Cloud Publications
International Journal of Advanced Earth Science and Engineering
2014, Volume 3, Issue 1, pp. 183-200, Article ID Sci-213
ISSN: 2320 – 3609

Research Article | Open Access

Illustration and Taxonomy of Late Neogene Deep Sea Agglutinated Benthic Foraminifera from the Exmouth Plateau in the Eastern Indian Ocean

Virendra Bahadur Singh[1], Ajai Kumar Rai[2] and Uday Bhan[3]

[1]Department of Petroleum Engineering, Graphic Era University, Dehradun, Uttarakhand, India
[2]Department of Earth and Planetary Sciences, Nehru Science Centre Building, Faculty of Science, University of Allahabad, Allahabad, Uttar Pradesh, India
[3]Department of Petroleum Engineering & Earth Sciences, University of Petroleum and Energy Studies, Dehradun, Uttarakhand, India

Correspondence should be addressed to Virendra Bahadur Singh, to.virendra@gmail.com

Publication Date: 25 September 2014

Article Link: http://scientific.cloud-journals.com/index.php/IJAESE/article/view/Sci-213

Abstract Agglutinated benthic foraminifera were investigated from two ODP Sites 762B and 763A located on the Exmouth Plateau off north west Australia in the eastern Indian Ocean over an interval of Late Miocene to Late Pleistocene. Sixteen species of agglutinated benthic foraminifera are recorded from 152 samples from these sites. The foraminifera are generally well preserved. All the recorded taxa described and illustrated herein belong to ten genera and five families.
Keywords *Benthic Foraminifera; Late Neogene; Taxonomy; Agglutinated; Eastern Indian Ocean; Paleoecology*

1. Introduction

Benthic foraminifera is one of the most abundant and diverse group of organisms which may form more than fifty percent of eukaryotic biomass in the deep sea (Gooday et al., 1992). They have probably the longest and most complete fossil record of any member of the deep sea benthos (Douglas and Woodruff, 1981). Studies show that many species have long stratigraphic ranges and cosmopolitan occurrences (e.g. Berggren, 1976; Boltovosky, 1978b; Tjalsma and Lohman 1983; Kaiho, 1998). Taxonomy play a significant role in the understanding of ecologic and biostratigraphic importance of benthic foraminifera. Ambiguous taxonomic identifications in many studies have resulted in inconsistent ecologic interpretations while using the same taxon or taxa in different regions. Thus a reliable taxonomy assists in comparing paleontologic data and offers a more reliable understanding of the paleoecological history of different regions. The present study will improve our understanding of the Eastern Indian Ocean agglutinated benthic foraminifera, their bathymetry, and water mass relation.

2. Study Area

The present work is based on agglutinated benthic foraminifera from the two ODP sites (Table 1) 762B (Lat. 19^0 53.24' S, Long. 112^0 15.24' E Water depth 1360 m) and 763A (Lat. 20^0 35.20' S, Long. 112^0 12.50' E Water depth 1368 m) drilled on the Exmouth Plateau in the Eastern Indian Ocean (Figure 1) during Leg 122 of D/V Glomar Challenger. Exmouth Plateau is bounded on the north by Argo abyssal plain, Gascoyne and Cuvier abyssal plain stretch westward from the Exmouth Plateau and western Australian margin. All these abyssal plains were formed by two separate rifting and sea-floor spreading events, as they contain correlatable seafloor spreading magnetic anomalies and basement seismic reflection pattern suggestive of oceanic crust (Powell, 1978; Veevers and Cotterill, 1978; Veevers, 1984) off north west coast of Australian margin creating first Argo then the Gascoyne and Cuvier abyssal plain (Powell, 1978). The Exmouth Plateau is a rifted and subsided fragment of continental crust which is above the calcium carbonate compensation depth making it an ideal site for deposition of fossiliferous calcareous sedimentary sequences. The core samples at both the sites are 10 cm^3 plugs of sediment consisting mainly of foraminifera rich nannofossil ooze. Both the sites have almost continuous and well-preserved Late Neogene sections.

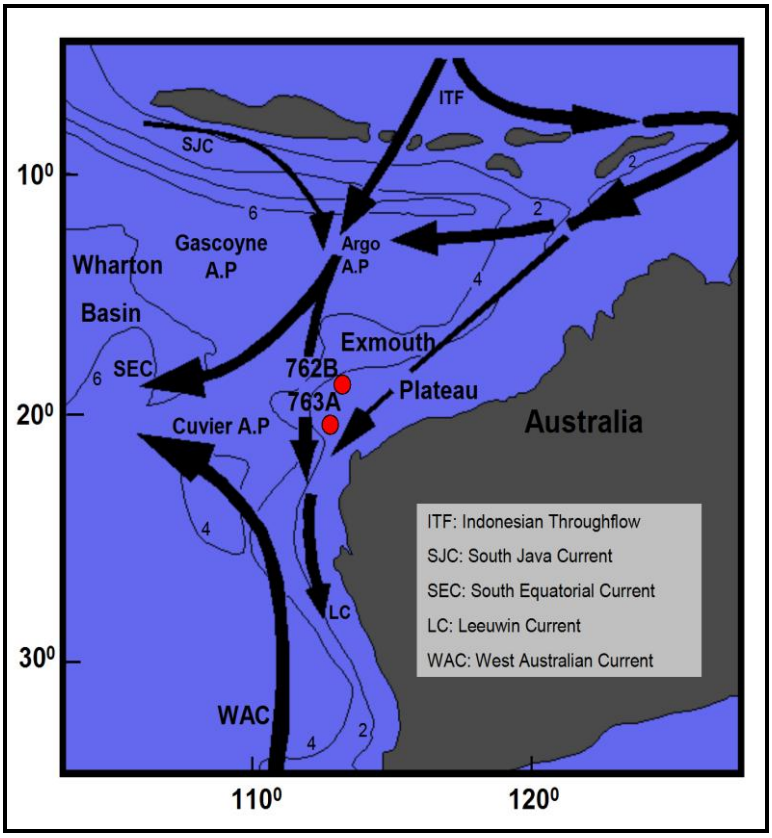

Figure 1: *Oceanographic Setting and Locations of ODP site 762B and 763A in the Southeast Indian Ocean; Depth Contours are in Kilometers*

