

KONINKLIJKE AKADEMIE VAN WETENSCHAPPEN
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“On Orbitoides in the neighbourhood of the Balik-Papan-Bay,
East-coast of Borneo.”

By L. RUTTEN.



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Geology. — “*On Orbitoides in the neighbourhood of the Balik Papan Bay, East-coast of Borneo.*” By L. RUTTEN. (Communicated by Prof. A. WICHMANN).

(Communicated in the meeting of February 25, 1911).

During a four months' exploration near the Balik-Papan Bay executed by order of the “Nederlandsche Maatschappij tot het verrichten van Mijnbouwkundige Werken”, the general geological results of which are described elsewhere, I collected rocks containing Foraminifera in several places.

With the consent of the Director of the Department of Agriculture, Mr. LOVINK I could make a thorough study of part of these fossils in the laboratory for geological observations at Buitenzorg, where the superintendent Dr. J. MOHR, with the greatest affability, set a room apart for me and was constantly ready to lend me a helping hand during the investigation.

I regret I had to dispose neither of sufficient time, nor of sufficient literature to be able to determine all Foraminifera; the greater part of the work was devoted to the Orbitoides which occurred in different species and a great number of specimens among my material. Together with the description of the Orbitoides, likewise the other Foraminifera will be mentioned, in so far as they could be determined.

For orientation a sketch-map on a scale of 1.250.000 is added to this communication, on which the places where the fossils have been found, are indicated, the principal ones by crosses, the others by circlets. Whereas Foraminifera occur chiefly in pure limestone or in hard marl, in which they can only be seen distinctly in thin sections, I succeeded in finding looser marl, from which the Foraminifera could be washed out in great quantities. The first place lies on the Sungei (river) Palamuan, about 2 km. west of the kampong of that name, the second on the Sungei Blakin, the last on the upper-course of the Sungei Mentawir. These three places are indicated on the map by a cross. Of these three places the one on the Sungei Palamuan is the oldest, that on the Sungei Mentawir the youngest. The greater part of the Foraminifera collected at these spots is in the collection of the Mineralogical-Geological Institute of the University of Utrecht; during my investigation I only disposed of small specimens which I had left behind here, so that it is not impossible that the chief material contains still some other forms than those I am about to describe.

The greater part of the forms I am going to describe, come from the three places mentioned; I found only one species in a limestone at

the declivity of the mountain-range where is the source of the Sungei Sepaku, which is as old as the strata on the Sungei Pamaluan; *Orbitoides* were likewise found in marl in Pulu Balan, on the Sungei Binuwang, and in the delta of the Sungei Pamaluan, but these were not distinct enough to allow a specific determination.

As all *Orbitoides* found belong to the subgenus *Lepidocyclina* and to the still younger, new subgenus *Lepidosemicyclina*, all strata are of a posteoocene age¹⁾.

A very great number of sorts of *Lepidocyclina* of the Indian Archipelago has already been described; I shall try to group these species in such a way as to give an easy survey of them, I am however quite aware of the fact that most likely I shall not fully succeed in this respect, on account of insufficient knowledge of the literature and inaccessibility of a great number of publications which, though not directly relating to the Indian forms, are nevertheless of great importance for the knowledge of *Orbitoides*.

Among the *Lepidocyclina* known in India some are easily distinguished because they are not round but star-shaped and even polygonal; one form is characterized by the appearance of several strata of median chambers, whilst both, the very large and the very small ones, can be easily separated from the others. The greatest difficulties offer the species with normal forms and average sizes.

If in this communication numbers are given about the dimensions of *Orbitoides* d always means the horizontal diameter, h the height (thickness).

1. Species of polygonal or radial form. To these belong *O. radiata* MARTIN²⁾ *O. Martini* SCHLUMBERGER³⁾, both of Java and perhaps *O. murrayana* JONES and CHAPMAN⁴⁾, of Christmas Island. *O. radiata* has an undulated circumference, the diameter is 8 m.m., *O. Martini* is purely star-shaped, the maximum-diameter is 6 m.m., *O. murrayana*, of which only a horizontal section is known, is quadrangular; d is 9,375 m.m. DOUVILLÉ has however rightly pointed out⁵⁾ that the latter form is perhaps not star-shaped or polygonal at all, but round and bent strongly saddle-shaped, so that the horizontal section must obtain a polygonal or star-shaped figure.

1) K. MARTIN, Samml. d. Geol. Reichsmuseums of Leiden, 6. p. 132—245, 1902.

2) K. MARTIN, Die Tertiärschichten auf Java. 1880.

3) C. SCHLUMBERGER, Samml. d. Geol. Reichsmuseums in Leiden, 6, p. 128—134. 1901.

4) T. RUPERT JONES and F. CHAPMAN. On the Foraminifera of the Orbitoidal Limestone and Reef Rocks of Christmas Island, in: C. ANDREWS, A Monograph Christmas Island, 1900, p. 226—264.

5) H. DOUVILLÉ, Bull. Soc. Géol. de France (4) 5, p. 435—465. 1905.

2. Species with more than 1 stratum of median chambers. As a form of this nature has only been described *O. multipartita* MARTIN¹⁾. The median chambers occur only in more than 1 stratum at the periphery, where the lateral chambers are reduced; *d* is about 7 mm. Only the form found in Java has been described. It is however my opinion that two forms of Christmas Island described by JONES and CHAPMAN (l.c.), i.e. *O. insulae natalis* var. *inaequali* and *O. ephippoides* should likewise be classed among *O. multipartita*. In the former one distinctly sees in the representation several strata of median chambers at the periphery, whilst the embryonal ventricle is large, as with *O. multipartita*. For the rest DOUVILLÉ has pointed out already that there was no reason for the introduction of a new species: *O. ephippoides* (l.c.).

