
				p							<i>C. valendisensis</i>
p											<i>E. caracolla</i>
	p		p							p	Rotaliacea Indet.
		p	p								<i>Cenosphaera</i> sp.
	p		p								Macrofossil debris
p	p										Ichthyoliths

Note: p = present (1–4 specimens); c = common (>5 specimens per 10-cm sample).

### Absolute Depth

The absolute depth of the depositional environment is difficult to determine. However, foraminiferal assemblages from Site 763 plot out in the outer shelf (50–200 m) to upper slope (200–1000 m) field on a triangular plot of foraminiferal “morphogroups” (Fig. 7). Note that the preponderance of textulariids as opposed to hormosinids within infaunal “morphogroup” C is more indicative of the outer shelf (Jones and Charnock, 1985). Further, foraminiferal assemblages from Site 763 are similar taxonomically to those from the middle to outer shelf (20–110 m) of the modern Niger Delta (Adegoke et al., 1976). Lituolids (including uncoiling forms), textulariids (*Textularia*, *Spiroplectammina*), nodosariids (*Lenticulina*), and sundry rotaliiforms are common to both.

Published bathymetric and paleobathymetric ranges of some of the individual foraminiferal taxa from Site 763 confirm the moderate depth. *Lenticulina muensteri* is regarded as an indicator of “mid” shelf (50–150 m) and regressive environments in the Jurassic (Johnson, 1976; Haynes, 1981; Stam, 1986; Morris, 1989), and *Spirillina minima* and various nodosariid and polymorphinid genera are regarded as indicators of outer shelf depths (100–200 m) in the Cretaceous (Sliter and Baker, 1972; Moullade, 1984; Olsson and Nyong, 1984; Olsson, 1988). Forms interpreted by Sliter and Baker (1972), Olsson and Nyong (1984) and Olsson (1988) as indicators of inner and middle shelf depths (0–30 m and 30–100 m, respec-

tively) are absent. These include miliolids and the nodosariid genus *Citharina*.

Astrorhizids, ammodiscids, and *Ammobaculites reophacoides* are regarded by Sliter and Baker (1972) and Moullade (1984) as indicators of slope environments in the Cretaceous. However, many astrorhizids and ammodiscids have upper depth limits as shallow as 30–60 m in the Holocene of the Mediterranean (Lacroix, 1928, 1929), possibly in response to a “delta-effect” of the type described by Pflum and Frerichs (1976) in the Gulf of Mexico. Further, *A. reophacoides* occurs in association with shelf species in the Lower Cretaceous of northwest Germany (Bartenstein, 1952; Bartenstein and Bettenstaedt, 1962) and in the North Sea Basin (authors’ unpublished observations).

Robertinacean species are regarded by Haynes (1981) as indicators of outer shelf and slope environments in the Holocene. However, their Cretaceous counterparts appear to have been restricted to shelf environments (Sliter and Baker, 1972; Hart, 1984; Moullade, 1984). Their apparent absence in Cretaceous slope environments may be at least in part a function of their low preservation potential below the aragonite compensation depth (M. B. Hart, pers. comm., 1990).

The presence of sighted ostracodes throughout the Barrow Group of Site 763 (see also Damotte, this volume) probably confirms an environment within the photic zone (by analogy with the Holocene, no deeper than about 130 m). However, some deeper water ostracodes possess eye tubercles (authors’ unpublished observations).

### Paleobathymetric Trends

The uphole replacement (at around the level of Core 122-763C-33R) of an agglutinate-dominated microfauna by one dominated by calcareous benthic foraminifers may be significant. Nagy (1985a, 1985b) and Nagy et al. (1988) interpret calcareous benthic foraminifers as of more open marine aspect than agglutinates. However, this is not to say that they are necessarily of deeper aspect: the agglutinates might represent an (overdeepened) intrashelf basin facies. It is unclear whether the observed uphole trend represents a deepening or a shoaling. It could even represent a response to a change in some parameter other than depth (such as turbidity).

### Conclusions

The Barrow Group succession at Site 763 is believed to have been deposited in a marine delta in water depths of about 100 m. Paleontological evidence for the presence of submarine fan deposits between Cores 122-763C-5R and 122-763B-52X is generally lacking, though the recovery of a nasselline radiolarian in Core 122-763C-5R could be construed as evidence of bathyal bathymetry (water depth >200 m).

The paleobathymetric significance of the observed changes in the benthic foraminiferal populations at around the level of Core 122-763C-33R remains unclear.

### PALEOBATHYMETRY OF SITE 762

The distribution of microfossils in the Barrow Group sequence of Site 762 is given on Table 1.

### Indications of a Deltaic Environment

As in the case of Site 763, the foraminiferal suborder ratio (Fig. 4) suggests a hyposaline marginal marine or normal marine deltaic environment. Abundance and (composite) diversity values from Site 762 (Fig. 5) are very low, which would tend to suggest some form of environmental stress (Murray, 1973). In this particular instance perhaps the most likely contender would be oxygen deficiency. Foraminiferal assemblages from Site 762 contain a higher proportion of calcareous



benthic foraminifers than those from Site 763 and are closer to (though not as diverse as) the "*Dentalina-Nodosaria*" assemblages described by Nagy (1985a, 1985b) from the Jurassic deltaics of the northern North Sea (see above). These indicate a distal deltaic marine setting characterized by low clastic sediment input (Fig. 6).

#### Absolute Depth

In regard to absolute depth, the foraminiferal "morphogroup" ratio (Fig. 7) suggests an outer shelf (50–200 m) to upper slope (200–1000 m) environment, with the proportion of "morphogroup" A (tubular forms interpreted as suspension-feeders) further suggesting the latter rather than the former (Jones and Charnock, 1985). The absence of sighted ostracodes probably confirms an environment below the "light floor" (130 m).

