Proc Indian Natn Sci Acad **86** No. 2 June 2020 pp. 1107-1120
© *Printed in India*.
DOI: 10.16943/ptinsa/2019/49714

Research Paper

Scanning Electron Microscopic Studies of Fossil Pteropods from the Andaman Sea: Inferences on Carbonate Dissolution

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(Received on 19 July 2017; Revised on 17 June 2018; Accepted on 16 August 2019)

Among the different microfossils group, pteropods are least studied zooplanktons having delicate aragonitic shells which are very susceptible to dissolution. The present study has been carried out to understand the effect of dissolution, shell structure and the morphological variations of extant pteropods shells preserved in the late Quaternary sediments of the Andaman Sea with the help of scanning electron microscope (SEM). The study has helped to identify fifteen species of pteropods belong to Family of *Limacinidae* (*Limacina inflata, L. bulimoides, L. trochiformis, Creseis chierchiae, C. virgula, Clio cuspidata* and *C. pyramidata*) and *Cavoliniidae* (*Creseis acicula*, *C. Conica, Diacria quadridentata*, *D. trispinosa*, *Clio convexa*, *Styliola subula*, *Cavolina gibbosa* and *Hyalocylis striata*). Microscopic dissolution features are observed on all the species belong to both *Limacinidae* and *Cavoliidae* family. Specifically, species like *H. striata* and *L. inflata* are more prone to dissolution. The magnified SEM images of pteropods preserved in the last glacial maximum (LGM) and Heinrich event 1(H1) are not showing any features of dissolution which indicates better preservation. However, presence of pits, cavities, fractures and crevices on the shell surfaces was observed on the specimens of inter-stadial period Bølling/Allerød (B/A). These dissolution features of B/A may be due to the increased strength of summer monsoon and resulted in high biological productivity which might have affected the pteropods shells owing to their vulnerability to dissolution. During high productivity, there is high concentration of dissolved inorganic carbon, resulting from high input and remineralisation of organic matter, lowering the pH of seawater which enhance dissolution of shells.

Keywords: **Andaman Sea; Pteropods; Aragonite; Scanning Electron Microscope; Carbonate Dissolution; Late Quaternary**

Introduction

Pteropods are marine gastropods, adapted to pelagic life and common members of calcareous zooplankton communities in the upper ocean (Bè and Gilmer, 1977; Almogi-Labin *et al.,* 1998; Singh and Conan, 2008). Because of their stunning appearance, they are also known as 'sea butterflies'. Unlike foraminifera, the composition of pteropods shells are aragonitic, a meta-stable polymorph of $CaCO_3$ which is less stable than calcite (Mucci, 1983; Millero, 1996; Morse and Arvidson, 2002). Pteropods are widely distributed in the open oceans from the polar to tropical regions. However, most species live in the tropical and subtropical warm-water region, only a few in the cold-temperate and polar regions (Bé and Gilmer, 1977; Herman, 1978). Pteropods are fast swimmers with observed escape speeds of up to 7 cm/s (*D. quadridentata*) or even 11-14 cm/s (for the *Cavolinia* species), which causes some difficulties to sample pteropods with plankton nets or water samplers (Gilmer, 1974). Euthecosomat ouspteropods (*Limacinidae* and *Cavoliniidae*) feed up on phyto- and zoo-plankton (Bé and Gilmer, 1977; Herman, 1978). Therefore, their abundance is related to phytoplankton blooms and nutrient levels (Bé and Gilmer, 1977).

The phylogenetic classification distinguishes two orders; *Gymnosomata* (naked pteropods; six families)

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and *Thecosomata* (mainly shelled pteropods, six families). Among these family *Limacinidae* (shell spirally coiled) and family *Cavoliniidae* (shell uncoiled) are abundant. Pteropods (*Limacinidae* and *Cavolinidae*) possess an aragonitic shell which is consisting of fine $CaCO_3$ crystallites (Harbison and Gilmer, 1992). Pteropod shell calcification depth varies between species and depend on environmental conditions such as temperature, food availability and aragonite saturation state (Bé and Gilmer, 1997). After the death of the organism, the shell settles rapidly to the floor due to its large size. Measurements of initial settling velocity in the laboratory show that it ranges from 1.0 cm/s to 5 cm/s (Byrne *et al*., 1984). Thus, pteropods shells reach the seafloor within a few days (Klöcker and Heinrich, 2006). Singh and Conan (2008) studied the pteropods flux in the Arabian Sea and estimated that about 22.5% of the total $CaCO_3$ produced in the western Arabian Sea was contributed by aragonitic pteropods.

Pteropods are known since the Cretaceous, but in pre-Pleistocene sediments, the preservation of the thin and fragile shells is rare due to the susceptibility to the dissolution of aragonite. The living pteropods are abundant in the pelagic environment but rarely preserved in deep-sea sediments because of their dissolution. In the Andaman Sea, pteropods are abundant even in the deeper cores during glacial periods (Sijinkumar *et al*., 2010; Sijinkumar *et al.,* 2015). Aragonite dissolution in the water column seems to be very unlikely for water depth < 2000m but has been observed by settling studies in deep waters of the Pacific Ocean (Byrne *et al*., 1984), which are strongly undersaturated with respect to aragonite. In the South Atlantic, dissolution occurs mainly at the seafloor (Gerhardt and Henrich, 2001). In the Indian Ocean, dissolution is varied with different locations which are controlled by OMZ intensity variations, changes in the intermediate circulation and monsoon induced high productivity (Böning and Bard, 2009; Sijinkumar *et al*., 2015).

In the Indian Ocean, pteropod studies initiated with the advent of the International Indian Ocean Expedition (Sakthivel, 1968; 1973). The study carried out by Singh *et al*. (1998 & 2005) gives detailed distribution of recent pteropods species over entire western continental shelf of India. The occurrence of pteropod in the tectonically active marginal basin of the Andaman Sea has been receiving much attention since the last few decades (Panchang *et al*., 2007). Pteropods do not occur all over the Andaman Sea due to their highly fragile and solution-prone nature (Panchang *et al*., 2007). But well preserved shells of the pteropods are observed in glacial sediments indicating their paleoceanographic significance (Sijinkumar *et al*., 2010). Based on the total dissolution of pteropod tests at different depth of the seabed sediments, aragonitic compensation depth (ACD) has been demarcated at a depth 1300 m (Bhattacharjee and Bandyopadhyay, 2002). The position of aragonite saturation depth (ASD) is demarcated at ~300 m (Sarma and Narvekar, 2001). The water depth of the cores studied is > 2000 m and was below the present ASD and ACD, which is believed to have remained stable throughout the Holocene.