3. Small species. The oldest description known of these is *O. Sumatrensis* BRADY²⁾, which is nearly globe-shaped, *d* 3, *h* 1¹/₂—¹/₂ mm. The median plane forms at the periphery a thin keel; only small macrospheric forms are known³⁾ with certainty; of the microspheric forms it is only occasionally mentioned that they can reach 15 m.m. diameter⁴⁾. Nias⁵⁾, Sarawak⁶⁾, S. Borneo⁴⁾ and Christmas Island⁶⁾.

K. MARTIN⁶⁾ has described a very small form of Timor but not given it a name, which seems in the main to be similar to *O. Sumatrensis* BRADY, in the middle the scale becomes gradually thicker, and the embryonal chamber and the succeeding one are very large, the Timor-form is only somewhat smaller and less globular: *d* 1—2, *h* 1—¹/₂ mm. TIMOR (GUNUNG ILHAUW), S. Borneo⁷⁾ New Guinea⁶⁾.

Another, very small form of Timor⁶⁾, however, differs decidedly from *O. Sumatrensis* by its flattening. For convenience' sake we shall indicate it as *O. Timor* 1.

Somewhat larger is a form described by BRADY²⁾ as *O. dispansa*; afterwards VERBEEK and FENNEMA⁹⁾ proved this determination to be

¹⁾ K. MARTIN, Die Fossilien von Java, Erstes Heft. 1891.

²⁾ H. BRADY, Jaarb. v. h. Mijnwezen in Ned. Indië, 7, p. 157—169, 1878.

³⁾ R. BULLEN NEWTON and R. HOLLAND, The Ann. and Magazine of Natural History (7). 3, p. 245—264, 1899.

⁴⁾ H. DOUVILLÉ, l.c.

⁵⁾ T. RUPERT JONES and F. CHAPMAN, l.c.

⁶⁾ K. MARTIN, Samml. des Geol. Reichsmuseums in Leiden, 1, p. 1—64, 1881.

⁷⁾ K. MARTIN, Samml. des Geol. Reichsmuseums in Leiden, 1, p. 131—193, 1883.

⁸⁾ K. MARTIN, Samml. des Geol. Reichsmuseums in Leiden, 1, p. 65—83.

⁹⁾ R. VERBEEK et R. FENNEMA, Description géol. de Java et Madura, p. 1176—1182, 1896.

incorrect, and determined it as their *O. 1A*. $d\ 6, h\ 2$ mm. The disk is in the centrum gradually thickened, and on both sides covered with warts (on BRADY's representation I count about 40 of these). Afterwards as a new sort of Christmas Island *O. neodispansa* has been described by JONES and CHAPMAN¹⁾, the diagnosis of which *O. dispansa* BRADY and *O. 1A* VERBEEK and FENNEMA ($d\ 5, h\ 1\frac{1}{2}$ mm.) This *O. neodispansa* consequently seems to occur in Christmas Island¹⁾, Nias¹⁾, Padangsche Bovenlanden¹⁾ and Java.

At all events *O. 2C* and *O. 2D* VERBEEK and FENNEMA¹⁾ differ from this *O. neodispansa*, the former of which is megalospheric, the latter microspheric, according to the representation the scale is quite smooth and provided with a central tubercle, $d\ 5-6\ h\ 2$ mm. Java.

At last the megalospheric form of *O. Tournoueri* LEM. et DOUVILLÉ ($d\ 4-5$ mm.) which has only a few warts in the centrum, belongs to these small forms.¹⁾

4. Large Forms. A great many large Orbitoides from the Indian Archipelago have been described, which, as they are not yet completely known, can be determined either with great difficulty or not at all. To these belong *O. gigantea* MARTIN¹⁾, *O. Carteri* MARTIN²⁾, *O. 3 E* and *O. 3 F* VERBEEK and FENNEMA¹⁾, all of Java. Of the latter two, the former is again micro- the other megalospheric. Most likely a few more are hidden among these two sorts, as for their horizontal diameter is given $4\frac{1}{3}-70$ mm., which is certainly a too great variability. A common property is the spatulate form of the median chambers, on horizontal section and their large dimensions (max. 0.250 mm. radial with 0.2000 mm. tangential), which is much more than with the evidently allied *O. Mantelli*.

Another gigantic incompletely known Orbitoid which consequently did not receive a name, is found in Great-Kei ($d\ 70$ mm.)¹⁾. Two large, incompletely known forms are found in Timor¹⁾, one of these has median chambers as *O. Mantelli* Mort³⁾.

A pretty large Orbitoid of Christmas Island *O. insulae-natalis* was first, very incompletely, and only on account of the vertical

¹⁾ Vide previous page.

²⁾ K. MARTIN. Die Tertiärschichten auf Java 1880.

³⁾ K. MARTIN, Samml. des Geol. Reichsmuseums, Leiden, 1, p. 8-64, 1881.

section, described by R. JONES and CHAPMAN¹⁾. Afterwards SCHLUMBERGER²⁾ has applied this name to a well-known form of Java, the thin section of which corresponded very well to the form of Christmas Island d 12—19 mm. h 5 mm. Skeleton columns very fine with little warts at the surface. This form is likewise known in Borneo³⁾ and Sumatra³⁾.

A rather large form of *O. formosa* first described by SCHLUMBERGER⁴⁾ as *O. formosa* is likewise well known. From the sections (he found the Orbitoide in hard lime-rock), he concluded that he had to do with a radius-shaped *Lepidocyclina*, but DOUVILLÉ³⁾ showed that the Orbitoide had a very pronounced saddle-shape, and consequently gave a radius-shaped horizontal section — megalospheric, median chambers on horizontal section half-circle-shaped, lateral chambers separated by very thin horizontal parietes d max. 18, h 2 mm. At the surface no warts are found. Borneo³⁾,⁴⁾, and Celebes³⁾.

