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EOCENE MOLLUSCAN FOSSILS FROM THE UPPER DISANG FORMATION OF IMPHAL VALLEY, MANIPUR, INDIA

UMARANI SIJAGURUMAYUM[1], Y. RAGHUMANI SINGH[1]* and **R.P. KACHHARA[2]**

[1] DEPARTMENT OF EARTH SCIENCES, MANIPUR UNIVERSITY, IMPHAL (INDIA)-795003
[2]31, MAYUR VAN COLONY, PANERION KI-MADRI TEKRI ROAD, UDAIPUR (INDIA)-313002
E-mail: yengmani@gmail.com

ABSTRACT

The present paper describes fourteen molluscan species from the Upper Disang Formation of Imphal Valley, Changamdabi Hills, Manipur. Of these, five (four bilvalves and one gastropod) are described as new species and nine are kept in open nomenclature. Of the latter, eight belong to Bivalvia and one to Gastropoda. The bivalve genera include *Nucula*, *Barbatia*, *Protonoetia*, *Septifer*, *Aviculoperna*, *Venericardia*, *Trachycardium*, *Tellina*, *Callista*, *Lentidium*, *Pholas,* whereas gastropods include *Patella* and *Natica*. Morphological comparison and a cladistic analysis place the fossils as closely related to group's last common ancestor, but they have one or more unique characteristics than their close ancestors.

Keywords: Upper Disang, Imphal valley, Changamdabi hills, bivalves, gastropods, Manipur

INTRODUCTION

Manipur is one of the states in the north-eastern region of India which shares international border with Myanmar-Burma on the eastern and southern sides. The remaining half of the state has border line with the states of Nagaland, Assam and Mizoram respectively on the northern, western and south-western sides where Cretaceous and Tertiary sedimentary rocks occur prominently in Manipur State. They are associated with minor igneous and metamorphic rocks, associated with pelagic sediments such as chert, limestone, shale, sandstone and flysch. The northeast and eastern part of the state is occupied by the older group of rocks, i.e. the Metamorphic Complex and the Ophiolite Mélange Zone. The central and western parts are composed of Tertiary flysch sediments.

Literature on the palaeontogical work of the Upper Disang Formation of Manipur is meagre. Although Mishra (1990), Kachhara *et al.* (2000), Jayajit *et al.* (2008), Singh *et al.* (2010) and Sijagurumayum *et al.* (2011) have worked on bivalves and gastropods from the Disang Group. During the course of present investigation, twelve species of bivalves and two of gastropods are recovered from the Upper Disang Formation in the study area. Bivalves and gastropods are quite abundant but in general are poorly preserved and occur as external casts and moulds.

MATERIALS AND METHODS

These fourteen molluscan species of bivalves and gastropods are recovered from the sandstone/siltstone of the Upper Disang Formation. The samples for the present palaeontological investigation were collected from two localities namely, Locality 1 and Locality 2 located at Changamdabi hills, Manipur (Fig. 2). The fossil specimens recorded here are mainly the external casts and moulds so the internal characters of the bivalves could not be studied.

LOCALITY DESCRIPTION

The fossils have been collected from the sandstone/siltstone beds of the Upper Disang Formation exposed in the Changamdabi hills. Locality 1 represents the lower portion of the middle part of the Upper Disang Formation with concerning strata which outcrop in a hill section of Maning Ching, Changamdabi about 8 km from Yairipok Bazaar (GPS 24^{0}41´34"N: 94^{0}05´07"E). This sequence is exposed along Yairipok to Keithelmanbi road. Locality 2 represents the lower part of the Upper Disang Formation exposed along Yairipok to Keithelmanbi road (Fig. 2, locality-2) namely Khongjai Chingkhong Section which is 12 Km from Yairipok Bazaar (GPS 24^{0}41´42"N: 94^{0}0.5´57"E).

REPOSITORY

All the illustrated specimens are housed in the Department of Earth Sciences, Manipur University, Canchipur, Imphal (India).

SYSTEMATIC DESCRIPTION

Bivalves

The present work follows the classification of the Bivalvia as suggested by Newell (in Moore *et al*, 1969). The identification of genera and species is mainly based on the external features but internal characters are also considered wherever available.

Phylum **Mollusca** Linné, 1758
Class **Bivalvia** Linné, 1758
Subclass **Palaeotaxodonta** Korobkov, 1954
Order **Nuculicea** Gray, 1824
Family **Nuculidae** Gray, 1824
Genus ***Nucula*** Lamarck, 1799

(*Type species*: ***Arca nucleus*** Linné, 1758; M. Recent; France)

Subgenus ***Leionucula*** Quenstedt, 1930

(*Type species*: *Nucula albensis* D'Orbigny, 1844. OD)

Nucula sp.

(Pl. I, figs. l, m)

Material: One left valve.

Horizon and locality: Upper Disang Formation; Changamdabi (Locality no. 1).

Description: Valve medium sized strongly, inflated, trapezoidal in outline with height about 70% of the length. Antero-dorsal profile is nearly straight, whereas the margin is gently arched. Anterior margin is feebly convex and merged with ventral one in an obtusely rounded angle. Ventral margin sinuated at posterior region. Postero-dorsal margin is very small and becoming concave adjacent to umbo. Posterior margin almost straight, sub-vertical and meeting the ventral one in a well-defined obtuse angle. Umbonal region obtusely rounded.

