ON QUATERNARY MOLLUSCA FROM THE ISLANDS OF BOENJOE AND TARAKAN, E. BORNEO

BY

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CONTENTS.

PREFACE.

The purpose of the present paper is to describe the remains of two post-tertiary molluscan faunas from Eastern Borneo. The material is kept in the collections of the Leiden Geological Museum.

This collection is valuable, as almost no quaternary mollusca are known from Borneo. The locality Poeloe Boenjoe [1]) is very important, but the collection from Poeloe Tarakan is small.

Moreover, the material is in exceptionally good preservation and as all species described still live in the East Indian seas, they provide for the future comparison between these fossil faunas and those of the present sea; at present very little is known of the recent fauna of Northeast Borneo.

I sincerely hope that the present faunas will serve for further studies of the geographic and bathymetric distribution of the recent and fossil molluscan populations of the East Indies, as well as for studies of the facies conditions, problems which promise to be of great value for the more accurate subdivision of East Indian and other deposits, in connection with similar investigations which it is hoped will be undertaken in the surrounding parts of Asia.

Concerning the quaternary faunae of the Dutch East Indies beyond Java, Timor, Blitong and Celebes so little is yet known that the fauna of Boenjoe and Tarakan has a special call upon our attention, especially as by further research in various parts of the Indian Archipelago and of the Philippines, the composition, correspondence and divergences of the quater-

[1]) *Oe* of Dutch orthography to be pronounced as *oo*; "*poeloe*" means *island*.

nary faunas of the East Indies, their origin and their continuation in the subdivisions of the recent fauna may be better understood.

The material was partly derived from a locality with a limited number of species on the island of Tarakan (fig. 1), while a much richer fauna was found on the island of Boenjoe, to the Northeast of Tarakan. These collections

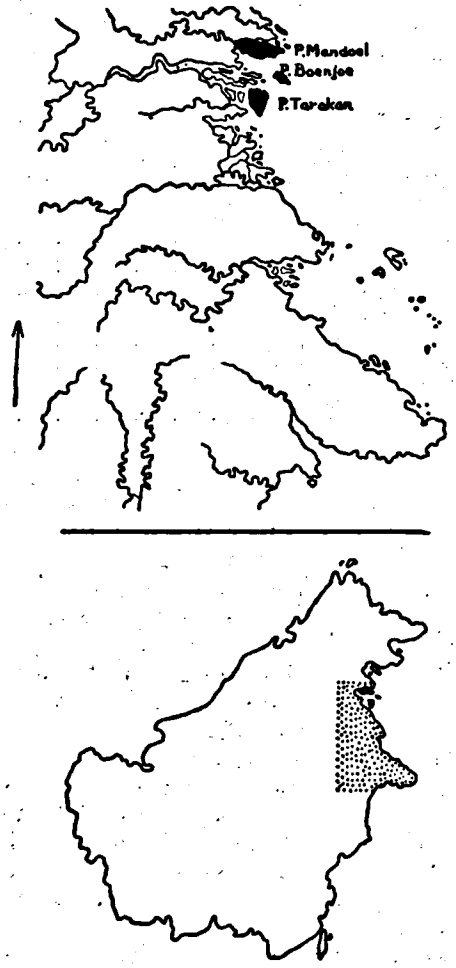


Fig. 1.

were assembled by order of the "BATAAFSCHE PETROLEUM MAATSCHAPPIJ", the directorate of which kindly allowed me to publish the results of the research, for which courtesy I wish here to express my thanks.

The material was examined at the end of 1922 by the late Prof. K. MARTIN; in a report to the "B. P. M." dated March 1923 MARTIN came to the conclusion that the faunas of Boenjoe and Tarakan were of quaternary age, that of Boenjoe certainly, of Tarakan probably.

Since that time, our knowledge of recent and fossil faunas in the

East Indies and neighbouring areas has been enlarged in many respects, both by new findings and by critical revisions and re-grouping of familiar data.

It appears from the identifications and is evident from the report, that MARTIN had used principally the collections of recent mollusca in the Natural History Museum in Leiden as basis of comparison; it would have been superfluous to go further in such cases, where the essential was to determine the age of the faunas as speedily as possible. This could be done with great ease, as — after MARTIN almost — all identified species proved to be in recent existence.

Moreover, it may be stated, that the collections of recent mollusca of the Natural History Museum have undergone great changes during the last years and lately they have been very much expanded (coll. MULDER). Also, by a comparison with the collection of the Zoological Museum in Amsterdam and by consulting valuable recent literature, new data on various Bornese fossils resulted in some additions and changes in the identifications, either through actually different determination or nomenclature, or by different conception of the limitations of the species.

Where alterations have been introduced, I have given the old identification beside the new one, so that anyone who may be able to compare MARTIN's report directly with the review now given, can easily follow the changes; a duplicate of MARTIN's report accompanies the collections.

It may further be remarked, that MARTIN's age determination at that time was, with reason, chiefly based upon the percentage of recent species, while now comparisons are made with the not distant Quaternary of North Celebes (Kajoe ragi) and of Blitong. Both the latter collections are also kept in the Geological Museum in Leiden and have been carefully examined, while the Pliocene? of the island of Mandoel (fig. 1) adjacent to Boenjoe, the Miocene of the same island, as well as faunas from numerous Neogene localities of East- and West-Borneo, which are still being worked out, have served as means of identification.

March 1944.

DESCRIPTIONS.

The numbers (St. ...) quoted in the present systematic part, are the registration numbers of specimens in the Geological Museum at Leiden.

The molluscan collection from Poeloe Boenjoe comprises the numbers St. 41757—'61 (inclusive), '63—'70, '73—'97, '99—41802, '04—'09; Tarakan: St. 41742—'50, '98. Other organisms: Boenjoe: St. 41762, '71, '72, '95, 41803; Tarakan: St. 41751, '52, '53, '54, '55.

Abbreviations: N. H. L. ("Rijksmuseum van Natuurlijke Historie", Leiden).
G. M. L. ("Rijksmuseum van Geologie en Mineralogie", Leiden).
Z. M. A. ("Zoölogisch Museum", Amsterdam).

In the following, the mollusca have been arranged according to THIELE's, WENZ's, and GRANT & GALE's systems.

A. POELOE BOENJOE.

Classis *Gastropoda*
Subclassis *Prosobranchia*

1. ARCHITECTONICA (ARCHITECTONICA) PERSPECTIVA (LINNÉ).

This species is widespread in recent time; in fossil state it also has a wide distribution (Neogene-Quaternary). It is represented by a single fine shell, which in every detail agrees with other specimens at my disposal, both recent (N. H. L., Z. M. A.) and fossil; alt. 6.6 mm, horizontal diameter 16 mm. References: vide VAN REGTEREN ALTENA, (1) 1938, p. 310; ALTENA & BEETS, 1944, pp. 37, 60, 66.
G. M. L., St. 41763.

2. TENAGODUS (TENAGODUS) TROCHLEARIS MÖRCH.

An East Indian species, showing more flattened (lower) whorls than other *Tenagodus*.

It is represented by a single shell, which had been left unidentified. The comparison of the Siboga expedition material in the Z. M. A. collections made the identification certain. *T. trochlearis* was hitherto unknown in East Indian deposits. References: vide SCHEPMAN, (2) 1909, p. 183. According to VREDENBURG (Mem. Geol. Surv. India, 50, II, 1928, p. 391) *T. trochlearis* will be synonymous with *"Siliquaria" granti* J. DE C. SOWERBY, 1839.
G. M. L., St. 41794.

