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Planktonic Foraminifera from the Neogene Volcaniclastic Sediments of South Andaman Island: Implication on Stratigraphy

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ABSTRACT

The Neogene volcaniclastic sediments of South Andaman are inter-bedded with shale and siltstone; and occur as a linear band in South Andaman. Planktonic foraminiferal assemblage comprising *Globigerinoides quadrilobatus triloba* Reuss 1850, *G. quadrilobatus altiapertura* Bolli 1957, *G. quadrilobatus primodius* Blow and Banner 1962, *G. quadrilobatus sacculifer* Brady 1877, *G. subquadratus* Brönninman & Bermùdez, 1960, *G. sicanus* de Stefani 1952, *Globorotalia foshi peripheroronda* Blow & Banner 1966, *G. scitula, G. siakensis* Leroy 1939, *Globorotalia* sp.cf. *G. opima nana* Bolli 1957, *G. kugleri* Bolli 1957, G. sp. cf. *G. scitula* Brady, 1882, *Globoquadrina* cf. *lermeuri* Akers, 1955, *G. altispira globosa* Cushman & Jervis, *G. dehiscens* Chapman, Parr & Collins, 1934 and *Globoquadrina* sp. from the inter-bedded shale and claystone indicate early Miocene age. Neogene Archipelago Group conformably overlies the Oligocene Andaman Flysch Group without any break in sedimentation. Planktonic foraminiferal assemblage in the lower part of the sequence indicates a level near to Oligo-Miocene boundary. The thick interlayered tuff sequence of South Andaman indicates rejuvenation of arc volcanism in this region during early Miocene.

INTRODUCTION

Occurrences of Neogene pyroclastic deposits in Andaman Islands are well known (Srinivasan and Azmi, 1979; Pal et al., 2002 & 2005). Volcanogenic sediments are also recorded from the Neogene sequences of Havelock Island and Inglis Islands, South Andaman, (Pal et al., 2002; Srinivasan, 1988). Occurrences of glass shards in these Neogene sediments of Archipelago Group were first recorded from Inglis Island (Srinivasan, 1988).

Pal et al. (2002) confirmed presence of felsic tuff in South Andaman which was later described as pyroclastic deposits by Pal et al. (2005). Volcanogenic sediments in the Neogene sequence of South Andaman are interbedded with clay, shale, siltstone and occasionally sandstone (Pal, 2002). Detailed study of the sequence in terms of their chemistry, diagenetic alteration and nature of volcanism has been carried out though the age connotation of these sequences and their stratigraphic status is contentious. These volcaniclastic sediments of different islands are generally mentioned with a broad age range of Mio-Pliocene (Ray, 1982; Pal et al., 2002 & 2005). This prompted the authors to attempt to demarcate precise age range for the volcaniclastic sequence of the South Andaman based on the planktonic foraminiferal data and field aspects.

The Mio-Pliocene sequence of Andaman & Nicobar islands, designated as Archipelago Group, is extensively developed in Ritchie's Archipelago, Little Andaman, Interview Island and Nicobar Group of Islands. The lower part of the Mio-Pliocene Archipelago Group comprises alternations of siliciclastic turbidites and subaqueous pyroclastic ûow deposits, while the upper part comprises carbonate turbidites (Pal et al., 2003). Archipelago Group being exposed in isolated and far apart islands, the stratigraphic framework is still far from unanimous. Biostratigraphic data (Azmi & Srinivasan, 1974; Srinivasan & Sharma 1973; Sharma & Srinivasan, 2007) are relatively affluent from the majority of the isolated islands though, not well correlated with the lithostratigraphic framework. Available stratigraphic schemes of the Archipelago Group has been established based on the studies of selected sections in Archipelago Group of Islands (Havelock, Neill, Long, Guitar, English, North Passage, John Lawrence, Henry Lawrence and Inglis islands), Little Andaman, Interview Island and Nicobar Group of Islands (Sharma and Srinivsana, 2007; Srinivsana and Azmi, 1976).

Though the Neogene sedimentary succession of South Andaman has been studied since 18th century (Oldham, 1885; Tipper, 1911; Gee, 1926), occurrence of sediments of Archipelago Group in South Andaman Island was confirmed only in 60s (Chatterjee, 1964; Karunakaran et al., 1968) and it was designated as Jhirkatang Limestone. Detailed palaeontological and stratigraphic information are not available for this unit. Moreover, the Neogene sequence exposed in the South Andaman Island was neither taken into account nor correlated with the stratigraphy established from the extensively studied areas (Sharma and Srinivasan, 2007). Hence, the stratigraphic status of the volcaniclastic sequence of South Andaman is still uncertain with respect to the stratigraphy of the Archipelago Group erected by Sharma & Srinavasan (2007). However, Jhirkatang Formation has been considered as one of the stratigraphic unit in some author's stratigraphic classification and broadly considered to be Mio-Pliocene (Karunakaran et al., 1968; Ray, 1982). Absolute age of 0.73±0.16 Ma for the thick bedded tuff unit located at Miletilek in South Andaman based on ^{40}Ar- ^{39}Ar dating of tuff samples from Miletilek area and consequently, proposed revision of the unit suggesting its inclusion in the Quaternary Nicobar Group (Awasthi et al., 2015) augments the ambiguity manifolds.

Well documented palaeontological data is not available pertaining to Archipelago sequence of the main island of South Andaman district except those mentioned by Chatterjee (1967) though, the forms were neither described nor illustrated.

Several forms of planktonic foraminifera have been studied and illustrated in the present work for the first time form the volcaniclastic sequence of South Andaman. Planktonic foraminifer has been used here as index because utility of planktonic foraminifera is widely accepted for precise and reliable correlation and dating (Stainforth et al., 1975). Large scale mapping in selected sectors has also been carried out to find out the contact relationship of the volcaniclastic sequence with the overlying and underlying sequences. The present

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work attempts to ascertain the stratigraphic status of the volcaniclastic sequence exposed in South Andaman based on the planktonic foraminiferal data and field data. Attempt has also been made to infer the Oligo-Miocene boundary event in South Andaman.

GEOLOGICAL SETTING

Andaman & Nicobar Group of islands is a part of an accretionary complex formed due to collision of Indian Plate with Sunda Plate (Roy, 1992; Curray, 2005; Allen et al., 2007). Andaman and Nicobar Islands lies east of the Sunda Arc that runs from Sumatra to Burma (Fig.1a).