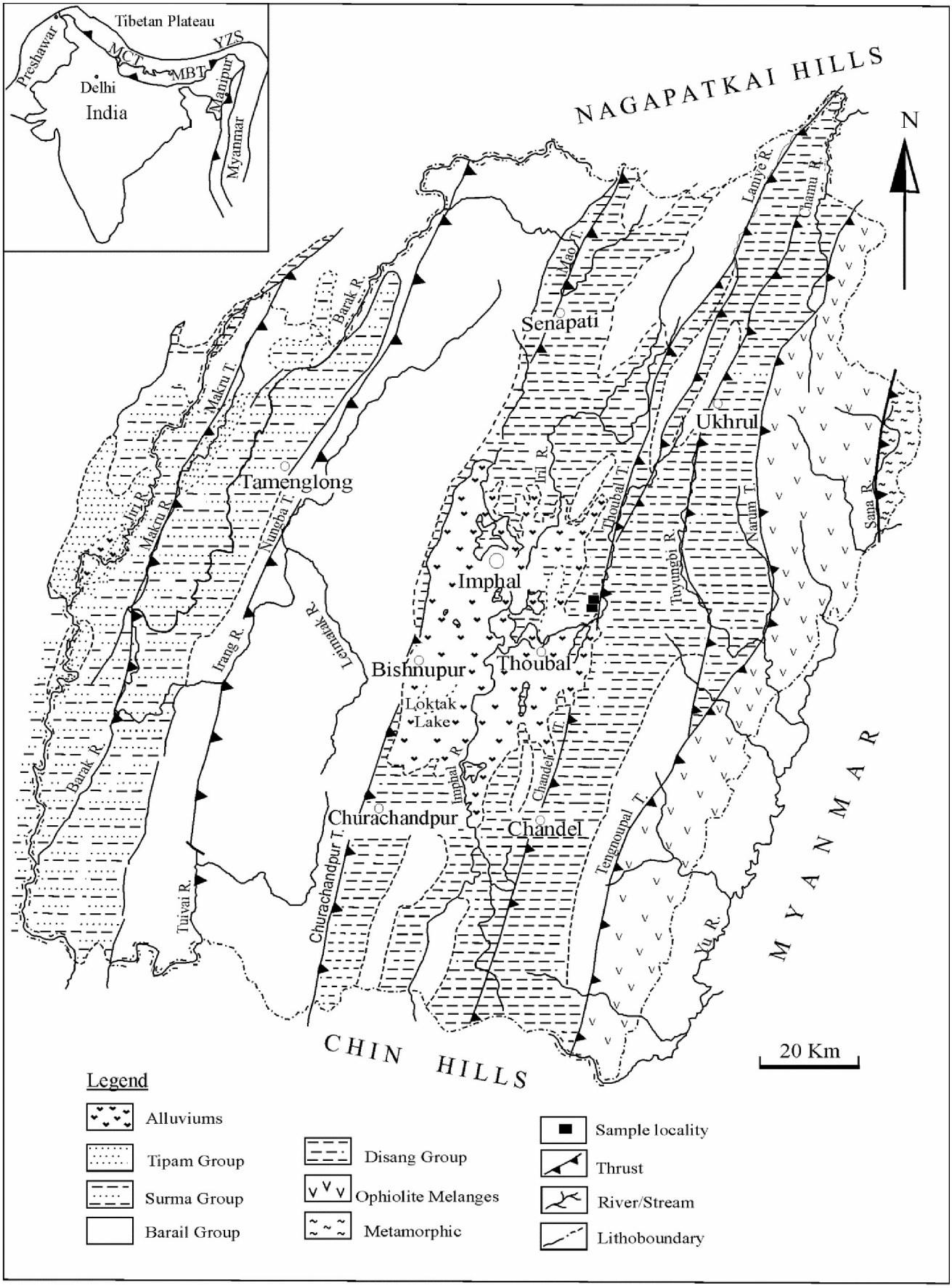

Fig. 1. Geological map of Manipur (after Singh *et al*., 2013) showing sample localities.

Umbo well incurved ophistogyrous and placed at posterior-sixth of shell length. Escutcheon well defined, cordiform, well- impressed and limited by umbonal ridges. Shell surface traversed by fine radial threads. Dentition taxodont – anterior series long whereas posterior one short.

Measurements in mm:

Sp. no.	Length	Height	Inflation
US_{2-} 5/2	21.0	15.0(71%)	14.0 (66.6%)

Remarks: The present species does not resemble with any of the earlier described Eocene form and appears to be new to science. *Nucula domandaensis* Eames (1951, p. 314, pl. ix, figs. 1 a, b) from Upper Chocolate clays of Pakistan is little large has more height i.e. sub-trigonal in outline with well ornamented lunule and escutcheon thus, different. *Nucula fragilis* Deshayes (White, 1959, p. 38 pl. 5, figs. 3, 4.) from Blackheath Beds of England is distinctly trigonal with height about 77% more than the present specimen in hand and bears prominent concentric growth halts in lower half of the shell, therefore, distinguishable. The present specimen appears to belong to a new species, however, it is described here as *Nucula* sp. in want of more well preserved specimen.

Subclass **Pteriomorphia** Beurlen, 1944
Order **Arcoida** Stoliczka, 1871
Super family **Arcacea** Lamarck, 1809
Family Arcidae Lamarck, 1809
Subfamily **Arcinae** Lamarck, 1809
Genus ***Barbatia*** Gray, 1842

(*Type species*: *Arca barbatia* Linné, 1758; Recent; Mediterranean)

Barbatia sp.
(Pl. I, fig. b)

Material: One external mould of left valve.

Horizon and Locality: Upper Disang Formation; Changamdabi (Locality no. 2).

Description: Shell small, sub-equilateral, elongate-ovoid, height about two-third of length, moderately inflated. Umbo is small, broad and sub-median. Anterior and posterior margins are broadly rounded and merging with feebly arched/ventral margin. A very shallow and broad sulcus runs down vertically from Umbo. A low and broadly rounded umbonal carina separates the gently sloping triangular posterior area. External surface seems to bear numerous radial costellae crossed over by fine concentric. Internal characters are unknown.