3. XENOPHORA (XENOPHORA) SOLARIOIDES (REEVE).

Determined as *X. calculifera* (REEVE), which is a widely different species. The comparison with literature and recent material (N. H. L., Z. M. A.) proved the real identity of the fossil specimen; alt. 3.3, horizontal diameter 22.3 mm. Vide SCHEPMAN, (2) 1909, p. 202. *X. solarioides* has not been recorded previously from East Indian deposits, but MARTIN's *Xenophora* spec. 1 from the Pliocene of Atcheen (MARTIN, 1928, pp. 5, 15) belongs to the present species, as is proved by duplicates in the Leyden Geological Museum.
G. M. L., St. 41782.

4. TEREBELLUM (TEREBELLUM) TEREBELLUM (LINNÉ).

Synonyms are *T. punctatum* and *T. subulatum*. This species is widespread in the whole Indopacific area. It is represented by two fine shells, determined as *T. punctatum*, and agreeing in all respects with recent (N. H. L., Z. M. A.) and fossil shells. Alt. 38 and 45.5 mm. For references vide VAN ES, 1931, p. 51; OOSTINGH, 1935, pp. 58, 211, 216.
G. M. L., St. 41797.

5. STROMBUS (CANARIUM) PLICATUS LAMARCK.

This species is known as *S. urceus* (n e c LINNÉ), *S. dentatus* and *S. muricatus*. It is represented by a single shell (alt. 36 mm), determined as *S. muricatus* MARTINI. Its apex is missing. References: vide VAN REGTEREN ALTENA, (2) 1941, p. 55.
G. M. L., St. 41765.

6. STROMBUS (LABIOSTROMBUS) VARIABILIS SWAINSON.

Two shells present; alt. 39 (+ ?) and 45.5 mm. They agree very well with recent specimens in the N. H. L. collections, one of them showing a brown spot on the middle of its columella, as in recent shells. Vide VAN REGTEREN ALTENA, (2) 1941, p. 54.
G. M. L., St. 41809.

7. STROMBUS (DOXANDER) VITTATUS GMELIN.

MARTIN recorded two shells, but now only one is available, with damaged bodywhorl; alt. 38 (+ ?) mm. It agrees perfectly with recent material in the N. H. L. collections, especially with specimens representing the variety *turritus* LAMARCK. In the G. M. L. collection I saw two unidentified specimens from the Quaternary of Blitong (coll. VERBEEK), which belong to the same variety. References: vide SCHEPMAN, (2) 1909, p. 148; VAN DER VLERK, 1931, p. 247.
G. M. L., St. 41780.

8. POLINICES (POLINICES) MAMMILLA (LINNÉ).

This wellknown, widespread recent and fossil species is represented by two shells, agreeing in every detail with recent (N. H. L., Z. M. A.) and fossil material from various localities; alt. 18.5 and 22 mm. References are given by VAN REGTEREN ALTENA, (2) 1941, p. 61 and BEETS, 1941, pp. 72, 169, 175, 188, 201.
G. M. L., St. 41775.

9. EROSARIA (EROSARIA) EROSA (LINNÉ).

A single shell which agrees very well with recent specimens identified by SCHILDER (N. H. L.), especially with some shells labelled as variety *subpellucida* SCHILDER. Alt. 29 mm; outer lip with 15, inner lip bearing 16 folds.
G. M. L., St. 41757.

10. EROSARIA (EROSARIA) MILIARIS MILIARIS (GMELIN).

This species is represented by a single shell, with traces of yellow colour, agreeing well with some of the typical shells in the N. H. L. collections identified by SCHILDER. Alt. 28 mm; it bears 16 folds on its outer lip, 13 on its inner; two faintly toothed prolongations on the inner margin of the fossula, one of them hardly developed. The present shell does not agree with the subspecies *effossa* SCHILDER, nor with the smaller recent race *differens* SCHILDER, with which it agrees in size.
G. M. L., St. 41768.

11. ERRONEA (ADUSTA) ONYX ONYX (LINNÉ).

This common East Indian species is represented by a single shell (alt. 28.2 mm), which agrees well with typical recent specimens in the N. H. L. collections, identified by SCHILDER.
G. M. L., St. 41806.

12. ERRONEA (ERRONEA) cf. ERRONES (LINNÉ).

A single rather juvenile shell (alt. 21.2 mm), agreeing rather well with recent specimens (N. H. L.) and also with a quaternary shell from Poeloe Tarakan: vide infra.
G. M. L., St. 41790.

13. APOLLON (APOLLON) BITUBERCULARIS (LAMARCK).

A variable species, represented in our collection by a single fine specimen with rather coarse ribs; alt. 32 mm. It agrees perfectly with recent (N. H. L.)

and fossil material at my disposal. For references vide: BAYER, 1933, p. 38; BEETS, 1941, pp. 88, 169, 188, 194, 201; VAN REGTEREN ALTENA, (4) 1942, p. 96.
G. M. L., St. 41760.

14. CYMATIUM (LAMPUSIA) VESPACEUM (LAMARCK).

A single shell, rather juvenile (alt. 17.2 mm), agreeing well with some recent specimens (N. H. L.). I agree with TRYON in considering *C. thersites* (REEVE) a synonym — at the most a variety — of *C. vespaceum*, as the N. H. L. collection contains a fine series of specimens showing all the variability needed for uniting these forms.

SCHEPMAN's posttertiary shell from Kajoe ragi (N. Celebes) in the G. M. L. agrees also perfectly with recent *vespaceum*. For references vide: SCHEPMAN, 1907, p. 181; (2) 1909, p. 111; VAN DER VLERK, 1931, p. 239 (*vespaceum, thersites*); BAYER, 1933, p. 53; NUMURA, (2) 1935, p. 166 (114).
G. M. L., St. 41786.

15. TONNA (TONNA) CEPA (ROEDING).

A single fine shell, determined as *Dolium olearium* BRUGUIÈRE, which is a name preoccupied by LINNAEUS: vide BAYER, 1937, p. 32; YOKOYAMA, 1928, p. 47. Our shell agrees in every detail with recent material in the N. H. L. collections; alt. 32.5 mm.
G. M. L., St. 41807.

16. TONNA (TONNA) COSTATA (MENKE).

One shell, incorrectly identified as *Dolium tessellatum* BRUGUIÈRE, which is a species differing widely from the present one. The specimen is partly damaged, but its condition certainly allows of an exact determination. I compared it with fossil shells and also with recent material in the N. H. L. collections: vide BAYER, 1937, p. 34; VAN REGTEREN ALTENA, (4) 1942, p. 115; ALTENA & BEETS, 1944, pp. 40, 60, 66.
G. M. L., St. 41774.

17. FICUS (FICUS) SUBINTERMEDIA (D'ORBIGNY).

This characteristic species is represented by a single shell (alt. 23 mm), which had been identified as *Pyrula ficus* LINNÉ, a very different species.

The specimen from Poeloe Boenjoe agrees in all details with recent material in the N. H. L. collection and with fossil material as well. Vide: BAYER, 1939, p. 379; VAN REGTEREN ALTENA, (4) 1942, p. 120; ALTENA & BEETS, 1944, pp. 40, 60, 66.
G. M. L., St. 41793.

18. MUREX (CHICOREUS) ADUSTUS LAMARCK.

Represented by a single shell (alt. 32.5 mm), which agrees very well with equally small and slender recent specimens (N. H. L.); it is a common East Indian species. References: vide SCHEPMAN, (3) 1911, p. 346; VAN DER VLERK, 1931, p. 236; ADAM & LELOUP, 1938, p. 155.
G. M. L., St. 41808.