A microscopic examination of pteropods can reveal vital information, which includes shell structure, morphology, and even their composition. Binocular microscopic studies of pteropods will not give adequate details about dissolution effects and shell morphology. The scanning electron microscope is very helpful in the understanding of several characteristics features of the pteropod shells such as dissolution effects, topography, morphology, composition, crystallographic information, etc. There are limited studies on pteropod abundances/preservation from the Andaman Sea (Bhattacharjee, 1997; Bhattacharjee and Bandyopadhyay, 2002; Panchang *et al.,* 2007; Sijinkumar *et al.,* 2010; 2015) but no attempt is made to observe the dissolution effects on pteropods shells. Similar to Andaman Sea, pteropod tests are limited to shallow tropical and subtropical oceanic regimes such as the Arabian Sea (e.g., Singh *et al.,* 1998 & 2006), the Red Sea and the Mediterranean Sea (e.g., Reiss *et al.,* 1980; Almogi-Labin, 1984; 1986, 1991; Wang *et al.,* 1997). In the present study, we observed highly magnified images of pteropods shells of the selected periods of last glacial viz., Heinrich event 1 (H1), LGM and Bølling/Allerød (B/A, 15-13 cal ka BP) for obtaining more detailed information on effects of dissolution on the shell surface at different climatic events and identification of rare and juvenile species. We selected H1 period as it is coinciding with so called pteropod spike (19-14 calka BP), and LGM (23-19 calka BP) because of its better preservation and Bølling/Allerød (B/A, 15-13 cal ka BP) for its high summer monsoon and productivity (Sijinkumar *et al*., 2016a and 2016b).

Oceanographic Settings

The Andaman Sea is a complex back-arc extensional basin located in the southeast of the Bay of Bengal, south of Myanmar, west of Thailand and east of the Andaman-Nicobar Islands.The Andaman Sea (maximum water depth is 4400 m) is a semi-enclosed marginal sea in the eastern part of the northern Indian Ocean and is interconnected with the Bay of Bengal by the Deep Prepares Channel, Ten Degree Channel, and the Great Channel. The Andaman Sea exchanges water masses with the Bay of Bengal in the north Indian Ocean and also with the marginal seas of western Pacific via shallow channels (Fig. 1a). The AAIW enters through the shallow sills connected with the Bay of Bengal as a mixture of overlying water mass containing SAMW, AAIW and the high salinity outflows from the Persian Gulf and the Red Sea and the underlying NADW (Naqvi *et al*., 1994). The average depth of the sea is about 1,000 m, and the northern and eastern parts are shallower than 180 m due to the silt deposits of the Irrawaddy River. One of the peculiarities of the Andaman Sea is the presence of several sills. The depth of these sills is about 1300 m, the deepest of which is located beneath the Great passage in the south (Naqvi *et al.,* 1994) and these sills have a significant influence on intermediate to deep water circulation in the Andaman Sea (Fig. 1a). Most important sediment contributor to the Andaman basin isfrom the Irrawaddy, Salween and Sitting rivers (Rodolfo, 1969) located in the Indo-Burmese ranges, which supplies enormous quantities of sediments to this basin.

According to Milliman and Meade (1983), Irrawaddy River drains ~428 km^3 of freshwater annually from the Irrawaddy catchment region to the Andaman Sea. The Andaman Sea is characterized by a low surface salinity ranging from 31.8 to 33.4 psu (Fig. 1b) due to the influence of freshwater discharge from the Irrawaddy-Salween river system (Sarma and Narvekar, 2001). A characteristic oxygen minimum zone is also reported from the Andaman Sea but not as strong in the Arabian Sea (Madhu *et al*., 2003). The average sea surface temperature of the Andaman Sea is 29°C, which is homogenous upto a depth of 50 m forming stratification and preventing vertical mixing (Sarma and Narvekar, 2001). The temperature falls below 13°C at a depth of 200 m and 9°C at 500-600 m with a total thermocline thickness of about 150 m (Saidova, 2008). Deep Andaman Sea water is consistently warmer than that of the Bay of Bengal with an approximate offset of 2°C (Sarma and Narvekar, 2001), which can be attributed to the enclosed nature of the Andaman Basin (Sengupta *et al.,*1981) or the transfer of intermediate Bay of Bengal waters into the Andaman deep (Naqvi *et al*., 1994). The high temperature of the deeper water in the Andaman Sea lowers the ACD in the region (Sijinkumar *et al.,* 2010).

Materials and Methods

The deep-sea sediment cores SK 168/GC 1 (11°42'N; 94°29'E, water depth: 2064 m, length: 4.20 m), AAS 11/GC 1 (9°00'N; 94°17'E, water depth: 2909 m, length: 4.28 m) and RVS 2/GC 3 (07°42'N; 93°58'E, water depth: 2301 m, length: 5.64 m) were collected from the Andaman Sea (Fig. 1a). SK 168 was collected during the 168th cruise of ORV *Sagar Kanya* from the Alcock Seamount Complex in the Andaman Sea. The core AAS 11 was collected during the 11th expedition of research vessel *A. A Sidorenko,* and Core RVS 2 was collected onboard German Research Vessel *F. S. Sonne*. Approximately 10 g of the dried sediment sample was soaked in milli-Q water in 1000 mL beakers. The beakers were labelled appropriately according to the sample number. The sample was then treated with 30% H_2O_2 (dispersing agent) and keep it for overnight to remove the organic matter and to disaggregate the coalesced clay and other soil particles. Then the sample stirred and made ready for the sieving process through a 63μm sieve. The sediment suspensions were mixed thoroughly and poured into the sieve. The sieve was continuously vibrated manually so that the particles <63μm in size pass through the sieve and were collected in a measuring cylinder of 1000 ml. The >63μm size fraction was then transferred to the beakers. After settling, the water was decanted from each beaker and then kept them in the oven at 60°C for drying for one day. The >63mm fractions was then dry sieved using 63 and 125mm mesh sieves. The >125mm fractions were used for the pteropods study under a stereo zoom binocular microscope.The picked pteropods were then mounted on the sample stubs, and the SEM images were taken. The pteropod species