Measurements in mm:

Sp. No.	Length	Height	Inflation
US_3/ 841	7.5	5.0 (55%)	3.0 (40%)

Remarks: The present species has resembled characters with *Barbatia* sp. described by Jayajit (2005, p.32, pl. i, fig.5) which exhibits same type of sculpture and *Barbatia* (*Plagiarca*) *pseudonavicula* Eames (1951, p.329, pl. ix, figs. 17 a, b) from Upper Eocene beds of Rakhi Nala section of Pakistan is matching in nature of ornamentation and sinuosity of ventral margin. But the present specimen is differing from above two mentioned forms because of their much elongate sub-rectangular outline and inequilateral. Author has not come across any other closely comparable form.

Family **Cuculiaeidae** Stewart, 1930
Genus ***Cucullaea*** Lamarck, 1801

(*Type species*: *Cucullaea auriculifera=Arca cucullaea* Roding, 1798; SD Children, 1823, Recent; Indo–Pacific)

Subgenus ***Cucullaea*** s. str.

Cucullaea (*Cucullaea*) sp.
(Pl. I, figs. g, k)

Material: One left valve

Horizon and locality: Upper Disang Formation; Changamdabi (Locality no.1).

Description: Valve sub-trapezoidal, slightly oblique with extended posterior –ventral corner, anterior end smaller than posterior one and strongly inflated with maximum along the rounded carina running down the umbo to postero-ventral corner. Hinge straight slightly shorter than the shell length. Dentition not well preserved and only at one place discernible just anterior to umbo in form of vertical taxodont teeth. Umbo raised above the narrow cardinal area, little tumid, distinctly prosogyrate and situated at about anterior fourth of shell length. Posterior margin obliquely truncated, making an angle of about 120^0 with posterior extremity of the hinge. Anterior margin is short, about one-third of the height, making an angle of 95^0 with the hinge. Ventral margin is much asymmetrical, gently and evenly curved in the posterior half then rapidly ascending to meet the almost vertical anterior margin in an even curve. Anterior carina is very small. Posterior area is narrow and feebly concave. Surface sculpture consists of equally spaced slightly elevated forty two

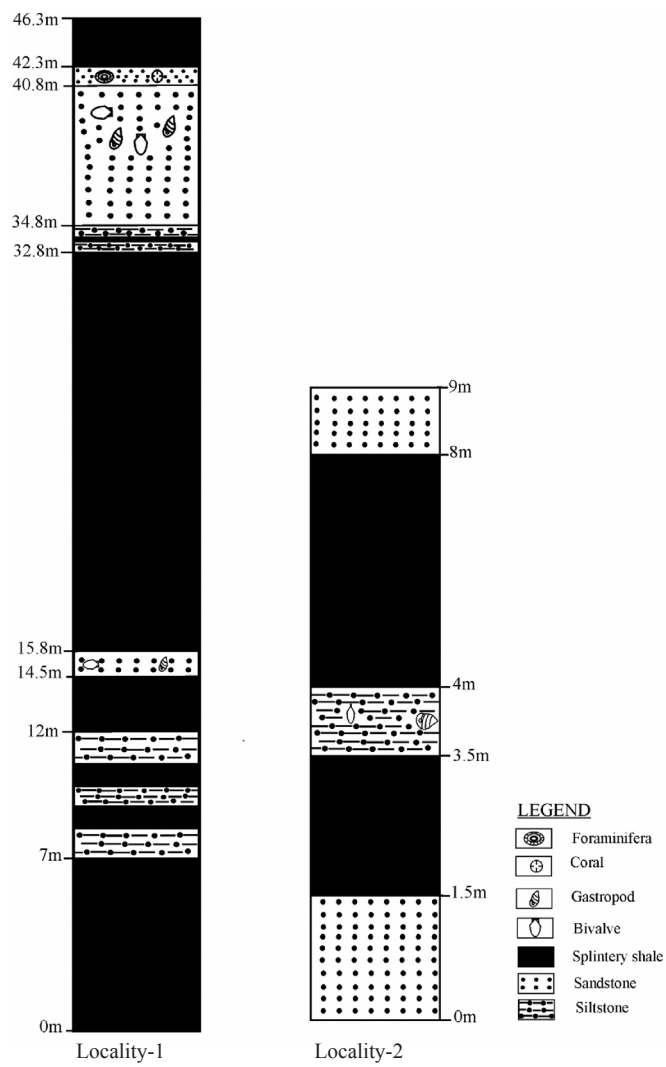

Fig. 2. Measured litho-columns of the Upper Disang Formation at the fossil localities.

radial ribs. Internal characters are unknown.

Measurements in mm:

Sp. no.	Length	Height	Inflation
US,-5/92	23.0	20.4(88%)	14.0 (60.8%)

Remarks: West Pacific living species namely *Cucullaea* (*Cucullaea*) *labiata* (*Solander*) is the most nearest to the present species in overall configuration but that one is larger with height slightly exceeding length and has more numerous radial ribs i.e., sixty two. Superficially these two taxa are akin to each other and the modern species appears to be the descendant form of the recorded one, therefore, it is christen as *Cucullaea* (*Cucullaea*) sp. The Lower Eocene taxon *Cucullaea* (?) sp. A reported by Eames (1951, p. 334, pl.10, figs. 32 a, b) from Zinda Pir section of Pakistan has similar dimensional ratios, number of radial ribs and angle at corner of hinge, however, former is very tiny hardly 1 mm in length and has sub-median umbo. *Cucullaea decussata* Parkinson (White, 1969, p. 42, pl. vii, figs. 6, 7) of Thanet sands has comparable horizon but differs with the recorded species due to its sub-quadrate outline, less asymmetrical vertical margin, broad umbo and in bearing distinct concentric lines.

Family **Noetiidae** Stewart, 1930

Subfamily **Noetinae** Stewart, 1930

Genus ***Protonoetia*** Mac Neil, 1938

(*Type species*: *Anadara nigeriensis* Newton, 1922; OD. Middle Eocene; West Africa (Nigeria)).

Protonoetia manipurensis n. sp.

(Pl. I, fig. n)

Derivation of name: The species is being named after the state of Manipur, India from where the collection is being made.

