Marine Micropaleontology 127 (2016) 26–41

Contents lists available at ScienceDirect

Marine Micropaleontology

journal homepage: www.elsevier.com/locate/marmicro

Ocean upwelling and intense monsoonal activity based on late Miocene diatom assemblages from Neil Island, Andaman and Nicobar Islands, India

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ARTICLE INFO

Article history:
Received 29 July 2015
Received in revised form 14 June 2016
Accepted 10 July 2016
Available online 14 July 2016

Keywords:
Diatom
Late Miocene
Andaman and Nicobar Islands
Ocean upwelling
Sea level fluctuation
Monsoon

ABSTRACT

The late Miocene (Tortonian) diatoms in 21 outcrop samples from Neil Island, Andaman and Nicobar Islands were investigated with eighty two planktonic and benthic taxa belonging to 35 genera. Principal Component Analysis reveals the existence of two distinct groups; samples dominated by *Thalassionema nitzschioides* and *Thalassiothrix longissima*, belong to one group and the other group is dominated by *Actinocyclus ellipticus*, *Azpeitia nodulifera*, *Coscinodiscus asteromphalus* and *C. radiatus*. Five palaeoecological zones have been proposed with the help of CONISS cluster analysis according to the dominance of diatom taxa. To ascertain high resolution palaeoecological zones SHEBI analysis was carried out, which reveals seven zones. The studied outcrop is also characterised by the late Miocene marker radiolarians of RN8 and RN9 zones. The overall analysis indicates a strong monsoonal system; however there are evidences of relatively weaker intermittent monsoonal activity. The diatom planktonic/benthic ratio shows evidence of minor sea level fluctuations during that period. The dominance of the upwelling diatom taxon *Thalassionema nitzschioides* confirms the strong monsoonal activity during the late Miocene in the study area.

1. Introduction

The global climatic variability has stimulated an increased concern within the international scientific community and fascinated the scientists dealing with different aspects of climate research. In this context, studies of past climate provide useful insights that may enable future climatic changes to be predicted. Climate records exist for the last few centuries, albeit based on different instruments, but not on a geological scale (Plaut et al., 1995). For this, we need proxies such as microfossils to interpret past environment and climatic changes. Biostratigraphic researches based on microfossils can correlate local and global geologic events. The abundance and distribution of microfossils can be related to past changes in physical and chemical parameters (Kuppusamy and Ghosh, 2011). Of the siliceous microfossils, diatoms have been used for palaeoclimatic (Barron, 1992b; Lazarus et al., 2014), palaeoceanographic (Barron et al., 1984; Lazarus et al., 2014) and biostratigraphic studies (Harwood and Scherer, 1988; Barron, 1992a) and are known to be excellent climatic proxies due to their sensitivity to environmental changes. Since the ecological preferences of many diatom taxa are relatively well known, reconstructing past oceanic conditions can be reconstructed with some degree of certainty. Generally diatoms are abundant and diversely present in the colder waters of middle to high latitudes, and are thus good tools for biostratigraphy. In low latitudes too they have been used for biostratigraphy (Barron, 1992a, 1992b), especially in the nutrient-rich equatorial upwelling regions. Neogene diatoms from Andaman and Nicobar Islands have been reported (Ehrenberg, 1851; Ball, 1870; Ghosh and Maitra, 1947; Jacob and Shrivastava, 1952; Desikachary and Maheswari, 1958; Mathur, 1973; Srinivasan and Srivastava, 1975; Singh et al., 1978; Singh, 1979; Singh and Sharma, 1996), but not for biostratigraphic and palaeoenvironmental studies. There are numerous reports on Miocene and Pliocene diatoms from different parts of the world, however, there is scarce information on fossil diatoms from the Andaman and Nicobar Islands, designated by certain workers as northern Indian Ocean (Srinivasan and Azmi, 1979). From the present study area there are several contributions on other microfossils such as planktonic foraminifers, nannofossils and radiolarians (Srinivasan and Azmi, 1976a; Sharma and Sharma, 1988, 1989; Singh and Vimal, 1973a, 1973b, Singh and Vimal, 1974; Gupta and Srinivasan, 1992; Jafar and Singh, 1996). In the case of diatom studies, the sediments of this study area has not yet been thoroughly analysed and correlated on regional and global scales. So, it is necessary to analyse various microfossil groups from the same outcrops that will provide a cross check and reduce the

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http://dx.doi.org/10.1016/j.marmicro.2016.07.005
0377-8398/

chance of erroneous age determination and interpretation of palaeoenvironment.

