

LABORATORY MANUAL FOR
MICROPALEONTOLOGY AND VERTEBRATE
PALEONTOLOGY

(GLC 508)



BY
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General instructions

- Switch on the illuminator only during the microscopic observation
- Don't play with goose neck light system
- Use the zoom-body up-down knob as well as focusing unit very gently
- Try to use low light during microscopic observation
- Set the eye-pieces as per your own eye-sight
- Don't move the microscope from its own position
- Cover the microscope properly after use
- Micropaleontological slides must be hold by two hands
- Micropaleontological slides must be keep in horizontal position
- Don't open the glass cover on micropaleontological slides

Course Type	Course Code	Name of Course	L	T	P	Credit
DC	GLC 508	Micropalaeontology and Vertebrate Palaeontology Practical	0	0	2	2

Course Objective

The primary objective of the course is to introduce students with benthic foraminifera (up to generic level) and planktic foraminifera (up to species level), few aspects of population counts of foraminifera. Also, students will be introduced with available molar teeth fossils of vertebrates.

Learning Outcomes

Upon completion of the course, students will be able to:

- Identify of benthic (with their depth, food and oxygen preference) and planktic groups with biostratigraphic ages.
- Apply census count for understanding paleo-events
- Identify teeth with food pattern and animal forms.

Unit No.	Topics to be Covered	Learning Outcome
1	Morphology, identification and systematics of some benthic foraminifera (Based on depth preference and physical properties of marine water).	Identification of different kind of benthic foraminifera based on their morphology. Also, knowledge will be imparted regarding their ecological preferences based on their morphology.
2	Morphology, identification and systematics of some Planktic foraminifera.	Identification of different kind of planktic foraminifera along with their stratigraphic distribution.
3	Study of some molar teeth of mammals	Practical observation of different molar tooth of kinds of elephant, horses etc. with their stratigraphic distribution.
4	Practical examination	Evaluation of learning outcome

Text Books:

1. Holbourn, A., Henderson, A. S., and MacLeod, N., (2013)-Atlas of Benthic Foraminifera.-Wiley-Blackwell, pp. 642.
2. Loeblich, A. R., and Tappan, H., 1988. Foraminiferal genera and their classification (Vol. 1 and 2). Van Nostrand Reinhold, USA, pp. 970 and plates 847.

Reference Books:

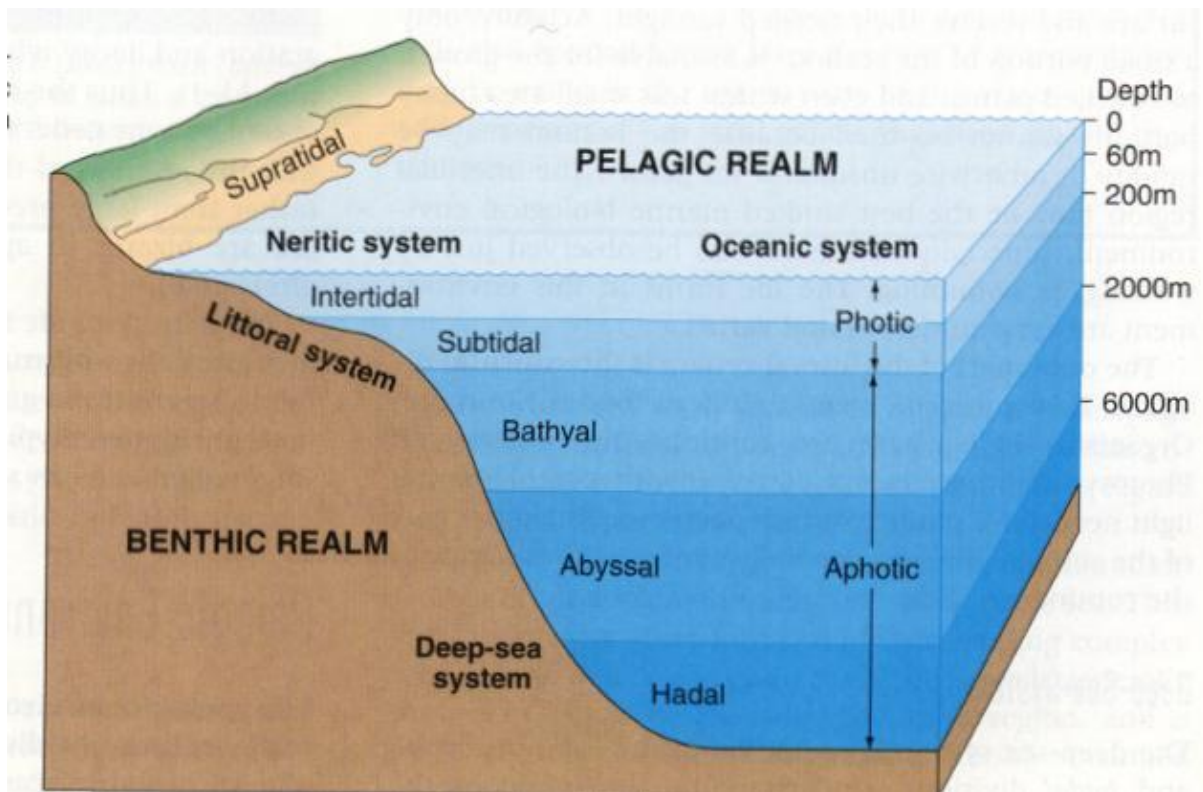
1. Practical hand books as available in laboratory.

Contents

Sl. No.	Aims	Outcome
1	Identification of neritic benthic foraminifera	Visualization of fossils of few genera like Ammonia, Elphidium, Amphistegina, Asterorotalia, Quinqueloculina, Nonionella. under stereo-zoom binocular microscope with their distinguishing characters. This knowledge will help to understand the depositional depth.
2	Identification of bathyal foraminifera	Visualization of fossils of few genera like Bolivina, Bulimina, Cassidulina, Uvigerina, Hoeglundina, Cibicides, Pyrgo under stereo-zoom binocular microscope with their distinguishing characters. This knowledge will help to understand the depositional depth.
3	Identification of abyssal benthic foraminifera	Visualization of fossils of few genera like Oridorsalis, Melonis, Pullenia, Globocassidulina, Gyroidinoides, Uvigerina under stereo-zoom binocular microscope with their distinguishing characters. This knowledge will help to understand the depositional depth.
4	Identification of well oxygenated benthic foraminifera	Visualization of fossils of few genera like Quinqueloculina, Cibicides, Pyrgo, Osangularia, under stereo-zoom binocular microscope. This knowledge will help to understand the oxic assemblages.
5	Identification of low oxygen preferring benthic foraminifera	Visualization of fossils of few genera like Bolivina, Bulimina, Fursenkoina, Chilostomella, Globobulina, Nonionella under stereo-zoom binocular microscope. This knowledge will help to understand the oxic assemblages.
6	Interpretation on benthic assemblages	Mixing of some foraminifera will be given to identify depth and oxygen conditions
7	Identification of tropical planktic foraminifera	Visualization of fossils of few species like <i>Sphaeroidinella dehiscens</i> , <i>Globorotalia truncatulinoides</i> , <i>Globorotalia menardii</i> , <i>Orbulina universa</i> , <i>Globigerinoides ruber</i> , <i>Globigerinoides sacculifer</i> , <i>Globigerinoides conglobatus</i> , <i>Pulleniatina obliquilocuta</i> under stereo-zoom binocular microscope. This knowledge will help to understand the oxic assemblages.
8	Identification of subtropical/transitional planktic foraminifera	Visualization of fossils of few species like <i>Neogloboquadrina dutertrei</i> , <i>Globorotalia truncatulinoides</i> , <i>Orbulina universa</i> , <i>Globigerina bulloides</i> under stereo-zoom binocular microscope. This knowledge will help to understand the oxic assemblages.
9	Identification of polar/subpolar species planktic foraminifera	Visualization of fossils species <i>Neogloboquadrina pachyderma</i> under stereo-zoom binocular microscope. This knowledge will help to understand the oxic

		assemblages.
10	Introduction with index foraminifera	Visualization of fossils species <i>Pseudogloborotalia ranikotensis</i> , <i>Halkyardia minima</i> , <i>Linderina kutchensis</i> , <i>Orbulinoides beckmanni</i> under stereo-zoom binocular microscope. This knowledge will help to understand the oxic assemblages.
11	Introduction with molar teeth of proboscidea and equidea	Morphological study along with stratigraphic range of molar tooth of Trilophodont, Stegodont, Elephas, Hipparion, Equus.
12	Practical examination	Practical examination

Ocean Profile



Intertidal zone: Zone between high tide and low tide

Inner neritic Zone: 0 to 30 m water depth

Middle neritic Zone: Outer neritic: 30 to 100 m water depth

Outer neritic Zone: 100 to 130/200 m water depth

Upper bathyal Zone: 200 to 1000 m water depth

Middle bathyal Zone: 1000 to 2000 m

Lower bathyal Zone: 2000 to 3000 m

Abyssal Zone: 3000 m to 5000 m

Hadal Zone: >5000 m

Taxonomy

Class : SARCODINA

Order : FORAMINIFERIDA

I. Suborder: TEXTULARIINA

- | | | |
|--------|----|------------------|
| Family | 1. | ATAXOPHRAGMIIDAE |
| | 2. | CYCLAMMINIDAE |
| | 3. | HORMOSINIDAE |
| | 4. | EGGERELLIDAE |
| | 5. | TEXTULARIIDAE |
| | 6. | TROCHAMMINIDAE |
| | 7. | VERNEULINIDAE |

II. Suborder: CARTERININA

- | | | |
|--------|----|-----------------|
| Family | 1. | CORNUSPIRIDAE |
| | 2. | OPHTHALMIDIIDAE |

III. Suborder: MILIOLINA

- | | | |
|--------|----|------------------|
| Family | 1. | SPIROLOCULINIDAE |
| | 2. | HAUERINIDAE |

IV. Suborder: LAGENINA

- | | | |
|--------|----|------------------|
| Family | 1. | NODOSARIIDAE |
| | 2. | POLYMORPHINIDAE |
| | 3. | ELLIPSOLAGENIDAE |
| | 4. | LAGENIDAE |
| | 5. | VAGINULINIDAE |

V. Suborder: ROBERTININA

- | | | |
|--------|----|---------------|
| Family | 1. | EPISTOMINIDAE |
| | 2. | ROBERTINIDAE |

VI. Suborder: ROTALIINA

- | | | |
|--------|----|----------------|
| Family | 1. | ANOMALINIDAE |
| | 2. | EPISTOMARIIDAE |
| | 3. | BOLIVINIDAE |
| | 4. | FURSENKOINIDAE |
| | 5. | BOLIVINITIDAE |