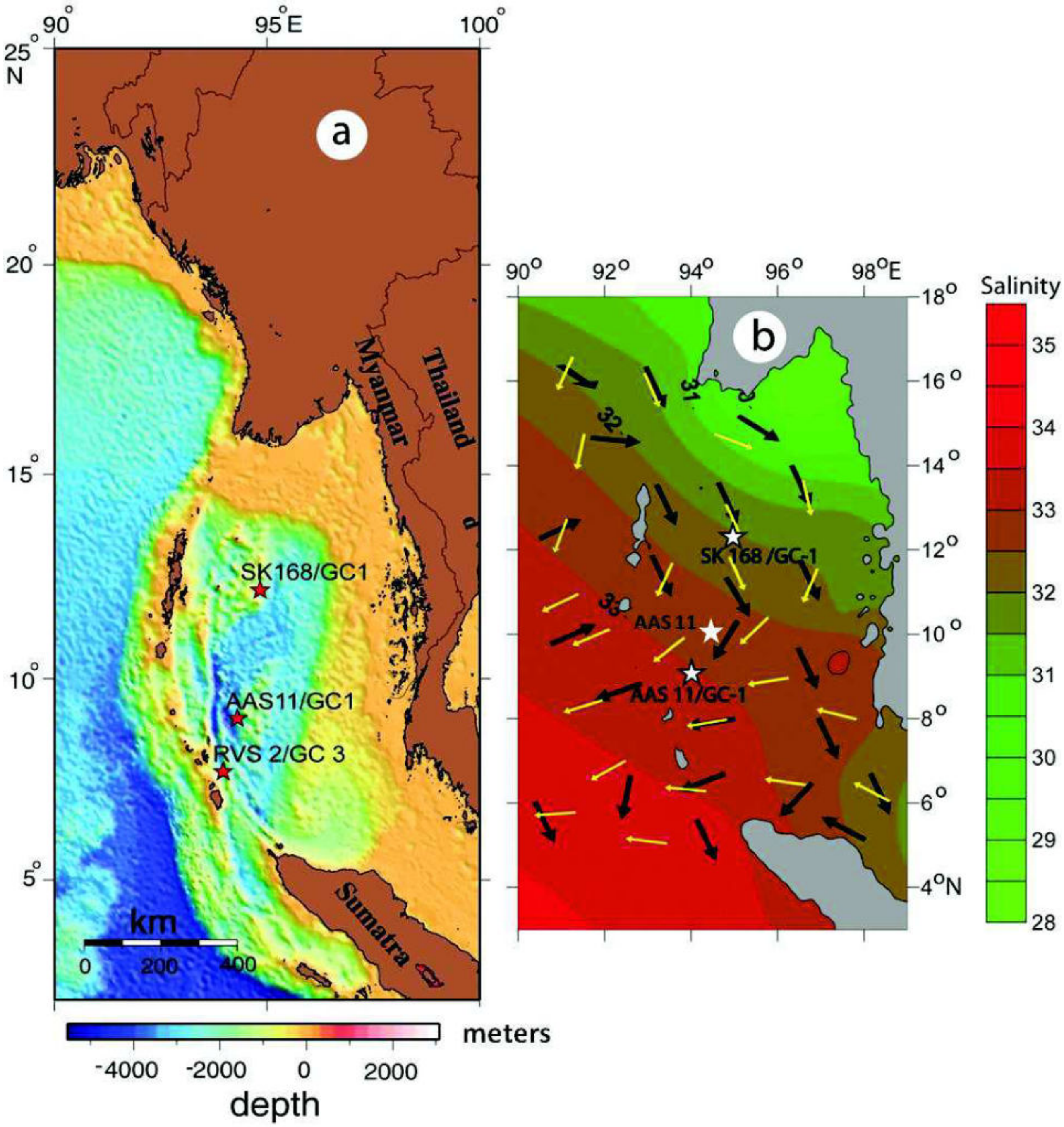

Fig. 1: Location map of the Andaman Sea showing core locations a) bathymetry of the Andaman Sea along with core locations; b) salinity (annual salinity at the surface, World Ocean Atlas, 2009, www.nodc.noaa.gov) and monsoon currents in the Andaman Sea black arrow-summer monsoon, yellow arrow-winter monsoon (modified from Sijinkumar *et al.*, 2010)

were identified following Van der Spoel (1967), Bè and Gilmer (1977) and Almogi-Labin (1982). The age model for the cores was constructed mainly by using Accelerator Mass Spectrometer (AMS) ^{14}C dates of planktonic foraminiferal tests (mixed *G. ruber* and *G. sacculifer*). Age models for all records have been previously published and we adopt these age models as published with no modifications (Sijinkumar *et al.*, 2011 & 2015).

Results and Discussion

Pteropod Abundance and SEM Studies

The present study is carried out to understand the effect of dissolution on shell surfaces, shell structure, morphological variations and identification of juvenile and rare species of pteropods preserved in the glacial sediments of the Andaman Sea. The core location/ site was below the ASD and ACD, which is believed to have remained stable throughout the Holocene and was reflected in poor/completely absence of pteropods. The stereoscopic binocular microscopic and followed by scanning electron microscopic analysis of pteropods has helped to identify about fifteen species of pteropods (Plate 1 to 4). The individual species abundance of all the three cores was already published (Sijinkumar *et al.,* 2010; Sijinkumar *et al.,* 2015). In all the cores, *L. inflata* is the most abundant species followed by *L. trochiformis* and all other species are below ten percentages (Fig. 2). The identified species belongs to genus *Limacinidae* and *Cavoliniidae*. There are seven species belongs to genus *Limacinidae* and eight species of genus *Cavolinidae*. Species belongs to *Limacinidae* are *Limacina inflata, L. bulimoides, L. trochiformis, Creseis chierchiae, C. virgula, Clio cuspidata and C. pyramidata*. The eight *Cavoliniidae* species are *Creseis acicula*, *C. Conica, Diacria quadridentata*, *D. trispinosa*, *Clio convexa*, *Styliolasubula*, *Cavolina gibbosa* and *Hyalocylis striata*. The SEM images of all the identified pteropod species are presented (Plate 1 to 4).

