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BENTHIC ECOLOGICAL MAPPING OF THE AYEYARWADY DELTA SHELF OFF MYANMAR, USING FORAMINIFERAL ASSEMBLAGES

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ABSTRACT

Information on benthic ecologies is a prerequisite to evaluate marine resources, their management and monitoring the impact arising from their exploitation. In the present study, benthic foraminiferal distributions from 124 surface sediment samples covering a total area of about 2,00,000 km^2 of the Ayeyarwady Continental Shelf are studied. 713 benthic species belonging to 222 genera are identified and illustrated herein. The assemblage leads to the assignment of the study-area to the Indo-Pacific foramo-geographic province. The generic abundances have been subjected to R-mode cluster analysis in order to group stations with similar ecologies. The cluster analysis revealed three major clusters: Cluster A represents the modern coral reefs in the study area; Cluster B represents the near shore low salinity regimes whereas the last cluster C represents outer shelf and slope regimes. These clusters have been described in terms of their constituent taxa, sediment texture and spatial distribution, which interestingly follow the benthic salinity regime in the study area. The present study indicates that the salinity gradient prevalent on the Ayeyarwady Delta Shelf controls its benthic environment. The present work serves as a ready-reconnaire for foraminiferal workers in the Indo-Pacific regime.

Keywords: Delta Shelf, foraminiferal assemblages, R-mode cluster analysis, salinity gradient, Indo-Pacific foramogeographic province

INTRODUCTION

Speciation in foraminifera is a function of their sensitivity to changing environments. Different environmental settings are represented by different species assemblages and thus are a very important attribute while assessing past as well as modern environments. Though analytical techniques like stable isotopic and trace elemental studies have taken over traditional micropalaeontological techniques, there is no alternative to identification and taxonomy. In an age when geochemical concentrations are measured on mono-specific samples of foraminifera, erroneous identification could lead to wrong geochemical signatures. Biostratigraphy continues to be the most important discipline in the oil-industry, which controls the global economy. Thus, a thorough knowledge about foraminiferal identification and taxonomy becomes a basic prerequisite not only in various disciplines of palaeo- research but also in industrial applications.

Whilst significant efforts are being directed towards understanding the bio-geo-chemically complex Northern-Indian Ocean (Cowie *et al.*, 2013), the Northern Andaman Sea is the least studied. The Indo-Myanmar Joint Oceanographic studies conducted in the Andaman Sea in 2002 have brought to light various aspects of this complex sedimentary basin [the tidal influence on suspended sediment distribution and dispersal (Ramaswamy *et al.*, 2004; Rao *et al.*, 2005), pteropod distribution (Panchang *et al.,* 2007), sources and distributions of organic carbon and nitrogen (Ramaswamy *et al.,* 2008), sea level fluctuations (Panchang *et al.*, 2008) and past high-resolution climatic signatures (Panchang and Nigam, 2012)]. The present study is directed at understanding the benthic environment covering a total area of about 2,00,000 km^2 on the continental shelf and slope off Myanmar (Burma) using benthic foraminiferal assemblages.

PHYSICAL SETTING

The oceanic regions surrounding Myanmar are characterised by one of the largest fluvial systems in the world. The catchments of the rivers Ayeyarwady (formerly known as Irrawaddy) and Salween adjoin each other, debouching into the Indian Ocean over a length scale similar to the deltas of the Ganges-Brahmaputra or the Amazon. Therefore, the Ayeyarwady and Salween rivers could be considered as a single point source contributing to the global ocean. The Ayeyarwady delta and inner-shelf mud belt is a potentially major repository of carbon of global significance (Ramaswamy *et al.,* 2008). At present, the Ayeyarwady is the third largest river in the world in terms of suspended sediment discharge and together with the Salween (also known as Thanlwin) contributes more than 600 million tons of sediment, annually (Robinson *et al.,* 2007). The Ayeyarwady–Salween river system transports 5.7 to 8.8 MtC per year of organic carbon, suggesting that presently it may be the second largest point source of organic carbon to the global ocean after the Amazon (Bird *et al.,* 2007). The implied organic carbon yield from the catchments is 8.4-12.9 t/km^2/yr, which is clearly amongst the highest in the world among rivers of similarly large size. (Bird *et al.,* 2008). The large fresh water discharge from the rivers Ayeyarwady and Salween cause significant salinity changes in the Andaman Sea. The Andaman Sea is also characterised by a rather high rate of sedimentation within the Indian Ocean and thus provides a high-resolution record of sediment history. As the major source of sediment influx here is the River Ayeyarwady (Rao *et al.,* 2005), which is in turn

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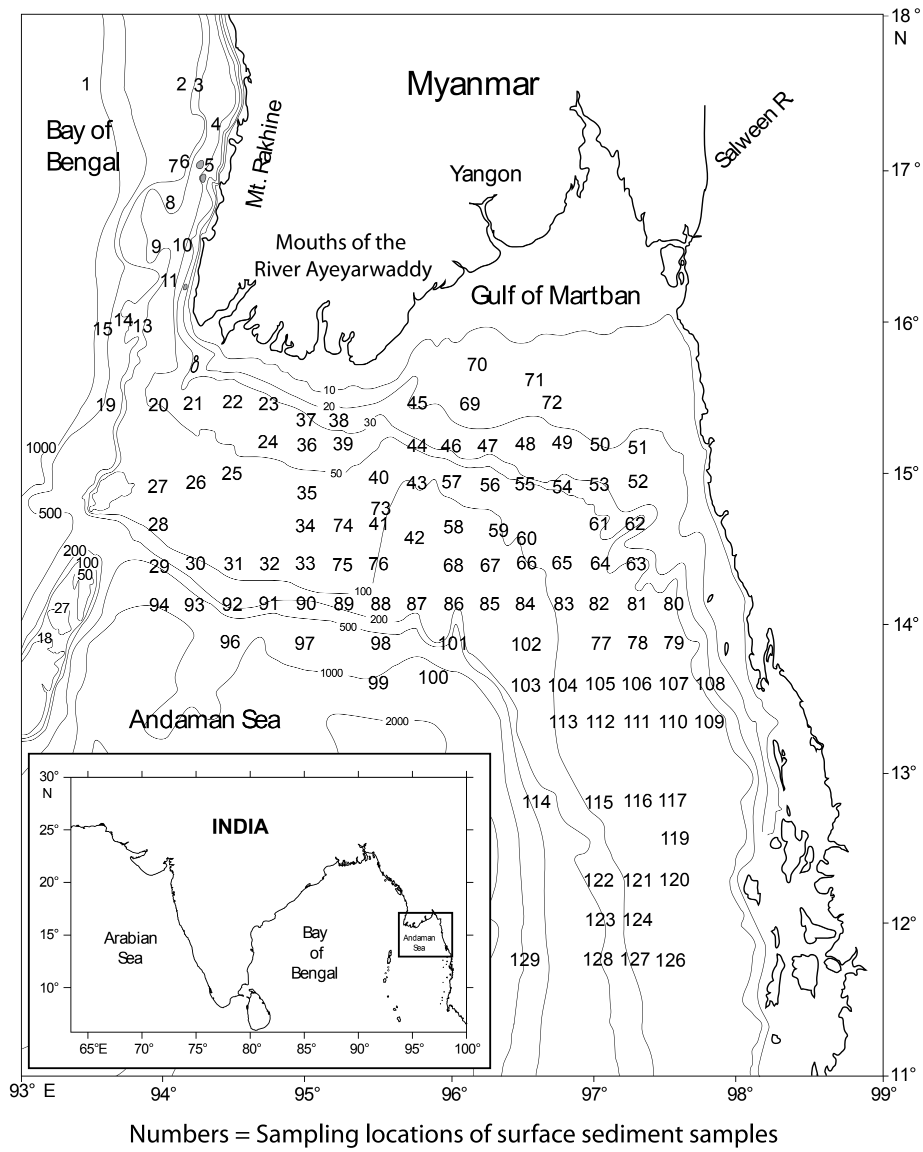

Fig. 1. Map of the study area showing the sampling locations and bathymetry.

controlled by the monsoons, the sediments of the Andaman Basin are ideal proxy for palaeomonsoonal precipitation (Panchang and Nigam, 2012).

The shelf region off the Ayeyarwady Delta also has a complex geological setting in the Andaman Basin (Curray *et al.,* 1979). The shelf width is about 170 km off the Ayeyarwady River mouths and increases to more than 250 km in the center of the Gulf of Martaban. Bathymetric data acquired during the present study shows that the shelf break is at 110 m isobath (Fig. 1). Beyond the shelf break the depth increases rapidly to approximately 2000 m, except in the bathymetric low, southwest of the acceretionary delta. The seafloor within the bathymetric low is riddled with erosion channels and "V-shaped" notches (Rao *et al.,* 2005). Based on grain size variations, three distinct areas of sediment texture have been delineated on the Ayeyarwady shelf, namely (i) near shore muds (ii) outer shelf relict sands and (iii)

EXPLANATION OF PLATE I

(Scale bar = 100µm unless otherwise mentioned)

1: ***Saccammina catenulata*** Cushman; 2: ***Jaculella acuta*** Brady; 3: ***Ammodiscus incertus*** (d'Orbigny); 4: ***Ammodiscus mestayeri*** Cushman (a&c) side views (b) lateral view; 5: ***Repmanina charoides*** (Jones & Parker) (a) side view (b) top view; 6. ***Hormosinella distans*** (Brady); 7: ***Reophax gaussicus*** (Rhumbler); 8: ***Reophax paloensis*** Hada; 9: ***Reophax scorpiurus*** Montfort: 10&11: ***Haplophragmoides canariensis*** (d'Orbigny) side view; (b) apertural view. 2 specimens have been illustrated to show the variation in texture of test and degree of lobate-ness in the periphery; 12: ***Cribrostomoides bradyi*** Cushman (a) side view (b) apertural view; 13&14: ***Cribrostomoides jeffreysii*** (Williamson) (a) side view (b) apertural view. Fig. 13 illustrates a mature specimen showing better coiling, but its terminal chambers are broken. Intact specimen is illustrated in Fig. 14; 15: ***Cribrostomoides*** sp. (a) side view (b) apertural view; 16& 17: ***Ammoscalaria pseudospiralis*** (Williamson) (a) dorsal view (b) dorsal view; 18: ***Discammina compressa*** (Goes) (a&b) side views; 19: ***Discammina*** sp. (a) side view (b) apertural view; 20: ***Glaphyrammina americanus*** (Cushman); 21 to 24: ***Ammobaculites agglutinans*** (d'Orbigny) Many specimens are illustrated in order to show variation in shape and size; 25: ***Ammobaculites calcareus*** (Brady); 26 to 27: ***Ammobaculites cylindricus*** Cushman. Fig. 26 illustrates specimens with uniform width throughout whereas 27 broadens towards the terminal end. 28: ***Ammobaculites*** sp.

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Plate I

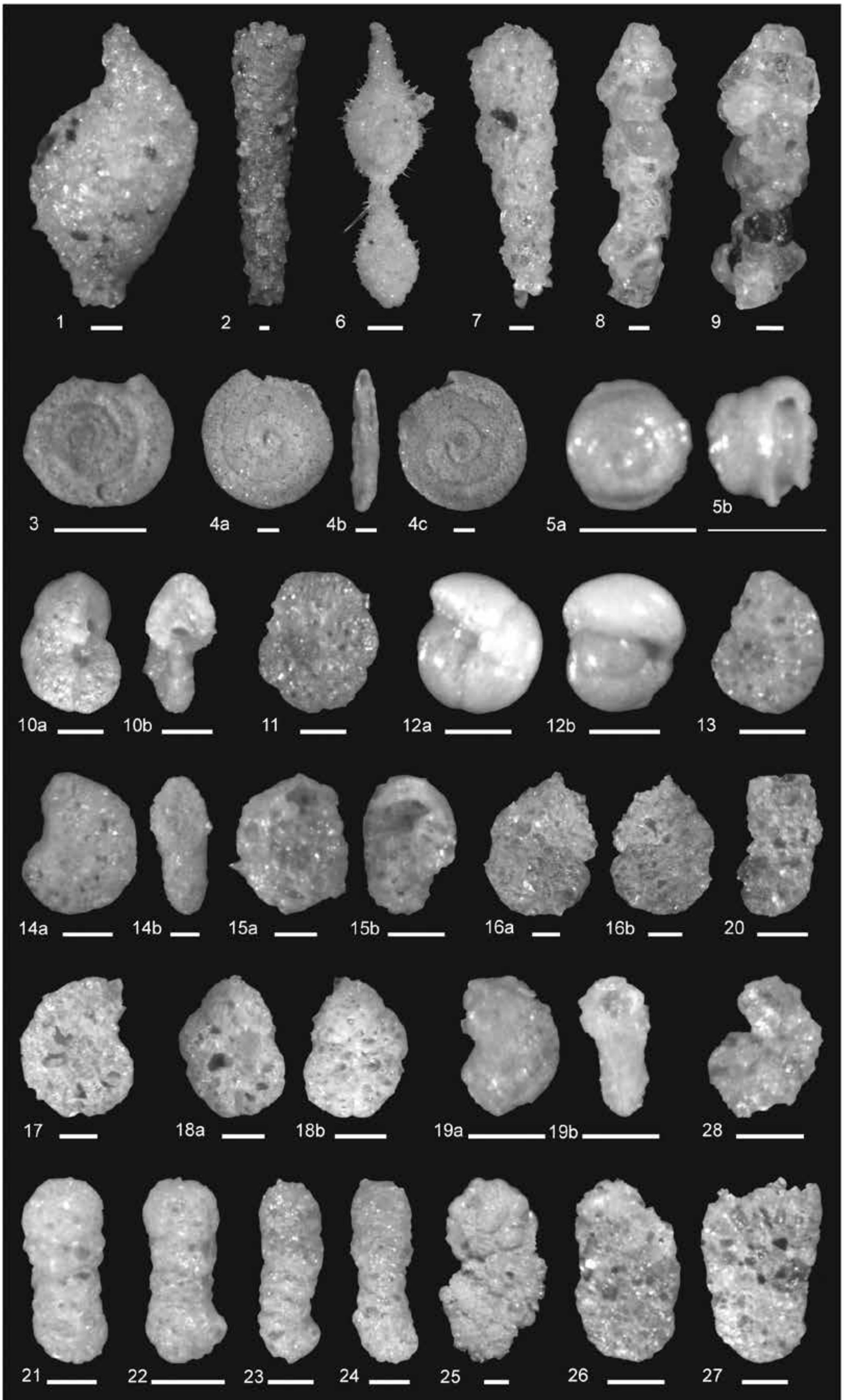

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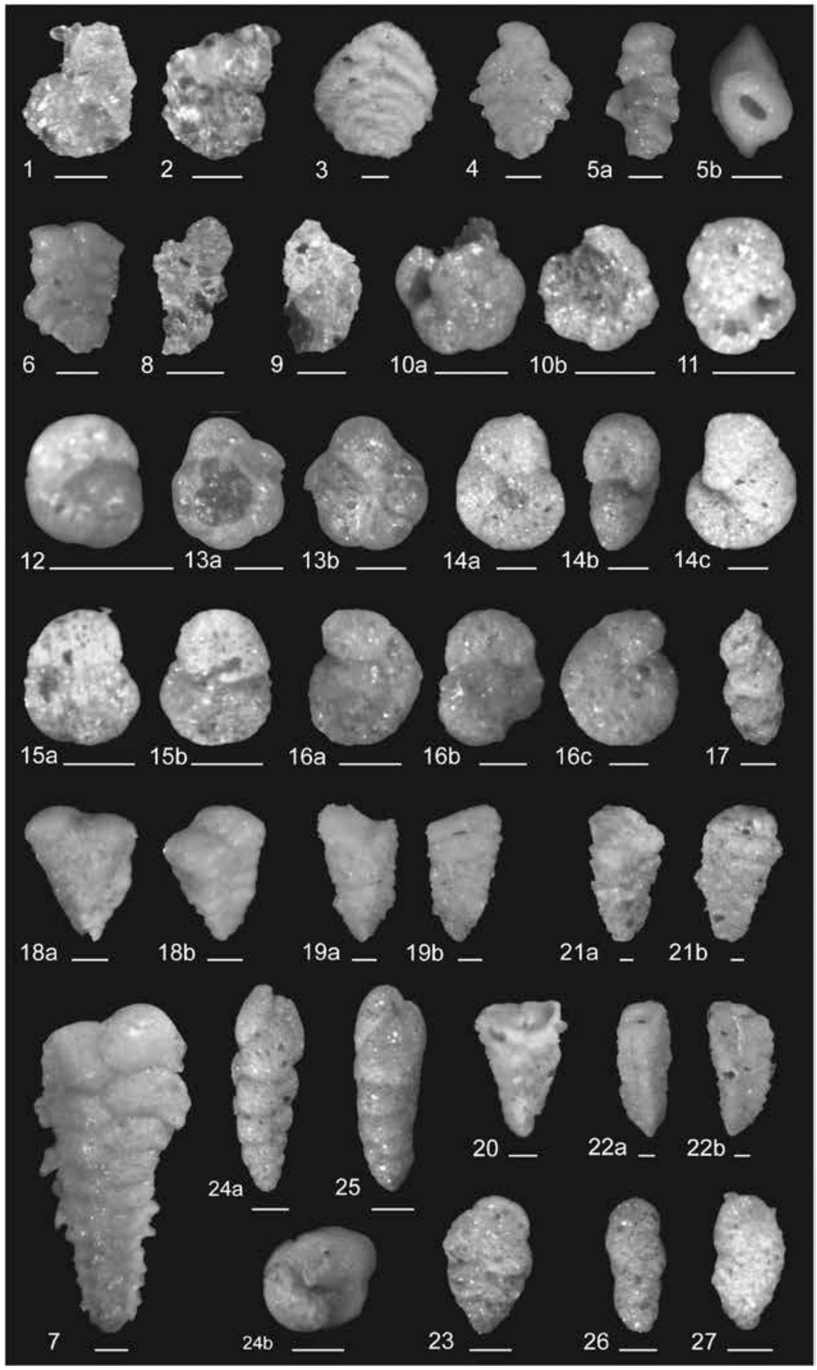
Plate II

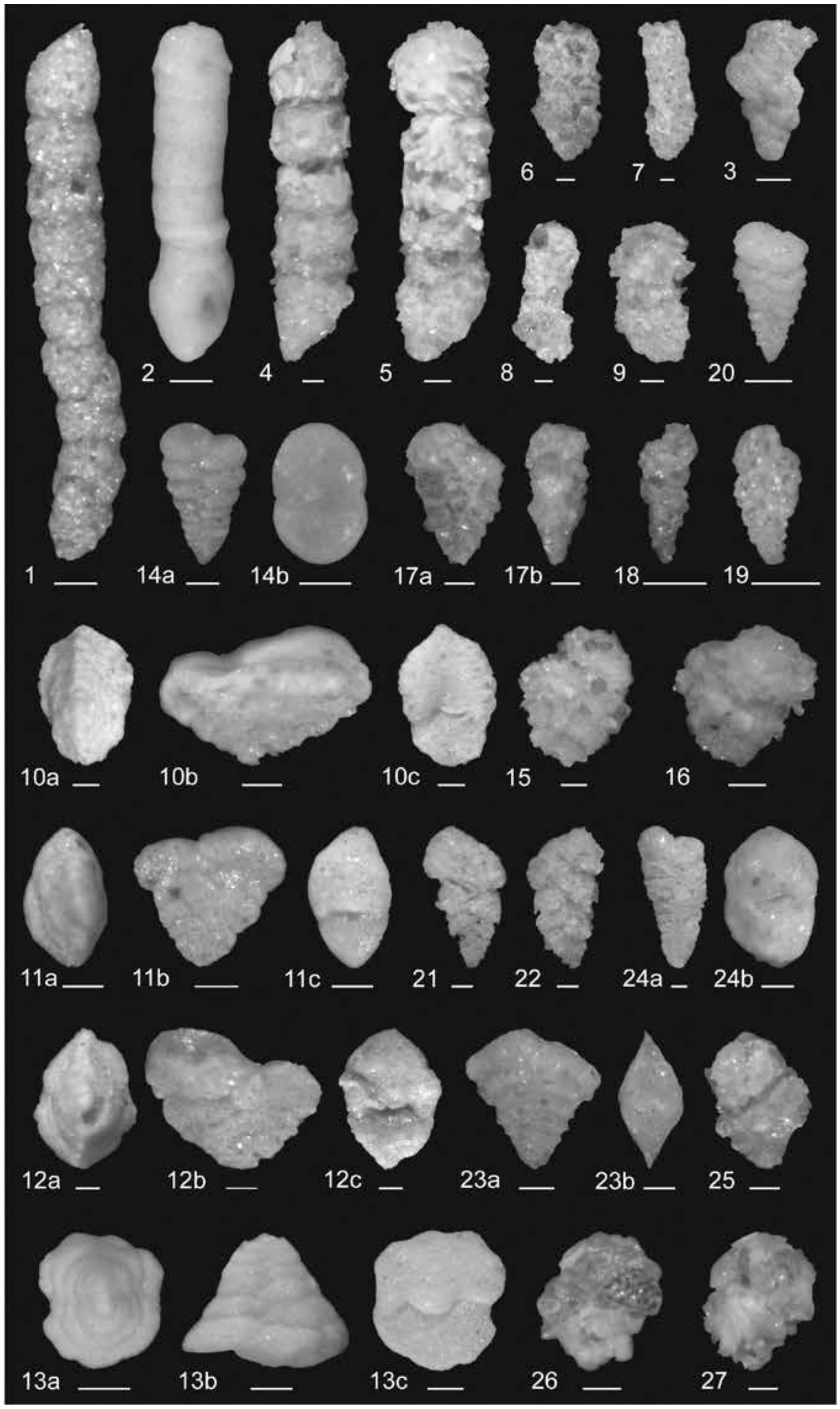


EXPLANATION OF PLATE II

(Scale bar =100µm unless otherwise mentioned)

1 to 2: ***Eratidus foliaceus*** (Brady) Specimens showing variations in shape and texture; 3: ***Vulvulina cuneata*** Smith; 4: ***Vulvulina*** cf. ***zespinosa*** Finlay; 5: ***Vulvulina*** sp. 1 (a) side view (b) apertural view; 6: ***Vulvulina*** sp. 2; 7: ***Spirotextularia fistulosa*** (Brady); 8&9: ***Nouria*** sp. Specimens showing variations in shape and texture; 10: ***Ammoglobigerina globigeriniformis*** (Parker & Jones) (a) dorsal view (b) ventral view; 11&12: ***Ammoglobigerina globulosa*** (Cushman) Dorsal views of two specimens showing variation in texture and lobulation of the periphery; 13: ***Trochammina inflata*** (Montagu) (a) dorsal view (b) ventral view; 14: ***Trochammina nitida*** Brady (a&c) side views (b) apertural view; 15: ***Trochammina tasmanica*** Parr (a) dorsal view (b) ventral view; 16: ***Trochammina*** sp. (a). dorsal view (b) apertural view (c) ventral view; 17. ***Karrerulina apicularis*** (Cushman); 18: ***Gaudryina angulata*** Cushman (a) side view (b) lateral view showing position of aperture; 19: ***Gaudryina convexa*** (Karrer) (a) side view (b) lateral view showing position of aperture; 20. ***Gaudryina flintii*** Cushman; 21: ***Gaudryina rudis*** Wright (a) side view (b) lateral view showing position of aperture; 22: ***Gaudryina trinitasensis*** Nuttall (a) side view (b) lateral view showing position of aperture; 23: ***Rhumblerella humboldti*** (Todd & Bronniman); 24&25: ***Verneuilinulla advena*** (Cushman) (a) side view (b) apertural view. Two specimens showing variation in texture and lobulation of the individual chambers; 26&27: ***Eggerelloides scabrus*** (Williamson) Specimens showing variation in test material, shape, size and texture.

Plate III



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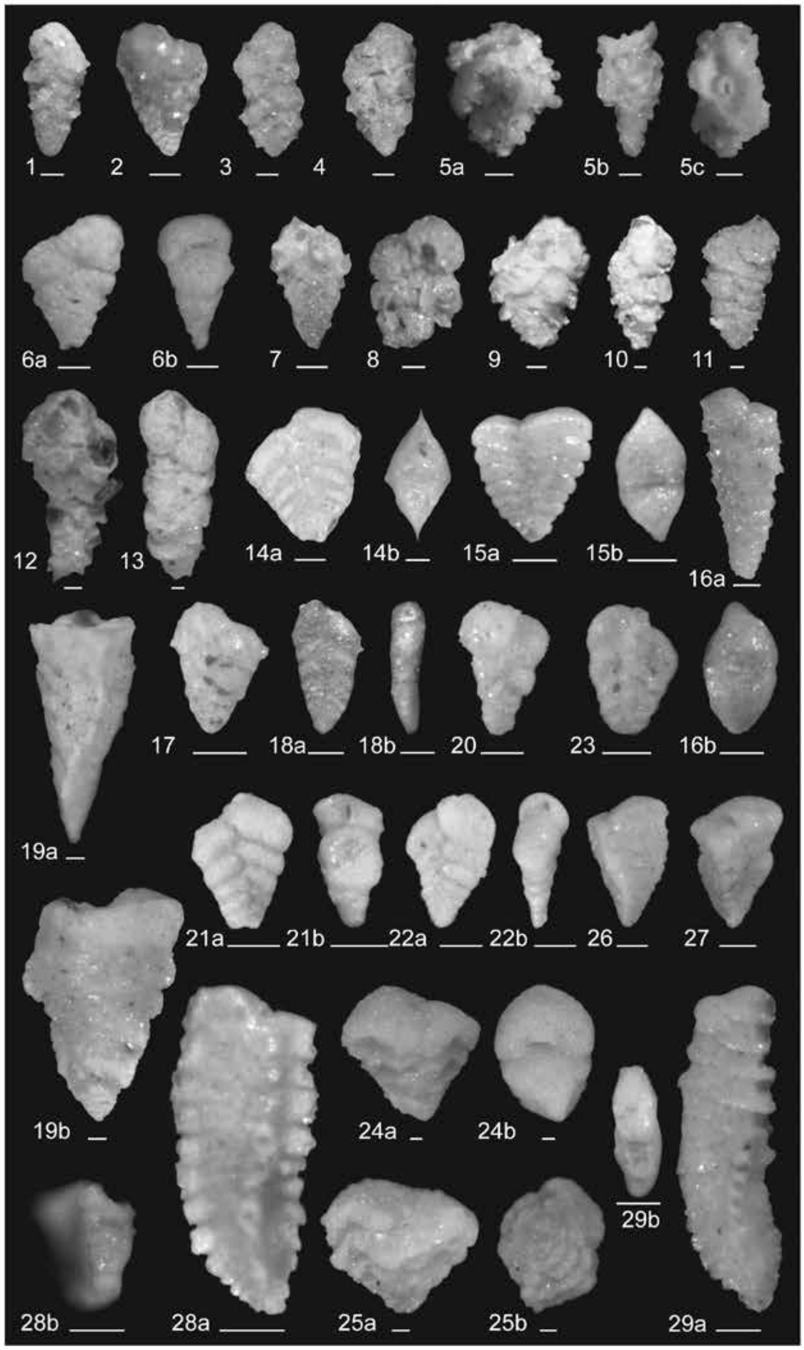
EXPLANATION OF PLATE III

(Scale bar = 100µm unless otherwise mentioned)

1: ***Martinottiella bradyana*** (Cushman); 2: *Martinottiella communis* (d'Orbigny); 3: ***Rudigaudryina inepta*** Cushman & McCulloch; 4 to 9: ***Bigenerina nodosaria*** d'Orbigny Different specimens showing variation in size, texture and finishing of test; 10 to 12: ***Sahulia conica*** (d'Orbigny) (a) top view (b) side view (c) apertural view. Three specimens showing variation in length: breadth ratio; 13: ***Sahulia patelliformis*** Loeblich & Tappan (a) top view (b) side view (c) apertural view; 14: ***Textularia agglutinans*** d'Orbigny (a) side view (b) apertural view; 15&16: ***Textularia aspera*** Brady. Two specimens showing variation in form; 17: ***Textularia calva*** Lalicker (a) side view (b) lateral view; 18&19: ***Textularia earlandi*** Parker; 20: ***Textularia fistula*** Cushman; 21&22: ***Textularia foliacea*** Heron-Allen & Earland. Two specimens showing variation in form; 23: ***Textularia folium*** Parker & Jones (a) side view (b) apertural view; 24: ***Textularia granulata*** Costa (a) side view (b) apertural view; 25 to 27: ***Textularia horrida*** Egger. Three specimens showing variation in shape and shell material.

Plate IV



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EXPLANATION OF PLATE IV

(Scale bar = 100μm unless otherwise mentioned)

1. ***Textularia lancea*** Lalicker & McCulloch; 2. ***Textularia lauta*** Lalicker & McCulloch; 3 to 5: ***Textularia lythostratiformis*** McCulloch (a) side view (b) lateral view (c) apertural view. Three specimens showing variation in shape and shell material; 6: ***Textularia neolancea*** McCulloch (a) side view (b) lateral view; 7: ***Textularia neolateralis*** McCulloch; 8: ***Textularia occidentalis*** Cushman; 9 to 10: ***Textularia oceanica*** Cushman. Two specimens showing variation in shape, finishing of test and grain size; 11: ***Textularia parvula*** Cushman; 12&13: ***Textularia porrecta*** Brady Two specimens showing variation in shape, grain size and finishing of test; 14: ***Textularia pseudocarinata*** Cushman (a) side view (b) apertural view; 15: ***Textularia pseudogramen*** Chapman & Parr (a) side view (b) apertural view; 16: ***Textularia soldanii*** Fornasini (a) side view (b) apertural view; 17: ***Textularia subagglutinans*** Cushman; 18: ***Textularia subplana*** Cushman (a) side view (b) lateral view; 19: ***Textularia undulatiformis*** McCulloch (a) side view (b) lateral view; 20. ***Siphotextularia arubaensis*** McCulloch; 21. ***Siphotextularia dawesi*** Kennet (a) side view (b) lateral view showing position of aperture; 22: ***Siphotextularia glabrata*** Zheng (a) side view (b) lateral view showing position of aperture; 23. ***Siphotextularia pulchra*** Zheng; 24&25: ***Septotextularia rugosa*** Cheng & Zheng (24a) side view (24b) apertural view (25a) side view (25b) distal view. Two specimens showing variation in length: breadth ratio; 26&27: ***Pseudogaudryina pacifica*** (Cushman & McCulloch) Two specimens showing variation in shape, size and test material; 28&29: ***Plotnikovina compressa*** (Cushman) (a) side view (b) apertural view, Two specimens showing variation in size and degree of maturity.