19. MUREX (MUREX) NIGRISPINOSUS REEVE.

This characteristic species is represented in our collection by a well-preserved shell; alt. 49 (+ ?) mm, its anterior canal partly damaged. The

specimen agrees perfectly with recent East Indian shells (N. H. L., Z. M. A.) and also with one of the specimens recorded by MARTIN (1880, p. 19) from the Quaternary of Blitong as *M. crassispina* LAMARCK (G. M. L.); the other Blitong shells might represent *M. tribulus* LINNÉ.

M. nigrispinosus has hitherto not been recorded from East Indian deposits. Vide SCHEPMAN, (3) 1911, p. 340.
G. M. L., St. 41758.

20. PHOS (PHOS) SENTICOSUS (LINNÉ).

This very characteristic species is represented by a single fine specimen; alt. 32.4 (+ ?) mm: apex missing. It agrees in all respects with recent East Indian shells (N. H. L., Z. M. A.). *P. senticosus* has not been recorded previously from East Indian deposits, but I saw a good specimen in the Quaternary collection of Blitong in the G. M. L. (coll. VERBEEK). Vide SCHEPMAN, (3) 1911, p. 304.
G. M. L., St. 41801.

21. NASSARIUS (NIOTHA) cf. LIVESCENS (PHILIPPI).

Two specimens in hand; alt. 16.6 and 17.2 mm. They agree well with some recent shells (N. H. L.) and also with SCHEPMAN's specimen from the Quaternary of Kajoe ragi (N. Celebes) in the G. M. L., which bears a very callous inner lip (vide VAN DER VLERK, 1931, p. 233).

The synonymics of this and other species related to it have been quoted in the literature quite unsatisfactorily, which is easily explained by the variability of the Nassariidae.

Thus PHILIPPI already noticed close relationship with *N. kieneri* DESHAYES, 1863 (nec ANTON, 1839), renamed as *N. seclusus* by P. FISCHER (1891: vide OOSTINGH, 1935, p. 77), a rather variable species, which has been observed sometimes as a fossil in the East Indian area. I could compare fossils from Java in the G. M. L. collections and from the Kendeng Mountains as well (det. VAN REGTEREN ALTENA), and indeed a general relationship cannot be denied. But according to the recent and fossil specimens of *N. seclusus* at my disposal, the Boenjoe and recent N. H. L. shells referred to *N. livescens* differ constantly in sculpture: the first always show coarser ribs on part of the body-whorl, although a few shells may be almost similar. Further the strong band along the upper suture is, in general, broader, and in any case the inner lip is never as much expanded to the left as in the shells referred to *N. livescens*.

Another question is, whether the real *N. livescens* (PHILIPPI: Zeitschr. f. Malak., 1848, p. 135), which was figured by LISCHKE (1871, p. 52, pl. 4, fig. 1—3), who compared the type material, is really the same species as the shells referred to it above, for LISCHKE's figures also show coarser ribs [1]) and a less expanded inner lip; TRYON gave a poor figure: (4) 1882, p. 54, pl. 16, fig. 304. In my opinion those authors, who suggest identity of *N. livescens* with *N. seclusus*, may be right, but I dare not identify my quaternary (and the recent N. H. L.) shells as *N. seclusus* s. str. I should like to give them a position nearer to *N. livescens*, whether taken as a synonym or variety of *N. seclusus* or as a separate species.

[1]) HIRASE (Coll. Jap. shells, 1936, pl. 106, fig. 8) has figured a representative of *N. livescens* which agrees perfectly with the Boenjoe fossils and the recent shells mentioned above as synonyms.

The real *N. livescens* has been observed from Japan to China, Philippines, East Indies, so it seems possible, that the recent and fossil shells mentioned above represent a more southern variety or subspecies, differing in having a more expanded inner lip and finer axial sculpture on the body-whorl. The outer lip of our fossils bears 10 inner plaits (vide OOSTINGH: *seclusus:* 11—14). In my opinion too, *N. marginulatus* (REEVE) [REEVE, Conch. Icon., 8, 1853, *Nassa*, spec. 43; TRYON, l. c., pl. 16, fig. 301] is a perfect synonym of *N. seclusus*, and *N. isabellei* (REEVE) [nec D'ORBIGNY] as well: TRYON, l. c., pl. 16, fig. 281, 303; REEVE, l. c., spec. 47.

N. livescens has been recorded from young Neogene and Quaternary deposits of Japan and Formosa by YOKOYAMA, OTUKA and other palaeontologists.

G. M. L., St. 41802.

NASSARIUS spec.

A single damaged shell, too bad to allow of an exact determination.

G. M. L., St. 41792.

22. LATIRUS (PERISTERNIA) LYRATUS (REEVE).

A single fine shell is available; alt. 33.3 mm. The specimen, which had been left unidentified, agrees perfectly with a recent representative of this rare species in the N. H. L. collections, which has been obtained very recently (1943, det. FULTON): vide REEVE, Conch. Icon., 4, *Turbinella*, 1847, pl. 3, spec. 13.

TESCH (1915 (1), p. 54, pl. 10, fig. 118*a*—*b*) has figured a fossil shell from Timor as *L. madiunensis* MARTIN — not quoted in VAN DER VLERK's checklist: 1931 — which I cannot distinguish from *L. lyratus*, according to the figures. It shows a remarkable resemblance with the Boenjoe specimen; on the other hand TESCH's figures are very different from the real *L. madiunensis* MARTIN (Foss. v. Java, p. 88), with which TESCH incorrectly identified the fossil from Timor.

G. M. L., St. 41761.

23. VEXILLUM (VEXILLUM) LYRATUM (LAMARCK).

This characteristic species is represented by a single fine specimen; alt. 53.4 (+ ?) mm, larger than recent East Indian shells in the N. H. L. References: vide SCHEPMAN, (3) 1911, p. 280; VAN DER VLERK, 1931, p. 227; DAUTZENBERG, (2) 1935, p. 126.

G. M. L., St. 41770.

24. VEXILLUM (PULCHRITIMA) VULPECULA (LINNÉ).

A single beautiful shell (alt. 48 mm), agreeing in all details with recent specimens (N. H. L.), especially with the more slender forms. Vide: SCHEPMAN, (3) 1911, p. 279; OOSTINGH, 1925, p. 265; VAN DER VLERK, 1931, p. 228; DAUTZENBERG, (2) 1935, p. 127.

G. M. L., St. 41795.

25. MARGINELLA (CRYPTOSPIRA) TRICINCTA HINDS.

Two shells with six columellar plaits; alt. 17.5 mm (maxim.). They were labelled *M. quinqueplicata* LAMARCK var. *minor* MARTIN, but agree well with

recent and fossil representatives of *M. tricincta*: vide OOSTINGH, (5) 1938, p. 121—122, 125. This species will be discussed in another paper.

In one of the present shells, a juvenile one, the very short spira is already surrounded by a callous wall, but it has not been fully covered as in adult specimens.
G. M. L., St. 41799.

26. TURRIS (TURRIS) BABYLONIA (LINNÉ).

This characteristic species is represented by a single beautiful shell; alt. 32 mm. It agrees perfectly with recent shells in the N. H. L. collections and shows even the typical colour spots very well. Fossil distribution in the East Indies: no previous records. For references vide: ADAM & LELOUP, 1938, p. 196.
G. M. L., St. 41789.

27. CONUS VITULINUS HWASS.

Not recorded previously from East Indian deposits, whether quaternary or older. It is represented by a single perfect specimen (alt. 28.1 mm), which agrees in every detail with some recent shells (N. H. L.). Vide: DAUTZENBERG, (3) 1939, p. 278.
G. M. L., St. 41769.