Stratigraphy of Andaman & Nicobar Group of Islands comprises four groups viz. Cretaceous-Palaeocene Ophiolite Group, Middle Late-Eocene Mithakhari Group, Eocene-Oligocene Andaman Flysch Group and Mio-Pliocene Archipelago Group (Table 1). First three groups are extensively developed in South Andaman whereas, the Archipelago Group is represented by the N-S trending linear band of volcanogenic and clastic sequence extending from Hasmatabat towards south to Jhirkatang towards north (Fig. 1b). Ophiolite Group which acted as a basement for the Palaeogene sediments (Sengupta et al., 1990), occurs as detached thrust slices along the east coast from Corbyns'cove to Chidiyatapu, in Badmaspahar area and Dhanikhari area (Fig. 1b). Cenozoic sediments were deposited unconformably on the ophiolites accreted to the margin of the subducting Indian plate (Bandopadhyay, 2005). Interstratified conglomerate, coarse grained sandstone, siltstone, shale and melange rocks of Mithakhari Groups (Karunakaran et al., 1968) are further classified into Lipa Black shale, Hopetown conglomerate and Namunagarh grit and are well exposed in Mithakhari, Caddlegunj, Tusanabad, Wright Mayo, east of Hobdeypur, Anikhet

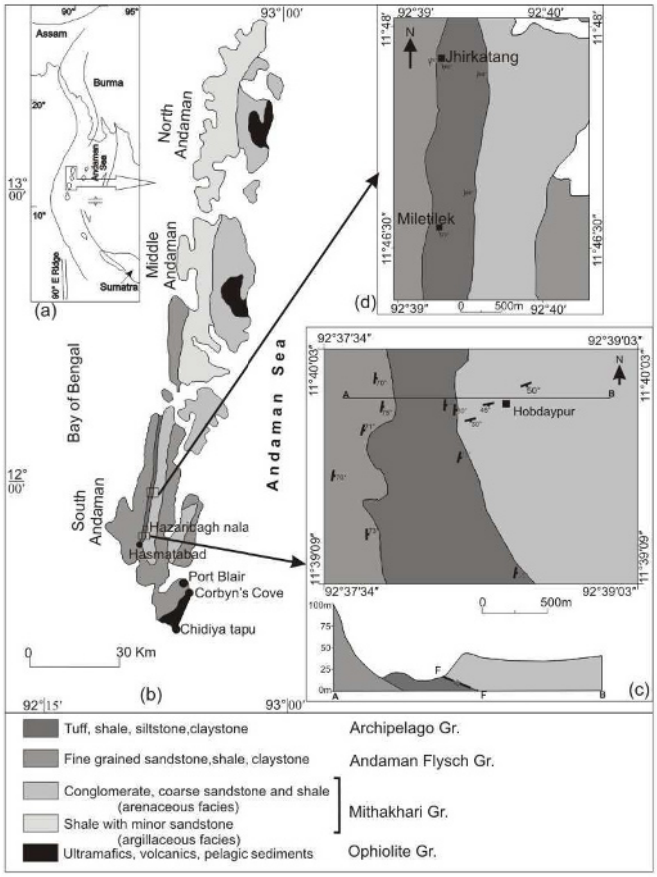

Fig.1. (a) Location of Andaman and Nicobar Islands with reference to the major tectonic elements of the region; **(b)** General geological map of Andaman Islands (modified after Bandopadhyay et al.); **(c)** Geological map of Hobdaypur area and geological cross section along A-B; **(d)** Geological map of Miletilek area

Table 1. Generalised stratigraphy of Andaman and Nicobar Island (after Ray, 1982)

Group	Formation	Lithology	Age
Archipelago Group		Limestone-tuff-Chalk-Claystone- Sandstone-Conglomerate	Early Miocene
Andaman Flysch Group		Sandstone –shale rhythmites with Bouma sequences.	Oligocene-Eocene
Mithakhari Group	Namunagarh Grit	Pebbly and gritty greywacke, green sandstone, siltstone	Middle to Late Eocene
	Hope Town Conglomerate	Polymictic matrix supported conglomerate alternated with pebbly-gritty sandstone and greenish claystone	
	Lipa Black Shale	yritiferous black shale Pand radiolarite earth	
- - - - - - - - - - - - - Unconformity - - - - - - - - - - - - -			
Ophiolite Group		Basic, ultrabasic and and intermediate igneous rocks and pelagic sediments.	Cretaceous to Palaeocene
- - - - - - - - - - - - - Unconformity - - - - - - - - - - - - -			
Older Sedimentaries		Metasedimentaries (Quartzite and quartz-mica schist)	Proterozoic ?

and in the area east of Mile Tilek and Hobdaypur (Fig. 1b). Andaman Flysch Group is siliciclastic turbidite sequence characterised by fine grained micaeceous sandstone, siltstone and shale in well developed Bouma sequence. The rocks of Andaman Flysch Group are exposed in Corbyn's Cove, Collinpur, Manpur, Wandoor, Hobdeypur, Hazaribagh and Miletilek areas (Fig.1b). The N-S trending band of Archipelago Group occurs mostly along a valley and is sandwiched between Andaman Flysch in the west and Mithakhari Group in the east (Fig. 1b).

FIELD ASPECT OF THE VOLCANICLASTIC SEQUENCE IN SOUTH ANDAMAN

Volcaniclastic sediments of South Andaman Island are represented by tuff-shale-siltstone-claystone and exposures of these sediments are discrete in the form of isolated mounds aligned in N-S trend. Further north, beyond Jhirkatang, extension of this band could not be confirmed as the area comes under Jarwa reserve forest. The sequence is well exposed in three sections viz. Hobdaypur, Hazaribaghnala and Miletilek. Thickness of the volcaniclasitic sequence is more in the Miletilek area than in the Hobdaypur and Hazaribaghnala area.