Diagnosis: Shell small, quadrate in outline, strongly inflated, maximum being just below the umbo with unequal radial ribs and sinuate ventral margin near postero-ventral corner.

Material: Two small left valves

Horizon and locality: Upper Disang Formation; Changamdabi (Locality no. 1).

Description: Valves small, more or less quadrate in outline, height little in excess of length, and strongly inflated, maximum being just below the umbo. Hinge straight, horizontal and almost equal to the length. Umbo is median, well inflated, slightly salient and ophistogyrate. Anterior and posterior margins are almost vertical, very feebly arched and sub-parallel. Ventral margin slightly curved and meeting anterior and posterior ones at an angle of about 90^0 uninterruptedly. External surface ornamented by flat concentric lines with narrow interspaces. This ornamentation is more distinct towards ventral region. In addition to concentric, radials are present in the posterior area as well as to anterior extremity. These radials are regular and evenly spaced. The posterior area is steeply inclined to the flank, separated by a rounded carina running down from the umbo to postero-ventral corner. Interior is not visible as it is hidden under the matrix.

Measurement in mm:

Sp. no	Length	Height	Inflation
US_2-5/44	2.4	2.5 (104%)	2.0 (85%)
US_2-5 /853	11.0	11.2(101.8%)	8.0(72.7%)

Remarks: The recorded specimens are tiny ones and author has not come across any species of the genus of such minute size. To some extent one specimen from the Kachchh No. H1/3 which is identified under the name *Protonoetia nigeriensis* (Newton) is also small which is about four times to the recorded example. However, *Protonoetia nigeriensis* (Newton) (Newell. 1959, p. N 262, fig. C9) is distinct in respect of being sub-quadrate in outline, length in excess of the height with unequal radial ribs throughout the valve surface and in having a sinuate ventral margin near postero-ventral corner. No other allied species is available in the literature for comparison.

Order **Mytiloida** Ferussac, 1822

Superfamily **Mytilacea** Rafinesque, 1815

Family **Mytilidae** Rafinesque, 1815

Subfamily **Mytilinae** Rafinesque, 1815

Genus ***Septifer*** Recluz, 1848

(*Type species*: *Mytilus bilocularis* Linné, 1758; SD Stoliczka, 1871, Recent; Indo-Pacific)

Subgenus ***Septifer*** s. str.

Septifer (*Septifer*) sp.

(Pl. I, figs. w, x)

Material: One right valve

Horizon and locality: Upper Disang Formation; Changamdabi (Locality no. 1).

Description: Shell mytiliform with narrow anterior and expanded posterior. Length is slightly in excess of height. Inflation moderate and attaining its maximum along a curved ridge running from umbo to postero-ventral corner. This ridge is narrow at anterior end and expands rapidly towards posterior. Umbo pointed, almost terminal and anteriorly placed. Hinge rectilinear is about four-fifth of the length and form the dorsal margin. Posterior margin sub-vertical, very feebly arched descending very rapidly and outwardly in oblique manner subtending an obtuse angle with the hinge line and in turn joining the rounded postero-ventral margin in an uninterrupted curve on one hand and slightly concave ventral one on the other. Anterior margin very short, slightly inward sub-vertically. In anterior region there is a small and oval antero-ventral bulge separated by a shallow groove from the ridge. Surface ornamented with radial ribs which are very fine on the antero-ventral bulge and little coarser on the remaining surface. These seem to cross over by commarginal lines which are more conspicuous at the antero-ventral bulge. Few of the radials are bifurcating near the posterior extremity. Inner margin is crenulated. Internal characters are unknown.

Measurement in mm:

Sp. no.	Length	Height	Inflation
US, -5/74	27.2	25.7 (94%)	9.6(35%)

Remarks: In respect of overall configuration, length-height ratio, it is quite close to the living genotype *Septifer bilocularis* (Linné) thrived in the Indo-Pacific region (Soot –Ryen 1959, p. N274, figs. C18, 2) but the recorded form can be differentiated immediately on the basis of that all radials are not bifurcated, possession of longer hinge line instead of two-third of the shell length, and in having comparatively less elongate posterior margin.

The Upper Eocene species from Myanmar namely *Septifer* cf. *denticulatus* Lamarck (Cotter, 1923, p. 38, pl. vii, fig. 9; GSI type No. 12389) and *Septifer* sp. indet. Recorded by Bhatia and Khosla (1978, p. 227, pl. iii, fig 10) from the lower Eocene beds of Rajasthan is easily distinguishable by its elongate sub-elliptical outline with the height much less than the length and many ribs are bifurcating again and again.

Order **Pterioida** Newell, 1965

Suborder **Pteriina** Newell, 1965

Superfamily **Pteriacea** Gray, 1847
Family **Bakevellidae** King, 1850
Genus ***Aviculoperna*** Cossmann, 1887

(*Type species*: *Perna aviculina* Deshayes 1864; OD. Upper Eocene; France)

Aviculoperna changamdabiensis n. sp.
(Pl. I, fig. a)

Derivation of name: The specific name is derived from its occurrence near the Changamdabi, Imphal East district, Manipur.

Diagnosis: Shell small in size, oblique, rounded, trigonal, height about four-fifth of length, moderately inflated and with terminal umbo. Posterior auricle narrow and elongated, surface sculpture with concentric ornamentation.

Material: Seven left valves

Horizon and Locality: Upper Disang Formation; Changamdabi (Locality no.1).

Description: Shell small, oblique, rounded trigonal, height about four-fifth of shell length and moderately inflated with maximum inflation little below and oblique to umbo. Umbo small and terminal; dorsal margin which corresponds to hinge is straight and little less than the shell length. Posterior margin obtusely rounded and almost parallel to concave anterior margin, ventral margin gently arched. Anterior auricle well-marked, separated from the shell surface by a groove. This auricle is sufficiently large and triangular in outline. Posterior auricle is narrow and elongated. There is faint trace of ligament pit and a lateral posterior tooth. Shell surface seems to bear concentric ornamentation which is more conspicuous towards ventral margin. It also seems to have fine radial threads.