This study has been undertaken with the objective of deciphering the late Miocene palaeoceanographic scenario in the Ritchie's Archipelago of the Andaman and Nicobar Islands based on diatoms. It may be specified here that according to Berggren et al. (1995) and Gradstein et al. (2004) the Miocene epoch is subdivided into early, middle and late subepochs. However, the division of subepochs is absent in The Geological Time Scale of Gradstein et al. (2012) and also in the International Chronostratigraphic Chart version 2015. Based on radiolarians and calcareous nannofossils the studied outcrop has been demarcated as Tortonian Stage of Gradstein et al. (2012). The prime focus of the present study is on the palaeoenvironment, specifically to deduce the sea level fluctuations and monsoonal activity during the late Miocene in the study area.

2. Physiographic overview

The Andaman and Nicobar Group of Islands lie in the central part of the Burma–Sunda–Java subduction complex and consist of 572 islands and islets. The Andaman Islands are the northernmost group of islands present in the Andaman, Sumatra and Java Islandic arc. This part is the subaerial expression of the mid oceanic ridge which connects the Arakan-Yoma Range of Western Burma to the islands south and west of Sumatra. Neil Island belongs to the Ritchie's Archipelago Group and is situated about 32 km east of Port Blair, the capital of the Andaman and Nicobar Group of Islands (Fig. 1). Neil Island is the southernmost part of the archipelago between Havelock and Sir Hugh Ross Island. The eastern part of the island is occupied by hillocks and forests. An almost continuous marine sequence ranging from late Miocene to Pleistocene is exposed in different parts of this island. The Mio-Pliocene Archipelago Group consists of alternations of siliciclastic turbidites and subaqueous pyroclastic flow deposits in the lower part and carbonate turbidites in the upper part. The selected outcrop for the present study lies on the northeastern coast of the island (Fig. 1).