Classis *Lamellibranchiata*
Ordo *Taxodonta*

28. ARCA (BARBATIA) DECUSSATA (SOWERBY).

A single left valve in hand, showing the typical features of *A. decussata* (Z. M. A.); length almost 50 mm. It had been identified as *A. helblingi*, which is another, though very closely allied form (= *Arca nivea*). The specimens in the N. H. L. collections, with which MARTIN compared the Boenjoe shell, do not agree with the latter; they were labelled afterwards as *A. foliata* FORSKÅL in the sense = *helblingi* = *nivea* = *decussata*. For references vide LAMY, 1907, pp. 65—71; VAN DER VLERK, 1931, p. 270 (pars [1]); PRASHAD, 1932, p. 42; ADAM & LELOUP, 1939, p. 40.
G. M. L., St. 41759.

Ordo *Anisomyaria*

PINNA spec. indet.

A single valve, too badly preserved to allow of an identification.
G. M. L., St. 41785.

29. PECTEN (JANIRA) PYXIDATUS (BORN).

A single concave left valve (height 25 mm) which had been left unidentified. It agrees perfectly with recent material (N. H. L., Z. M. A.) from the East Indies. Ventral margin and ears are partly damaged. For *Janira* vide: GRANT & GALE, 1931, p. 220.

[1]) Exclusive of Bibl. 65[3], p. 206 = *Arca cheribonensis* OOSTINGH (1935, pp. 126—128, 218).

P. pyxidatus has been recorded previously by OOSTINGH from East Indian deposits (1935, pp. 150, 218). For references vide also: LYNGE, 1909, p. 153.
G. M. L., St. 41776.

OSTREA spec. indet.

Too juvenile to allow of an exact determination.
G. M. L., St. 41783.

Ordo *Eulamellibranchiata*

30. CRASSATELLA RADIATA SOWERBY.

This typical East Indian and Indian Ocean species (→ Red Sea) is represented by a left valve, which agrees perfectly with recent material (N. H. L.) and fossil shells at my disposal (Miocene to Quaternary); height 14, length 19.4, diameter 3.7 mm. For references vide: LAMY, 1914, p. 224; VAN DER VLERK, 1931, p. 275; VAN ES, 1931, pp. 58, 96, 116, 119; PRASHAD, 1932, p. 141; OOSTINGH, 1935, pp. 165, 218.
G. M. L., St. 41777.

31. CARDITA (CARDITA) CANALICULATA REEVE.

An easily recognizable species, represented by five valves, the biggest with the following dimensions: height 25.7, length 30, thickness 16.5 mm. I could compare some typical recent shells in the N. H. L.

C. canaliculata was hitherto unknown in East Indian deposits. References: vide LAMY, 1921, p. 328 (*Cardita* = *Cardites*: vide THIELE, 2, p. 847).
G. M. L., St. 41787.

32. TARAS (TARAS) GLOBOSUS (FORSKÅL).

Syn.: *Diplodonta*: vide GRANT & GALE, 1931, p. 293. One complete shell and two valves, which had been left unidentified. They agree perfectly with "*Lucina* spec." (MARTIN, 1880, p. 18) from the Quaternary of Blitong, which also is a true "*Diplodonta*". This species is rather variable in outline. I compared some recent specimens in the Z. M. A.: vide also PRASHAD, 1932, p. 165. Our shells bear a shallow radial depression along the posterior dorsal margin, which is developed more clearly than in the material I compared. Fossil occurrence: no previous records.
G. M. L., St. 41781.

CHAMA spec. indet.

A single juvenile valve (MARTIN reported two valves). I compared it in vain with recent and fossil material in the N. H. L., Z. M. A. and other collections. More than one species showed close affinities.
G. M. L., St. 41796.

LAEVICARDIUM (TRACHYCARDIUM) spec.

A single damaged valve, determined as *Cardium flavum* LINNÉ, but bearing only superficial resemblance with the anterior portion of a few of the specimens of this variable recent and fossil species which were compared.

For the moment it had to be left unidentified, as I could not find it among the species present in the N. H. L. and Z. M. A. collections or in literature (more than one species showing resemblance, judging by figures only).
G. M. L., St. 41800.

33. PAPYRIDEA (FULVIA) PAPYRACEA (BRUGUIÈRE).

One left valve present; length 19.4, height 20.2, diameter 7 mm. I compared it with recent material in the N. H. L. and Z. M. A. collections. The specimen even shows the fine granulation between the anterior riblets and agrees in all details with the specimens compared. Vide: VAN DER VLERK, 1931, p. 276 *("Cardium")*; LYNGE, 1909, p. 258.
G. M. L., St. 41791.

34. LIOCONCHA ORNATA (DILLWYN).

Syn.: *Lioconcha picta* (LAMARCK). For some reason MARTIN has left unidentified a single right valve, which agrees perfectly with recent specimens in the N. H. L. and Z. M. A. collections, and with the quaternary shells from Kajoe ragi (N. Celebes) and Blitong in the G. M. L. as well. Length 27.7, height 22.4, diameter 8 mm. The specimen agrees especially with relatively longer (lower) recent and fossil representatives of this species. For references vide: OOSTINGH, 1925, p. 293; VAN DER VLERK, 1931, p. 277 (*"Circe"*) and 278 (*"Cytherea"*); PRASHAD, 1932, p. 219; LAMY & FISCHER—PIETTE, (2) 1937, p. 274.
G. M. L., St. 41788.

35. GAFRARIUM (CIRCE) SCRIPTUM (LINNÉ).

Syn.: *Circe undatina* LAMARCK. Seven valves in hand, identified as *Cytherea undatina* LAMARCK, representing a common East Indian faunal element and agreeing very well with recent specimens (N. H. L., Z. M. A.) and also with a series of fossil shells from Blitong (MARTIN, 1880), especially from the collection-VERBEEK in the G. M. L. (not mentioned in literature). References: vide PRASHAD, 1932, p. 223; OOSTINGH, 1935, pp. 180, 219; LAMY & FISCHER—PIETTE, (3) 1937, pp. 384—385; BEETS, 1941, pp. 195, 197.
G. M. L., St. 41778.

36. GAFRARIUM (CIRCE) SULCATUM (GRAY).

A single right valve, which was left unidentified and agrees perfectly with the Siboga expedition material in the Z. M. A. collection. Its dimensions are: length 16.5, height 14.8, diameter 3.8 mm. References: vide PRASHAD, 1932, p. 226. This species is unknown in other East Indian deposits.
G. M. L., St. 41764.

37. PITAR (MACROCALLISTA) LILACINUS (LAMARCK).

Determined as *Cytherea* (*Callista*) *spuma* BOLTEN. I compared recent shells in the N. H. L. and Z. M. A. collection and some fossil specimens from W. Java (det. ALTENA & BEETS), with which our two fossil valves agree very well, especially with forms rather pointed anteriorly.

The smallest valve, with partly eroded surface, shows superficial resemblance in sculpture with *P. floridus* (LAMARCK), but it may easily be distinguished from this species on account of its pointed instead of rounded anterior margin. Vide: LAMY & FISCHER—PIETTE, (1) 1937, p. 213; ALTENA & BEETS, 1944, pp. 56, 61.
G. M. L., St. 41805.

DOSINIA spec. indet.

A few fragments, which perhaps might be identified if more material from the same locality becomes available.
G. M. L., St. 41766.

38. **VENUS (LIROPHORA) TIARA** DILLWYN.

