C. M. B. CAUDRI

TERTIARY DEPOSITS OF SOEMBA

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PROEFSCHRIFT

TER VERKRIJGING VAN DEN GRAAD VAN DOCTOR IN DE WIS- EN NATUURKUNDE AAN DE RIJKSUNIVERSITEIT TE LEIDEN, OP GEZAG VAN DEN RECTOR MAGNIFICUS Mr D. VAN BLOM, HOOGLEERAAR IN DE FACULTEIT DER RECHTSGELEERDHEID, PUBLIEK TE VERDEDIGEN OP DONDERDAG 12 JULI 1934 DES NAMIDDAGS TE 4 UUR

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AAN MIJN OUDERS

PROMOTOR PROF. DR. B. G. ESCHER

HET PROEFSCHRIFT WERD GESCHREVEN ONDER LEIDING VAN
DR. I. M. VAN DER VLERK *

* OP VERZOEK VAN PROF. ESCHER EN DR. VAN DER VLERK GEEN VOORWOORD.

SAMENVATTING

De foraminiferenhoudende gesteenten van Soemba, die het onderwerp vormen van deze publicatie, werden verzameld door het Mijnbouwkundig Geologisch Onderzoek „Kleine Soenda-Eilanden", ressorteerend onder den Opsporingsdienst van den Mijnbouw in Nederlandsch-Indië in de jaren 1920—1925. Het onderzoek van Soemba (1924—'25) stond onder leiding van wijlen Dr. G. L. L. KEMMERLING, destijds ingenieur bij den Dienst van den Mijnbouw.

De resultaten van het veldwerk op dit eiland zijn in het kort als volgt:

De ondergrond bestaat uit sedimenten, eruptiva en contactmetamorfe gesteenten van prae-tertiairen ouderdom. Hoe oud deze formatie precies is kon niet worden vastgesteld, doch in de sedimentserie is met vrij groote zekerheid Jura aangetoond. Deze sedimenten zijn geplooid en volgens KEMMERLING heeft het opdringen van granitisch en gabbroïsch magma waarschijnlijk gelijktijdig plaats gehad met deze plooiing. Dit opdringen van magma, waarbij het omringende gesteente contactmetamorf veranderd werd, terwijl ook effusiva zich een weg konden banen naar de oppervlakte, valt vóór het Eoceen, vermoedelijk in het Boven-Krijt.

In het Tertiair kan men duidelijk twee afdeelingen onderscheiden; het Oud-Tertiair, dat voornamelijk uit grauwblauwe of bruinachtige gesteenten bestaat en dat duidelijk geplooid is, en het Jong-Tertiair, dat hoofdzakelijk witte gesteenten bevat en dat, plaatselijke storingen buiten beschouwing gelaten, slechts zeer weinig door orogenetische krachten is beïnvloed.

Als jongste afzetting ligt hier overheen een dunne bedekking van horizontaal gelegen subrecente terraskalk, waarvan in het binnenland slechts losse relicten te vinden zijn, doch die langs de kust meestal nog een samenhangend geheel vormen. Door de stijgende beweging, waarin het eiland zich in subrecenten tijd bevindt, hebben deze terrassen zich trapsgewijs ontwikkeld, vooral langs de Oost-, Noord- en Westkust (zie tekstfig. 1). Langs de Zuidkust, die een steile breukkust is, ontbreken zij of zijn zij slechts als relicten aanwezig.

De assen der drie plooiingen (prae-tertiaire, oud-tertiaire en jong-

tertiaire) loopen parallel, n.l. ongeveer E.—W. Bij de jong-tertiaire plooiing kan men twee assen onderscheiden, n.l. een in West-Soemba en een in Oost-Soemba. De Oost-Soemba-plooi culmineert in het Massoebergland, de plooi van West-Soemba culmineert niet in één gebergte, doch in vier berggroepen. In de culminaties van die plooien werd Prae-Tertiair en Oud-Tertiair aangetoond; naar Oost en West duiken beide plooien weg onder het jong-tertiaire plateaulandschap, dat $^{9}/_{10}$ van het oppervlak van het eiland beslaat. In Midden-Soemba, waar de twee plooien elkaar aflossen, strekt dit plateau zich ononderbroken uit van de N.- tot de S.-kust. In Oost- en in West-Soemba, dichter bij de culminaties, hebben de breuken en verzakkingen langs de S.-kust echter de oude kern van de plooien aangesneden. Behalve in de gebergten en langs de S.-kust wordt Oud-Tertiair en Prae-Tertiair alleen in de diepste rivierinsnijdingen aangetroffen.

Het Oud-Tertiair was in het veld te verdeelen in een onderste afdeeling, onderscheiden als „Oudste Eoceen", die is opgebouwd uit bijna zuiver terrigene afzettingen, en een bovenste afdeeling, die veel meer organogene bestanddeelen bevat. Deze laatste afdeeling bleek bij het foraminiferenonderzoek drie à vier etages van het Tertiair te omvatten, n.l. Tertiair-a_2, -b, -c en -d (indeeling van VAN DER VLERK en UMBGROVE 1927 en van LEUPOLD en VAN DER VLERK 1931), terwijl de onderste afdeeling in verband hiermee tot het Tertiair-a_1 gerekend zou moeten worden. Het Tertiair-a_2 kan zoowel zandig of mergelig als zuiver kalkig zijn, en bevat op Oost-Soemba een typische *Assilina*- en *Fasciolites*-fauna, zonder *Pellatispira*. Op West-Soemba werd wel *Pellatispira* gevonden in gezelschap van *Assilina*, doch hier ontbreekt *Fasciolites* geheel.

Het voorkomen van Tertiair-b op Soemba werd slechts in één geval bewezen door het voorkomen van het gidsfossiel *Camerina djokdjokartae*. Bij de verdere determinatie van het Tertiair-b werd behalve van gidsfossielen als *Camerina*, *Pellatispira* en *Discocyclina* ook gebruik gemaakt van een negatieven factor, n.l. het ontbreken van de typische fauna van Tertiair-a. Het is dus mogelijk, dat enkele der als Tertiair-b gedeterminneerde monsters eigenlijk nog tot het Tertiair-a behooren, doch waarschijnlijk is dit niet.