Measurement in mm:

Sp. no.	Length	Height	Inflation
US,-5/736	25.0	21.0 (84%)	7.0(28%)
US,-8/465	14.2	17.0 (119%)	6.0(42%)
US,-8/632	11.5	15.5(134.7%)	5.0(43%)
US,-8/614	15.0	20.5 (136.6%)	5.0(33%)
US,-8/714	16.7	18.7(111.9%)	7.0(41.9%)
US,-8/914	16.0	17.9 (111.8%)	5.0(31%)
US,-8/7	18.0	20.0 (111%)	6.0(33%)

Remarks: In respect of hinge, dentition and auricle, it is very close to Upper Eocene form *Aviculoperna aviculina* Deshayes (Moore 1969, P.N. 308, figs. C40, 5), however, that one is quite distinct by its sub-rhomboidal outline, bearing of prominent radials and in having larger posterior wing. No other taxon in closely comparable in the available literature.

Superfamily **Carditacea** Fleming, 1820
Family **Carditidae** Fleming, 1828
Subfamily **Venericardiinae** Chavan, 1969
Genus ***Venericardia*** Lamarck, 1801

(*Type species*: *Venericardia imbricata =Venus imbricate* Gmelin, 1791; SD Schmidt, 1818; Middle Eocene; France)

Venericardia (*Venericardia*) *spondyliformis* n. sp.
(Pl. I, figs. c, f)

Derivation of name: The specific name is derived from its ribbing pattern.

Diagnosis: Shell small in size, slightly oblique and sub-trigonal, about 50% inflation, surface sculpture with radical ribs.

Material: Three external moulds (one left and two right valves)

Horizon and Locality: Upper Disang Formation; Changamdabi (Locality no. 1).

Description: Shell small, slightly oblique and sub-trigonal, height little in excess of length, about 50% inflation attaining its maximum below the umbo at about dorsal third of the height. Antero-dorsal margin small, concave little less than a centimetre in length and moderately inclined. Postero-dorsal and posterior margin are straight and quite long extending from umbo to rounded postero-ventral corner and inclined at angle of 70^0, ventral margin is rather straight, gently raising up to a point vertically below the umbo, then very rapidly ascending to meet the broadly curved and comparably short (about a centimetre) anterior margin. Umbonal region well inflated. Umbo angular, pointed prosogyrous and situated at about anterior third of the shell length. Surface evenly convex but to the posterior steeply inclined. External ornamentation consists of 36 radical ribs which are rounded and broadly spaced in anterior extremity and narrowly spaced to the posterior. In the anterior region radial ribs are sub-angular in the middle part almost flat with narrow interspaces.

Measurement in mm:

Sp. no.	Length	Height	Inflation
US_2-5/52	18.5	21.0(113.5%)	10.0(54%)
US_2-5/907A	14.0	15.5(110.7%)	8.0(54%)
US_2-5/914A	10.0	12.0(120%)	7.0(70%)

Remarks: In respect of numbers of ribs it approaches *Venericardia hollandi* Cossmann and Pissarro (1927, p. 15, pl. II, fig.38) can be distinguished easily on the basis of sub-orbicular outline. Its ribbing pattern isolates it from all other known species of *Venericardia.*

Subclass **Heterodonta** Neumayr, 1884
Order **Veneroida** Adams and Adams, 1856
Superfamily **Cardiacea** Lamarck, 1809
Family **Cardiidae** Lamarck, 1809
Subfamily ***Trachycardiinae*** Stewart, 1930
Genus ***Trachycardium*** Morch, 1853
Subgenus ***Trachycardium*** s. str.

(*Type species*: *Cardium isocardia* Linné 1758; SD Von Martens, 1870. Recent; West Indies)

Trachycardium (*Trachycardium*) *yairipokensis* n. sp.
(Pl. I, figs. p, q, r)

Derivation of name: The species is assigned for its occurrence at Yairipok.

Diagnosis: Shell small in size, tall, trigonally ovate, narrow dorsally, strongly inflated, convex anterior and posterior margins, surface sculpture with radial ornamentation.

Material: Three specimens (one complete specimen and two incomplete left valves)

Horizon and Locality: Upper Disang Formation; Changamdabi (Locality no.1).

Description: Shell-small, tall, trigonally ovate, narrow dorsally, maximum length at about ventral two-fifth of height, strongly and evenly inflated, height more than one and quarter to the length. Anterior and posterior margins are slightly convex and subtending an angle of 66^0 at umbo. Ventral margin broadly convex and joining these two margins at about ventral third of height. Hinge is very short and curved. Umbones are prominent, incurved, salient and distinctly prosogyrate. Surface ornamented with radial ribs which are irregularly spaced and about forty in number. These radials are bearing spines. The bases of the spines are clearly visible especially near posterior extremity. Internal characters are unknown.

Measurement in mm:

Sp. no.	Length	Height	Inflation
US_2-5/59	13.6	18.6(136.7%)	100(75.7%)
US_2-5/9	11.0	15.0 (136%)	11.5(104.5%)
US_2-5/70	11.5	15.5 (134.7%)	7.4(64%)

Remarks: It does not appear that recorded form is similar to any of the described Eocene species of *Trachycardium*. However, the genotype *Trachycardium* (*Trachydardium*) *isocardia* Linné (Moore, 1969, p. N586, figs. E86, 5) thrive in Northern seas is distinctly broad and bear 27 ribs. On the other hand, *Trachycardium coxi* Mathur (1975, p. 23, fig.21, R-S) in also small in size but differs in being sub-triangular in outline and in bearing 18-21 radial ribs only.