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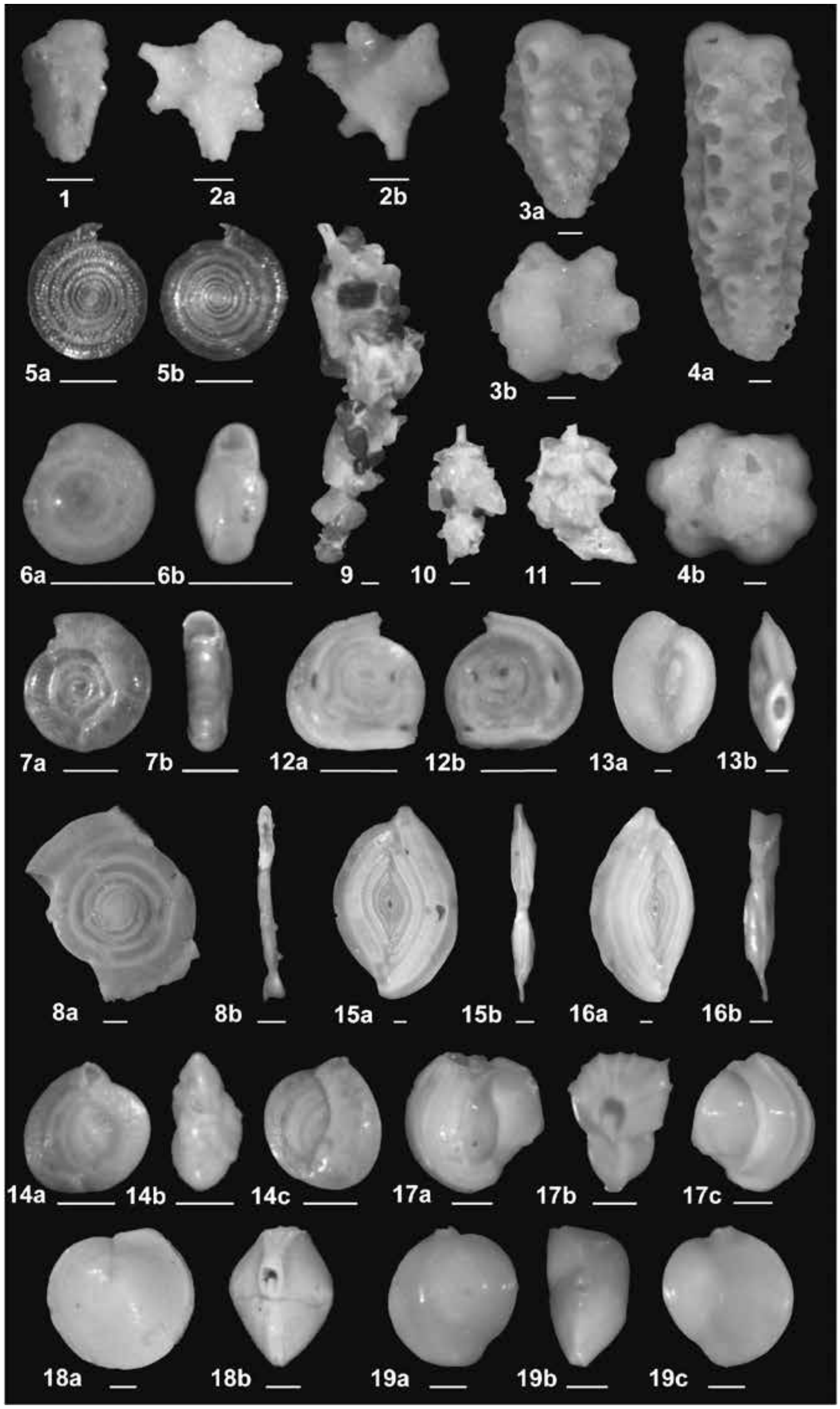
Plate V



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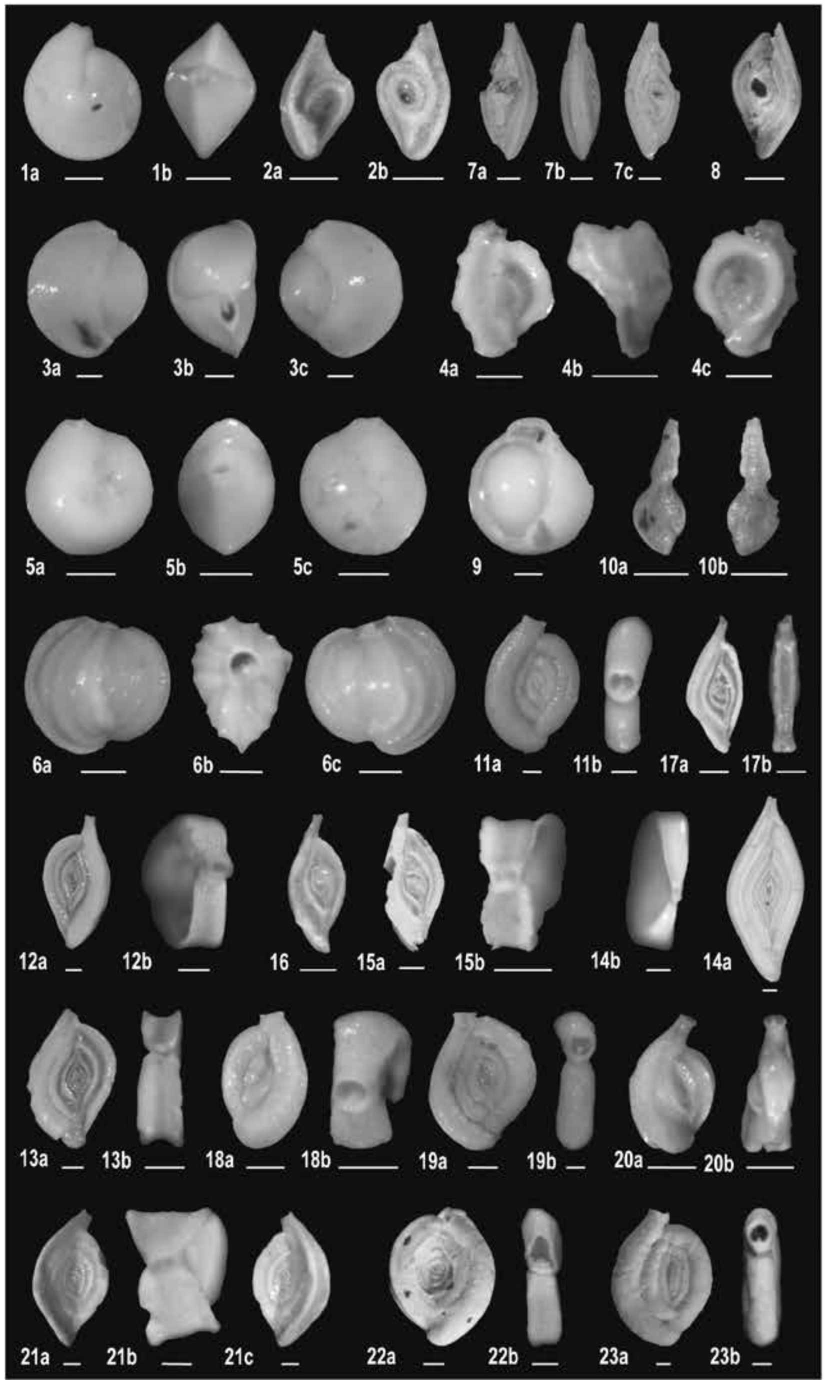
EXPLANATION OF PLATE V

(Scale bar = 100µm unless otherwise mentioned)

1. ***Plotnikovina*** (?) sp.; 2 to 4: ***Siphoniferoides siphoniferus*** (Brady) (2a) apertural view (2b) distal view (3a&4a) side views (3b&4b) apertural views. Three specimens showing variation in shape, size, shell material and degree of maturity; 5: ***Spirillina helenae*** Chapman & Parr (a) ventral view (b) dorsal view; 6: ***Cornuspira planorbis*** Schultze (a) side view (b) lateral view showing aperture; 7: ***Fischerina rhodiensis*** Terquem (a) side view (b) lateral view showing aperture; 8: ***Planispirinella complanata*** (Dakin) (a) side view (b) lateral view showing aperture; 9 to 11: ***Nubeculina divaricata*** (Brady); 12: ***Cornuloculina inconstans*** (Brady) (a&b) side views; 13: ***Edentostomina milletti*** (Cushman) (a) side view (b) apertural view; 14: ***Ophthalmina spiratula*** Rhumbler (a&c) side views (b) apertural view; 15: ***Spirophthalmidium acutimargo*** (Brady) (a) side view (b) apertural view; 16: ***Spirophthalmidium*** sp. (a) side view (b) apertural view; 17: ***Adelosina angulata*** Weisner (a&c) side views (b) apertural view; 18: ***Adelosina bicornis*** (Walker & Jacob) (a) side view (b) apertural view; 19: ***Adelosina laevigata*** d'Orbigny (a&c) side views (b) apertural view.

Plate VI



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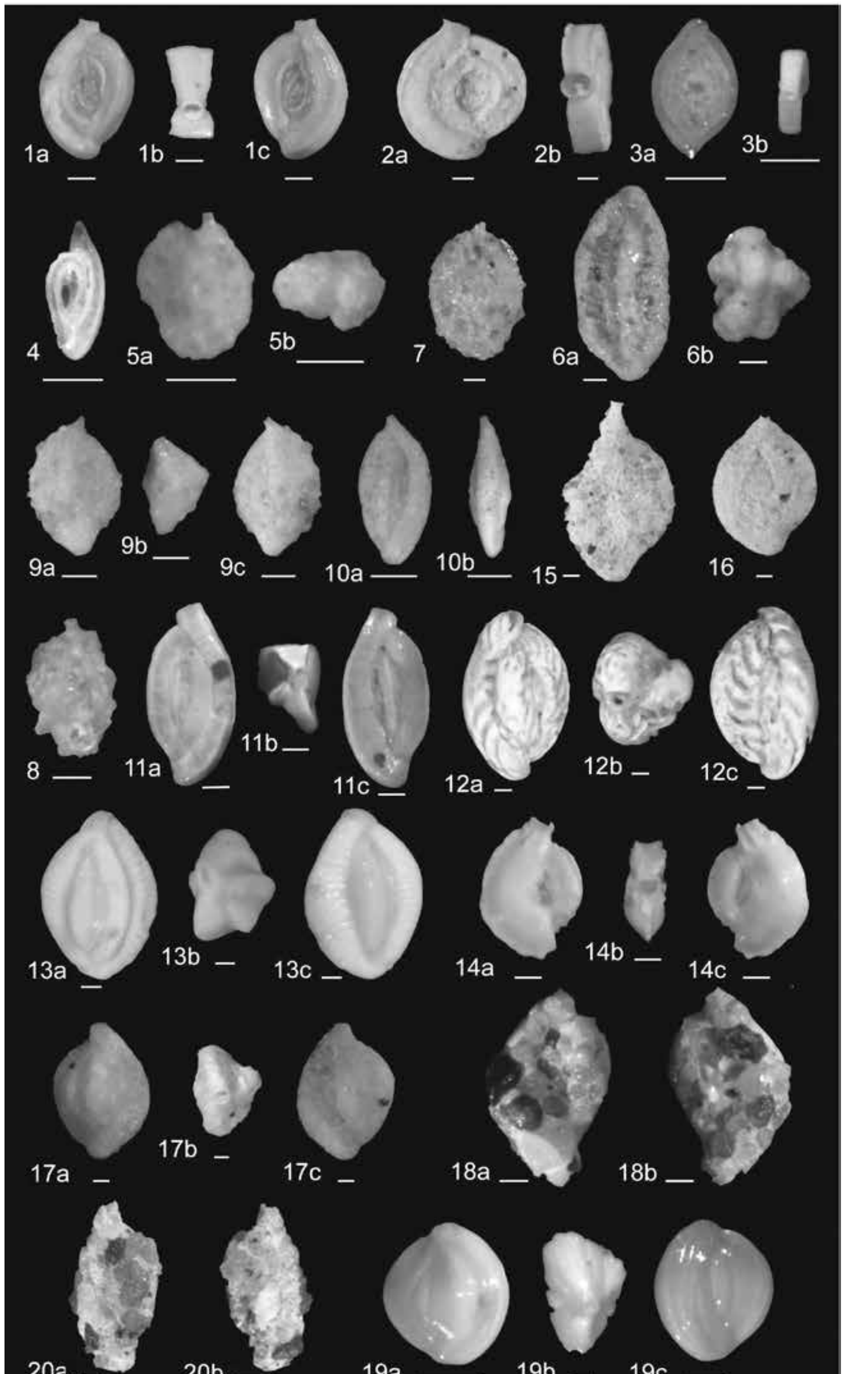
EXPLANATION OF PLATE VI

(Scale bar = 100µm unless otherwise mentioned)

1: ***Adelosina laevigata*** d'Orbigny (a) side view (b) apertural view; 2: ***Adelosina pulchella*** d'Orbigny (a&b) side views; 3: ***Adelosina rotundata*** Terquem (a&c) side views (b) apertural view; 4: ***Adelosina separans*** Wiesner (a&c) side views (b) apertural view; 5: Unidentified young miliolid (a&c) side views (b) apertural view; 6: ***Cribrolinoides curtus*** (Cushman) (a&c) side views (b) apertural view; 7: ***Inaequalina affixa*** (Terquem) (a&c) side views (b) apertural view; 8: ***Inaequalina jadwigae*** Luckowska; 9: ***Nummulopyrgo*** aff. ***wrangellensis*** (McCulloch); 10: ***Rectospiroloculina galapagoensis*** McCulloch (a&b) side views; 11: ***Spiroloculina ampla*** Terquem (a) side view (b) apertural view; 12: ***Spiroloculina convexa*** Said (a) side view (b) apertural view; 13: ***Spiroloculina dispar*** McCulloch (a) side view (b) apertural view; 14: ***Spiroloculina elegantissima*** Said (a) side view (b) apertural view; 15&16: ***Spiroloculina excisa*** Cushman & Todd (a) side view (b) apertural view. Specimen in Fig. 15 is mature, shows all internal whorls very clearly; however is broken. Fig. 16 shows an intact younger specimen; 17: ***Spiroloculina impressa*** Terquem (a) side view (b) apertural view; 18: ***Spiroloculina*** cf. ***inflata*** Terquem (a) side view (b) apertural view; 19: ***Spiroloculina laevigata*** Cushman & Todd; 20: ***Spiroloculina parvula*** Chapman (a) side view (b) apertural view; 21: ***Spiroloculina polita*** Cushman & Todd (a&c) side views (b) apertural view; 22: ***Spiroloculina rotunda*** d'Orbigny (a) side view (b) apertural view; 23: ***Spiroloculina subaequa*** McCulloch (a) side view (b) apertural view.

Plate VII



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EXPLANATION TO PLATE VII

(Scale bar = 100µm unless otherwise mentioned)

1: ***Spiroloculina subcommunis*** McCulloch (a&c) side views (b) apertural view; 2: ***Spiroloculina subimpressa*** Parr (a) side view (b) apertural view; 3: ***Spiroloculina tenuissima*** Reuss (a) side view (b) apertural view; 4: ***Spiroloculina*** sp.; 5: ***Pseudoflintina triquetra*** (Brady) (a) side view (b) apertural view; 6: ***Schlumbergerina alveoliniformis*** (Brady) (a) side view (b) apertural view; 7: ***Siphonaperta crassatina*** (Brady); 8&9: ***Siphonaperta horrida*** (Cushman) (a&c) side views (b) apertural view. Two specimens showing varying degree of coarseness in texture; 10: ***Siphonaperta minuta*** (Collins) (a) side view (b) lateral view; 11: ***Cycloforina contorta*** (d'Orbigny) (a&c) side views (b) apertural view; 12: ***Cycloforina semiplicata*** (McCulloch) (a&c) side views (b) apertural view; 13: ***Cycloforina*** sp. (a&c) side views (b) apertural view; 14: ***Massilina spinata*** Cushman & Ponton (a&c) side views (b) apertural view; 15&16: ***Proemassilina arenaria*** (Brady) Fig.15 illustrates a specimen with coarse but compact agglutination and well developed phialine aperture while that in Fig. 16 is fine grained and has a smooth finish; 17: ***Quinqueloculina agglutinans*** d'Orbigny (a) 4-chambered view (b) apertural view (c) 3-chambered view; 18: ***Quinqueloculina ammophila*** Parr (a) 4-chambered view (b) 3-chambered view; 19: ***Quinqueloculina angulosriata*** Cushman & Valentine (a) 4-chambered view (b) apertural view (c) 3-chambered view; 20: ***Quinqueloculina arenata*** Said (a) 4-chambered view (b) 3-chambered view.

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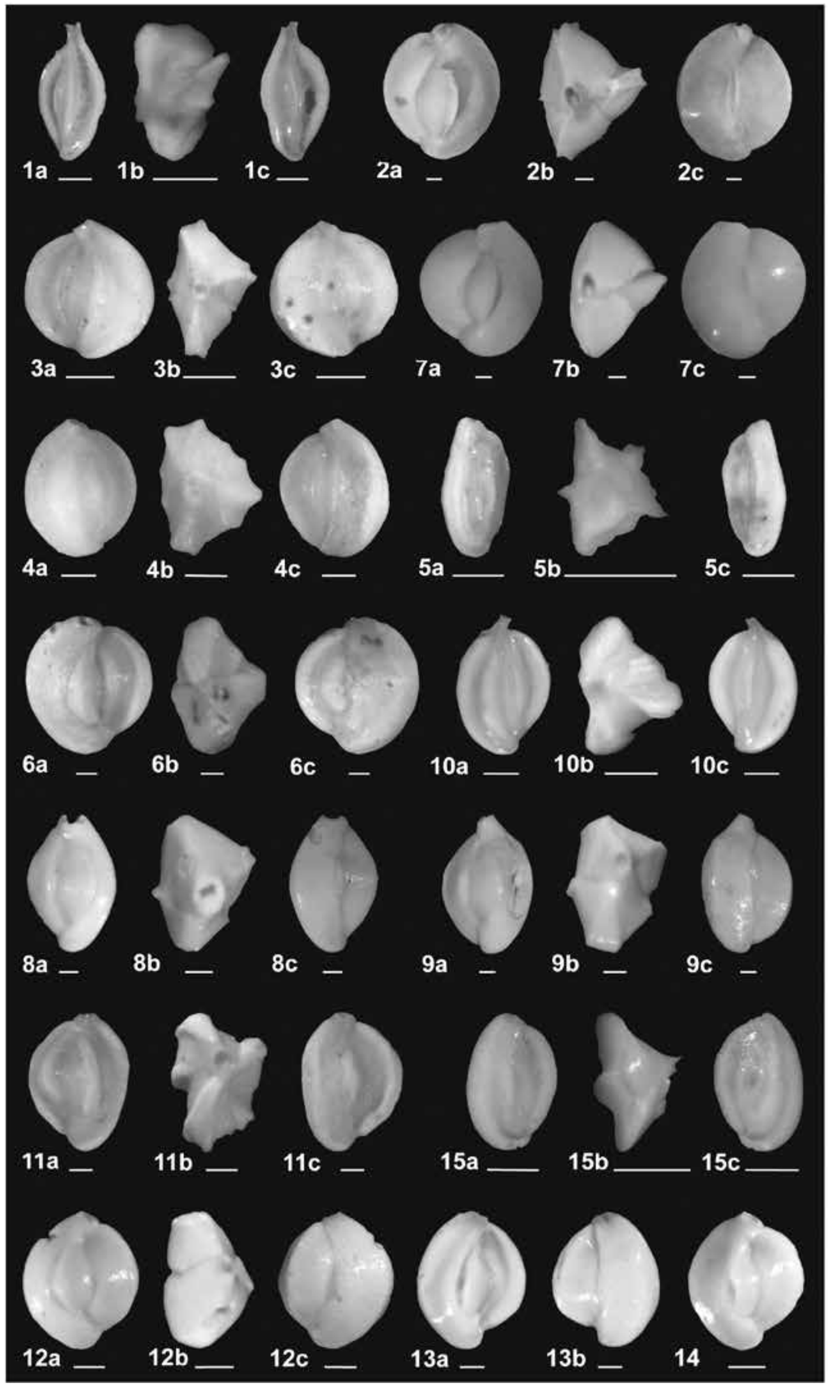
Plate VIII



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EXPLANATION OF PLATE VIII

(Scale bar = 100µm unless otherwise mentioned)

1: ***Quinqueloculina berthelotiformis*** McCulloch (a) 4-chambered view (b) apertural view (c) 3-chambered view; 2: ***Quinqueloculina bicarinata*** d'Orbigny (a) 4-chambered view (b) apertural view (c) 3-chambered view; 3&4: ***Quinqueloculina bicostata*** d'Orbigny (a) 4-chambered view (b) apertural view (c) 3-chambered view. Two specimens exhibiting variation in morphology; 5: ***Quinqueloculina blackbeachiana*** McCulloch (a) 4-chambered view (b) apertural view (c) 3-chambered view; 6: ***Quinqueloculina bubnanensis*** McCulloch (a) 4-chambered view (b) apertural view (c) 3-chambered view; 7: ***Quinqueloculina buchiana*** d'Orbigny (a) 4-chambered view, (b) apertural view (c) 3-chambered view; 8&9: ***Quinqueloculina collumnosa*** Cushman (a) 4-chambered view (b) apertural view (c) 3-chambered view. Fig 8 illustrates an immature specimen with a broken neck and underdeveloped angles whereas specimen in Fig 9 is a mature specimen; 10: ***Quinqueloculina crassicarinata*** Collins (a) 4-chambered view (b) apertural view (c) 3-chambered view; 11: ***Quinqueloculina* cf. *cuvieriana*** d'Orbigny (a) 4-chambered view (b) apertural view (c) 3-chambered view; 12 to 14: ***Quinqueloculina cuvieriana*** d'Orbigny subsp. ***Queenslandica*** Collins (a) 4-chambered view (b) apertural view (c) 3-chambered view. (13a) 4-chambered view (13b) 3-chambered view. Three specimens showing variation in morphology; 15: ***Quinqueloculina cuylerensis*** McCulloch (a) 4-chambered view (b) apertural view (c) 3-chambered view

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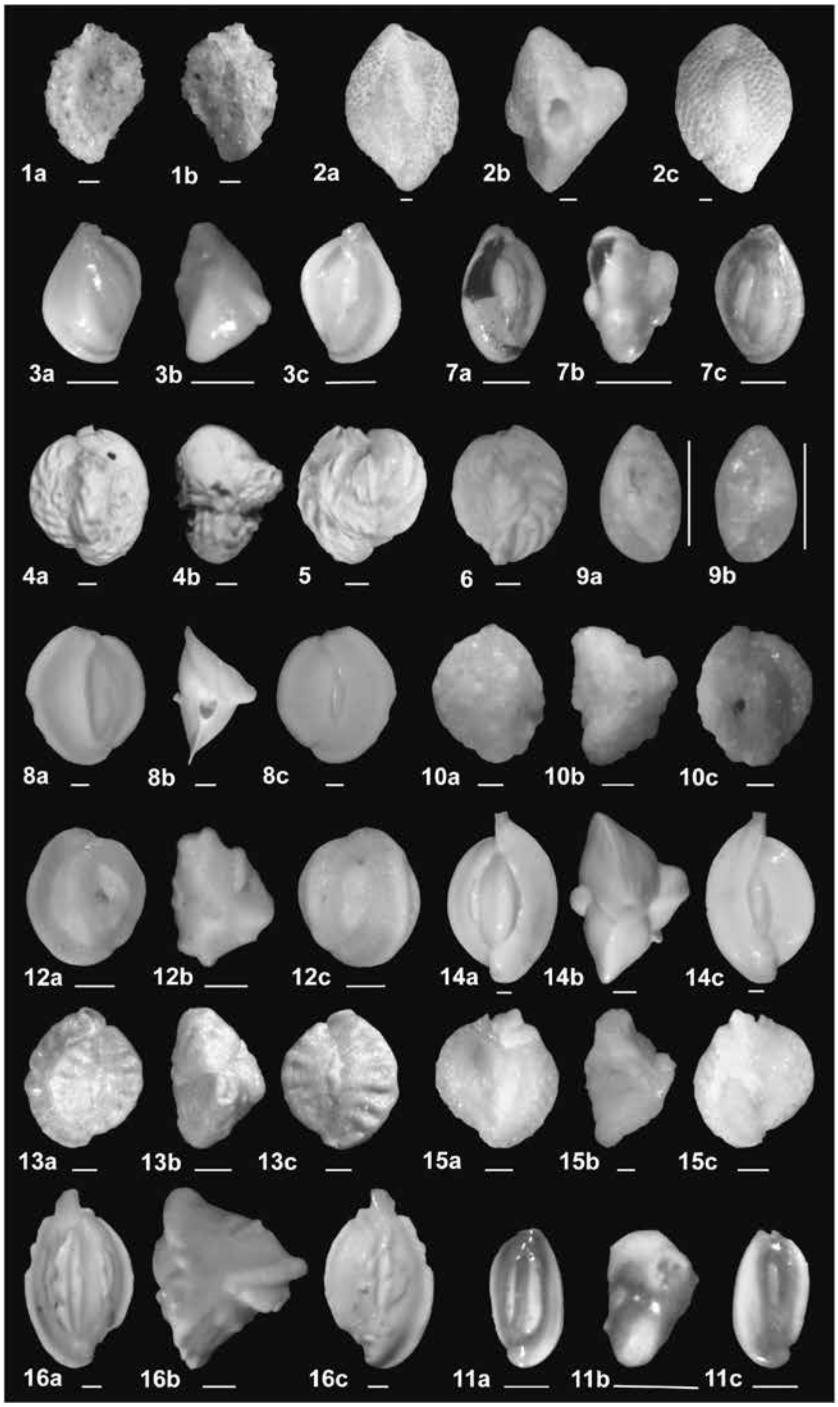
Plate IX



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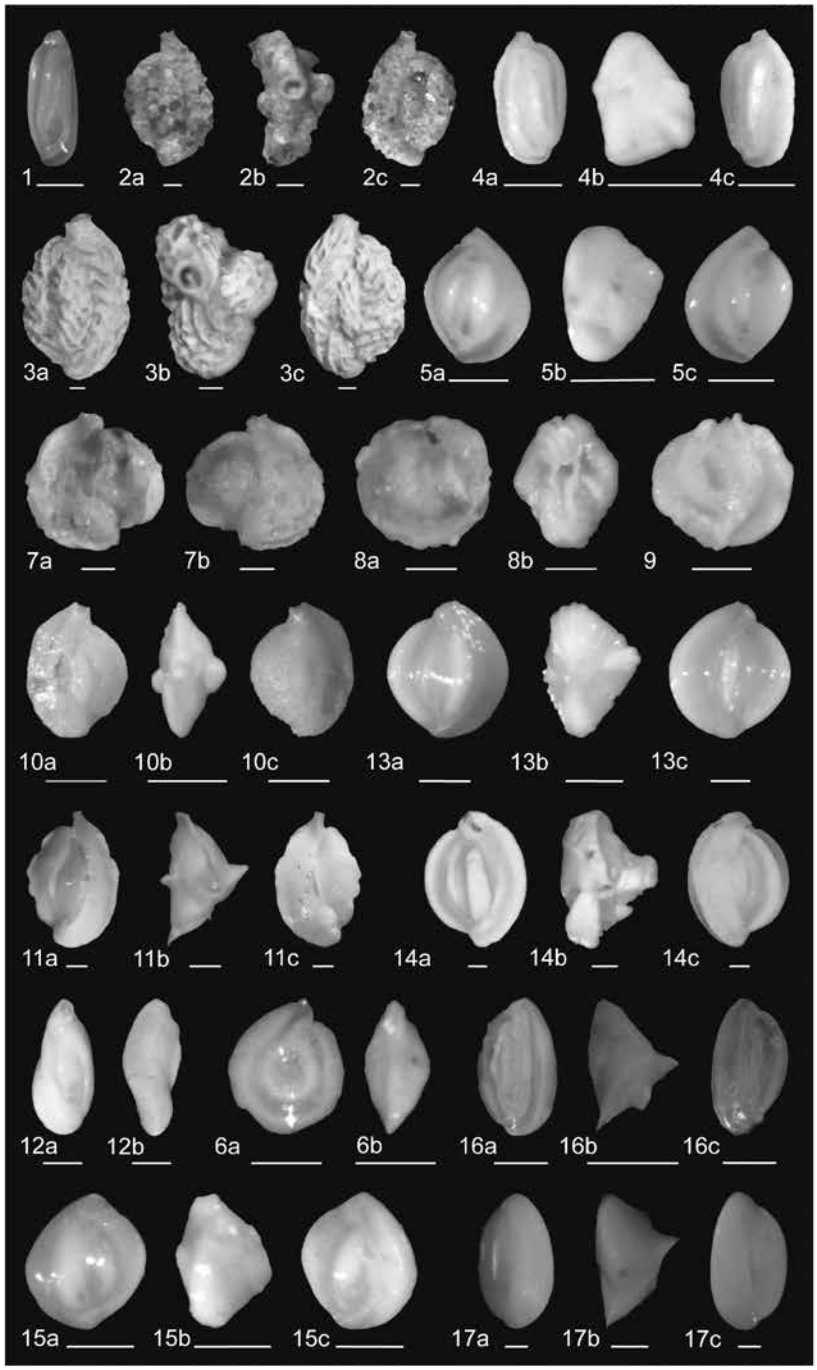
EXPLANATION OF PLATE IX

(Scale bar = 100μm unless otherwise mentioned)

1: ***Quinqueloculina distorqueata*** (Cushman) (a) 4-chambered view (b) 3-chambered view; 2: ***Quinqueloculina elongata*** Leroy (a) 4-chambered view (b) apertural view (c) 3-chambered view; 3: ***Quinqueloculina inaequalis*** d'Orbigny (a) 4-chambered view (b) apertural view (c) 3-chambered view; 4 to 6: ***Quinqueloculina kerimbatica*** (Heron-Allen & Earland) (a) 4-chambered view (b) apertural view. Three specimens showing slight variation in morphology and surface ornamentation; 7: ***Quinqueloculina laevigata*** d'Orbigny (a) 4-chambered view (b) apertural view (c) 3-chambered view; 8: ***Quinqueloculina lamarckiana*** d'Orbigny (a) 4-chambered view (b) apertural view (c) 3-chambered view; 9: ***Quinqueloculina lucida*** Karrer (a) 4-chambered view (b) 3-chambered view; 10: ***Siphonaperta macbeathi*** Vella(a) 4-chambered view (b) apertural view (c) 3-chambered view; 11: ***Quinqueloculina mixta*** McCulloch (a) 4-chambered view (b) apertural view (c) 3-chambered view; 12: ***Quinqueloculina neobicostata*** McCulloch (a) 4-chambered view (b) apertural view (c) 3-chambered view; 13: ***Quinqueloculina parkeri*** (Brady) (a) 4-chambered view (b) apertural view (c) 3-chambered view; 14: ***Quinqueloculina partschii*** d'Orbigny (a) 4-chambered view (b) apertural view (c) 3-chambered view; 15: ***Quinqueloculina philippinensis*** Cushman (a) 4-chambered view (b) apertural view (c) 3-chambered view; 16: ***Quinqueloculina*** cf. ***pinasbayensis*** McCulloch (a) 4-chambered view (b) apertural view (c) 3-chambered view.