3. Materials and Methods

Approximately 10cm^3 of each core sample was soaked in dilute (<5%) hydrogen peroxide solution and water (1:3 ratio) until clays had fully disaggregated. It was then gently washed over a 63 µm and 149 µm Tyler Sieves. Though the H_2O_2 is aggressive to carbonates, the concentration is too low (< 2%) to affect the test of benthic foraminifera. After drying a microsplitter was used to separate a representative portion of the >149 µm fraction estimated to contain about 300 specimens of benthic foraminifera. All the benthic foraminiferal specimens from the splitted samples >149 µm size fraction

were picked and mounted on microfaunal assemblage slides for identification. These slides are kept in the Micropaleontology Laboratory of Department of Earth and Planetary Sciences, Allahabad University, Allahabad, India. The >149 µm fraction was selected because it gives the most climatic information in the shortest time (Imbrie and Kipp, 1971) and is the size fraction adopted by many paleoclimatic studies especially those in the Indian Ocean (e.g. Corliss 1979a; Gupta and Srinivasan, 1992a, b; Wells et al., 1994; Nomura, 1995; Rai and Srinivasan, 2000 and others). All the mounted benthic foraminiferal individuals were then identified, counted and recorded as the percentage of the total assemblage.

Table 1: *Location of Sites, Their Depth and Number of Samples*

Leg	Site	Latitude	Longitude	Depth (m)	Name of Samples
122	762B	$19^0$53.24' S	112^0 15.24' E	1360 m	76
122	763A	$20^0$35.20' S	112^0 12.50' E	1368 m	80

4. Systematics

We presented systematic taxonomy for all the agglutinated species recorded at the sites 762B and 763A. For determinations at the generic level, we largely followed the taxonomy established by Loeblich and Tapan (1987), but taxonomic studies by Barker (1960), Bolotoskoy (1978a), Srinivasan and Sharma (1980), Hermelin (1989), Bornmalm (1997) have also been considered. Identifications of foraminiferal species were made using Barker (1960), Boltovskoy (1978a), Srinivasan and Sharma (1980), Hermelin (1989) and Bornmalm (1997). The generic nomenclature follows Loeblich and Tapan (1964, 1987)

Order : FORAMINIFERIDA Eichwald, 1830
Suborder : TEXTULARIINA Delage and Herouard, 1896
Superfamily: SPIROPLECTAMMINACEA Cushman, 1927
Family : SPIROPLECTAMMINIDAE Cushman, 1927
Subfamily : SPIROPLECTAMMININAE Cushman, 1927
Genus : *Bolivinopsis* Yakovlev, 1891
Type Species: *Bolivinopsis capitata* Yakovlev, 1891