The finding of the pelagic spumelline radiolarian *Cenosphaera* in Cores 122-762C-89X and 122-762C-88X is significant: modern spumellines are most common in live form between depths of 0–500 m in the water column (their spherical and spinose morphology probably represents an adaptation to reduce sinking rate and to maintain a position close to the photic zone, where symbiotic zooxanthellae can provide a food source) and in dead form in underlying bottom sediments. Greater depths can probably be ruled out on the basis of the absence of bathypelagic nassellines (see above).

#### Conclusion

The Barrow Group succession at Site 762 is believed to have been deposited in a marine delta in water depths of about 200–500 m.

#### SUMMARY OF RESULTS

Micropaleontological analysis indicates that the Barrow Group succession of Sites 762 and 763 is of Berriasian-Valanginian age.

Analogy with ancient and modern counterparts indicates that Barrow Group microfossil assemblages from Sites 763 and 762 were deposited in a marine delta. Paleobathymetry at Site 763 (proximal) and Site 762 (distal) is interpreted as having been of the order of 100 m and 200–500 m, respectively. Paleontological evidence for the presence of deep-water submarine fans at Site 763 is lacking. The paleobathymetric significance of the observed variations in the benthic foraminiferal populations at Site 763 remains unclear.

#### Regional Implications

Paleontological evidence points to a greater paleobathymetry at Site 762 than at Site 763 throughout the studied interval. The apparent Triassic-Jurassic structural "high" underlying Site 762 (see Fig. 2) may therefore be a secondary rather than a primary feature. It may be due to differential subsidence at the two sites brought about by differences in deposited thickness of Barrow Group sediments.

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## APPENDIX A

SYSTEMATIC MICROPALAEONTOLOGY  
FORAMINIFERA

The suprageneric classification adopted herein is essentially that of Loeblich and Tappan (1964), with some modifications after Haynes (1981). Original generic designations of all species are given in order to enable interested readers to compare the figures in this paper with the type figures (by reference to the Ellis and Messina Catalogue of Foraminifera (1940 et seq.)). Specimens figured in this paper are housed at the BP Research Centre, Sunbury-on-Thames.

Suborder TEXTULARIINA  
Superfamily AMMODISCACEA  
Family SACCAMMINIDAE

Saccamminid indet.

## Family ASTRORHIZIDAE

*Bathysiphon* sp. Close to *Bathysiphon* sp. as figured by Bartenstein (1974) from the Upper Jurassic–Lower Cretaceous of DSDP Sites 259 and 261, eastern Indian Ocean.

*Hyperammina* sp. Close to *Hyperammina* spp. B and C as figured by Crespin (1963) from the Lower Cretaceous of Australia and *H.* sp. 1 as figured by Bartenstein (1974) from the Upper Jurassic–Lower Cretaceous of DSDP Sites 259 and 261, eastern Indian Ocean.

## Family AMMODISCIDAE

*Ammodiscus* sp.  
*Glomospira gaultina* (Berthelin) [*Ammodiscus gaultinus* Berthelin]  
*Glomospira* sp.

## Superfamily LITUOLACEA

Lituolacea indet.

## Family LITUOLIDAE

*Ammobaculites reophacoides* Bartenstein. Differs from the types only in the proportionately larger diameter of the planispiral portion. In this respect it is close to *A. subcretaceus* Cushman and Alexander, from which it differs in its inflated test form.

*Ammomarginulina* sp.

*Haplophragmium inconstans inconstans* Bartenstein and Brand. Appears identical to the specimens figured by Kuznetsova (1974) from DSDP Site 261, eastern Indian Ocean.

*Haplophragmoides cushmani* Loeblich and Tappan This species was originally described from the Albian of the United States. Our specimens are close to that figured by Bartenstein and Brand (1951) from the Valanginian-Hauterivian of northwest Germany and to that figured (as *Haplophragmoides nononoides* (Hauessler)

(sic) by Gradstein et al. (1989) from the Tithonian of central Nepal.

*Haplophragmoides* cf. *infracaloviensis* Dain. Appears identical to specimens figured under this designation by Løfaldli and Nagy (1983) from the Volgian (boreal equivalent of the early Berriasian and Tithonian) of Spitzbergen. Also to *H.* cf. *concaus* (Chapman) as recently figured by Lott et al. (1986) from the Ryazanian (boreal equivalent of the late Berriasian) of the Speeton Clay Formation of northeast England.

*Haplophragmoides* sp. A strongly biumbilicate form, approaching *H. nonioninoides* of authors (not Reuss).

*Hormosina* sp.

*Praecystammia*? sp. The apparently streptospiral coiling and areal aperture indicate placement in the genus *Praecystammia* Krasheninnikov, previously known only from Late Cretaceous deep-water sediments (e.g., Indian and Pacific oceans (Krasheninnikov (1973, 1974)). Trochospirally coiled forms with areal apertures belong in *Pseudotrochammia* Frerichs.

#### Family TEXTULARIIDAE

*Textularia bettenstaedti* Bartenstein and Oertli. Appears identical to the specimen recently figured under this designation by Szejn (1988) from the Ryazanian of the Polish Lowlands. Also to *T. depravata* Schwager as figured by Kuznetsova (1974) from the Upper Jurassic–Lower Cretaceous of DSDP Site 261, eastern Indian Ocean. *T. foeda* Reuss is morphologically similar, but records indicate that this is a stratigraphically younger (Barremian–Albian) species.

*Textularia* sp. 1. Close to *T. chapmani* Lalicker. However, records indicate that this is a stratigraphically younger (Albian–Cenomanian) species.

*Textularia*? sp. Close to *T. inversa* (Terquem) as figured by Kuznetsova (1974) from the Upper Jurassic–Lower Cretaceous of DSDP Site 261, eastern Indian Ocean. The absence through breakage of the initial part of the test renders confirmation of the identification impossible.

*Spirolectammia*? sp. Arguably a growth stage of the ultimately uniserial genus *Ammobaculoides*.

