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Benthic Foraminifera from the Lower Miocene Sediments of Murachbann, Western Kachchh, Gujarat, India: Implications for Inferring Palaeoenvironment

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Abstract

A thorough taxonomic study was carried out for the first time using high-resolution microscopy from Neogene sections of western Kachchh, India. In the present study, 25 species of benthic foraminifera belonging to 3 classes *viz.* Globothalamea, Tubothalamea, Nodosariata and 4 orders Rotaliida, Textulariida, Miliolida and Polytmorphinida have been identified from limestone and silty-claystone of Murachbann section belonging to lower Miocene. This taxonomic study provides the distribution of benthic foraminifera species from Murachbann section. The attempt is made to interpret depositional palaeoenvironment based on this distribution of the studied foraminifera.

Keywords: Morphology, Taxonomy, Benthic Foraminifera, Limestone, Palaeoenvironment, Chhasra Formation.

Introduction

The Kachchh region of Gujarat, India is commonly known for its excellent primitive life preserved in the form of fossils (Kumar *et al*., 2022). The detailed study of foraminifera from the Cenozoic of Kachchh has been well documented several workers (Tewari, 1956; Tewari *et al*., 1968; Dasgupta, 1973; Raju, 1974; Raju and Drooger, 1978; Jauhri, 1981, 1994; Saraswati, 1994, 1995; Kumar and Saraswati, 1997; Sengupta, 2009; Kundal, 2014). The lower Miocene deposits exposed at Chhasra and Vinjhan villages were recognized with marker species *Miogypsina* (Jauhri, 1990). Further, Catuneanua and Dave (2017) based on the occurrence of *Miogypsinoides* sp., *Miogypsina dehaarti* and *Miogypsina indica* assigned the lower Miocene age to the Chhasra Formation. In spite of voluminous papers on the various aspects of Miocene foraminifers, there is a paucity of advanced documentation of foraminifera using the Scanning Electron Microscope (SEM). Therefore, the present study deals with the precise documentation of foraminifera recovered from the lower Miocene limestone and silty-claystone of the Murachbann Section of Kachchh, Gujarat, India. This paper is also attempts to interpret the palaeoenvironmental conditions on of the Murachbann Section.

Geological Setting

Structurally, the Kachchh region of western India is a pericratonic rift basin with an east-west orientation and tilted horst blocks with prevailing half-graben towards the north, bordered by the Great Rann of Kachchh (Biswas, 2005). This basin experienced marine transgression at regular intervals from the late Paleocene to mid-Eocene period overlapping the Deccan Volcanic Provenience (DVP) and disconformably on Mesozoic rocks (Biswas, 2016 a,b). The marine Paleogene-Neogene deposits of this basin are widespread (Fig. 1) and deposited during transgression phase (Raju, 2011). The entire thickness of Cenozoic succession is about 900 m (Biswas, 2005). The complete successions from Palaeocene to Holocene are well preserved in this region (Fig. 1).

Material and Methods

The sampling was carried out from the Murachbann section (23°30'05" N, 68°53'00" E), located at 2 km from Walaram Teerthdham of western Kachchh, Gujarat. Approximately 1 Kg of each rock sample was collected from the field and about 1/4th of the sample was taken for analysis and soaked in concentrated H_2O_2 for 48-72 hours for the separation of fossils and processed for sieve analysis. Well-preserved foraminifera are photographed using a Scanning Electronic Microscope (SEM, ZEISS) at the Agharkar Research Institute (ARI), Pune, Maharashtra, India, focusing on the different morphological features and surface composition. The studied material is lodged in the Post Graduate Department of Geology, Government Institute of Science, Aurangabad, Maharashtra, India.

The limestone and silty claystone of Murachbann Section consists of large quantities of bryozoans, ichnofossils, ostracods, gastropods, bivalves, and foraminifera. The fossiliferous limestone is exposed at the bottom of the section while silt and clay alternate with carbonate are present towards top of the section (Fig. 2). The studied benthic foraminifera have been identified based on the descriptions stated by Loeblich and Tappan (1987) for the supra