The microspheric form of *O. Tournoueri* LEM. and DOUV. is likewise large and according to DOUVILLÉ³⁾ likewise smooth.

5. Orbitoides of average size. Not many forms of average size remain. BRADY⁵⁾ described from the Padangsche Bovenlanden an Orbitoid as *O. papyracea*, afterwards VERBEEK and FENNEMA⁶⁾ proved the incorrectness of this determination and called the form which they knew likewise from Nias *O. 1 B.* NEWTON and HOLLAND⁷⁾ found this *Lepidocyclina* back in Sarawak and christened it *O. VERBEEKI*. They found there both the microspheric form, and the macrospheric one, the former is the larger d 5—12 mm. h $1\frac{1}{2}$ —2 mm. By the smooth surface and the gradual thickening towards the centrum this form is sufficiently characterized; it can only be mistaken for *O. formosa*. Incidentally *O. VERBEEKI* is likewise mentioned from Christmas Island⁸⁾.

1) T. RUPERT JONES and F. CHAPMAN, l.c. p. 242—243.

2) C. SCHLUMBERGER, Samml. des Geol. Reichsmuseums in Leiden, 6, p. 128—134, 1901.

3) H. DOUVILLÉ, l.c.

4) C. SCHLUMBERGER, Samml. des Geol. Reichsmuseums in Leiden, 6, p. 250—253, 1902.

5) H. BRADY, l.c.

6) R. VERBEEK et R. FENNEMA, l.c.

7) BULLEN NEWTON and HOLLAND, l.c.

8) JONES and CHAPMAN, l.c.

At last, though very incompletely, a new species from Christmas Island is described by JONES and CHAPMAN as *O. Andrewsiana*. There is only a median tubercle d 9.75 mm.

At last from a great number of places the subgenus *Lepidocyclina* is mentioned, the forms however could not definitely be determined, these places are Java ¹⁾, N. W. Guinea ²⁾, Koor ³⁾, Batjan ³⁾, Obi ³⁾ and the Philippines ⁴⁾.

Of all authors only H. DOUVILLÉ has tried to make use of the Indian *Lepidocyclinas* as leading fossils, in doing which he supports himself on experience gathered elsewhere. He gives the following table:

Burdigalien	L. Tournoueri, L. sumatrensis.
Aquitaniensup.	L. insulae-natalis.
Aquitaniensup.	L. formosa.
Stampien	L. formosa, with <i>Nummulites subbrongniarti</i> .

In the following description of our material we shall combine the sorts that belong stratigraphically together, beginning with the oldest, so that we shall be able to see, whether our results agree with those obtained by DOUVILLÉ.

O. (Lepidocyclina) aff. formosa SCHLUMBERGER.

In a lime-marl, about 2 km. West of the Kampong Pamaluan occurred, besides small *Orbitoides*, other Foraminifera and corals, many splendidly conserved large *Orbitoides*, which could be washed out in toto from the marl, so that it was easy to prepare orientated sections.

The scale is flat, circular (d . 23 mm.) and provided with a median tubercle (d 4 h 3.5 mm.). Most scales are flat, some however show a saddle-shaped bend. At the surface one easily discovers the lateral ventricles bordered by polygons, whilst at the edges one can here and there see the median chambers dimly shining through. Scarcely any vestiges of skeleton-columns are to be seen at the surface.

Horizontal section. Two horizontal sections have cut the median chambers in various sectors. These are more or less spatulate. The embryonal chamber is not touched; it must however be very small,

¹⁾ K. MARTIN, Samml. d. Geol. Reichsmuseums in Leiden, 6, p. 135—245, 1902.

²⁾ K. MARTIN, Samml. d. Geol. Reichsmuseums in Leiden, 1, p. 65—83.

³⁾ K. MARTIN, Samml. d. Geol. Reichsmuseums in Leiden, 7, p. 225—230, 1904.

⁴⁾ K. MARTIN, Centralbl. f. Mineralogie etc. 1901, p. 326—327.

as the other chambers reach to the immediate vicinity of the centrum. Most of the central chambers that are next to the embryonal one are flattened in a radial direction, the radial diameter is 40—60, the tangential one 60—80 μ . Only farther towards the periphery the median chambers become pretty regularly six-angular, whilst the most peripheric ones are spatulate. In general the size of the chambers increases towards the periphery, but occasionally rings of smaller chambers occur between larger ones. Whilst by far the greater part of the median chambers are ranged in circles, their arrangement in the centrum is a little more irregular, and at the periphery sometimes not continued curves are linked between the continued concentric circles. The number of concentric circles of median chambers amounts to more than 100. The radial diameter of the peripheric chambers is 150—250 μ , their tangential diameter 140—150 μ . Especially at the periphery the parietes of the median chambers

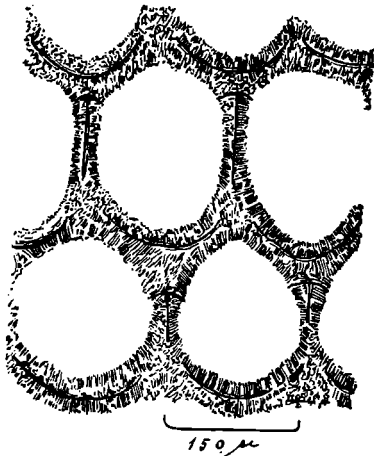


Fig. 1.

show a typical structure (fig. 1). The parietes namely consist of a dark untransparent central lamella to which granular, grey calcite sticks. In this section the central lamella is not continued round the chambers, but consists of a tangential, peripheral curve, two tangential, central parts of a curve (each the half of a tangential peripheral curve of chambers placed more towards the centrum) and of two radial lamellae, ending towards the centre in a tangential curve. Perhaps there is above this

little curve a porus of a tangential shape uniting the chambers of the same curve. In many ventricles the central lamella is on all sides covered by symmetrically thick secondary parietes, in others these secondary parietes are thinnest on the tangential parietes.