Individual Species Characteristics

Limacina inflata is the most abundant species in all the cores (Fig. 2). The species belongs to family *Limacinidae* and the genus *Limacina*. It is a tiny shelled, left-coiled pteropod (Plate 1a,b,c). It is a mesopelagic warm belt species which does not live in high latitudes (Bè and Gilmer, 1977) was most dominant among the pteropod assemblage being almost monospecific at certain depths (Sijinkumar *et al.*, 2010). Morphologically, this species has wide aperture and a prolonged base. Shell apex is depressed by subsequently expanding whorls as noted by the Bhattacharjee (1997). According to Boltovskoy (1974), the species is characterized by the presence of granules. These granules are dense, varying in size

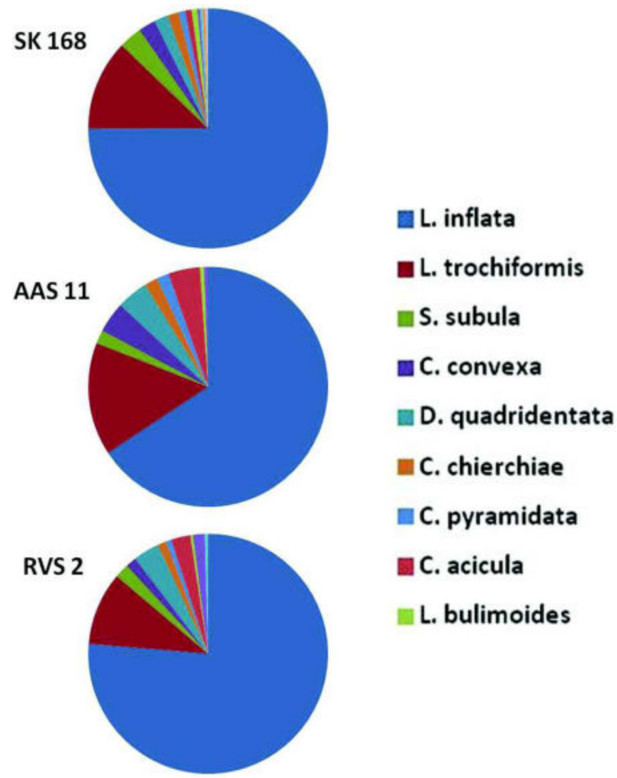

Fig. 2: Schematic representation of individual pteropod species abundances (average) in cores SK168, AAS 11 and RVS 2 in the Andaman Sea during MIS 2 (23 to 11 ka)

and give the surface a bumpy appearance when viewed under high magnification. The granulation is due to an outer layer composed of tiny, brick-shaped aragonite prisms (Bè *et al*., 1972). These granules are broken in some samples probably due to dissolution effect. There are three types of *L. inflata* were noticed in the glacial sections such as white, cloudy and transparent. The presence of transparent *L. inflata* was seen only in LGM and H1 samples pointing good carbonate preservation.

L. trochiformis is the second most abundant pteropod species in the Andaman Sea (Fig. 2), belongs to family *Limacinidae* and the genus *Limacina*. Shells of this species have a moderately low spire with a firmly inflated body whorl, umbilicus constricted and aperture oval. Shell dissolution features seen very less in *L. trochiformis* than *L. inflata.* The size of the shell is ranging from 0.4 mm to 0.7 mm (Plate 2a). The species *L. bulimoides* belongs to family *Limacinidae* and the genus *Limacina*. Morphologically blunt spire and highly coiled (Plate

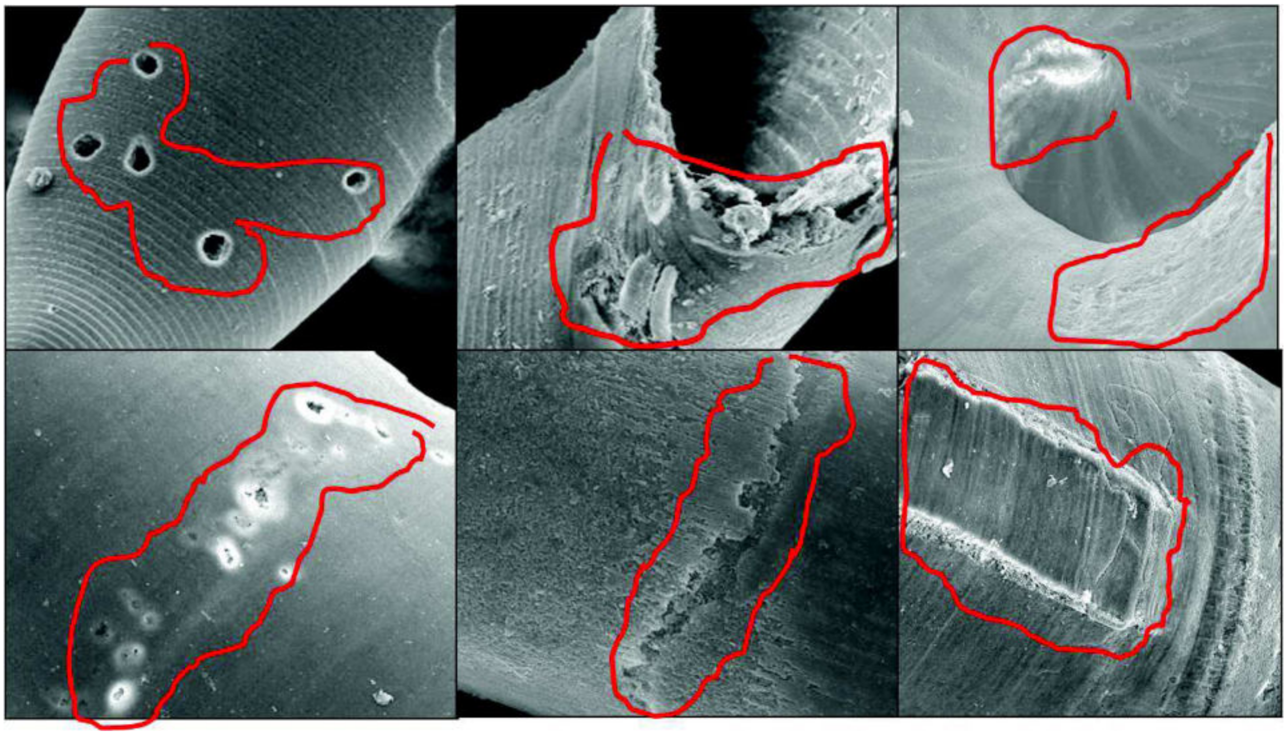

Fig. 3: Dissolution features (pits, cavities, fractures and crevices) seen on the surface of pteropod species (*C. convexa, D. quadridentata, C. chierchiae*) picked from the B/A sections. Dissolution features are marked with red circle