Bolivinopsis praelonga (Schwager, 1866)
Plate 1, Figure 1

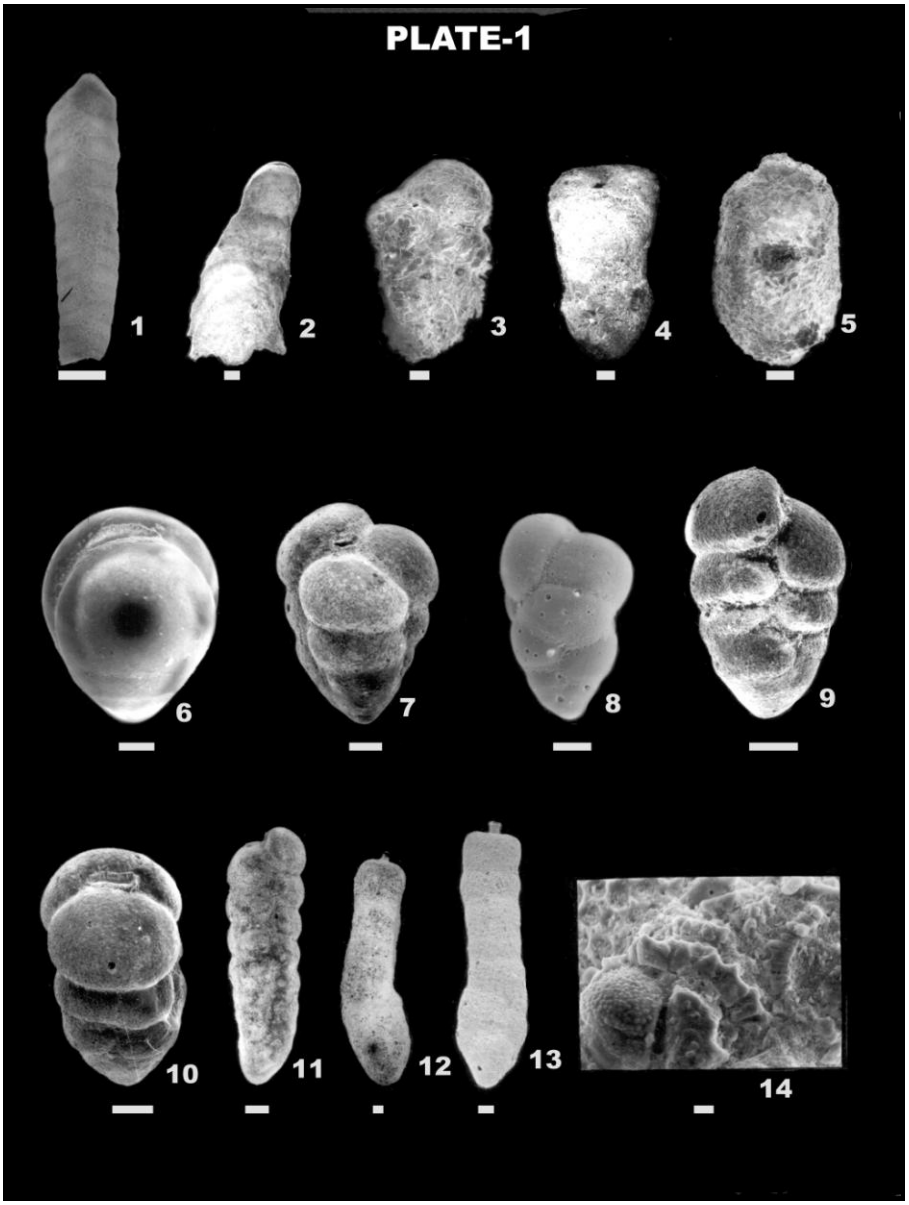

Plate 1: *(Scale bar 100µm for Figures 1-13, 10µm for Figure 14)*

Figure 1: Bolivinopsis praelonga (Schwager) side view; Figure 2: Vulvulina nicobarica (Schwager) side view; Figures 3-4: 14. Gaudryina solida Schwager, 3 side view, 4 apertural views, and 14 enlarged view of Figure 3 showing apertural area. Surface covered with broken fragments of foraminiferal test; Figure 5: Ruakituria magdalidiforme (Schwager) side view; Figure 6: Dorothia brevis Cushman and Stainforth side view; Figure 7: Eggerella bradyi (Cushman) top view; Figure 8: Karreriella baccata (Schwager) side view; Figure 9-10: Karreriella bradyi (Cushman) side view, 10 apertural view; Figure 11: Karreriella subrotundata (Schwager) side view; Figure 12-13: Martinottiella communis (d'Orbigny) side view

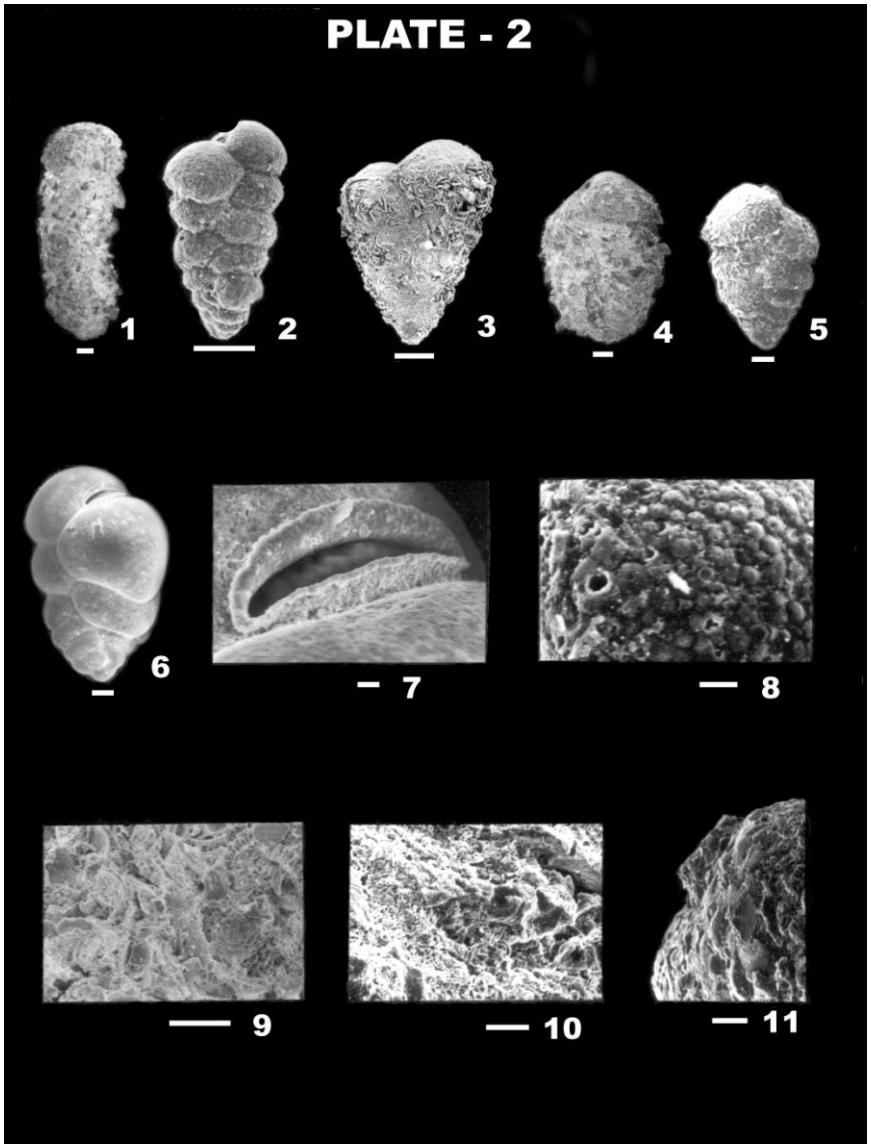

Plate 2: *(Scale bar 100µm for Figures 1-6, 9, 10µm for Figures 7-8, 10-11)*
Figures 1, 9. Martinottiella scabra (Cushman), 1 Side View, 9 enlarged view of Figure 1 showing apertural area. Surface Covered with Broken fragments of foraminiferal test; Figures 2, 8. Textularia agglutinans d'Orbigny, 2 side view, 8 enlarged view of Figure 2 showing surface covered with Nanoforam; Figure 3. Textularia halkyardi Lalicker side view; Figures 4, 10. Textularia lythostrotta (Schwager), 4 side view, 10 enlarged view of Figure 4; Figures 5, 11. Siphotextularia rolshauseni Phleger and Parker, 5 side view, 11 enlarged view of Figure 5; Figures 6-7 Siphotextularia solita (Schwager), 6 side view, 7 enlarge view of Figure 6