Tuff-shale-claystone-sandstone sequence is exposed along the road cut section on the slope of a small mound just west of Hobdaypur village (Fig. 2). The 12m thick sequence comprises of siltstone, shale and claystone in alternation with occasional tuff bands at base and thick bedded light grey and greenish colour tuff towards top (Fig. 3). Attitude of the strata varies from N-S to NNE-SSW with 30° to 40° easterly dip. Fine grained micaceous sandstone of Andaman Flysch Group underlies this volcaniclastic association at the western flank of valley. Direct contact between Andaman Flysch Group and the volcaniclastic sediments could not be found in this section. However, strata of Andaman Flysch Group trending NNE-SSW with 50°-70° easterly dips maintains a conformable relationship with the volcaniclastic sequence of Archipelago Group. East of Hobdaypur, the volcaniclastic sequence is juxtaposed with coarse grained sandstone

Fig.2. Tuff –shale alternation in Hobdaypur section

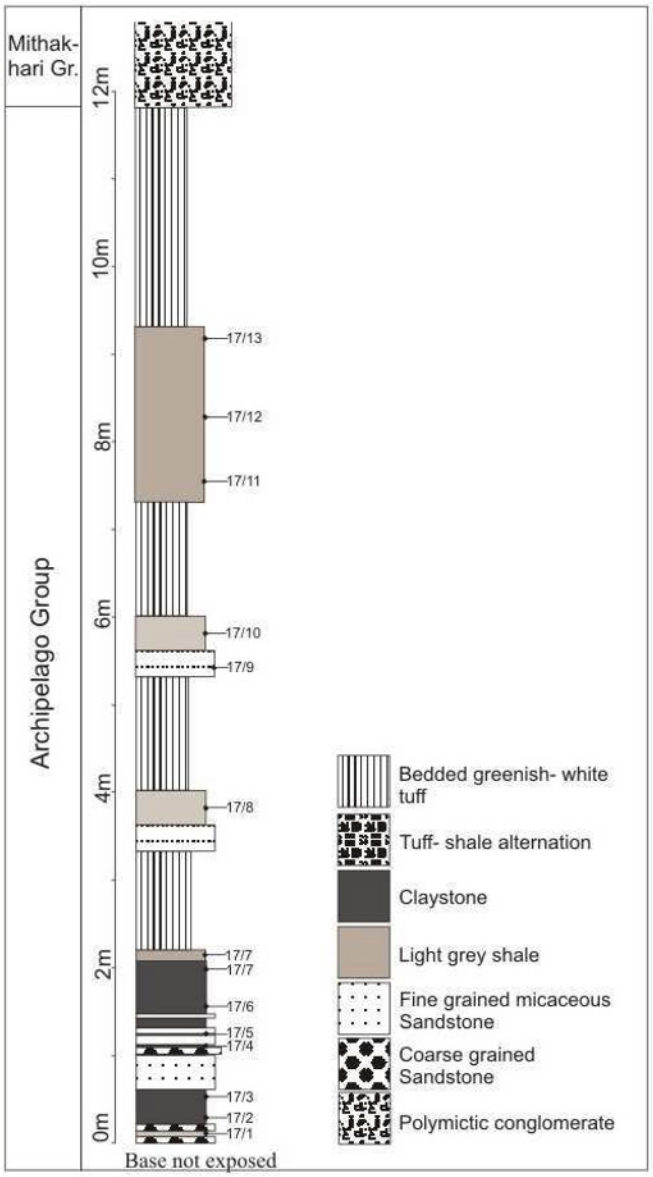

Fig.3. Litholog of Hobdaypur section showing sample positions.

and polymictic conglomerate sequence of Mithakhari Group along a faulted contact (Fig. 1c). Trend of sandstone beds in Mithakhari Group 70°-80° with 30°-50° southerly dip making high angle with the trend of the volcaniclastic sequence.

Volcaniclastic sequence of tuff, shale and siltstone is exposed in the form of a mound in Hazaribaghnala (Fig. 4) with thickness of about 6m (Fig. 5). Attitude of exposed strata is NNW-SSE with around 50° easterly dip which is more or less conformable to underlying fine grained micaceous sandstone of Andaman Flysch Group which trends NNW-SSE with 25° easterly dip. Contact between these two units is gradational, while contact with Mithakhari Group is concealed in this area.

Andaman Flysch, Archipelago and Mithakhari groups in Miletilek area are disposed in similar pattern as in Hobdaypur and Hazaribaghnala (Fig. 1d). The volcaniclastic sequence of South Andaman is developed with maximum thickness in Miletilek area (Fig. 6). About 160m thick tuff, shale and siltstone sequence (bedding attitude NNE-SSW with 65°-70° easterly dip) overlies Andaman Flysch Group (bedding attitude NNE-SSW° with 70-75° easterly) with a sharp conformable contact. Bedded buff to light green tuff is interlayered with shale, siltstone (Figs. 7 & 8) and the top of the sequence is occupied by calcareous claystone. Very coarse grained to gritty sandstone of Mithakhari Group overlies the tuff-shale-siltstone-claystone sequence. However, contact between the volcaniclastic sequence and Mithakhari Group could not be observed in this section.

The volcaniclastic sequence of South Andaman is sandwiched between Andaman Flysch to the west and Mithakhari Group to the east (Fig. 1c). A faulted contact between Archipelago and Mithakhari Group can be logically inferred. Near the contact, strike of bedding planes in Mithakhari Group are at very high angle to the trend of the Archipelago Group (Fig.1c) which indicates considerable rotational component during the movement of the hanging wall. However, the contact between these two groups is faulted may not be thrusted in strict sense as interpreted earlier (Pal et al., 2003).

MATERIAL AND METHOD

Samples of claystone and shale interbedded with tuff along with few samples from the underlying fine grained micaceous sandstone of Andaman Flysch were collected systematically in three sections viz. Hobdaypur section, Hazaribaghnala section and Miletilek section. About 250 gms of sample was crushed into mm size and the crushed sample was boiled in water with washing soda for about 30 minutes. The mixture was allowed to cool and washed under jet of water through a set of three sieves of 80, 120, and 230 mesh size. The three fractions were dried in room temperature. About 10 gms of samples from the processed samples were scanned under stereozoom microscope (Leica MZ 12) and specimens of planktonic foraminifera were picked. +80 and +120 fractions yielded the planktonic foraminifera illustrated in this work. As +230 fractions yielded some broken tests and few juvenile forms of planktonic forams, those were not taken into account in the present study. SEM images of representative specimens were taken for studying morphological details.