Vertical section. From this section appears likewise that the embryonal chamber must be very small, though it is not visible itself. The height of the median chambers namely decreases from the periphery to very close to the centre from 120 to 60 μ . The peripheral parietes of the median chambers are always convex to the outside, the structure of the parietes is only very unsatisfactorily visible. The lateral chambers have very thick parietes, and are strongly flattened in a vertical direction; their height is 30—50 μ the thickness of the parietes 30—40 μ . Because the parietes are

regularly laterally interlocked, more or less vertical thickenings of the parietes are formed slightly diverging from the centre, which are imperfectly developed skeleton-columns. On either side of the median plane are in the centrum about 20, at the periphery only 5 strata of median ventricles.

In a dense, grey limestone, which is found half way to the top of the range of mountains containing the spring of the Sepaku, I found many *Orbitoides*, showing in the main great resemblance to those just described. The shape of the median chambers, the structure of their parietes, their dimensions and likewise the shape and situation of the lateral chambers are completely alike. The largest diameter is 23 mm. Only the shape of the embryonal chamber, which like the second chamber is very large, shows a great difference. Both these chambers communicate with each other by a very wide opening.

The two described *Orbitoides* consequently form a distinct pair: the fossils of the Pamaluan are the microspheric, those of the Sepaku the megalospheric forms.

There are only very slight differences between the described form and *O. formosa*. The inferior and rare, saddle-shaped bend of our *Orbitoides* is of little importance, it is well-known that in this respect many sorts are very variable. SCHLUMBERGER (l. c.) however reports about *O. formosa*, when describing the lateral chambers, that these are: "très surbaissées et séparées par de très minces parois"; whilst in our form the horizontal parietes between the lateral ventricles are very thick. S. communicates too little about the shape of the median chambers to enable us to discover eventual differences with our form.

In the lime-rock of the Sepaku-spring-mountains occurs another little *Lepidocyclina* that cannot be more exactly determined, besides the *Orbitoid* described; further *Globigerina*, and most likely *Textularia*. The limestone is grey and rather transparent on the section; it contains here and there microscopic grains of pyrite, which often fill the ventricles of *Orbitoides*.

In the marl of the Sungei Pamaluan a few more smaller *Lepidocyclina* were found (5 specimens) whose diameter was only 5 mm., in one case even less. The median chambers are rhombic on the horizontal section, most likely the embryonal chamber is small. The skeleton-columns at the surface have the appearance of small warts, the situation and number of which vary strongly even in this insignificant material. In two specimens there was only one central wart, two others showed many warts scattered all over the disk, whilst in the last specimen only a few warts lie round the centre. In general these characteristics agree very well with what is known of *O. neo-*

dispansa JONES and CHAPMAN (*O. dispansa* BRADY and *O. 1 A* VERBEEK and FENNEMA); the material is however too insignificant to admit of a reliable determination. It is however of importance that we find in a level characterized by a frequent occurrence of a primitive *Lepidocyclina*, likewise a few representatives of types younger according to DOUVILLÉ (l. c. p. 449). Perhaps it is likewise remarkable that these younger forms show here evidently great variety in one important characteristic, (the wart-shaped appearance of the skeleton-columns at the surface).

From a lime-marl at the Sungei Blakan by washing a great number of Foraminifera were obtained, the greater part of which belonged to *Orbitoides*. From this rough material the different sorts could now be selected, and it appeared that in this way strongly separated series of forms could be obtained, it was but seldom doubtful among which group a definite specimen ought to be ranged.

With great application and perseverance my wife performed the fatiguing work, taking up so much time of washing and selecting the sorts.

The sorts collected here are the following :

O. (Lepidocyclina) acuta n. sp.

Of this sort about 50 specimens were found the horizontal diameter of which varied from 3—7 mm. One sees at the surface the irregularly bordered lateral chambers, whilst at the edge sometimes the median chambers are likewise visible, as here the lateral ventricles may be missing. The centre of the disk is taken up by a single skeleton-column which is sometimes diffuse and variable in size, and can likewise consist of an agglomeration of small columns. There are no other skeleton-columns placed nearer towards the periphery. The central part of the disk is strongly drawn out in a vertical direction, so that the Foraminifere is pointed at both extremities, which gives to this *Orbitoid* a very peculiar shape (*acuta*). The fact that these skeleton-columns are restricted to the lengthened vertical axis is obviously very appropriate. This lengthening in a vertical direction is however subject to many variations; it can be so important, that the vertical diameter becomes longer than the horizontal one (I measured in one case $d\ 3\ h\ 3\frac{1}{2}$ mm.). The peripheral edge is with this form always flat never bent saddle-shaped.

Horizontal section. Neither could I observe the embryonal chamber here; it must however be very small, as the median chambers reach to the immediate vicinity of the centre. The more central

median chambers are flattened in a radial direction (rad. diam. 17, tang. diam. 30 μ). In these chambers already the parietes are thick (10 μ); only an indistinct central lamella can be observed in the parietes.