1866 *Textularia praelonga* Schwager: p. 252, pl. 7, Figures 104
1930 *Textilaria praelonga*; Mc Donald, p. 70, pl. 1, Figure 104
1941a *Spiroplectoides praelonga*; Le Roy, p. 31, pl. 3, Figures 95-96
1978a *Bolivinopsis cubensis*; Boltovskoy, p. 154, pl. 1, Figures 30-32
1980 *Bolivinopsis praelonga*; Srinivasan and Sharma, p. 12, pl. 4, Figure 1
1985 *Bolivinopsis praelonga*; Boersma, p. 988, pl. 3, Figures 3-4
2004 *Bolivinopsis praelonga*; Rai and Singh, Jour. Geol. Soc. of India, v. 63, p. 418

Remarks

The specimen found in this work is closely similar to *Bolivinopsis cubensis* reported by Boltovskoy, 1978a from the Late Cenozoic deep sea sequences of the northern Indian Ocean.

Bathymetry and Paleoecology

Bolivinopsis praelonga was recorded from lower bathyal (1253m) to lower abyssal (3010m) in the Indian Ocean (Boltovskoy, 1978a; Rai and Singh, 2004). Nomura (1991) also reported this species from lower bathyal depth (1074m) from the Broken Ridge in the eastern Indian Ocean. This species has also been recorded from lower bathyal depths in the Tasman Sea and Chatham Rise (Boersma, 1986). *B. praelonga* lives as deep infaunal and having higher $\delta^{13}C$ than epifaunal species because *B. praelonga* construct a test which is granular in appearance and the microstructure of the shell material may influence the isotopic values of the test (Rathburn et al., 1996).

Distribution at Sites 762B and 763A

B. praelonga shows rare and sporadic occurrences during Late Miocene to Early Pliocene at both the sites 762B and 763A.

Subfamily : VULVULININAE Saidova, 1981
Genus : *Vulvulina* d'Orbigny, 1826
Type species : *Vulvulina capreolus* Cushman, 1928

Vulvulina nicobarica (Schwager), 1866
Plate 1, Figure 2

1866 *Bigenerina nicobarica* Schwager; p. 196, pl. 4, Figures. 7a-c. (Labelled in the plate caption as *B. nicobarensis*)
1927 *Vulvulina spinosa*; Cushman, p. 111, pl. 23, Figure 1
1930 *Bigenerina nicobarensis*; Mc Donald, p. 68, pl. 1, Figure 7
1934 *Vulvulina nicobarica*; Cushman, p. 105, pl. 10, Figures 6a-b
1978a *Vulvulina spinosa*; Boltovskoy, p. 173, pl. VIII, Figures 41
1980 *Vulvulina nicobarica*: Srinivasan and Sharma, p. 12, pl. 2, Figures 5-7
1995 *Vulvulina spinosa*; Nomura, pl. 3, Figures 19a, b
2004 *Vulvulina nicobarica*; Rai and Singh, Jour. Geol. Soc. of India, v. 63, p. 420 (list)

Remarks

Vulvulina spinosa Cushman recorded by Boltovskoy (1978a), Nomura (1991) from Indian Ocean are closely resembles with the *Vulvulina nicobarica* recorded in the present work.

Bathymetry and Paleoecology

V. nicobarica has been recorded from 1253 to 2237m depths at Ninetyeast Ridge (Boltovskoy, 1978a; Nomura, 1991), 1074m at the Broken Ridge (Nomura, 1991) in the Indian Ocean. Gupta (1994) reported *V. nicobarica* from 832m depth in the Red Sea and 4300 to 4600m water depth from Pacific Ocean (Thomas, 1985).

Distribution at Sites 762B and 763A

Vulvulina nicobarica occurs rarely and sporadically during Late Miocene to Late Pliocene at both the sites 762B and 763A.

Superfamily : VERNEUILINACEA Cushman, 1911
Family : VERNEUILINIDAE Cushman, 1911
Subfamily : VERNEUILININAE Cushman, 1911
Genus : *Gaudryina* d'Orbigny 1839
Type species : *Gaudryina rugosa* Cushman, 1911

Gaudryina solida Schwager, 1866
Plate 1, Figures 3-4, 14

1866 *Gaudryina solida* Schwager; p. 119, pl. 4, Figures 11a-c
1930 *Gaudryina solida*; Mc Donald, p. 68, pl. 1, Figures 11a-c
1937 *Gaudryina solida*; Cushman, p. 59, pl. 9, Figures 6-7
1941b *Gaudryina solida*; Le Roy, p. 69, pl. 2, Figures 6,7
1964 *Gaudryina solida*; Le Roy, p. 18, pl. 1, Figures 28, 29
1978a *Gaudryina trinitatensis*; Boltovskoy, p. 160, pl. 4, Figures 10, 11
1980 *Gaudryina solida*; Srinivasan and Sharma, p. 15, pl. 2, Figures 1-3
2004 *Gaudryina solida*; Rai and Singh, Jour. Geol. Soc. of India, v. 63, p. 419 (list)

Remarks

G. solida has distinct agglutinated test which is composed of calcareous particles and broken foraminiferal tests (Pl. 1, Figure 14) cemented together. Comparison of *G. solida* with the forms recorded as *Gaudryina trinitatensis* Nuttall from the Late Cenozoic deep sea sections of the northern Indian Ocean (Boltovskoy, 1978a) reveals that both these forms are identical. Therefore *G. trinitatensis* has been included in the synonymy.