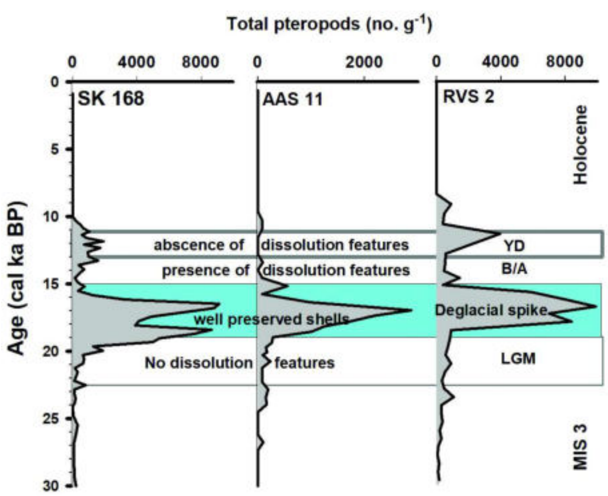

Fig. 4: Absolute abundance of pteropods in the Andaman Sea cores. Pteropods are picked from the periods marked (YD, B/A, Deglacial spike and LGM) are studied under SEM for identification of dissolution features

3a,b). Some shells are having a height of nearly 2 mm, and the diameter reaches upto 1.4 mm. The surface is ornamented with flat ridges as also reported by Boltovskoy (1974). *Diacria quadridentata* belongs to family *Cavoliniidae* and the genus *Diacria*. Shells of this species are flattened biconvex, ventral side more convex than the dorsal side and with well ornamented (Plate 7a,b). The prominent longitudinal ridge on the dorsal side, distinct marginal striation on the apertural face and spherical protoconch (Battacharjee, 1997). This species widely reported from the tropical Indian Ocean (Sakthivel, 1968).

Diacria trispinosa belongs to family *Cavoliniidae* and the genus *Diacria* and their shell was large, flattened, elongated with two prominent lateral spines (Plate 6a). Species were characterized by concentric growth lines on both the ventral and dorsal sides as reported by the Bhattacharjee (1997). The length of the shell was ranging from 4-6 mm and very rarely up to 7 mm. *Creseis chierchiae* belongs to family *Limacinidae* and the genus *Creseis*. The species is elongated, conical and gradually increasing in size. This species also shows characteristics of concentric growth lines with alternate dark and light colour (Plate 8a,b). Dissolution effects such as small pits are seen some of the species under magnified image might be the result of subsurface currents.

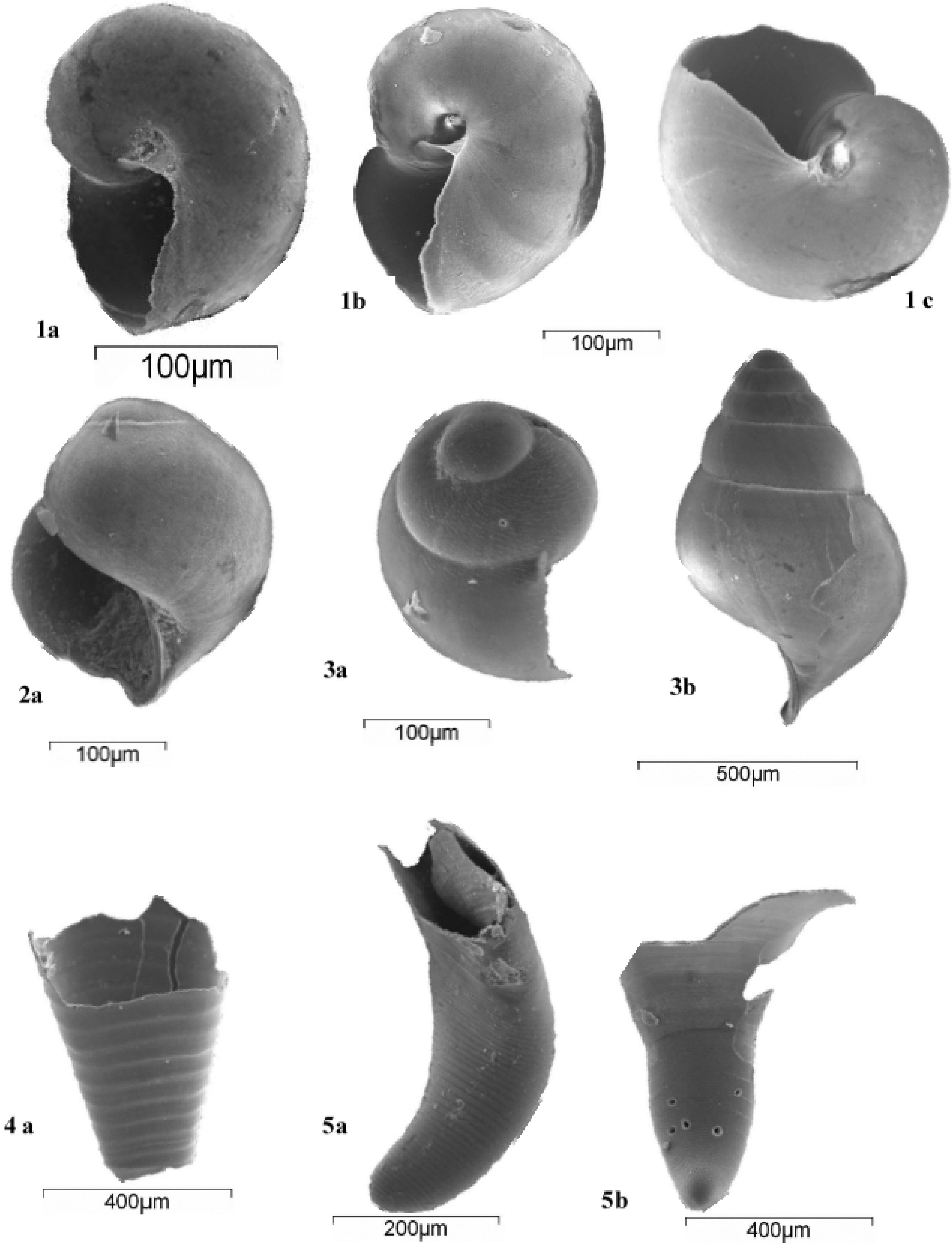

Plate 1: ***Limacina inflata*** **(d' Orbigny) 1a, 1b, 1c;** ***L. trochiformis*** **(d' Orbigny) (very juvenile) 2a.** ***L. bulimoides*** **(d' Orbigny) 3a (very juvenile), 3b;** ***Hyalocylis striata*** **(Rang, 1828) 4a** ***Cavolinia gibba*** **(d' Orbigny) 5a, 5b**