6. BULIMINIDAE
7. BULIMINELLIDAE
8. UVIGERINIDAE
9. REUSSELLIDAE
10. CASSIDULINIDAE
11. CHILOSTOMELLIDAE
12. QUADRIMORPHINIDAE
13. ORIDORSALIDAE
14. HETEROLEPIDAE
15. GAVLINELLIDAE
16. EPONIDIDAE
17. DISCORBIDAE
18. ROSALINIDAE
19. SPHAEROIDINIDAE
20. BAGGINIDAE
21. PSEUDOPARRELLIDAE
22. DISCORBINELLIDAE
23. NONIONIDAE
24. PLANULINIDAE
25. CIBICIDIDAE
26. CYMBALOPORIDAE
27. PLEUROSTOMELLIDAE
28. ROTALIIDAE
29. ELPHIDIIDAE
30. STILOSTOMELLIDAE

VII Suborder: SPIRILLININA

Family 1. SPIRILLINIDAE

SYSTEMATIC AND MORPHOLOGICAL DESCRIPTIONS

Class : SARCODINA
Order : FORAMINIFERIDA
Suborder : ROTALIINA

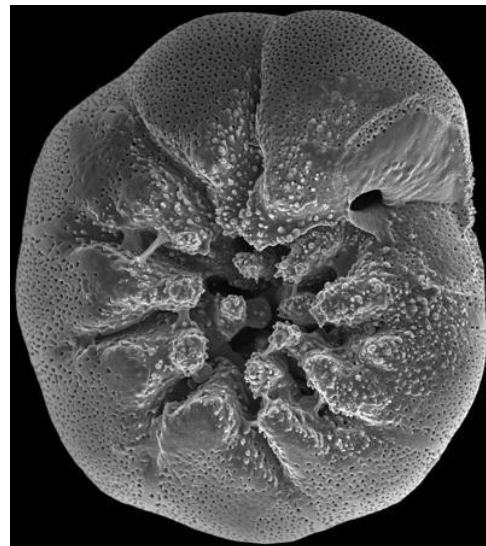
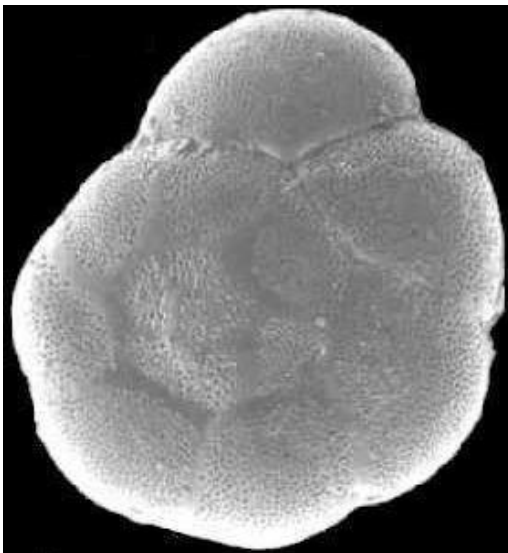
AMMONIA (C607)

Superfamily : ROTALIACEA Ehrenberg 1839
Family : ROTALIIDAE Ehrenberg 1839
Subfamily : AMMONIINAE Saidova 1981
Genus : AMMONIA Brünnich 1772

Morphological description: Test free, biconvex, low trochospiral coil of 3 or 4 volutions, sutures slightly curved, thickened, depressed on umbilical side, septa primarily double; wall calcareous, finely perforate, radial in suture; umbilical surface with irregular granules along suture and over umbilical region; umbilicus with open umbilical fissures and plug in young forms, which is broken up into numerous fused pillars and bosses in adult specimens, umbilical plugs extending inward to proloculus; aperture interio-marginal.

Ecology: Typical abundant within shallow water, sandy-mud rich environment like estuarine/marsh/tidal flat/subtidal/nearshore/shelf areas with a maximum water depth of 200m, preferred relatively higher oxygen concentration and considered as oxic species (>2 ml/l).

Stratigraphic range: Miocene to Recent



ANOMALINA (C754)

Superfamily : ASTERIGERINACEA d'Orbigny 1839

Family : ANOMALINIDAE Cushman 1927

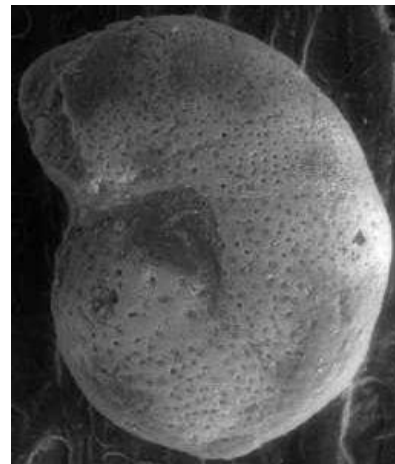
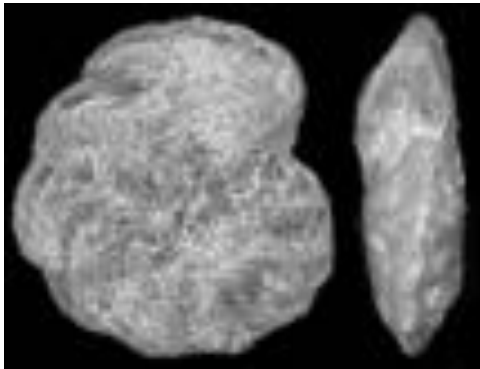
Subfamily : ANOMALININAE Cushman 1927

Genus : ANOMALINA d'Orbigny 1826

Morphological description: Test free, low trochospiral or nearly planispiral, spiral side with umbonal boss, opposite side with depressed umbilicus, periphery rounded; chambers few, sutures radiate; aperture an interior marginal equatorial opening, extending slightly to umbilical side.

Ecology: Represent shelf environment and good indicator of flooding or incursion of marine water in to estuary.

Stratigraphic range: Recent



MELONIS (C761)

Superfamily : NONIONACEA Schultze 1854

Family : NONIONIDAE Schultze 1854

Subfamily : PULLENIINAE Schwager 1877

Genus : MELONIS de Montfort 1808

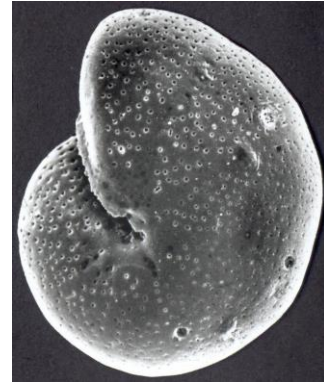
Morphological description: Test free, early stage slightly trochospiral, adult panispiral, symmetrical and involute, deeply biumbilicate, with umbilicus commonly bordered by rim of nonperforate skeletal material, periphery broadly rounded; about 9-12 chambers per whorl; sutures flush to slightly depressed, radiate, straight to slightly curved, septa double, bilamellar; wall calcareous, coarsely perforate, granular in structure, apertural face, septa, and



umbilical thickened rim imperforate, surface smooth; aperture an elongate iteriomarginal, equatorial slit, extending laterally to umbilicus on both sides of test.

Ecology: Bathyal to abyssal species, low oxygen, high organic carbon, preferred degraded organic carbon, feed on bacteria

Stratigraphic range: Upper Cretaceous, Paleocene to Recent.



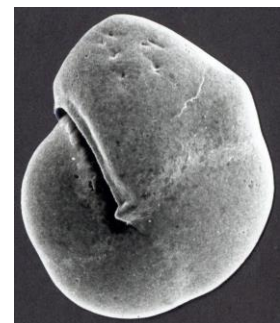
PULLENIA (C748)

Superfamily : NONIONACEA Schultze 1854
Family : NONIONIDAE Schultze 1854
Subfamily : PULLENIINAE Schwager 1877
Genus : PULLENIA Parker and Jones 1862

Morphological description: Test free, spheroidal to compressed, planispiral and involute; chambers few, 3 to 6 in final whorl; sutures radial; wall calcareous, finely perforate, granular in structure; aperture a narrow crescentic interiomarginal slit extending nearly from umbilicus on one side to that opposite.

Ecology: Bathyal to abyssal, low oxygen, high organic carbon

Stratigraphic range: Upper Cretaceous to Recent.



ASTRONONION (C746)

Superfamily : NONIONACEA Schultze 1854
Family : NONIONIDAE Schultze 1854
Subfamily : ASTRONONIONINAE Saidova 1981
Genus : ASTRONONION Cushman and Edwards 1937

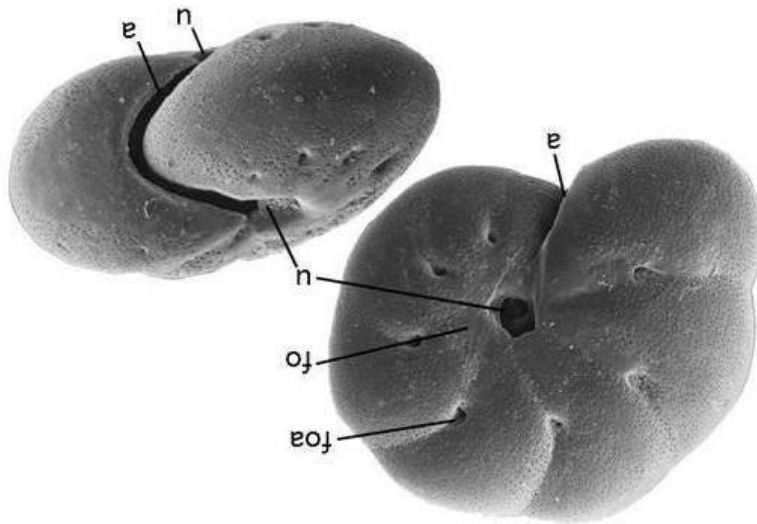
Morphological description: Test free, planispiral and involute, umbilical region slightly excavated, peripheral margin rounded; chambers increasing gradually in size, each with backward-projecting, nonporous, umbilical flap which partially covers preceding suture and

umbilical region but leaves small cavity open beneath it, giving appearance of secondary chamberlets; sutures radial, depressed, slightly curved; wall calcareous, finely perforate, granular in structure, surface smooth; aperture a low, interiomarginal, equatorial slit.