#### Family TROCHAMMINIDAE

*Trochammia* sp. A distinctive high-spired *Trochammia* close to *T. gryci* Tappan and to *T. topagorukensis* Tappan, originally described from the Upper Jurassic of the arctic slope of Alaska, and subsequently recorded from the Oxfordian–Valanginian of Spitzbergen by Løfaldli and Nagy (1983). However, it differs from the former in possessing fewer chambers per whorl and from the latter in possessing radial sutures on the spiral side. Compressed specimens recall both *T. neocomiana* Myatliuk and *T. depressa* Lozo. *T. neocomiana* was originally described from the Barremian of the U.S.S.R. and has subsequently been recorded from the Berriasian of that country (Basov et al., 1973), while *T. depressa* was originally described from the Comanchean (broadly Aptian–Albian) of Texas and has subsequently been recorded in the Ryazanian (boreal equivalent of the late Berriasian) to early Barremian of northwest Europe (Hart et al., 1981).

#### Family VERNEUILINIDAE

*Protomarssonella kummi* (Zedler) [*Marssonella kummi* Zedler]. Appears identical to the specimens recently figured by Desai and Banner (1987) from the Hauterivian of Speeton. The total range of this species is Valanginian–Hauterivian.

*Verneuilinoides neocomiensis* (Myatliuk) s.l. [*Verneuilina neocomiensis* Myatliuk]. Included here are not only forms which are triserial throughout and therefore typical *Verneuilinoides*, but also some which are more loosely coiled and tend toward biseriality or semi-uniseriality, thereby approaching *Gaudryina*, *Gaudryinella*, and *Pseudobolivina* (see Chamney (1976, 1978) on the difficulties of separating these genera). Certain of the latter bear a close resemblance (particularly in terms of apertural characteristics) to specimens of *Gaudryina tailleuri* Tappan (1962) from the Albian and older Fortress Mountain Formation of the arctic slope of

Alaska and (to a slightly lesser extent) to the “Neocomian” (?Barremian) *G. tappanae* Chamney from Rock Unit 1 of the Mount Goodenough section, Aklavik Range, District of Mackenzie, Canada.

#### Suborder ROTALIIDAE Superfamily NODOSARIACEA Family NODOSARIIDAE

Generic placement within this group follows Loeblich and Tappan (1964). I have not recognized any of the genera distinguished solely on the basis of surface ornamentation by Loeblich and Tappan (1988).

*Astacolus* sp. Close to *A. dilectus* (Reuss), as figured by Kuznetsova (1974) from the Upper Jurassic–Lower Cretaceous of DSDP Site 261, eastern Indian Ocean. (1983) from the Albian of DSDP Site 511, Falkland Plateau.

*Dentalina* sp. 2. Appears identical to *D.* sp. 2 Bartenstein and Brand from the Valanginian of northwest Germany.

*Fronicularia* cf. *hastata* Roemer. Probably a megalospheric juvenile of this species.

*Fronicularia* sp. Close to *F. concinna* Koch, but lacks the longitudinal ornament.

*Lagena neocomiana* (Bartenstein and Brand) [*L. apiculata* (Reuss) var. *neocomiana* Bartenstein and Brand] *Oolina apiculata* Reuss possesses a radiate aperture and is in fact the type-species of the genus *Reussolina* Colom, 1956. The erstwhile variety *neocomiana* is therefore herein treated as a distinct species of *Lagena*. *L. hauteriviana hauteriviana* Bartenstein and Brand, which evolved from *L. neocomiana* at the base of the Hauterivian (Bettenstaedt and Spiegler, 1975) differs in being more elongate-ovate.

*Lagena* sp. 1. Close to the Hauterivian–Barremian form *L. hauteriviana cylindracea* Bartenstein and Brand, but differs in possessing costate ornament.

*Lagena* sp. 2. Appears identical to *L. oxystoma* Reuss as figured by Bartenstein and Brand (1951) and Bartenstein and Bettenstaedt (1962) from the Valanginian and Hauterivian–Barremian respectively of northwest West Germany, but unlikely to be conspecific with Reuss's original from the Tertiary. One specimen appears to possess apertures at either end, and might represent the broken terminal portion of a multilocular foraminifer such as *Marginulinopsis foeda* (Reuss) or *M. gracilissima* (Reuss).

*Lagena* sp. 3

*Lenticulina* ex gr. *muensteri* (Roemer) [*Robulina muensteri* Roemer]. All inornate lenticulines are herein referred to this morphologically plastic relict Jurassic group. As herein interpreted, it includes not only forms close to *L. muensteri* s.s. (Pl. 2, Fig. 9), but also uncoiling forms approaching the essentially Valanginian species *L. subangulata* (Reuss) (Pl. 2, Fig. 10) and forms with apparent incipient sutural nodosity approaching the Valanginian–early Hauterivian species *L. nodosa* (Reuss).

*Marginulinopsis* cf. *robusta* (Bartenstein and Brand) [*Lenticulina (Marginulinopsis) robusta* Bartenstein and Brand]. Close to the types, but has fewer and stronger longitudinal costae.

cf. *Nodosaria sceptrum* Reuss. Fragments tentatively assigned to this species on the basis of the similarity of their ornament.

*Pseudonodosaria* cf. *humilis* (Roemer) [*Nodosaria humilis* Roemer]. Appears identical to *Pseudoglandulina* cf. *humilis* (Roemer) as figured by Bartenstein and Brand (1951) from the Valanginian of northwest West Germany. Close to *Rectoglandulina humilis* (Roemer) as figured by Kuznetsova (1974) from the Upper Jurassic–Lower Cretaceous of DSDP Site 261, eastern Indian Ocean, and to *Pseudonodosaria humilis* (Roemer) as figured by Lott et al. (1986) from the Valanginian–Hauterivian of the Speeton Clay Formation, northeast England. The identity with Roemer's original from the Cretaceous Kreideformation of Germany cannot be confirmed.