Hetzelfde geldt ook voor de etages Tertiair-c en -d. Beide etages werden slechts in een gedeelte der monsters volledig gekarakteriseerd door de typische combinatie van gidsfossielen; daarnaast is er een aantal monsters, dat alleen *reticulate Camerinae* bevat, zonder *radiate Camerinae* of *Lepidocyclinae* en die dus zoowel tot -c als tot -d kunnen behooren.

Voorloopig zijn ze allen tot het Tertiair-c gerekend; gegarandeerd Tertiair-d is uiterst zeldzaam. Tertiair-c en -d zijn uitsluitend van Oost-Soemba bekend.

In de jong-tertiaire plateaubedekking zijn de etages Tertiair-e en -f zeker vertegenwoordigd; de grenzen van deze etages konden niet palaeontologisch worden vastgesteld en de mogelijkheid bestaat, dat dit Jong-Tertiair ook nog de etages -g en -h omvat.

Tusschen het Oud- en Jong-Tertiair ligt een hiaat, een landperiode. Het is mogelijk, dat West-Soemba reeds na het Tertiair-b boven het zeeniveau werd opgeheven; op Oost-Soemba moeten in het Tertiair-d en misschien zelfs in het begin van Tertiair-e ($e_{1.2}$) nog gedeelten onder water zijn geweest. Op de landperiode volgde een groote transgressie, waarbij de zee het geheele eiland, op de hoogste toppen der bergen na, overstroomde. Deze groote transgressie valt in het Tertiair-$e_{4.5}$ (waarschijnlijk e_5) en kan dus gerekend worden tot wat LEUPOLD en VAN DER VLERK de „Beboeloeh-transgressie" noemen, een transgressie, die reeds op zoovele plaatsen van den Nederlandsch-Indischen Archipel geconstateerd is.

Uit de detail-profielen is af te leiden, dat Soemba eigenlijk gedurende het geheele Tertiair in beweging is geweest. De hoofdplooiingsphase, die de oud-tertiaire lagen in steilen stand bracht, valt echter tusschen Tertiair-c en -e_5; waarschijnlijk heeft de plooiing het eerst in West-Soemba haar invloed doen gelden en zich daarna uitgebreid over Oost-Soemba. De zwakke jong-tertiaire plooiing bereikte haar maximum waarschijnlijk in het Midden- tot Boven-Tertiair-f. Deze plooiingstijd komt overeen met den tijd, die UMBGROVE aanneemt voor de hoofdphase van de jong-tertiaire plooiing op de reeks van eilanden, die liggen in de door VENING MEINESZ aangetoonde strook van negatieve gravimetrische anomalie. Doch terwijl deze jong-tertiaire plooiing op die eilanden zeer sterk is geweest (ten deele zelfs dekbladen heeft doen ontstaan), heeft ze op Soemba weinig invloed gehad. Een merkwaardige coïncidentie is, dat de strook der negatieve anomalie juist bij Soemba een onderbreking vertoont.

De foraminiferencollectie van Soemba heeft vele interessante gegevens geleverd voor de palaeontologie. Het was een rijk en goed geconserveerd materiaal, zoodat het kon dienen als uitgangspunt voor een gedetailleerd onderzoek en voor een critische beschouwing van oudere literatuur. Enkele nieuwe soorten werden beschreven, n.l. *Camerina discoidea*, *C. Kemmerlingi*, *Lepidocyclina* (*Eulepidina*) *tjendanensis* en *Rotalia elphidioides*. Verder behooren waarschijnlijk ook een *Discocyclina* en een *Orthocyclina* tot nieuwe soorten, doch de groep der *Discocyclinae sensu lato* is nog te weinig systematisch onderzocht om hierin werkelijk goed begrens-

de soorten te kunnen onderscheiden. Dit zelfde geldt voor de *Fasciolitidae*: alhoewel er zeer merkwaardige afwijkende vormen op Soemba gevonden zijn, kan men die toch nog niet met een bepaalden soortnaam aanduiden. De studie dezer foraminiferen moet, in aansluiting op de monografie van BAKX, nog verder voortgezet worden om de waarde der verschillende eigenschappen als soortkenmerk te kunnen beoordeelen.

Van verschillende, nog onvoldoend bekende foraminiferen kon een aanvullende beschrijving gegeven worden. De kenmerken van de *Assilinae* werden uitvoerig besproken, evenals die van enkele *Lepidocyclinae*. Het subgenus *Trybliolepidina* werd als subgenus geschrapt.

Voor de *Assilinae*, enkele *radiate* en *reticulate Camerinae*, het genus *Tinoporus* en eenige „kleinforaminiferen" werd nagegaan, welke waarde zij kunnen hebben voor de stratigrafie. Het belangrijkste resultaat is, dat kon worden aangetoond, dat *Camerina Nuttalli* en *C. thalica*, de typische gidsfossielen voor het Oud-Eoceen van Britsch-Indië, tot nu toe nog niet in Nederlandsch-Indië zijn gevonden. *Globigerina quadripartita* en *G. tripartita*, die alleen bekend waren van een vindplaats, die tot het Tertiair-e werd gerekend, werden hier onder eenig voorbehoud beschouwd als gidsfossielen voor het Tertiair-f. De eigenaardige *Globigerina* van Kaboe (thans *G. Kochi* genoemd) kan, evenals *Uvigerina javana*, niet als gidsfossiel voor het Plioceen of het bovenste gedeelte van het Mioceen (Tertiair-g-h) gebruikt worden, zooals KOCH veronderstelde.

De fauna van het Tertiair-a_2 van Oost-Soemba vertoont een zeer opvallende overeenkomst met die van de oud-tertiaire gesteenten van Nias, en komt ook in verschillende belangrijke punten overeen met die van Boeloengan (E. Borneo) en Timor, en met den fossielinhoud van de onderste Taballar-lagen op het schiereiland Mangkalihat (N.E. Borneo). Het Oud-Tertiair van Java daarentegen verschilt palaeontologisch sterk van dat van Soemba.