Three left valves, agreeing in every detail with recent specimens (N. H. L., Z. M. A.) and with fossil material from W. Java (det. ALTENA & BEETS); length maxim. 25 mm. A synonym is *V. foliacea* PHILIPPI. References: vide YOKOYAMA, 1928, p. 80; PRASHAD, 1932, p. 239; NOMURA, (1) 1933, p. 86; ALTENA & BEETS, 1944, pp. 57, 61.
G. M. L., St. 41804.

39. **PAPHIA (PARATAPES) TEXTILE** (GMELIN).

Only a damaged left valve, determined as *Tapes textrix* CHEMNITZ, which is a synonym. Hinge and part of the shell are in perfect condition and it agrees very well with recent East Indian specimens (N. H. L.). For references vide:: PRASHAD, 1932, p. 239; OOSTINGH, 1935, pp. 190, 219; FROMAGET, 1927, p. 189.
G. M. L., St. 41784.

SOLEN (SOLEN spec. indet.

A single damaged and juvenile valve, which I could not identify, although it seems to correspond to *Solen* spec. from the Quaternary of Blitong in the G. M. L. (MARTIN, 1880).
G. M. L., St. 41773.

40. **ALOIDIS CRASSA** (HINDS).

Syn.: *Aloidis socialis* nec (MARTIN) [pars]: TESCH, 1920, VAN ES, 1931; *Aloidis lamellata* (FISCHER): 1927.

Some well preserved valves are available. I compared them with the recent shells in the Z. M. A. collection (vide also PRASHAD, 1932, p. 309) and found the whole series rather variable in shape and sculpture, more than is illustrated by PRASHAD's figures.

As in the Siboga expedition material and FISCHER's fossil shells, of which I compared some duplicates (in the G. M. L. collection: det. FISCHER) with ribs closer than in FISCHER's figures (1927, p. 131, pl. 6, fig. 124*a*—*c*, 125—126), the concentric ribs may lie at short or rather broad intervals. Fine radial striations are well developed. As some recent shells agree in every detail with FISCHER's figures I cannot doubt the revised identification. OOSTINGH has stated (1935, p. 204, note 1), that part of VAN ES' fossil material of *A. "socialis"* (1931, pp. 116, 120) from Java belongs to *A. lamellata*; on the other hand a certain amount of TESCH's fossils from Timor must belong to *A. crassa* too, in any case the shells of his figures 285*a*—*b* and 286*a*—*b* [(2) 1920, p. 106 pars, pl. 22]; the other specimens from Timor are fairly characteristic *socialis* (fig. 284 ???).

I know *A. crassa* also from the Quaternary of Blitong (coll. VERBEEK, G. M. L.), from the Miocene of Western Borneo (this material will be discussed in another paper), and from the javanese Poetjangan-layers (Kendeng beds): Nr. 217 and 218, 1934 in the Geological Institute at Utrecht.
G. M. L., St. 41767.

41. CRYPTOMYA cf. TRUNCATA GOULD.

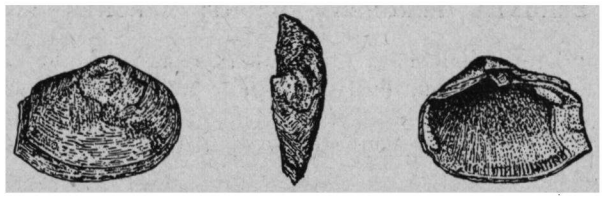
Textfigures.

A single right valve which I could not identify with any of the figured recent or fossil species known. It differs from *C. elliptica* in having a pointed transition between ventral and posterior margin, and a distinctly truncated instead of rounded posterior margin.

LAMY (1926, p. 172) gives the synonymics of *C. elliptica* and quotes *C. truncata* GOULD, 1861 as a synonym on the authority of ADAMS. Unfortunately GOULD did not figure his species, for it seems very probable, that the Boenjoe shell may represent *C. truncata*; in that case *C. truncata* undoubtedly would represent — in our opinion — a separate species from *C. elliptica*, according also to its name, which cannot possibly apply to a shell like that of *C. elliptica*.

For the moment this question must be left an object for further investigation, and as it might be of interest for other students I figure the valve from Boenjoe.

The inner surface of the valve is radially striate, more pronounced near



Cryptomya cf. *truncata* GOULD, nat. size. Loc. Boenjoe. C. B. del.

the basal margin, perhaps owing to fossilisation conditions. Muscle scars are well developed, the anterior along the anterior margin of the valve, the posterior on an elevation along the upper margin.

The outer surface shows a marked growth-interval, according to a coarse growth-line near the outer margin. The growth-lines of the posterior and ventral parts meet at an angle corresponding with the ventral posterior point of the valve; the radial line from the umbo to this point does not correspond with a radial elevation: the greater part of the valve is rather flat, except anteriorly, where a rounded angle marks the transition between the flattened portion and a separate anterior radial zone.

A certain part of the shell-surface is rather corroded, but the remainder shows that the numerous fine growth-lines, which cover the greater portion of the valve, are replaced by a weakly lamellated sculpture on a radial posterior zone anteriorly along the line which corresponds with the point mentioned above. The dorsal posterior portion is ornamented with rather coarse growth-lines corresponding with the distinct truncation of the valve. Very inconspicuous radial lines are visible on a well preserved part of the middle of the shell-surface; they are too faint to be figured correctly.
G. M. L., St. 41779.

B. POELOE TARAKAN.

Classis *Gastropoda*
Subclassis *Prosobranchia*

42. LIOTIA (LIOTINA) PERONII (KIENER).

A single shell, agreeing very well with a few recent specimens (N. H. L., Z. M. A.), especially with one bearing fewer and coarser radial ribs than other shells and a rather coarse ridge around the umbilicus (vide REEVE's figures). References: vide SCHEPMAN, (1) 1908, p. 34. The fossil has the following dimensions: alt. 15.5, horizontal diameter 17 mm.
G. M. L., St. 41745.

43. CERITHIUM TRAILLI SOWERBY.

This characteristic species was abundantly represented: MARTIN reported 23 shells, but apparently some of them were sent back to the "B. P. M." after identification, for now only 12 specimens are available. They all agree perfectly with recent shells (N. H. L.), especially with some with faded colours. The whorls may be more angulated or flattened, as in recent examples. Vide SOWERBY, Thes. Conchyl., 2, 1855, *Cerithium*, p. 871, pl. 182, fig. 173—174. [nec ADAM & LELOUP, 1938, p. 107].
G. M. L., St. 41746.

44. ERRONEA (ERRONEA) ERRONES ERRONES (LINNÉ).

A single undetermined shell, but MARTIN suggested close relationship to *E. errones*, although he apparently did not have a good series of recent shells such as is now available. The shell shows typical colour remains and agrees perfectly with some recent shells identified by SCHILDER (N. H. L.). Length 31 mm.
G. M. L., St. 41749.

45. DRUPA (MORULA) CONCATENATA (LAMARCK).

A single well preserved shell; alt. 22.5 mm. It agrees in every detail with recent and fossil shells (det. SCHEPMAN) and with TESCH's figures as well: vide SCHEPMAN, (3) 1911, p. 357; VAN DER VLERK, 1931, p. 238; ADAM & LELOUP, 1938, p. 162.

Most features of this species agree with the type of *Morula, D. ricinus* (LINNÉ), but the fainter dentition of its inner and outer lip agree better with *Drupella*: type: *D. ochrostoma* (DE BLAINVILLE); this, however, is a differently sculptured group.
G. M. L., St. 41747.