*Saracenaria valanginiana* (Bartenstein and Brand) [*Lenticulina (Saracenaria) valanginiana* Bartenstein and Brand]

*Saracenaria* sp. Close to *S. topagorukensis* Tappan from the Upper Jurassic of the arctic slope of Alaska.

*Vaginulina* sp. Close to both *V. incurvata* (Reuss) and *V. exilis* (Reuss) as figured by Kuznetsova (1974) from the Upper Jurassic–Lower Cretaceous of DSDP Site 261, eastern Indian Ocean.

Nodosariidae indet.  
Family LINGULINIDAE

*Lingulina* sp. Close to the Early Cretaceous species *L. nodosaria* Reuss, but differs in lacking a lobulate periphery. In this respect it approaches *L. semiornata* var. *crassa* Chapman from the Aptian-Albian of Surrey, southeast England, from which it differs in lacking sutural ornament. The presence of weak longitudinal ridges on the present form is notable, and calls to mind the essentially Early Jurassic *L. tenera* plexus.

Family POLYMORPHINIDAE  
Polymorphinid indet.  
Superfamily ROBERTINACEA  
Family CONORBOIDIDAE

*Conorboides valendisensis* Bartenstein and Brand

Family EPISTOMINIDAE

*Epistomina caracolla* (Roemer) [*Gyrodina caracolla* Roemer]

Superfamily ROTALIACEA  
Rotaliacea indet.  
Superfamily SPIRILLINACEA  
Family SPIRILLINIDAE

*Spirillina minima* Schacko. Appears identical to the types from the Cretaceous of Germany and to the specimens figured by Kuznetsova (1974) from the Upper Jurassic-Lower Cretaceous of DSDP Site 261, eastern Indian Ocean. Similar specimens from the Berriasian-Barremian of France and Germany have been described by Moullade (1961, 1966) and more recently by Decker and Rögl (1988) (as *S. neocomiana* Moullade).

RADIOLARIANS

The suprageneric classification adopted herein is essentially that of Campbell and Moore (1954), with some modifications after Sanfilippo and Riedel (1985) and Dyer and Copestake (1989): generic assignment is provisional only (see also Blome, this volume).

Suborder SPUMELLINA  
Superfamily LIOSPHAERICAE  
Affinity uncertain

*Cenosphaera* sp.

Suborder NASSELLINA  
Affinities uncertain

*Eucyrtis?* sp. The present specimen is close to representatives of the genus *Eucyrtis* as figured by Sanfilippo and Riedel (1985), notably to *E. hanni* s.l., which ranges from Berriasian-Aptian and is known to occur in the southern Pacific. However, its cephalis is proportionately larger and lacks an apical horn and its distal segments are unornamented.

APPENDIX B

STUDIED SAMPLES

122-762C-81X-1, 60-62 cm	122-763C-17R-2, 109-111 cm
122-762C-82X-2, 60-62 cm	122-763C-18R-2, 107-111 cm
122-762C-84X-CC	122-763C-19R-2, 109-111 cm
122-762C-85X-2, 61-63 cm	122-763C-20R-2, 109-111 cm
122-762C-86X-1, 60-62 cm	122-763C-21R-2, 109-111 cm
122-762C-87X-1, 60-62 cm	122-763C-22R-2, 107-110 cm
122-762C-88X-1, 61-63 cm	122-763C-23R-2, 110-112 cm
122-762C-89X-3, 60-62 cm	122-763C-24R-2, 107-109 cm
122-762C-90X-1, 60-62 cm	122-763C-25R-2, 109-111 cm
122-762C-91X-1, 61-63 cm	122-763C-26R-2, 108-110 cm
122-762C-96X-2, 110-112 cm	122-763C-27R-2, 109-111 cm
122-763B-47X-2, 78-80 cm	122-763C-28R-2, 108-110 cm
122-763B-49X-2, 109-111 cm	122-763C-29R-2, 106-109 cm
122-763B-50X-2, 107-109 cm	122-763C-30R-2, 109-111 cm
122-763B-51X-2, 109-111 cm	122-763C-31R-1, 109-111 cm
122-763B-52X-CC	122-763C-32R-2, 110-112 cm
122-763B-53X-1, 109-111 cm	122-763C-33R-2, 109-111 cm
122-763B-54X-1, 95-97 cm	122-763C-34R-2, 109-111 cm
122-763C-4R-CC	122-763C-35R-2, 109-111 cm
122-763C-5R-CC	122-763C-36R-1, 108-110 cm
122-763C-6R-3, 28-30 cm	122-763C-37R-2, 109-111 cm
122-763C-7R-2, 109-111 cm	122-763C-38R-2, 109-111 cm
122-763C-8R-3, 109-111 cm	122-763C-39R-2, 109-111 cm
122-763C-9R-3, 107-109 cm	122-763C-40R-2, 109-111 cm
122-763C-10R-3, 65-68 cm	122-763C-41R-3, 110-112 cm
122-763C-11R-1, 114-116 cm	122-763C-42R-2, 112-114 cm
122-763C-12R-1, 107-109 cm	122-763C-43R-2, 107-109 cm
122-763C-13R-2, 110-112 cm	122-763C-44R-2, 110-112 cm
122-763C-14R-2, 109-111 cm	122-763C-45R-2, 110-112 cm
122-763C-15R-1, 109-111 cm	122-763C-46R-2, 109-111 cm
122-763C-16R-2, 109-111 cm	