Bathymetry and Paleoecology

G. solida has been reported from lower bathyal depth (1253 m) at Ninetyeast Ridge in the Indian Ocean (Boltovskoy, 1978a). Boersma (1985) recorded this species from Ontong-Java Plateau at 2207 m and Tasman Sea at 1068 to 2131m depths.

Distribution at Sites 762B and 763A

Gaudryina solida shows common occurrence during Late Miocene to Late Pleistocene at both the sites 762B and 763A.

Superfamily : ATAXOPHRAGMIACEA Schwager, 1877
Family : GLOBOTEXTULARIIDAE Cushman, 1927
Subfamily : LIEBUSELLINAE Saidova, 1981
Genus : *Ruakituria* Kennett, 1967
Type species : *Ruakituria pseudorobusta* Kennett, 1967

Ruakituria magdalidiforme (Schwager, 1866)
Plate 1, Figure 5

1866 *Ataxophragmium magdalidiforme* Schwager; p. 193, pl. 4, Figures 1a-c

1918 *Bulimina magdalidiforme*; Sidebottom, p. 124, pl. 3, Figures 12-15
1930 *Ataxophragmium magdalidiforme*; Mc Donald, p. 68, pl. 1, Figures 1a-c
1937 *Textulariella magdalidiformis*; Cushman, p. 66, pl. 7, Figures 9, 10
1980 *Ruakituria magdalidiforme*; Srinivasan and Sharma, p. 20, pl. 1, Figures 1-10, 15, 23
2004 *Ruakituria magdalidiforme*; Rai and Singh, Jour. Geol. Soc. of India, v. 63, p. 420 (list)

Remarks

R. magdalidiforme has a characteristic elongated comma-shaped aperture. Srinivasan and Sharma (1980) considered *R. magdalidiforme* and *R. laceratum* as microspheric and megalospheric forms respectively. The microspheric forms are distinctly larger and subcylindrical with broad, rounded initial end than the megalospheric forms.

Distribution at Sites 762B and 763A

R. magdalidiforme occurs very rarely during Late Pliocene to Middle Pleistocene at site 762B.

Superfamily : TEXTULARIACEA Ehrenberg, 1838
Family : EGGERELLIDAE Cushman, 1937
Subfamily : DOROTHIINAE Balakhmatova, 1972
Genus : *Dorothia* Plummer, 1931
Type species : *Gaudryina bulletta* Carsey, 1926

***Dorothia brevis* Cushman and Stainforth, 1945**
Plate 1, Figure 6

1945 *Dorothia brevis* Cushman and Stainforth; p. 18, pl. 2, Figure 5
1978a *Dorothia brevis*; Boltovskoy, p. 158, pl. 3, Figure 31
1985 *Dorothia brevis*; Kurihara and Kennett, pl. 1, Figure 10
2004 *Dorothia brevis*; Rai and Singh, Jour. Geol. Soc. of India, v. 63, p. 418 (list)

Remarks

Dorothia brevis is characterized by initial polyserial stage followed by abruptly expanding biserial stage.

Bathymetry and Paleoecology

This species has a very wide depth range (~1200 m to 4,500 m) in the Indian Ocean (Boltovskoy, 1978a; Nomura, 1991; Gupta, 1994).

Distribution at Sites 762B and 763A

D. brevis shows rare and sporadic occurrences during Late Miocene to Late Pleistocene at both the sites 762B and 763A.

Subfamily : EGGERELLINAE Cushman, 1937
Genus : *Eggerella* Cushman, 1935
Type species : *Verneuilina bradyi* Cushman, 1911

Eggerella bradyi (Cushman, 1911)
Plate 1, Figure 7

1911 *Verneuilina bradyi* Cushman: p. 54, Figure 87
1937 *Eggerella bradyi*; Cushman, p. 52, pl. 15, Figures 19a-b
1953 *Eggerella bradyi*; Phleger, Parker and Pierson, p. 27, pl. 5, Figures 8-9
1960 *Eggerella bradyi*; Barker, p. 96, pl. 47, Figures 4-7
1978a *Eggerella bradyi*; Boltovskoy, p. 158, pl. III, Figure 33
1985 *Eggerella bradyi*; Mead, p. 225-226, pl. 1, Figures 1a-b
1989 *Eggerella bradyi*; Hermelin, p. 32, pl. 2, Figures 1-2
1991 *Eggerella bradyi*; Nomura, p. 55, pl. 1, Figures 12a-b
1992 *Eggerella bradyi*; Mackensen, p. 668, pl. 1, Figures 1-2
1994 *Eggerella bradyi*; Gupta, p. 362, pl. 1, Figure 2
1997 *Eggerella bradyi*; Bornmalm, p. 23, Figures 13E-F
2005 *Eggerella bradyi*; Hess and Kuhnt, Mar. Micropal., v. 54, text Figure 5a

Remarks

The test of *Eggerella bradyi* is finely agglutinated which is composed of calcareous particles cemented together. *E. bradyi* shows considerable variation in its height: width ratio. Both, highly conical and more cylindrical forms of this species are recorded in the present work.

Bathymetry and Paleoecology

E. bradyi has wide geographic distribution and it has been reported from the all bathyal and abyssal depths of the world's oceans. Mead (1985) recorded a regular increase in the relative abundance of this species with depth between 1493 m to 3122 m in the southeast Atlantic. Nomura (1991) reported *E. bradyi* from lower bathyal depths at the Broken Ridge and Ninetyeast Ridge in the Indian Ocean. Gupta (1994) found *E. bradyi* from lower bathyal (1623 m) to lower abyssal (5082 m) depths in the Indian Ocean. In the southeast India Ocean *E. bradyi* is reported between 2500 and 4500 m depths (Corliss, 1979a). This species shows highest relative abundance during interglacial episodes (Schnitker, 1984). Peterson (1984) found a close association of this species with the Indian Deep Water (IDW). *E. bradyi* has very high abundance in deeper water especially below 3500 m in the South China Sea (Jian and Wang, 1997). In the Somali basin *E. bradyi* found to associated with degraded organic matter (Gupta, 1997).