Towards the periphery the chambers become first hexagonal afterwards spatulate; in these peripheral chambers the cavity of the ventricle however always remains oval. It is very typical that with this form, the chambers are placed so irregularly, so that very often not continued curves are linked between the concentric circles. The dimensions of the peripheral chambers vary considerably; radial 65—90 μ tang. diam. 55 μ . The number of concentric rings of chambers is more than 50 and less than 100. At some places of the preparations the more delicate structure of the parietes could be studied. Here likewise a central lamella can be distinguished which is however often indistinct. The secondary parietes are here separated much sharper from the later chamber-filling than with *O. formosa*, which however may partly be a consequence of the conservation. Here namely every chamber is filled with single crystal of calcite, whilst by *O. formosa* the ventricles were usually filled with an aggregate of exceedingly fine crystals of calcite. At some places the wide pori can be seen that lead from one median ventricle obliquely outward to two median chambers of the ring lying more peripherally. Numerous pori run from the median chambers vertically or somewhat obliquely upward and downward to the adjacent lateral chambers.

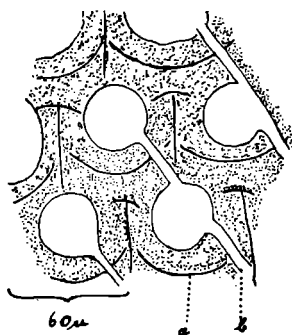


Fig. 2.

In the main the shape of the central chambers is the same as with *O. formosa*; the radial parts however are continued here as far as the periphery (fig. 2).

Vertical section. In the vertical section one sees very distinctly the increase of the vertical diameter; the strong, central skeleton-column is especially on one side clearly represented. The system of the median chambers consists of only one stratum, the chambers are low (45 μ) and their horizontal parietes are very thick (25 μ). The pori between the median and the lateral chambers are represented here lengthwise; it appears likewise that the lateral chambers communicate with each other by means of many wide, vertical pori, which are partly infiltrated with a brown mineral containing Fe. The number of strata of lateral chambers on both sides of the median plane amounts to about 20.

O. (Lepidocyclina) flexuosa n sp.

A second form of Sungei Blakin is somewhat less numerous than the former, I could dispose of about 20 specimens agreeing very well with each other. The Foraminifera consist of a lens-shaped body surrounded peripherally by an edge which is strongly plaited in a vertical direction (*flexuosa*). The horizontal diameter is 4—7 m.m. the vertical one about 3 m.m. At the surface one sees distinctly, especially in the centre, the wart-shaped extremities of many not thick skeleton-columns between the lateral chambers enclosed in irregular polygons.

Horizontal section. On account of the strong bend of the median plane in a horizontal section of course only irregular areas of median chambers can be hit. Again the embryonal chamberlet must be very small; it is however not hit in a single section. The first peripheral chambers lie irregularly round the centre; those lying farther outside seem to be placed in regular concentric rings. Near the centre the median chambers are again flattened in a radial direction; d 40μ rad. and 55μ tang. More towards the periphery the median chambers become first hexagonal, afterwards rhombus-shaped or spatulate, it seems that the rhombus-shaped chambers have the majority. The dimensions of these peripheral chambers are: d 20 — 120μ rad., 60 — 100μ tang. The number of concentric chamber-rings amounts to 50—100.

Likewise in this form a primary lamella can be distinguished at the parietes of the median chambers, the secondary thickenings of the parietes change here gradually into the later chamber-filling. The shape of the median lamellas is typical, each ventricle is bounded

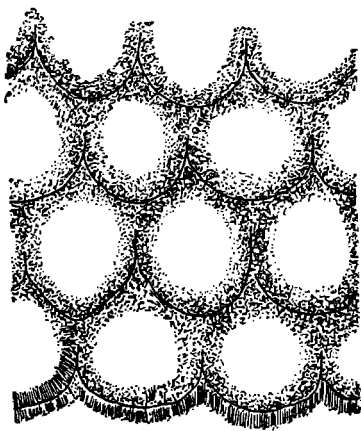


Fig. 3.

by a peripheral arched piece, that passes into two radial parts whilst at the central side two arched pieces are found (fig. 3). Pori between the median chambers could not be discovered with certainty.

The lateral chambers are in this section likewise enclosed in irregular polygons, their parietes are very thick; they correspond by means of rare, very wide, horizontal pori, whilst at favourable places one sees exactly into the openings of numerous vertical pori.

Vertical section. Whilst in the centre there is but one stratum of median chambers, they gradually increase towards the periphery, so that there 2 or 3 strata of median chambers are found. From the centre several skeleton-columns extend towards the periphery, others are linked in at half-height. The height of the median chambers in the centre amounts to 25μ . The lateral chambers are here likewise strongly flattened, and communicate with each other by numerous vertical pori. The number of strata of lateral chambers at the centre is about 20 or more, at the periphery it is sometimes 0.

The *Lepidocyclina* described has the greatest resemblance to *O. multipartita* MART., but differs again from it by a smaller size, greater thickness, inferior extension of the median plane towards the periphery and by the small embryo-chambers. Neither can *O. flexuosa* be regarded as the microspheric form of *O. multipartita*, as the microspheric forms are always larger than the megalospheric ones. From *O. insulae-natalis* the described sort distinguishes itself by its smallness and general shape, from *O. neodispansa* by its thickness and the much less great warts.

O. (Lepidocyclina) polygona n. sp.

A form that is no longer round but more or less regularly polygonal (*polygona*) contrasts very strongly with the two former. It is a little thin *Lepidocyclina* (*d* $1\frac{1}{2}$ —3 mm., *h* 0.9 mm.) of a trigonal to hexagonal shape. At the surface one sees distinctly the irregularly confined chambers, whilst at the angles comparatively very strong columns in the shape of warts, are found at the surface. Among my material there was only 1 specimen with 3 warts, 40 with 5 warts and 13 with 6. As a general rule may be admitted, that the number of warts and consequently likewise the polygonamy increases with the size, yet there are many exceptions to this rule.