Plate X



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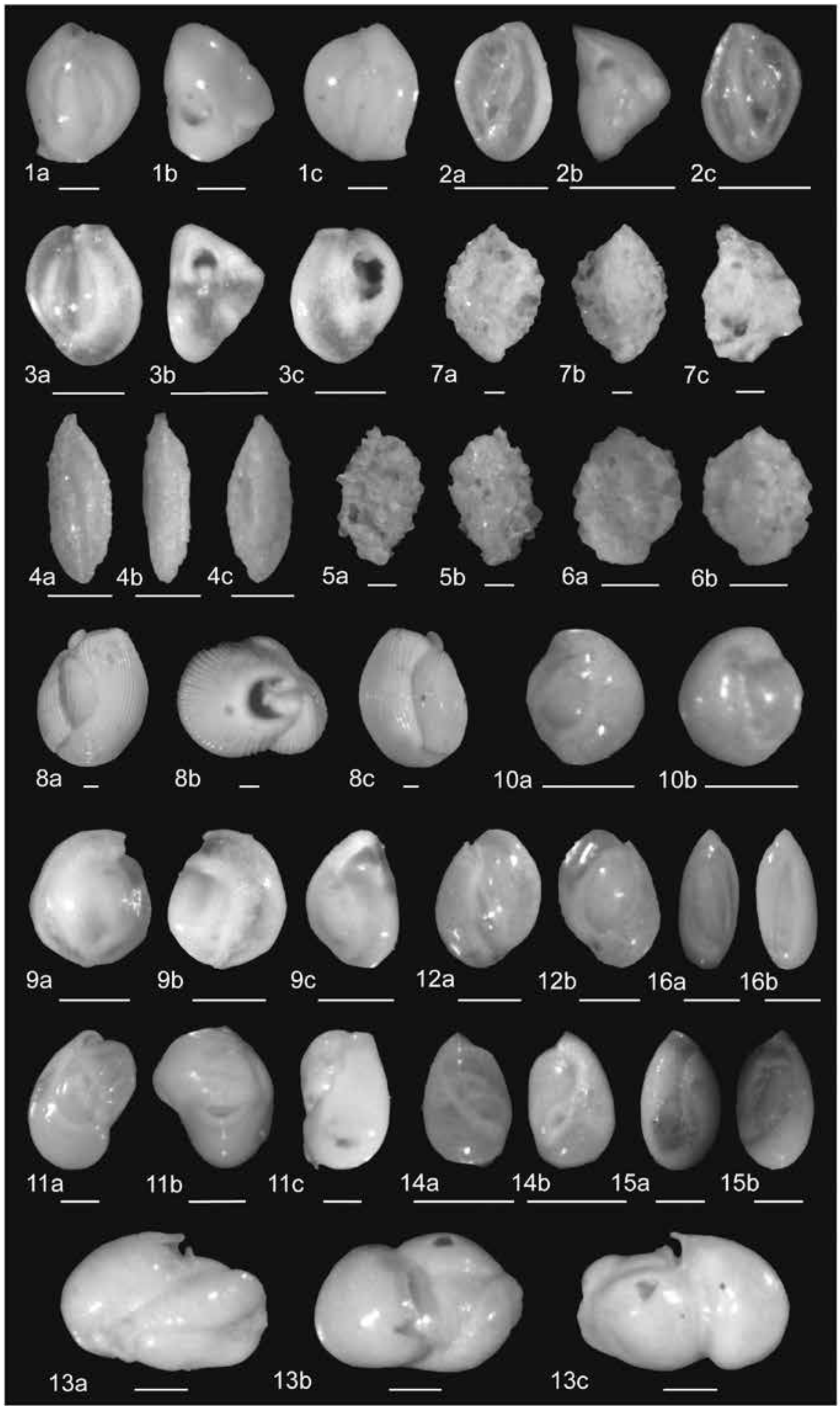
EXPLANATION OF PLATE X

(Scale bar = 100µm unless otherwise mentioned)

1: ***Quinqueloculina pygmaea*** Reuss; 2: ***Quinqueloculina quadrata*** Norvang (a) 4-chambered view (b) apertural view (c) 3-chambered view; 3: ***Quinqueloculina*** aff. ***rariformis*** McCulloch (a) 4-chambered view (b) apertural view (c) 3-chambered view; 4: ***Quinqueloculina schlumbergeri*** (Weisner) (a) 4-chambered view (b) apertural view (c) 3-chambered view; 5:***Quinqueloculina seminula*** (Linneaeus) (a) 4-chambered view (b) apertural view (c) 3-chambered view; 6: ***Quinqueloculina*** cf. ***semistriata*** d'Orbigny (a) side view (b) apertural view; 7 to 9: ***Quinqueloculina sinuosa*** Terquem (7a) 4-chambered view (7a) 3-chambered view (8a) 4-chambered view (8b) apertural view. Three specimens showing variation in morphology/ development; 10: ***Quinqueloculina*** aff. ***sinuosiformis*** McCulloch (a) 4-chambered view (b) apertural view (c) 3-chambered view; 11: ***Quinqueloculina soldanii*** d'Orbigny (a) 4-chambered view (b) apertural view (c) 3-chambered view; 12: ***Quinqueloculina spiralis*** Cushman (a) 4-chambered view (b) apertural view (c.) 3-chambered view; 13: ***Quinqueloculina striatula*** Cushman (a) 4-chambered view (b) apertural view (c) 3-chambered view; 14: ***Quinqueloculina sub-bicosta*** McCulloch (a) 4-chambered view (b) apertural view (c) 3-chambered view; 15: ***Quinqueloculina subcarinata*** Terquem (a) 4-chambered view (b) apertural view (c) 3-chambered view; 16 & 17: ***Quinqueloculina venusta*** Karrer (a) 4-chambered view (b) apertural view (c) 3-chambered view. Fig. 16 illustrates an immature specimen while Fig. 17 illustrates a well developed mature form.

Plate XI



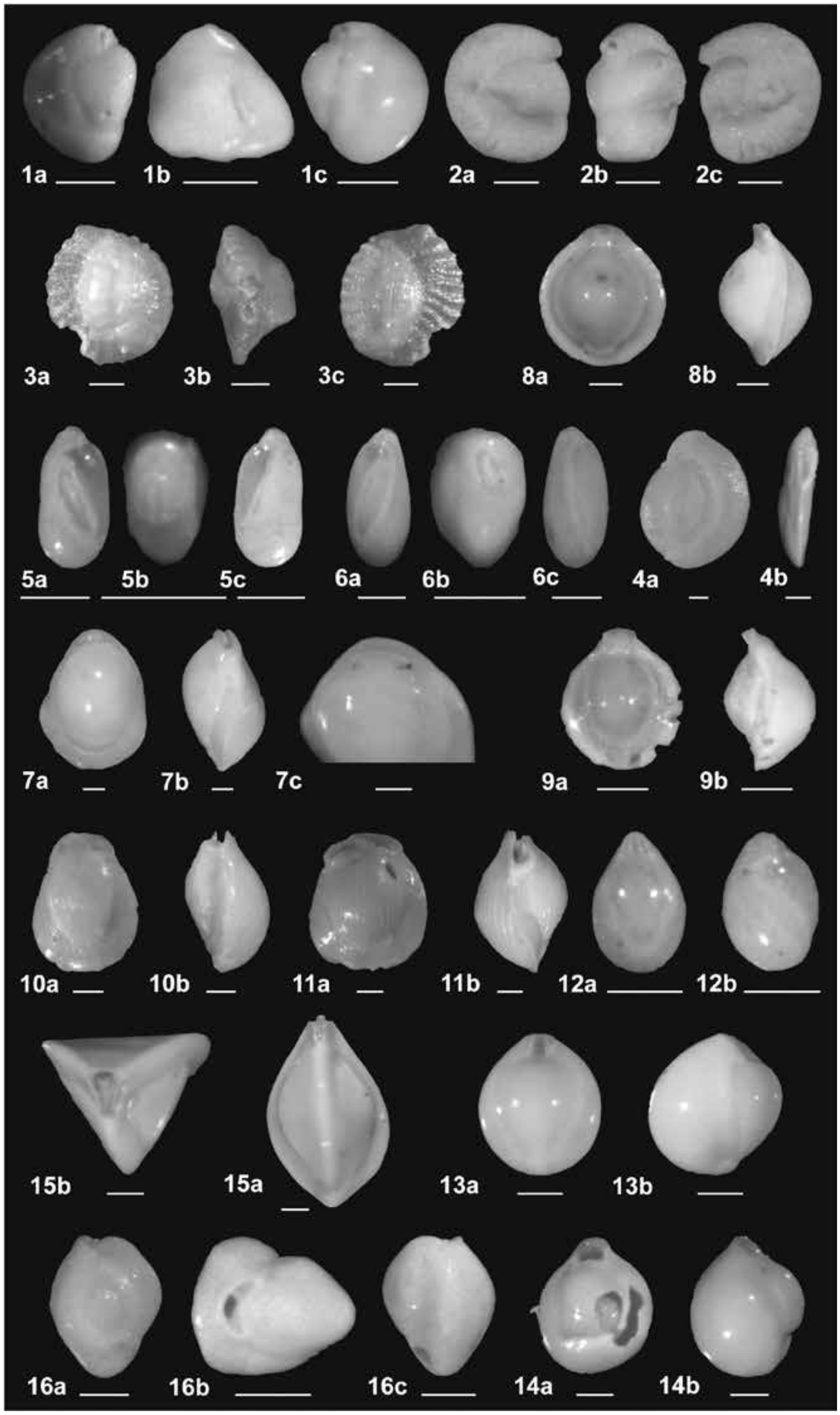
PANCHANG AND NIGAM

EXPLANATION OF PLATE XI

(Scale bar = 100μm unless otherwise mentioned)

1: ***Quinqueloculina weaveri*** Rau (a) 4-chambered view (b) apertural view (c) 3-chambered view; 2: ***Quinqueloculina*** sp. 1 (a) 4-chambered view (b) apertural view (c) 3-chambered view; 3: ***Quinqueloculina*** sp. 2 (a) 4-chambered view (b) apertural view (c) 3-chambered view; 4: ***Quinqueloculina*** sp. 3 (a) 4-chambered view (b) lateral view (c) 3-chambered view; 5: ***Quinqueloculina*** sp. 4 (a) 4-chambered view (b) 3-chambered view; 6: ***Quinqueloculina*** sp. 5 (a) 4-chambered view (b) 3-chambered view; 7: ***Quinqueloculina*** sp. 6 (a) 4-chambered view (b) apertural view (c) 3-chambered view; 8: ***Flintina bradyana*** Cushman (a) 4-chambered view (b) apertural view (c) 3-chambered view; 9: ***Miliolinella australis*** (Parr) (a) 4-chambered view (b) lateral view (c) 3-chambered view; 10: ***Miliolinella circularis*** (Bornemann) (a & b) side views; 11: ***Miliolinella diversiformis*** (McCulloch) (a & c) side views (b) apertural view; 12: ***Miliolinella elongata*** Kruit (a & b) side views; 13: ***Miliolinella labiosiformis*** (McCulloch) (a & c) side views (b) apertural view; 14: ***Miliolinella neomicrostoma*** McCulloch (a-b) side views; 15 & 16: ***Miliolinella oblonga*** (Montagu) (a-b) side views. Two specimens showing variation in morphology.

Plate XII



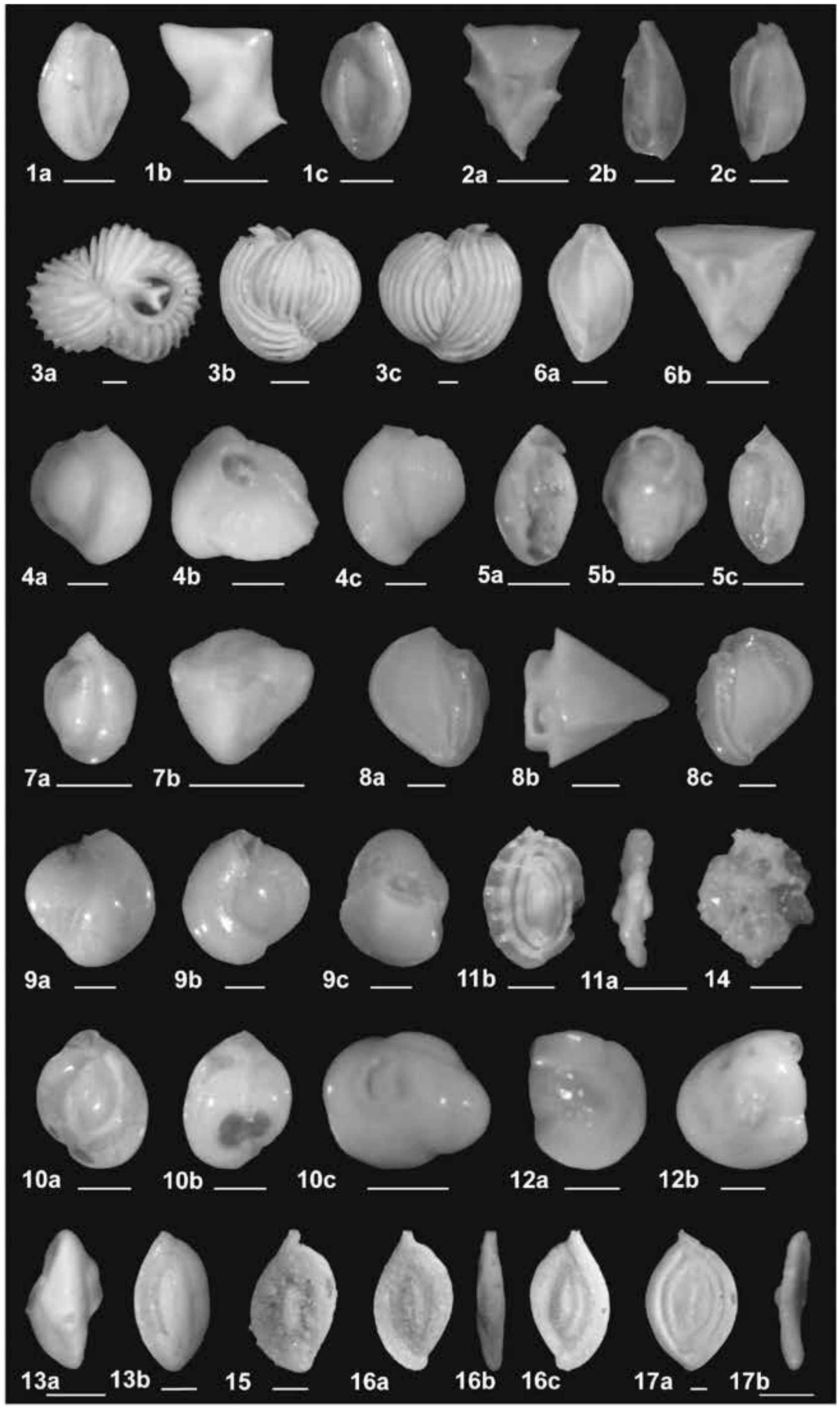
PANCHANG AND NIGAM

EXPLANATION TO PLATE XII

(Scale bar = 100μm unless otherwise mentioned)

1: ***Miliolinella vigilax*** Vella (a & c) side views (b) apertural view; 2: ***Neopateoris*** sp. (a & c) side views (b) apertural view; 3: ***Parahauerina elongata*** (McCulloch) (a & c) side views (b) apertural view; 4: ***Pseudomassilina dissidens*** (McCulloch) (a & c) side views (b) apertural view; 5: ***Pseudotriloculina chrysostoma*** (Chapman) (a & c) side views (b) apertural view; 6: ***Pseudotriloculina microstoma*** (Warren) (a & c) side views (b) apertural view; 7: ***Pyrgo denticulata*** (Brady) (a) side view (b) lateral view (c) enlarged view of apertural region; 8: ***Pyrgo laevis*** Defrance (a) side view (b) lateral view; 9: ***Pyrgo nasutus*** Cushman (a) side view (b) lateral view; 10 & 11: ***Pyrgo striolata*** (Brady) (a) side view (b) lateral view. Two specimens showing variation in morphology and degree of striations; 12 &13: ***Pyrgoella dokici*** (Pavlovic) (a) side view (b) lateral view. Specimen in Fig 12 is a juvenile while that in Fig. 13 is a mature one; 14: ***Pyrgoella*** sp. (a) side view (b) lateral view; 15: ***Triloculina advena*** Cushman (a) side view (b) apertural view; 16: ***Triloculina asymmetrica*** Said (a) 3-chamber view (b) apertural view (c) 2 chamber view.

Plate XIII



PANCHANG AND NIGAM

EXPLANATION TO PLATE XIII

(Scale bar = 100μm unless otherwise mentioned)

1: ***Triloculina dissidens*** McCulloch (a) 3-chamber view (b) apertural view (c) 2 chamber view; 2: ***Triloculina earlandi*** Cushman (a) 3-chamber view (b) apertural view (c) 2 chamber view; 3: ***Triloculina insignis*** (Brady) (a) 3-chamber view (b) apertural view (c) 2 chamber view; 4: ***Triloculina multistriata*** Cushman (a) 3-chamber view (b) apertural view (c) 2 chamber view; 5: ***Triloculina striatella*** Karrer (a) 3-chamber view (b) apertural view (c) 2 chamber view; 6: ***Triloculina tricarinata*** d'Orbigny (a) side view (b) apertural view; 7: ***Triloculina trigonula*** (Lamarck) (a) 3-chamber view (b) apertural view; 8: ***Triloculina*** sp.; 9: ***Triloculinella corrugata*** (Zheng) (a) 3-chamber view (b) apertural view (c) 2 chamber view; 10: ***Triloculinella neocircularis*** (McCulloch) (a) 3-chamber view (b) apertural view (c) 2 chamber view; 11: ***Anchihauerina delicatissima*** McCulloch (a) side view (b) apertural view; 12: ***Nummoloculina jamesbayensis*** McCulloch; 13: ***Sigmoilina elliptica*** Galloway & Wissler (a) side view (b) apertural view; 14: ***Sigmoilina*** aff. ***orinocoensis*** Hedberg; 15: ***Sigmoilina subtenuis*** He Hu Wang; 16: ***Sigmoilinita asperula*** (Karrer) (a & c) side views (b) apertural view; 17: ***Sigmoilinita* (?) *delacaboensis*** (McCulloch) (a) side view (b) apertural view.

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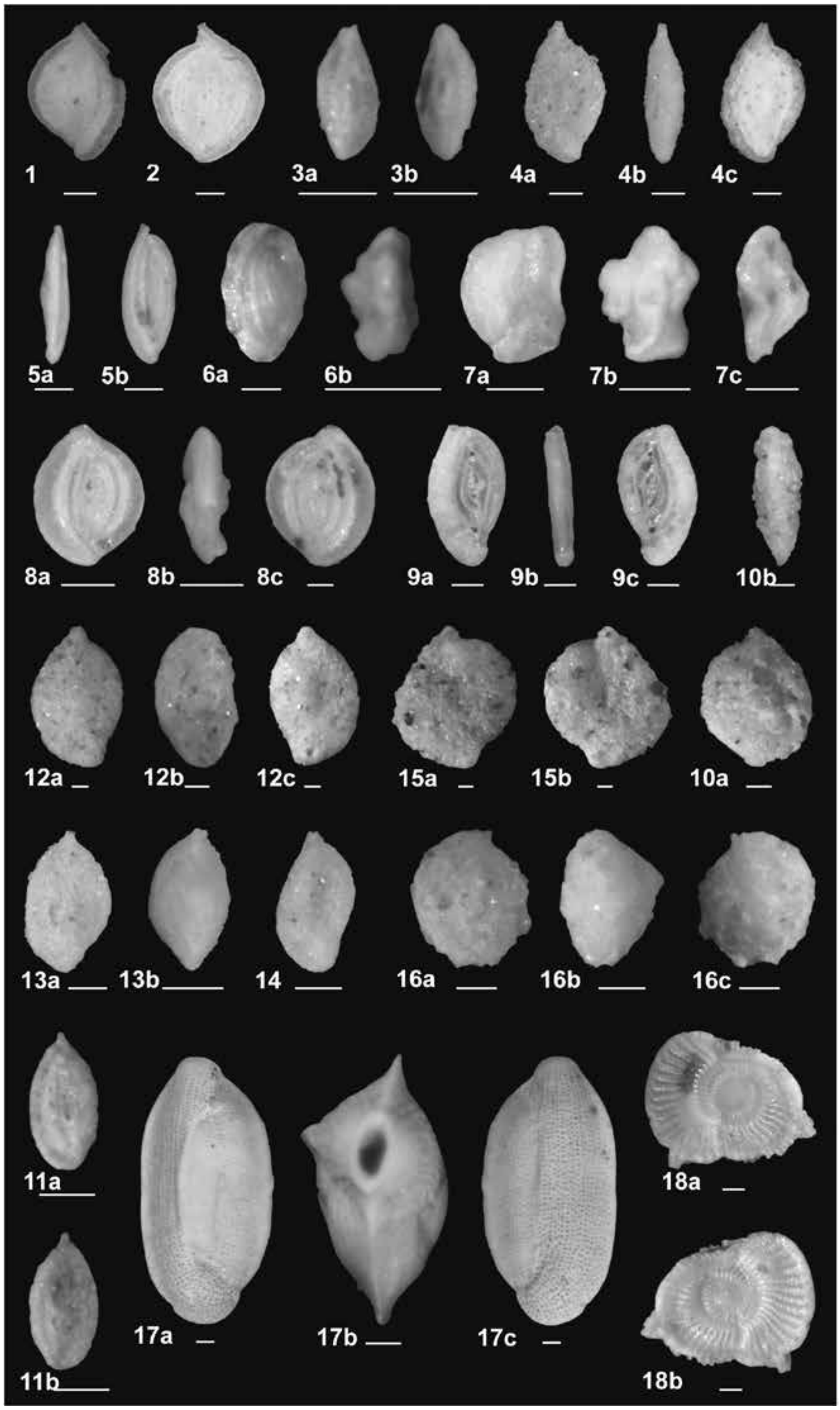
Plate XIV



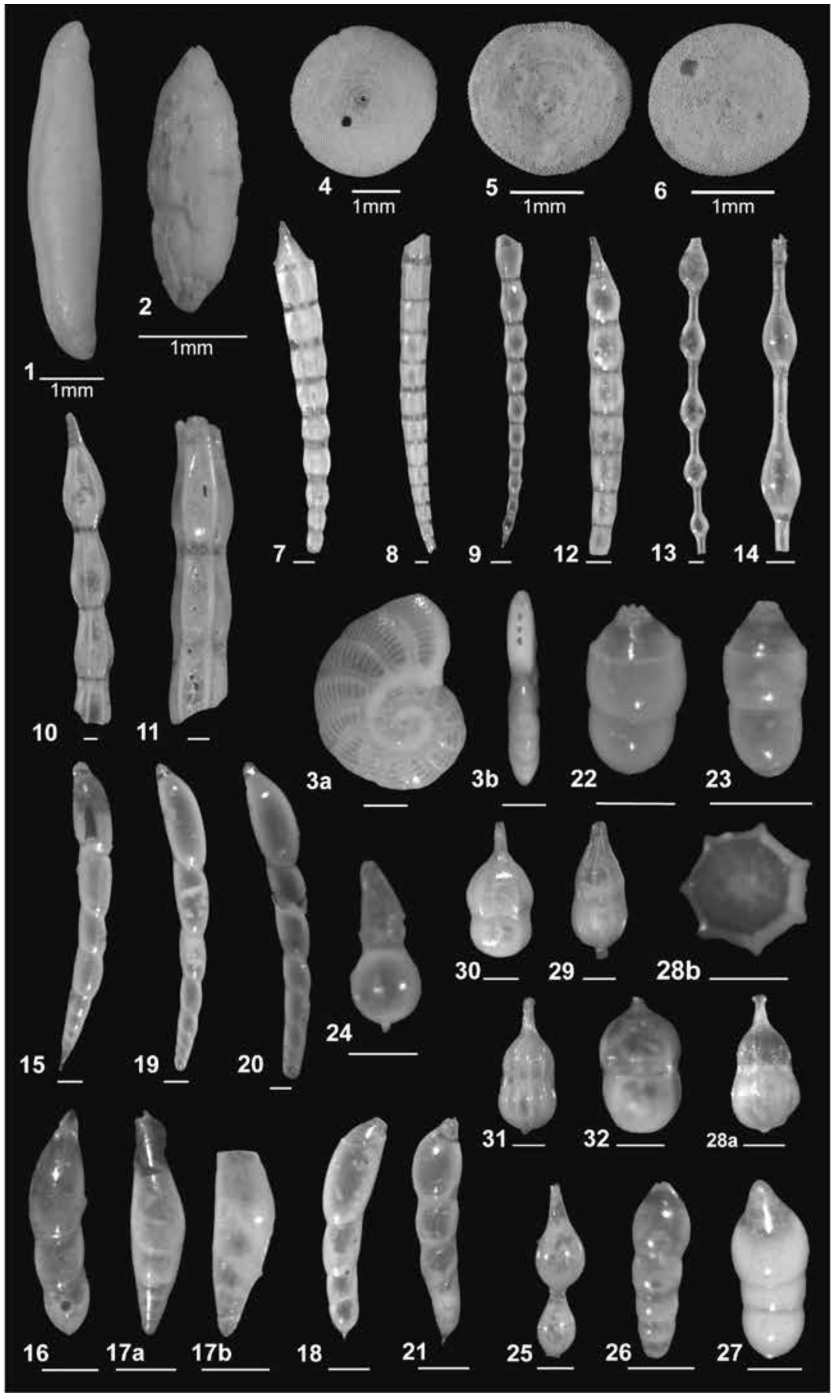
PANCHANG AND NIGAM

EXPLANATION OF PLATE XIV

(Scale bar = 100µm unless otherwise mentioned)

1&2: ***Sigmoilinita latissima*** (Chapman) Two specimens showing variation in morphology and texture of agglutination; 3: ***Sigmoilinita tenuis*** (Earland) (a&b) side views; 4: ***Sigmoilinita*** sp. (a) side view (b) lateral view (c) chamber arrangement as seen after wetting the specimen; 5: ***Spirosigmoilina bradyi*** Collins (a) side view (b) apertural view; 6: ***Spirosigmoilina flexuosa*** Popescu (a) side view (b) apertural view (c) lateral view; 7: ***Spirosigmoilina parri*** Collins (a&c) side views (b) apertural view; 8: ***Spirosigmoilina pusilla*** (Earland); Neck is broken. (a&c) side views (b) apertural view; 9: ***Spirosigmoilina tschokrakensis*** F. *Angusta* (Gherke) (a) side view (b) lateral view; 10: ***Sigmoilopsis compressa*** Hornibrook (a) side view (b) lateral view; 11: ***Sigmoilopsis finlayi*** Vella (a&c) side views (b) apertural view; 12&13: ***Sigmoilopsis schlumbergeri*** (Silvestri) (a) side view (b) apertural view. Specimens showing variation in shape; 14: ***Sigmoilopsis wanganuiensis*** Vella (a) side view (b) dorsal view; 15: ***Sigmoilopsis*** aff. ***zeaserus*** Vella (a&c) side views (b) apertural view; 16: ***Sigmoilopsis*** sp. (a&b) side views; 17: ***Rupertianella rupertina*** (Brady) (a) 3-chamber view (b) apertural view (c) 2 chamber view; 18: ***Pseudohauerina ornatissima*** (Karrer) (a&b) side views.

Plate XV



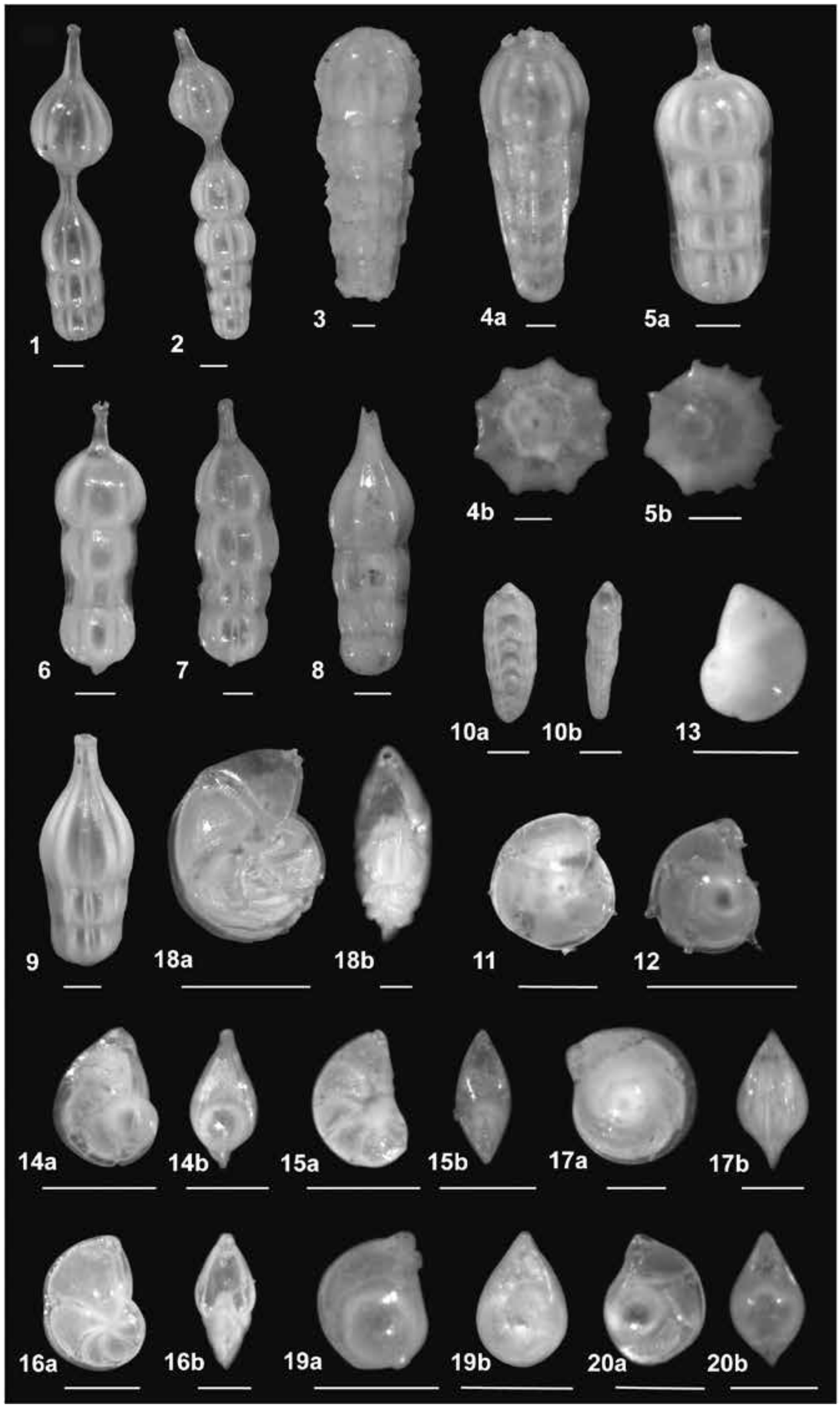
PANCHANG AND NIGAM

EXPLANATION OF PLATE XV

(Scale bar = 100µm unless otherwise mentioned)

1: ***Alveolinella quoii*** (d'Orbigny) (Scale bar = 1mm); 2: ***Alveolinella*** sp. (Scale bar = 1mm); 3: ***Peneroplis pertusus*** (Forskal) (a) side view (b) apertural view; 4 to 6: ***Parasorites orbitolitoides*** (Hofker) (Scale bar = 1mm) Specimens showing variation in size and maturity; 7&8: ***Dentalina albatrossi*** (Cushman). Fig. 7 shows an intact specimen with a lobate periphery towards the early chambers while Fig. 8 is a mature specimen lacking lobateness and with a broken apertural end; 9: ***Dentalina catenulata*** (Brady); 10&11: ***Dentalina jugosus*** (Montagu). Fig. 10 shows a specimen with an intact apertural end whereas Fig. 11 shows a closeup of the surface ornamentation of the specimen; 12: ***Dentalina vertebralis*** (Batsch); 13: ***Grigelis guttifera*** (d'Orbigny); 14: ***Grigelis*** cf. ***pyrula*** (d'Orbigny); 15: ***Laevidentalina aphelis*** Loeblich & Tappan; 16: ***Laevidentalina diversa*** McCulloch; 17: ***Laevidentalina margaritensis*** (McCulloch); 18: ***Laevidentalina phiala*** (Costa); 19&20: ***Laevidentalina tortugaensis*** McCulloch. Two specimens showing variation in morphology; 21: ***Laevidentalina*** sp.; 22&23: ***Nodosaria calomorpha*** Reuss. Two specimens showing variation in morphology; 24: ***Nodosaria simplex*** Silvestri. Terminal chamber broken and hence is inclined; 25: ***Nodosaria* cf. *subaculeata*** Chapman; 26: ***Nodosaria translucens*** (Parr); 27: ***Pseudonodosaria glanduliniformis*** (Dervieux); 28 to 32: ***Pyramidulina catesbyi*** (d'Orbigny) (a) side view (b) apertural view. Five specimens showing variation in morphology.