Planktonic foraminiferal assemblage has been recorded in 06

Fig.4. Exposed of tuff-shale sequence in Hazaribaghnala area

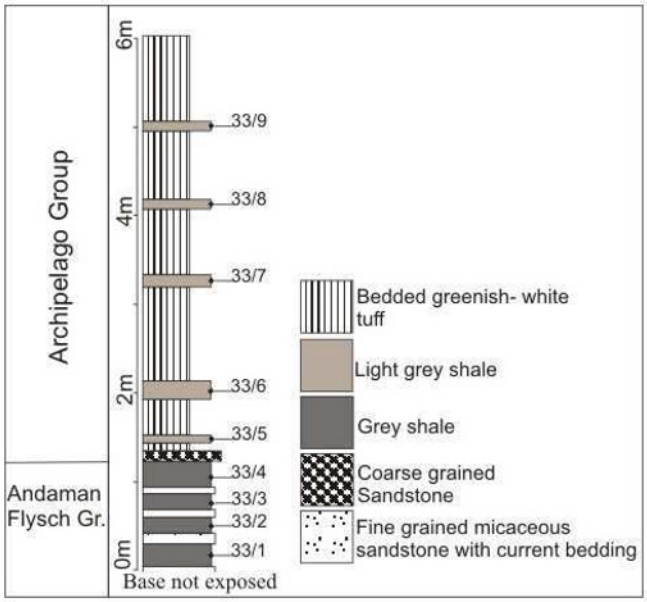

Fig.5. Litholog of Hazaribaghnala section showing sample positions

samples out of 40 collected samples. Planktonic foraminifera recovered from these samples are fairly well preserved. The studied materials are kept in the repository of Eastern Region, Geological Survey of India, Salt Lake, Kolkata.

RESULTS

Interbedded shale-tuff-claystone sequence in the lower part of Hobdaypur section is rich in planktonic foraminifera, whereas, the tuff beds of upper part are unfossiliferrous. Claystone and shale beds from the lower part of Hobdaypur section have yielded planktonic foraminifera viz. *Globigerinoides quadrilobatus triloba* Reuss, 1850 (Pl.- I, Figs. 1-4), *G. quadrilobatus altiapertura* Bolli, 1957 (Pl.- I, Figs. 5-7), *G. quadrilobatus primodius* Blow and Banner, 1962 (Pl.- I, Figs. 8-10), *G. sacculifer* Brady, 1877 (Pl.- I, Figs. 11-14), *G. subquadratus* Brönninman & Bermùdez, 1960 (Pl.- I, Figs. 15-17), *G. sicanus* de Stefani, 1952 (Pl.- I, Figs. 18-20), *Globorotalia foshi peripheroronda* Blow & Banner, 1966 (Pl.- II, Figs. 1-4), *G*. sp. cf. *G. scitula* Brady, 1882 (Pl.- II, Figs. 5-7), *G. siakensis* Leroy, 1939 (Pl.- II, Figs. 8-11), *Globorotalia* sp. cf. *G. opima nana* Bolli, 1957 (Pl.- II, Figs. 12-14), *G. kugleri* Bolli 1957 (Pl.- II, Figs. 15-16), *Globoquadrina* cf. *lermeuri* Akers, 1955 (Pl.- III, Figs. 1-3), *G. altispira globosa* Cushman & Jervis, (Pl.- III, Figs. 4-6), *G. dehiscens* Chapman, Parr & Collins, 1934 (Pl.- III, Figs. 7-13) and *Globoquadrina* sp. (Pl.- III, Figs. 14-16).

The planktonic foraminiferal assemblage of Hazaribaghnala Section is exactly similar to that of the Hobdaypur section (Table 2). Tuff dominated lower part of Miletilek section is unfossiliferrous, whereas, the claystone on the top of the section is richly fossiliferous. *Globigerinoides primodious*, *Globorotalia kugleri*, and *Globorotalia* sp. cf. *G. opima nana* is not recorded in planktonic foraminiferal

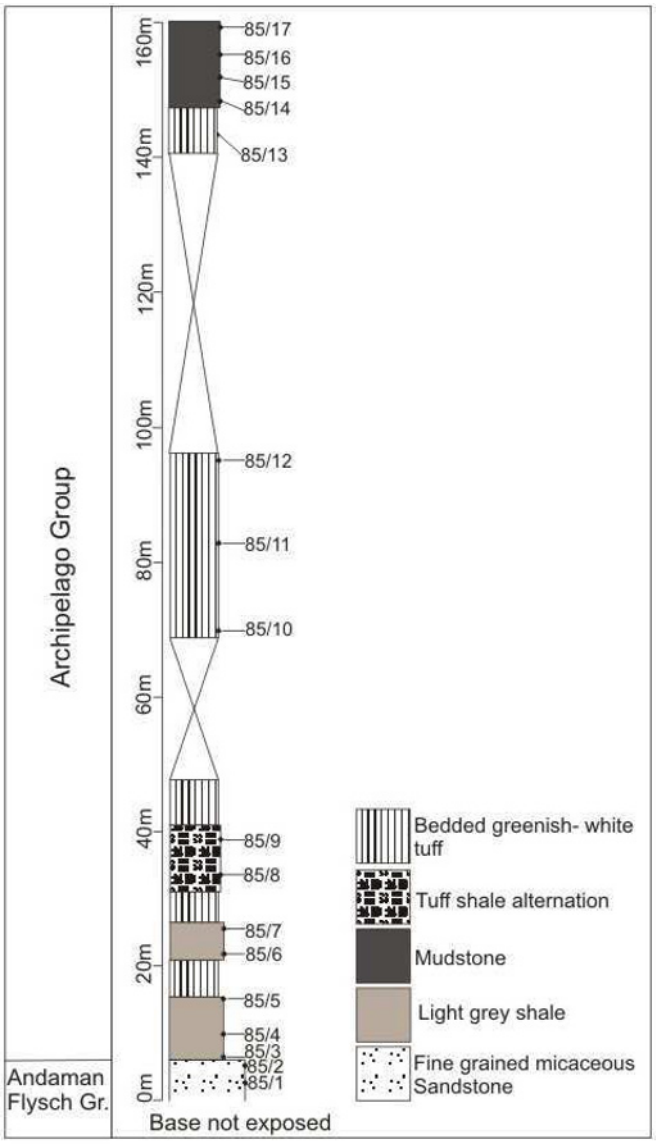

Fig.6. Litholog of Miletilek section showing sample positions

assemblage identified from the claystone of Miletilek section (Fig. 5, Table 2). All other elements of the planktonic foraminiferal assemblage recorded in Hobdaypur and Hazaribaghnalla continues up to the top part of the Miletilek section (Fig. 5, Table 2).

Fig.7. Volcaniclastic sequence in Miletilek section. Andaman Flysch in the background covered by thick vegetation.