Superfamily **Tellinacea** de Blainville, 1814
Family **Tellinidae** de Blainville, 1814
Subfamily T**ellininae** de Blainville, 1814
Genus ***Tellina*** Linné, 1758

(*Type species*: *Tellina albicans* Gmelin, 1791; OD Recent; Algeria)

Subgenus ***Peronidia*** Dall, 1900
Tellina (*Peronidia*) sp.
(Pl. I, figs. u, v)

Material: One left valve

Horizon and locality: Upper Disang Formation; Changamdabi (Locality no.1).

Description: Shell elongate, sub-elliptical, height about half of length, and compressed. Antero-dorsal margin straight and gently inclined at an angle of 25^0 and slightly shorter than postero-dorsal one which is also straight and inclined at about 30^0. Anterior and posterior margins almost of same height and narrow, however, former is convex and latter is vertically truncated. Ventral margin is gently convex. Umbo small, indistinct, situated at about anterior two-fifth of shell length. From umbo an angular carina runs to postero-ventral corner succeeded by a sulcus adjacent to it. Remaining posterior area is very narrow almost parallel sided and steeply inclined. A faint shallow sulcus is slightly oblique, sub-vertical running from antero-ventral corner to the dorsal margin. Shell surface covered by fine concentric commarginal grooves. Internal characters are unknown.

Measurement in mm:

Sp. no.	Length	Height	Inflation
US_2-8/ 901A	18.0	10.0 (55.5%)	3.0 (16.6%)

Remarks: The genotype *Tellina* (*Peronidia*) *albicans* Gmelin (Moore, 1969, p. N619 figs. E107, 3a-c) is also sub-elliptical but differs in having posterior margin much shorter than the anterior one and have two carinae instead of one. No other closely comparable form has been described by earlier workers.

Superfamily **Veneracea** Rafinesque, 1815
Family **Veneridae** Rafinesque, 1815
Subfamily **Pitarinae** Stewart, 1930
Genus ***Callista*** Poli, 1791

(*Type species*: *Venus chione* Linné, 1758; SD Meek, 1876. Recent; Mediterranean)

Subgenus ***Macrocallista*** Meek, 1876

(*Type species*: *Venus gigantea =Venus nimbosa* Lightfoot, 1786; Recent; Caribbean)

Callista (*Macrocallista*) sp.
(Pl. I, fig. o)

Material: One left valve

Horizon and Locality: Upper Disang Formation; Changamdabi (Locality no. 1).

Descriptions: Valve elongate, transversely sub-elliptical, height about $3/4^{th}$ of length with broad anterior and narrow posterior, and moderately inflated. Umbo small, prosogyrous and situated at about anterior –third of shell length. Lunule is small and well-marked. Escutcheon elongate and ill defined. Postero-dorsal margin is slightly convex and gently inclined. Antero-dorsal one short almost straight and moderately are descending. Posterior and narrowly rounded; anterior end broad and sub-angular. Ventral margin are evenly and moderately convex. Surface ornament consists of broadly spaced concentric grooves. Internal characters are unknown.

Measurement in mm:

Sp. no.	Length	Height	Inflation
US_3/781	16.5	3.0 (78%)	6.0 (36%)

Remarks: The best available comparable form seems to be the genotype thriving in recent seas of Caribbean Islands namely *Callista* (*Macrocallista*) *nimbosa.* Lightfoot (Moore, 1969, p. N677, fig. E144, 6) to which it is similar in respect of umbonal position, overall configuration and surface ornamentation and differs only in being more high 78% instead of 56%, in having narrow posterior end, and slightly convex ventral margin instead of sub-rectilinear. In all probabilities it seems to be are ancestral form of this Recent taxon, hence christened as *Callista* (*Macrocallista*) sp.

EXPLANATION OF PLATE I

(a). ***Aviculoperna changamdabiensis*** n. sp., Specimen No. US_2-5/2, external view of left valve x 1.5.
(b). ***Barbatia*** sp., Specimen No. US_3/841, external mould x 5.
(c), (f). ***Venericardia* (*Venericardia*) *spondyliformis*** n. sp., Specimen No. US_2-5/52: (c). external view of left valve x 2, (f). external view of left valve x 1.5.
(g), (k). ***Cucullaea* (*Cucullaea*)** sp., Specimen No. US_2-5/92: (g). external view of right valve x 2, (k). external view of right valve x 1.5.
(h). ***Lentidium* (*Lentidium*)** sp., Specimen No. US_3/938c, external view of right valve x 3.5.
(i), (j). ***Natica* (*Cochlis*) *manipurensis*** n. sp., Specimen No. US_2-5/56: (i) apertural view x 3, (j) dorsal view (same size).
(l), (m). ***Nucula* (*Nucula*)** sp., Specimen No. US_2-5/2, external view of left valve x 2.
(n). ***Protonoetia manipurensis*** n. sp., Specimen No. US_2-5/853, external view of left valve x 2.5.
(o). ***Callista* (*Macrocallista*)** sp., Specimen No.US_3/781, external view of left valve x 2.5.
(p), (q), (r). ***Trachycardium* (*Trachycardium*) *yairipokensis*** n. sp., Specimen No. US_2-5/9: (p) external view x 2, (q, r). side view (same size).
(s), (t). ***Pholas* (*Pholas*)** sp., Specimen No. US_2-5/403: (s). ventral view x 3, (t). external view of right valve (same size).
(u), (v). ***Tellina* (*Peronidia*)** sp., Specimen No. US_2-8/901A, external view of left valve x 3.
(w), (x). ***Septifer (Septifer)*** sp., Specimen No. US_2-5/74: (w). external view of right valve x 2.5, (x) external view of right valve x 1.
(y), (z). ***Patella*** sp., Specimen No. US_3/668: (y). posterior view x 3, (z). side view (same size).