Median horizontal section. In impure median sections one sees the irregularly confined, lateral chambers and the skeleton columns, consisting of an aggregate of crystals of calcite. Here and there pori running vertically or obliquely upward can be seen between the lateral chambers.

The embryonal chamberlet is very large, the second chamber is still larger and partly encloses the former; the exterior parietes of these two chambers are thick, the separating parietes between these two chambers are very thin. The maximal diameter of the second chamber amounts to 300—400 μ . Though in general the median chambers in this genus are still spatulate, their shapes vary however considerably,

whilst they are moreover placed very irregularly; it is difficult to find back here the concentric rings. The parietes of the median chambers are always thick; there was no vestige of a primary central lamella. Very numerous pori run vertically or obliquely, even horizontally, from the median chambers to the lateral ones.

Vertical section. There is but one stratum of median chambers, the height of the ventricles is $35\ \mu$, the thickness of the horizontal parietes $10\ \mu$. It is very distinctly to be seen how the skeleton-columns begin only at some distance from the median plane, and become gradually thicker towards the periphery. On either side of the median chambers are only 11 strata of lateral chambers.

O. (Lepidocyclina) sumatrensis Brady.

This form is by far the most numerous at the Sungei Blakin. It can very easily be distinguished from all other forms of the same place; with *O. sumatrensis*, which has been minutely described especially by NEWTON and HOLLAND (l.c.) it shows only slight differences, which are not sufficient to make a new species of it.

The disk has never or scarcely ever warts at the surface, it is very thick ($d\ 2-4$, $h\ 2-2.7$ mm.) and sometimes even cylindrical. In the middle, one can follow a thin wedge often ending in flaps.

Horizontal section. This form is megalospheric; the embryonal chamber is partly surrounded by the second chamber, just as with *O. polygona* and the little *Orbitoides* of Timor described by MARTIN (l.c.). The outer-parietes of these two chambers is $33\ \mu$ thick; the separating parietes between the two chambers only $10\ \mu$. The maximal diameter of the embryonal chamber, is $190\ \mu$, that of the second chamber $310\ \mu$. The median chambers are more rhombus-shaped than spatulate, situated in rather regular concentric rings, often lengthened in a tangential direction. Their diameter is tang. 90 , rad. $60-70\ \mu$. The median lamella is indistinct. The number of concentric rings is $30-50$.

The shape of the lateral chambers is not so irregular as with the greater part of *Orbitoides*; they are also placed in rather regularly concentric rings, which is likewise mentioned by NEWTON and HOLLAND (l.c.) about *O. sumatrensis*.

Vertical section. There is only one stratum of median chambers and on either side of these 15 strata of lateral chambers. Though at the surface no warts can be observed, it appears that there exists doubtlessly in the interior a firm interjacent skeleton. The height of the lateral chambers is $70\ \mu$, the thickness of the horizontal parietes is $30\ \mu$.

Subgenus novum Lepidosemicyclina.

Besides the Orbitoides described I found in the marl of the Sungei Blakin still numerous Foraminifera, which offer in several respects great affinity with Lepidocyclina. With those too a system of median chambers exists, which in general have on the horizontal section a spatulate shape, and develop themselves round a few large embryonal chambers; with those too on either side of these median chambers there are lateral ventricles, of an irregular shape, and between these a supporting skeleton is found, ending at the surface in numerous warts. In one respect however these forms show great differences with Lepidocyclina: the median chambers namely do not lie in concentric rings, but only in half- or quarter-circles, in which the embryonal chambers are lying at the periphery, in the central point of the circle-sector. Consequently a new subgenus was introduced for these forms: Lepidosemicyclina.

Lepidosemicyclina thecideaeformis n. sp.

At the Sungei Blakin occurs only one species of this subgenus having usually the shape of a circle-sector of somewhat less than 180° , and being a little thickened in the central point of the circle, so that the little shells make us think of Brachiopod Thecidea. One side of the shell is often more convex than the other, the latter can even be concave, so that the horizontal median plane is no longer a pure symmetrical plane. At the surface there is no vestige of lateral or median chambers; the whole disk is covered with little densely accumulated warts. There is some variety in the general shape, because now the tangential, now the radial diameter is the larger, (2—4 mM.) Sometimes the shell is slightly bent, in most cases however quite flat.

Horizontal section. In a good section one sees distinctly the large embryonal chamber, which lies a little beside the central point of the circle. It is large and round, and its parietes are thick (d. 160 thickness of the parietes 20μ). With this embryonal chamber is connected a still larger chamber, which lies at the extremity of the shell, i. e. in the central point of the circles and partly surrounds the embryonal chamber. Its peripheric parietis is still thicker than that of the embryonal chamber (30μ); the borderparietis is only 15μ thick. Two more large chambers, lying more to the centre, are connected with this second parietis; these three ventricles surround the embryonal chamber in an indistinct spiral. The following

chambers are already rhombus-shaped. A primary lamella can never be distinguished at the parietes. Radial diameter of the peripheric chambers $100\ \mu$ tangential $90\ \mu$. At thicker spots in the preparations one sees very distinctly the wide vertical pori going to the lateral chambers.

Vertical section. There is only one stratum of median chambers. In vertical section this stratum is rather slightly strung at the extremities of the chambers. On either side of it are 5—6 strata of lateral chambers, which are very flat and placed on each other somewhat in the way of scales. The thickness of the fossil is 0.8 mm.

Besides the Foraminifera mentioned I found in the marl of the Sungei Blakin: Operculina spec., Amphistegina spec. ? Cycloclypeus spec., and other Foraminifera, which I could not determine.