Fig.8. Bedded tuff and shale alternation in Miletilek section.

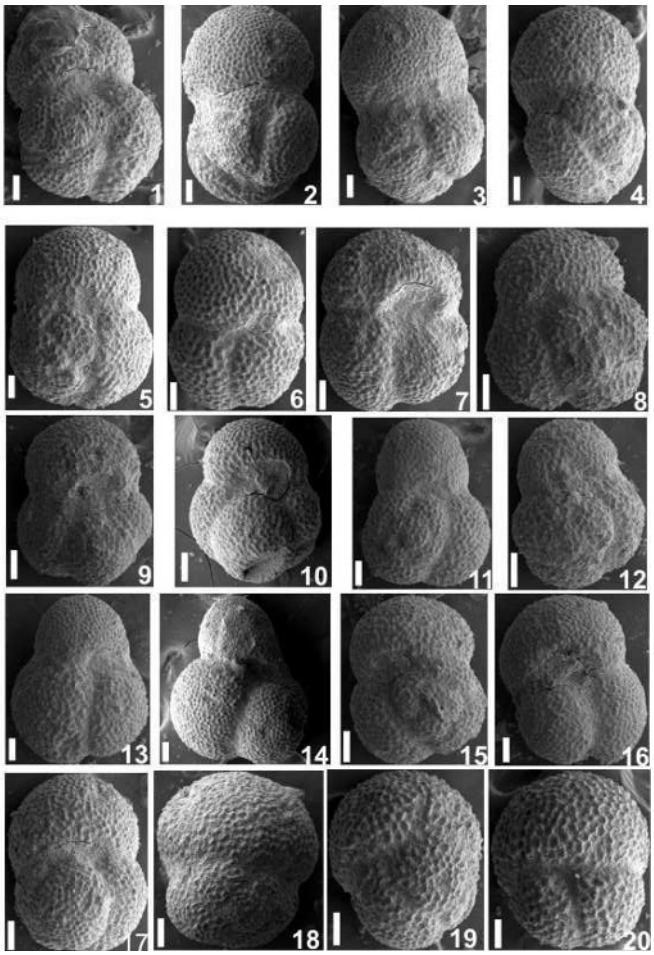

Plate 1: SEM Photographs of Planktonic Foraminifera from volcaniclastic sequence of South Andaman Island.**1-4:** *Globigerinoides quadrilobatus triloba* Reuss (1 - spiral view; 3- umbilical view; 2, 4 –side view). **5-7:** *Globigerinoides quadrilobatus altiapertura* Bolli (5, 6 – spiral view;7- umbilical view). **8-10:** *Globigerinoides quadrilobatus primodius* Blow & Banner (8 -spiral view; 9, 10- umbilical view). **11-14:** *Globigerinoides sacculifer* Brady (11, 12 - spiral view; 13, 14- umbilical view). **15-17:** *Globigerinoides subquadratus* Brönninman & Bermùdez, 1960 (15 -spiral view, 16, 17- umbilical view). **18-20:** G. sicanus de Stefani (18, 19 -spiral view, 20- umbilical view). All scale bars represent 60 µm.

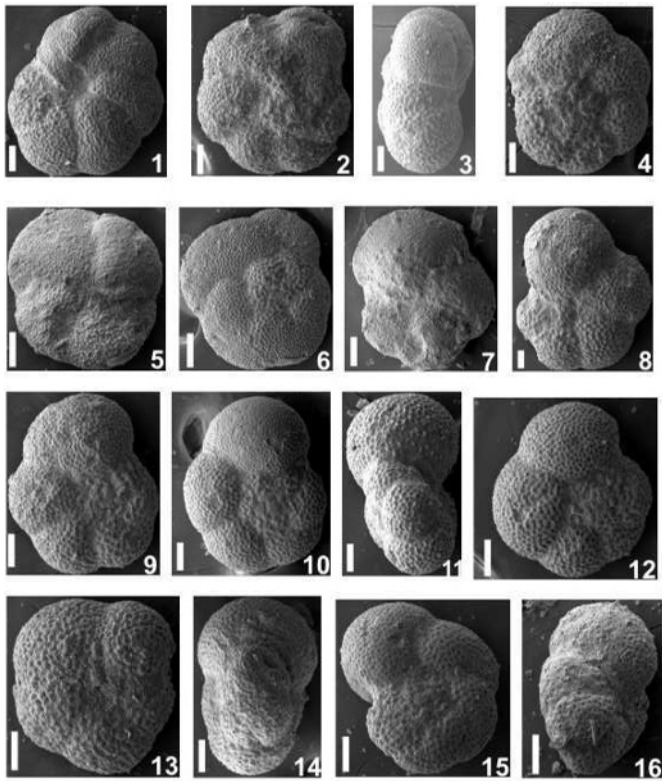

Plate - II. SEM Photographs of Planktonic Foraminifera from volcaniclastic sequence of South Andaman Island**. 1-4:** *Globorotalia foshi peripheroronda* Blow & Banner 1966 (1-umbilical view; 2, 4– spiral view, 3- side view), **5-7:** *Globorotalia* cf. *G. scitula* Bandy (5- umbilical view; 6-spiral view), **8-11:** *Globorotalia siakensis* Leroy 1939 (8- umbilical view 9; 10&12 -spiral view; 11- side view), **12-14:** *Globorotalia* cf. *G. opima nana* Bolli (12- spiral view;13 - umbilical view; 14 – side view). **15-16:** *G. kugleri* Bolli 1957 (15 -spiral view; 16-side view). All scale bars represent 60 µm.

DISCUSSION

Volcaniclastic sediments of South Andaman occur in association with shale and claystone as an interbedded sequence with a maximum thickness of about 160 m (Fig. 6). In general, the lower part of the sequence comprises of alternation of buff to white tuff with thin shale, claystone, minor sandstone which gradually turns into thickly bedded buff to greenish grey tuff and towards top it is occupied by fossiliferous light grey claystone. The sequence is developed with the maximum thickness in the Miletilek Section whereas; in Hobdaypur and Hazaribaghnalla area only the lowermost part of the sequence is exposed.