Distribution at Sites 762B and 763A

E. bradyi occurs commonly and almost continuously throughout the studied section from Late Miocene to Late Pleistocene at both the sites 762B and 763A.

Genus : *Karreriella* Cushman, 1933
Type species : *Gaudryina siphonella* Reuss, 1851

Karreriella baccata (Schwager, 1866)
Plate 1, Figure 8

1866 *Gaudryina baccata* Schwager; p. 200, pl. 4, Figures 12a-b
1884 *Gaudryina baccata*; Brady, p. 379, pl. 46, Figures 8-11 (in part)
1930 *Gaudryina baccata*; Mc Donald, p. 68, pl. 1, Figures 12a-b
1937 *Karreriella baccata*; Cushman, p. 133, pl. 15, Figures 20, 22-24 (not Figure 21)
1980 *Karreriella baccata*; Srinivasan and Sharma, p. 17, pl. 2, Figures 12, 19
1994 *Karreriella baccata*; Gupta, p. 364, pl. 1, Figures 3

Remarks

The test of *K. baccata* shows considerable variation in its twisting along the axis. According to Srinivasan (in Srinivasan and Sharma, 1980), the forms referred to *baccata* by Brady (1884) from the southwest Ireland are identical to Schwager's species.

Bathymetry and Paleoecology

K. baccata is comparatively a deep water species (Brady, 1884). Gupta (1994) reported this species in a wide depth range from lower bathyal (1623 m) to lower abyssal (4054 m) depths in the Indian Ocean. *K. baccata* has been also recorded by Boersma (1985) from the Ontong-Java Plateau (2207 m), Tasman Sea (1299 m) and Chatham Rise (1209 m).

Distribution at Sites 762B and 763A

K. baccata is a very rare species which occurs during Late Miocene to Late Pliocene at site 762B and Late Miocene to Middle Pleistocene at site 763A.

Karreriella bradyi (Cushman, 1911)
Plate 1, Figures 9-10

1911 *Gaudryina bradyi* Cushman; p. 67, text-Figure 107
1937 *Karreriella bradyi*; Cushman, p. 135, pl. 16, Figures 6-11
1945 *Karreriella bradyi*; Cushman and Todd, p. 8, pl. 1, Figure 20
1949 *Karreriella bradyi*; Bermudez, Cushman Lab. Foram. Res., Spec. Publ., no. 24, p. 89 pl. 5, Figures 11-16
1960 *Karreriella bradyi*; Barker, p. 94, pl 46, Figures 1- 4
1978a *Karreriella bradyi*; Boltovskoy, p. 162, pl. IV, Figures 28, 29
1979 *Karreriella bradyi*; Corliss, p. 5, pl. 1, Figures 5-6
1985 *Karreriella bradyi*; Hermelin and Scott, p. 212, pl. 1, Figure 8
1989 *Karreriella bradyi*; Hermelin, p. 33.
1991 *Karreriella bradyi*; Nomura, p. 55, pl. 1, Figures 13a-c
1992 *Karreriella bradyi*; Mackensen, p. 668, pl. 1, Figures 11-12
1995 *Karreriella bradyi*; Nomura, pl. 2, Figure. 40, pl. 3, Figures 11a-b, 12a-b
1997 *Karreriella bradyi*; Bornmalm, p. 24, Figure 13 G

Remarks

Karreriella bradyi has finely agglutinated test which is composed of calcareous particles cemented together. The specimens *encountered* in the present work are identical to the forms described as *K. bradyi* from northern Indian Ocean (Boltovskoy, 1978a) and eastern Indian Ocean (Nomura, 1991).

Bathymetry and Paleoecology

K. bradyi is an almost cosmopolitan species with a wide depth range from lower neritic zone to abyssal zone (Brady, 1884; Pflum and Frerichs, 1976). Miao and Thunell (1993) recorded *K. bradyi* midway between the lysocline (3,200 m) and CCD (3,800 m) in the South China Sea.

Distribution at Sites 762B and 763A

K. bradyi frequently occurs throughout the studied section from Late Miocene to Late Pleistocene at both the sites 762B and 763A.

Karreriella subrotundata (Schwager), 1866
Plate 1, Figure 11

1866 *Gaudryina subrotundata* Schwager; p. 198, pt. 4, Figures 9a-c
1930 *Gaudryina subrotundata*: Mc Donald, p. 68, pl. 1, Figures 9a-c
1937 *Dorothia* (?) *subrotundata*; Cushman, p. 94, pl. 10, Figure 15
1980 *Karreriella subrotundata*; Srinivasan and Sharma, p. 17, pl. 2, Figures 11, 18

Remarks

K. subrotundata differs from *K. bradyi* in possessing rounded aperture on slender neck. The specimens of present investigation are found to be identical to the forms figured and described as *K. subrotundata* by Boltovskoy, (1978a) from northern Indian Ocean and Srinivasan and Sharma (1980) from Andman Nicobar Island.

Bathymetry and Paleoecology

The characteristic elongate and tapered test of *K. subrotundata* broadly reveals an infaunal microhabitat preference (Gooday, 1994).

Distribution at Sites 762B and 763A

K. subrotundata occurs sporadically during Late Miocene to Late Pliocene at site 762B and Late Miocene to Middle Pleistocene at site 763A.

Distribution at Sites 762B and 763A

Late Miocene to Middle Pleistocene.