Plate XIV



PANCHANGA AND NIGAM

EXPLANATION OF PLATE XVI

(Scale bar = 100μm unless otherwise mentioned)

1: ***Pyramidulina luzonensis*** (Cushman); 2: ***Pyramidulina pauciloculata*** Cushman; 3&4: ***Pyramidulina raphanus*** (Linneaeus) (a) side view (b) apertural view. Two specimens showing varying degree of preservation; 5: ***Pyramidulina*** cf. ***tubulata*** (Koch) (a) side view (b) apertural view; 6: ***Pyramidulina*** sp. 1; 7: ***Pyramidulina*** sp. 2; 8&9: ***Pyramidulina*** sp. 3 Two specimens showing variation in morphology; 10: ***Plectofrondicularia parri*** Finlay (a) side view (b) lateral view; 11&12: ***Lenticulina calcar*** (Linneaeus) Two specimens showing different levels of maturity; 13: ***Lenticulina convergens*** (Bornemann); 14: ***Lenticulina crassa*** (d'Orbigny) (a) side view (b) lateral view showing aperture; 15: ***Lenticulina lucidiformis*** (McCulloch) (a) side view (b) lateral view showing aperture; 16: ***Lenticulina nitida*** (d'Orbigny) (a) side view (b) lateral view showing aperture; 17: ***Lenticulina orbicularis*** (d'Orbigny) (a) side view (b) lateral view showing aperture; 18: ***Lenticulina papillosoechinata*** (Fornasini) (a) side view (b) lateral view showing aperture; 19&20: ***Lenticulina pliocaena*** (Silvestri) (a) side view (b) lateral view showing aperture. Fig. 19 shows a juveline specimen whereas Fig. 20 shows a mature specimen.

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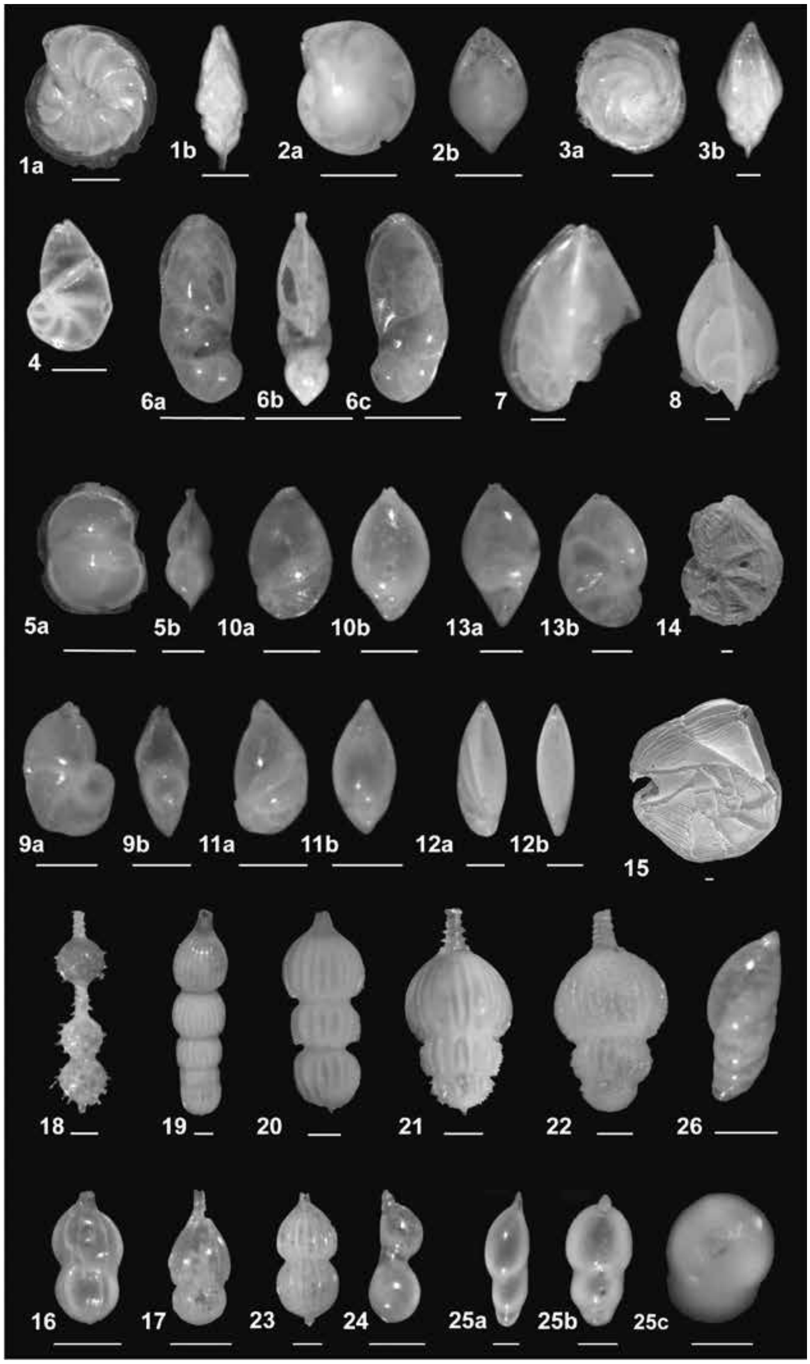
Plate XVII



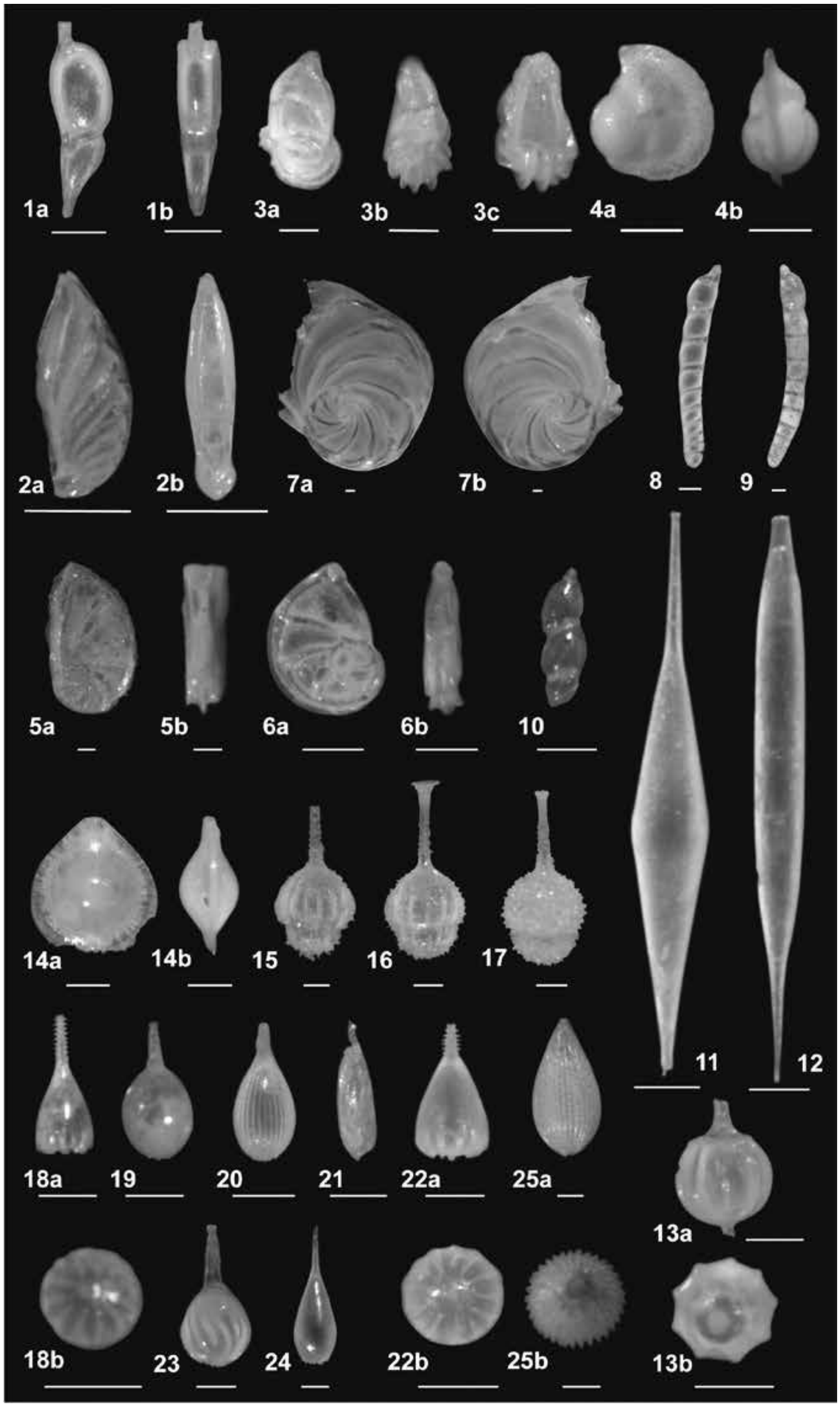
PANCHANG AND NIGAM

EXPLANATION OF PLATE XVII

(Scale bar = 100μm unless otherwise mentioned)

1: ***Lenticulina submamilligera*** (Cushman) (a) side view (b) lateral view showing aperture; 2: ***Lenticulina thalmanni*** (Hessland) (a) side view (b) lateral view showing aperture; 3: ***Lenticulina vortex*** (Fichtel & Moll) (a) side view (b) lateral view showing aperture; 4: ***Neolenticulina dissensa*** McCulloch; 5: ***Neolenticulina peregrina*** (Schwager) (a) side view (b) lateral view; 6: ***Neolenticulina variabilis*** (Reuss) (a&c) side views (b) lateral view; 7&8: ***Saracenaria*** cf. ***angularis*** Natland. Fig. 7 showing the flat apertural face with aperture intact on dorsal margin. Fig. 8- Dorsal carinate angle of a specimen with final chamber broken; 9: ***Saracenaria carribbeanica*** McCulloch (a) side view (b) lateral view; 10&11: ***Saracenaria jamaicensis*** Cushman & Todd (a) side view (b) apertural view. Two specimens showing variation in morphology; 12&13: ***Saracenaria latifrons*** (Brady) (a) side view (b) apertural view. Two specimens showing variation in morphology; 14&15: ***Spincterules anaglyptus*** Loeblich & Tappan (Scale bar = 200μm). Fig. 14 shows an ill preserved specimen with broken apertural end and Fig. 15: SEM image showing intact aperture and surface ornamentation; 16&17: ***Amphycoryna*** cf. ***bilocularis*** (Rhumbler) Two specimens showing variation in morphology; 18: ***Amphycoryna hirsuta*** (d'Orbigny); 19: ***Amphycoryna paucicostata*** (Cushman); 20: ***Amphycoryna*** aff. ***rugosocostata*** (d'Orbigny); 21: ***Amphycoryna scalaris*** (Batsch); 22: ***Amphycoryna seminuda*** (Chapman); 23: ***Amphycoryna variabilis*** (Terquem and Berthelin); 24: ***Hemirobulina*** cf. ***albemarlensis*** (McCulloch); 25: ***Hemirobulina galapagoensis*** (McCulloch) (a) side view (b) ventral margin (c) apertural view; 26: ***Hemirobulina neomulticamerata*** (McCulloch).

Plate XVIII



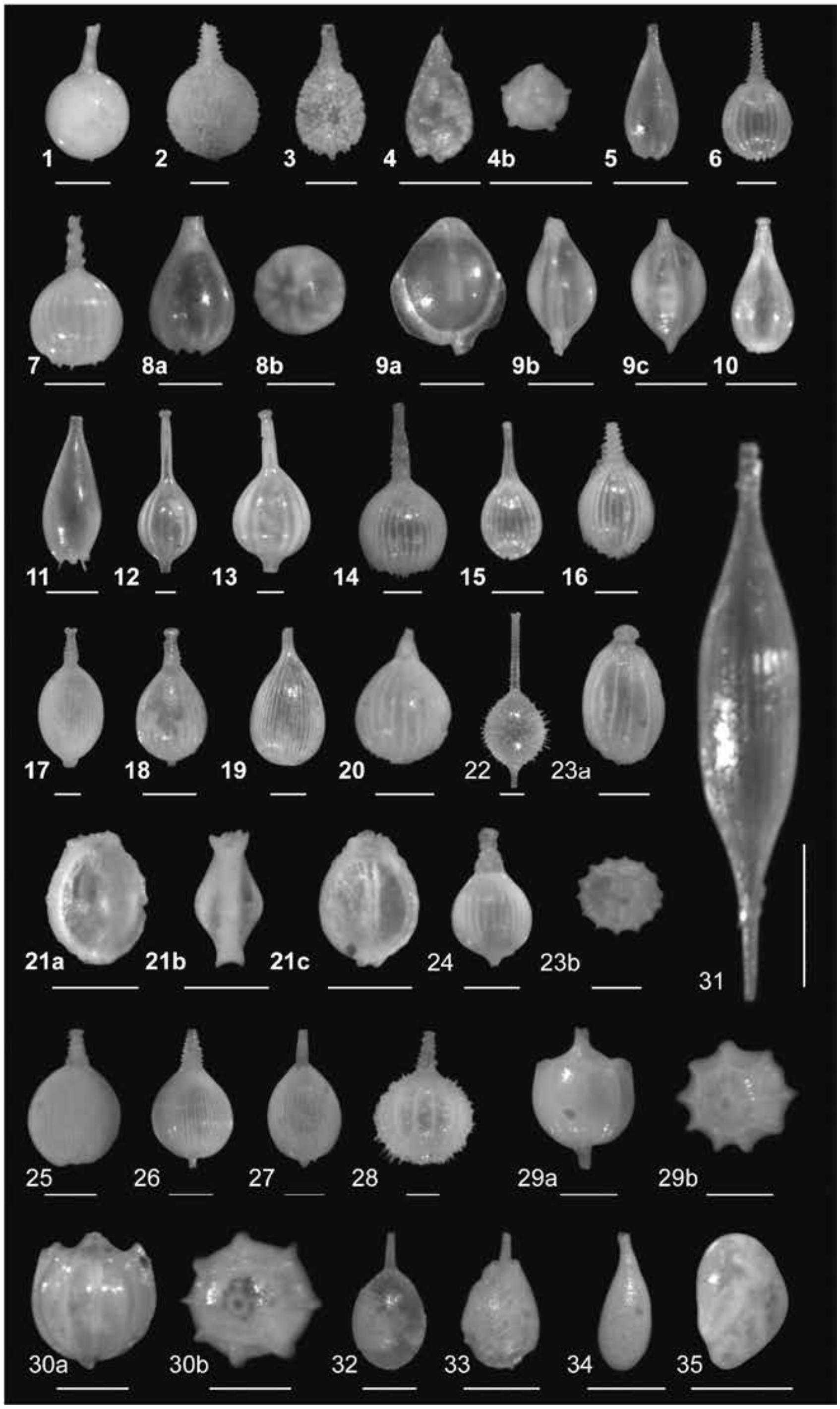
PANCHANG AND NIGAM

EXPLANATION OF PLATE XVIII

(Scale bar = 100µm unless otherwise mentioned)

1: ***Prismatomorphina*** sp.; 2: ***Planularia australis*** Chapman; 3: ***Planularia dissensa*** McCulloch; 4: ***Planularia siddallina*** (Brady); 5&6: ***Planularia* cf. *tricarinella*** (Reuss) (5a&5b) side views (5b) apertural view (6b) lateral view showing tricarinate dorsal margin. Fig. 6 shows a juvenile specimen; 7: ***Planularia*** sp.**;** 8&9: ***Vaginulina inflata*** (Schuvert) Two specimens showing difference in size; 10: ***Vaginulina subelegans*** Parr; 11: ***Hyalinonetrion distomapolita*** (Parker & Jones); 12: ***Hyalinonetrion elongata*** (Ehrenberg); 13: ***Lagena acuticosta*** Reuss (a) side view (b) apertural view; 14: ***Lagena alata*** Cushman (a) side view (b) lateral view; 15-17: ***Lagena bicamerata*** Jones. Three specimens showing variation in type and degree of surface ornamentation; 18: ***Lagena bifidoannulata*** Albani and Yassini (a) side view (b) distal view; 19: ***Lagena blomaeformis*** Yassini and Jones; 20: ***Lagena calvatiformis*** McCulloch; 21: ***Lagena*** cf. ***chathamensis*** McCulloch; 22: ***Lagena crenata*** Parker & Jones (a) side view (b) distal view; 23: ***Lagena*** cf. ***curvilineata*** Balkwill & Wright; 24: ***Lagena doveyensis*** Haynes; 25: ***Lagena eufoveolata*** McCulloch (a) side view (b) apertural view.

Plate XIX



PANCHANG AND NIGAM

EXPLANATION OF PLATE XIX

(Scale bar = 100μm unless otherwise mentioned)

1: ***Lagena flatulenta*** Loeblich and Tappan; 2: ***Lagena gibbera*** Buchner; 3: ***Lagena hispida*** Reuss; 4: ***Lagena multilagenoides*** McCulloch (a) side view (b) apertural view; 5: ***Lagena oceanica*** Albani; 6: ***Lagena peculiariformis*** Albani and Yassini; 7: ***Lagena peculiaris*** Cushman and McCulloch; 8: ***Lagena perlucida*** (Montagu) (a) side view (b) distal view; 9: ***Lagena polita*** Chapman & Parr (a) side view (b) lateral view (c) apertural view; 10: ***Lagena semistriata*** Williamson; 11: ***Lagena setigera*** Millett; 12&13: ***Lagena spicata*** Cushman & McCulloch. Two specimens showing variation in size; 14: ***Lagena spiratiformis*** McCulloch; 15: ***Lagena striata*** (d'Orbigny); 16: ***Lagena striatiformis*** McCulloch; 17&18: ***Lagena strumosa*** Reuss. Two specimens showing variation in morphology; 19: ***Lagena substriata*** Williamson; 20: ***Lagena sulcata*** (Walker and Jacob); 21: ***Lagena unicostata*** Sidebottom (a&c) side views (b) lateral view; 22: ***Lagena*** sp. 1; 23: ***Lagena*** sp. 2 (a) side view (b) apertural view; 24: ***Lagena*** sp. 3; 25: ***Lagena*** sp. 4; 26: ***Lagena*** sp. 5; 27: ***Lagena*** sp. 6; 28: ***Lagena*** sp. 7; 29: ***Lagena*** sp. 8 (a) side view (b) apertural view; 30: ***Lagena*** sp. 9 (a) side view (b) apertural view; 31: ***Procerolagena gracilis*** (Willamson); 32&33: ***Pygmaeoseistron hispidula*** (Cushman) Two specimens showing varying degree of hispid texture; 34: ***Pygmaeoseistron*** sp.; 35: ***Guttulina*** sp.

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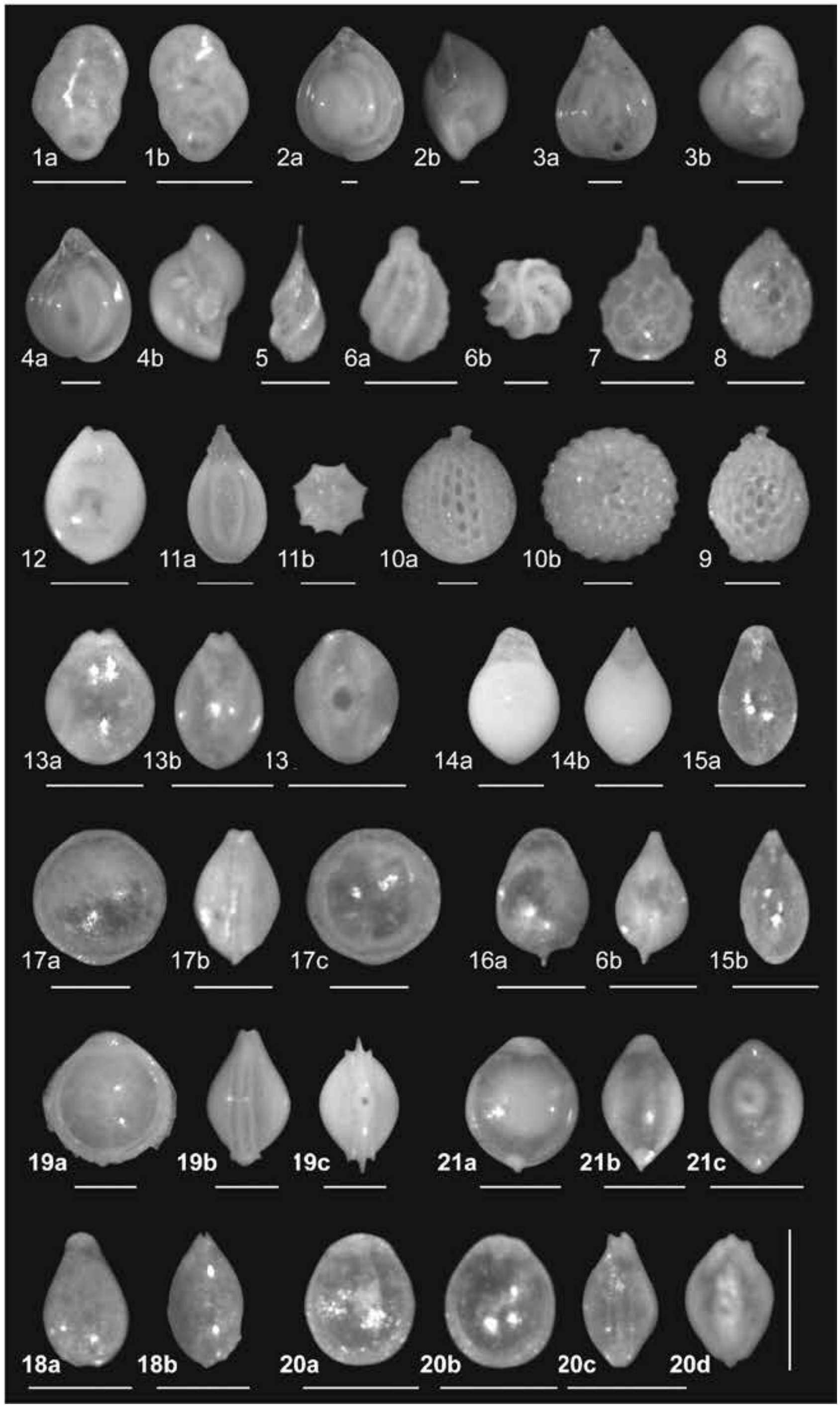
Plate XX



PANCHANG AND NIGAM

EXPLANATION OF PLATE XXI

(Scale bar = 100μm unless otherwise mentioned)

1: ***Krebsina pilasensis*** (McCulloch) (a&b) side views; 2: ***Sigmoidella elegantissima*** (Parker & Jones) (a) side view (b) apertural view; 3: ***Sigmoidella pacifica*** Cushman & Ozawa (a) side view (b) apertural view; 4: ***Sigmoidella pulcherrima*** McCulloch (a) side view (b) apertural view; 5: ***Cushmanina cubensis*** (Palmer & Bermudez); 6: ***Cushmanina tasmaniae*** (Quilty) (a) side view (b) apertural view; 7: ***Favulina hexagona*** (Willamson); 8&9: ***Favulina hexagoniformis*** McCulloch. Two specimens showing variation in shape, size and perfection of surficial ornamentation; 10: ***Favulina squamosa*** (Montagu) (a) side view (b) apertural view; 11: ***Homalohedra guntheri*** (Earland) (a) side view (b) apertural view; 12: ***Oolina globosa*** (Montagu); 13: ***Oolina*** sp. (a) side view (b) lateral view (c) apertural view; 14: ***Fissurina algiersensis*** McCulloch (a) side view (b) lateral view; 15: ***Fissurina*** **cf.** ***collata*** McCulloch (a) side view (b) lateral view; 16: ***Fissurina crassiporosa*** McCulloch (a) side view (b) lateral view; 17: ***Fissurina extera*** McCulloch (a&c) side views (b) apertural view; 18: ***Fissurina globosocaudata*** Albani and Yassini (a) side view (b) lateral view; 19: ***Fissurina imporcata*** McCulloch (a) side view (b) lateral view (c) apertural view; 20: ***Fissurina mediana*** McCulloch (a&b) side views (c) lateral view (d) apertural view; 21: ***Fissurina nudiformis*** McCulloch (a) side view (b) lateral view (c) apertural view.

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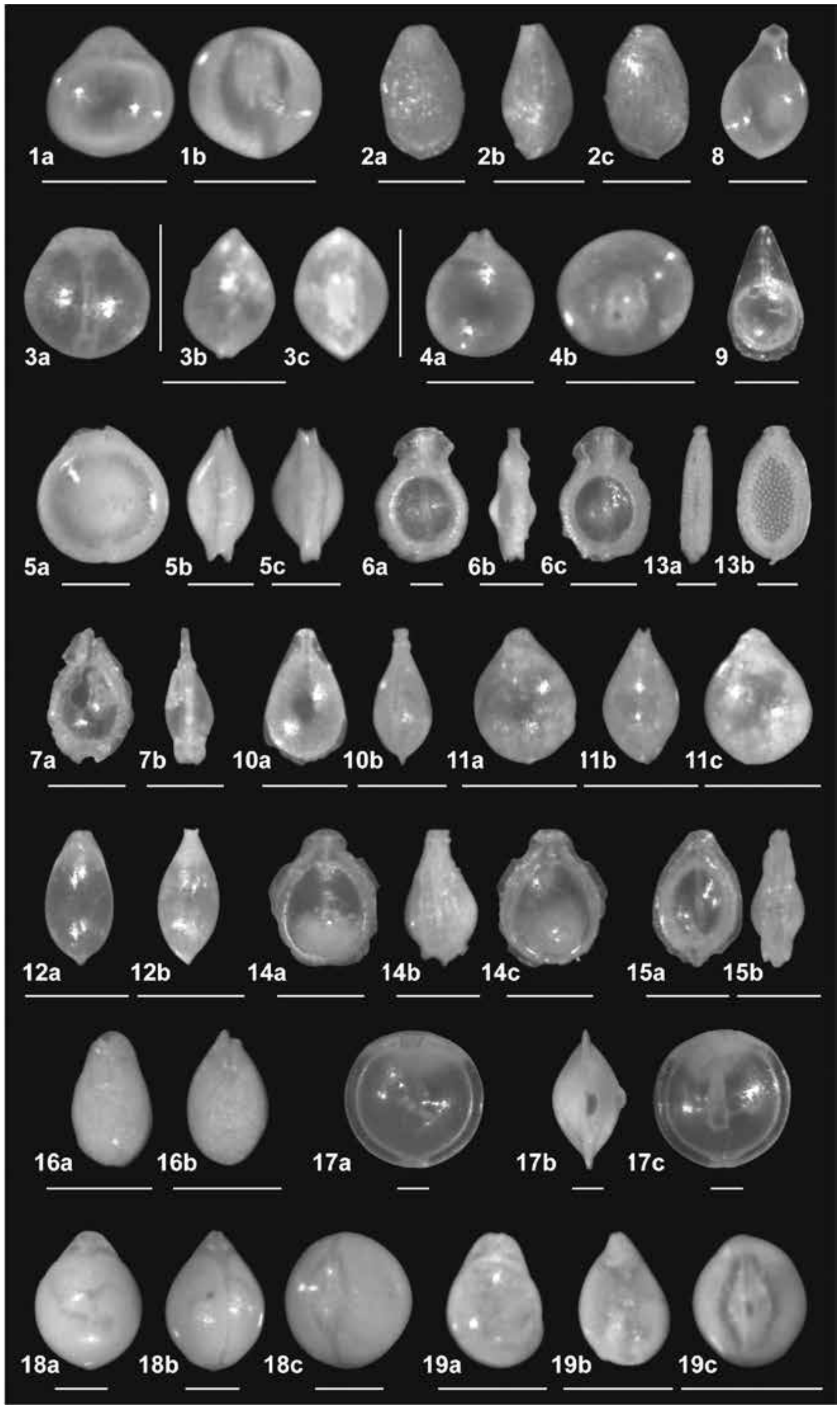
Plate XXI



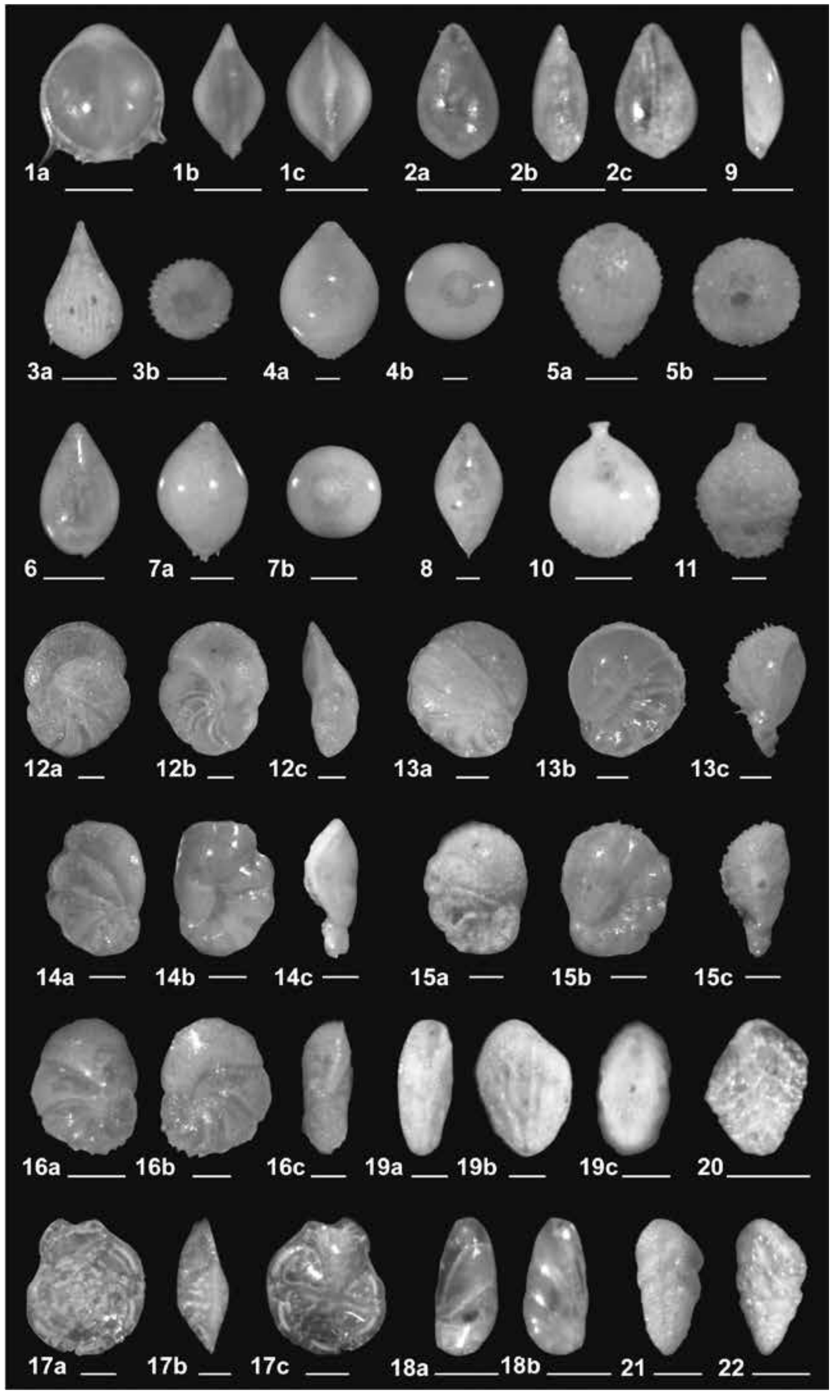
PANCHANG AND NIGAM

EXPLANATION OF PLATE XXI

(Scale bar = 100μm unless otherwise mentioned)

1: ***Fissurina pristina*** McCulloch (a) side view (b) apertural view; 2: ***Fissurina* cf. *southbayensis*** McCulloch (a) ventral view (b) lateral view (c) dorsal view; 3: ***Fissurina tobagoensis*** McCulloch (a) side view (b) lateral view (c) apertural view; 4: ***Fissurina*** sp. 1 (a) lateral view (b) apertural view; 5: ***Fissurina*** sp. 2 (a) side view (b) lateral view (c) apertural view; 6: ***Lagenosolenia*** cf. ***bicarinidiscors*** McCulloch (a&c) side views (b) lateral view; 7: ***Lagenosolenia*** cf. ***discors*** McCulloch (a) side view (b) lateral view; 8: ***Lagenosolenia* aff. *dubiosa*** McCulloch; 9: ***Lagenosolenia eucerviculata*** McCulloch; 10: ***Lagenosolenia inflatiperforata*** McCulloch (a) side view (b) lateral view; 11: ***Lagenosolenia orbiculiperforata*** McCulloch (a&c) side views (b) lateral view; 12: ***Lagenosolenia petila*** McCulloch (a) side view (b) lateral view; 13: ***Lagenosolenia protecta*** McCulloch (a) side view (b) lateral view; 14: ***Palliolatella bradyiformis*** (McCulloch) (a&c) side views (b) lateral view; 15: ***Palliolatella*** sp. (a) side view (b) lateral view; 16: ***Parafissurina*** cf. ***fusuliformis*** Loeblich and Tappan (a) side view (b) lateral view; 17: ***Parafissurina marginata*** (Wiesner) (a&c) side views (b) apertural view; 18: ***Parafissurina neocurta*** McCulloch (a) side view (b) lateral view (c) apertural view; 19: ***Parafissurina obsoleta*** McCulloch (a) side view (b) lateral view (c) apertural view.