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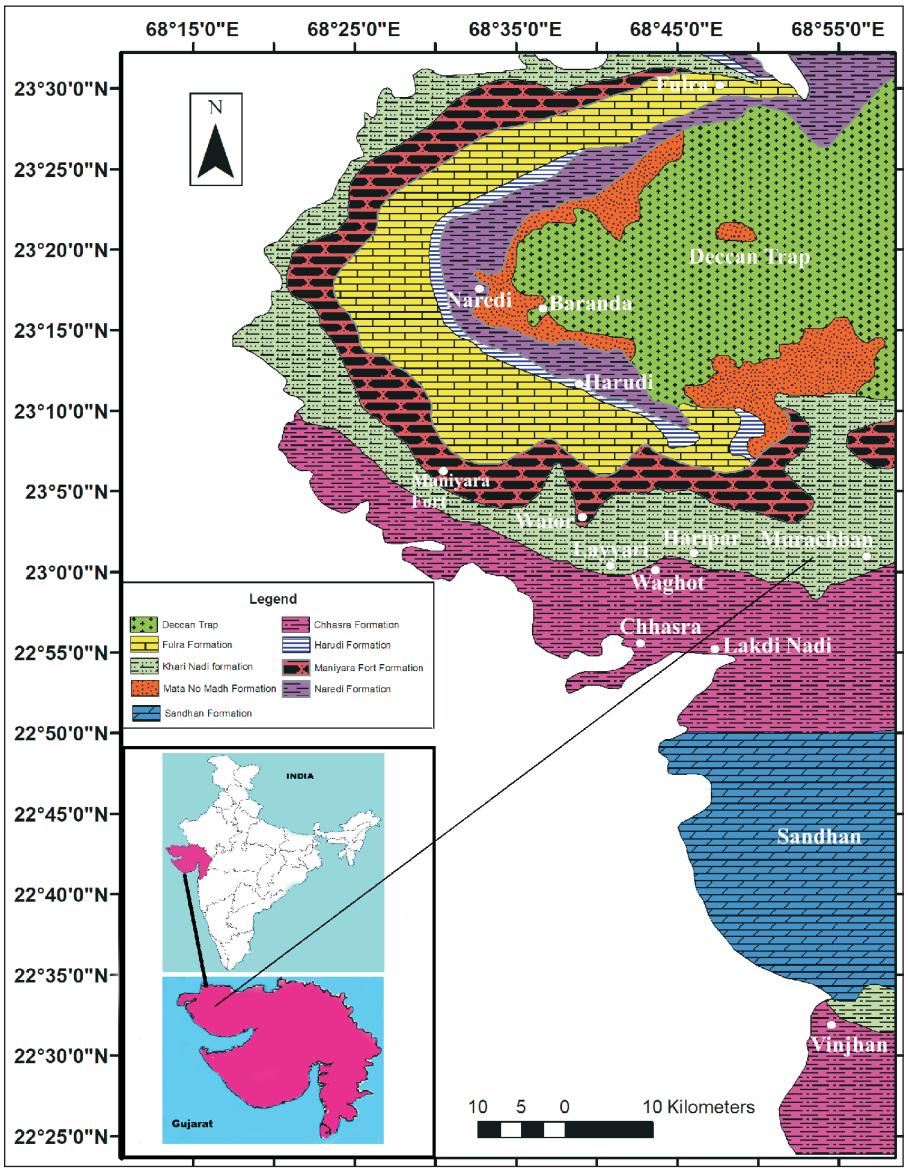

Fig.1. Geological map of Kachchh, Gujarat, India (*Modified after* Sonar *et al.,* 2022; Biswas, 2005).

generic level. However, the other standard literature has also been used for the identification of benthic foraminifera (Szarek, 2001; Kaminski *et al.,* 2002; Murray, 2003; Riveiros and Patterson, 2007; Margreth, 2010; Milker and Schmiedl, 2012; Debenay, 2012; Parker, 1962). The revised names for species are according to the World Register of Marine Species (WoRMS).

Systematic Palaeontology

The present study illustrates 25 species of benthic foraminifera belonging to 03 classes *viz.*, Globothalamea (Pawlowski *et al*., 2013), Tubothalamea (Pawlowski *et al*., 2013) and Nodosariata (Mikhalevich, 1992 and Rigaud *et al.*, 2015) with 4 orders *viz.*, Rotaliida (Delage and Hérouard, 1896), Textulariida (Mikhalevich, 1980), Miliolida (Delage and Hérouard, 1896) and Polytmorphinida (Mikhalevich, 1980) (Fig. 2).