Stratigraphic range: Eocene to Recent

Ecology: varied water depth (shelf to bathyal), preferred high salinity

Stratigraphic range: Eocene to Recent



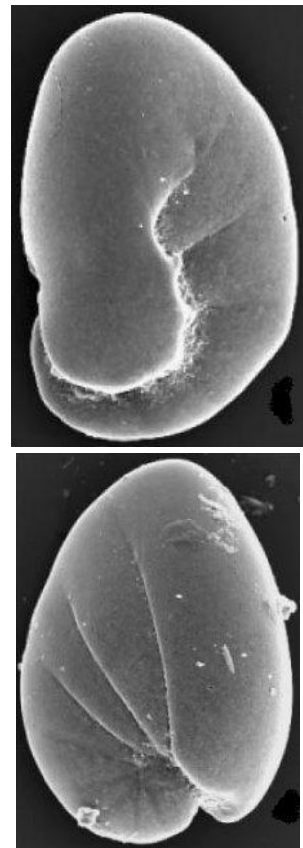
NONIONELLA (C748)

- Superfamily : NONIONACEA Schultze 1854
- Family : NONIONIDAE Schultze 1854
- Subfamily : NONIONINAE Schultze 1854
- Genus : NONIONELLA Cushman 1926

Morphological description: Test free, trochospiral, slightly compressed, periphery rounded, spiral side partially evolute with umbonal boss, opposite side involute with final chamber overhanging umbilical region and may appear to form distinct umbilical flap; chambers relatively numerous, broad, low; wall calcareous, perforate, granular in structure; aperture interiomarginal, a low arch near periphery extending somewhat onto umbilical side.

Ecology: Mostly shallow water depth, anoxic to dysoxic condition, Oxygen minimum zone species

Stratigraphic range: Upper Cretaceous to Recent.



BOLIVINA (C549)

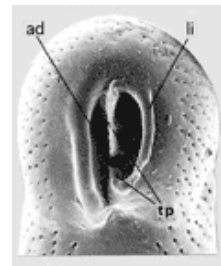
Superfamily : BOLIVINACEA Glaessner 1937

Family : BOLIVINIDAE Glaessner 1937

Subfamily : BOLIVININAE Glaessner 1937

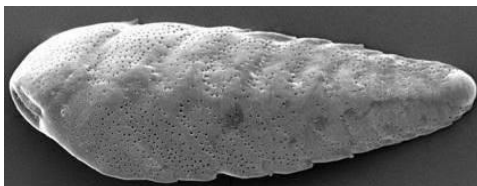
Genus : BOLIVINA d'Orbigny 1839

Morphological description: Test elongate, may be somewhat compressed; chambers broad, low, biserially arranged throughout, basal margins of chambers with retral processes or backward directed chamber overlaps; wall calcareous, perforate, radial in structure, smooth, striate, or costate and may have marginal keel; aperture a narrow, elongate loop up chamber face, one margin ending blindly or bent upward as collar, opposite boarder attached to one side of doubly folded internal tooth plate, attached half of tooth plate projecting inward to coalesce with free half of tooth plate of previous foramen, free half of tooth plate projecting through aperture at one extremity and bisecting it, narrow rapidly inward, tooth plate thus being trough-shaped structure with concave portion alternately turning from one side to opposite in successive chambers.



Ecology: Mostly shallow water depth, anoxic to dysoxic environment

Stratigraphic range: Upper Cretaceous to Recent



BULIMINA (C559)

Superfamily : BULIMINACEA Jones 1875

Family : BULIMINIDAE Jones 1875

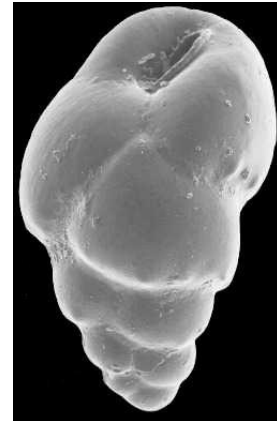
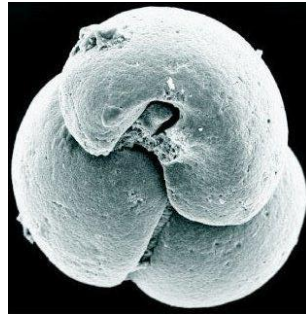
Subfamily : BULIMININAE Brady 1881

Genus : BULIMINA d'Orbigny 1826

Morphological description: Test triserial in early stage, may tend to reduce to uniserial in later portion; wall calcareous, finely to coarsely perforate, radial in structure; aperture extending up from base of apertural face, with free border that may have elevated rim and fixed border attached to internal folded tooth plate, which with fixed shank is attached to internal chamber wall below aperture, with free shank that may be dentate or smooth, flaring or enrolled and sub-tabular.

Ecology: Shelf to bathyal zone, low oxygen, highly labile organic carbon, seasonal food supply

Stratigraphic range: Paleocene to Recent



GLOBOBULIMINA (C559)

Suborder : ROTALIINA Delage and Hérouard 1896

Superfamily : BULIMINACEA Jones 1875

Family : BULIMINIDAE Jones 1875

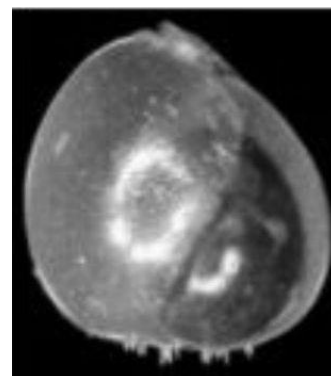
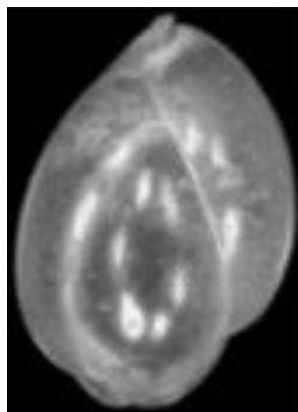
Subfamily : BULIMININAE Brady 1881

Genus : GLOBOBULIMINA Cushman 1927

Morphological description: test globular to ovate, chambers triserially arranged, strongly overlapping earlier ones; wall calcareous, thin, finely perforate, radial in structure, surface smooth; aperture loop-shaped, with tendency to become terminal, tooth plate doubly folded pillar-like trough joined to apertural border at one side, upper part with projecting fanlike tip, lower portion extending into chamber cavity as arched trough, then curving forward, free shank coalescing with free border of aperture, lower part of tooth plate touching projected tip of tooth plate of preceding chamber.

Ecology: bathyal to abyssal, low oxygen, high organic carbon

Stratigraphic range: Paleocene to Recent



CASSIDULINA (C737)

Superfamily : CASSIDULINACEA d'Orbigny 1839

Family : CASSIDULINIDAE d'Orbigny 1839

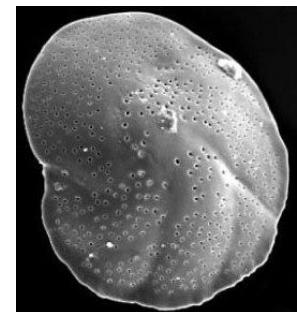
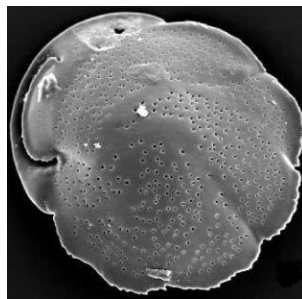
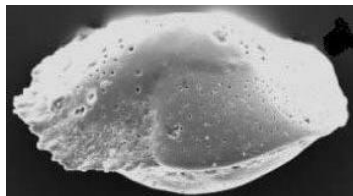
Subfamily : CASSIDULININAE d'Orbigny 1839

Genus : CASSIDULINA d'Orbigny 1826

Morphological description: Test free, lenticular, commonly biumbonate, with clear central bosses; chambers biserially arranged in coil, chambers alternating on each side of periphery, each reaching boss on one side and only extending part way to boss of opposite side, sometimes with keel; succeeding chamber extending to center on alternate sides; wall calcareous, hayaline, perforate, granular in structure, surface generally smooth; aperture an elongate slit, extending from base of final chamber upward in curve paralleling anterior margin of chamber with narrow bordering lip on lower margin but lacking internal tooth.

Ecology: Shelf to bathyal zone, low oxygen, highly labile organic carbon, seasonal food supply

Stratigraphic range: Eocene to Recent



GLOBOCASSIDULINA (C737)

Superfamily : CASSIDULINACEA d'Orbigny 1839

Family : CASSIDULINIDAE d'Orbigny 1839

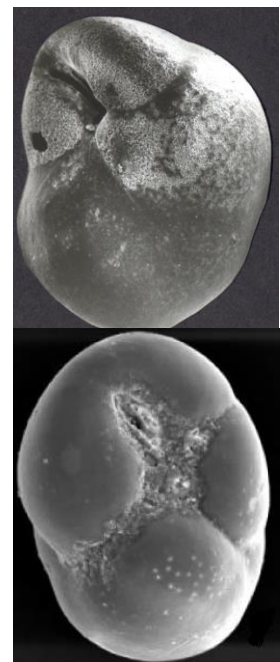
Subfamily : CASSIDULININAE d'Orbigny 1839

Genus : GLOBOCASSIDULINA Voloshinova 1960

Morphological description: Test free, globular; chambers biserially arranged in coil, chambers alternating on each side of periphery, nonkeeled test; succeeding chamber extending to center on alternate sides; wall calcareous, hayaline, perforate, granular in structure, surface generally smooth; aperture tripartite, lacking internal tooth.

Ecology: Shelf to bathyal zone, low oxygen, high organic carbon

Stratigraphic range: Eocene to Recent



CHILOSTOMELLA (C742)

Superfamily : CHILOSTOMELLACEA Brady 1881

Family : CHILOSTOMELLIDAE Brady 1881

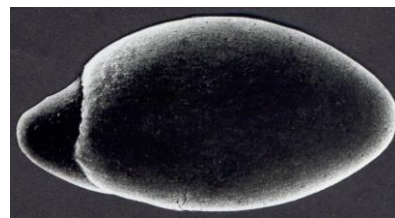
Subfamily : CHILOSTOMELLINAE Brady 1881

Genus : CHILOSTOMELLA Reuss 1849

Morphological description: Test free, ovate, planispiral and involute, with 2 chambers to whorl, chambers embracing; wall calcareous, perforate, granular in structure; aperture a narrow interio-marginal equatorial slit, which may have slight lip.