Genus : *Martinottiella* Cushman, 1933
Type species : C*lavulina communis* d'Orbigny, 1826

Martinottiella communis *(d'Orbigny, 1826)*
Plate 1, Figures 12-13

1826 *Clavulina communis* d'Orbigny: p. 196, pl. 12, Figures 1, 2
1884 *Clavulina communis*; Brady, p. 394-395, pl. 48, Figures 1-13
1937b *Martinottiella communis*; Cushman, p. 148, pl. 17, Figures 4-9
1960 *Martinottiella communis*; Barker, p. 98, pl. 48 Figures 3, 4, 6-8
1980 *Martinottiella communis*; Ingel, Jr. et al. p. 140, pl. 4, Figures 14, 15
1986 *Martinottiella communis*; Belanger and Berggren, p. 331, pl. 1, Figures 3, 4
1989 *Martinottiella communis*; Hermelin, p. 34, pl. 2, Figures 5-6
1997 *Martinottiella communis*; Bornmalm, p. 25, pl. 1, Figure 13H
2005 *Martinottiella communis*; Murgese and Deckker, Mar. Microp., v. 56, p. 46 (list)

Remark

In the present work encountered species shows aperture a small round opening on a neck at the centre of the ultimate chamber.

Bathymetry and Paleoecology

Gupta (1994) reported *M. communis* from the upper abyssal depth (2262 m) at Ninetyeast Ridge in the Indian Ocean. Thompson (1980) found this species from 3300 m to 6000 m in the Japan Trench area. Boersma (1985) recorded *M. communis* from lower bathyal depths (1068-1391 m) in the Tasman Sea and Chatham Rise. This species has also been recorded at lower bathyal depth in the eastern South Atlantic Ocean (Schmield et al., 1997). Hayward et al (2001, 2003) reported this species from shallower depth (300m) in the New Zealand Sea.

Distribution at Sites 762B and 763A

M. communis occurs almost continuously from Late Miocene to Late Pleistocene at both the sites 762B and 763A.

Martinottiella scabra *(Cushman, 1936)*
Plate 2, Figures 1, 9

1936 *Pseudoclavulina scabra* Cushman: p. 20, pl. 3, Figure 11
1978a *Martinottiella scabra* ; Boltovskoy, Marine Geology, vol. 26, p. 162, pl. IV, Figures 34, 35
2004 *Martinottiella scabra*; Rai and Singh, Jour. Geol. Soc. of India, v. 63, p. 420 (list)

Remarks

This species is characterized by coarsely agglutinated test, comprising mainly of broken foraminiferal tests (Pl. 2, Figure 9). Examined specimens are identical to those figured by Boltovskoy (1978a) as *Martinottiella scabra* from the northern Indian Ocean deep sea cores.

Bathymetry and Paleoecology

This species occurs in a wide depth range (1074m to 3010m) in the Indian Ocean. (Boltovskoy, 1978a; Nomura, 1991).

Distribution at Sites 762B and 763A

M. scabra shows rare and sporadic occurrences during Late Miocene to Late Pliocene at both the sites 762B and 763A.

Family : TEXTULARIIDAE Ehrenberg, 1838
Subfamily : TEXTULARIINAE Ehrenberg, 1838
Genus : *Textularia* Defrance, 1824
Type species : *Textularia sagittula*, Defrance, 1824

Textularia agglutinans d'Orbigny, 1839
Plate 2, Figures 2, 8

1839 *Textularia agglutinans* d'Orbigny: p. 144, pl. 1, Figures 17, 18
1884 *Textularia agglutinans*; Brady, p. 363, pl. 43, Figures 1-3
1960 *Textularia agglutinans*; Barker, p. 88, pl. 43 Figures 1-3
1985 *Textularia agglutinans*; Boersma, pl. 10, Figures 3-4
2005 *Textularia agglutinans*; Murgese and Deckker, Maine Micropaleontology, v. 56, p. 46 (list)

Remarks

Specimens are similar to form recorded and figured as *Textularia agglutinans* by Gupta (1994).

Bathymetry and Paleoecology

Gupta (1994) reported *T. agglutinans* from upper middle bathyal (832m) to lower bathyal (1795m) depths in the Red Sea and from lower bathyal (3030m) to abyssal (5082m) depths in the Indian Ocean. This species has also been reported by Jian et al. (1999) at 1556 m depth in the South China Sea. Boersma (1985) reported this species from lower bathyal depths in the Coral Sea, Tasman Sea and Chatham Rise. Murgese and Deckker (2005) also reported this species in the eastern Indian Ocean from lower bathyal depth.

Distribution at Sites 762B and 763A

This species shows very rare and sporadic occurrence during Pliocene at site 762B and Late Miocene to Late Pleistocene at site 763A.

Textularia halkyardi Lalicker, 1935
Plate 2, Figure 3

1935 *Textularia halkyardi* Lalicker: p. 45, pl. 7, Figure 5.
1978a *Textularia halkyardi*; Boltovskoy, p. 170, pl. VII, Figures 47-48
2004 *Textularia halkyardi*; Rai and Singh, Jour. Geol. Soc. of India, v. 63 p. 420 (list)

Remarks

Specimens of *T. halkyardi* recorded in the present work are identical to those figured as *T. halkyardi* by Boltovskoy (1978a) from the northern Indian Ocean.

Bathymetry and Paleoecology

T. halkyardi has been recorded from lower bathyal depths (1200m to 2000m) at the Ninetyeast Ridge in the Indian Ocean Boltovskoy (1978a). Nomura (1991) also reported this species from lower bathyal (1074 m) depth at the Broken Ridge, eastern Indian Ocean.

Distribution at Sites 762B and 763A

This species shows infrequent and low occurrences during Late Miocene to Middle Pleistocene at both the sites 762B and 763A.