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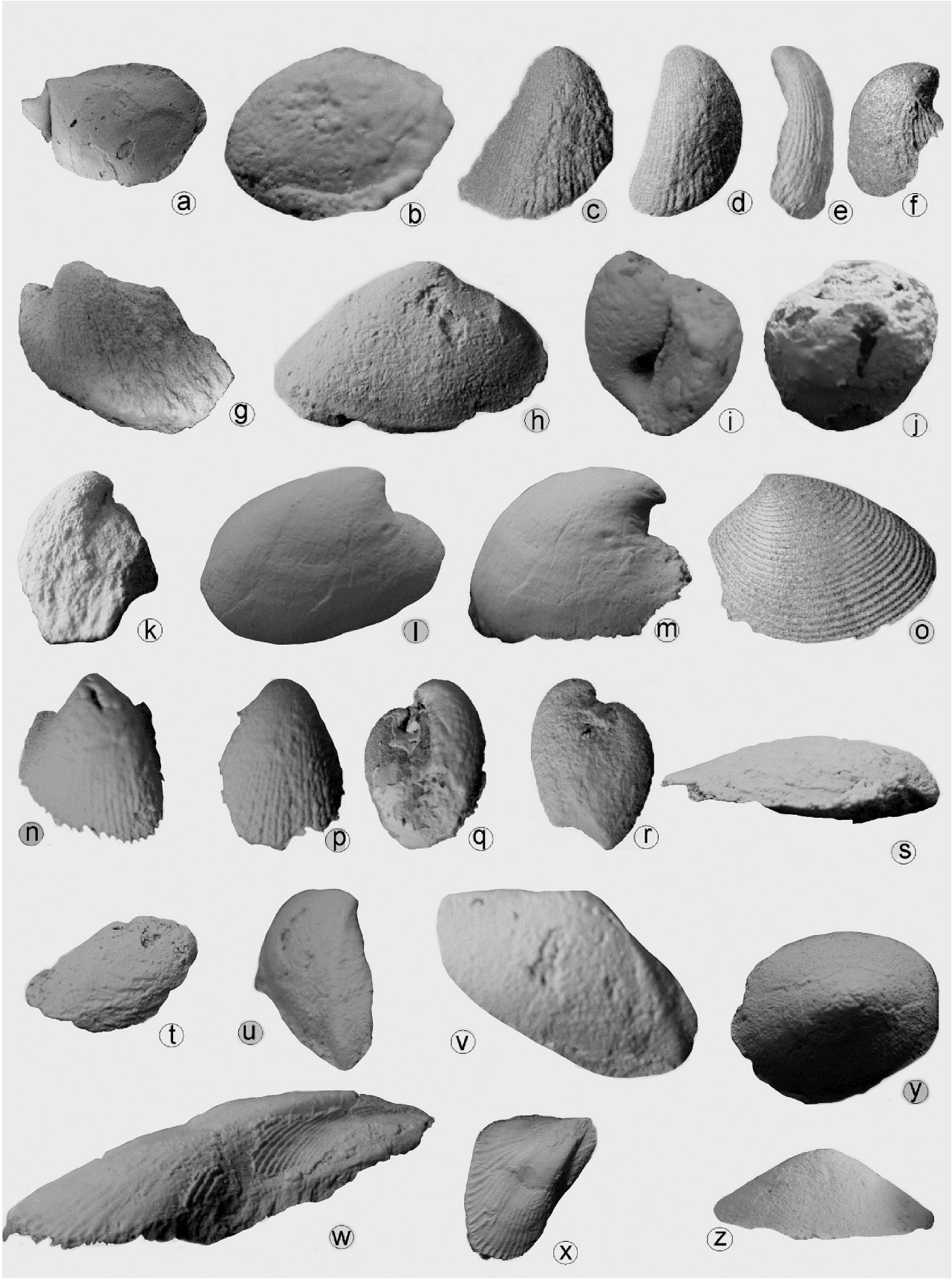
Plate I



Order **Myoida** Stoliczka, 1870
Suborder **Myina** Stoliczka, 1870
Superfamily **Myacea** Lamarck, 1809
Family **Corbulidae** Lamarck, 1818
Subfamily **Lentidiinae** Vokes, 1945
Genus ***Lentidium*** Cristofori and Jan, 1832.
Subgenus ***Lentidium*** s. str.

(*Type species*: *Lentidium maculatum* = *Tellina mediterranean* Costa, 1829; SM. Recent; Italy)

Lentidium (*Lentidium*) sp.
(Pl. I, fig. h)

Material: One right valve only

Horizon and Locality: Upper Disang Formation; Changamdabi (Locality no. 2).

Descriptions: Valve sub-triangular in outline, height about two-third of shell length, evenly convex and gently inflated with narrow anterior end and broad posterior end which in turn slightly and obliquely truncated, height about two-third of shell length, evenly convex and gently inflated. Umbo is small, sub-medium, slightly anterior to mid- line and indistinctly ophistogyrous. Antero-dorsal margin short, slightly convex merging with rounded anterior one in an uninterrupted curve. Ventral margin almost straight and meeting sub-vertically truncated posterior one in an acute angle slightly less than the right angle. Postero-dorsal margin longer than the antero-dorsal one straight and very gently inclined from umbo. An angular prominent carina runs from umbo to postero-ventral corner which in turn separates the steep posterior area. The nature of carina and area are like that of Tellinids. Surface is smooth except for very fine commarginal. Hinge plate is lacking as per character of the subfamily.

Measurement in mm:

Sp. no.	Length	Height	Inflation
US_3/ 938c	15.01	10.0(66.6%)	4.0 (26.6%)

Remarks: In overall configuration it is more nearer to living genotype *Lentidium* (*Lentidium*) *mediterraneum* (Costa) (Moore, 1969, p. N697, figs. E158, 5a.b) which is different on account of half the size, distinctly convex ventral margin, and vertically truncated posterior margin. As compared to *Lentidium tawneyi* curry (White, 1959, p. 56. pl. 14, fig. 1) from Upper Eocene of England which is also very small but has distinct narrow rounded posterior end as compared to anterior one. *Lentidium ?Kyushuense* Nagao (Oyama *et.al*., 1960, p. 82, pl. LXIII, figs. 3a,-c) from Eocene beds of Japan has outline just like equilateral triangle thus, different. It in the first record of genus from Eocene beds of India.