Ecology: Shelf to bathyal zone, extremely low oxygen, high organic carbon, feed on bacteria

Stratigraphic range: Upper Cretaceous to Recent



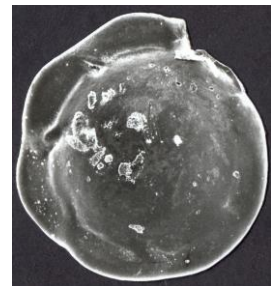
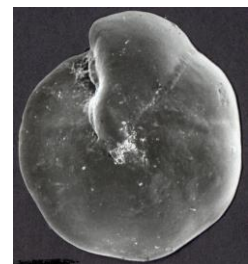
ORIDORSALIS (C750)

Superfamily : CHILOSTOMELLACEA Brady 1881

Family : ORIDORSALIDAE Loeblich and Tappan 1984

Genus : ORIDORSALIS Andersen 1961

Morphological description: Test free, lenticular, periphery carinate; chambers arranged in low trochospiral coil, chambers broad, low, all visible on spiral side but only those of final whorl visible on opposite side; sutures radial, slightly curved on spiral side, strongly sinuate on umbilical side; wall calcareous, very finely perforate, granular in structure, primary aperture interiomarginal, extending from periphery nearly to closed umbilicus of umbilical side; small secondary sutural opening of spiral side near junction of spiral and septal sutures, with similar small sutural openings at mid-point of sutures at sinuate curve on umbilical side.



Ecology: Deep water species, cosmopolitan, good for isotopic analysis

Stratigraphic range: Oligocene to Recent.

CIBICIDES (688)

Superfamily : PLANORBULINACEA Schwager 1877

Family : CIBICIDIDAE Cushman 1927

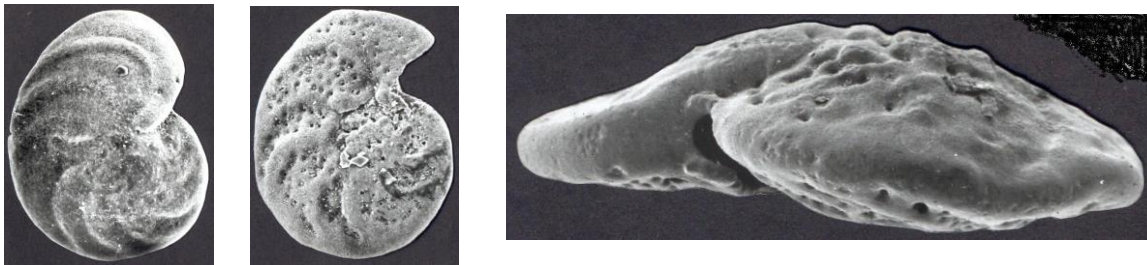
Subfamily : CIBICIDINAE Cushman 1927

Genus : CIBICIDES de Montfort 1808

Morphological description: Test attached, plano-convex, trochospiral, spiral side flat to excavated, evolute, umbilical side strongly convex, involute, apertural face sharply angled, distinct from umbilical side, periphery angular, with nonporous keel; wall calcareous, radial in microstructure, bilamellar, coarsely perforate on spiral side, large pores of earlier chambers may be closed by lamellar thickening of wall, finely perforate on umbilical side, apertural face nonporous; aperture a low interio-marginal opening with narrow lip, may extend along spiral suture on spiral side.

Ecology: varied depth (neritic to abyssal), well-oxygenated, raised epibenthic, bears equilibrium with sea water and ideal for isotopic analysis.

Stratigraphic range: Cretaceous to Recent



DENTALINA (516)

Superfamily : NODOSARIACEA Ehrenberg 1838

Family : NODOSARIIDAE Ehrenberg 1838

Subfamily : NODOSARIINAE Ehrenberg 1838

Genus : DENTALINA Risso 1826

Morphological description: Test elongate, arcuate, uniserial; sutures commonly oblique; aperture radiate, terminal, may be eccentric or nearly central.

Ecology: Deep infaunal, low oxygen, high organic carbon

Stratigraphic range: Permian to Recent



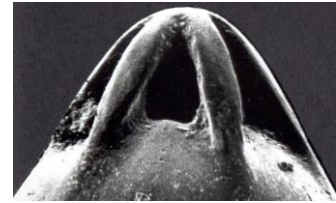
NODOSARIA (C512)

Superfamily : NODOSARIACEA Ehrenberg 1838

Family : NODOSARIIDAE Ehrenberg 1838

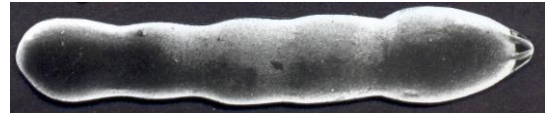
Subfamily : NODOSARIINAE Ehrenberg 1838

Genus : NODOSARIA Lamarck 1812



Morphological description: Test free, multilocular, rectilinear, rounded in section, sutures distinct and commonly perpendicular to axis of test, surface smooth, costate, striate, hispid or tuberculate; aperture terminal, central, basically radiate, may be produced on neck.

Ecology: Deep infaunal, low oxygen, high organic carbon



Stratigraphic range: Permian to Recent.

DISCORBIS (C572)

Family : DISCORBIDAE Ehrenberg 1838

Subfamily : DISCORBISINAE Cushman 1927

Genus : DISCORBIS Lamarck 1804

Morphological description: Test free, trochospiral, plano-convex, flattened on umbilical side, periphery angled; all chambers visible on umbonate spiral side, only chambers of final whorl visible on umbilical side, with a flap extending from basal portion of each chamber toward umbilical region, opening extending along proximal side of each radial umbilical flap, connecting through cavity beneath flaps to interior of chambers themselves; aperture an interiomarginal, extraumbilical arch, secondary sutural openings at opposite side of chamber flap remaining open as later chambers are formed; biflagellate gametes occur.



Ecology: well oxygen, low organic carbon

Stratigraphic range: Eocene to Recent

EPISTOMINELLA (C578)

Superfamily : DISCORBINELLACEA Sigal 1952
Family : PSEUDOPARRELLIDAE Voloshinva 1952
Subfamily : PSEUDOPARRELLINAE Voloshinva 1952
Genus : EPISTOMINELLA Husezima and Maruhasi 1944

Morphological description: Test trochospiral; all chambers visible on spiral side, only those of last whorl visible on umbilical side; sutures oblique on spiral side, nearly radial on umbilical side; wall calcareous, perforate, radial in structure and monolamellid; aperture an elongate vertical slit in face, near and parallel to peripheral keel.

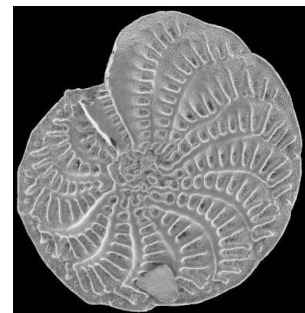
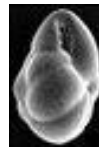
Ecology: Varied water depth, low oxygen, high organic carbon, Phytodetritus pulse

Stratigraphic range: Upper Cretaceous to Recent

ELPHIDIUM (C631)

Family : ELPHIDIIDAE Galloway 1933
Subfamily : ELPHIDIINAE Galloway 1933
Genus : ELPHIDIUM de Montfort 1808

Morphological description: Test planispiral, bilaterally symmetrical, involute, chambers numerous, with numerous retral processes or internal chamber projections along septal borders, ending blindly against septal face in final chamber, but pierced by tiny pore formed by resorption of septum at the base of retral process in earlier chambers, resulting in numerous tabular perforations connecting chambers; septa secondarily doubled, incomplete septal flap being formed against apertural face as succeeding chamber forms, leaving septum single-layered near center and base and doubled near outer edges where it encloses canal system, with prominent lamellar thickening of outer wall; canal system complex, spiral canal present along umbilical chamber margins leading to vertical umbilical canals through umbilical plug, and also giving rise to subsutural septal canals at each septum in intraseptal space between septal face, communicating with surface by means of diverging canals; wall calcareous, finely perforate, radial in structure, surface commonly with grooves



or ridges paralleling periphery and commonly coinciding with internal retral processes, or surface may be smooth or finely pustulose; aperture consisting of row of pores at the base of the septal face.

Ecology: Typical abundant within shallow water, sandy-mud rich environment like estuarine/marsh/tidal flat/subtidal/nearshore/shelf areas with a maximum water depth of 200m, preferred relatively higher oxygen concentration and considered as oxic species (>2 ml/l).

Stratigraphic range: Late Eocene to Recent

FURSENKOINA (C731)

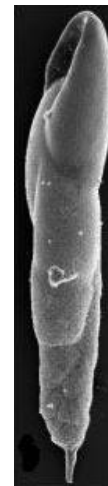
Superfamily : FURSENKOINACEA Loeblich and Tappan 1961

Family : FURSENKOINIDAE Loeblich and Tappan 1961

Subfamily : FURSENKOININAE Loeblich and Tappan 1961

Genus : FURSENKOINA Loeblich and Tappan 1961

Morphological description: Test free, narrow, elongate, rounded to ovate in section; chambers inflated, greater in height than breadth, early portion in highly twisted biserial arrangement, later becoming less sigmoidal and more typically biserial, sutures distinct, depressed-oblique, wall calcareous, very finely perforate, granular in structure, surface smooth; aperture narrow, elongate, extending up face of final chamber, lower part may be closed, leaving only suture toward base of chamber, upper part open, resulting in comma-shaped opening, tooth plate attached to close suture of aperture.



Ecology: Extremely low oxygen, can survive without oxygen for 72 hours

Stratigraphic range: Upper Cretaceous to Recent



GYROIDINOIDES (C750)

Family : GAVLINELLIDAE, Hofker 1956
Subfamily : GYROIDINOIDINAE Saidova 1981
Genus : GYROIDINOIDES Brotzen 1942

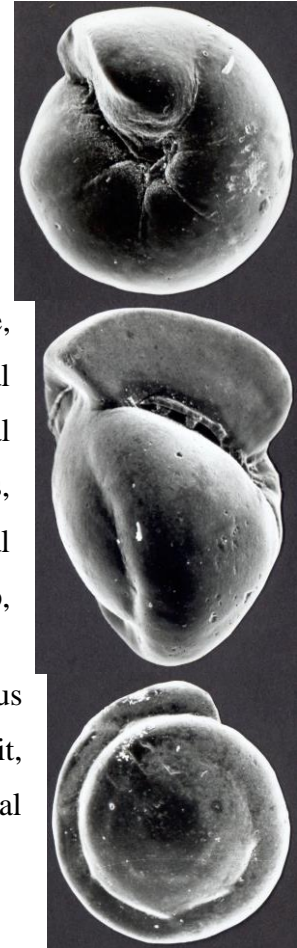
Morphological description: Test free, trochospiral, periphery

rounded to sub-truncate, spiral side flattened with all chambers visible, opposite side elevated and umbilicate with only chambers of final whorl visible; chambers rhomboidal in section, with angled umbilical shoulder; sutures radial to oblique, flush to depressed; wall calcareous, perforate, granular in structure; primary aperture a low interiomarginal slit restricted to mid-portion of apertural face, bordered by narrow lip,

small secondary apertures umbilical in position, against previous chamber wall with projecting umbilical flap extending backward over it, so that is not evident except when test is viewed obliquely, or final chamber is dissected so that secondary aperture may be seen.