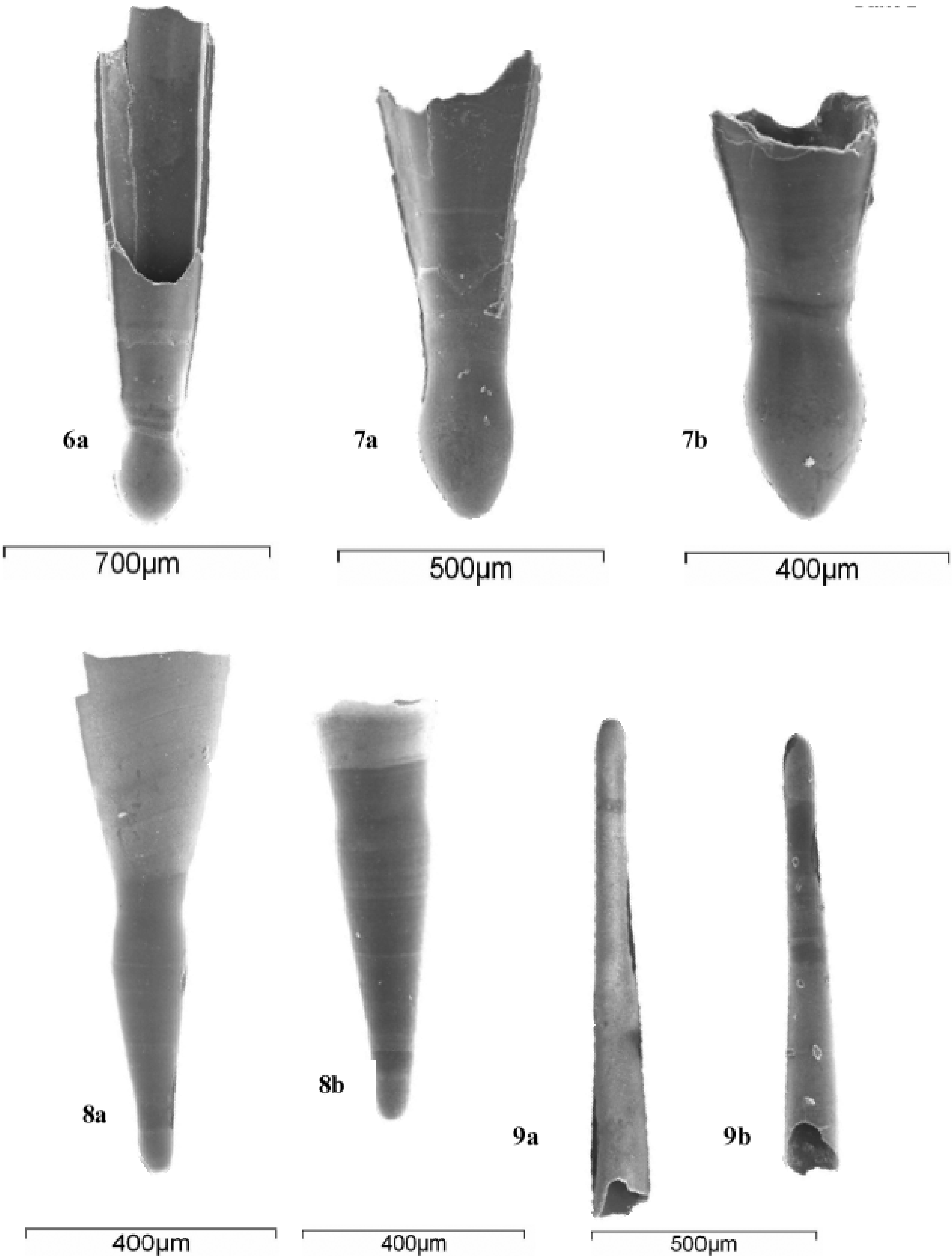

Plate 2: ***Diacria trispinosa*** **(de Blainville) 6a;** ***D. quadridentata*** **(de Blainville) 7a, 7b;** ***Creseis chierchiae*** **(Boas) 8a, 8b;** ***C. acicula*** **(Rang) 9a, 9b**