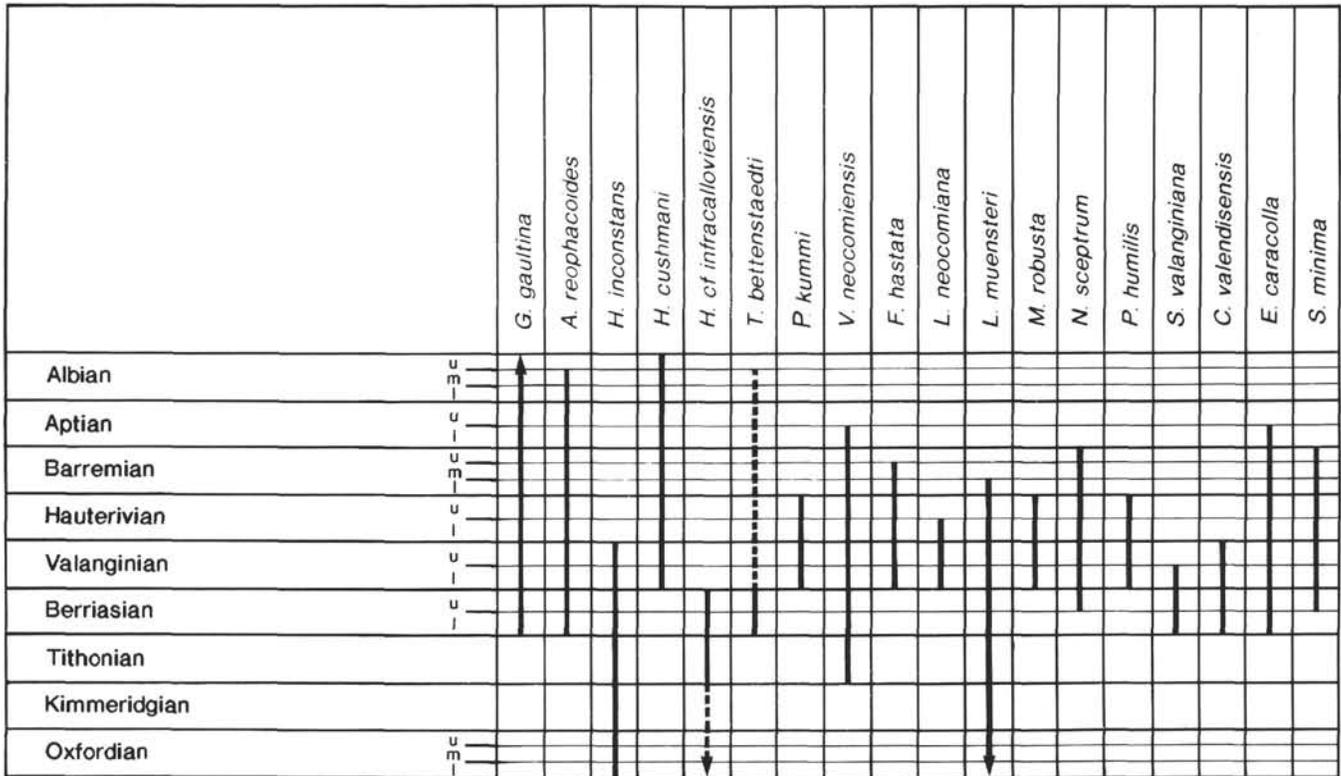


Figure 3. Known stratigraphic ranges of microfossils found in the Barrow Group, Sites 762 and 763.

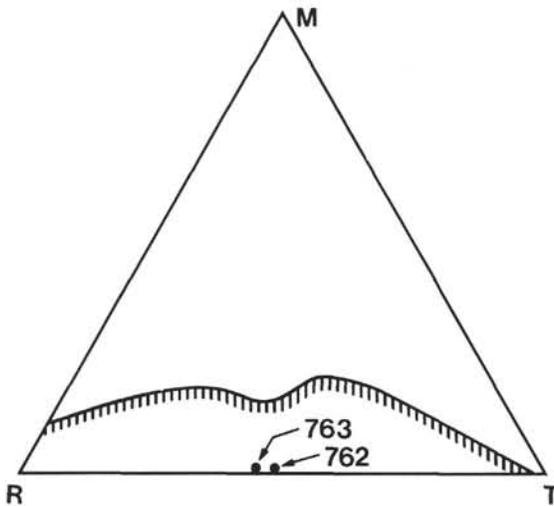


Figure 4. Triangular plot of foraminiferal suborders, Sites 762 and 763. T = Textulariina; M = Miliolina; R = Rotallina. Enclosed area is the shelf sea field of Murray (1973). Note that bathyal and abyssal assemblages also plot out in this field (Jones, 1984).

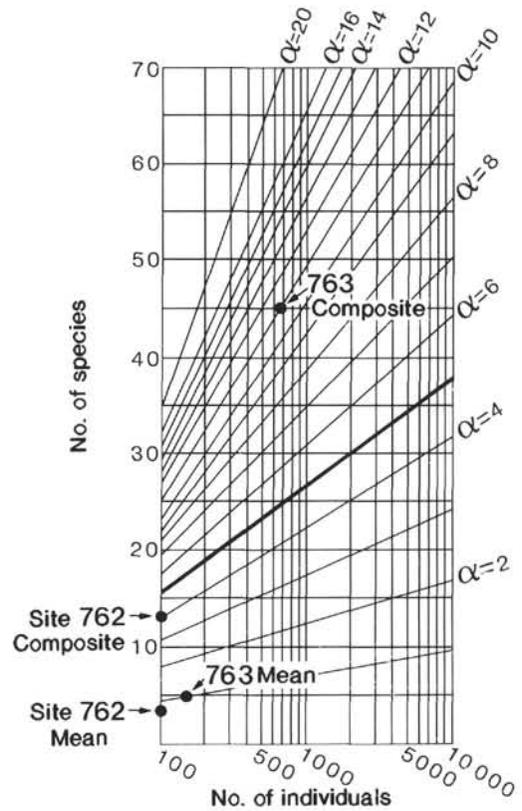


Figure 5. Fisher ( $\alpha$ ) diversity plot of foraminifers, Sites 762 and 763.