Ecology: Varied depth, well oxygenated

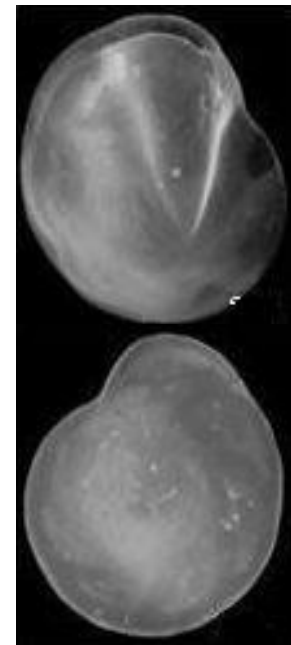
Stratigraphic range: Eocene to Recent



HOEGLUNDINA (C775)

Superfamily : CERATOBULIMINACEA Cushman 1927
Family : EPISTOMINIDAE Wedekind 1937
Subfamily : EPISTOMININAE Wedekind 1937
Genus : HOEGLUNDINA Brotzen 1948

Morphological description: Test free, trochospiral, close-coiled, biconvex, chambers with more highly developed internal secondary partition extending from posterior wall of chambers and always secondarily resorbed from earlier chambers; latero-marginal aperture nearly peripheral in position extending breadth of chambers; those of earlier chambers may remain open or be secondarily closed; aperture a peripheral slit nearly in plane of coiling, with lip, apertures of earlier chambers closed by secondary skeletal material, but distinctly noticeable as peripheral grooves in these earlier chambers.



Ecology: Bathyal zone, low oxygen, high organic carbon, oxygen minimum zone species

Stratigraphic range: Mid Jurassic to Recent

PLEUROSATOMELLA

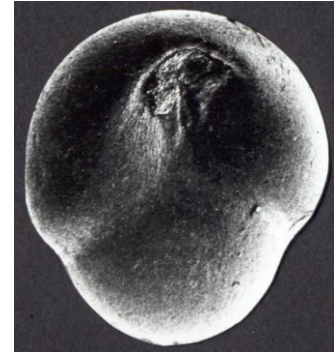
Superfamily : PLEUROSATOMELLACEA Reuss 1860

Family : PLEUROSATOMELLIDAE Reuss 1860

Subfamily : PLEUROSATOMELLINAE Reuss 1860

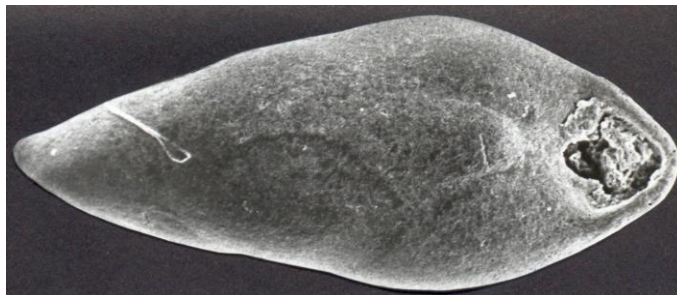
Genus : PLEUROSATOMELLA Reuss 1860

Morphological description: Test small, elongate, chambers in early stage biserially arranged, or cuneate and alternating in position, later becoming more nearly straight and horizontal, wall calcareous, finely perforate, granular in structure; aperture terminal, with projecting hood at one side, 2 small teeth on opposite side, and internal tube.



Ecology: Low oxygen, high organic carbon, unable to tolerate cold environment

Stratigraphic range: Late Cretaceous to Mid-Pleistocene Transition (0.6 Ma)



STILOSTOMELLA (C559)

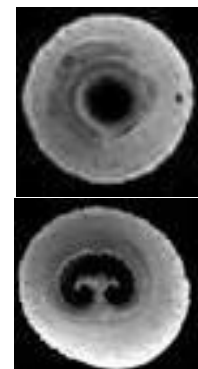
Superfamily : STILOSTOMELLACEA Finlay 1947

Family : STILOSTOMELLIDAE Finlay 1947

Subfamily : STILOSTOMELLINAE Finlay 1947

Genus : STILOSTOMELLA Guppy 1894

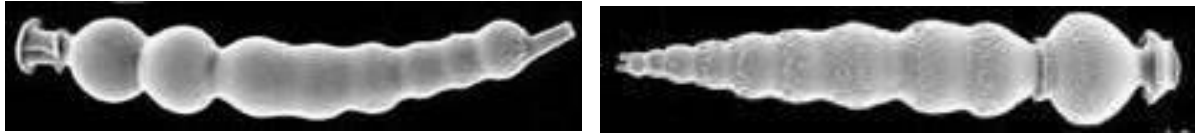
Morphological description: Test free, elongate, uniserial and rectilinear, with gradually enlarging subglobular chambers; wall calcareous, hyaline, finely perforate, surface may be spinose, or spines may be restricted to lower chamber margin; aperture terminal, may be produced on neck, with phialine



lip and slight indentation at one side owing to surface reflection of internal spatulate tooth.

Ecology: Low oxygen, high organic carbon, unable to tolerate cold environment

Stratigraphic range: Cretaceous to Mid-Pleistocene Transition (0.6 Ma)



UVIGERINA (C565)

Family : UVIGERINIDAE Haeckel 1894

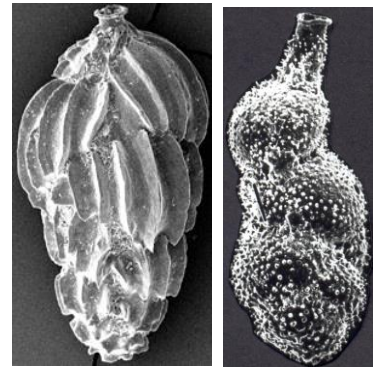
Subfamily : UVIGERININAE Haeckel 1894

Genus : UVIGERINA d'Orbigny 1826

Morphological description: Test elongate, triserial, rounded in section, chambers inflated, wall calcareous, perforate, surface smooth, hispid or costate; aperture terminal, rounded with nonperforate neck and may have phialine lip, internal tooth plate with distinct wing at one side.

Ecology: High organic carbon, detrital input, independent of bottom water oxygenation

Stratigraphic range: Eocene to Recent.



Class : SARCODINA

Order : FORAMINIFERIDA

Suborder : MILIOLINA

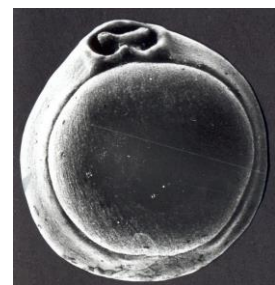
PYRGO (C465)

Superfamily : MILIOLACEA Ehrenberg 1839

Family : HAUERINIDAE Schwager 1876

Subfamily : MILIOLINELLINAE Vella 1957

Genus : PYRGO DeFrance, 1824



Morphological description: Test free, inflated, discoidal to ovate, proloculus followed by chambers one-half coil in length; in microscopic form early chambers arranged in quinqueloculine pattern, later triloculine, and finally biloculine; megalospheric forms may be biloculine throughout development, with successive discoidal to hemispherical chambers opposing each other; wall calcareous, imperforate, porcelaneous; aperture terminal, near junction of 2 last chambers, rounded to elongate, with distinct and commonly bifid tooth.



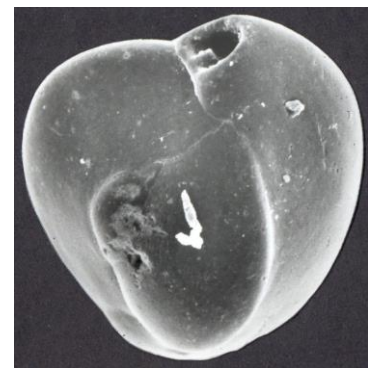
Ecology: varied water depth, well oxygenated, low food

Stratigraphic range: Jurassic to Recent.

QUINQUELOCULINA (C458)

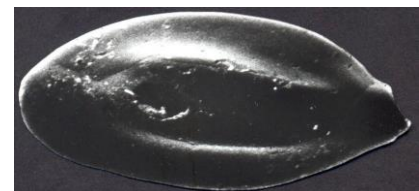
Superfamily : MILIOLACEA Ehrenberg 1839
Family : HAUERINIDAE Schwager 1876
Subfamily : HAUERININAE Schwager 1876
Genus : QUINQUELOCULINA d'Orbigny 1826

Morphological description: Test coiled, with chambers one-half coil in length and alternating regularly in 5 planes of coiling 72° apart, but with successive chambers in planes 144° apart, so that 3 chambers are visible from exterior on one side of test and 4 visible from opposite side; wall calcareous, porcelaneous, imperforate, with inner pseudochitinous layer, rarely with some agglutinated grains added to exterior; aperture terminal, rounded, with simple or bifid tooth.



Ecology: varied water depth, well oxygenated, low organic carbon

Stratigraphic range: Jurassic to Recent.



SPIROLOCULINA (C453)

Superfamily : MILIOLACEA Ehrenberg 1839
Family : SPIROLOCULINIDAE Wiesner 1920
Subfamily : SPIROLOCULININAE Wiesner 1920

Genus : SPIROLOCULINA d'Orbigny 1826

Morphological description: Test free, commonly with flattened sides and lanceolate or fusiform outline, earliest stage may consist of single chamber completely encircling proloculus, later chambers being added 2 to whorl on alternate sides and in single plane; wall calcareous, imperforate, procelaneous; aperture at open end of final chamber, with simple or bifid tooth.

Ecology: Sallow water, well oxygenated

Stratigraphic range: Upper Cretaceous to Recent.



TRILOCULINA (C466)

Superfamily : MILIOLACEA Ehrenberg 1839

Family : HAUERINIDAE Schwager 1876

Subfamily : MILIOLINELLINAE Vella 1957

Genus : TRILOCULINA d'Orbigny 1826



Morphological description: Test free, with chambers each one-half coil in length, early chambers at least in microspheric generation in quinqueloculine arrangement, later triloculine, with successive chambers added in planes 120° apart, only final 3 chambers visible externally; wall calcareous, imperforate, porcelaneous, or rarely with surfacial agglutinated layer; aperture terminal, typically with bifid tooth.

Ecology: well oxygenated, shallow water

Stratigraphic range: Jurassic to Recent.