The third place where numerous Orbitoides could be gathered, lies on the upper-course of the Sungei Mentawir in strata that are certainly younger than those on the Sungei Blakin and that most likely, towards the top gradually pass into the pliocene strata, very rich in coal, which occur everywhere in the lower part of the Balik Papan Bay.

O. (Lepidocyclina) sumatrensis Brady, var. minor nov. var.

Most numerous is here again a very small Orbitoid agreeing in nearly every respect with *O. sumatrensis* of the Sungei Blakin. The principal difference consists in the fact that the sort on the Sg. Mentawir is considerably smaller ($d\ 1\frac{1}{2}$ —2, $h\ 1, 2$ — $8\frac{1}{2}$ m.m.) This cannot be accidental, because we should have gathered from this place only the smallest varieties: the material gathered in both places being much too large. For the further description we can refer almost entirely to *O. sumatrensis*. Only no or hardly any skeleton-columns occur with the form of the Sungei Mentawir, which would indeed be astonishing with so small a form which by its globosity possesses already a natural maximal solidity.

O. (Lepidocyclina) neodispana Jones and Chapham, var. minor, nov. var.

I can dispose of about 20 specimens of this form tallying very well with one another. In general these have again great resemblance to *O. neodispana*. The disk is gradually thickened towards the middle and a number of comparatively large warts (max. 20

indicate the superficial end of the skeleton-columns. They are however smaller than *O. neodispansa*: $d\ 1\frac{1}{2}$ —3, $h = 1$ — $1\frac{1}{2}$ mm.

Horizontal section. The embryonal chamber is large and has thick parietes (d max. 270, thickness of the parietes $20\ \mu$). The chambers round it are half-circular, and further towards the periphery pretty well rounded hexagonal, but always irregular. It is very typical that the median chambers at the periphery are not placed in concentric circles, but in the circumference of concentric hexagons, the sides of which are somewhat concave to the outside. Horizontal pori between the median chambers are not visible, but very many vertical pori can be observed. The lateral chambers are irregularly limited and have a wide lumen. They are united together by many almost horizontal pori. The diameter of the median chambers is 45 — $50\ \mu$; the thickness of the parietes $15\ \mu$.

Too little is known of the interior structure of *O. neodispansa* to enable us to decide whether the described form agrees in every respect with this sort; the resemblance in outward characteristics however is so great that I have not hesitated to describe these *Lepidocyclines* of the Sungei Mentawir as a variety of *O. neodispansa*.

O. (Lepidocyclina) glabran sp.

Ultimately about 15 specimens of a somewhat larger *Lepidocyclina* were collected at this place, characterized by the indistinctness or even the absence of superficial warts. By its form it has the greatest resemblance to *O. neodispansa* ($d\ 2$ — 5 , $h\ 1$ — 2 mm.), but the absence of warts forbids us to class it with this form.

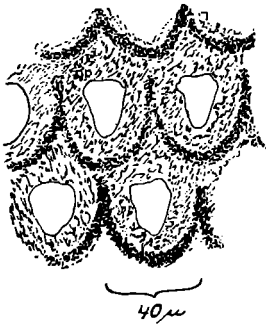


Fig. 4.

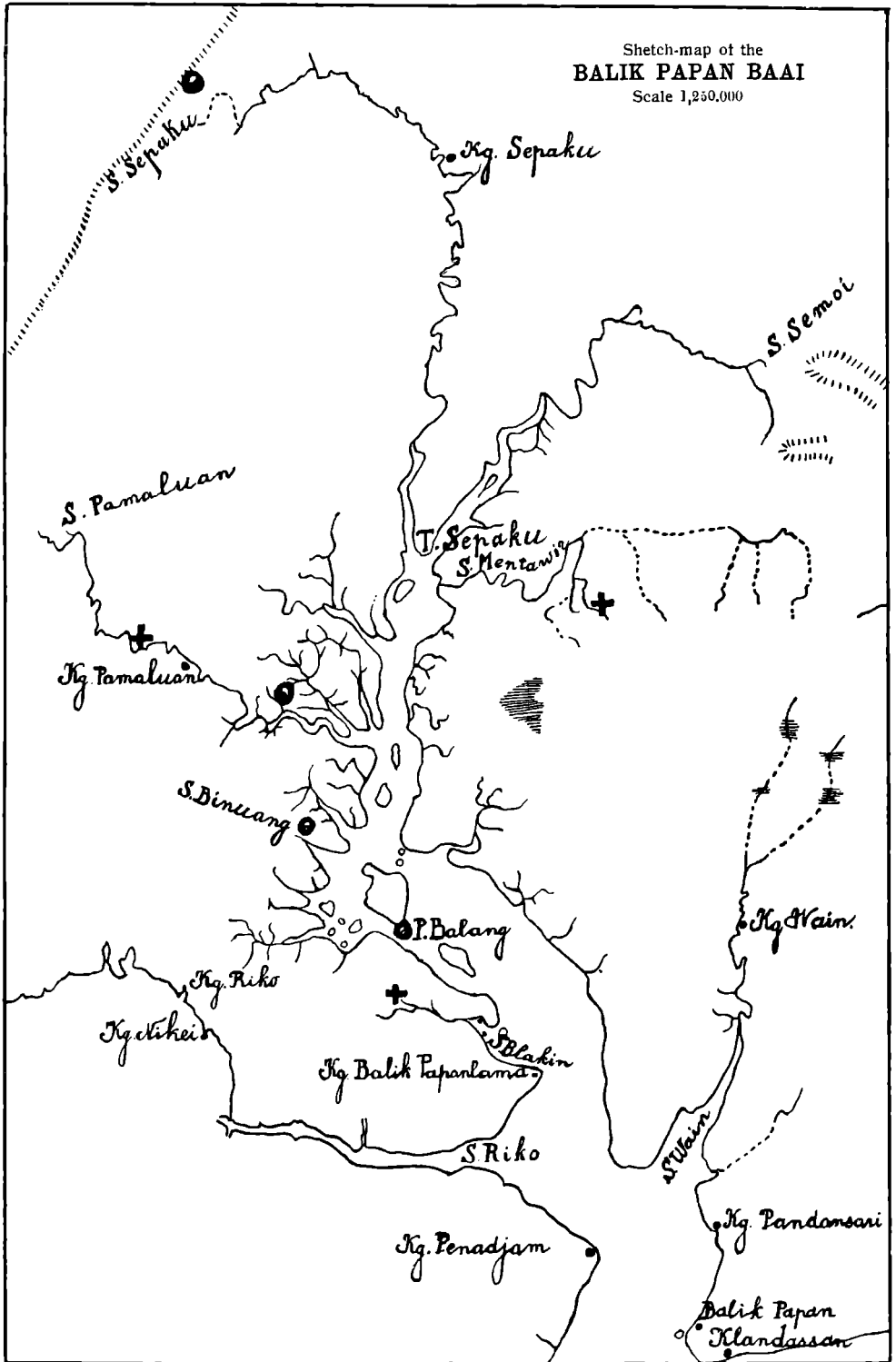
Horizontal section. Likewise by its microscopic structure this sort is obviously separated from those hitherto described. Most likely the embryonal chamber is large, the first peripheric median chambers are irregularly roundish; towards the outside however the chambers become soon spatulate and show a peculiar typical central lamella which has the same shape as that of *O. flexuosa*, but is much thicker (fig. 4). Perhaps there are in this primary lamella very fine channels.