The following are the foraminiferal species of the class Globothalamea belonging to genera *Rotalidium* (Asano, 1936): *Rotalidium* Sp., *R. annectan* (Parker and Jones, 1865); genera

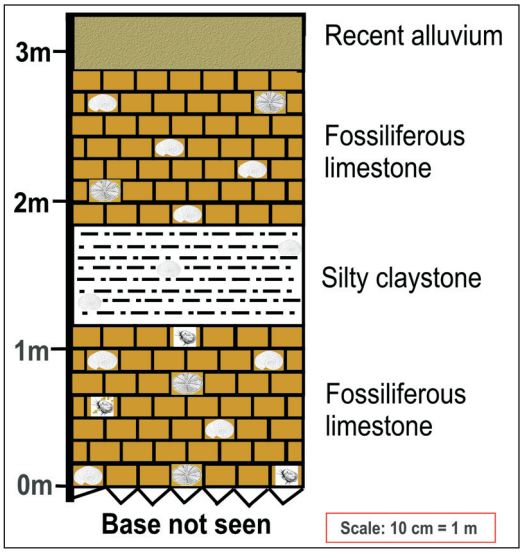

Fig.2. Litholog of Murachbann section (lower Miocene) of Kachchh, Gujarat

Amphistegina (d'Orbigny, 1826): *A. Lobifera* (Larsen, 1976); genera *Elphidium* (Montfort, 1808): *E. hispidulum* (Cushman, 1936), *E. Advenum* (Cushman, 1922); genera *Lamellodiscorbis* (Bermúdez, 1952): *Lamellodiscorbis* sp.; genera *Miogypsina* (Sacco, 1893): *M. intermedia drooger* (Drooger, 1952); genera *Textularia* (Defrance, 1824): *T. agglutinate* (d'Orbigny, 1839*)*, *Textularia* Sp., *T. martini* (Pijpers, 1933) and genera *Bolivina* (d'Orbigny, 1839): *Bolivina* Sp., *B. globulosa* (Cushman, 1933), *B. digitali* (d'Orbigny, 1846). The species of Class Tubothalamea has genera *Spiroloculina* (d'Orbigny, 1826): *S. cummunis* (Cushman and Todd, 1944); genera *Triloculina* (d'Orbigny, 1826): *Triloculina* Sp.; genera *Quinqueloculina* (d'Orbigny, 1826) with species *Q. bosciana* (d'Orbigny, 1839a,b), *Varidentella* Sp. and genera *Massilina* (Schlumberger, 1893): *M. laevigata* (Cushman and Todd, 1944). The species of Class Nodosariata has genera *Oolina* (d'Orbigny, 1839a,b): *O. globassa* (Montagu, 1803); genera *Lagena* (Walker *et al.*, 1798): *L. striata* (d'Orbigny, 1839c), *L. Substriata* (Williamson, 1848), *lagena* Sp., *Pygmaeoseistron* Sp.; genera *Dentalina* (Risso, 1826): *D. ittai* (Loeblich and Tappan, 1953) and genera *Nonionella* (Voloshinova, 1958): *N. labrodorica* (Dawson, 1860) (Fig.3-4).

Discussion

The basal part of the Murachbann Section is made up of 1.2 m thick limestone followed up by about 10 to 20 cm clayey limestone which is subsequently overlain by 1 m thick silty claystone in younging direction. The sediment distinct characteristic of this section from bottom to top and associated with varied fossils content indicates fluctuation in the sea level during the deposition of these sediments (Fig.5). The overall studies indicate that the region has mainly faced the marine transgression phase in addition to the regression phase for shorter duration. The presence of the marker species *Miogypsinoides* Sp., *Miogypsina dehaarti* and *Miogypsina indica* recorded from the Chhasra and the Vinjhan Formations show fluctuating marginal marine to shallow inner shelf depositional environment (Jhauri, 1990; Catuneanua and Dave, 2017). The basal limestone of the Murachbann Section revealed the abundance of *Rotalidium* sp., *Massilina laevigata*, *Textularia agglutinate,* the middle silty-claystones show *Miogypsina* sp., *Bolivina* sp., *Elphidium* sp., *Lagena* sp., *Rotalidium* sp, and the upper limestone beds have the presence of *Rotalidium* sp., *Spiroloculina laevigata*, *and Textularia agglutinate* indicating shallow marine condition of