Class : SARCODINA
Order : FORAMINIFERIDA
Suborder : TEXTULARIINA

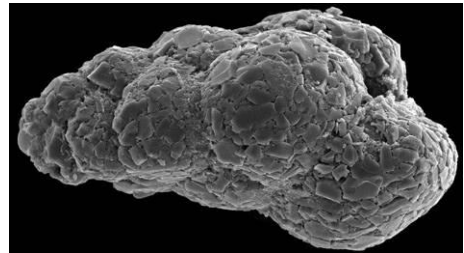
EGGERELLA (C275)

Superfamily : TEXTULARIACEA Ehrenberg 1838
Family : EGGERELLIDAE Cushman 1937
Subfamily : EGGERELLINAE Cushman 1937
Genus : EGGERELLA Cushman 1935

Morphological description: Test trochospiral coil, with 5 chambers to whorl in early stage of microspheric form, gradually reduced to 3 to whorl in adult; wall finely agglutinated on psudochitinous base, may be of calcareous particles in calcareous cement; aperture a low interiomarginal slit.

Ecology: well oxygenated, cold water, found below CCD

Stratigraphic range: Upper Cretaceous, Eocene to Recent.



MARTINOTTIELLA (C282)

Superfamily : TEXTULARIACEA Ehrenberg 1838
Family : EGGERELLIDAE Cushman 1937
Subfamily : EGGERELLINAE Cushman 1937
Genus : MARTINOTTIELLA Cushman 1933

Morphological description: Test free, elongate, cylindrical, early chambers trochospiral with 4 or 5 to whorl, progressively reduced to triserial, biserial, and uniserial development; wall finely agglutinated; aperture terminal, elongate slit, commonly arcuate, with bordering lip.

Ecology: well oxygenated, cold water, found below CCD

Stratigraphic range: Paleocene to Recent.



GAUDRYINA (C269)

Superfamily : VERNEUILINACEA Cushman 1911

Family : VERNEUILINIDAE Cushman 1911

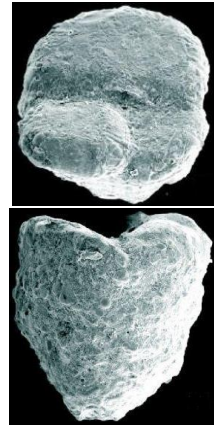
Subfamily : VERNEUILININAE, Cushman 1911

Genus : GAUDRYINA d'Orbigny 1839

Morphological description: Test free, elongate, early stage triserial and commonly triangular, later portion biserial; aperture interiomarginal.

Ecology: well oxygenated, cold water, found below CCD

Stratigraphic range: Upper Triassic to Recent.



REOPHAX (C216)

Superfamily : HORMOSINACEA Haeckel 1894

Family : HORMOSINIDAE Haeckel 1894

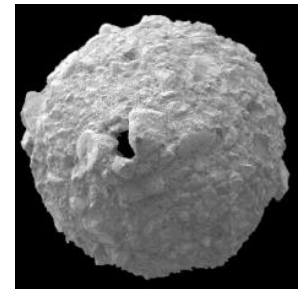
Subfamily : REOPHACINAE Cushman 1910

Genus : REOPHAX de Montfort 1808

Morphological description: Test free, elongate, nearly straight or arcuate; chambers few; increasing in size as added; sutures nearly horizontal, obscure to moderately constricted; wall agglutinated, with comparatively little cement, surface rough; aperture terminal, rounded, at end of distinct tubular neck.

Ecology: Shallow water, well oxygenated

Stratigraphic range: Lower Carboniferous to Recent.



TEXTULARIA (C253)

Superfamily : TEXTULARIACEA Ehrenberg 1838

Family : TEXTULARIIDAE Ehrenberg 1838

Subfamily : TEXTULARIINAE Ehrenberg 1838

Genus : TEXTULARIA Defrance 1824

Morphological description: Test free, elongate, biserial, generally more or less compressed in plane of biserially or rarely oval to circular in cross section; chambers numerous, generally closely appressed; wall agglutinated, simple; aperture single low arch at base of last chamber.

Ecology: well oxygenated, cold water, found below CCD

Stratigraphic range: Upper Carboniferous to Recent.



DEPTH WISE DISTRIBUTION LIST

(A) Intertidal zone:

1. *Ammonia baccr*
2. *Elphidium advenum*
3. *Discorbis subvilardeboanus*
4. *Buliminella sculpturata*

(B) Inner neritic zone (0-30m)

1. *Elphidium crispum*
2. *Ammonia batavus*
3. *Quinqueloculina weaveri*
4. *Quinqueloculina lamarckiana*

(C) Middle neritic zone (30-100m)

1. *Textularia agglutinans*
2. *Elphidium macellum*
3. *Triloculina tricarinata*
4. *Amphistegina lessonii*
5. *Quinqueloculina venusta*
6. *Peneroplis pertusus*

(D) Outer neritic zone (100-130m)

1. *Cassidulina carinata*
2. *Cibicides bradyi*
3. *Nonionella japonicum*
4. *Fursenkoina bradyi*
5. *Uvigerina proboscidea*
6. *Pullenia salisburyi*

(E) Upper to middle bathyal zone (130-1000m)

1. *Bolivina pusilla*
2. *Cassidulina laevigata*
3. *Uvigerina hispido-costata*
4. *Gyroidinoides nitidula*
5. *Bulimina aculeata*
6. *Pullenia quinqueloba*
7. *Cibicides kullenbergi*

(F) Lower bathyal zone (1000-3000m)

1. *Oridorsalis umbonatus*
2. *Stilostomella lepidula*
3. *Melonis barleeaanum*
4. *Gyroidinoides polius*
5. *Pleurostomella brevis*
6. *Globocassidulina subglobosa*
7. *Epistominella exigua*
8. *Pyrgo murrhina*
9. *Eggerella bradyi*
10. *Cibicides cicatricosus*

(F) Abyssal zone (>3000m)

1. *Epistominella exigua*
2. *Melonis pompilioides*
3. *Nuttalides umbonifera*

PRACTICAL NOTES ON PLANKTIC FORAMINIFERA

Tropical water mass assemblages

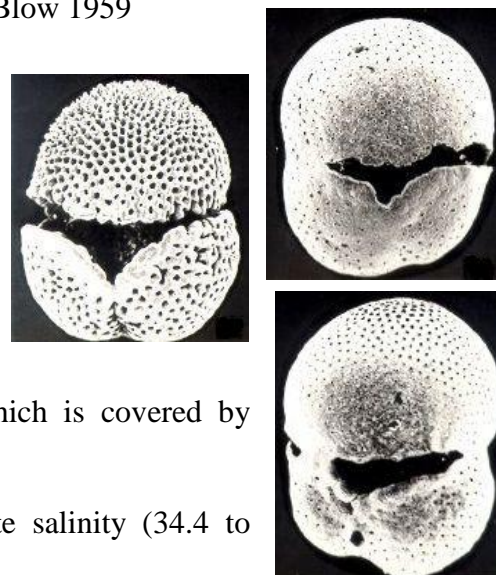
Sphaeroidinella dehiscens (212)

Order : FORAMINIFERIDA
 Suborder : ROBERTININA Loeblich & Tappan 1984
 Superfamily : GLOBIGERINACEA Carpenter, Parker, & Jones 1862
 Subfamily : SPHAEROIDINELLINAE Banner & Blow 1959
 Genus : SPHAEROIDINELLA Cushman 1927
 Species : DEHISCENS

Morphological description: Test large, trochospiral compact, equatorial periphery broadly ovoid or spherical; chambers three in the final whorl, strongly inflated, subglobular, becoming increasingly embracing in the adult; sutures flush, cover by secondary thickening; primary surface coarsely perforate similar to *Globigerinoides sacculifer*, which is covered by secondary thickening.

Ecology: Tropical to subtropical, deep dweller, intermediate salinity (34.4 to 35.9‰)

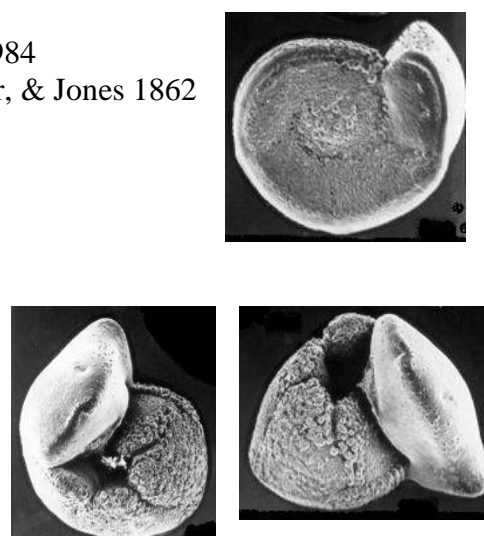
Stratigraphic range: Early Pliocene (Zone N19) to Recent.



Globorotalia truncatulinoides (148)

Order : FORAMINIFERIDA
 Suborder : ROBERTININA Loeblich & Tappan 1984
 Superfamily : GLOBIGERINACEA Carpenter, Parker, & Jones 1862
 Family : GLOBOROTALIIDAE Cushman 1927
 Subfamily : GLOBOROTALIINAE Cushman 1927
 Genus : GLOBOROTALIA Cushman 1927
 Species : TRUNCATULINOIDES

Morphological description: Test low trochospiral, planoconvex, equatorial periphery almost circular, axial periphery acute with a distinct keel, chambers five in the final whorl, increasing slowly in size as added; sutures on spiral side straight to gently curved, flush to slightly depressed; on umbilical side almost radial, depressed; surface finely perforate, postulate on umbilical as well as on the spiral side; umbilicus wide deep, aperture interiomarginal, extraumbilical-umbilical, a low arch bordered by a lip.



Ecology: Warm subtropical to tropical, salinity relatively high (35.6‰) and low nutrient level.

Stratigraphic range: Early Pleistocene (Zone N22) to Recent.

Globorotalia menardii (124)

Order : FORAMINIFERIDA
Suborder : ROBERTININA Loeblich & Tappan 1984
Superfamily : GLOBIGERINACEA Carpenter, Parker, & Jones 1862
Family : GLOBOROTALIIDAE Cushman 1927
Subfamily : GLOBOROTALIINAE Cushman 1927
Genus : GLOBOROTALIA Cushman 1927
Species : MENARDII

Morphological description: Test large, low trochospiral, compressed, equatorial periphery lobulate, axial periphery acute with a prominent keel; 5 to 6 wedge-shaped chambers in the final whorl, increasing regularly in size as added;

sutures on spiral side strongly curved, raised; on umbilical side radial to slightly curved, depressed: surface smooth, densely perforate with circular pores; umbilicus wide, shallow, aperture interiomarginal, umbilical – extraumbilical, a low arch bordered by a thick lip.

Ecology: Deep dweller species, indicate warm water environment,

Intermediate saline condition.

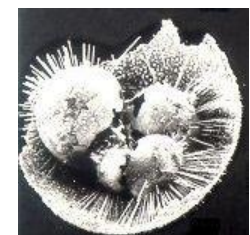
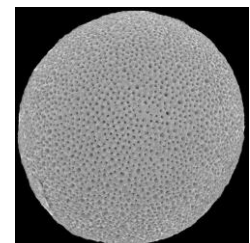
Stratigraphic range: Middle Miocene (Zone N12) to Recent.