Classis *Lamellibranchiata*
Ordo *Taxodonta*

46. ARCA (BARBATIA) FUSCA BRUGUIÈRE.

Syn.: *Arca javana* MARTIN (fossil). Two shells represent this common East Indian species; they are so fresh looking, that I can hardly distinguish them from recent specimens, of which I could compare a good series (N. H. L., Z. M. A.). The length of the valve is 60 mm. References: vide PRASHAD, 1932, p. 45; ADAM & LELOUP, 1939, p. 40; BEETS, 1941, pp. 5, 148, 171, 181, 188, 190, 194, 197.
G. M. L., St. 41744.

Ordo *Anisomyaria*

47. BRACHYODONTES (SEPTIFER) BILOCULARIS (LINNÉ).

This very common East Indian and Indian Ocean species is relatively abundantly represented by shells which are hardly distinguishable from recent specimens (N. H. L., Z. M. A.). For references vide: OOSTINGH, 1925, p. 263; VAN DER VLERK, 1931, p. 270; PRASHAD, 1932, p. 69; ADAM & LELOUP, 1939, p. 46.
G. M. L., St. 41743.

48. OSTREA (LOPHA) HYOTIS (LINNÉ).

A single valve; MARTIN reported two, so apparently one has been sent back to the "B. P. M." after identification. The specimen agrees perfectly with recent shells (N. H. L., Z. M. A.). References: vide VAN DER VLERK, 1931, p. 265; VAN ES, 1931, pp. 58, 89, 97; PRASHAD, 1932, p. 129; NOMURA, 1933, p. 48; ADAM & LELOUP, 1939, p. 66.
G. M. L., St. 41742.

49. OSTREA cf. TOWNSENDI MELVILL.

A single juvenile valve (height 33.5 mm), which I compared with recent material in the N. H. L. collection, but as the latter is much larger I dare not give the small fossil a more definite position. The condition of the shell is perfect; like the recent oyster it still shows violet colours. Vide MELVILL, 1898, Mem. a. Proc. Manchester Lit. a. Phil. Soc., 42, p. 27, pl. 2, fig. 14; COX, 1930, Glasgow Univ. Publ. 17, p. 128.
G. M. L., St. 41798.

Ordo *Eulamellibranchiata*

50. CHAMA PLINTHOTA COX.

Syn.: *Chama imbricata* BRODERIP, 1834 [nec LAMARCK, 1801 (= *macrophylla* GMELIN[1])]: vide COX, 1927, p. 98.

A single globular valve; height 70, diameter 35 mm. MARTIN did not identify it, for he only compared the N. H. L. collections, containing no material comparable with the present fossil. I saw a perfectly identical specimen in the Z. M. A. collection, a shell recorded by Miss VAN BENTHEM JUTTING from prehistoric remains: Dudumunir (VAN BENTHEM JUTTING, 1940). Vide SCHEPMAN, 1907, p. 197; LAMY, 1927, p. 321; ADAM & LELOUP, 1939, p. 70.
G. M. L., St. 41750.

51. MACOMA (MACALIA) BRUGUIEREI (HANLEY).

One unidentified left valve, more thick-shelled than SCHEPMAN's quaternary right valve from Kajoe ragi (N. Celebes) in the G. M. L. collection: SCHEPMAN, 1907, p. 195. I know this rare species also from the Pliocene? of the island of Mandoel near Boenjoe and Tarakan, and from the Neogene of N. Guinea [Coll. Geol. Inst. Utrecht, No. 482, 483, 484, 485: 1934 (Loc. Wichmann No. 630, 631, 632, 640)].
G. M. L., St. 41748.

[1]) According to LAMY, 1927, pp. 308—310.

DISCUSSION OF RESULTS.

I.

A. Poeloe Boenjoe.

The locality at which the species were collected, so far yielded 40 determinable mollusca. All of them could be identified by comparison not only with illustrations but with recent (and fossil) material, which for palaeontological research is naturally of great importance, especially as it could be demonstrated that all the determined species are of recent occurrence.

The high percentage (maxim.) of recent species can point only to a young quaternary, subrecent age of the fauna, which must therefore be younger than most of the quaternary faunas of Java, Timor and Celebes, in which a certain percentage of extinct forms leads to a lower percentage figure.

As MARTIN quite rightly observes in his report, this fact is not affected by the occurrence of some of the determined species (he referred to gastropoda: see below), both gastropods and lamellibranchs, in various neogene deposits — even down to Old Miocene — of the Dutch East Indies and the neighbourhood: Burma, Assam, the Philippines, as well as Formosa, Japan, India, East Africa and Persia.

All species, it should be emphasized, are typical elements of the Indo-Pacific fauna; many of them may indeed be regarded as distinctive elements of the East Indian fauna, which are little found elsewhere. This is a further argument in support of the age determination by the percentage method, as the fauna of the East Indian Neogene, on the contrary, contains many elements which betray foreign influence, besides elements which bear an extremely local character.

The excellent preservation of the material moreover, although by itself a most unreliable distinction, confirms the evidence of the above criteria.

MARTIN came to the same conclusion in his report, basing it upon 25 (24) gastropods; he left the lamellibranchs out of consideration, owing to absence of sufficient comparison material and knowledge of their distribution in the Neogene, although he mentioned that the percentage figure of the bivalves determined by him agreed with the more certain results of the gastropoda research. No further comparisons are indicated in this report.

A very similar case amongst the East Indian fossil faunas is found in the fauna of Blitong, the only directly comparable case so far known[1]).

In the first place we may compare the conservation of the material: the remarkably good state of preservation of most specimens matches the Blitong-fauna (vide: MARTIN, 1880). In many cases the shells show the original polish and often traces of colour are preserved. The total number of species was 49 and all of them are still to be found alive; they are known from surrounding waters or nearby.

MARTIN in 1880 concluded (l. c., pp. 17—20): "In the first place there can be no doubt, that species occuring in posttertiary strata must belong, when representatives of the same species are still living, to the same zoogeographical area of the present time, in which that species is now found... A change may however have taken place in the distribution of the animals

[1]) Vide also the subrecent fauna of Goenoeng Mendong [(Kari Orang): Fig. 2] which will be discussed in another paper.

in these areas with regard to the several islands during the posttertiary epoch as well. Still when similar faunas, as the one here described from Blitong, will gradually become known from a number of other islands, they can yield interesting results with respect to the distribution of animals at a former period."

We must also take into consideration, that for the present there is no possibility of establishing a detailed scheme of the distribution of species over small areas. Like this the f a c i e s must be minutely examined and conclusions drawn from it. Unfortunately, no sufficient data are available yet. Palaeontology seems to be a step in advance of biology in this respect, as the fossil sediments can be much more easily studied — at least in vertical sense — although less thoroughly, than most of the recent deposits.

In this case it is perhaps of little zoogeographic significance that of the species from the Quaternary of Boenjoe (and Tarakan) so few are found in the Neogene of East Borneo, as a difference in the *milieu* during the deposition of the Neogene and the Quaternary in Eastern Borneo may very well account for the differences so far noted, with a lack of data taking only the second place.

If we take as an example the Pliocene? of the neighbouring island of Mandoel (see figs. 1, 2), we find that of some 66 species (which are still under inspection) not one also occurs in the quaternary fauna of Boenjoe, while no less than 34 species from Mandoel still occur in the recent fauna. This contrast is quite significant: Boenjoe represents a facies differing clearly from that of Mandoel.