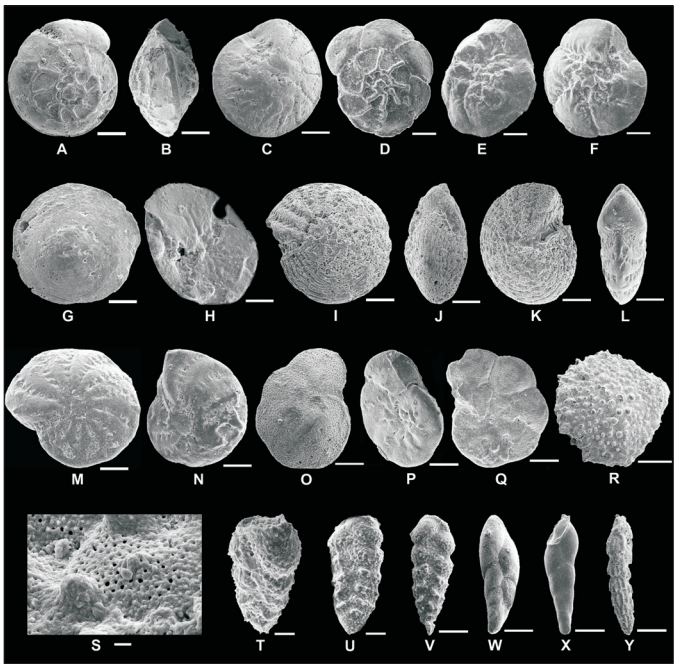

Fig.3. A-C, *Rotalidium* sp., in dorsal view (Scale equals 20 µm) (A); in apertural view (Scale equals 20 µm) (B); in ventral view (Scale equals 20 µm) (C). D-F, *Rotalidium annectens* (Parker and Jones, 1865) in dorsal view (Scale equals 20 µm) (D); in apertural view (Scale equals 20 µm) (E); in ventral view (Scale equals 20 µm) (F). G-H, *Amphistegina lobifera* Larsen, 1976 in dorsal view (Scale equals 20 µm) (G); in ventral view (Scale equals 20 µm) (H). I-K, *Elphidium hispidulum* (Cushman, 1936) in dorsal view (Scale equals 20 µm) (I); in apertural view (Scale equals 20 µm) (J); in ventral view (Scale equals 20 µm) (K). L-N, *Elphidium advenum* (Cushman, 1922) in apertural view (Scale equals 20 µm) (L); in dorsal view (Scale equals 20 µm) (M); in ventral view (Scale equals 20 µm) (N). O-Q, *Lamellodiscorbis dimidiatus* (Carpenter, 1862) in dorsal view (Scale equals 20 µm) (O); in apertural view (Scale equals 20 µm) (P); in ventral view (Scale equals 20 µm) (Q). R-S, *Miogypsina intermedia* Drooger, 1952 in dorsal view (Scale equals 100 µm) (R); in ventral close view pores (Scale equals 2 µm) (S). T, *Textularia agglutinate* d'Orbigny, 1839, dorsal view (Scale equals 10 µm). U, *Textularia* sp., dorsal view (Scale equals 20 µm). V, *Textularia martini* (Pijpers, 1933), dorsal view (Scale: 10µm). W, *Bolivina* sp., dorsal view (Scale equals 20µm). X, *Bolivina globulosa Cushman, 1933*, dorsal view (Scale equals 20 µm). Y, *Bolivina digitalis* d'Orbigny, 1846, dorsal view (Scale equals 20 µm).