Nauwkeurige parallelisaties met gebieden buiten den Oost-Indischen Archipel kunnen niet worden gemaakt. In tegenstelling met de opvatting van GERTH en DOORNINK, dat de foraminiferenfauna van Java goed te vergelijken is met die van Britsch-Indië en zelfs met die van Europa, leidden mijn onderzoekingen tot de conclusie, dat de fauna's van Oost-Indië en Britsch-Indië, wat de soorten en hun opeenvolging betreft, meer punten van verschil opleveren dan van overeenkomst en dat men geen gedetailleerde parallelisatie kan doorvoeren in die twee gebieden, waartusschen in die tijden waarschijnlijk geen open zeeverbinding bestond.

Aan de hand van studiën van MARTIN en van UMBGROVE over de

kwestie van zeeverbindingen tusschen Europa en Nederlandsch-Indië in het Tertiair en van verschillende werken over de palaeontologie en de stratigrafie van Britsch-Indië en Burma, wordt een aanvullend overzicht gegeven van de mogelijkheid van zulke zeeverbindingen. Het is waarschijnlijk, dat het Nederlandsch-Indische gebied in het Oud-Eoceen land was en dat de zee eerst aan het einde van het Oud-Eoceen over de randen van dit vasteland transgedeerde. De oudste tertiaire fauna, die van Nederlandsch-Indië bekend is, is van midden-eoceenen ouderdom. Verder valt uit de literatuurstudie af te leiden, dat er reeds vanaf het begin van het Tertiair geen sprake meer kan zijn geweest van een samenhangende Tethys; de marine fauna van Nederlandsch-Indië is gedurende het geheele Tertiair een besloten eenheid met een autochtone ontwikkeling geweest (waarin alleen in het Oligoceen enkele vreemde vormen zijn binnengedrongen) en de afzettingen in Nederlandsch-Indië zullen nooit in detail en met scherpe begrenzingen rechtstreeks kunnen worden geparalleliseerd met die van West-Europa.

CONTENTS

INTRODUCTION

In 1920, the NETHERLANDS INDIA GEOLOGICAL SURVEY undertook a geological and mining examination of the islands of Timor and Flores. In 1923, when the fieldwork upon these islands was almost concluded, it was decided to extend the investigation over the rest of the Lesser Soenda Islands. From a mining point of view this was not expected to yield important results, but it was hoped that a general survey of the geology of these islands, to which hitherto only little attention had been paid, would throw a valuable light upon the tectonic construction of the south west Molukkers.

In February 1924, the late Dr. G. L. L. KEMMERLING, engineer in the Geological Survey, was entrusted with the superintendance of this research, and in March the survey of the island of Soemba was begun. After work had been going on for fifteen months, the whole scheme was put an end to in May 1925, so that Soemba is the only island beyond Timor and Flores that has been benefitted by the plan.

The survey of Soemba was carried out under Dr. KEMMERLING'S guidance by the geologist Dr. M. F. HÜNERWADEL and the assistant-geologists F. ECOMA VERSTEGE and W. A. B. GROSSJOHANN with some native helpers, while Dr. KEMMERLING himself visited the various fields and examined the results. The absence of a topographic map of the island and various infavourable circumstances, such as the very unhealthy climate, made it difficult to make more than a general survey, and only an ore reef in the South of East Soemba (Wai Baoe, between Tanah Roong and Tawoei) and the subrecent terraces were submitted to a more minute examination.

The working out of the extensive material of reports, maps and rock samples from the expedition and the making of a final general report, was an arduous and lengthy piece of work, demanding years of application. It was begun by Dr. KEMMERLING in the Indies, and, after a long interruption due to his health, he continued it in Europe. His untimely death in May 1932 left his work unfinished. When later I obtained access to his papers, I found that only a few chapters of the report were completed, namely, the introduction with a general description

of the morphology and hydrography of the island (written about 1929—1930; hydrography of East Soemba unfinished) and a detailed study of the Nangamessi Bay (raised sea terraces). Besides this I found a short temporary report of the results of the Soemba survey (September 1925) and a small topographic map (1 : 500.000) on which the belt of subrecent terraces along the coast was drawn in (see text fig. 1).

The 1500 or so rock samples that were collected on Soemba are divided into two collections, *collection O. S.* (from East and Middle Soemba) and *collection W. S.* (from West Soemba). The greater part of these collections has now been worked out, only the pre-tertiary sediments and metamorphic rocks, which Dr. KEMMERLING had reserved for his own share of the work, are still awaiting further examination. The eruptiva were principally examined by Dr. W. F. GISOLF (not published). The tertiary deposits, which contain a rich foraminiferal fauna, were in part determined provisionally during the field work by Dr. I. M. VAN DER VLERK; in 1929 another preliminary report was brought out, which included a rather greater number of samples. In the same year I was asked to undertake a final palaeontological examination of the entire collection of tertiary sedimentary rocks, which I have now completed.

As East and Middle Soemba were much more minutely surveyed in the field than West Soemba, and the material in the O. S.-collection proved moreover to be the softest and palaeontologically the most interesting, I have devoted most attention to East and Middle Soemba, while only the most important samples from West Soemba have been examined. In the whole research it has been the Lower Tertiary that roused the greatest interest.

I have, for stratigraphical purposes made use of Dr. KEMMERLING'S papers mentioned above and also of the original reports of the field work, corrected and annotated by him. But for most of my geological knowledge of the island I am indebted to Dr. KEMMERLING for his verbal information. I shall always cherish a grateful remembrance of the skill and the inexhaustible patience with which the leader of the Soemba expedition drew for me the picture of the country which was my object of study, but which I had never seen.

At the same time I should like here to express my thanks to Mrs. KEMMERLING—VINKE for the hospitality with which she always received me when I wished to consult the papers and documents of the expedition.

The detailed descriptive list of the samples examined, with their complete fossil contents, could not be published on account of the

great expense; it reposes in the National Museum of Geology and Mineralogy at Leiden. The complete collection of samples, and the greater part of the slides which were lent me to examine, are in the Head Office of the Geological Survey at Bandoeng (Java). The duplicate collection, which was sent to Holland and which is the basis of my special research, as well as the type specimens of the foraminifera described, may, however, also be found in the Museum at Leiden.