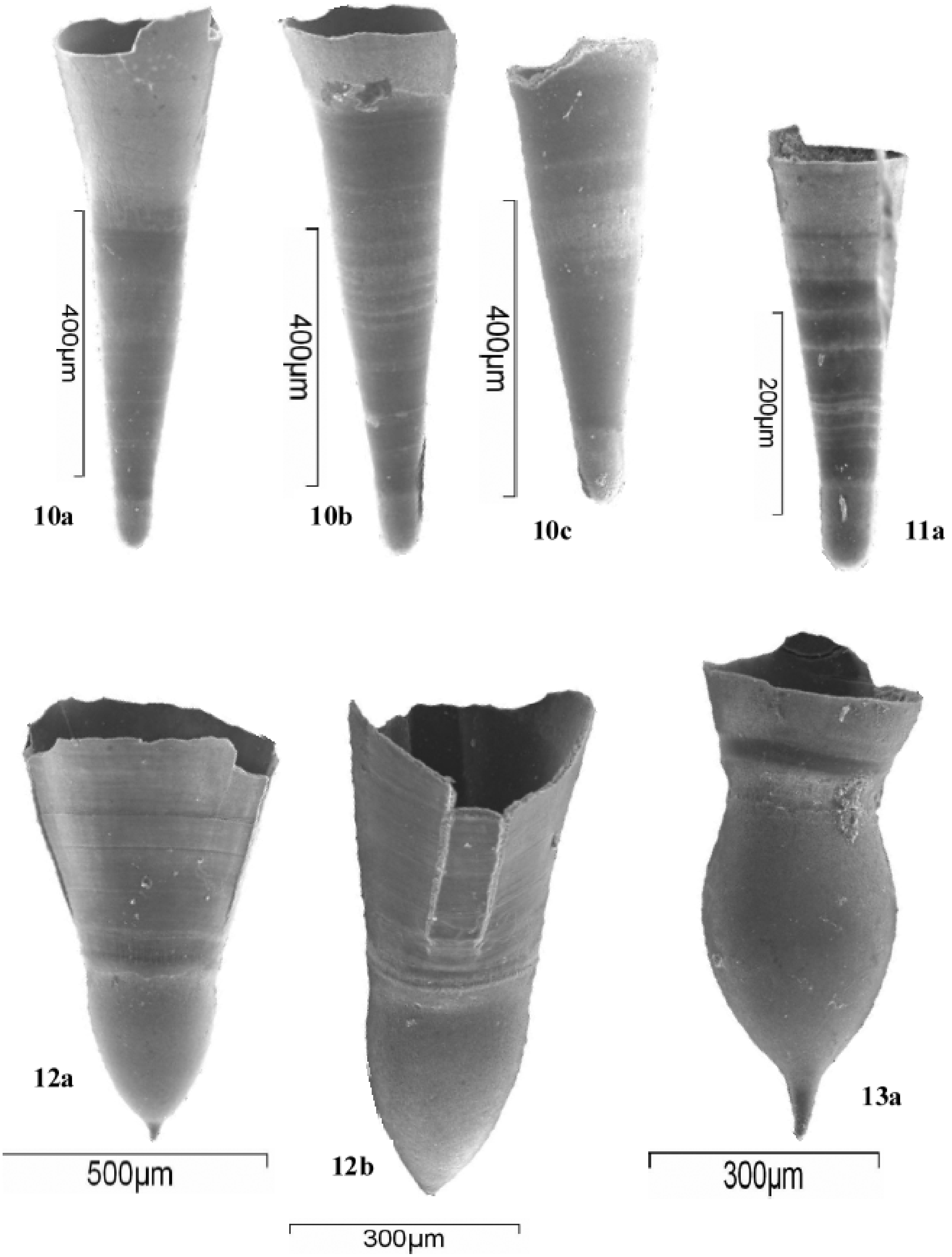

Plate 3: ***Clio virgula*** **(Rang) 10a, 10b, 10c;** ***C. conica*** **(Rang) 11a,** ***C. convexa*** **(Boas) 12a, 12b;** ***C. cuspidata*** **(Bosc) 13a**

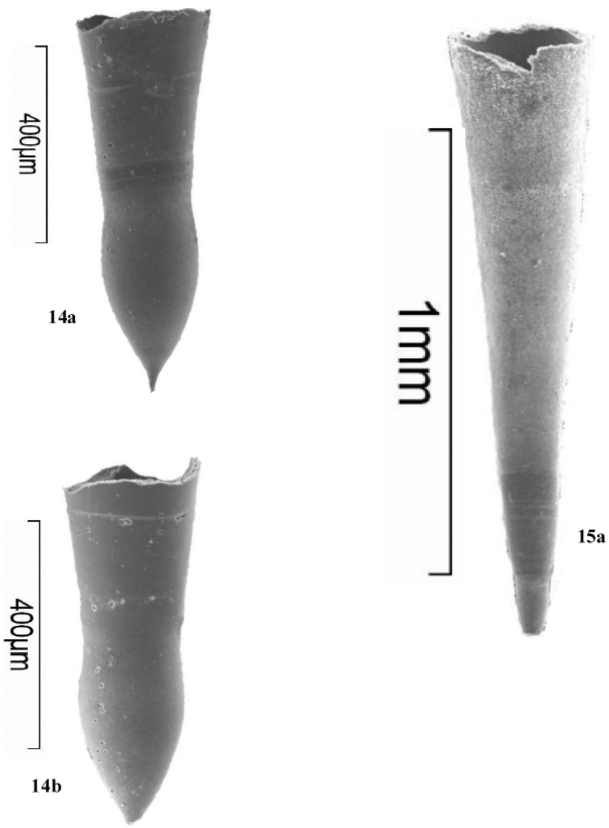

Plate 4: ***C. pyramidata*** **(Linnaeus) 14a, 14b;** ***Styliola subula*** **(Quoy and Gaimard) 15a (protoconch is broken)**

Creseis acicula belongs to family *Cavoliniidae* and the genus *Creseis* which is reaching up to 6 mm long. The surface of the shell is smooth, short and narrow tube shaped without any curve. The ratio of shell length to diameter is usually 1/6th and rarely transverse striations are found (Plate 9a,b). *Creseis virgula* belongs to family *Limacinidae* and the genus *Creseis* which is having a slightly curved conical test. The shell was long, narrow tube shaped and curved with a smooth surface. Its general distribution was comparable to *Creseis acicula* and it was less abundant in the glacial Andaman Sea.

Creseis conica belongs to family *Cavoliniidae* and the genus *Creseis*. The test was usually long, conical, tube-like, uncoiled and the aperture was circular in shape (Plate 11a). There were species with length reaching up to 7 mm. The cross-section of the shell was round, and the surface of the shell was smooth. *Clio convexa* belongs to family *Cavoliniidae* and the genus *Clio*. Shell elongated, posterior side curved ventrally and double lined lateral ribs present on the surface (Bhattacharjee, 1997). This is a shelled, uncoiled, pyramid shaped, pelagic snail, up to 8 mm long (Plate 12a,b). Growth lines are prominent; the lateral sides are gutter-shaped in cross-section.