Plate XXII



PANCHANG AND NIGAM

EXPLANATION OF PLATE XXII

(Scale bar = 100μm unless otherwise mentioned)

1: ***Parafissurina quadrispinata*** Zheng (a) side view (b) lateral view (c) apertural view; 2: ***Parafissurina tectulostoma*** Loeblich and Tappan (a&c) side views (b) lateral view; 3: ***Bifarilaminella advena*** (Cushman) (a) side view (b) apertural view; 4: ***Euglandulina impolitiformis*** McCulloch (a) side view (b) apertural view; 5: ***Euglandulina inusitata*** McCulloch (a) side view (b) apertural view; 6: ***Euglandulina translucens*** McCulloch; 7: ***Glandulina basispinata*** Cushman (a) side view (b) apertural view; 8: ***Glandulina suezensis*** McCulloch; 9: ***Laryngosigma*** sp.; 10: ***Bombulina spinata*** (Cushman); 11: ***Bombulina*** sp.; 12: ***Lamarckina airensis*** Carter (a) dorsal view (b) lateral view (c) ventral view; 13: ***Lamarckina erinacea*** (Karrer) (a) dorsal view (b) lateral view (c) ventral view; 14: ***Lamarckina*** sp. 1 (a) dorsal view (b) lateral view (c) ventral view; 15: ***Lamarckina*** sp. 2 (a) dorsal view (b) lateral view (c) ventral view; 16: ***Lamarckina*** sp. 3 (a) dorsal view (b) lateral view (c) ventral view; 17: ***Hoeglundina elegans*** (d'Orbigny) (a) dorsal view (b) lateral view (c) ventral view; 18: ***Sidebottomina parviformis*** McCulloch (a&b) side views; 19: ***Bolivina*** cf. ***bicostata*** Cushman (a) side view (b) lateral view (c) apertural view; 20: *Bolivina cincta* Heron-Allen & Earland; 21&22: ***Bolivina compacta*** Sidebottom. Two specimens showing variation in length : breadth ration and surface texture.

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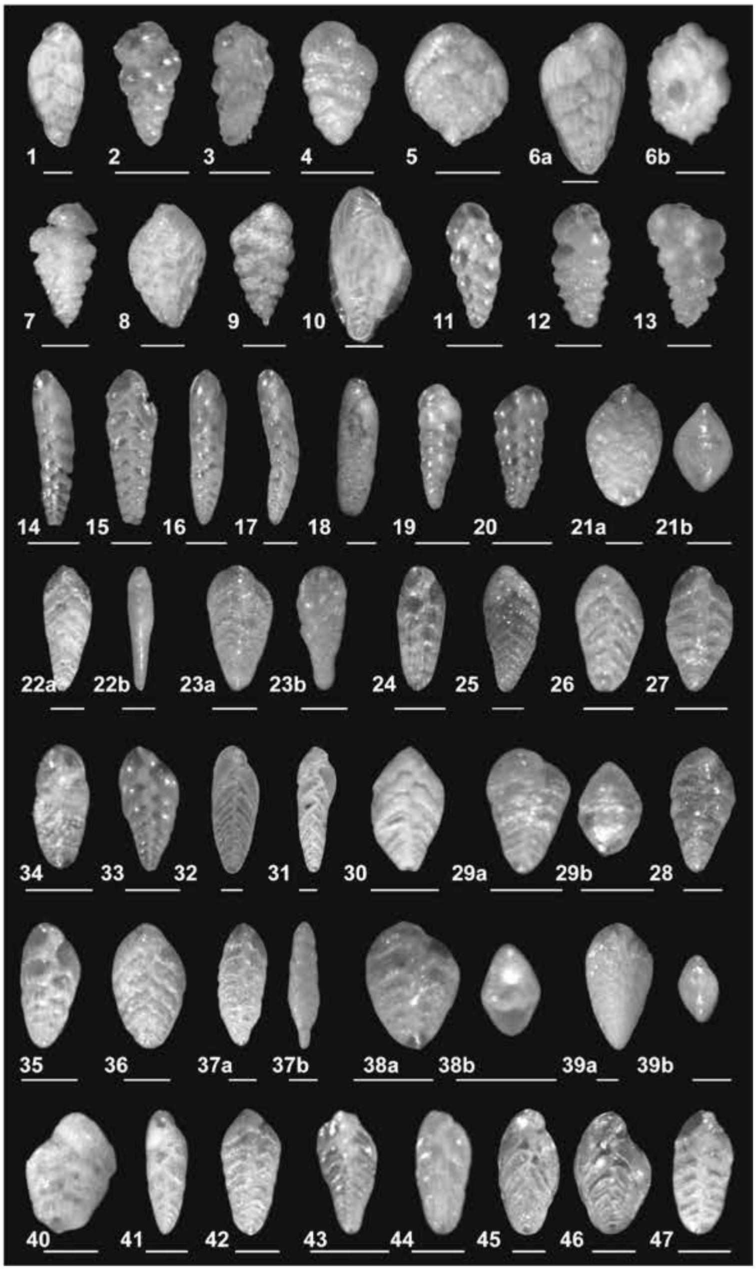
Plate XXIII



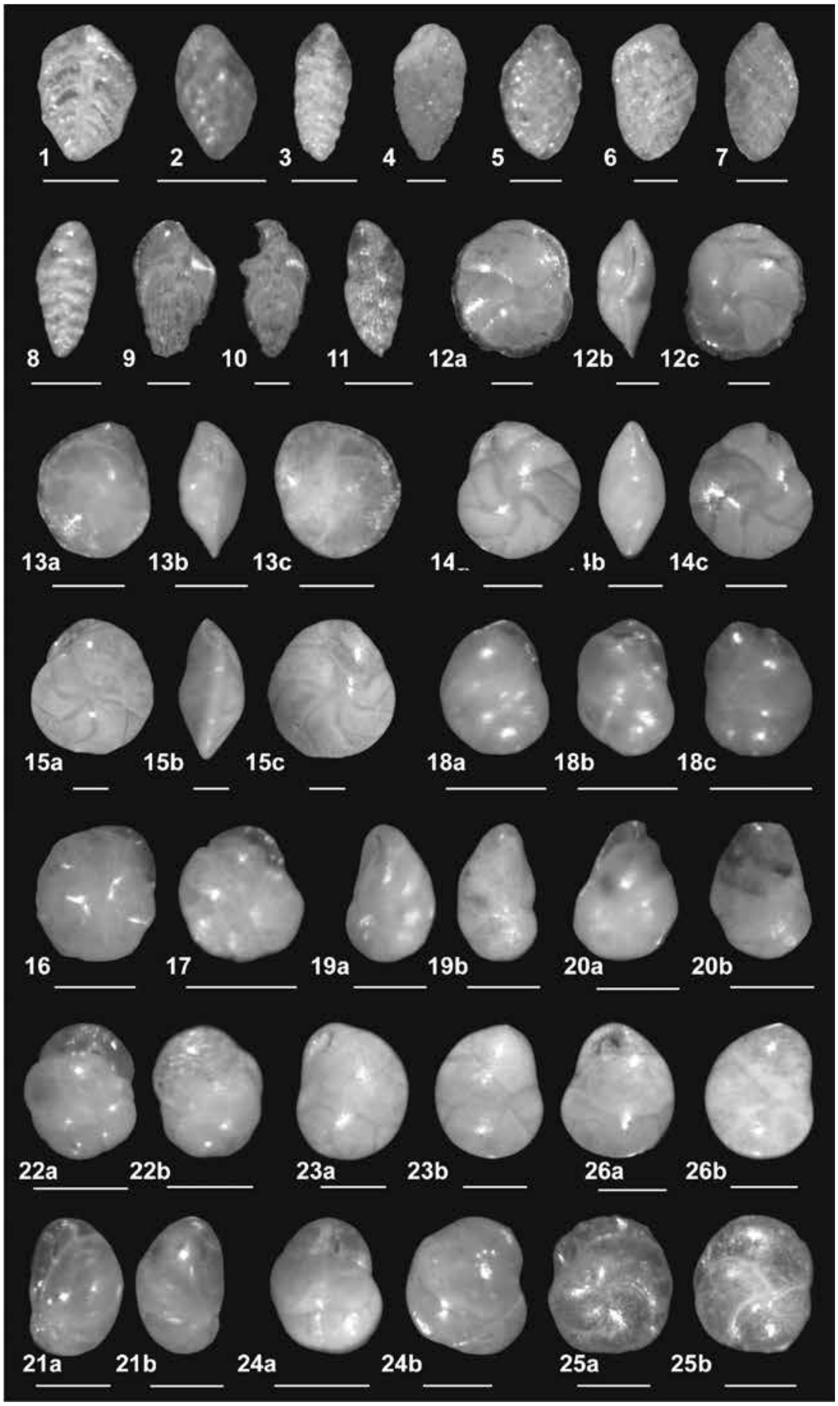
PANCHANG AND NIGAM

EXPLANATION OF PLATE XXIII

(Scale bar = 100µm unless otherwise mentioned)

1: ***Bolivina costata*** d'Orbigny; 2: ***Bolivina globulosa*** Cushman; 3: ***Bolivina hirsuta*** Rhumbler; 4: ***Bolivina mera*** Cushman & Ponton; 5: ***Bolivina obscura*** He Hu Wang; 6: ***Bolivina ogasaensis*** Asano (a) side view (b) apertural view; 7: ***Bolivina pseudolobata*** Yassini & Jones; 8: ***Bolivina pseudoplicata*** Heron-Allen & Earland; 9: ***Bolivina scabrata*** Cushman & Bermudez; 10: ***Bolivina semicostata*** Cushman; 11: ***Bolivina spinescens*** Cushman; 12: ***Bolivina subspinescens*** Cushman; 13: ***Bolivina zanzibarica*** Cushman; 14: ***Bolivinellina earlandi*** (Parr); 15: ***Bolivinellina lucidopunctata*** (Conato); 16: ***Bolivinellina pacifica*** (Cushman & McCulloch); 17: ***Bolivinellina pescicula*** Saidova; 18: ***Bolivinellina seminuda*** (Cushman); 19: ***Bolivinellina silvestrina*** (Cushman); 20: ***Bolivinellina translucens*** (Phleger & Parker); 21: ***Brizalina abbreviata*** (Longinelli) (a) side view (b) apertural view; 22& 23: ***Brizalina catanensis*** (Seguenza) (a) side view (b) lateral view. Two specimens showing variation in length: breadth ratio. Specimen in Fig. 22 is microspheric while that in 23 is megalospheric; 24: ***Brizalina conica*** (Cushman); 25&26: ***Brizalina currai*** (Sellier) Two specimens showing variation in length: breadth ratio. Specimen in Fig 25 is microspheric while that in 26 is megalospheric; 27&28: ***Brizalina dilatata*** (Reuss) Two specimens showing variation in morphology; 29: ***Brizalina dilatata*** subsp. *mekranensis* (Haque) (a) side view (b) apertural view; 30: ***Brizalina goesii*** (Cushman); 31&32: ***Brizalina lanceolata*** (Parker) Two specimens showing variation in length: breadth ratio. Specimen in Fig. 31 is microspheric while that in 32 is megalospheric; 33: ***Brizalina lowmani*** (Phleger & Parker); 34: ***Brizalina makiyamai*** (Ishizaki); 35: ***Brizalina ornata*** (Cushman); 36: ***Brizalina ovata*** (Egger); 37: ***Brizalina papulata*** (Cushman) (a) side view (b) lateral view; 38: ***Brizalina perrini*** (Kleinpell) (a) side view (b) apertural view; 39: ***Brizalina robusta*** (Brady) (a) side view (b) apertural view; 40: ***Brizalina sabiana*** (Smitter); 41: ***Brizalina semiperforata*** (Martin); 42&43: ***Brizalina spathulata*** (Williamson) Two specimens showing variation in morphology; 44: ***Brizalina striatula*** (Cushman); 45&46: ***Brizalina subspathulata*** (Boomgart) Two specimens showing variation in length:breadth ratio; 47: ***Brizalina vadescens*** (Cushman).

Plate XXIV



PANCHANG AND NIGAM

EXPLANATION OF PLATE XXIV

(Scale bar = 100µm unless otherwise mentioned)

1: ***Brizalina*** sp.; 2: ***Latibolivina*** cf. ***anastomosa*** (Finlay); 3&4: ***Latibolivina persiensis*** (Lutze) Two specimens showing variation in length: breadth ratio; 5 to 7: ***Latibolivina subreticulata*** (Parr) Three specimens showing variation in morphology; 8: ***Latibolivina variabilis*** (Williamson); 9&10: ***Lugdunum hantkenianum*** (Brady) Fig. 9 shows an intact specimen while that in Fig. 10 is a broken one; 11: ***Loxostomum salvadorensis*** Smith; 12: ***Cassidulina carinata*** Silvestri (a&c) side views (b) lateral view; 13: ***Cassidulina crista*** Pishanova (a&c) side views (b) lateral view; 14: ***Cassidulina kazusaensis*** Asano & Nakamura (a&c) side views (b) lateral view; 15: ***Cassidulina laevigata*** d'Orbigny (a&c) side views (b) lateral view; 16: ***Cassidulina micae*** (Saidova); 17: ***Cassidulina minuta*** Cushman; 18: ***Cassidulina reniforme*** Norvang (a&c) side views (b) lateral view; 19: ***Evolvocassidulina nana*** McCulloch (a) ventral view (b) dorsal view; 20: ***Evolvocassidulina orientalis*** (Cushman) (a) ventral view (b) dorsal view; 21: ***Evolvocassidulina seranensis*** (Germeraad) (a) ventral view (b) dorsal view; 22: ***Globocassidulina gemma*** (Todd) (a) ventral view (b) dorsal view; 23: ***Globocassidulina oblonga*** (Reuss) (a) ventral view (b) dorsal view; 24: ***Globocassidulina subglobosa*** (Brady) (a) ventral view (b) dorsal view; 25: ***Islandiella cushmani*** (Stewart & Stewart) (a) ventral view (b) dorsal view; 26: ***Islandiella islandica*** (Norvang) (a) ventral view (b) dorsal view.

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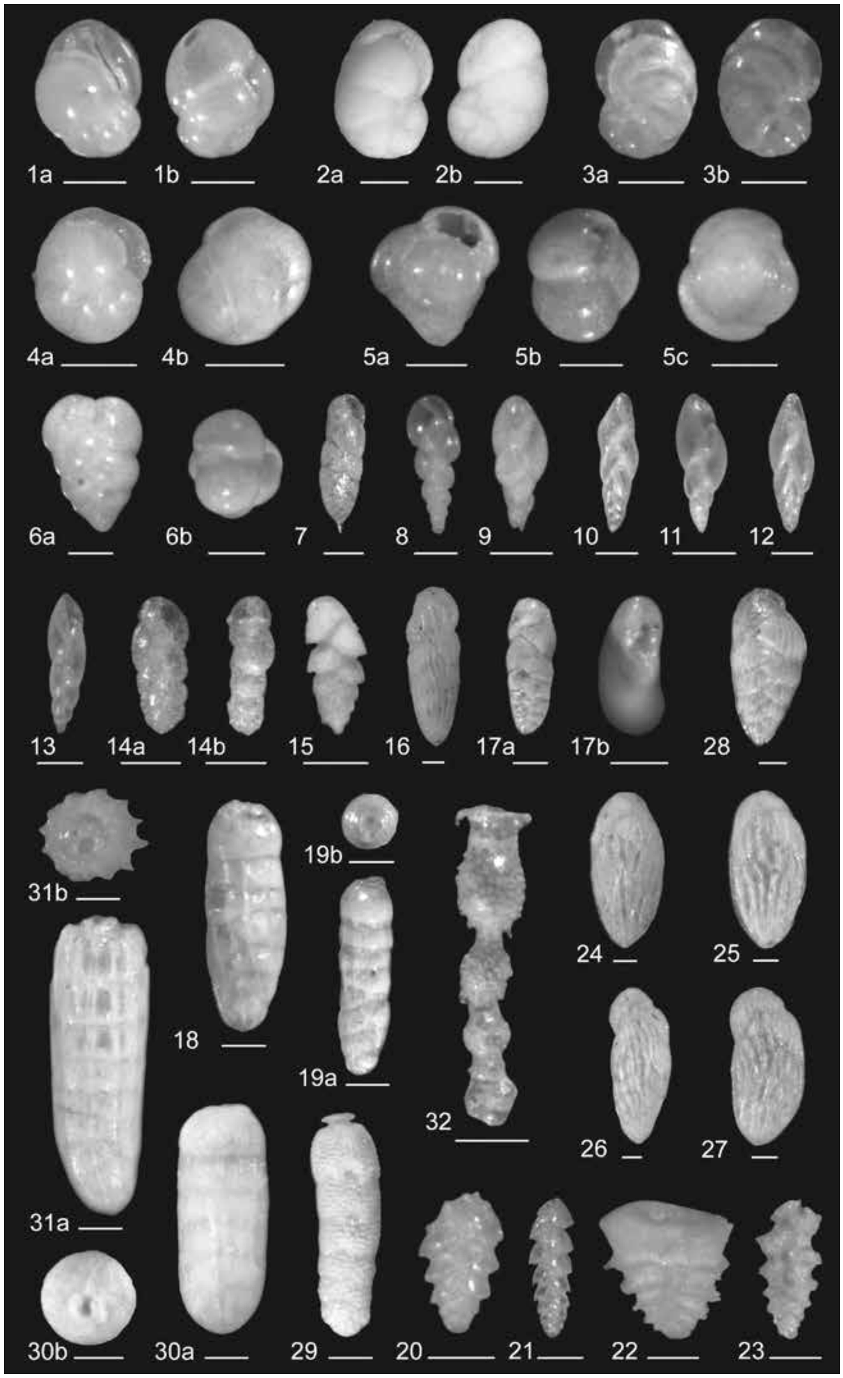
Plate XXV



PANCHANG AND NIGAM

EXPLANATION OF PLATE XXV

(Scale bar = 100μm unless otherwise mentioned)

1: ***Lernella auri*** Saidova (a) ventral view (b) dorsal view; 2: ***Paracassidulina lata*** (McCulloch) (a) ventral view (b) dorsal view; 3: ***Paracassidulina nipponensis*** (Eade) (a) ventral view (b) dorsal view; 4: ***Takayanagia delicata*** (Cushman) (a) ventral view (b) dorsal view; 5: ***Tosaia hanzawai*** Takayanagi (a) side view (b) apertural view (c) distal view; 6: ***Tosaia symmetrica*** McCulloch (a) side view (b) apertural view; 7: ***Cassidellina hadai*** (Uchio); 8: ***Cassidelina nodosa*** (Stewart & Stewart); 9: ***Stainforthia brevis*** McCulloch; 10: ***Stainforthia complanata*** (Egger); 11: ***Stainforthia loeblichi*** (Feyling-Hanssen); 12: ***Stainforthia panayensis*** McCulloch; 13: ***Stainforthia*** sp.; 14: ***Virgulinopsis cubana*** (Bermudez) (a) side view (b) lateral view; 15: ***Euloxostomum durandii*** (Millet); 16: ***Loxostomina mayori*** (Cushman); 17: ***Parabrizalina limbatum*** (Brady) (a) side view (b) apertural view; 18&19: ***Rectobolivina bifrons*** (Brady) (a) side view (b) apertural view. Two specimens showing variation in size and morphology; 20: ***Sagrinella campanulata*** (Egger); 21: ***Sagrinella convallaria*** (Millett); 22: ***Sagrinella guinai*** Saidova; 23: ***Sagrinella lobata*** (Brady); 24 to 27: ***Saidovina amygdalaeformis*** (Brady) Two specimens showing variation in shape, size, morphology and longitudinal costae; 28: ***Saidovina carinatum*** (Millet); 29: ***Siphogenerina pacifica*** Cushman; 30: ***Siphogenerina raphanus*** (Parker & Jones) (a) side view (b) apertural view; 31: ***Siphogenerina transversus*** Cushman 1918 (a) side view (b) apertural view; 32: ***Siphogenerina virgula*** (Brady).

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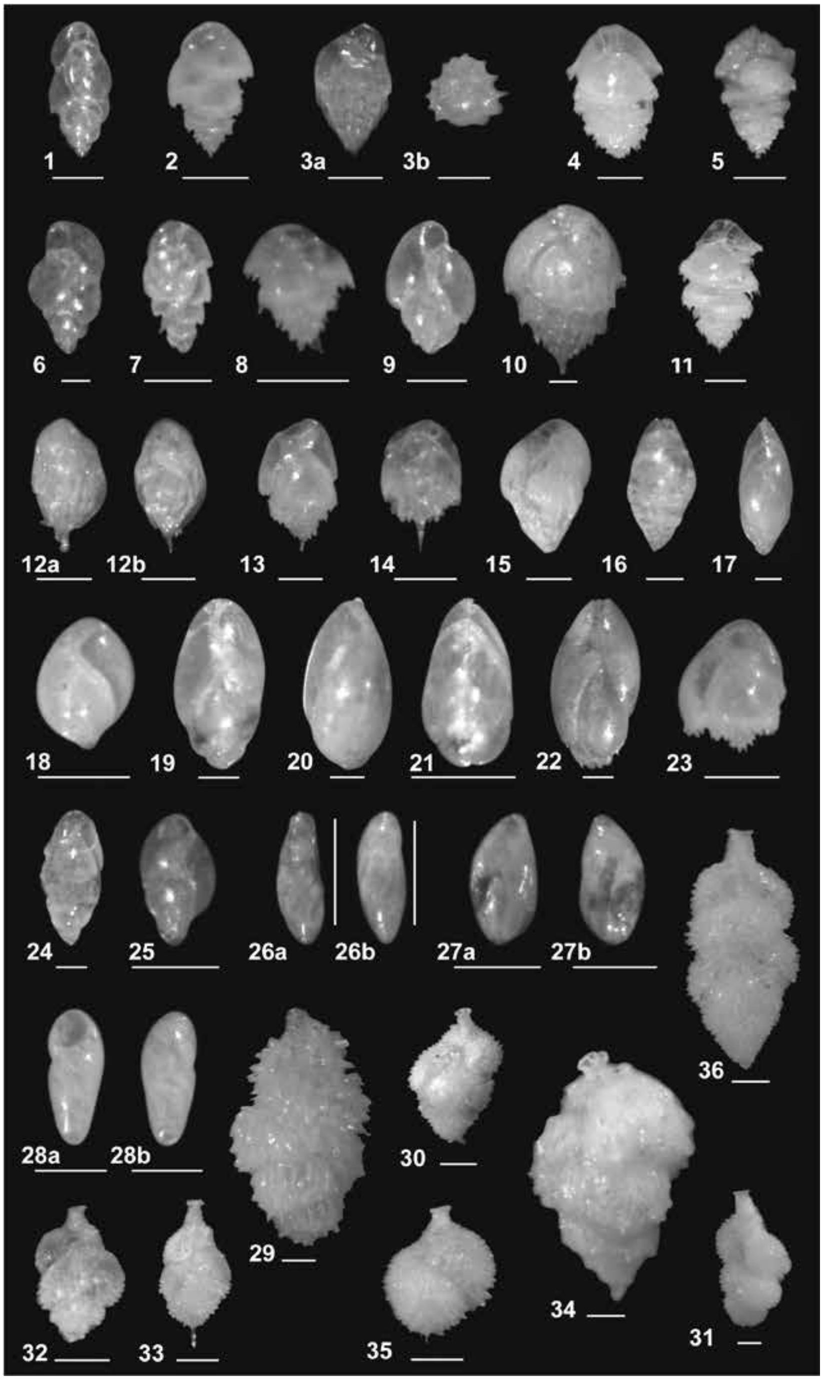
Plate XXVI



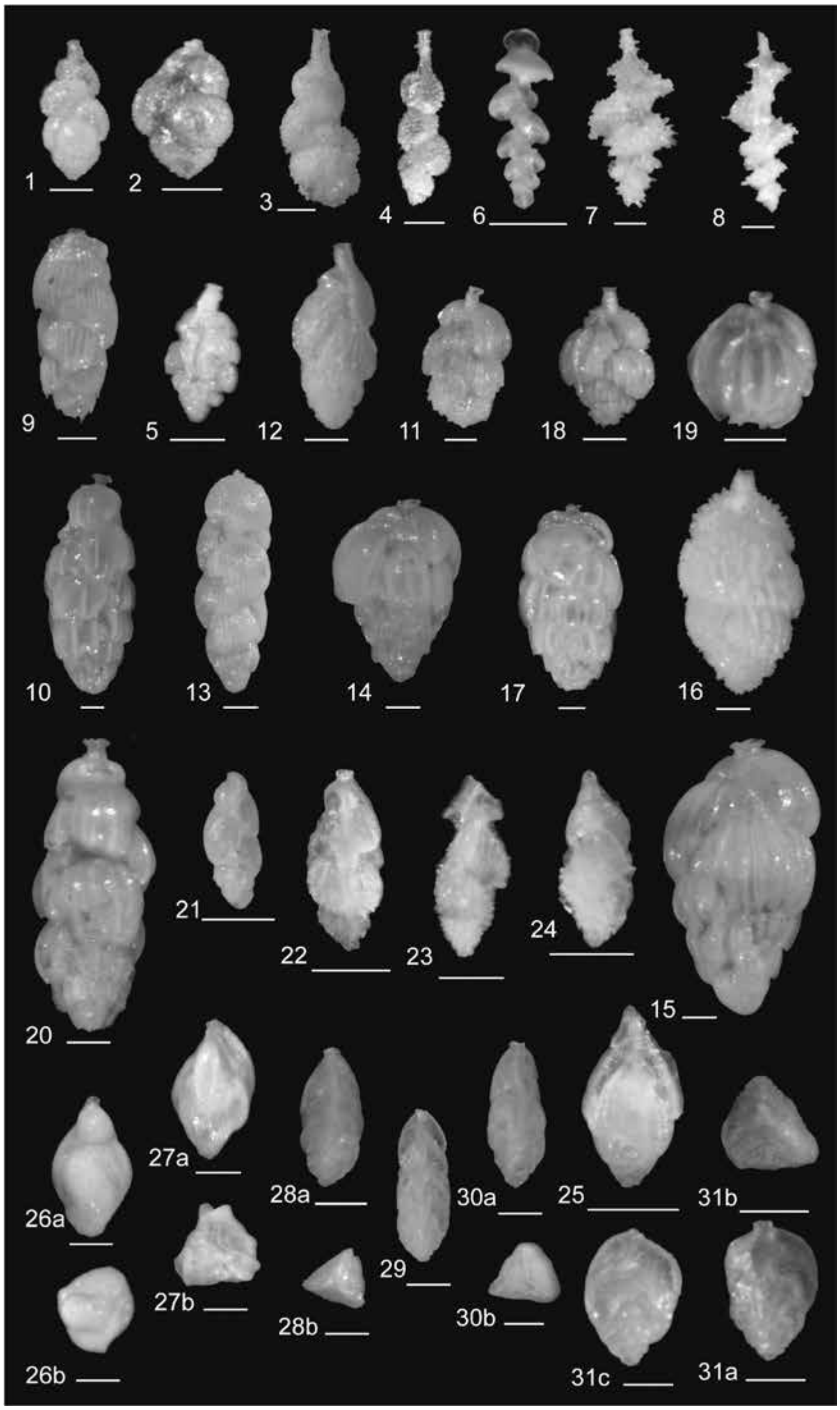
PANCHANG AND NIGAM

EXPLANATION OF PLATE XXVI

(Scale bar = 100μm unless otherwise mentioned)

1: ***Bulimina acanthia*** Costa; 2: ***Bulimina biserialis*** Millet; 3: ***Bulimina delreyensis*** Cushman & Galliher. (a) side view (b) apertural view; 4&5: ***Bulimina denudata*** Cushman & Parker. Two specimens showing variation in length: breadth ratio; 6: ***Bulimina fijiensis*** Cushman; 7&8: ***Bulimina marginata*** d'Orbigny. Two specimens showing variation in morphology; 9: ***Bulimina marginospinata*** Cushman & Parker; 10: ***Bulimina mexicana*** Cushman; 11: ***Bulimina pagoda*** Cushman; 12: ***Bulimina rostratiformis*** McCulloch. (a) lateral view (b) side view; 13&14: ***Bulimina spinosa*** Seguenza. Two specimens showing variation in morphology; 15&16: ***Bulimina subornata*** Brady. Two specimens showing variation in length: breadth ratio; 17: ***Globobulimina auriculata*** (Bailey); 18: ***Globobulimina globosa*** Leroy; 19: ***Globobulimina hoeglundi*** Uchio; 20: ***Globobulimina notovata*** (Chapman); 21: ***Globobulimina pacifica*** Cushman; 22&23: ***Praeglobobulimina* cf. *spinescens*** (Brady) Two specimens showing morphological differences; 24: ***Protoglobobulimina pupoides*** (d'Orbigny); 25: ***Buliminella dubia*** Barbat & Johnson; 26&27: ***Buliminella elegantissima*** (d'Orbigny) (a) ventral view (b) dorsal view. Two specimens showing morphological differences; 28: ***Buliminella* cf. *oceanica*** (Terquem) (a) ventral view (b) dorsal view; 29: ***Euuvigerina aculeata*** (d'Orbigny); 30: ***Euuvigerina asperula*** (Czjzek); 31: ***Euuvigerina attenuata*** (Cushman & Renz); 32&33: ***Euuvigerina auberiana*** (d'Orbigny) Two specimens showing variation in morphology; 34: ***Euuvigerina bradyana*** (Fornasini); 35: ***Euuvigerina globulosa*** (Egger); 36: ***Euuvigerina hispida*** (Schwager).