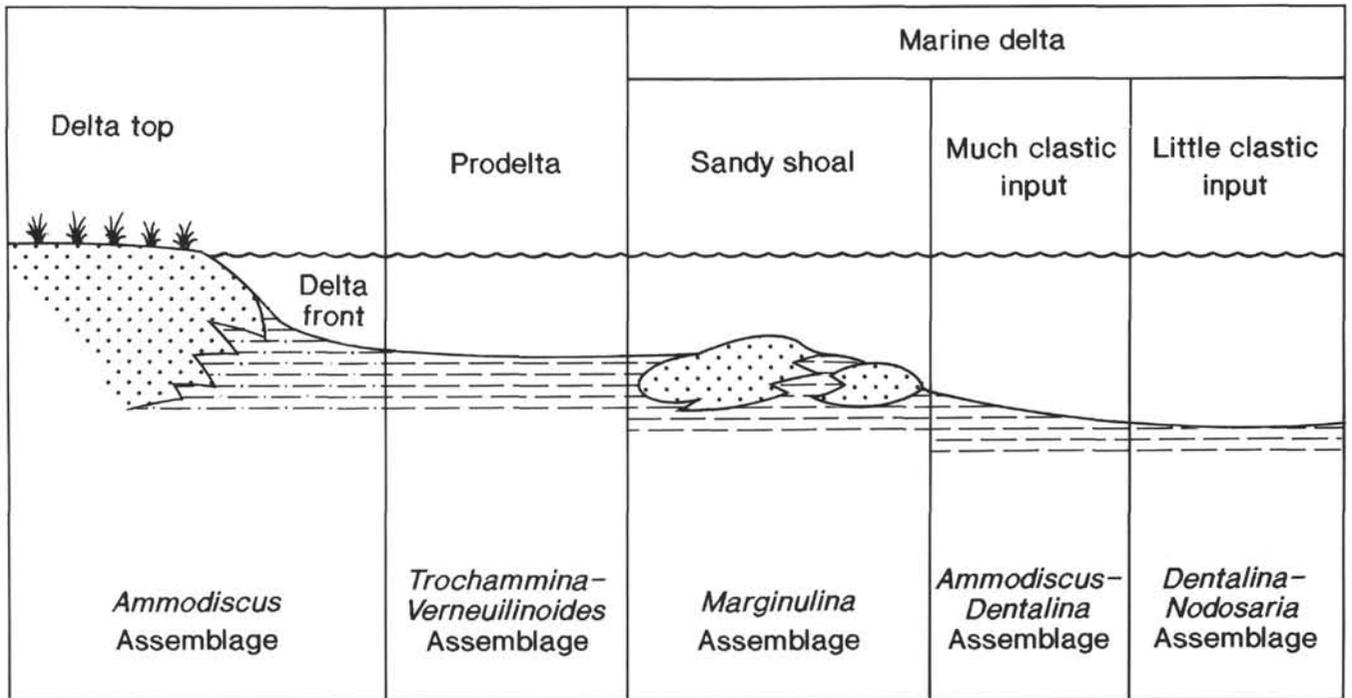


Figure 6. Conceptual model of foraminiferal distribution in deltaic sub-environments in the Mesozoic (after Nagy, 1985a, 1985b). No scale implied.

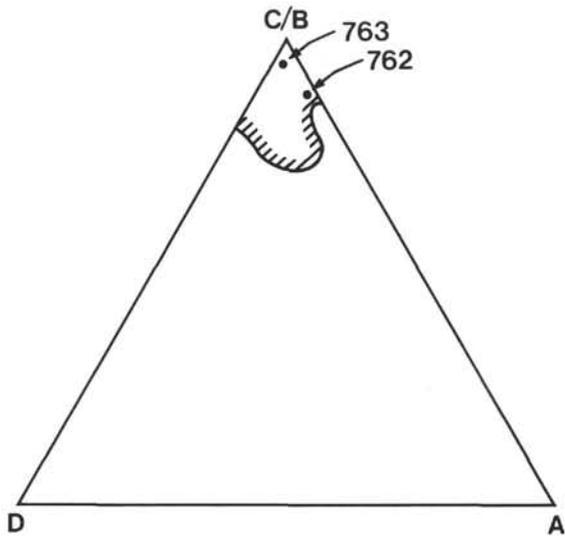


Figure 7. Triangular plot of foraminiferal "morphogroups," Sites 762 and 763. A = suspension feeders; C/B = epifaunal/infaunal detritivores; D = herbivores. Enclosed area is the outer shelf-upper slope field of Jones and Charnock (1985).