Orbulina universa (86)

Order : FORAMINIFERIDA
Suborder : ROBERTININA Loeblich & Tappan 1984
Superfamily : GLOBIGERINACEA Carpenter, Parker, & Jones 1862
Subfamily : ORBULININAE Schultz 1854
Genus : ORBULINA d' Orbigny 1839
Species : UNIVERSA

Morphological description: Test spherical composed of a single spherical chamber entirely enveloping the earlier part of the test, which is usually reduced. In the adult, an internal Globigerina stage may be enveloped by the final spherical chamber. Surface densely perforate with numerous small openings of two distinct sizes.



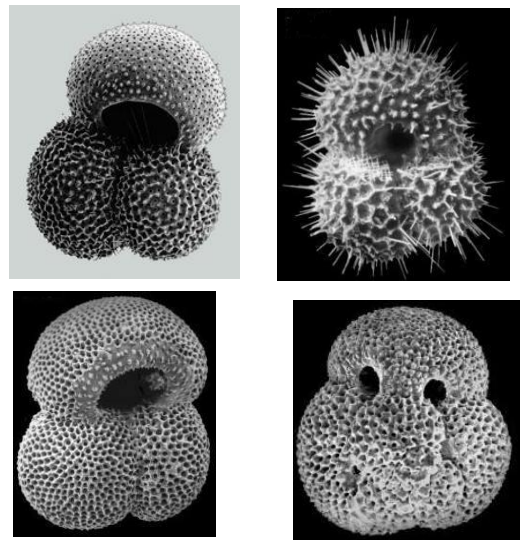
Ecology: Tropical to subtropical, indicates high surface salinity (35.4 to 36.9‰), cool temperate and low phosphate environment.

Stratigraphic range: Early Miocene (Zone N9) to Recent.

Globigerinoides ruber (78)

Order : FORAMINIFERIDA
Suborder : ROBERTININA Loeblich & Tappan 1984
Superfamily : GLOBIGERINACEA Carpenter, Parker, & Jones 1862
Family : GLOBIGERINIDAE Carpenter, Parker, & Jones 1862
Subfamily : GLOBIGERININAE Carpenter, Parker, & Jones 1862
Genus : GLOBIGERINOIDES Cushman 1927
Species : RUBER

Morphological description: Test medium, low to high trochospire with three subspherical chambers in the final whorl, increasing moderately in size; sutures radial, distinctly depressed; surface coarsely perforate; thin secondary calcite crusts surround the spine bases; calcite crust developing between spine bases from a honeycomb shaped surface; umbilicus narrow, primary aperture interiomarginal, umbilical with a wide-arched opening bordered by a rim, with two supplementary sutural apertures situated opposite sutures of earlier chambers.



Ecology: Surface dweller, tropical to sub-tropical, warm water, high saline water (>36‰), phosphate level is intermediate.

Stratigraphic range: Late Middle Miocene (Zone N15) to Recent.

Globigerinoides sacculifer (66)

Order : FORAMINIFERIDA
Suborder : ROBERTININA Loeblich & Tappan 1984
Superfamily : GLOBIGERINACEA Carpenter, Parker, & Jones 1862
Family : GLOBIGERINIDAE Carpenter, Parker, & Jones 1862
Subfamily : GLOBIGERININAE Carpenter, Parker, & Jones 1862
Genus : GLOBIGERINOIDES Cushman 1927
Species : SACCULIFER

Morphological description: Test low trochospiral, chambers spherical except the final one, which is elongate, sack like; three and a half to four in the final whorl, increasing slowly in size as added, the last chamber may be rather small, or it may be elongate and lobulate; sutures on the both sides slightly curved and depressed; surface with regular subhexagonal pore pits; umbilicus narrow,

primary aperture interiomarginal, umbilical, a distinct arch bordered by a rim; prominent supplementary apertures on spiral side.

Ecology: Surface dweller, tropical to sub-tropical, high saline water (>36‰).

Stratigraphic range: Early Miocene (Zone N9) to Recent.



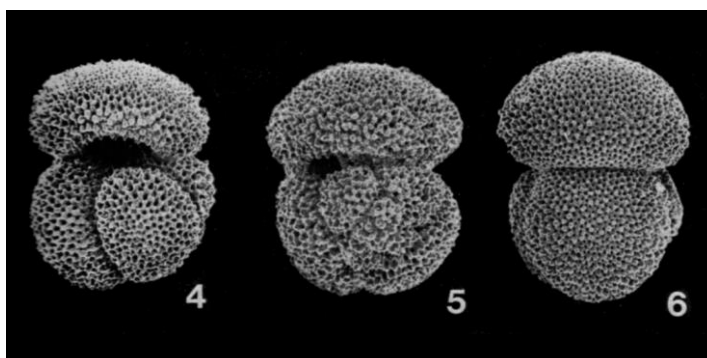
Globigerinoides conglobatus (58)

Order	: FORAMINIFERIDA
Suborder	: ROBERTININA Loeblich & Tappan 1984
Superfamily	: GLOBIGERINACEA Carpenter, Parker, & Jones 1862
Family	: GLOBIGERINIDAE Carpenter, Parker, & Jones 1862
Subfamily	: GLOBIGERININAE Carpenter, Parker, & Jones 1862
Genus	: GLOBIGERINOIDES Cushman 1927
Species	: CONGLOBATUS

Morphological description: Test large, tightly coiled, trochospiral, subglobular to subquadrate, three to three and a half chambers in the final whorl increasing very slowly in size as added; sutures distinctly depressed, almost radial; surface coarsely perforated with spines and spine bases; umbilicus narrow; primary aperture interiomarginal, umbilical, a long, low asymmetric arch bordered by a thin rim; sutural supplementary apertures, small, irregular on the spiral side.

Ecology: Tropical to subtropical, warm water, intermediate salinity (34.4 to 35.4‰), low to medium phosphate level.

Stratigraphic range: Late Miocene (Zone N17B) to Recent.



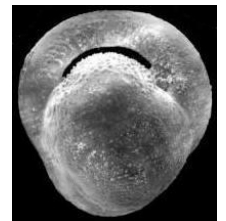
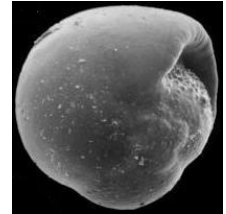
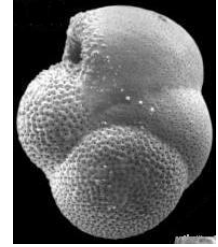
Pulleniatina obliquiloculata (202)

Order	: FORAMINIFERIDA
Suborder	: ROBERTININA Loeblich & Tappan 1984
Superfamily	: GLOBIGERINACEA Carpenter, Parker, & Jones 1862
Family	: GLOBIGERINIDAE Carpenter, Parker, & Jones 1862
Subfamily	: GLOBIGERININAE Carpenter, Parker, & Jones 1862
Genus	: PULLENIATINA Cushman 1927
Species	: OBLIQUELOCULATA

Morphological description: Test globose, initially trochospiral, later streptospiral almost involute, axial periphery broadly rounded, four to five broadly rounded chambers in the final whorl; sutures almost flush; surface smooth, granular in apertural areas; umbilicus covered; aperture a low arch, extending from umbilical area to periphery and onto spiral side.

Ecology: Tropical to subtropical, warm water, low saline (<34‰).

Stratigraphic range: Early Pliocene (Zone N19) to Recent.



Transitional water mass assemblages

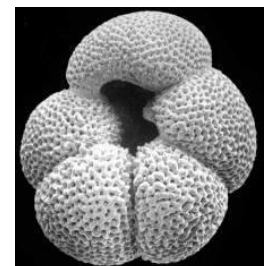
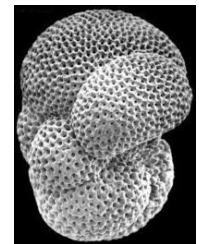
Neogloboquadrina dutertrei (198)

Order	: FORAMINIFERIDA
Suborder	: ROBERTININA Loeblich & Tappan 1984
Superfamily	: GLOBOROTALIACEA Cushman 1927
Family	: GLOBOROTALIDAE Cushman 1927
Genus	: NEOGLOBOQUADRINA Bandy, Frerichs, & Vincent 1967
Species	: DUTERTREI

Morphological description: Test globose, trochospiral, spire flat to slightly convex, five to six inflated chambers in the final whorl; sutures on spiral side almost radial to slightly curved, depressed; on umbilical side almost radial, depressed; surface uniformly moderately perforate, with distinct pore pits in tropical forms, pore pits partly or fully constricted by growth of euhedral calcite crystals in subtropical forms; umbilicus open, moderately broad and deep; aperture umbilical, umbilical-extraumbilical in young specimens; tooth-like umbilical plates often present.

Ecology: Tropical to subtropical, associated with high-nutrient water, indicate post upwelling condition, low salinity indicator in the Indian Ocean.

Stratigraphic range: Late Pliocene (Zone N21) to Recent.



Orbulina universa (Already described in tropical water mass assemblages)

Globorotalia truncatulinoides (already describe in tropical water mass assemblages)

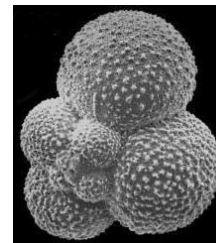
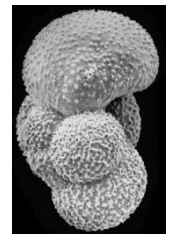
Globogerina bulloides (36)

Order : FORAMINIFERIDA
Suborder : ROBERTININA Loeblich & Tappan 1984
Superfamily : GLOBIGERINACEA Carpenter, Parker, & Jones 1862
Family : GLOBIGERINIDAE Carpenter, Parker, & Jones 1862
Subfamily : GLOBIGERININAE Carpenter, Parker, & Jones 1862
Genus : GLOBIGERINA d' Orbigny 1826
Species : BULLOIDES

Morphological description: Test low-trochospiral, usually four chambers in the final whorl; chambers spherical to subspherical, increasing regularly in size as added; sutures distinctly depressed; surface uniformly and densely perforate with simple spines; aperture umbilical, a high symmetrical arch.

Ecology: Polar to sub-polar, mostly found in upwelling areas, warmer, more saline and low nutrient level environment. Abundant is more where dissolved phosphate and silicate is high and thermocline is weak and shallow.

Stratigraphic range: Middle Miocene (Zone N9) to Recent.