Planktonic foraminiferal assemblage containing *Globigerina ciperoensis* recorded from Andaman Flysch Group exposed in the

Table 2. Planktonic foraminifera recorded in Hobdaypur, Hazaribaghnala and Milektilek sections

Miletilek Section	*G. fohsi peripheroronda, G.* sp. *G. scitula, Globorotalia* sp., *Globigerinoides quadrilobatus triloba, G. quadrilobatus sacculifer, G. quadrilobatus altiapertura, G. sicanus, G. subquadratus, Globoquadrina dehiscens, G. altiapertura globosa, G. larmeuri, Globoquadrina* sp.
Hobdaypur and Hazari-baghnala sections	*Globorotalia kugleri, G. fohsi peripheroronda, G. cf. G. opima nana, G. obesa, Globorotalia* sp., *Globigerinoides quadrilobatus triloba, G. quadrilobatus sacculifer, G. quadrilobatus altiapertura, G. quadrilobatus primodius, G. subquadratus, Globoquadrina dehiscens, G. altiapertura, G. larmeuri, Globoquadrina* sp.

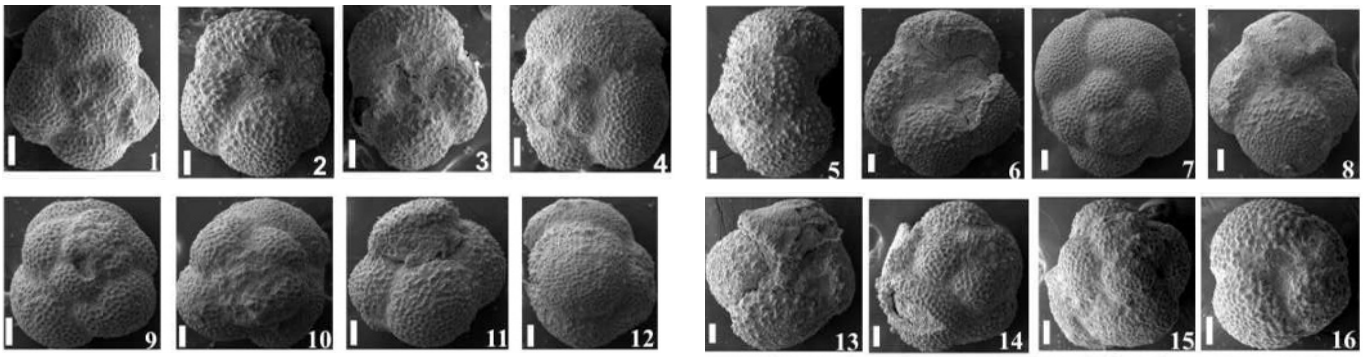

PLATE - III. SEM Photographs of Planktonic Foraminifera from volcaniclastic sequence of South Andaman Island. **1-3:** *Globoquadrina* cf. *Larmeuii* Akers (1 -spiral view; 2, 3- umbilical view), **4-6:** *Globoquadrina altispira globosa* Cushman and Jarvis (4 -spiral view; 5 – side view, 6-umbilical view), **7-13:** *Globoquadrina dehiscens* Chapman, Parr & Collins (7, 9, 10 -spiral view; 8, 11, 13- umbilical view; 12 side view), **14-16:** *Globoquadrina* sp. (14, 15 -spiral view; 16- umbilical view). All scale bars represent 60 µm.

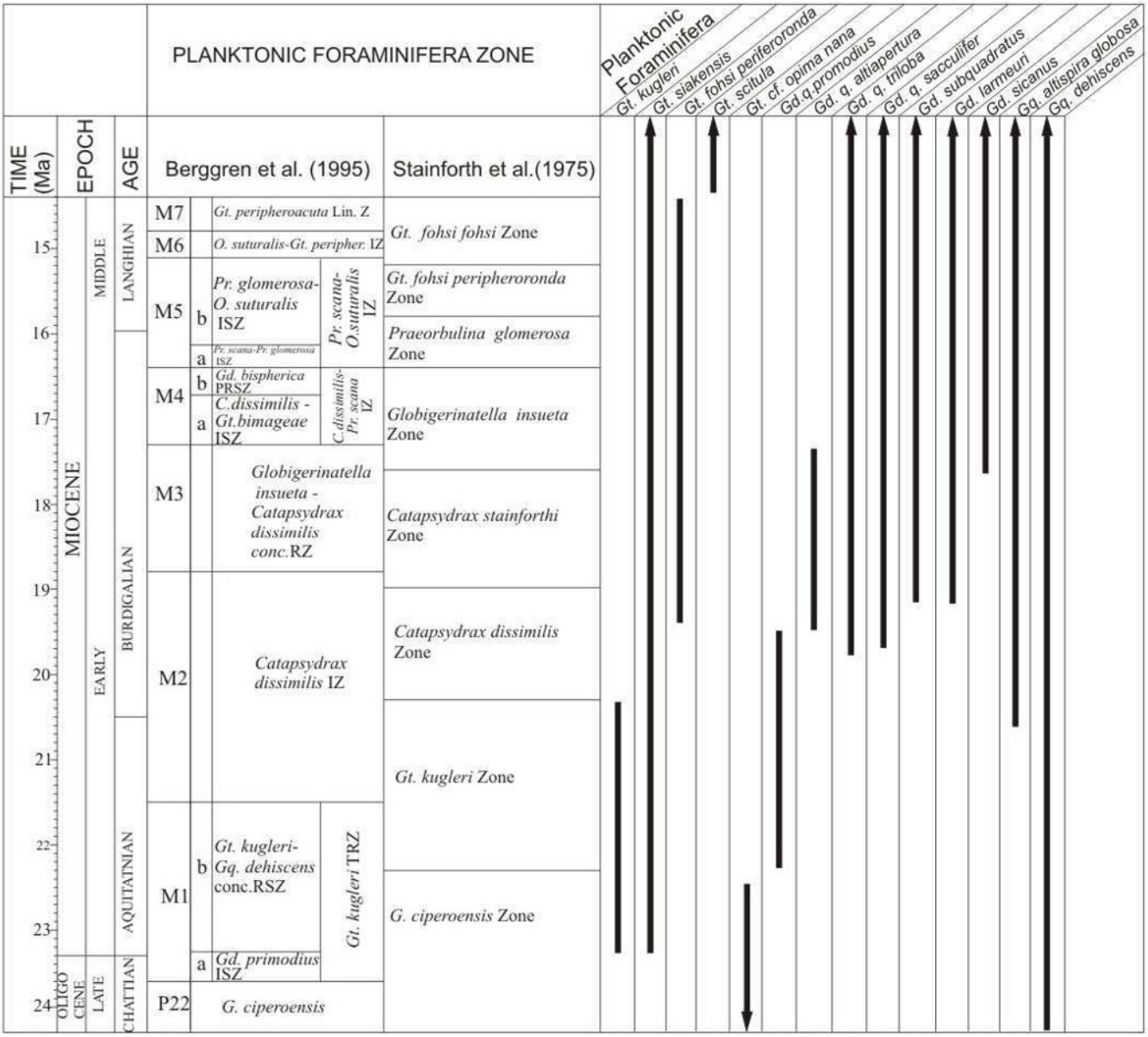

Fig.9. Comparison of planktonic foraminifera biozones of Berggren et al.(1995) and Stainforth et al. (1975) and range of the planktonic foraminifera species