Plate XXVII



PANCHANG AND NIGAM

EXPLANATION OF PLATE XXVII

(Scale bar = 100µm unless otherwise mentioned)

1&2: ***Euuvigerina proboscidea*** (Schwager) Two specimens showing variation in morphology; 3: ***Neouvigerina ampullacea*** (Brady); 4: ***Neouvigerina interrupta*** (Brady); 5: ***Neouvigerina porrecta*** (Brady); 6 to 8: ***Siphouvigerina fimbriata*** (Sidebottom). Three specimens showing difference in shape of chambers, surface texture and chamber arrangement; 9: ***Uvigerina aculeata*** Hosius; 10: ***Uvigerina akitaensis*** Asano; 11: ***Uvigerina brevis*** Cita; 12: ***Uvigerina flintii*** Cushman; 13: ***Uvigerina hollicki*** Thalmann; 14: ***Uvigerina* aff. *mediterranea*** Hofker; 15: ***Uvigerina multicostata*** Leroy; 16: ***Uvigerina parvula*** Cushman & Thomas; 17: ***Uvigerina peregrina*** Cushman; 18: ***Uvigerina pygmea*** d'Orbigny; 19: ***Uvigerina rutila*** Cushman & Todd; 20: ***Uvigerina yabei*** Asano; 21: ***Uvigerinella*** cf. ***glabra*** (Millet); 22: ***Angulogerina angulosa*** (Williamson); 23&24: ***Angulogerina bella*** Phleger & Parker. Two specimens showing variation in degree of globulation; 25: ***Angulogerina carinata*** Cushman; 26: ***Angulogerina*** cf. ***fornasinii*** Selli (a) side view (b) apertural view; 27: ***Angulogerina picta*** Todd (a) side view (b) apertural view; 28: ***Trifarina advena*** Cushman (a) side view (b) apertural view; 29&30: ***Trifarina bradyi*** Cushman (a) side view (b) apertural view. Two specimens showing variation in morphology; 31: ***Trifarina californica*** Mallory (a) side view (b) lateral view (c) apertural view.

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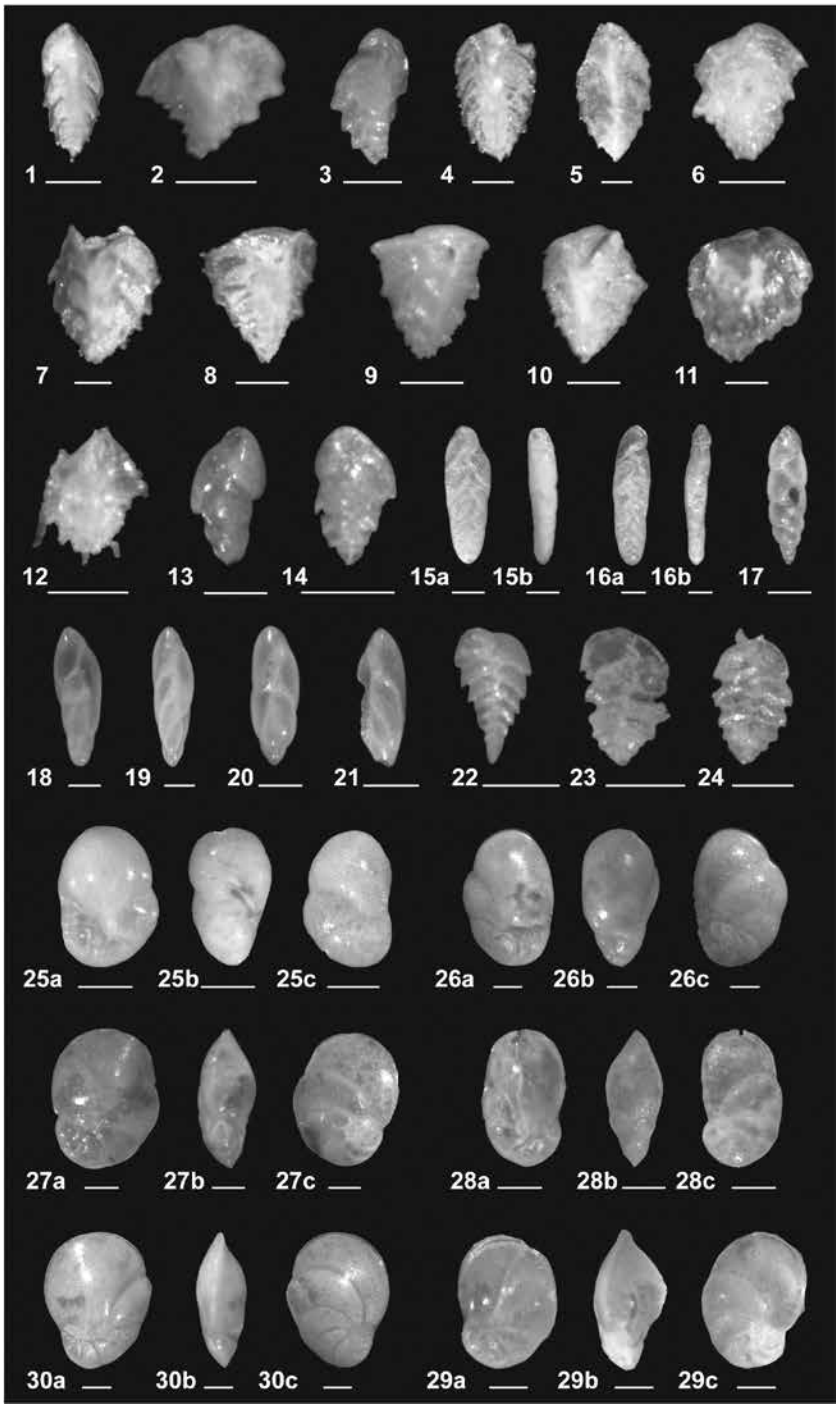
Plate XXVIII



PANCHANG AND NIGAM

EXPLANATION OF PLATE XXVIII

(Scale bar = 100μm unless otherwise mentioned)

1: ***Reussella aequa*** Cushman & McCulloch; 2: ***Reussella aguayoi*** Bermudez; 3: ***Reussella checchia-rispolii*** Kicinski; 4: ***Reussella lavelaensis*** McCulloch; 5: ***Reussella mortenseni*** Hofker; 6: ***Reussella neapolitana*** Hofker; 7: ***Reussella pulchra*** Cushman; 8&9: ***Reussella spinulosa*** (Reuss) Two specimens showing variation in morphological changes and spinosity; 10: ***Reussella*** cf. ***weberi*** Hofker; 11: ***Reussella*** sp.; 12: ***Trimosina milletti*** Cushman subsp. *multispinata* Collins; 13: ***Trimosina orientalis*** Cushman; 14: ***Trimosina*** sp.; 15: ***Coryphostoma laevigatum*** (Karrer) (a) side view (b) lateral view; 16: ***Coryphostoma sinuosum*** (Cushman) (a) side view (b) lateral view; 17: ***Fursenkoina exilis*** (Loeblich & Tappan); 18 to 20: ***Fursenkoina pauciloculata*** (Brady) Three specimens showing variation in morphology; 21: ***Fursenkoina pontoni*** (Cushman); 22&23: ***Suggrunda alata*** (Seguenza) Two specimens showing variation in length: breadth ratio and degree of preservation; 24: ***Suggrunda pygmaea*** (Brady); 25: ***Baggina bubnanensis*** McCulloch (a) ventral view (b) lateral view (c) dorsal view; 26: ***Baggina indica*** (Cushman) (a) ventral view (b) lateral view (c) dorsal view; 27: ***Cancris auriculus*** (Fichtel & Moll) (a) ventral view (b) lateral view (c) dorsal view; 28&29: ***Cancris carinata*** (Millet) (a) ventral view (b) lateral view (c) dorsal view. Fig. 28 shows specimen with a distinct keel running down its apertural face; 30: ***Cancris communis*** Cushman & Todd (a) ventral view (b) lateral view (c) dorsal view.

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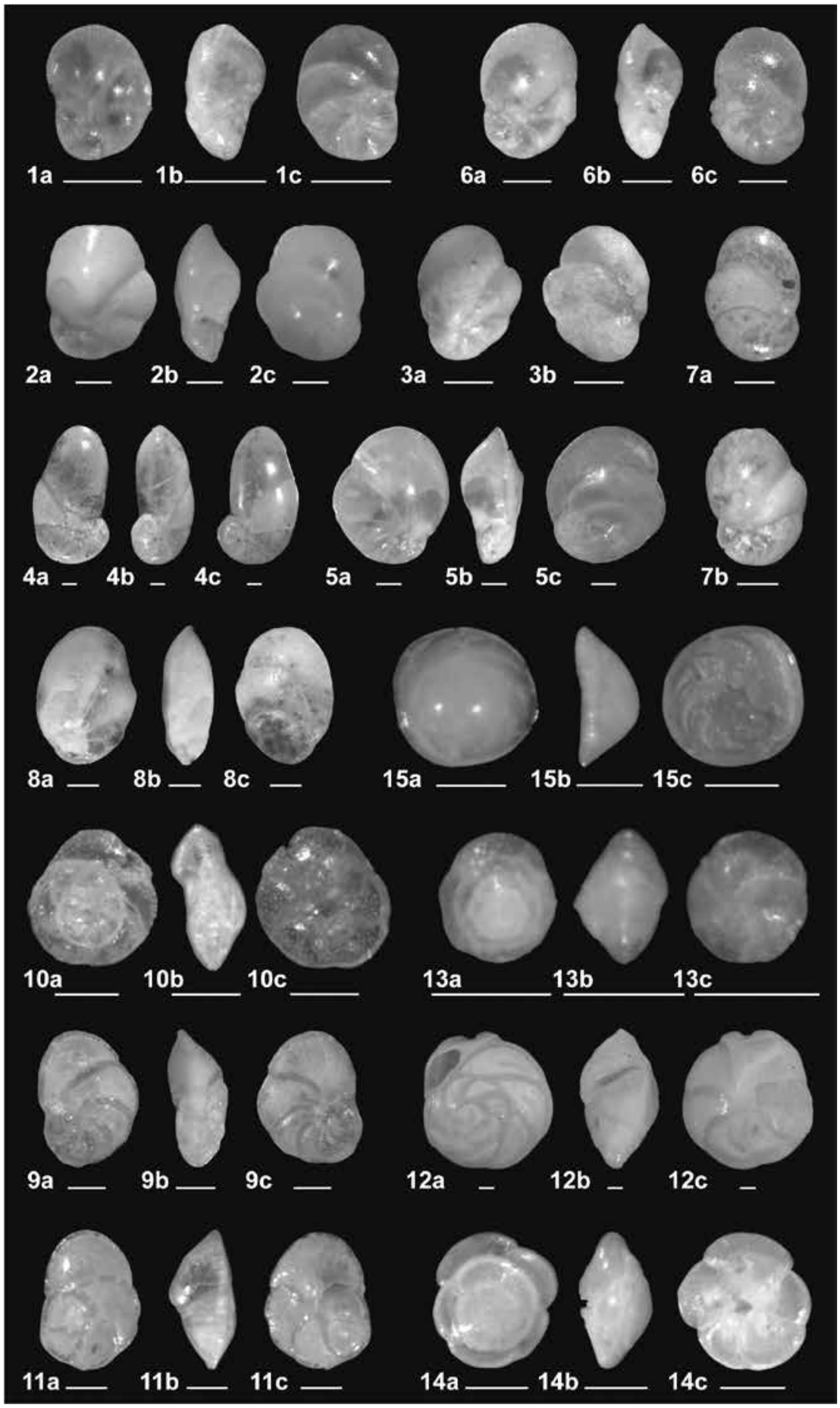
Plate XXIX



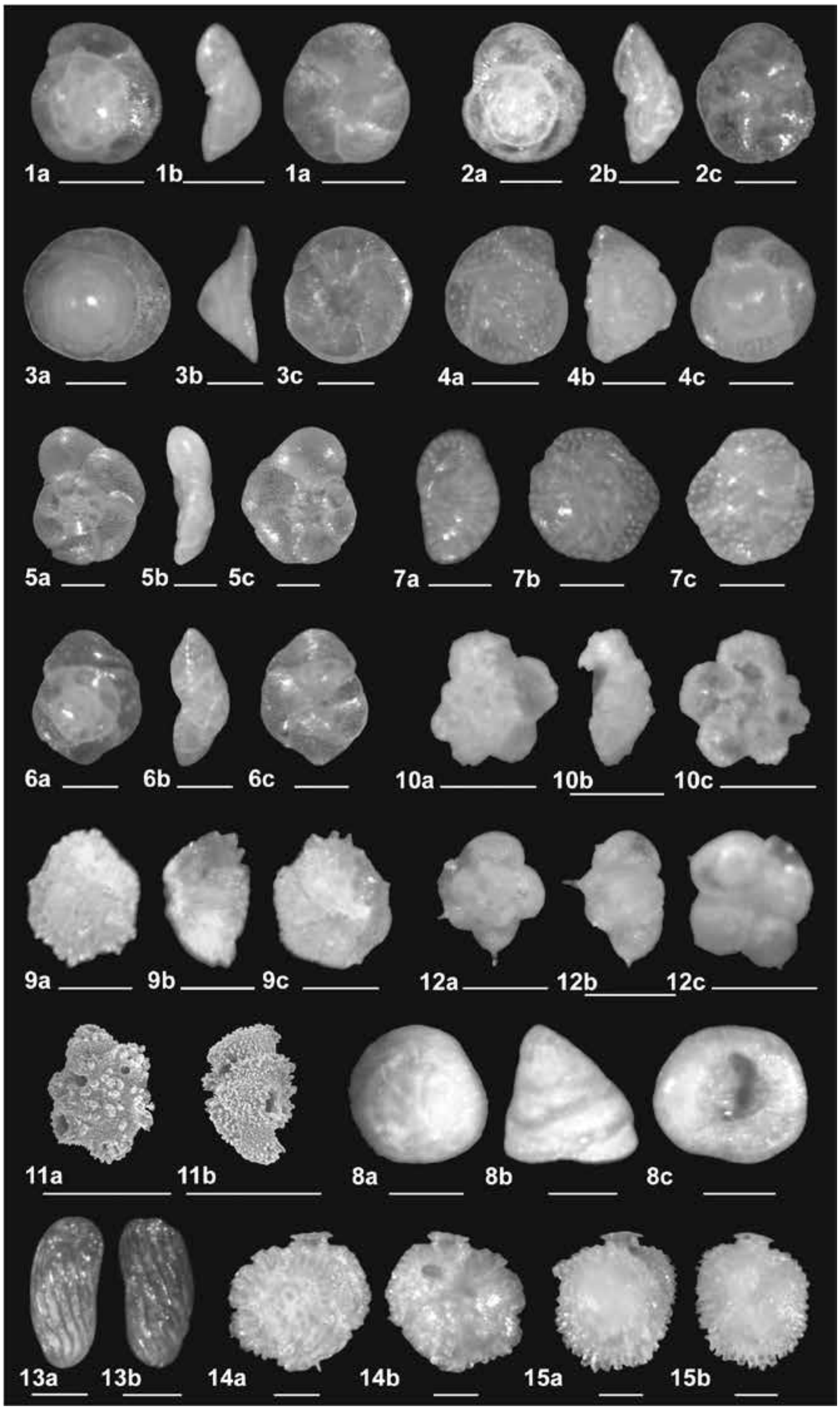
PANCHANG AND NIGAM

EXPLANATION OF PLATE XXIX

(Scale bar = 100μm unless otherwise mentioned)

1: ***Cancris differens*** McCulloch (a) ventral view (b) lateral view (c) dorsal view; 2&3: ***Cancris morrisae*** McCulloch (a) ventral view (b) lateral view (c) dorsal view. Two specimens showing variation in morphology; 4: ***Cancris oblongus*** (Williamson) (a) ventral view (b) lateral view (c) dorsal view; 5: ***Cancris panayensis*** McCulloch (a) ventral view (b) lateral view (c) dorsal view;6&7: ***Cancris penangensis*** McCulloch (a) ventral view (b) lateral view (c) dorsal view. Two specimens showing variation in degree of maturity; 8: ***Cancris sagra*** (d'Orbigny) (a) ventral view (b) lateral view (c) dorsal view; 9: ***Cibicorbis*** cf. ***herricki*** Hadley (a) ventral view (b) lateral view (c) dorsal view; 10: ***Donsissonia*** sp. (a) dorsal view (b) lateral view (c) ventral view; 11: ***Eponides cribrorepandus*** (Asano & Uchio) (a) dorsal view (b) lateral view (c) ventral view; 12: ***Eponides repandus*** (Fichtel & Moll) (a) dorsal view (b) lateral view (c) ventral view; 13: ***Neoeponides schreibersii*** (d'Orbigny) (a) dorsal view (b) lateral view (c) ventral view; 14: ***Strebloides advenus*** (Cushman) (a) dorsal view (b) lateral view (c) ventral view; 15: ***Trochulina malovensis*** (Heron-Allen & Earland) (a) dorsal view (b) lateral view (c) ventral view.

Plate XXX



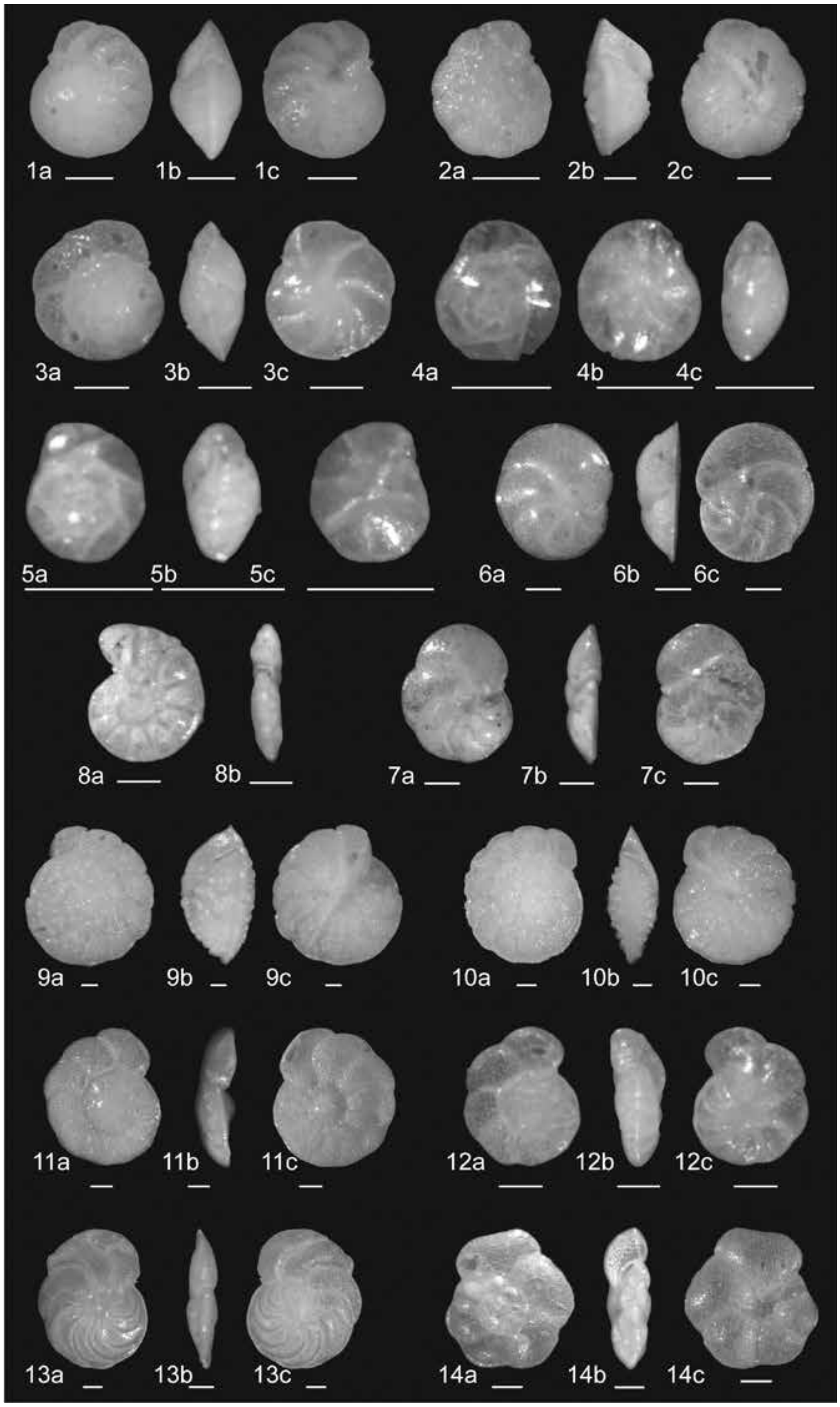
PANCHANG AND NIGAM

EXPLANATION OF PLATE XXX

(Scale bar = 100m unless otherwise mentioned)

1: ***Gavelinopsis hamatus*** Vella (a) dorsal view (b) lateral view (c) ventral view; 2: ***Gavelinopsis praegeri*** (Heron-Allen & Earland) (a) dorsal view (b) lateral view (c) ventral view; 3: ***Planodiscorbis circularis*** (Sidebottom) (a) ventral view (b) lateral view (c) dorsal view; 4: ***Planodiscorbis*** sp. (a) ventral view (b) lateral view (c) dorsal view; 5: ***Rosalina bradyi*** Cushman (a) dorsal view (b) lateral view (c) ventral view; 6: ***Rosalina irregularis*** (Rhumbler) (a) dorsal view (b) lateral view (c) ventral view; 7: ***Rotorboides granulosus*** (Heron-Allen & Earland) (a) dorsal view (b) lateral view (c) ventral view; 8: ***Glabratellina tabernacularis*** (Brady) (a) dorsal view (b) lateral view (c) ventral view; 9: ***Murrayinella murrayi*** (Heron-Allen & Earland) (a) dorsal view (b) lateral view (c) ventral view; 10: ***Murrayinella nicaraguaensis*** (McCulloch) a. dorsal view; b. lateral view; c. ventral view; 11: ***Murrayinella soccoroensis*** (McCulloch) (a) dorsal view (b) lateral view (c) ventral view; 12: ***Schackoinella sarmatica*** Weinhandl (a) dorsal view (b) lateral view (c) ventral view; 13: *Buliminoides williamsonianus* (Brady) (a) ventral view (b) dorsal view; 14&15: ***Siphonina tubulosa*** Cushman (a) dorsal view (b) ventral view. Two specimens showing variation in surface ornamentation.

Plate XXXI



PANCHANG AND NIGAM

EXPLANATION OF PLATE XXXI

(Scale bar = 100μm unless otherwise mentioned)

1: ***Cibicidoides*** cf. ***arubiana*** McCulloch (a) ventral view (b) lateral view (c) dorsal view; 2: ***Cibicidoides*** cf. ***goodhilli*** McCulloch (a) ventral view (b) lateral view (c) dorsal view; 3: ***Cibicidoides simplex*** McCulloch (a) ventral view (b) lateral view (c) dorsal view; 4: ***Epistominella exigua*** (Brady) (a) ventral view (b) lateral view (c) dorsal view; 5: ***Epistominella pulchella*** Husezima & Maruhasi (a) ventral view (b) lateral view (c) dorsal view; 6: ***Discorbinella bertheloti*** (d'Orbigny) (a) dorsal view (b) lateral view (c) ventral view; 7: ***Discorbinella complanata*** Sidebottom (a) dorsal view (b). lateral view (c) ventral view; 8: ***Hyalinea balthica*** (Schroeter) (a) side view (b) lateral view; 9&10: ***Cibicides margaritiferus*** (Brady) (a) ventral view (b) lateral view (c) dorsal view. Fig. 9 shows a high trocho-spiral specimen whereas Fig. 10 shows a low trocho-spiral specimen; 11: ***Cibicides patalaensis*** Haque (a) ventral view (b) lateral view (c) dorsal view; 12: ***Cibicides pokuticus*** Afzenshtat (a) ventral view (b) lateral view (c) dorsal view; 13: ***Fontbotia wuellerstorfi*** (Schwager) (a) ventral view (b) lateral view (c) dorsal view; 14: ***Montfortella*** sp. (a) dorsal view (b) lateral view (c) ventral view.

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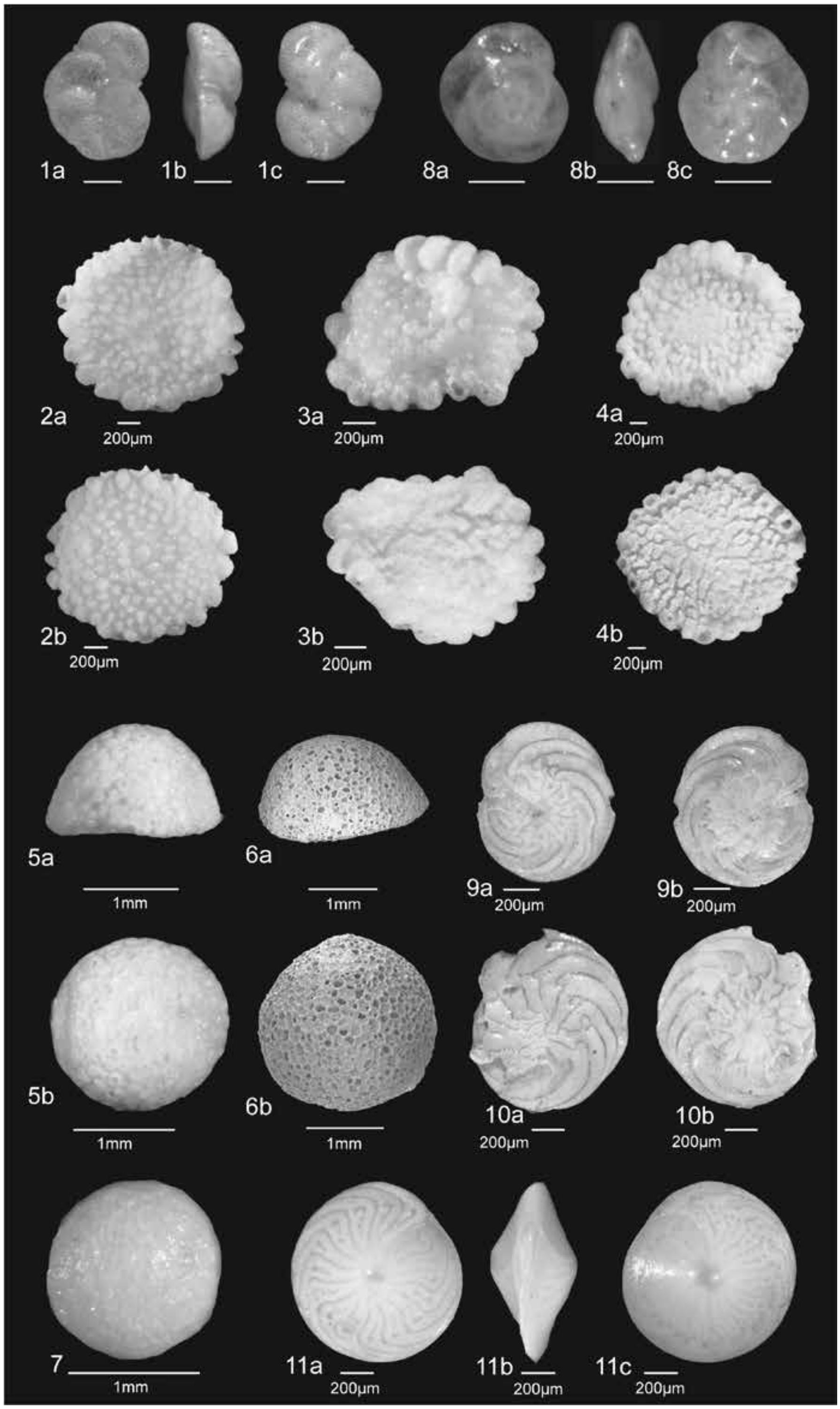
Plate XXXII



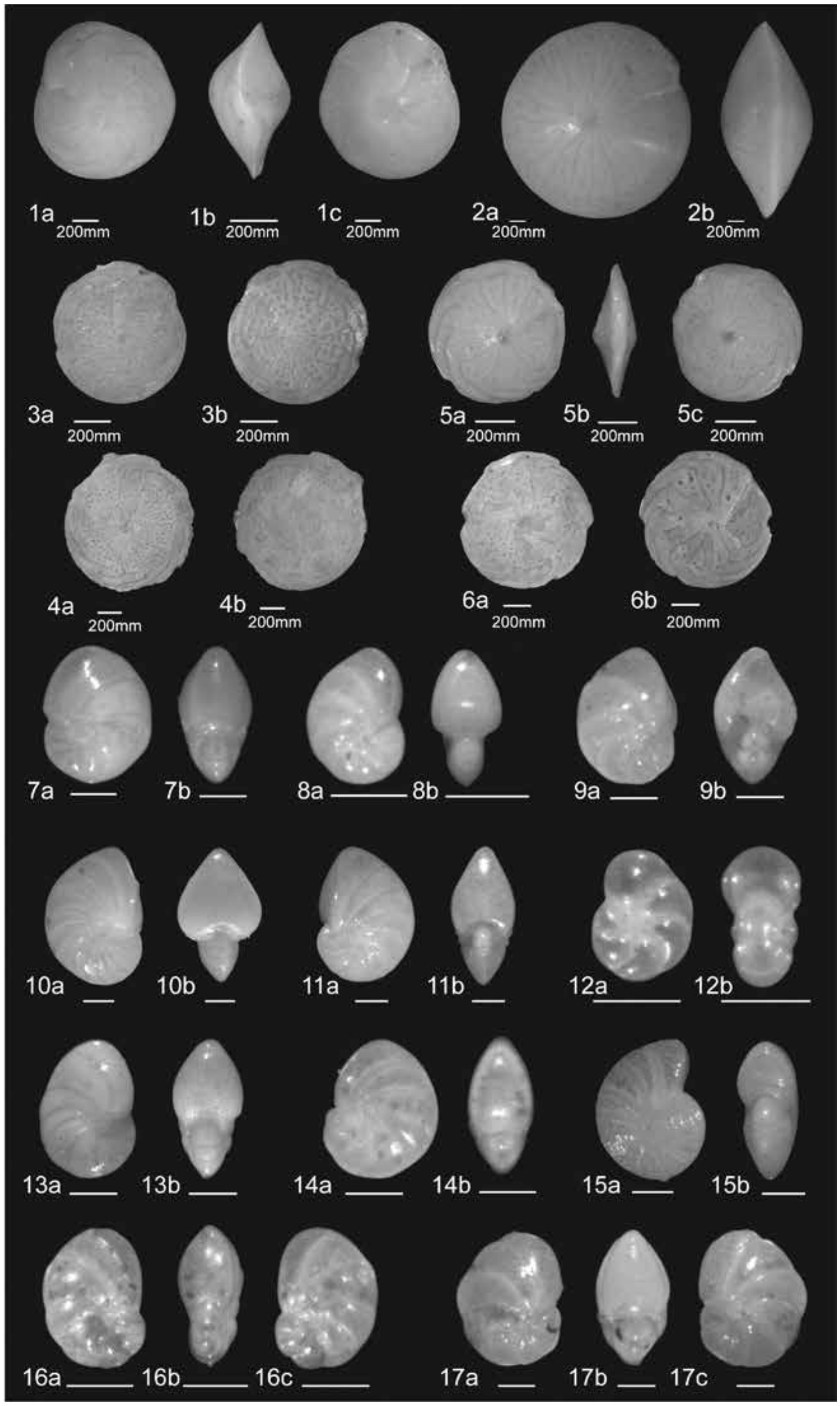
PANCHANG AND NIGAM

EXPLANATION OF PLATE XXXII

(Scale bar = 100µm unless otherwise mentioned)

1: ***Caribeanella katasensis*** (Ujiie) (a) dorsal view (b) lateral view (c) ventral view; 2: ***Planorbulina acervalis*** Brady (Scale bar = 200µm) (a) ventral view (b) dorsal view; 3: ***Planorbulina mediterranensis*** d'Orbigny (Scale bar = 200µm) (a) ventral view (b) dorsal view; 4: ***Planorbulinella larvata*** (Parker & Jones) (Scale bar = 200µm) (a) ventral view (b) dorsal view; 5&6: ***Gypsina vesicularis*** (Parker & Jones*)* (Scale bar = 1mm) (a) side view (b) top view. Fig. 6 SEM image showing surface texture; 7: ***Sphaerogypsina globulus*** (Reuss) (Scale bar = 1mm) side view; 8: ***Pseudoeponides japonicum*** Uchio (a) dorsal view (b) lateral view (c) ventral view; 9&10: ***Amphistegina bicirculata*** Larsen (Scale bar = 200µm) (a) ventral view (b) dorsal view. Two specimens showing variation in size, maturity and degree of preservation; 11: ***Amphistegina gibbosa*** d'Orbigny (Scale bar = 200µm) (a) ventral view (b) lateral view (c) dorsal view.