On the other hand the fauna of Boenjoe has a few species in common with a fauna of approximately the same age of Blitong (the Quaternary of Java may be left out of consideration for the present), viz.,

(Between square brackets: MARTIN's denomination of 1880)

Terebellum terebellum [*subulatum*].
Strombus plicatus [*urceus* (n e c LINNÉ)]
Polinices mammilla
Murex adustus
Murex nigrispinosus [*crassispina* (partim)]
Taras globosus [*Lucina* spec.: p. 18]
Papyridea papyracea
Lioconcha ornata [*Cytherea picta*]
Gafrarium scriptum [*Circe undatina*].

Nine species, which number rises to 12 as in the VERBEEK collection of similar age from Blitong (G. M. L. collections) I recognized the following species, also known from Boenjoe:

Strombus vittatus var. *turritus*
Phos senticosus
Aloidis crassa.

I have also thoroughly compared the Boenjoe fauna with the quaternary fauna of Kajoe ragi (N. Celebes: vide fig. 2) in the G. M. L. collections, which was identified by SCHEPMAN (1907). The general preservation of this material is even better than of the Boenjoe fauna, but the material contains some extinct forms. The number of species is about 212, containing some 17 extinct forms; the percentage figure of recent species is therefore about 92 %. Eight species also occur in the fauna of Boenjoe, viz.,

Strombus plicatus [*dentatus, muricatus*]
Erosaria erosa
Apollon bitubercularis
Cymatium vespaceum [*thersites*]
Tonna costata
Nassarius cf. *livescens*
Vexillum lyratum
Lioconcha ornata.

It would certainly be dangerous to draw further conclusions from these data at present, but it may be stated that the fauna of Boenjoe shows more affinities to the certainly older Quaternary of Northern Celebes and the contemporaneous Young Quaternary of Blitong than to the numerous Neogene-faunas from Eastern Borneo at my disposal (from the South to Mandoel) or to the Neogene fauna from some localities in Serawak and Broenei in Western Borneo.

B. Poeloe Tarakan.

Of this locality only nine species have been determined with certainty, all of which, as in Boenjoe, are still found existant. For this fauna the same holds with a fairly great degree of certainty as for Boenjoe as regards age, *however small the number of species may be.*

The material is in general even better preserved than that from Boenjoe and hardly looks like a fossil fauna. A few shells (see text) cannot be distinguished by their state of preservation from part of the recent specimens compared. The corals, also, which were collected with these mollusca, have a very young habitus. The *Chama* shell, however, which is covered with moss on one side, shows that the fauna was lifted above sea-level and that it was not collected on the beach.

The only species that this limited fauna has in common with the Pliocene? fauna of Mandoel is *Macoma bruguierei*, with the Quaternary of Blitong *Arca fusca*, with the fauna of Kajoe ragi:

Drupa concatenata
Arca fusca
Chama plinthota [*imbricata*]
Macoma bruguierei.

It is very remarkable that there should be such a contrast to the fauna of Boenjoe; it cannot be attributed to a difference in age that only one form occurs in both faunas (see II): *Erronea errones.*

II.

Concerning the conditions in which the faunas under discussion lived, the following may be remarked: the fauna of Boenjoe contains exclusively such species as are known in the present day fauna as neritic-litoral elements. A survey of the bathymetric distribution of these species reveals the following:

Architectonica perspectiva	18—55 m;	mud, loose rocks among muddy sands, coral, reef, mud and coral sand.
Tenagodus trochlearis ...	8—73 m;	sand and pieces of dead coral, *Lithothamnium* and *Halicornium*, stone with some *Lithothamnium*, coral bottom, dead coral, limit between mud and coral.
Xenophora solarioides	21—57 m;	coral, coral sand, sand-mud-coral, sand-shells, stones.
Terebellum terebellum ...	7—55 m;	
Strombus plicatus	0—36 m;	coral reefs, shores, etc., coral bottom, muddy bottom, sand, mud-coral-*Lithothamnium*, coral sand.
Strombus variabilis	28—45 m;	sand, coral, mud.
Strombus vittatus	13—37 m;	mud-shells, sand-shells, sand-mud-shells.
Polinices mammilla	0—55 m;	various bottoms.
Erosaria erosa	0—60 m;	reefs, also sand, coral, mud, sand-stones-mud, coral sand.
Erosaria miliaris	0—54 m;	
Erronea onyx		
Erronea cf. *errones*		
Apollon bituberoularis ...	8—88 m.	
Tonna cepa	on reefs.	
Tonna costata	13—36 m,	litoral; muddy shore.
Fious subintermedia	54—90 m.	
Murex adustus	0—34 m;	reefs (between tide-marks), mud, coral, *Lithothamnium*.
Murex nigrispinosus	0—40 m;	reefs, mud, coral sand, sand, shells.
Phos senticosus	0—75 m;	mud, coral, coral sand, sand-mud, fine sand (hard bottom).
(*Latirus lyratus*	on sands).	
Vexillum lyratum	9—34 m;	mud, mud-sand.
Vexillum vulpecula	0—36 m;	sand, coral, mud, on stones lying on mud banks at low water.
Marginella tricincta	15—56 m;	sand, mud, corals, stones, reefs.
Arca decussata	2—54 m;	mud, coral, coral sand, coral reef, mud with patches of fine coral sand, *Lithothamnium* bottom, sand, stones with some *Lithothamnium*, mud-sand, coral sand (reef), coral-*Lithothamnium*, sand-corals.
Pecten pyxidatus	4—57 m;	coral reef (4—5 m), mud, clay, mud grounds — at lowest tide above water, on sandy mudground, 11—57 m.
Crassatella radiata	2—55 m;	sandy bottom, sand-mud, clay, shells, stony bottom.
Taras globosus	14—390 m;	mud, coral, coral sand, mud-coral sand, coarse coral sand with pebbles, sand, sandy mud.
Papyridea papyracea	neritic;	sand.
Lioconcha ornata	2—55 m;	sand, mud, gravel, near reefs, coral, coral sand, coral-coral sand, coral with stones, mud with patches of coral sand, mud-sand-shells, dead coral-*Halicornium*-*Lithothamnium*, mud-coral-*Lithothamnium*, sand-coral-mud, mud-sand.
Gafrarium scriptum	2—62 m;	muddy bottom, mud-sand, reefs.
Gafrarium sulcatum	?—36 m;	gravel, sand, mud, sand-mud, coral, coral sand, *Lithothamnium* bottom.
Venus tiara	2—82 m;	mud, coral, coral sand.
Paphia textile	7—58 m;	muddy bottom.
Aloidis crassa	55—94,	sometimes 366 m; shells, sand, sand-mud, mud-sand, coarse sand, mud-coral sand, sand-shells, sand-dead shells.

If we combine all the data it may be concluded that the fauna lived at a depth between 25 and 50 m. But we must not forget, that there are many gaps in our conception and that all kinds of circumstances which cannot be determined in the very least without much further research (effect of river mouths, etc.), influence the situation which is most favourable for a particular fauna. Although many data plead for nearby coral reefs, an attempt to make use of the lithology only, proved unsuccessful because of the usually indifferent character of the species and the fact that minute research on

the spot would be necessary; data concerning the nature of the locality are not at our disposal.

Moreover we must remember that while a species lives at a depth of from 0 to 150 m, its optimum occurrence may be 100—150 m, whereas the optimum of another species, living from 0—150 m too, may be 25—75 m; there is little known of these particulars, but future frequency research may prove most useful.

In the present case it is clear, that the fauna lived in the same place were it is found. This is shown by its perfect state of preservation. Further the fauna in general indubitably indicates open-sea conditions during its existence, although a certain influence of brackish water cannot be denied, which moreover corresponds to the present position of Boenjoe. The coast must have been near, the water contained a certain amount of clay particles, at any rate sometimes.