At the conclusion of my task I gratefully acknowledge the help I received from many quarters.

In the first place from the HEAD OF THE RESEARCH DEPARTMENT OF THE NETHERLANDS INDIA GEOLOGICAL SURVEY, who entrusted the collection to me and who gave permission for the reports and maps, even after the death of Dr. KEMMERLING, to remain at my disposal. In this connection I also wish to express my thanks to Dr. N. WING EASTON, who procured this concession for me. Moreover I owe many thanks to Dr. R. RUTSCH of the Natural History Museum at Basel, Dr. A. G. BRIGHTON of the Sedgwick Museum at Cambridge, Prof. Dr. H. GERTH of the Geological Institute of the Amsterdam University and to the Directors of the National Museum of Geology and Mineralogy at Leiden, who furnished the opportunity for examining the types of several important foraminifera in the collections of these institutions.

Finally my most cordial thanks to Dr. I. M. VAN DER VLERK, whose advice and kindly criticism have been a constant support during my work.

GEOGRAPHIC POSITION OF THE ISLAND OF SOEMBA

The island of *Soemba*, also called *Poelau Tjendana* or *Sandelwood Island*, belongs to the southern group of the Lesser Soenda Isles (Soemba, Savoe, Rotti and Timor). It is separated from the northern group (Flores) by Soemba Straits; in the East it is bounded by the Savoe Sea and on the South and West coast by the Indian Ocean.

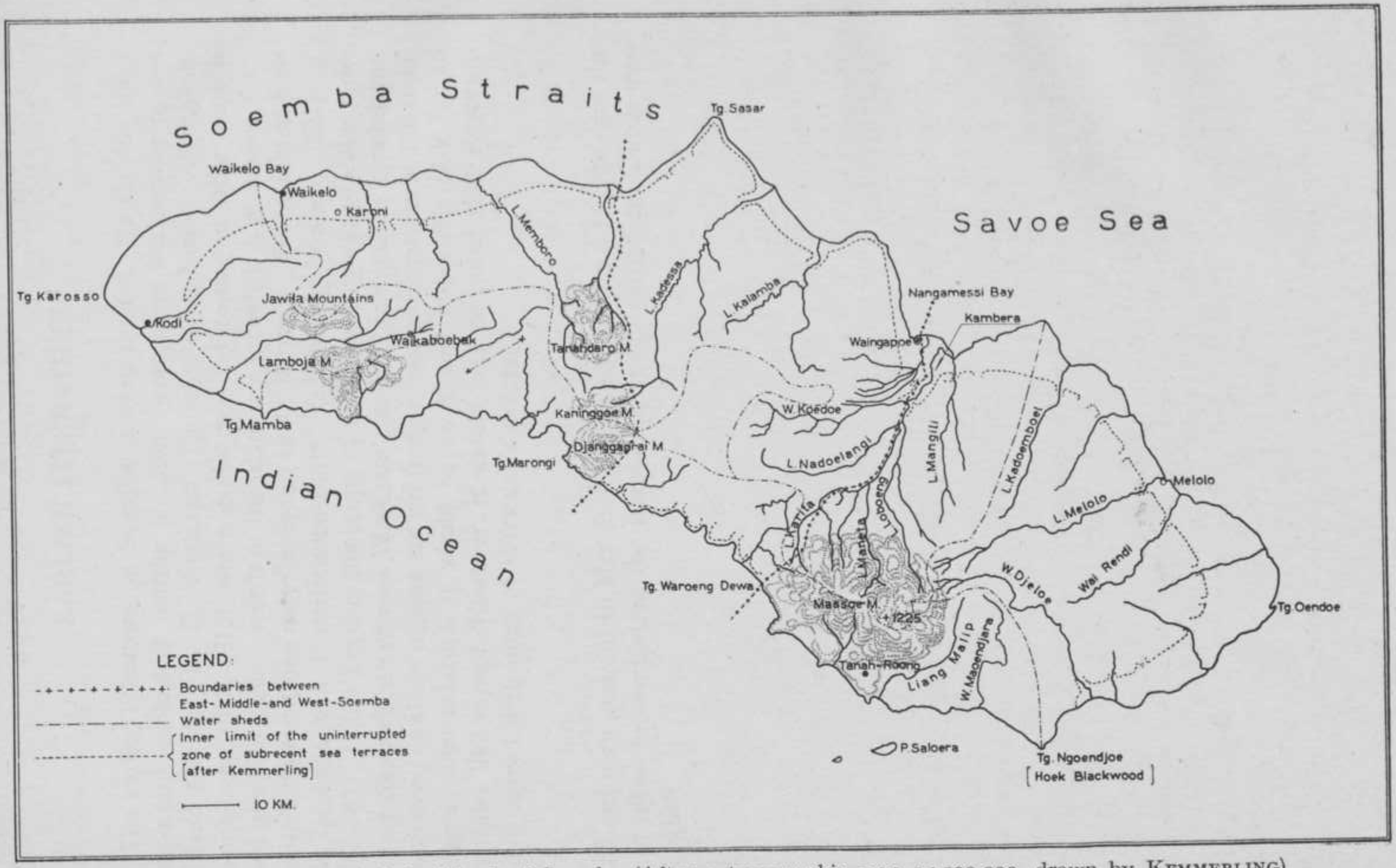
The length of the island, from Tg. Karosso to Tg. Oendoe, is about 215 K.M. and the total area, which has not yet been quite accurately measured, is about 10.000—14.000 K.M.^{2} (= about $\frac{1}{3}$ of Holland).

NB. Throughout the whole publication topographical names such as "Soemba", "Tg. Oendoe", etc. are written with "oe" (as in Dutch); "oe" is pronounced "u" in these names.