Clio cuspidata (Plate 13a) belongs to family *Limacinidae* and the genus *Clio*. Shell distinctly curved dorsally, pyramid-shaped, transparent, and triangular in outline and in cross-section. Growth lines prominent, lateral sides rounded in cross-section. More juveniles are seen than an adult. *Clio pyramidata* belongs to family *Cavoliniidae* and the genus *Clio*. Test triangular, smooth to very little ornamented, transverse diameter increasing gently and uniformly (Plate 14a,b,c). Transverse striation and growth lines are distinct. Shell length was about 18 mm; its width about 8 mm. *Styliola subula* belongs to family *Cavoliniidae* and the genus *Styliola*. Test conical, elongated, and nearly smooth. The longitudinal groove running slightly obliquely along the dorsal length. Cross-section nearly circular (Bhattacharjee, 1997). Surface with faint growth lines was seen in some specimens (Plate 15a). Posterior shell-end was generally pointed, here protoconch was broken off (it should be pointed in *Styliola*, but rounded in *Creseis conica*).

Cavolina gibbosa belongs to family *Cavoliniidae* and the genus *Cavolinia*. The identified species was very juvenile conch of *C. gibba.* Adult species were not seen in any of the cores. *C. gibba* was a globular shelled pteropod, about 10 mm long, lateral spines were small and the caudal spine was pronounced. *Hyalocylis striata* belong to family *Cavoliniidae* and the genus *Hyalocylis*. It has a conical shell with a length of 8 mm, slightly curved dorsally, very faintly ornamented by numerous growth increments (Bhattacharjee, 1997). Shell is fragile, cross-section round, surface with transverse undulations, long, tube-shaped, slightly curved dorsally at the end. Embryonic shell discarded in adults punctuated closing membrane formed near the place of rupture. The species identified was fragmented, full species was not obtained in any of the samples studied and indicated one of the highly susceptible and delicate pteropod species.

Dissolution Features on the Pteropod Shells

The pteropod shells were picked from the well preserved glacial sections as well as poorly preserved inter-stadial (Bølling/Allerød-B/A) period for the comparison of dissolution features. Pteropods from the glacial sections (LGM and H1) are free of any dissolution features whereas those collected from B/A have shown dissolution effects on shells (Fig. 3, 4). The major dissolution features noticed on the shell surfaces are pits, cavities, fractures and crevices. These features are indicating climate-induced dissolution event in the Andaman Sea during B/A (Fig. 4). The poor preservation/abundance of pteropods during B/A were already reported from the Andaman Sea (Sijinkumar *et al.,* 2010). The poor preservation and the more dissolution features of the pteropod shells of the B/A period may be due to the increased strength of summer monsoonresulted in high biological productivity which might have affected the pteropods shells owing to their vulnerability to dissolution. It is reported that intensity of summer monsoon strength is stronger during the B/A in the Andaman Sea and adjacent Bay of Bengal (Rashid *et al.,* 2007, Rashid *et al.,* 2011; Sijinkumar *et al.,* 2016a).

Pteropods shells of Holocene couldn't be tested as there was no preservation of pteropods in the cores studied. The complete absence of pteropods during Holocene was interpreted due to shoaling of ACD from last glacial to interglacial transition. The water depth of the cores are well below the present ASD and ACD, which is believed to have remained stable throughout the Holocene (Sijinkumar *et al.,* 2010). The poor preservation during Holocene was attributed to enhanced summer monsoon and high productivity (Sijinkumar *et al.,* 2015). High productive regions are characterized by poor pteropod preservation (Berger, 1978; Ganssen and Lutze, 1982; Gerhardt and Heinrich, 2001), which is attributed to high concentration of dissolved inorganic carbon (DIC), resulting from high input and remineralisation of organic matter, lowering the pH (Millero *et al.,* 1998). Similar conditions were also expected during B/A owing high summer monsoon. Supralysoclinal or biologically mediated carbonate dissolution through decomposition of organic matter within the sediments lowers pore water pH (Milliman *et al.,* 1999). According to Orr *et al.* (2005), dissolution can be also possible in living organisms during exposure to water under saturated with respect to aragonite. Microscopic dissolution features are seen on all the species belongs to both family *Limacinidae* and *Cavoliidae* but species like *H. striata* and *L. inflata* are more prone to dissolution. Transparent shells of *L. inflata* were also common in well preserved sections like H1 and YD. As pteropod shells are so delicate and prone to dissolution, the observation and identification of dissolution features on the shell surfaces are direct tools for assessing carbonate dissolution and correlating global pteropods abundance/preservation spikes.

Conclusions

The morphological features and structural variations of pteropods were studied using SEM techniques. The SEM studies have helped in identifying fifteen pteropod species from the late Quaternary glacial sediments of the Andaman Sea. Among the species identified, seven were belonging to *Limacinidae* and eight of *Cavolinidae. Limacina inflata*, one of the most abundant species were seen in three different shell types such as transparent, milky and white forms. Coarse SEM images were used to identify the degree of dissolution in the pteropod shells. The major dissolution features noticed on the pteropod shell surfaces are pits, cavities, fractures and crevices. Microscopic dissolution features are seen on all the species belongs to both family, *Limacinidae* and *Cavoliidae.* However, species like *H. striata* and *L. inflata* are more prone to dissolution. The magnified SEM images of pteropods preserved in the last glacial maximum (LGM) and Heinrich event 1 (H1) are not showing any features of dissolution and pointing towards better preservation,whereas presence of pits, cavities, fractures and crevices on the shell surfaces was seen on the specimens of inter-stadial period Bølling/Allerød (B/A). Pteropods shells of Holocene couldn't be tested as there was no preservation of pteropods in the cores studied. These dissolution features of B/A may be due to the increased strength of summer monsoon and resulted in high biological productivity which might have affected the pteropods shells owing to their vulnerability to dissolution. During high productivity, there is a high concentration of dissolved inorganic carbon, resulting from high input and remineralisation of organic matter, lowering the pH of seawater which enhances dissolution of shells. As pteropod shells are so delicate and prone to dissolution, the observation and identification of dissolution features on the shell surfaces are direct tools for assessing late Quaternary carbonate dissolution.

Acknowledgements

We thank the Director, CSIR-National Institute of Oceanography, Goa, for the permission to publish this paper. Council of Scientific and Industrial Research (CSIR) has funded hiring two ships (AAS 11 and RVS 2) and the Ministry of Earth Science, New Delhi has provided the ship time for cruise SK 168. Captain and crew of *ORV Sagar Kanya*, *RV Sonne,* and *A.A. Sidorenko* are thanked for their help. Our thanks are due to Mr. D Khedekar for their help in SEM studies.AVS acknowledge UGC for the BSR Startup Grant (No. F.30-366/2017).

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