Rad. diam. of the median chambers 45 , tang. $35\ \mu$.

Lepidosemicyclina polymorpha n. sp.

In the younger strata of the Sungei Mentawir we meet with a form

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(East-coast of Borneo)."



of *Lepidosemicyliina*, corresponding in structure entirely to the older form of the Sungei Blakin, so that we can refer to the latter. Externally the young form differs greatly from the primitive form, especially by its great variability. Some forms are found that can hardly be distinguished from *L. thecideaformis*, other specimens are strongly plaited, scalloped at the peripheral edge, are considerably protracted in a radial direction and have even a quite irregular shape.

There are some features that point very vaguely to the fact that *thecideaformis* was able to creep, whilst *L. polymorpha* had become fastened. Whilst namely the other Orbitoids are constructed radially, which with great probability points to a floating way of living (plankton) *L. thecideaformis* has not only become bilaterally symmetric in a vertical direction, but has also obtained an upper- and a lower-edge (difference in convexity) and has consequently adopted the symmetry we are accustomed to find in creeping animals. Hereto comes however that the younger form shows so great a variability and such irregular forms as we are only accustomed to see of animals that are fastened (*Ostrea*).

Besides the Orbitoids described we find in the marl of the Mentawir still *Amphistegina*.

In a few words we shall still discuss rocks of other finding-places containing only generically determinable fossils.

As old as the clay-marl on the Sungei Pamaluan is a limestone, found on rather a large scale in the delta of the mentioned river. Herein the vertical section of a little Orbitoid, a *Globigerina* and perhaps also *Amphistegina* was found. The limestone is very compact, becomes scarcely transparent under the microscope and contains occasionally grains of pyrite.

Younger than the Pamaluan-marl, but perhaps older than the Blakin-marl is a marly sandstone, found on the Sungei Binuwang.

Under the microscope the marl appears to consist of polygonal grains of quartz united together by a cement rich in Fe- and Ca. It contains *Amphistegina*, a single *Alveolina* 5 mm. long, a few Orbitoides and a large spiral-shapedly constructed Foraminifere (not *Spiroclypus*) entirely unknown to me.

A marl that is found on the S. E. coast of Pulu Balang and of which a specimen contains a large enclosure of resin is entirely filled with Foraminifera, among which: *Miliola*, a very small *Alveolina*, *Globigerina*, *Amphistegina*, a small Orbitoid and others can be recognized. The marl contains many polygonal grains of quartz, whilst the fossils often enclose grains of pyrite.

Consequently the Orbitoides described above may be classed into

three different divisions of the Tertiary on the Balik Papan Bay :

Mentawir-strata	<i>L. sumatrensis</i> var. <i>minor</i> , <i>L. neodispansa</i> var. <i>minor</i> , <i>L. glabra</i> , <i>Lepidosemicyclina</i> polymorpha.
Pulu Balang-strata (Sungei Blakiu)	<i>L. acuta</i> , <i>L. flexuosa</i> , <i>L. sumatrensis</i> , <i>Lepidosemicyclina thecideaeformis</i> .
Pamaluan-strata	<i>L. aff. formosa</i> , <i>L. ? neodispansa</i> .

The stratigraphical succession thus obtained does not entirely agree with the one given by H. DOUVILLÉ. It is true that with us in the oldest strata occur simple forms of the type *L. formosa*, but beside these immediately forms of the type *O. neodispansa* are found, which according to DOUVILLÉ must be much younger. On the Sungei Blakin occur then beside each other forms with strongly and feebly pronounced skeleton-columns (*O. flexuosa*) forms of the type of *L. sumatrensis*, and forms with one single, large, central wart, which according to DOUVILLÉ should occur in separate horizons. The same holds for the youngest strata, the Mentawir-strata.

It is however remarkable, that in the oldest level the simplest forms occur, that in the middle level the number of species is greatest, and that in the youngest level, which cannot be much older than the dying-out-period of the genus, two minor forms occur, whilst of a third species very peculiar variations are found.