EARLIER LITERATURE

The earlier literature on Soemba is very limited. By far the most important geological writing is „Een Geologische Verkenning op het Eiland Soemba" by H. WITKAMP (Tijdschr. Kon. Nederl. Aardrijksk. Genootsch., 1912, 1913), which is also very interesting in other respects and in which earlier records of the island are included. A résumé of WITKAMP's observations may be found in L. RUTTEN „Voordrachten over de Geologie van Nederlandsch-Indië" (edited by Wolters, 1927), p. 667—671. It lies beyond the scope of the present work, to draw a detailed comparison between WITKAMP's and KEMMERLING's conclusions; moreover, as these regions are subject to constant changes in the topographic nomenclature, it would be an almost impossible task for an outsider like myself. However, it should here be noted that KEMMERLING agreed with most of WITKAMP's points.

I am very grateful to Mrs. D. KUENEN—WICKSTEED for the care she has taken in completing the translation of my work from Dutch into English.



Textfig. 1. General map of the island of Soemba (After a topographic map 1 : 500.000, drawn by KEMMERLING)

CHAPTER I

REVIEW OF THE RESULTS OBTAINED BY THE GEOLOGICAL RESEARCH IN THE FIELD

This chapter will be devoted to a general statement of the geology of the island of Soemba, as it was known when the research in the field was terminated, that is, before the result of further research on the foraminifera by Dr. VAN DER VLERK and by myself had been applied to it.

The following is a short description of the morphology and geology of the whole island, compiled from the monthly, quarterly and annual reports of the head of the research, the late Dr. G. L. L. KEMMERLING, with his assistants Dr. M. F. HÜNERWADEL (geologist) and F. ECOMA VERSTEGE (assistant, now: chief assistant). Especial use has been made of KEMMERLING's Annual Report from 1924, as well as a short Sketch Report of the Results of the „Mijnbouwkundig Geologisch Onderzoek Kleine Soenda-Eilanden", which KEMMERLING wrote at Bandoeng in 1925. Occasionally I have inserted sentences and descriptions taken from these two reports in my own text.

MORPHOLOGY AND GEOLOGY OF THE ISLAND OF SOEMBA

A – Morphology

The island of Soemba, as regards its morphology, may be divided into three clearly defined unites:

I – EAST SOEMBA, taking as western boundary the main valley of the Loko Karita-Kambera, that is the line that connects the Tandjong Waroeng Dewa (South coast) with Waingapoe (North coast) [1]).

1) Loko, Lokoe, Lai, Wai = water, river.
Tandjong (Tg.) = cape.

II – MIDDLE SOEMBA. The extensive plateau west of this line up to the eastern foot of the Kaninggoe-Djangga Prai Mountains and the Tanah Daro Mountains and further on to the valley of the Palamedo, roughly speaking to a line running from Tandjong Marongi (South coast) to Tandjong Palamedo (North coast).

III – WEST SOEMBA. That part of the island lying to the west of the above mentioned line.

The landscape of EAST SOEMBA presents three distinct features:

a – *Mountain land* in the S. W. portion, known by the name of the Massoe Mountains, the highest peak of which is Wangga Mati (about 1225 m. above sea level) at the same time the highest peak on the whole island. These mountains form the central point for the hydrography of this part of Soemba.

b – A *plateau*, which covers this mountain formations like a quilt on the West, North and East sides, but in the South, between Tg. Ngoendjoe and Tg. Waroeng Dewa is absent or can only be recognised in some remains.

c – Undulating *hills*, belonging to the river basins of Liang Malip and Loko Maoendjara and roughly bounded by the triangle Tanah Roong (Tg. Haoli, S. coast)-Kananggar-Tg. Ngoendjoe (Hoek Blackwood, S. coast).

In WEST SOEMBA the aspect is somewhat different. There is no great central mountain mass forming the chief feature of the landscape; there are *four mountain groups*, which, from their morphologic appearance, are clearly distinguished from their surroundings, viz. the Jawila Mountains (about 887 m. above sea level) the Lamboja Mountains (about 637 m. above sea level), the Tanah Daro Mountains (about 895 m.) and the Kaninggoe-Djangga Prai Mountains (about 790—825 m.).

As in East Soemba the mountains are covered by a *plateau* that stretches unbroken from Tg. Mamba (S. coast) to Tg. Palamedo (N. coast), but is absent or only found in relics to the South, between Tg. Mamba and Tg. Marongi.

Finally in W. Soemba there is also a district of *foot hills;* this runs along the S. coast from Tg. Mamba to Tg. Marongi and is bounded on the North by the water shed between the S. and N. parts of West Soemba.

This hill country is not so markedly developed as in East Soemba, as it has kept more of the aspect of the plateau formation and is only of a hilly character in the broad valleys. KEMMERLING, in his final report of this district calls it: *plateau-hill-landscape.*

In MIDDLE SOEMBA the *plateau* extends over the whole region from N. coast to S. coast. According to Witkamp it is a very monotonous country, "a sea of petrified waves", above whose surface a few low peaks arise only in the upper valley of the L. Kadessa and the L. Kalamba (G. Kepiki 610 m. above sea level and G. Kambaonideta 600 m. [2])).

In the *plateau*, which covers $^9/_{10}$ of the island, the rivers have cut themselves in more or less deeply, according as their fall is larger or smaller. In the most westerly region (district of Kodi, central hydographic point the Jawila Mountains) and the most easterly (district of Rendi, central point the Massoe Mountains) the rivers flow radially over the plateau shield. The rivers that arise on the plateau itself form only shallow valleys; the longer rivers that have their source in the mountains, flow through deep cañon-like valleys, which they have often cut out through the thick limestone and marl covering, down to the earlier base. The faintly accentuated water-shed between the Savoe Sea and the Indian Ocean lies much nearer to the South than to the North coast over the whole extent of this region; the rivers that flow southwards therefore have a much greater fall and their power of erosion is proportionately stronger. This gives a very different appearance to the landscape especially in Middle Soemba: south of the water-shed the field is ploughed into deep cañons, north of it only a few of the largest rivers have been able to excavate a cañon, while further there are nothing but shallow, dry, winding valleys, morasses and flat pans. Most of the rain water sinks in and drains off underground; some of it gives rise to the springs which feed the tributaries of the large rivers.