Another very remarkable thing is the great preponderance of z o o p h a g a: *Strombidae, Naticidae, Fasciolariidae, Cymatiidae, Tonnidae, Ficidae, Muricidae, Buccinidae, Nassariidae, Mitridae, Marginellidae* and *Conidae.* The p h y t o p h a g a are: *Architectonicidae, Vermetidae.*

This fact alone would be a strong reason to expect the close proximity of reefs, and corals — which have been found — living on the sediment of the present locality: this reconstruction is supported by the above mentioned observations on the connection between lithology and fauna. The lamellibranchs feed upon the sediment and plankton; sometimes they are distinctly phytophagous. As is known they partly live in the sediment, as some gastropods do.

As the sea-water on the whole seemingly was clear, the phytophaga will have been able to live in somewhat deep water — which the bathymetric distribution indicates — and to find their vegetable food there. The excellent preservation of the delicate shells, apex, spines and outer lip of the gastropods also indicate a deposition below the effect of strong waves.

Taking all facts together, it may be concluded that the fauna of Boenjoe more likely may have lived at ± 35 to 40 m depth than 25 m, mainly under open-sea conditions, with normally clear water, in the vicinity of reefs, upon a bottom that probably consisted of sand, mud and shells. Consequently the rise of the island since the fossilisation of the mollusca may have been at least 35 to 40 m.

T a r a k a n: the small fossil fauna from this island is typically a part of a true litoral fauna. The distribution of the species is:

Liotia peronii	on reefs.
Cerithium traillii (a b u n d a n t)	litoral zone; Cerithiidae often in brackish, muddy water near river mouths, on muddy bottoms.
Erronea errones	on reefs.
Drupa concatenata	on reefs and corals, 0—32 m, shelly bottom (pearl oysters).
Arca fusca	litoral-neritic, shores, reefs (0—45 m); mud, sand, shells, coral sand, dead corals, coral bottom-*Lithothamnium, Lithothamnium-Halicornium,* mud-hard sand, coral, mud, mud-coral-*Lithothamnium.*
Brachyodontes bilocularis (a b u n d a n t)	0—91 m; a typical element, very common near and in the tidal zone, on shells, sand, mud, river mud, gravel, coral burrows, coral sand, coral-coral sand, coral-stones, sand-shells, dead coral blocks, rocks, reefs, fine sand, coral-shells-stones, coral-*Lithothamnium,* stones with some *Lithothamnium.*

Ostrea hyotis ..... on reefs (litoral part of neritic), down to 90 m; shells, mud, sand.
Chama plinthota ..... litoral zone.

This small fauna apparently lived in very shallow, muddy water (see the present position of the island opposite river mouths: fig. 1), most probably upon a special kind of reef, such as is found along the muddy coasts of Eastern Borneo today, while *Cerithium traillii* and *Brachyodontes bilocularis*, to judge from the number of individuals, found the best living conditions. The general features indicate a *milieu* which differed considerably from that of the fauna of Boenjoe. The different facies may be the reason of the great contrast in composition between these faunas.

As the fauna of Tarakan has at the least been found at 0 m height — in this case, also, the locality is not known — it is obvious, that the relative rise of the island, coupled with negative shore shifting, must have been at least 5 to 10 m, since the Young Quaternary.

As the fauna of Tarakan is very small, the conclusions have a restricted value.

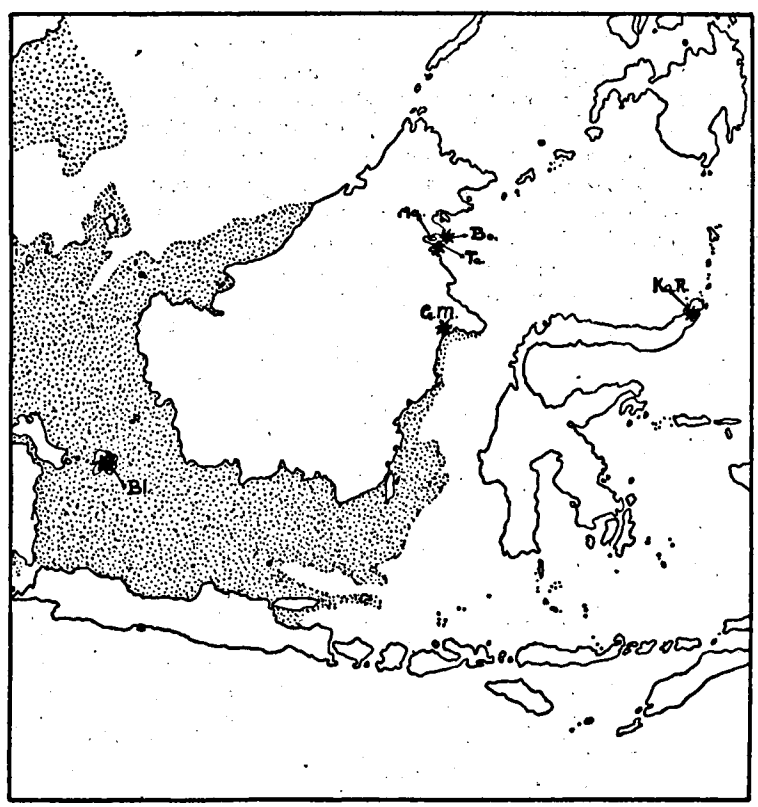


Fig. 2.

Dotted: Pleistocene Soenda-flat, bordered by the 40 fathom line which at the same time follows a part of the old coast of this flat (after MOLENGRAAFF). Young Quaternary deposits Bl: Blitong; Bo: Boenjoe; G.M.: Goenoeng Mendong (discussed in another paper); Ka. R.: Kajoe ragi; Ma.: Mandoel; Ta: Tarakan.

III.

In the above a few rough conclusions have been drawn as to the elevation of the islands of Boenjoe and Tarakan since the Young Quaternary.

By some authors some stress has been laid upon subrecent rise of Borneo and other islands, supported by data of various kinds. In connection with this we may refer to the résumé of RUTTEN (1927, pp. 303—307) who published various arguments for such a young elevation, while VAN TUIJN added a subsidiary review (1932, pp. 95—97).

Considering the fact that only a small part of the enormous coast of Borneo has been discussed above with regard to this phenomenon, this is not the place to defend one side or the other in the ancient strife as to whether the negative shore shiftings which have been noticed are caused by a rise of the land or a fall of the sea-level in an absolute sense. In the meantime it is certain that the subrecent rise of Boenjoe and Tarakan with respect to the sea-level, deduced from the molluscan faunas, corresponds to young elevations of closely adjacent areas of Borneo.

Moreover, the age of the faunas renders it quite probable that the rise of the land has taken place much later than the rise of the sea "shortly" after the Pleistocene, so that the amount of the positive shifting of the shore need not be added to the above mentioned figures.

It is known that after the Pleistocene a rise of the sea-level took place over a great part of the earth in an absolute sense, by which in the East Indies, as has been demonstrated by MOLENGRAAFF and others, the great "flats" were submerged; old river valleys and deposits were covered by the invading sea: cf. RUTTEN, 1927, pp. 185—190, and UMBGROVE's map: 1942, p. 131. In fig. 2 the "Soenda flat" is given; after the submergence of the flat, young quaternary faunas lived upon erosion relics, such as the island of Blitong, or at any rate submerged parts of them, which finally, as on Boenjoe and Tarakan, were raised above sea-level.

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