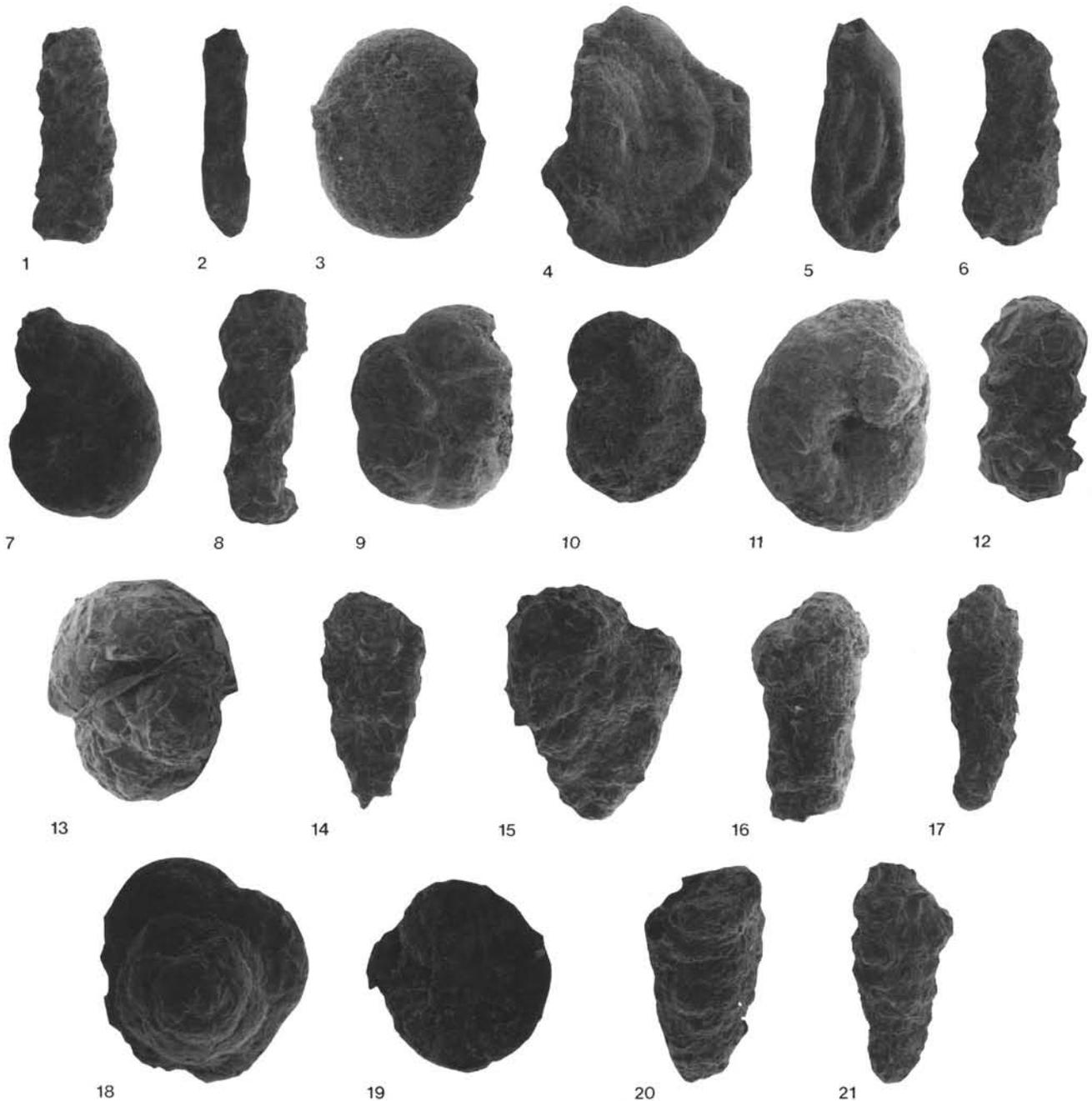


Plate 1. Agglutinating foraminifera. 1. *Bathysiphon* sp., Sample 122-763C-31R-1, 109–111 cm,  $\times 75$ . 2. *Hyperammina* sp., Sample 122-763C-37R-2, 109–111 cm,  $\times 45$ . 3. *Ammodiscus* sp., Sample 122-763C-25R-2, 109–111 cm,  $\times 165$ . 4. *Glomospira gaultina* (Berthelin), Sample 122-763C-21R-2, 109–111 cm,  $\times 80$ . 5. *Glomospira* sp., Sample 122-763C-21R-2, 109–111 cm,  $\times 100$ . 6. *Ammobaculites reophacoides* Bartenstein, Sample 122-763C-24R-2, 107–109 cm,  $\times 45$ . 7. *Ammomarginulina* sp., Sample 122-763C-6R-3, 28–30 cm,  $\times 37.5$ . 8. *Haplophragmium inconstans inconstans* Bartenstein and Brand, Sample 122-763C-30R-2, 109–111 cm,  $\times 40$ . 9. *Haplophragmoides cushmani* Loeblich and Tappan, Sample 122-763C-31R-1, 109–111 cm,  $\times 115$ . 10. *H.* cf. *infracallovienensis* Dain, Sample 122-763C-4R-CC,  $\times 100$ . 11. *H.* sp., Sample 122-763C-8R-3, 109–111 cm,  $\times 60$ . 12. *Hormosina* sp., Sample 122-763C-34R-2, 109–111 cm,  $\times 80$ . 13. *Praecystammina?* sp., Sample 122-763C-24R-2, 107–109 cm,  $\times 90$ . 14. *Textularia bettenstaedti* Bartenstein and Oertli, Sample 122-763C-34R-2, 109–111 cm,  $\times 110$ . 15. *T.* sp. 1, Sample 122-763C-33R-2, 109–111 cm,  $\times 135$ . 16. *T.?* sp., Sample 122-763C-16R-2, 109–111 cm,  $\times 125$ . 17. *Spiroplectammina?* sp., Sample 122-763C-32R-2, 110–112 cm,  $\times 55$ . 18, 19. *Trochammina* sp., Sample 122-763C-6R-3, 28–30 cm,  $\times 150$ . 20. *Protomarssonella kummi* (Zedler), Sample 122-762C-91X-1, 61–63 cm,  $\times 125$ . 21. *Verneuilinoides neocomiensis* (Myatliuk) s.l., Sample 122-763C-34R-2, 109–111 cm,  $\times 75$ .