The coast of Soemba presents a very remarkable profile from the great number of *terraces* which surround the island. Along the N. coast especially, where the plateau rises rather abruptly from the sea, the stair-like profile can be very well seen to the W. of Nangamessi Bay; along the W. and E. coast it is much less pronounced, owing to the gentle slope of the plateau. The S. coast is of a completely different character. A great number of sharp capes, cliffs and rocks, between which lie bays with narrow entrances, form a fantastic coast-line; there

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2) Goenoeng (G) = mountain, hill.

are no sea-terraces or only relics of them. Where they have been able to develop locally, they are fewer in number than on the other coasts. According to KEMMERLING this whole coast formation is due to constant faulting and sliding down of the land towards the Indian Ocean.

B – Geology

KEMMERLING and his assistants began by making a classification of the rocks, which was confirmed in its principle lines by further laboratory research. This classification which applies to the whole island is as follows, from upper to lower beds:

Coral and gravel terraces (sub-recent, recent)
Upper tertiary marl series (Pliocene-Miocene)
Original body of the island (Oligocene and earlier deposits and eruption).

CORAL AND GRAVEL TERRACES

The coral and gravel terraces belong to the latest deposits, which are not confined to the coast only, but are found far into the Plateau as relics of the uppermost covering on the marl series. The same deposit, which is found to more than 600 m. above sea level, can be seen in process of formation along the recent sea coast.

If the reef that becomes bare at low tide be counted in as the latest (recent) terrace, seven or eight terraces may be distinguished, usually at 0, 15, 50, 275, 450 and 550—600 m. above sea level.

Where there are rivers running into the sea, gravel terraces are formed; in places where the water is not made turbid by river ooze, reef limestone is developed. As transition between the two are found coral terraces mixed with gravel. The same alternation of coral limestones and gravel banks is found in the terraces inland.

The depth of these terraces is usually very small: 1—2 m., maximum 6 m. Below these lies a more marly deposit, which forms a sloping transition between these horizontal banks. In some places, e.g. along the N. coast, E. of Waingapoe, this recent marl is light grey, in contrast to the white teriary foraminiferous marls. The terrace limestones are white or yellowish, often also pink in colour; they are usually hard and cavernous and contain chiefly corals and shells.

UPPER TERTIARY MARL SERIES

Deposits of upper tertiary age predominate on Soemba; they form the entire plateau and a part of the hills. They are principally globigerina marls and compact chalk marls, amongst which conglomerates and limestone banks are found. But tuffogenous deposits are also frequently found, in various niveaus of the Neogene. The occurrence of these rocks in very scattered places indicates, according to KEMMERLING, considerable eruptions over the whole extent of the island during the Upper Tertiary.

In the Upper Tertiary two divisions could be distinguished everywhere. The uppermost stage was called in the field "*Waingapoe series*", after the most important seaport of East Soemba, in the neighbourhood of which this deposit first attracted the attention [3]); but it was left undecided which division of the Tertiary it represented. The Waingapoe series is generally speaking a series of horizontal strata, the dip is as a rule 0—5°, but inclining in different directions. Witkamp speaks of a "discordant parallel structure on a large scale". On close examination, however, local disturbances prove to be very frequent; both faults and folds were observed. Secondary foldings, especially in the lowest strata, may be very marked, so much so, that KEMMERLING writes that at the sight of a good exposure of these folded strata one might imagine oneself in the Säntis Mountains.

The Waingapoe Series consists of constantly alternating wedging-out strata of fine chalk marl, coarse globigerina-marls and conglomerate banks. They are white rocks with very little tuffogenous material and practically no larger foraminifera. Regional differences of facies are not found in these deposits.

Below the Waingapoe Series, often clearly divided from it by an unconformity, lies an earlier bed of the Neogene, the dip of which varies between 6° and 20° (usually not more than 12°), again in various directions. At first this series presented some difficulty in the field work, as here, in contrast to the Waingapoe Series, there were great differences of facies. In the East of East-Soemba a white tuff-marl series was found, which was given the name of "*Kananggar series*", from the good exposure in the neighbourhood of Kananggar and the upper Wai Djeloe and in

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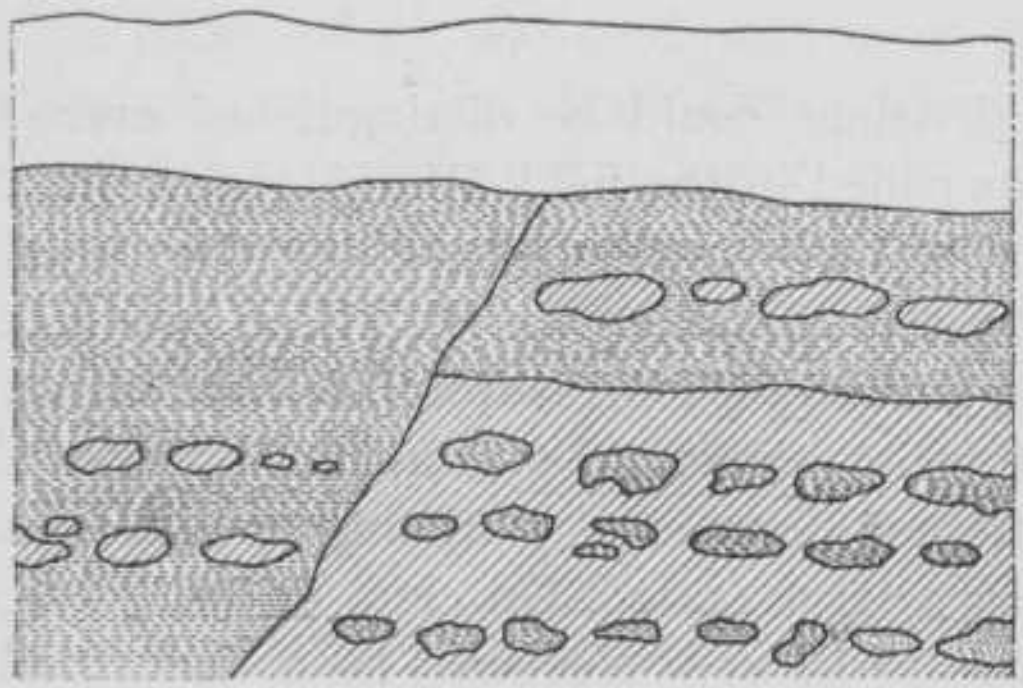
3) KEMMERLING replaces this name by a letter in his last general report. I myself, however, see no objection to continuing to use the name for this very definitely defined series of strata in the local stratigraphy; I shall also use the other names of stratigraphic unities here and there.