Textularia lythostrota (Schwager, 1866)
Plate 2, Figures 4, 10

1866 *Placanium lythostrotum* Schwager; p. 194, pl. 4, Figures 4a-c
1930 *Placanium lythostrotum*; Mc Donald, p. 68, pl. 1, Figures 4a-c
1934 *Textularia* cf. *lythostrotum*; Cushman, p. 105, pl. 10, Figures 3
1940 *Textularia lythostrotum*; Coryell and Rivero, p. 324, pl. 41, Figures 3
1964 *Textularia lythostrota*; Le Roy p. 17, pl. 16, Figure 1b
1980 *Textularia lythostrota*; Srinivasan and Sharma, p. 13, pl. 1, Figures 19-21
1985 *Textularia lythostrota*; Boersma, p. 990, pl. 3, Figures 8-9

1994 *Textularia lythostrota*; Gupta, p. 366, pl. 1, Figures 4, 15
2005 *Textularia lythostrota*; Murgese and Deckker, Mar. Micropal., v. 56, p. 46 (list)

Remarks

This species has characteristic pentagonal shape and coarsely agglutinated test which is composed of fragments of foraminiferal test (Pl. 2, Figure 10).

Bathymetry and Paleoecology

Gupta (1994) recorded *T. lythostrota* from lower bathyal (1623-1764m) and abyssal (5082m) depths in the Indian Ocean. This species has also been reported from lower bathyal (1299m) to upper abyssal (2131m) depths in the Tasman Sea (Boersma, 1985).

Distribution at Sites 762B and 763A

T. lythostrota is characterized by common and frequent occurrences during Late Miocene to Late Pleistocene at both the sites 762B and 763A.

Subfamily : SIPHOTEXTULARIINAE Loeblich and Tappan, 1985
Genus : *Siphotextularia* Finlay, 1939
Type species : *Siphotextularia wairoana* Finlay, 1939

Siphotextularia rolshauseni Phleger and Parker, 1951
Plate 2, Figures 5, 11

1951 *Siphotextularia rolshauseni* Phleger and Parker: p. 4, pl. 1, Figures 23, 24
1953 *Siphotextularia rolshauseni*; Phleger, Parker and Pierson, p. 26, pl. 5, Figure 7
1971 *Siphotextularia rolshauseni*; Schnitker, p. 210, pl. 1, Figures 15a-b
1978a *Siphotextularia rolshauseni*; Boltovskoy, p. 169, pl. VII, Figure 10
1981 *Siphotextularia rolshauseni*; Cole, p. 36, pl. 5, Figure 7
1986 *Siphotextularia rolshauseni*; Kurihara and Kennett, pl. 1: 3
1999 *Siphotextularia rolshauseni*; Kuhnt, Hess and Jian, p. 141 pl. 2 Figure 1
2001 *Siphotextularia rolshauseni*; Hayward, Carter, Grenfell and Hayward, J., New Zealand Journal of Geology and Geophysics, v. 44, Figures 14H-I
2003 *Siphotextularia rolshauseni*; Hayward, Grenfell, Sabaa and Hayward, J., New Zealand Journal of Geology and Geophysics, v. 46, Figure 4A
2004 *Siphotextularia rolshauseni*; Rai and Singh, Jour. Geol. Soc. of India, v. 63, p. 420 (list)

Remarks

This species is characterized by distinctly agglutinated test and rounded aperture produced on a tubular neck (Pl. 2, Figure 11).

Bathymetry and Paleoecology

Boltovskoy (1978a) recorded this species from lower bathyal (1253m) to lower abyssal (3010m) depths at the Ninetyeast Ridge in the northern India Ocean. Corliss (1979a) reported this species from 2500 to 4600m in the southeast Indian Ocean. Jian et al., (1999) found this species at 1556m depth in the South China Sea. *S. rolshauseni* has a bathymetric range from the lower middle bathyal to abyssal depths in the Gulf of Mexico (Pflum and Frerichs, 1976). *S. rolshauseni* is a characteristic

indicator species for low organic carbon flux rates during the Last Glacial Maximum (LGM) in the Norwegian Greenland Sea (Nees and Struck, 1994).

Distribution at Sites 762B and 763A

This species has been frequently recorded from Late Miocene to Late Pleistocene section at sites 762B and 763A.

Siphotextularia solita (Schwager, 1866)
Plate 2, Figures 6, 7
1866 *Placanium solitum* Schwager: p. 195, pl. 4, Figures 6a-c
1930 *Placanium solitum*; p. 68, pl. 1, Figures 6a
1934 *Textularia solita*; Cushman, p. 104, pl. 10, Figures 2a-b
1980 *Siphotextularia solita*; Srinivasan and Sharma, p. 14, pl. 2, Figures 9, 10, 15

Remarks

The encountered specimens are identical to the form reported and figured as *Siphotextularia solita* by Srinivasan and Sharma (1980).

Bathymetry and Paleoecology

Gupta (1994) reported this species from lower bathyal (1623m) to lower abyssal (3633m) depths in the Indian Ocean. *S. solita* has also been recorded from lower bathyal depths (1000-2000m) in the Coral Sea, Tasman Sea and Chatham Rise (Boersma, 1985).

Distribution at Sites 762B and 763A

This species has been frequently recorded during Late Miocene to Late Pleistocene section at both the sites 762B and 763A.

5. Conclusion

Deep-sea sediments of the Exmouth Plateau in the Eastern Indian Ocean are represented by well preserved agglutinated benthic foraminifera. The depth range of the most of the recorded agglutinated benthic foraminifera suggests lower bathyal to abyssal deep sea environments.

Acknowledgements

We thank ODP for providing samples. We also thank Dr. Devesh K. Sinha for their help in SEM. This work was supported by grants of Council of Scientific and Industrial Research, Government of India [No. 24(0231/96/EMR-II)].

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