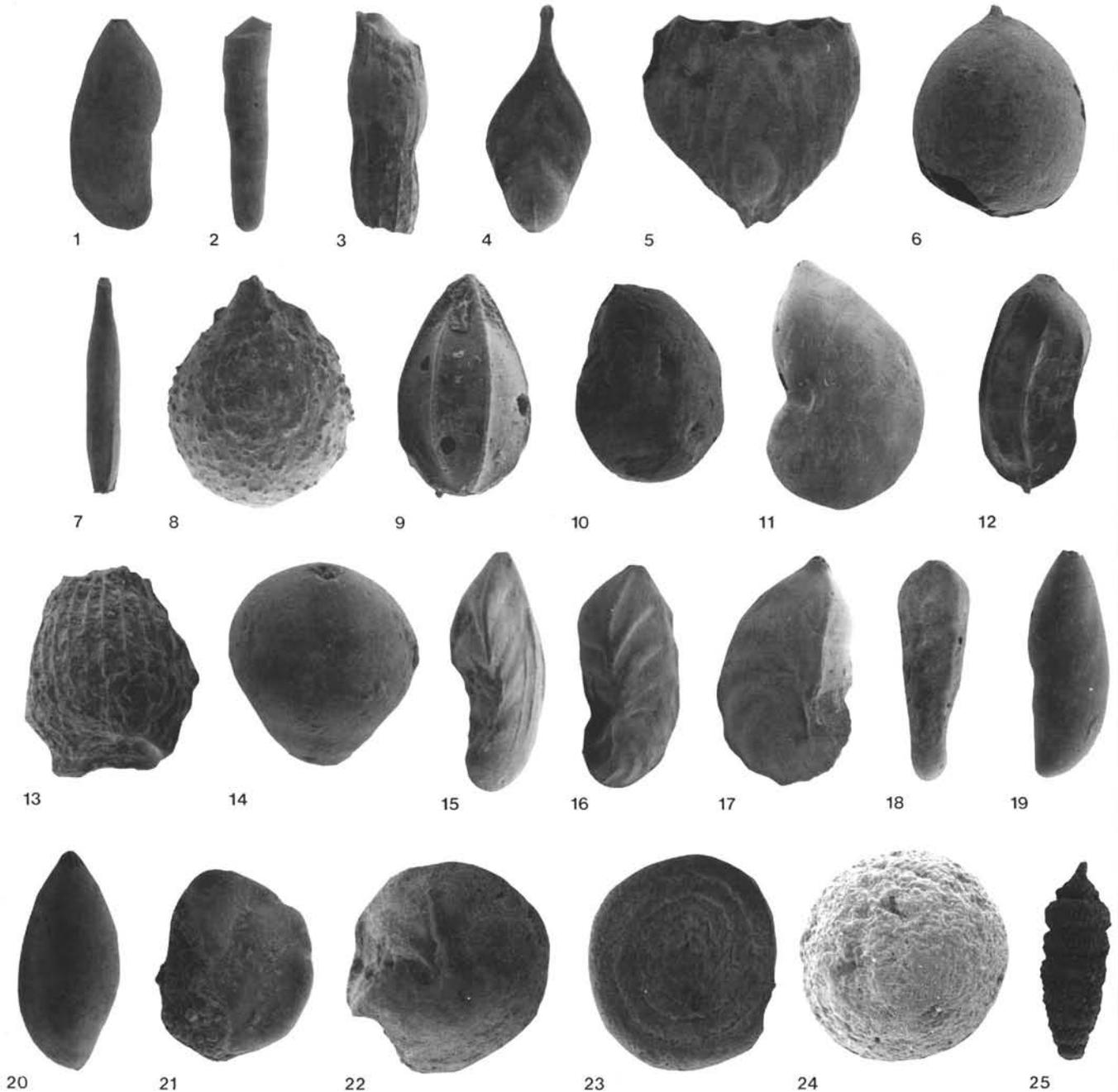


Plate 2. Calcareous benthic foraminifers and radiolarians. 1. *Astacolus* sp., Sample 122-763C-38R-2, 109–111 cm,  $\times 75$ . 2. *Dentalina* sp. 1, Sample 122-763C-19R-2, 109–111 cm,  $\times 45$ . 3. *D.* sp. 2, Sample 122-763C-16R-2, 109–111 cm,  $\times 55$ . 4. *Frondicularia* cf. *hastata* Roemer, Sample 122-763C-21R-2, 109–111 cm,  $\times 70$ . 5. *F.* sp., Sample 122-763C-32R-2, 110–112 cm,  $\times 60$ . 6. *Lagena neocomiana* (Bartenstein and Brand), Sample 122-763C-33R-2, 109–111 cm,  $\times 110$ . 7. *L.* sp. 1, Sample 122-763C-21R-2, 109–111 cm,  $\times 65$ . 8. *L.* sp. 2, Sample 122-763C-46R-2, 109–111 cm,  $\times 110$ . 9. *L.* sp. 3, Sample 122-763C-16R-2, 109–111 cm,  $\times 150$ . 10, 11. *Lenticulina* ex gr. *muensteri* (Roemer), Sample 122-763C-5R-CC,  $\times 110$  (10); Sample 122-763C-19R-2, 109–111 cm,  $\times 100$  (11). 12. *Marginulinopsis* cf. *robusta* (Bartenstein and Brand), Sample 122-763C-20R-2, 109–111 cm,  $\times 80$ . 13. cf. *Nodosaria sceptrum* Reuss, Sample 122-763C-30R-2, 109–111 cm,  $\times 125$ . 14. *Pseudonodosaria* cf. *humilis* (Roemer) Sample 122-763C-8R-3, 109–111 cm,  $\times 115$ . 15, 16. *Saracenaria valanginiana* (Bartenstein and Brand), Sample 122-763C-11R-1, 114–116 cm,  $\times 40$  (15); Sample 122-762C-86X-1, 60–62 cm,  $\times 25$  (16). 17. *S.* sp., Sample 122-763C-16R-2, 109–111 cm,  $\times 70$ . 18. *Vaginulina* sp., Sample 122-763C-21R-2, 109–111 cm,  $\times 80$ . 19. *Lingulina* sp., Sample 122-763C-31R-1, 109–111 cm,  $\times 50$ . 20. Polymorphinid indet., Sample 122-763C-7R-2, 109–111 cm,  $\times 75$ . 21. *Conorboides valendisensis* Bartenstein and Brand, Sample 122-763C-8R-3, 109–111 cm,  $\times 125$ . 22. *Epistomina caracolla* (Roemer), Sample 122-762C-91X-1, 61–63 cm,  $\times 135$ . 23. *Spirillina minima* Schacko, Sample 122-763C-38R-2, 109–111 cm,  $\times 100$ . 24. *Cenosphaera* sp., Sample 122-762C-88X-1, 61–63 cm,  $\times 100$ . 25. *Eucyrtis?* sp., Sample 122-763C-5R-CC,  $\times 75$ .