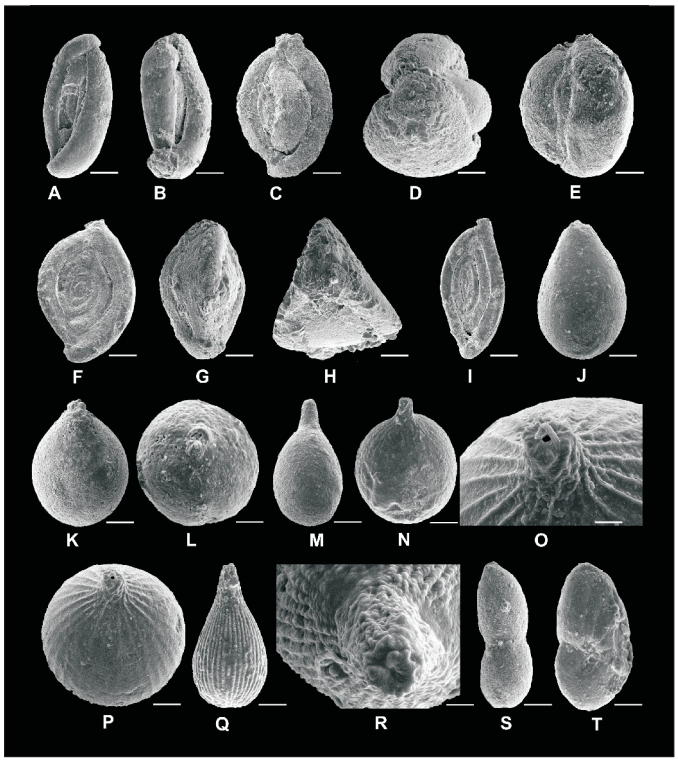

Fig.4. A-B, *Quinqueloculina* bosciana d'Orbigny, 1839 in dorsal view (scale equals 20 µm) (A); in ventral view (scale equals 20 µm) (B). C-E, *Varidentella* sp. Łuczkowska, 1972 in dorsal view (scale equals 20 µm) (C) and (D); in ventral view (scale equals 20 µm) (E). F, *Massilina laevigata* Cushman & Todd, 1944, dorsal view. (scale equals 20 µm). G-H, *Triloculina* sp. d'Orbigny, 1826 in dorsal view (scale equals 20 µm) (G) and (H). I, *Spiroloculina communis* Cushman and Todd, 1944, dorsal view (scale equals 20 µm). J, *Oolina globosa* Montagu, 1803, dorsal view (scale equal 20 µm). K-L, *Lagena striata* d'Orbigny, 1839, in dorsal view (scale equal 20 µm) (K); in apertural view (scale equals 20 µm) (L). M, *Pygmaeoseistron* sp. dorsal view (scale euals 20µm). N-P, *Lagena substriata* Williamson, 1848, in dorsal view (scale equal 20 µm) (N); in ventral view (scale equal 20 µm) (O); in apertural view (scale equal 2 µm) (P). Q-R, *Lagena* sp., in dorsal view (scale equal 20 µm) (Q); in apertural view (scale equal 20 µm) (R). S, *Dentalina ittai* Loeblich & Tappan, 1953, dorsal view (scale equal 20 µm). T, *Nonionellina labradorica* Dawson, 1860, dorsal view (scale equal 20 µm).

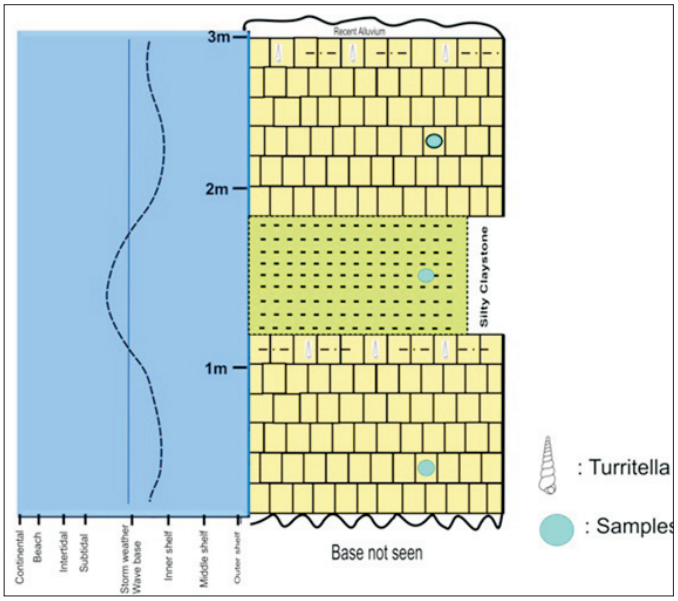

Fig .5. Relative bathymetry associated with sea level changes in Murachbann Section.

their deposition with a water depth of not more than 50m (Reiss and Hottinger 1984; Kumar and Saraswati 1997; Kundal 2014; Nouradini *et al*. 2015; Fig.5). The presence of *Spiroloculina* assemblage indicates inner shelf conditions while *Miogypsina* a eurytopic form inhabiting lagoon to shallow subtidal environment and low to high energy conditions (Kumar and Saraswati, 1997). *Elphidium* sp. and *Quinqueloculina bosciana*, *Varidentella* sp., *Massilina laevigata*, *Triloculina advena* (class Miliolids) show an indifferent reaction to any environmental change, as they are greatly tolerant to physical or chemical changes (Drinia, 2001). Besides these foraminifers, the presence of *Turritella* sp. in the upper horizons of carbonate beds suggests the prevalence of the estuarine environment intermittently.

Conclusions

The present foraminifera assemblage and lithofacies observations show that the Murachbann sediments were deposited under fluctuating paleo-depositional environments, ranging from estuarine to shallow marine sub-tidal to inner shelf open marine environments with a maximum water depth of 50 meters, under low to high energy conditions.

Authors' Contributions

SNK: Investigation, Writing-Original Draft, Formal Analysis. MAS: Conceptualization, Supervision, Reviewing. KMW: Investigation, Formal Analysis and Editing.

Conflict of Interest

No conflict of interest among the authors.

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