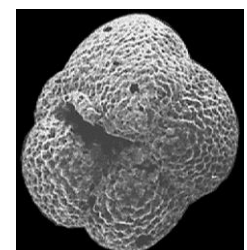
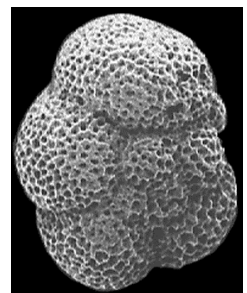
Polar and sub-polar species

Neogloboquadrina pachyderma (192)

Dextral (right handed coiling) and sinistral (left handed coiling) viewed from the apertural side

Order : FORAMINIFERIDA
Suborder : ROBERTININA (LOEBLICH & TAPPAN, 1984)
Superfamily : GLOBOROTALIACEA Cushman 1927
Family : GLOBOROTALIDAE Cushman 1927
Genus : NEOGLOBOQUADRINA Bandy, Frerichs, & Vincent 1967
Species : PACHYDERMA

Morphological description: Test low trochospiral, equatorial periphery slightly lobulate axial periphery rounded; chambers spherical to ovate, four to four and one half chambers in the final whorl, increasing rapidly in size as



added; closely embracing, final chamber irregular, often a kummerform; sutures on both spiral and umbilical sides radial, depressed; surface distinctly cancellate, thickened specimens have surface covered with euhedral calcite crystal giving rosette patterned surface; umbilicus narrow, deep; aperture interiomarginal, umbilical-extraumbilical, a rather low arch with a thick apertural rim.

Ecology: Polar to sub-polar, cold water, low saline (<34‰) and high nutrient levels.

Stratigraphic range: Late Miocene (Zone N16) to Recent.

Upwelling species

Globogerina bulloides (Already described in transitional water mass assemblages)

Index fossils

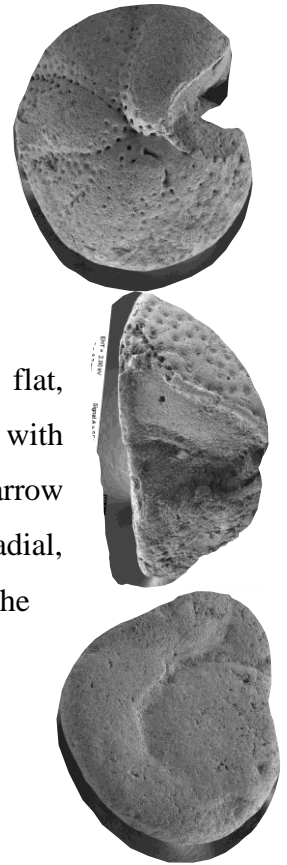
Pseudogloborotalia ranikotensis

Order	: FORAMINIFERIDA
Suborder	: ROBERTININA Loeblich & Tappan 1984
Superfamily	: PLANORBULINACEA Schwager, 1877
Family	: CYMBALOPORIDAE Cushman, 1927
Subfamily	: CARPENTERIINAE Saidova, 1981
Genus	: PSEUDOGLOBOROTALIA Haque, 1956
Species	: RANIKOTENSIS

Morphological description: Test trochospiral, planoconvex, spiral side flat, sutures oblique and curved back at the periphery, convex umbilical side with angular umbilical shoulder, radial and nearly straight incised sutures and narrow deep umbilicus, periphery angular, carinate; wall calcareous, optically radial, perforate, surface smooth; aperture a low interiomarginal arch between the umbilical shoulder and periphery.

Ecology: Tropical, warm, eutrophic, shallow marine environment.

Stratigraphic range: Paleocene.



Halkyardia minima

Order	: FORAMINIFERIDA
Suborder	: ROBERTININA Loeblich & Tappan 1984
Superfamily	: PLANORBULINACEA Schwager, 1877
Family	: CYMBALOPORIDAE Cushman, 1927
Subfamily	: HALKYARDIINAE Kudo, 1931
Genus	: HALKYARDIA Heron-Allen and Earland, 1918
Species	: MINIMA

Morphological description: Test commonly small, up to about 1.3 mm in diameter, biconvex, spiral side more convex, megalospheric test with large hemispherical protoconch, large deuteroconch, and two primary auxiliary chambers, later chambers in numerous cycles, small as seen from the spiral side, arched toward the periphery and alternating the in position with those of the preceding cycle, only those of the final whorl visible on the opposite side, where the chambers appear elongate, inflated, and tubular, umbilical region



beneath the embryonic chambers filled with a wide perforate plug formed by horizontal lamellae and connecting pillars, periphery subangular, peripheral outline lobulated; wall calcareous, optically radial, thickened by addition of lamellae on the distinctly perforate spiral side; no aperture other than the surface pores.

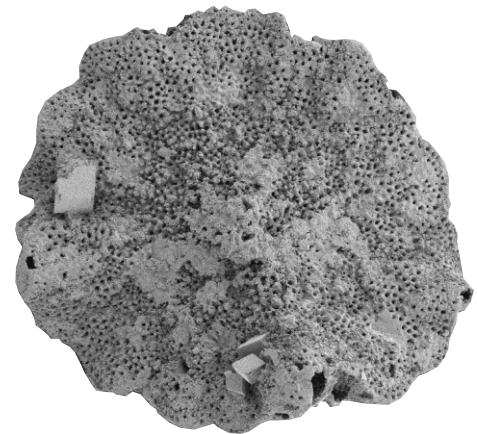
Ecology: Shallow marine environment.

Stratigraphic range: Middle Eocene (Lutetian) to Middle Oligocene (Rupelian).

Linderina kutchensis

Order : FORAMINIFERIDA
Suborder : ROBERTININA Loeblich & Tappan 1984
Superfamily : ORBITOIDACEA Schwager, 1876
Family : LINDERINIDAE Loeblich and Tappan, 1984
Genus : LINDERINA Schlumberger, 1893
Species : KUTCHENSIS

Morphological description: Test large, up to 3.5 mm in diameter, discoidal, centrally thickened, early chambers of microscopic test in an irregular cluster, rather than in a distinct spire, megalospheric test with bilocular embryo followed by nepionic ring seven to eight small chambers, layers of concentric series of small arched chambers in a single equatorial layer, those of successive series progressively larger and alternating in position, early stage covered by numerous layers of calcite, resulting in an inflated central region that may be traversed by fine pores connecting the chambers to the exterior, periphery rounded, peripheral outline lobulated; wall calcareous, surface with small pustules; aperture and intercameral openings at the base of the chamber against the chambers of the preceding cycle.



Ecology: shallow marine

Stratigraphic range: Middle Eocene (Lutetian) to Upper Eocene

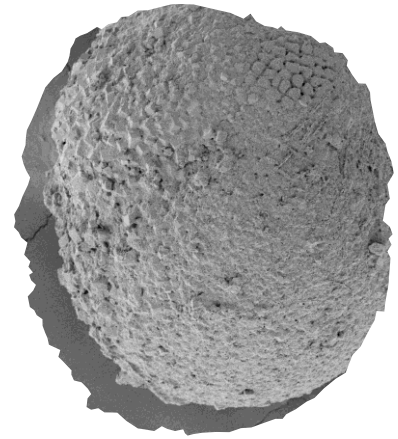
Orbulinoides beckmanni

Order	: FORAMINIFERIDA
Suborder	: ROBERTININA Loeblich & Tappan 1984
Superfamily	: GLOBIGERINICAE Carpenter, Parker, Jones, 1862
Family	: GLOBIGERINIDAE Carpenter, Parker, Jones, 1862
Subfamily	: PORTICULASPHAERINAE Banner, 1982
Genus	: ORBULINOIDES Cordey, 1986
Species	: BECKMANNI

Test spherical, early subglobular chamber in a trochospiral coil, increasing regularly in size as added, 5-6 per whorl, final chamber strongly inflated, turn shaply to completely overlap the umbilical side of the earlier stage, sutures radial on the spiral side, depressed; wall calcareous, perforate, hyaline, optically radial, surface finely spinose, at latest in the early stage; primary aperture single and intereomarginal at the early stage, adult with numerous arch opening at the base of the final chamber and a few smaller supplementary sutural opening on the spiral side.

Ecology: warm, tropical, mid latitude taxon, related to middle Eocene climatic optimum (MECO)

Stratigraphic range: Upper Middle Eocene (Middle Lutetian)

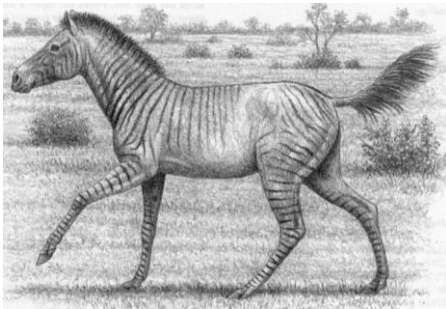


Molar tooth of vertebrates

Hipparion

Molar tooth elongated, prismatic, squarish in outline; root smaller than crown, hypsodont; crown surface flat sloping inward, lingual side slightly convex; both inner and outer side with three longitudinal ridges and two corresponding furrows; upper surface of the crown with three cones, an elliptical protocone in front, a metacone on outer side and a paracone on inner side; Each cone with enamel border which shows complicated folding, cement occurs within the valleys; protocone isolated.

Age: Pliocene- Pleistocene.



Equus

Similar to Hipparion, except the tooth slightly more elongated with more sloping upper surface; protocone joined with the outer cusp.

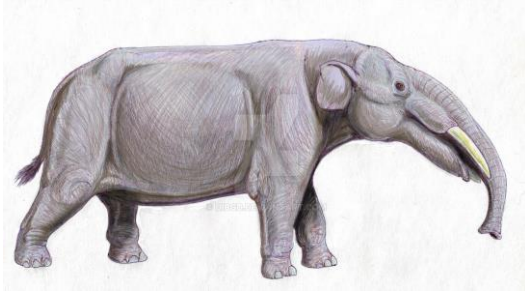
Age: Upper Pliocene- Recent.



Trilophodon

Molar tooth moderately large, elliptical in outline, upper surface of crown composed of three and a half distinct transverse ridges; each ridge with two large cone with rounded apex and few smaller connules in between larger cones, ridges separated by V shaped valleys; lophodont.

Age: Miocene- Pliocene.



Stegodon

Molar tooth large, elongated rectangular in outline, flat sided, root larger than crown; upper surface of the crown composed of 7 to 8 transverse ridges and corresponding furrows; each ridge composed of 5/7 connules, the upper surface of each connule becomes flat, cross crested; lophodont.

Age: Pliocene- Pleistocene.



Elephas

Molar tooth large, elongated, elliptical in outline, roots smaller than crown; crown surface smooth; upper surface of crown composed of flattened lamellae occurring transversely side by side; the outer margin of each lamella composed of enamel which encloses dentatine materials inside, cement fills the space between the successive lamellae.

Age: Pleistocene- Recent.