3. Geological setting

Amongst the Andaman and Nicobar Group of Islands, Ritchie's Archipelago Group is the latest to have evolved and is the topmost stratigraphic unit of the Neogene sequence. The uplifted Neogene sequence of this region bears organic-rich mud turbidites with layers of sandstones and is devoid of any mega-benthic fossils. Outcrops of Neogene sediments are distributed along the east and west coasts of Neil Island. Chronostratigraphically, Neillian and Sawain Regional Stages representing late Miocene to early Pliocene sediments are well exposed on this island (Sharma and Srinivasan, 2007). The type section of the Neillian Stage is exposed along the east coast of the island and is also represented at Nipple Hill Section, situated in the northeastern part (Sharma and Srinivasan, 2007). The type section of the Sawain Stage is named after the Sawai Bay Section of Car Nicobar Island. The Sawain Stage is also distributed on the east coast and in the Nipple Hill sections of Neil Island. The west coast of Neil Island is represented by late Pliocene to early Pleistocene sediments (Taipian and Shompenian Regional stages) (Sharma and Srinivasan, 2007). Lithostratigraphically, the east coast belongs to the Sawai Bay Formation and the west coast belongs to the Neil West Coast Formation (Srinivasan and Azmi, 1976a). Several micropalaeontological studies have been carried out on this island specifically on planktonic and benthic foraminifers, nannofossils, radiolarians and ostracods (Sharma and Sharma, 1988, 1989; Singh and Vimal, 1973a, 1973b, 1974; Gupta and Srinivasan, 1992; Gupta and Fernandes, 1995; Jafar and Singh, 1996). However, there are very few reports on diatoms from the Neogene sequence of this island (Singh et al., 1978; Singh, 1979 and Singh and Sharma, 1996). Singh et al. (1978) reported the occurrence of 31 species of diatom from an early Pliocene outcrop situated in the northern part of Neil Island and later on Singh (1979) listed an additional 30 species of diatoms from the same samples. Singh and Sharma (1996) provided a taxonomic list of diatoms from the same early Pliocene outcrop of Neil Island that includes 63 species. All these authors deduced the age of the sediments based on planktonic foraminiferal zonation, however, their studies were mainly focused on the taxonomic aspects. The sediments of Cave Point Section, Neil Island analysed for the present investigation belongs to the Sawai Bay Formation of the Neillian Stage. The total duration of the Neillian Stage is approximately 5.1 Myr and based on the planktonic foraminiferal assemblage it is demarcated by the evolutionary first appearance of *Neogloboquadrina acostaensis* (N16 Zone of Srinivasan and Kennett, 1981a, 1981b) to the evolutionary first appearance of *Globorotalia tumida tumida* (N18 Zone of Srinivasan and Kennett, 1981a, 1981b). Based on nannofossils (Jafar and Singh, 1996) the Sawai Bay Formation has been dated as late Miocene represented by *Discoaster berggrenii* (CN9a Zone of Okada and Bukry, 1980) corresponding to the lower part of the *D. quinqueramus* Zone (NN11 of Martini, 1971). During microscopic observation we also have identified the marker radiolarians of RN8 and RN9 zones (Sanfilippo and Nigrini, 1998). The base of the studied outcrop is demarcated by the top of *Diartus hughesi* (datum/event), whereas, the secondary datum/event is represented by the base of *Didymocyrtis penultima* (Chakraborty and

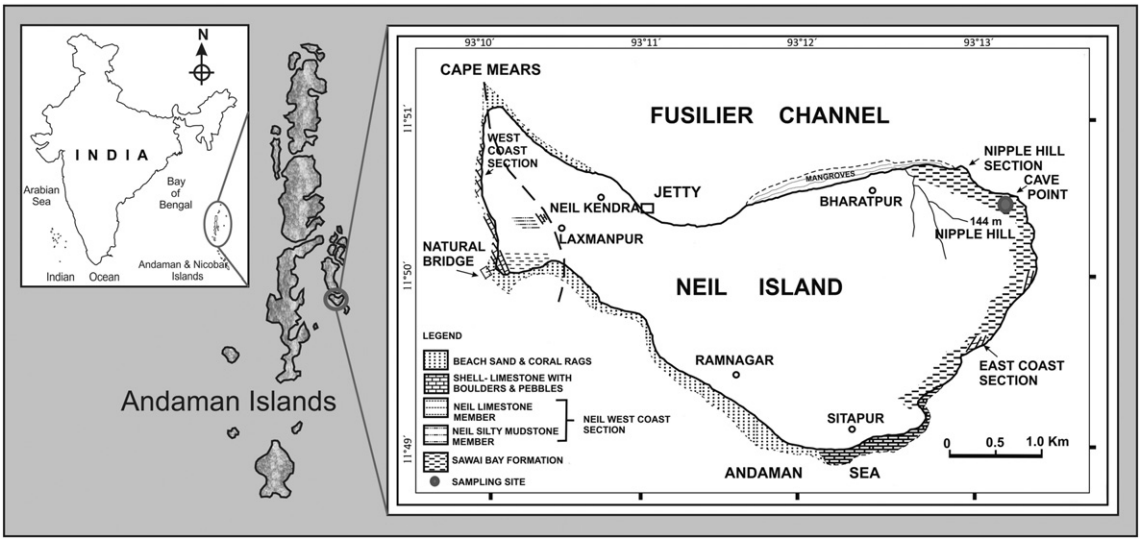

Fig. 1. Location map and Geological map of Neil Island, Andaman and Nicobar Islands, India.