the W. of it (in the West of East-Soemba and in Middle Soemba) a pale red tuff deposit, which in the neighbourhood of Kambaoni is particularly well developed, and was given the name of "*Kambaoni series*". The finding of *Nummulites* in the Kambaoni series set the surveying party on a false scent; they thought it must be a lower tertiary formation, an earlier deposit, therefore, than the Kananggar series, which contained *Lepidocyclinae*. When, however, KEMMERLING made a visit to the district, he found that the *Nummulites* did not come from solid rock, but from boulders in the conglomeratic tuff, while the horizontal transition from red tuff to white tuff-marl became very evident in the field N. E. of Kananggar. This showed the two formations to be of the same age and KEMMERLING gives the following diagram as illustration of the position of these beds (monthly report May 1924, KEMMERLING), see fig. 2.



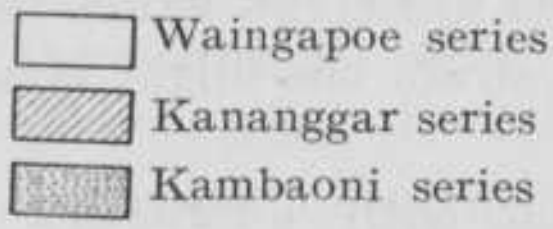


Fig. 2.
Composite section of the neogene series in the neigbourhood of Kananggar.

Later on it was found that a third, more limy facies might occur in the lower division of the Neogene which to the West of the Kambaoni series (Middle and West Soemba) becomes predominant. Mixture with tuff-bearing material is there much less frequent than in the eastern half of the island.

THE ORIGINAL BODY OF THE ISLAND

KEMMERLING assigns everything to this "original body" that is earlier than the neogene covering, which forms such a distinct morphologic unity in the field. This core embraces both the Lower Tertiary (which was called by the men in the field "*Tanah Roong series*" after the village Tanah Roong in the Liang Malip valley) and the eruptiva and even earlier sediments, which form the foundation of the Tertiary. From above downwards can be distinguished:

Nummulites-, *Orbitoid-* and *Alveolina*-marls and reef limestones.

a series of grey-blue conglomerates, sandstones, lime sandstones, the last with a characteristic fauna: remains of *crabs, gastropoda, lamellibranchs* and remains of plants [4]). These deposits were called by KEMMERLING in the field: "*Lowest Eocene*".

} TANAH ROONG-SERIES

SHALES AND SANDY SHALES ("shale formation"): these are more extensively found in W. Soemba than in E. Soemba. KEMMERLING assigns some locally developed sandstones, lime sandstones, conglomerates and tuff agglomerates to this formation also [5]).

a formation consisting of contact metamorphic sedimentary rock (felspathised, pyritizised, silicified). A white silicified tuff is characteristic, but darker rock is also found, such as contact-metamorphic or felspathised tuffsandstone, tuff-conglomerates and shales (?).

IGNEOUS ROCK. In this various rocks could be distinguished:
plutonic rocks (granites, granodiorites and gabbros),
effusive rocks (rhyolites, dacites and andesites and here and there basalts),
and *dike rocks* (diabases, melaphyres).

A complete section in which these beds could be seen in the right order was not found; often one or more of the stages are absent and the foraminiferous limestone, for instance, lies directly on top of the eruptive bodies or the contact zone. The stratigraphy given above was composed from a combination of numerous small local sections. The whole collection of rocks is more or less deeply folded and severed from the neogene covering by an usually distinct unconformity. It contrasts with the Neogene further by the darker colour (red-brown, brown, dark yellow, grey-blue, etc.).

This original body is found in *East Soemba* in the Massoe mountain country as well as in all the valleys which are S. of the line running through Melolo-Kambaoni-Lingi Tana. From Tg. Ngoendjoe to Tg. Waroeng Dewa rocks of this basal formation form the coast-line.

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4) KEMMERLING attaches particular value to this lime sandstone, as he thought it could be parallelised with a similar rock which he had found near Moeara Teweh in the Barito basin, S. E. Borneo, underlying the *Nummulites* marls. (See: Tijdschrift Koninklijk Aardrijksk. Genootschap, 2nd series, part. XXXII, 1915).

5) The working up of these rocks KEMMERLING had reserved for himself but he was not able to complete his research. I do not know to which formation he finally assigned these agglomerates and lime-sandstones (cf. p. 17). But at any rate they are of pre-tertiary age.

On *Middle Soemba* this core only comes to light in the deepest ravines of the northward flowing rivers (principally in the upper reaches of the Palamedo, the Kadessa and the Kalamba) and south of the water shed only at the boundary of West Soemba (Pr. Langina, Pr. Kaninggoe, Djangga Prai). The whole of the rest of Middle Soemba is dominated by the neogene stage, even along the S. coast from Tg. Waroeng Dewa to Wai Kadjeloe (north west of Tg. Marongi).

In *West Soemba* on the upper reaches of the rivers flowing towards the N. and W. coast outcrops of the original core are constantly met with. Presumably the range of mountain peaks, beginning at the G. Jawila in the West and ending with the G. Bai and Lamboe in the east forms the crest of the folded central core. The rivers that flow south have almost all cut down into the original core and the coast from Takonda bay to Tg. Mamba is principally formed of this early rock.

C – The relation of the geology to the morphology of the Island

Generally speaking the geology of Soemba can easily be reconstructed from the formation of the land.