Table 3. Abundance of foraminiferal species in Hazaribaghnala, Hobdaypur and Miletilek Sections. (Abundant, F- Frequent, R- Rare, 0- Absent)

		Gt. kugleri	*Gt. siakensis*	*Gt. fohsi peripheroronda*	*G. cf. opima nana*	*Gt.* Cf. *scitula*	*Gt.* sp.	*Gld. quadribatus triloba*	*Gld. q. sacculifer*	*Gld. q. altiapertura*	*Gld. q. primodius*	*Gld. sicanus*	*Gld. subquadratus*	*Gq. dehiscense*	*Gq. altiapertura*	*Gq. larmeuri*	*Gq.* sp
Miletilek section	85/16	0	R	A	0	R	F	A	A	R	0	R	F	F	0	F	F
	85/15	0	R	A	0	R	F	A	A	A	0	R	F	F	0	F	F
	85/14	0	0	F	0	R	F	A	A	A	0	0	F	F	0	F	F
	85/13	0	0	A	0	R	F	A	A	A	0	0	F	F	0	F	F
	85/12	0	0	0	0	R	F	A	A	A	0	R	F	F	0	F	F
	85/11	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	85/10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	85/9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	85/8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	85/7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	85/6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	85/5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	85/4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	85/3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	85/2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	85/1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Hobdaypur section	17/13	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	17/12	F	0	R	R	A	R	A	R	F	R	F	R	F	A	R	F
	17/11	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	17/10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	17/9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	17/8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	17/7	F	0	R	R	A	R	R	R	F	R	0	R	F	A	R	F
	17/6	F	0	R	R	A	R	0	R	R	R	0	R	F	A	R	F
	17/5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	17/4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	17/3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	17/2	F	0	R	R	A	R	0	R	R	R	0	R	F	A	R	F
	17/1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Hazaribaghnala section	33/9	F	0	R	R	0	F	R	R	R	F	0	R	R	F	0	R
	33/8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	33/7	F	0	0	F	0	R	R	R	R	F	0	R	R	F	0	R
	33/6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	33/5	A	0	0	R	0	R	R	R	R	F	0	R	0	F	R	A
	33/4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	33/3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	33/2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	33/1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

western part of South Andaman (Collinpur and Wandoor sections) suggest Oligocene age for the Andaman Flysch Group (Chatterjee, 1964; Koley et al., 2015). This volcaniclastic sequence conformably overlies Andaman Flysch Group (Figs. 1c, 1d). Contact between the Archipelago Group and Andaman Flysch Group is gradational in Hazaribaghnala and sharp in Miletilek area. Towards east, the shale-tuff-claystone sequence is juxtaposed against conglomerate, pebbly sandstone and gritty to coarse grained sandstone of Mithakhati Group. Mithakhari Group is broadly assigned Eocene age based on the larger foraminifera viz. *Nummulites atacicus* Leymerie, *Assilina* cf. *papillata* Nuttal and *Discocyclina* cf. *undulata*, *Pellatispira* and *Biplanispira* from the grit exposed in Namunagarh and Ferrargunj area of South Andaman (Chatterjee, 1964; Gururaja and Rao, 1976).

Planktonic foraminiferal assemblages in Hobdaypur and Hazaribaghnala sections are characterised by the occurrence of *Globorotalia kugleri* with rare presence of *Globigerinoides quadrilobatus primodius* (Table -3). *Globorotalia kugleri*, even in broad sense, represents the level near the Oligocene-Micocene boundary on the either side of the Atlantic and in Pacific region (Stainforth et al., 1975). The basal foraminiferal zones of Miocene epoch, *Globorotalia kugleri* Zone of Stainforth et al. (1975) and M1 Zone of Berggren et al. (1995) are defined by the total range of the *Globorotalia kugleri* (Fig. 9). *Globigerinoides primodious* is restricted to earliest Miocene mainly in the *Globorotalia kugleri* Zone to a little way into *Catapsydrax dissimilis* Zone (Stainforth et al., 1975). The concurrence of short ranging *Globorotalia kugleri*, *Globigerinoides primodius* indicates proximity to the Oligo-Miocene boundary. *Globorotalia kugleri* and *Globorotalia primodius* is restricted to the lower part of the sequence exposed in Hobdaypur and Hazaribaghnala sections (Fig. 10). However, level of their last occurrence in the volcaniclastic sequence of South Andaman could not be confirmed. Hence the lowermost part of the volcaniclastic sequence of South Andaman represents the level near to the Oligo-Miocene boundary.

Middle part of the volcaniclastic sequence of South Andaman is unfossiliferous. The calcareous claystone occurring in the top part of the sequence has yielded abundant planktonic foraminifera with