Suborder **Pholadina** Adams and Adams, 1858
Superfamily **Pholadacea** Lamarck, 1809
Family **Pholadidae** Lamarck, 1809
Subfamily **Pholadinae** Lamarck, 1809
Genus ***Pholas*** Linné, 1758
Subgenus ***Pholas*** s. str.

(*Type species*: *Pholas dactylus* Linné, 1758; SD Children, 1822; Recent; Malta)

Pholas (*Pholas*) sp.
(Pl. I, figs. s, t)

Material: One right valve

Horizon and Locality: Upper Disang Formation; Changamdabi (Locality no. 1).

Description: Valve small, well elongated height about less than half of the length, very inequilateral, more or less cylindrical in middle and compressed toward both ends. Umbo placed anteriorly at about one-fourth of shell length except for anteriorly beak like transversely elliptical in outline, dorsal and ventral margins almost parallel and sub-rectilinear, posterior end narrow and rounded, and anterior end beaked. There is presence of indistinct sulcus from umbo to ventral margin marked by sinuosity in ventral margin slightly anterior to umbo, surface ornamentation in form of the growth lines which are oblique to the dorsal margin, parallel to the ventral one and turning upward along sulcus and intersecting with ventral margin at gentle angle. Due to ill preservation nature of protoplast is not clear. Interior is hidden under the matrix.

Measurement in mm:

Sp. no.	Length	Height	Inflation
US_2-5/ 403	+12.0	6.2(51.6%)	3.0 (-25%)

Remarks: It is very small size with more height percentage distinguishes it from the genotype *Pholas* (*Pholas*) *dactylus* Linné (Moore, 1969, p. N708, fig. E165, 5a) living in Modern seas of Malta which is of very large size and narrow (height about one-third of length), thus, different. No other comparable form available for comparison.

Gastropods

The classification of Gastropods given by Davies (1971, Vol. I, pp.280-444) has been followed. The type species of the described genera and some of the authors are not given since a comprehensive Treatise is not available for reference.

Phylum **Mollusca** Linné, 1758
Class **Gastropoda** Cuvier, 1797
Subclass **Prosobranchia** Milne Edwards, 1848
Order **Archaeogastropoda** Thiele, 1925
Suborder **Patellina** Von Ihering, 1876
Superfamily **Patellacea** Rafinesque, 1815
Family **Patellidae** Rafinesque, 1815
Subfamily **Patellinae** Rafinesque, 1815
Genus ***Patella*** Linné, 1758

(*Type species*: *Patella Vulgata* Linné, 1758; SD. Fleming 1818. Recent; France)

Patella sp.
(Pl. I, figs. y,z)

Material: One internal mould

Horizon and Locality: Upper Disang Formation; Changamdabi (Locality no. 2).

Description: Shell capuliform with oval outline slightly narrow towards the anterior, apex sub-central slightly anterior to middle, apical angle of 130^0 surface appears to be sculptured with eleven strong radials and widely spaced concentric.

Measurement in mm:

Sp. no.	Height	Diameter at base	Spire angle
US_3/668	5.5	13.7	36.50

Remarks: The genotype from France namely *Patella* (*Patella*) *vulgata* Linné (Moore, 1960, p. I 234, figs., 147, 2) also have strong eleven radial ribs but differs in respect of having two to three secondary radial ribs between two primaries and has much narrow anterior periphery. In similar fashion *Patella caerulea* Linné a living species from France (Davies, 1971, p. 291, fig, 639) is distinguishable by its irregular oval outline, sufficiently narrow anterior end and in having irregularly distributed radial ribs.

Order **Caenogastropoda** Cox, 1959
Superfamily **Naticacea**
Family **Naticidae**
Subfamily **Naticinae**
Genus ***Natica***
(*Type species*: ***Natica vitellus*** Linnaeus, 1758)
Subgenus ***Cochlis***
Natica (*Cochlis*) *manipurensis* n. sp.
(Pl. I, figs. i, j)

Derivation of name: The species is named after the state of Manipur, India from where the collection is being made.

Diagnosis: Shell small conch, globose and naticoid without protoconch, spire small, distinct, fairly low, body whorl very large and convex, periphery of base regularly convex, umbilicus distinct and open, no funicle, parietal callus absent, aperture holostomatus oval.

Material: Five specimens

Horizon and Locality: Upper Disang Formation; Changamdabi (Locality no.1).

Description: Conch small, globose and naticoid without protoconch, spire small, distinct, fairly low and smooth comprises almost in plane with the apical margin of the body whorl and separated by deep channelled suture, overall height of the conch is about 80% of the diameter, body whorl very large and convex, periphery of base regularly convex, umbilicus distinct and open, no funicle, parietal callus absent, aperture holostomatus oval and occupies whole height of the conch. Inner and outer lips are feebly convex and almost parallel. Labrum thin, sinuous, prosocline and nearly vertical with upper part slightly reflected. There is a shallow vertical sulcus adjacent to outer lip. Surface of the last whorl bears fine reticulation as evenly spaced spiral threads crossed over by fined axial ones.

Measurement in mm:

Sp. no.	Height	Diameter at base	Spire angle
US$_2$-5/ 563	11.3	11.5	75
US$_2$-5/14	12.4	12.8	76
US$_2$-5/560	23.3	24.5	75
US$_2$-5/535	13.9	14.5	75
US$_2$-5/930B	23.5	23	75

Remarks: *Natica obscura* Sowerby (1940, pl XXVI, fig. 2) is very much similar in respect of nature of aperture and base but can be differentiated in having small and slightly raised spire at the same time aperture not occupying the whorl height. *Natica callosa* Sowerby (Noetling, 1895, pl. V, fig. 8) is an obliquely ovate form, therefore, different.

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