Plate XXXIII



PANCHANG AND NIGAM

EXPLANATION OF PLATE XXXIII

(Scale bar = 100μm unless otherwise mentioned)

1: ***Amphistegina lessoni*** d'Orbigny (Scale bar = 200μm) (a) ventral view (b) lateral view (c) dorsal view; 2: ***Amphistegina lobifera*** Larsen (Scale bar = 200μm) (a) ventral view (b) lateral view; 3&4: ***Amphistegina papillosa*** Said (Scale bar = 200μm) (a) ventral view (b) dorsal view. Two specimens showing variation in size and degree of preservation; 5&6: ***Amphistegina radiata*** (Fichtel & Moll) (Scale bar = 200μm) (5a) ventral view (5b) lateral view (5c) dorsal view (6a) ventral view (6b) dorsal view. Two specimens showing variation in size and degree of preservation; 7: ***Nonion asterizans*** (Fichtel & Moll) (a) side view (b) apertural view; 8: ***Nonion basispinata*** Cushman & Moyer (a) side view (b) apertural view; 9: ***Nonion chincaense*** (McCulloch) (a) side view (b) apertural view; 10: ***Nonion costiferum*** (Cushman) (a) side view (b) apertural view; 11: ***Nonion fabum*** (Fichtel & Moll) (a) side view (b) apertural view; 12: ***Nonion laevigatum*** (d'Orbigny) (a) side view (b) apertural view; 13: ***Nonion scaphum*** (Fichtel & Moll) (a) side view (b) apertural view; 14: ***Nonion sloanii*** (d'Orbigny) (a) side view (b) apertural view; 15: ***Nonion subcarinata*** (Seguenza) (a) side view (b) apertural view; 16: ***Nonionella auricula*** Heron-Allen & Earland (a&c) side views (b) apertural view; 17: ***Nonionella auris*** (d'Orbigny) (a&c) side views (b) apertural view.

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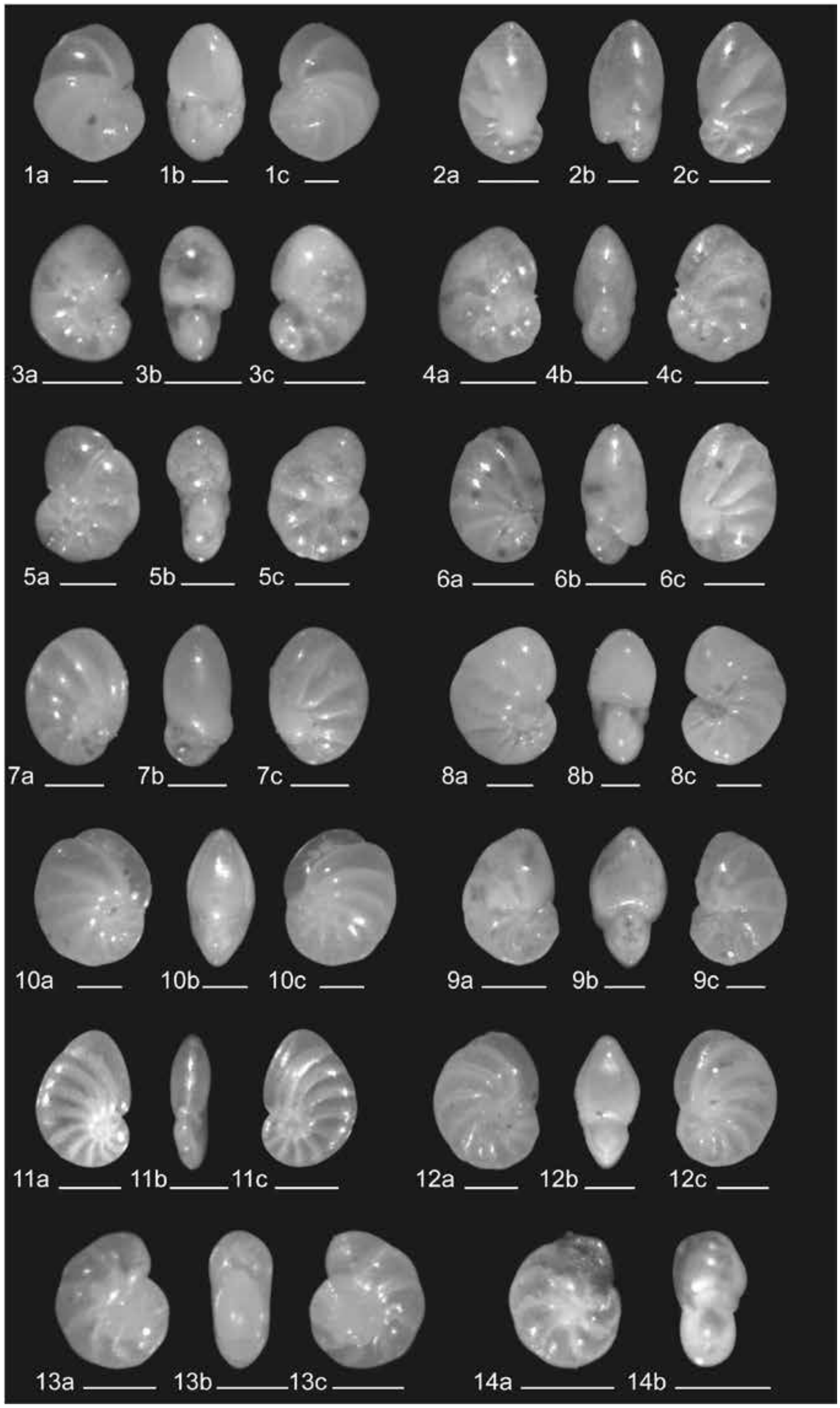
Plate XXXIV



PANCHANG AND NIGAM

EXPLANATION OF PLATE XXXIV

(Scale bar = 100μm unless otherwise mentioned)

1: ***Nonionella auris*** (d'Orbigny) (a&c) side views (b) apertural view; 2: ***Nonionella basiloba*** Cushman & McCulloch (a&c) side views (b) apertural view; 3: ***Nonionella bradyi*** (Chapman) (a&c) side views (b) apertural view; 4: ***Nonionella limbato-striata*** Cushman (a&c) side views (b) apertural view; 5: ***Nonionella mioceanica*** Cushman (a&c) side views (b) apertural view; 6: ***Nonionella monicana*** Zalesny (a&c) side views (b) apertural view; 7: ***Nonionella stella*** Cushman & Moyer (a&c) side views (b) apertural view; 8&9: ***Nonionellina labradorica*** (Dawson) (a&c) side views (b) apertural view. Two specimens showing different stages of maturity; 10: ***Nonionoides boueanum*** (d'Orbigny) (a&c) side views (b) apertural view; 11: ***Nonionoides grateloupi*** (d'Orbigny) (a&c) side views (b) apertural view; 12: ***Pseudononion japonicum*** Asano (a) dorsal view (b) apertural view (c) ventral view; 13: ***Fijinonion fijiense*** (Cushman & Edwards) (a&c) side views (b) apertural view; 14: ***Pacinonion novozealandicum*** (Cushman & Edwards) (a) side view (b) apertural view.

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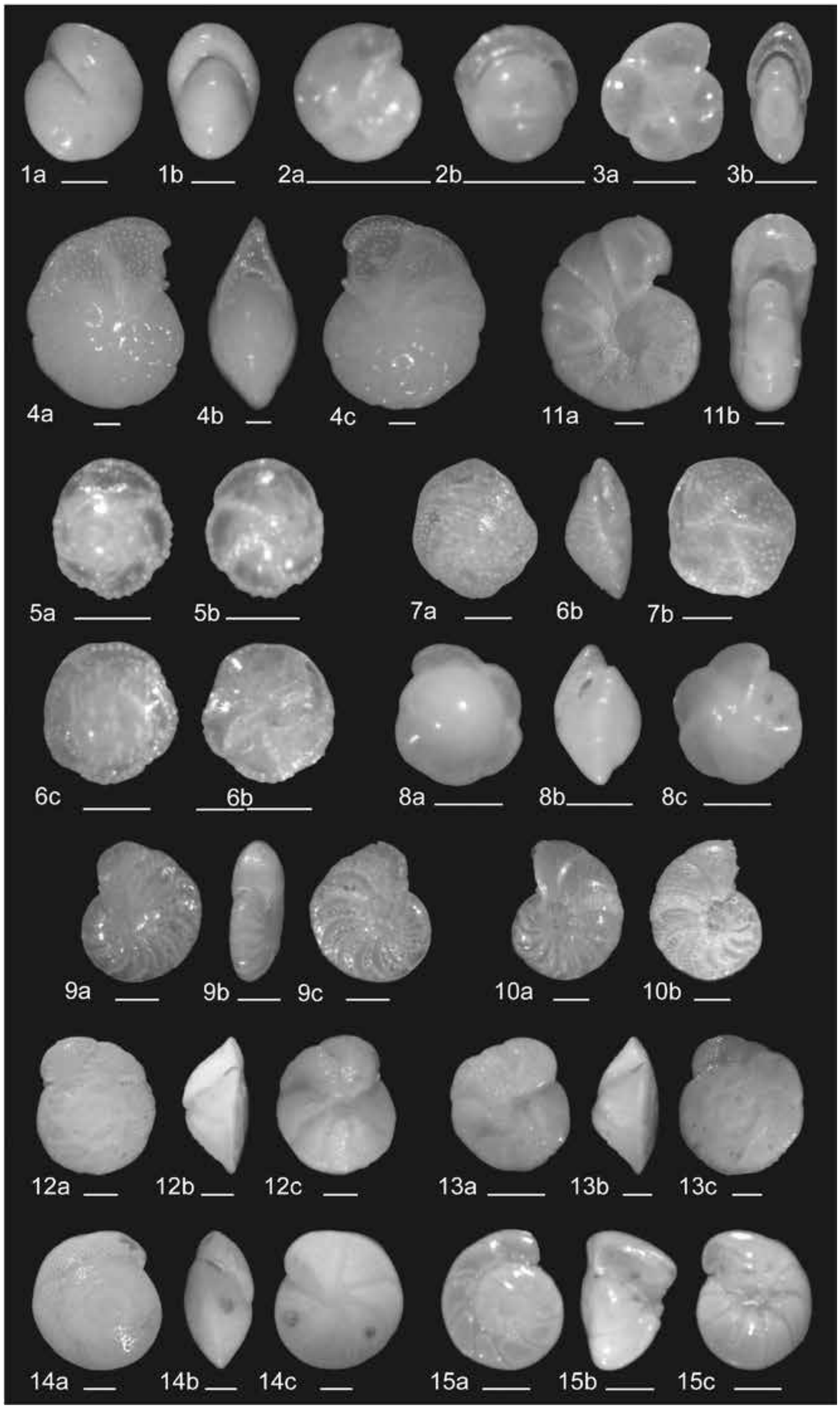
Plate XXXV



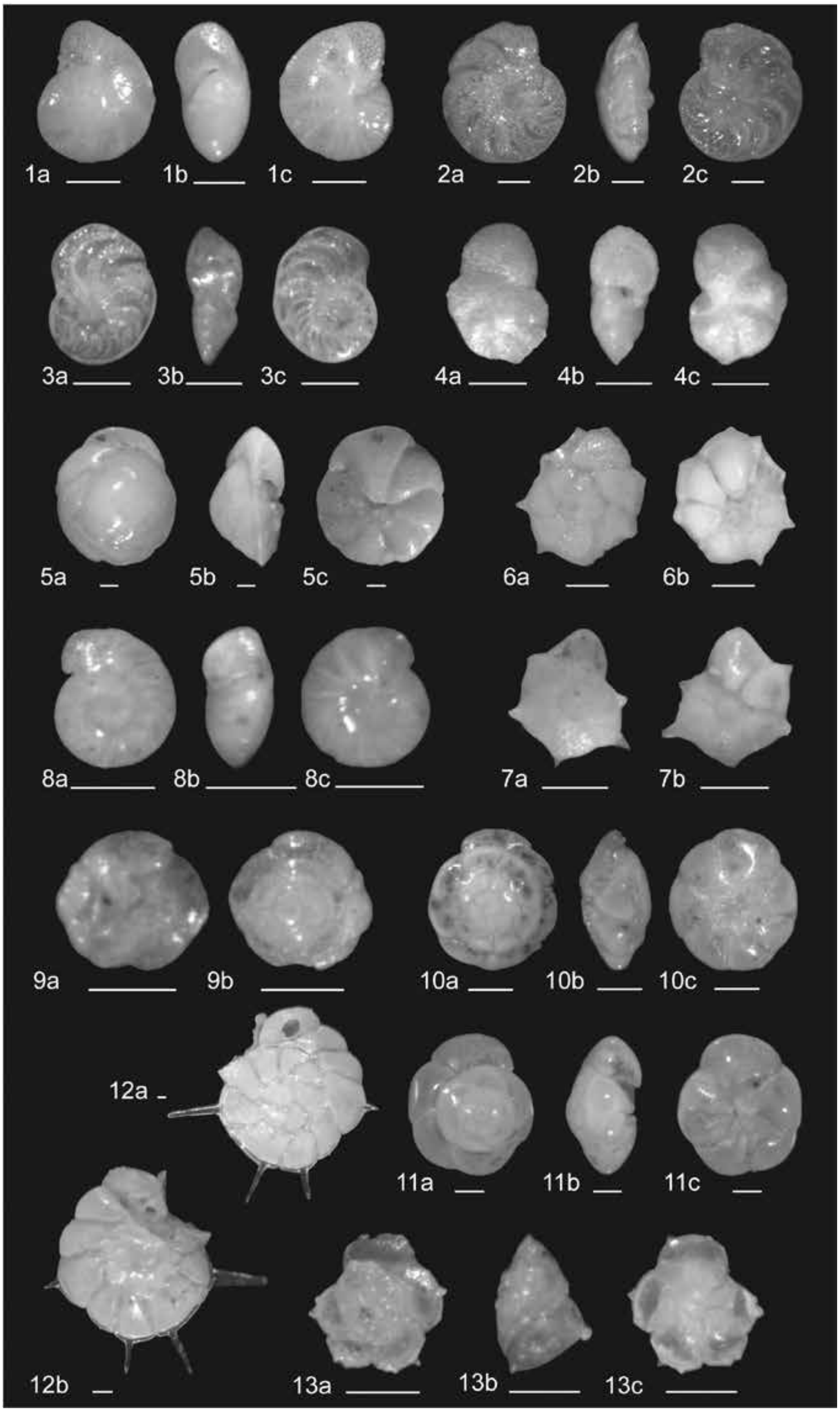
PANCHANG AND NIGAM

EXPLANATION OF PLATE XXXV

(Scale bar = 100µm unless otherwise mentioned)

1: ***Melonis pompilioides*** (Fichtel & Moll) (a) side view (b) apertural view; 2: ***Pullenia bulloides*** (d'Orbigny) (a) side view (b) apertural view; 3: ***Pullenia compressa*** Seguenza (a) side view (b) apertural view; 4: ***Anomalinella rostrata*** (Brady) (a&c) side views (b) apertural view; 5: ***Svratkina decorata*** (Phleger & Parker) (a) dorsal view (b) ventral view; 6: ***Svratkina decoratiformis*** McCulloch (a) dorsal view (b) ventral view; 7: ***Svratkina*** sp. (a) dorsal view (b) lateral view (c) ventral view; 8: ***Oridorsalis umbonatus*** (Reuss) (a) dorsal view (b) lateral view (c) ventral view; 9&10: ***Anomalinoides colligerus*** (Chapman & Parr) (9a) dorsal view (9b) lateral view (9c) ventral view (10a) dorsal view (10b) ventral view. Fig. 9 shows an intact juvenile specimen not showing the initial whorles. Fig. 10 shows a mature specimen with the apertural chamber broken but displaying the inner two whirles clearly; 11: ***Anomalinoides glabrata*** (Cushman) (a) dorsal view (b) apertural view; 12: ***Heterolepa praecincta*** (Karrer) (a) ventral view (b) lateral view (c) dorsal view; 13: ***Heterolepa semisinuosa*** McCulloch (a) ventral view (b) lateral view (c) dorsal view; 14: ***Heterolepa subhaidingerii*** (Parr) (a) ventral view (b) lateral view (c) dorsal view; 15: ***Gyroidinoides subzelandica*** Hornibrook (a) dorsal view (b) lateral view (c) ventral view.

Plate XXXVI



PANCHANG AND NIGAM

EXPLANATION OF PLATE XXXVI

(Scale bar = 100μm unless otherwise mentioned)

1: ***Gyroidina politula*** McCulloch (a) dorsal view (b) lateral view (c) ventral view; 2: ***Hanzawaia concentrica*** (Cushman) (a) dorsal view (b) lateral view (c) ventral view; 3: ***Hanzawaia nipponica*** Asano (a) dorsal view (b) lateral view (c) ventral view; 4: ***Holmanella*** **(?)** sp. (a) dorsal view (b) lateral view (c) ventral view; 5: ***Bucella frigida*** (Cushman) (a) dorsal view (b) lateral view (c) ventral view; 6&7: ***Pararotalia calcar*** (d'Orbigny) (a) dorsal view (b) ventral view; Two specimens showing variation in size and degree of maturity; 8: ***Ammonia gigantica*** Leroy (a) dorsal view (b) lateral view (c) ventral view; 9: ***Ammonia pauciloculata*** (Phleger & Parker) (a) dorsal view (b) lateral view (c) ventral view; 10: ***Ammonia sobrina*** (Schupack) (a) dorsal view (b) lateral view (c) ventral view; 11: ***Ammonia tepida*** (Cushman) (a) dorsal view (b) lateral view (c) ventral view; 12: ***Asterorotalia dentata*** (Parker & Jones) (a) dorsal view (b) ventral view; 13: ***Asterorotalia inflata*** (Millet) (a) dorsal view (b) lateral view (c) ventral view.

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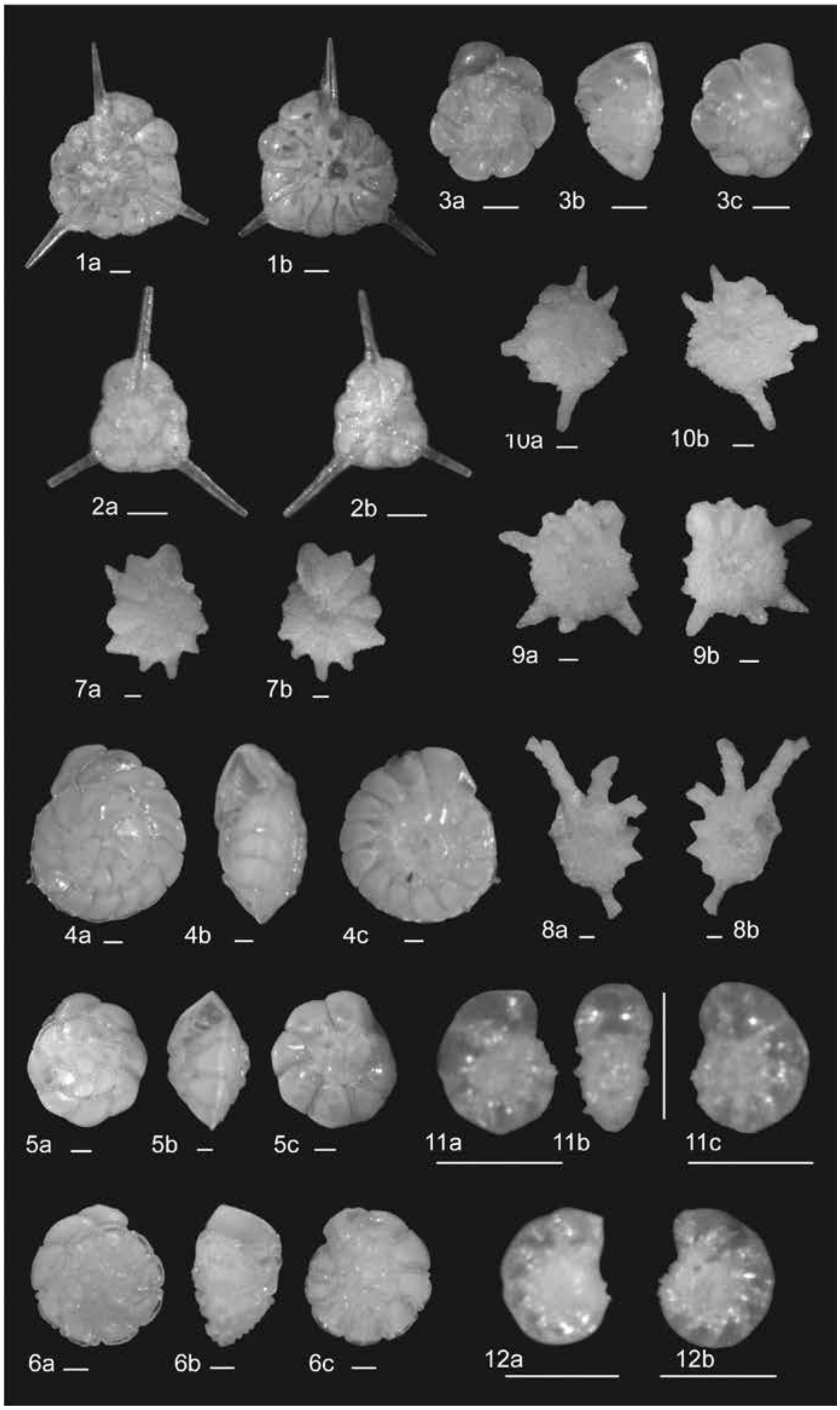
Plate XXXVII



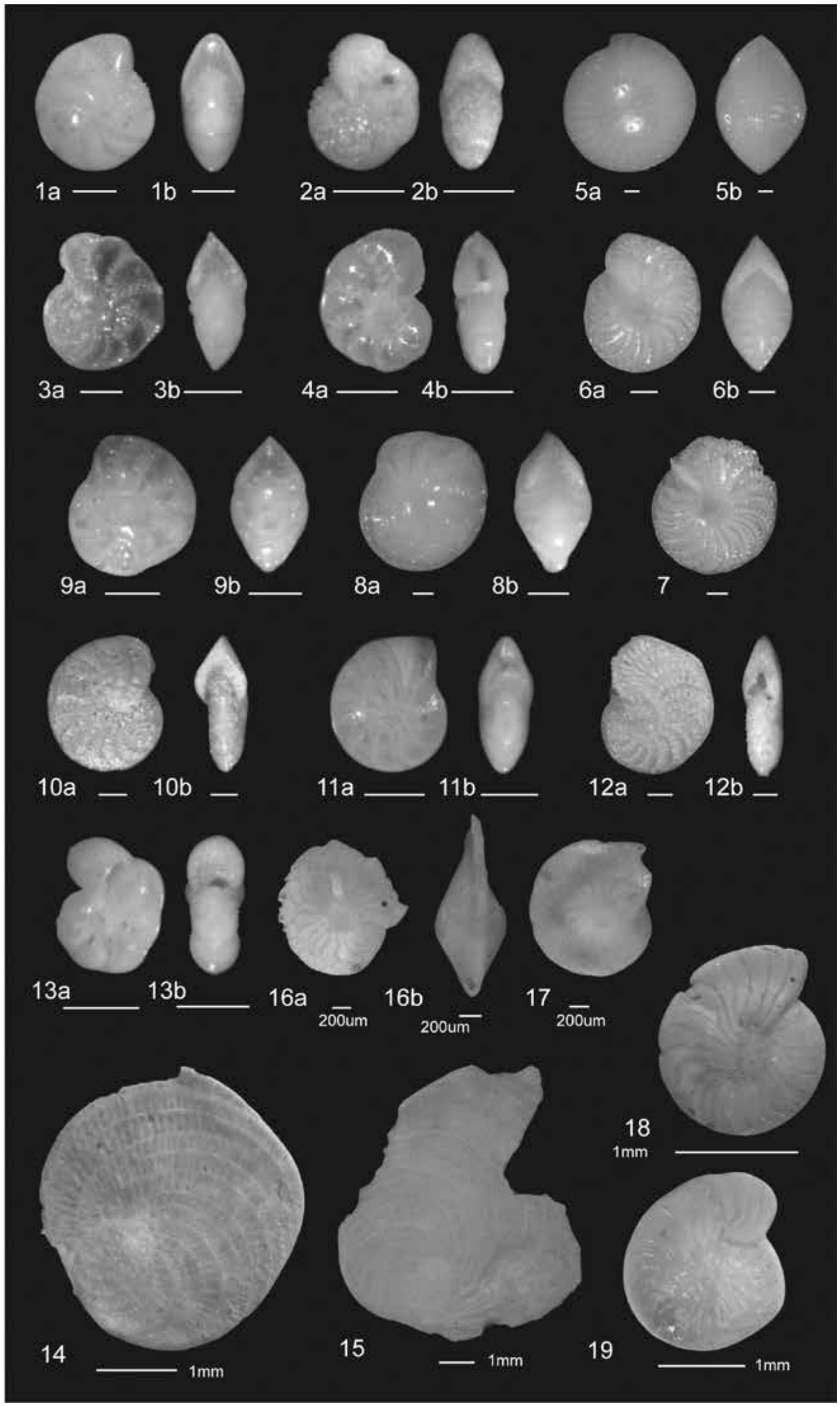
PANCHANG AND NIGAM

EXPLANATION OF PLATE XXXVII

(Scale bar = 100µm unless otherwise mentioned)

1&2: ***Asterorotalia trispinosa*** (Thalmann) (a) dorsal view (b) ventral view (1) megalospheric form (2) microspheric form; 3: ***Pseudorotalia schroeteriana*** (Parker & Jones) (a) dorsal view (b) lateral view (c) ventral view; 4&5: ***Rotalidium annectans*** (Parker & Jones) (a) dorsal view (b) lateral view (c) ventral view (4) megalospheric form (5) microspheric form; 6: ***Rotalinoides papillosa*** (Brady) (a) dorsal view (b) lateral view (c) ventral view; 7: ***Calcarina hispida*** Brady (a) dorsal view (b) ventral view; 8: ***Calcarina pulchella*** Chapman (a) dorsal view (b) ventral view; 9&10: ***Calcarina spengleri*** (Gmelin) (a) dorsal view (b) ventral view. Two specimens showing variation in degree of maturity; 11&12: ***Cribroelphidium subgranulosum*** (Egger) (11a&c) side views (11b) apertural view (12a&b) side views. Fig. 11 shows an intact specimen while the apertural chamber is broken in Fig. 12. They both show different stages of maturity.

Plate XXXVIII



PANCHANG AND NIGAM

EXPLANATION OF PLATE XXXVIII

(Scale bar = 100μm unless otherwise mentioned)

1: ***Cribrononion dattai*** Singh, Jauhari & Vimal (a) side view (b) apertural view; 2: ***Cribrononion heteroporum*** (Egger) (a) side view (b) apertural view; 3&4: ***Elphidium advenum*** (Cushman) (a) side view (b) apertural view. Two specimens showing variation in morphology; 5: ***Elphidium craticulatum*** (Fichtel & Moll) (a) side view (b) apertural view; 6&7: ***Elphidium crispum*** (Linnaeus) (a) side view (b) apertural view. Fig. 6 shows an intact juvenile specimen while Fig. 12 shows a well developed mature specimen with terminal chambers broken; 8&9: ***Elphidium macelliforme*** McCulloch (a) side view (b) apertural view. Two specimens showing variation in morphology and size; 10: ***Elphidium macellum*** (Fichtel & Moll) (a) side view (b) apertural view; 11: ***Elphidium parviforme*** McCulloch (a) side view (b) apertural view; 12: ***Elphidium planiforme*** McCulloch (a) side view (b) apertural view; 13: ***Elphidium rugulosum*** Cushman & Wickenden (a) side view (b) apertural view; 14&15: ***Assilina ammonoides*** (Gronovius) Two specimens showing variation in morphology and level of maturity; 16&17: ***Heterostegina operculinoides*** Hofker (Scale bar = 1mm) Two specimens showing variation in morphology and level of maturity; 18&19: ***Heterostegina suborbicularis*** d'Orbigny (Scale bar = 200μm) (a) side view (b) apertural view. Two specimens showing variation in morphology.

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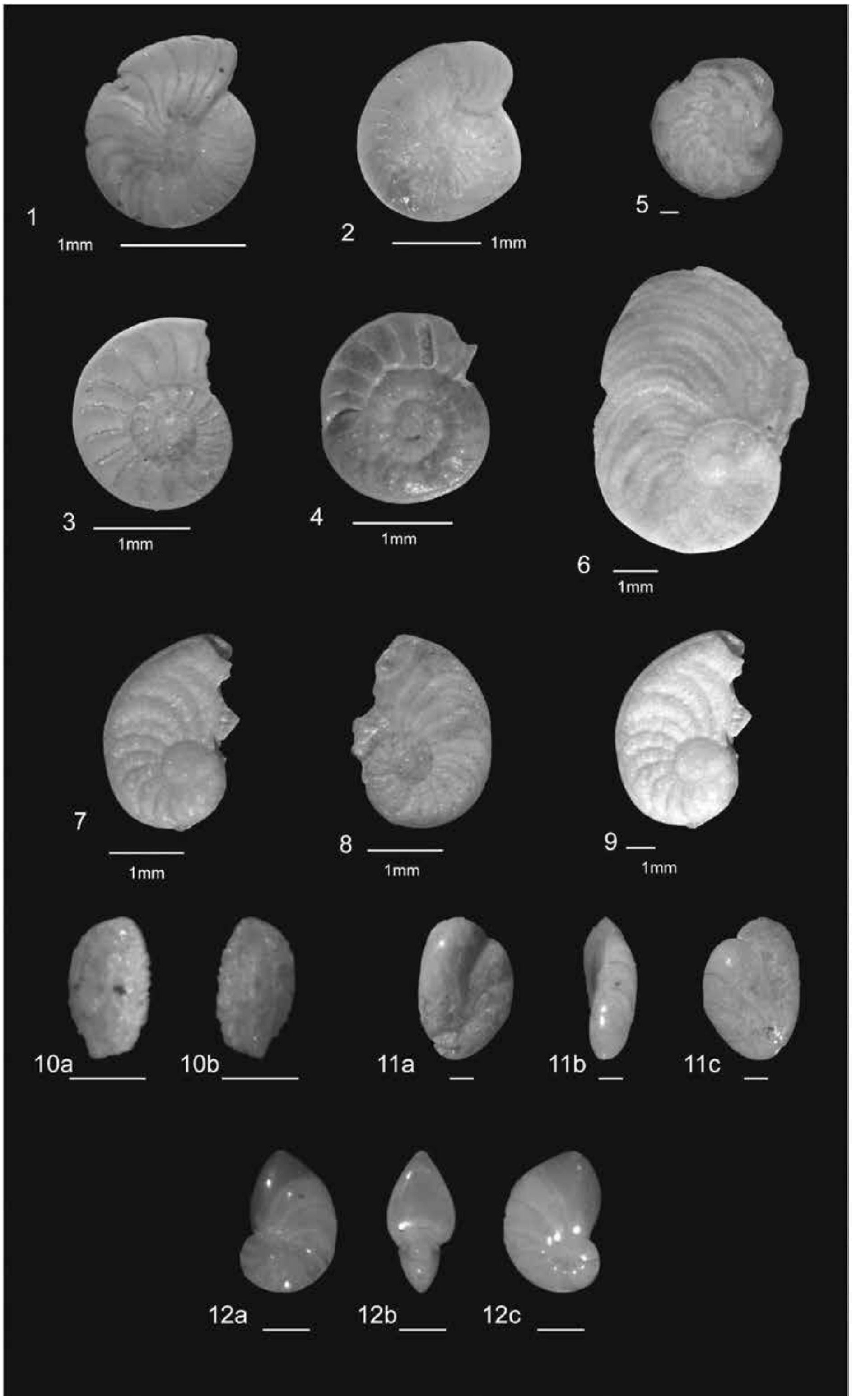
Plate XXXIX



PANCHANG AND NIGAM

EXPLANATION OF PLATE XXXIX

(Scale bar = 100µm unless otherwise mentioned)

1&2: ***Nummulites cumingii*** (Carpenter) (Scale bar = 1mm) Two specimens showing variation in size and shape of periphery; 3: ***Operculina complanata*** (Defrance) (Scale bar = 1mm); 4: ***Operculina granulosa*** Leymerie (Scale bar = 1mm); 5: ***Operculina hardiei*** d'Archaic and Haime; 6 to 9: ***Operculina heterosteginoides*** Hofker (Scale bar = 1mm) Two specimens showing variation in morphology. Addendum 10a-b: ***Miliammina fusca*** (Brady); 11a-c: ***Cancris peroblonga*** (Cushman); 12a-c: ***Nonion elongatum*** (d'Orbigny)

Table 1: Correlation matrix indicating between various parameters and the sixteen major genera encountered in the study area.