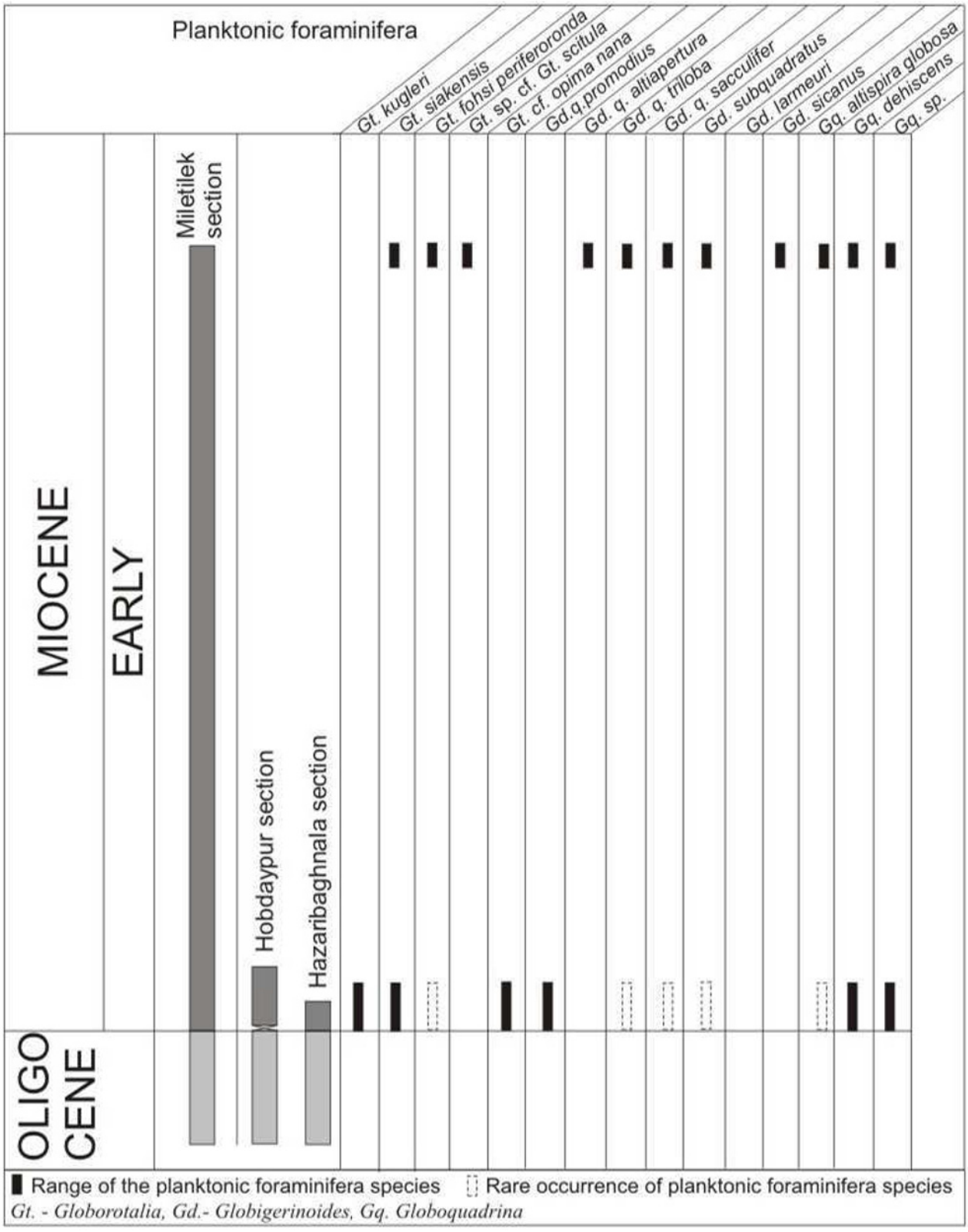

Fig.10. Range of the recorded planktonic foraminifera species in the three sections.

proliferation of *Globigerinoides*. The foraminiferal assemblage recorded from this claystone comprises of abundant *Globigerinoides quadrilobatus triloba*, *G. quadrilobatus sacculifer*, *G. subquadratus*, *G. quadrilobatus altiapertura*, *Globoquadrina dehiscens*, *Globoquadrina altispira globosa* with rare *Globigerinoides sicanus* (Table. 3). *Globigerinoides quadrilobatus triloba*, *G. quadrilobatus sacculifer*, *G. subquadratus*, *G. quadrilobatus altiapertura* made their appearance in early Miocene (M2 Zone of Berggren et al., 1995 and *Catapsydrax dissimilis* Zone of Stainforth et al., 1975). *G. quadrilobatus altiapertura* is a short ranging from restricted within early Miocene (*Catapsydrax stainforthi* Zone of Stainforth et al., 1995). *Globoquadrina dehiscens* and *G. altispira globosa* also appeared in early Miocene [in M1 Zone of Berggren et al. (1995); *Catapsydrax dissimillis*; Zone -N4 of Bolli and Sanders (1989)] and confined to Miocene. *Globorotalia siakensis* is long ranging form which is from late Oligocene to late Miocene and considered as good index of post-

Oligocene sequence (Blow, 1969; Bolli and Sanders, 1989; Stainforth et al., 1975).

Planktonic foraminiferal assemblage of the claystone on the top of the Miletilek section implies early Miocene age [(M1- M2 Zone of Berggren et al. (1995) and *Globototalia kugleri* Zone to *Catapsydrax dissimilis* Zone of Stainforth et al. (1975)] for the volcaniclastic sediments of Archipelago Group exposed in the main island of South Andaman. The tuff beds exposed in the Miletilek area occur in a continuous sediment package conformably overlying the Andaman Flysch Group. The maiden absolute age data (^{39}Ar-^{40}Ar) of 0.73+ 0.16 Ma estimated by Awasti et al. (2015) from the tuff of Miletilek does not corroborate with the levels indicated by the foraminiferal assemblage recoded in the present study. Disposition of the lithounits and foraminiferal assemblage of volcanogenic sedimentary sequence of South Andaman confirm that this sequence represent the basal part of the Archipelago Group.

The period from early Eocene to early Miocene is marked by absence of arc volcanism in Andamn-Java-Sumatra part of the subduction complex (Hall, 2002; Pal, 2003). Present palaeontological data also suggests that volcanogenic sediments are present at the level which is in proximity to the Oligo-Miocene boundary. As the tuff beds in South Andaman are in situ and not a product of reworked tephra (Pal et al., 2002; Awasthi et al., 2015), they represent the fall out of early Miocene arc volcanism. Further South, the position of Nias Island with respect to the tectonic elements of the subduction complex is identicial with the Andaman and Nicobar Islands. Presence of ash deposits in Nias Beds during early Miocene period (Moore, 1980) also corroborate with the findings of the present study.

CONCLUSION

The volcaniclastic sequence of South Andaman Island belongs to the Archipelago Group. Foraminiferal assemblage of this sequence belongs to the M1-M2 zone of Berggren et al. (1995) indicating early Miocene age of the sequence. Volcaniclastic sediments represent the basal part of the Archipelago sequence of Andaman Islands. The lower part of the volcaniclastic sequence of South Andaman represents a level in proximity with the Oligo-Miocene boundary. After a long quiescence since early Eocene arc volcanism rejuvenated during early Miocene in the region.

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