	Depth	Sand	Silt	Clay	TOC	Sal.	Temp.
Ammonia	-0.23*	-0.42*	0.42*	0.33*	0.02 *ns*	-0.50*	0.44*
Asterorotalia	-0.27*	-0.42*	0.48*	0.30*	0.02 *ns*	-0.62*	0.47*
Bolivina	0.51*	-0.00 *ns*	0.14 *ns*	-0.07 *ns*	-0.15 *ns*	0.39*	-0.55*
Brizalina	0.02 *ns*	-0.04 *ns*	0.01 *ns*	0.04 *ns*	0.04 *ns*	0.23*	-0.14 *ns*
Bulimina	-0.00 *ns*	-0.25*	0.02 *ns*	0.32*	0.17 *ns*	0.16 *ns*	-0.07 *ns*
Cassidulina	0.16 *ns*	0.34*	-0.41*	-0.23*	-0.08 *ns*	0.41*	-0.28*
Cibicides	0.09 *ns*	0.53*	-0.48*	-0.45*	-0.20*	0.33*	-0.20*
Eggerelloides	-0.15 *ns*	-0.35*	0.20*	0.36*	0.05 *ns*	-0.51*	0.27*
Elphidium	-0.23*	-0.06 *ns*	0.17 *ns*	-0.00 *ns*	-0.02 *ns*	-0.36*	0.35*
Globocassidulina	0.51*	0.08 *ns*	0.05 *ns*	-0.14 *ns*	0.15 *ns*	0.38*	-0.62*
Hanzawaia	-0.22*	0.02 *ns*	0.05 *ns*	-0.06 *ns*	-0.20*	-0.21*	0.33*
Heterolepa	-0.07 *ns*	0.42*	-0.39*	-0.35*	-0.18 *ns*	0.11 *ns*	0.07 *ns*
Latibolivina	-0.14 *ns*	0.31*	-0.22*	-0.30*	-0.20*	0.16 *ns*	0.08 *ns*
Nonion	-0.15 *ns*	-0.36*	0.19*	0.39*	0.09* *ns*	-0.16*	0.27*
Quinqueloculina	-0.12 *ns*	0.26*	-0.23*	-0.22*	-0.11 *ns*	0.20*	-0.03 *ns*
Textularia	-0.15 *ns*	0.25*	-0.25*	-0.20*	-0.11 *ns*	-0.00 *ns*	0.15 *ns*
ns = non-significant; *significant at $p<0.05$							

mixed sediments in the Martaban (Rao *et al.,* 2005). The outer shelf has been known to be a zone of non-deposition and starved of modern fine-grained sediments. The relict sands cover an area of about 50,000 km^2 suggesting probable deposition during the Holocene transgression (Rodolfo, 1969). Most of the sediments discharged by the Ayeyarwady are displaced eastwards by the prevailing westerly currents into the Gulf of Martaban. The Gulf of Martaban acts as a sediment trap. The Martaban Canyon is a conduit for terrigenous sediments reaching deep Andaman Sea. The Gulf is characterised by modern muds and mixed sediments. At the center of the Gulf the mud belt is as wide as 250 km and ranks amongst the largest modern mud belts of the world oceans (Rao *et al.,* 2005).

The annual mean surface temperature in the study area is ~28°C and drops gradually to ~27°C up to a depth of 40 m, after which the temperature gradient is very high. The temperature drops to about 22°C at a depth of 100 m. Again, beyond the depth of 200 m the gradient becomes gentle. The temperature is about 10°C at 400 m depth and drops to about 5°C at 1000 m (Levitus and Boyer, 1994). Closer to the coastline along the 15.5°N latitude, the surface salinity varies between 31.4 p.s.u. west of the shelf to 30.2 p.s.u. in the Gulf of Martaban. The water column is well stratified in terms of salinity and a horizontal is attained at a shallow depth of ~15 m. However, the salinity increases rapidly up to a depth of 30 m, after which the waters are thickly stratified. At about 100 m, the salinity drops to 34.5 p.s.u. and to a maximum of 35 p.s.u. at about 200 m and remains constant up to a depth of 600 m. (Levitus and Boyer, 1994). At shallower depths the salinities are lower towards Gulf of Martaban. The surface waters across the delta shelf seem to be well oxygenated (~5 ml/l dissolved O_2), especially towards the Gulf of Martaban. The drop in oxygen content is very gradual and drops to below 1 ml/l beyond 90 m. The dissolved oxygen concentration drops to 0.2 ml/l at depths between 140 m and 350 m in the water column (Levitus and Boyer, 1994).

Given its least understood complex physico-chemical settings, the present study seems inevitable.

MATERIALS AND METHODS

In April 2002, 124 grab samples (surface sediments) were collected on the continental shelf and slope off Myanmar from depths ranging between 10-1030 m (Fig. 1) using a modified Peterson Grab, during the 175th cruise of the ORV *Sagar Kanya* in the Exclusive Economic Zone (EEZ) of Myanmar. Details of the sampling such as coordinates of sampling locations, depth–salinity-temperature of sampling, sediment textures and TOC generated per sample have been previously published (Panchang and Nigam, 2012). CTD profiles obtained at a few stations during the cruise and the station-wise data obtained from Levitus Climatology (NOAA/PMEL TMAP FERRET Ver. 5.22, Dataset: levannual.ac) was used to plot benthic temperature and salinity maps of the study area (Figs. 2a-b).

15 to 20 g of sediments from each of the 124 surface samples were first analysed for sand-silt-clay percentage ratios. They were dried overnight in the oven at 60°C. Each dried sample was weighed and soaked in distilled water. Subsequently, 10 ml of 10% sodium hexa-metaphosphate was added to them to dissociate the clay particles followed by 5 ml of 10% hydrogen peroxide to oxidise the organic matter, if present. The treated samples were wet sieved through 63 µm (250 mesh) size sieve. The sand fraction retained over the sieve was dried at 60°C and used for foraminiferal analysis. It was coned and quartered to obtain a representative aliquot from which a minimum of 300 benthic foraminiferal specimens were picked from each sample to obtain statistically adequate numbers to portray the faunal distribution (Ujjie, 1962; Chang, 1967; Dennison and Hay, 1967). They were mounted on micropalaeontological slides and percentages of the individual benthic species were calculated.

The foraminifera were picked and identified using an Olympus SZX-16 stereozoom binocular microscope. Descriptions made by Loeblich and Tappan (1988) were used to ascertain the generic status of specimens. Final specific nomenclatures were assigned after comparing our specimens with the type specimens described in the Ellis and Messina Catalogue of Foraminifera (EMFORCAT)-2007.

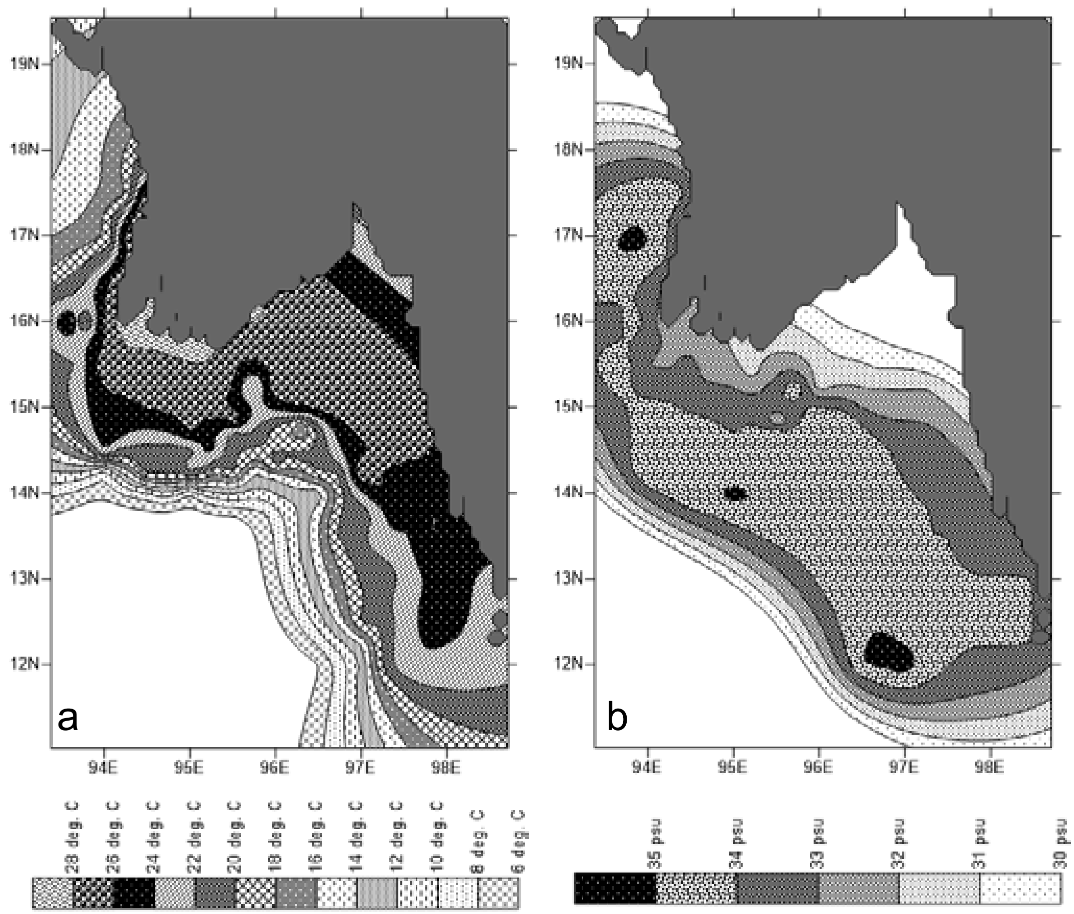


Fig. 2. Spatial distribution of (a) bottom water temperature in °C and (b) bottom water salinity in p.s.u.

The generic abundances at each station and the environmental parameters (depth, temperature, salinity, TOC, sand, silt and clay) at the respective locations were subjected to correlation analysis using STATISTICA 5.0. The results were used to draw inferences regarding the ecological preferences of different genera. Table 1 includes the correlation matrix of dominant genera i.e. those with abundances of 5% or more, at least at five stations in the study area. In order to identify the contribution of every foraminiferal group in the delineation of different microenvironments within the study area, the total fauna (i.e. 222 benthic genera) occurring at 124 stations was subjected to cluster analysis (R-mode) using the statistical software Primer 5.0. The complete dataset was analysed for similarity. It was first standardised by applying to it a square root transformation, to obtain a similarity matrix. This matrix was analysed to form clusters, which was plotted in a dendrogram. The constituent stations of major clusters were plotted on the sampling station map to obtain the geographic distribution of these clusters.

RESULTS

Of the total 124 samples, only 120 yielded foraminifera. Their analysis revealed 713 benthic species belonging to 222 genera which have been taxonomically arranged and illustrated (Plates 1 to 39) to compile a ‘ready catalogue’ of all the species occurring in the surface sediment samples of the Ayeyarwady Delta Shelf.

The station-wise values obtained for benthic temperature and salinity were plotted on contour diagrams to reveal their spatial variation in the benthic environment (Figs. 2a-b).

The correlation matrix indicated that the distribution of most genera was not significantly correlatable with TOC as against the significant relationship with substrate parameters and salinity. The most suggestive correlation revealed by the multivariate correlation matrix is the negative correlation between distribution of *Ammonia*, *Asterorotalia*, *Elphidium* and *Hanzawaia* with salinity, depth and sand (*Hanzawaia* does not have a preference for substrate texture).

The cluster analysis produced a dendrogram showing three major clusters at the level of similarity 30 (Fig. 3). The stations constituting each of these clusters were plotted on the study area map to obtain the geographic distribution of these clusters (Fig. 4).

Cluster A is a minor cluster and comprises of only those two stations, namely 15 and 20, where *Amphistegina* and *Calcarina* occur as dominant genera in the study area. The fauna indicates the presence of live coral reefs in the study area. This cluster seems to be controlled by 80 to 100% sand substrate and covers a surface area of about 1573 km^2.

Cluster B comprises of 25 stations. They are all near shore, shallow stations (10 to 35 m) located around the mouths of the Ayeyarwady and in the Gulf of Martaban. All these stations are located in the low salinity regime (30.7 to 33.1 p.s.u.) influenced by fresh water influx. This cluster is characterised by *Ammonia, Asterorotalia*, *Brizalina, Elphidium, Hanzawaia, Nonion, Eggerelloides* and *Trochammina* as the dominant

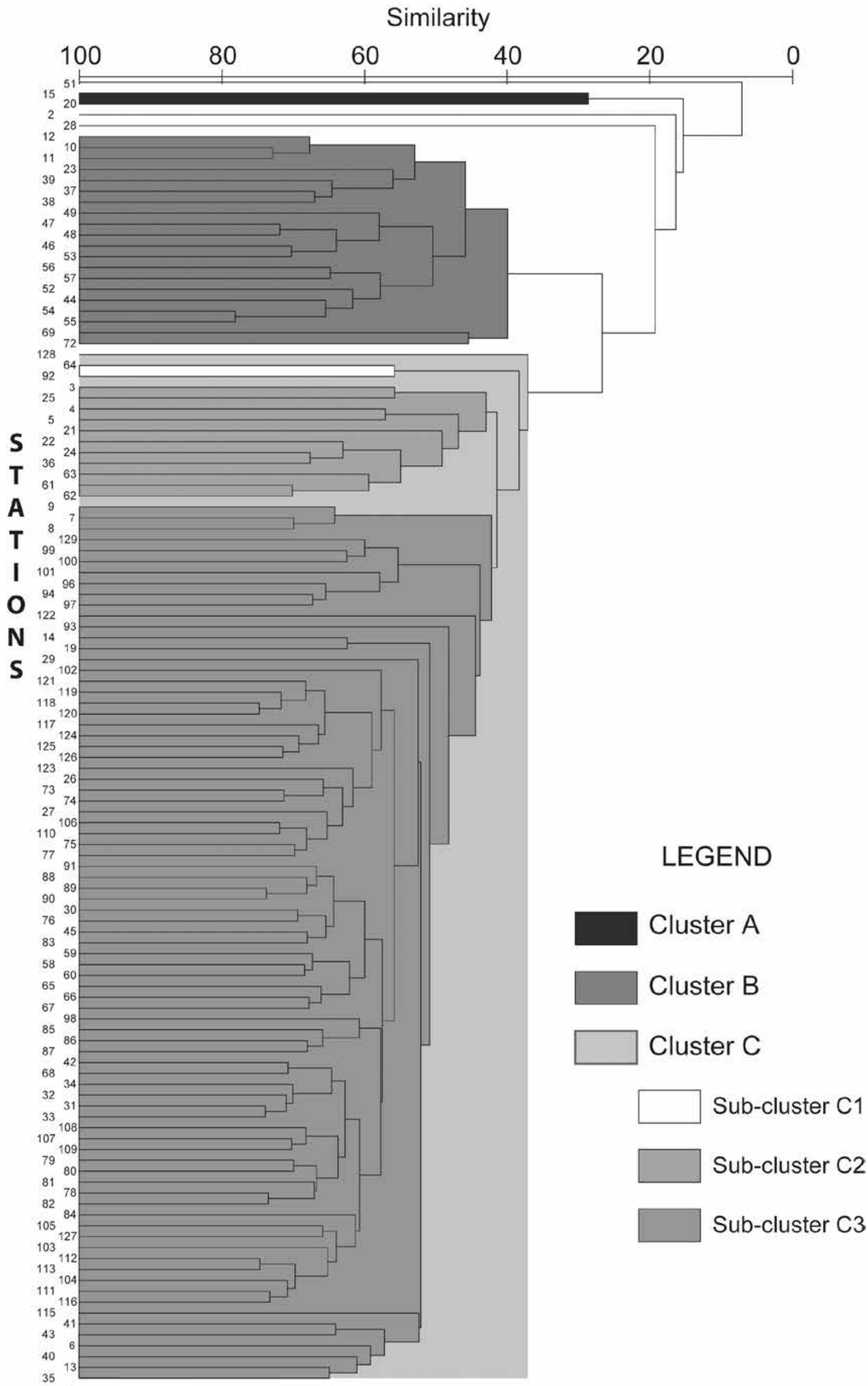


Fig. 3. R-mode cluster dendrogram obtained by running similarity statistics of 222 benthic genera encountered at the 124 sampled stations in the study area.

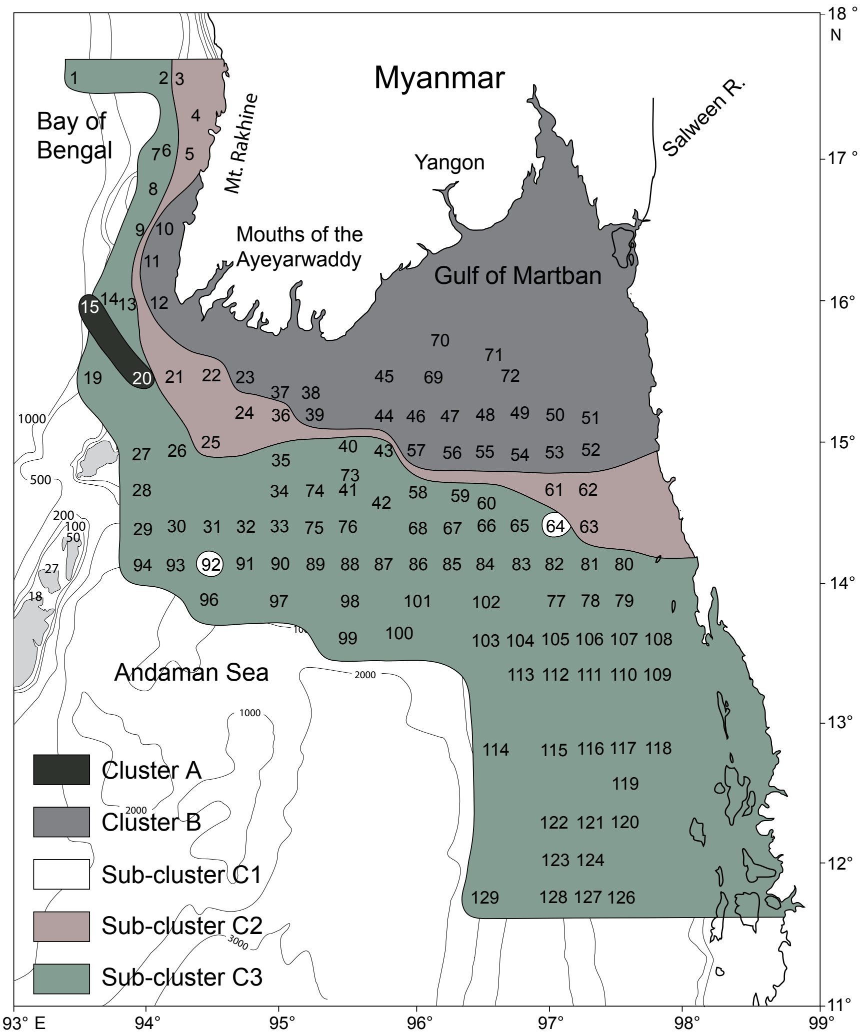


Fig. 4. Map showing the spatial location and extent of the clusters derived from the cluster analysis.

genera. The associated genera include *Ammoscalaria, Eratidus, Glaphyrammina, Cribrononion, Melonis* and *Nonionella.* The assemblage indicates that this regime supports shallow water agglutinated genera, apart from the dominant calcareous genera tolerant to low salinities (as inferred from the correlation statistics). This cluster is also characterised by a very narrow range of temperature (27.1 to 27.8°C) and silty-clay substrates. This cluster occupies an area of about 55,882 km^2 and extends outwards for 50 km over the delta shelf. This cluster is much wider (150 to 250 km) in the Gulf of Martaban.

Cluster C largely comprises 97 stations located on the shelf and slope regions. The major feature of this cluster is that the abundances of *Ammonia, Hanzawaia, Elphidium and Asterorotalia*, drop drastically towards the outer shelf, away from the low salinity regime. This cluster is characterised by erratic substrate, mixed depth distribution and salinities higher than 33.1 p.s.u. Within Cluster C, at level of similarity 40, three sub-clusters, C1, C2 and C3 are evident. These 3 sub-clusters seem to exhibit further zonation in the salinity distribution.

C1 comprises two stations viz. 64 and 92 and together cover an area of about 635 km^2. High abundances of *Hanzawaia*, accompanied by *Brizalina, Cassidulina, Ammonia, Bolivina, Euuvigerina* and *Bulimina* as dominant genera characterise this cluster. This cluster occurs as two isolated stations within sub-cluster C3. These stations are characterised by clayey sands.

C2 comprises 11 stations occurring in a very narrow belt just beyond the low salinity regime, represented by Cluster B. This belt trending nearly East-West is only 7 to 10 m wide in the Gulf of Martaban and extends to ~65 km wide on either sides of the Gulf. This cluster is characterised by erratic distribution of sediments (clayey-silty-sands), depth variation from 32 to 49 m, a narrow range of salinity between 33.1 and 33.8 p.s.u. and bottom temperatures ranging from 26.4 to 27.48 °C. The dominant genera at these stations are *Ammonia, Asterorotalia, Bigenerina, Cibicides, Discorbinella, Elphidium, Hanzawaia, Heterolepa, Latibolivina, Pseudorotalia, Textularia* and *Quinqueloculina.* The accessory genera are *Bolivina, Brizalina, Bulimina, Cassidulina, Cribrononion, Epistominella, Fissurina, Fontbotia, Gavelinopsis, Pacinonion, Murrayinella, Miliolinella, Fursenkoina, Neouvigerina, Nonion, Nonionella, Quinqueloculina, Rotalidium* and *Rotalinoides.*

The remaining 84 stations in Cluster C are included in C3. This cluster covers an area of ~1,17,833 km^2 on the outer shelf and slope areas off Myanmar. This cluster is characterised by relatively very low abundances to zero abundances of *Asterorotalia, Ammonia, Hanzawaia* and *Elphidium*. The genera characteristic of this cluster are *Quinqueloculina, Cibicides, Bolivina, Bulimina, Latibolivina, Rotalinoides, Textularia* and *Uvigerina* as the dominant species. *Cassidulina, Cibicidoides, Globocassidulina, Gyroidina, Heterolepa, Lenticulina, Miliolina, Rosalina, Saidovina, Sigmoilinita, Sigmoilopsis, Siphonaperta,* and *Triloculina* are the commonly associated genera of this cluster. The salinity ranges between 33.5 and 35.4 p.s.u. and temperatures cover a very wide range between 5.87 and 26.4 °C. The depth and sediment distribution is highly variable.

The cluster C3 can be further split into several more at a higher level of similarity. For example, the first 'cluster' noticeable within C3 is made of only 8 stations, namely station #8, 94, 96, 97, 99, 100, 101 and 129. If plotted on the map, all these stations account for shelf edge stations, probably indicating assemblages typical of the shelf break in the study area. However, in order to avoid over-interpretation, the smaller clusters have not been discussed.

DISCUSSION

Prior to the present study undertaken on the Ayeyarwady Shelf, only Frerichs (1970) has described the benthic foraminiferal distribution from the Andaman Sea. He reported over 300 benthic species from the entire Andaman Sea (13 to 3778 m). Of these, only 33 samples fall within the purview of the present study area. He attributed the foraminiferal distributions on the shelf to the general variations in all the physico-chemical parameters. Based on the dominant and characteristic species, he divided the area under present study into three faunal provinces, namely the Delta Front, Gulf of Martaban and the Mergui Platform. However, the foraminiferal population only >250 µ was studied, because of which the occurrence, distribution of smaller species and their significance has not been accounted for. Neither does Frerichs (1970) list the species with the names of their original authors nor are they supported with illustrations or photographs. In the absence of the two, the report could be incomprehensive to new workers in the region, because foraminiferal taxonomy as well as microscope resolutions (which enable better observations and identification) have undergone tremendous change since then i.e. over 4 decades.

The current work addresses all the lacunae in the previous works and compiles the first comprehensive report on foraminiferal taxonomy from the region off Myammar accompanied by illustrations (Plates I to XXXIX). Comparing the foraminiferal assemblages from the study area with those from the West Coast of India (Mazumder, 2005), East Coast of India (Subbarao *et al.*, 1979; Rao, 1998; Saraswat, 2006), Eastern Kalimantan (Lambert, 2003; Renema, 2006) and South China Sea (Saidova, 2007), it is evident that the study area has greater number of species (230) that are common to the Bay of Bengal and only 150 species common to the Arabian Sea. At the same time, the study area has 154 species common to the Bay of Bengal, South China Sea and Eastern Kalimantan, which have not earlier been reported from the Arabian Sea. Thus, it seems like the study area shares more similarity with the faunal realms east of the Indian sub-continent.

In view of the foregoing it seems like this region has a strong affinity towards the 'mixed zone' proposed by Bhalla (1970) and/or Indo-Pacific foramogeographic province of Cushman (1948). At the same time, the faunal assemblages from the Bay of Bengal and the Arabian Sea are quite different. The species *Asterorotalia trispinosa* has never been reported from the Arabian Sea (Rao, 1998; Mazumder, 2005). It, however, occurs all along the East Coast of India and also further east of the study area, up to Eastern Kalimantan. This indicates a foramogeographic boundary between the east and west coast of India, which could be attributed to ecological differences in the two water bodies.

The present study further employs a statistical approach to delineate different environments within the study area. R-mode cluster analysis has been carefully chosen in order to group stations that are similar on the basis of their constituent taxa. It is interesting to find that these clusters can also be defined by a characteristic set of environmental conditions. The occurrence of zooxanthellae-bearing larger foraminiferal taxa in Cluster A suggests occurrence of coral reefs in the study area. Panchang *et al.* (2008) have earlier reported the occurrence of fossil reefs and soft coral sclerites in the study area. This cluster occupies an isolated position southwest of the Rakhine coast and it appears to lie away from the influence of the low salinity and turbid waters emanating from the mouths of the Ayeyarwady. This explains the formation of this cluster characterised by salinity of 32.9 p.s.u.

Clusters B and C can be clearly demarcated on the basis of lower and higher salinity regimes, 33.1 p.s.u. being the partitioning value. Only 2 stations which constitute sub-cluster C1 share similar sediment characteristics. Relict foraminifera have been reported from these two locations (Panchang *et al.,* 2008). Thus, this sub-cluster seems to be controlled by the substrate. Similarly, relict foraminifera have also been earlier reported from 7 out of the 11 stations in cluster C2, namely stations #3, 21, 22, 24, 25, 61 and 63 (Panchang *et al.,* 2008). This indicates that the distribution of these two clusters coincide with the relict sand zone in the study area, but have been defined by the salinity variation separating them. Similarly, salinity is the only parameter that isolates the two stations within sub-cluster C2 from sub-cluster C3, despite the fact that the latter geographically surrounds the former. Cluster A also is surrounded by C3, because they both fall within the high salinity zone (>34 p.s.u.), but are separated by sediment type.

In the present study, the R-mode cluster analysis explicitly demonstrates the sensitivity of benthic foraminifera and thereby their ability to map small ecological variations within the extensive benthic environments. Clusters B, C2 and C3 occurring as progressive zones engulf the Ayeyarwady Delta. There is a gradual increase in the salinity gradient southwards. The geographic distribution of the clusters obtained during the present study closely correlates with the benthic salinity map of the study area (Fig. 2b). The distribution of the clusters are neither fully dependent on the sediment distribution nor the TOC distribution described by previous studies (Rao *et al.,* 2005; Ramaswamy *et al.,* 2008). This suggests that the faunal assemblages are defined by their sensitivity to the strong salinity gradient prevalent in the study area. The significance of mapping these benthic ecologies on the Burmese shelf lies in the fact that the clusters cover extensive areas spanning thousands of square kilometres on the Ayeyarwady Delta Shelf.

It has been suggested that out of the several biotic and abiotic environmental factors, abiotic factors play a dominant role in shaping the benthic foraminiferal assemblage, especially in marginal marine environments (Murray, 1991; Sen Gupta, 1999). Of the abiotic factors, temperature and salinity have been reported as the most important ecological parameters, which affect the distribution, growth and reproduction of foraminifera along the coastal areas (Boltovskoy and Wright, 1976). Out of these, several biological and physico-chemical factors affecting the benthic foraminiferal distribution in the marginal marine areas, fresh water runoff related salinity changes are especially effective in shallow water areas (Samir *et al.,* 2003; Hromic *et al.,* 2006; Horton and Murray, 2007; Eichler *et al.,* 2008; Bouchet *et al.,* 2009; Frezza and Carboni, 2009). Panchang and Nigam (2012) have been able to infer past salinity variations off Myanmar using downcore distribution of foraminiferal assemblages.

While relating deep sea ecology and monitoring to oil and gas operations, Kropp (2004) suggested that it is important to follow the best taxonomical techniques and measure community features to serve as biomarkers. He recommends monitoring and management of resources and ecosystems to enable future generations to access such information. As per the Coastal Water Habitat Mapping (CWHM) toolkit defined by Coastal Cooperative Research Center (Coastal CRC), Australia, seafloor mapping is critical to improve our understanding of ecosystem dynamics and relationships between biota and habitats (OzCoasts GeoScience Australia, 2012). Without these details local, state, federal as well as industrial resource managers are poorly equipped to make decisions about the effects of different activities on marine habitats. Benthic mapping is useful in predicting species and resource distribution, anticipating future pressures, evaluating effects of managements. If biodiversity can be represented in habitat maps, managers will be more readily able to protect those areas important to maintaining a diverse, functioning ecosystem.

The benthos (the organisms as well as the rocks, reefs and sediments that form the habitat) is an extremely valuable component of marine and estuarine environments. Benthic systems are important to recycling of nutrients and the burial and storage of organic matter (OzCoasts GeoScience Australia, 2012). The understanding of the spatial distribution of foraminiferal assemblages ascertained in the present study will primarily be useful in understanding the benthic environment on the expanse of the Ayeyarwady Delta Shelf. In a situation where Myanmar is opening up several sectors of its market to foreign investment and exploration of natural resources, the present work will be useful in the marine resource assessment in its EEZ as well as help in post exploration/exploitation environmental impact assessment in the future.

CONCLUSIONS

The present study reports 713 benthic forminiferal species belonging to 222 genera from the delta shelf off Myanmar and assigns the study area to the Indo-Pacific foramogeographic province. It also delineates three distinct benthic environments off Myanmar, namely: Cluster A- representing modern coral reef environment; Cluster B- representing extremely low salinity regimes in regions close to the mouths of the Ayeyarwady and the Gulf of Martaban; Cluster C- represents the shelf environments with higher salinity regimes. This environment is further broadly clustered into 3 major sub-clusters, to reveal microenvironments within the shelf. The geographical distributions of the clusters establish that the benthic foraminiferal assemblages are governed by the strong salinity gradient prevalent in the study area.

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