The latest deposits, the SUBRECENT CORAL-REEFS AND CONGLOMERATES, where they still form a continuous whole are, as we have already said, easily recognisable at the first sight. These form the terraces, characteristic of an island that has gradually risen up from the sea, especially well developed on the North and also the East coast, leaving no doubt as to their origin and age. On the South coast, where they have only been able to form in some places, and where they have largely been destroyed by land slips after their formation, they are very difficult to recognise. Their formation is also hard to follow on the plateau further from the coast, where they probably once formed a continuous covering, of which erosion has now left only disconnected relics. But in these places, again, they can be discovered by their white or pink colour, their almost horizontal position, usually in hard banks on the hill-tops, and further by the vegetation. KEMMERLING takes it as a general rule that where coral limestone lies there is forest and generally speaking it may be said with certainty, that the wooded tops of the hills that rise above the plateau consist of sub-recent coral limestone.

The UPPER TERTIARY, which is by far the most widely spread in the

field, forms the extensive plateau of principally white, or at any rate very pale coloured, rock. The deposits are well stratified and the alternation of hard and soft layers lends itself to the cutting out of regular cañons by the larger rivers. The eroded form of these rocks makes "the sea of petrified waves", as WITKAMP calls it: an unlimited extense of humps and small pyramidal hills, with their crests and tops all lying more or less in the same horizontal plane, separated by shallow, sometimes boggy basins and pans without any superficial drainage or narrow winding forked valleys. The pyramidal shape of the hill tops is characteristic of the "*Waingapoe series*", the most recent Tertiary. The "*Kananggar series*" and the limy facies of the same stage in West Soemba gave a similar appearance to the landscape, except that where they form the surface of the plateau it is less characteristically divided into hills and valleys. Where hard limestones come to the surface, they may be weathered, like recent coral limestones, with sharply protruding ridges and banks, with a surface of similar conical points and basins, like the whole landscape, but on a very minute scale. KEMMERLING called these banks: "reef-shaped eroding limestones", in contrast to the relics of real, subrecent, reef limestones, with which they were often at first confused in the field.

The weathering of the "*Waingapoe series*" and the limy and marly facies of the lower Upper Tertiary does not produce fertil soil, while the circulation of water in the ground is insufficient to permit a thick vegetation. There is no forest on the plateau (except on an occasional top which still bears a remnant of coral limestone); the extensive territory is covered with thin grass through which the whitish rock is everywhere visible, so that the vegetation accentuates, rather than conceals, the outcrop of the different strata on the slopes of all the hills and ravines. The grass, in which one particular species seems to predominate, is a dull green in the wet season and yellow in the dry season; colours which are typical of the very monotonous Soemba landscape.

The tuff facies in the neighbourhood of Kambaoni, the so called "*Kambaoni series*", has been quite differently affected by erosion. The rivers have not been able to hollow out any cañons in this soft, not well stratified rock; the valleys are troughs with sloping sides. Moreover as the erosion soil is dark red instead of pale in colour, and the vegetation is more luxuriant (green pasture and arrable land), the Kambaoni series gives rise to an entirely different landscape to the rest of the upper tertiary rock.

The rocks of the ORIGINAL BODY OF THE ISLAND are differentiated from the Upper Tertiary in the first place by their colour; they are usually darker in colour, not only the eruptiva but the sediments as well. As a rule the sediments of the *shale-formation* and the lowest beds of the *"Tanah Roong series"* are dark grey-blue or greyish brown; the upper "Tanah Roong" beds are grey, greyish brown, bright yellowish brown or dark red-brown. The Tanah Roong series is best developed in East Soemba in the well known triangle of the hill country, in the river basin of the Liang Malip and the Wai Maoendjara. These two big rivers have not hollowed out a cañon in the steeply inclined, often disturbed strata; the valleys are wide, especially of the Liang Malip, and have a broad flat bottom and steep walls with a great many rock falls. The original upper tertiary covering of this region has been undermined by erosion; very little of it remains in situ, except in the uppermost reaches of the rivers, but the valley is covered with waste, in which much material from the younger marl series is found. The enormous rock falls in these parts make it very difficult to draw the boundary between the foundation, Lower and Upper Tertiary. The long broad ranges of hills with their steep slopes, however, certainly consist of Lower Tertiary marls and limestones, except the summits of the highest mountains (Tandoela Djangga), which are crowned by a horizontal bed of conglomerate of a different geological age.

The *eruptive rocks*, finally, form the mountainous parts of the island, with sharp crests and v-shaped valleys, again a completely different formation to the hilly district. In East Soemba genuine reef limestones may sometimes be found against the highest crests, which by their yellowish brown colour and on nearer view their conspicuous nummulitic fauna, are immediately distinguishable from the white or pink fossil-poor subrecent reefs and must be assigned to the Lower Tertiary.

GEOLOGICAL HISTORY OF SOEMBA

The age of the lowest deposits on Soemba is veiled in complete obscurity. It is not clear from KEMMERLING's reports how old he estimated the basis to be; unfortunately he was not able to complete his geolocical research which he had hoped would yield an answer to this problem. In one of his reports he mentions that WITKAMP thought he could recognise Cretaceous in similar rocks. But at the same time he reminds us that a few badly preserved fossils which WITKAMP found in a sandstone

bed of the shale formation on the south coast of West Soemba, were determined by BOEHM, with reservation, as *Posidonomya Becheri* (1911), which presents the possibility that the basis is, to some extent, of Carboniferous age. The locality of this fossil was searched again without any success [6]).

In any case these deposits, which are very poor in fossils, are of PRE-TERTIARY age. They have been *folded* in an equally un-ascertainable geologic age, and were *contact metamorphosed by the rising of granitic and gabbroic magma.* As the eocene deposits lie transgressively over both the igneous and the contact metamorphic rocks, it must be assumed, according to KEMMERLING, that the contact influence, the rising of the magma, took place before the eocene period, presumably in the Uppermost Cretaceous. It is KEMMERLING's opinion that the folding of these sediments and the rising of the magma took place at the same time, so that effusiva could win a way to the surface, an opinion based on the find of dike-rocks and tuffs in this formation. Soemba must have been land at that time.

The EOCENE commenced with an enormous erosion accompanied by a gradual sinking below the level of the sea. Graywackes, arkoses, conglomerates and sandstones, which bear unmistakable signs that they are derived from this old land, represent the lowest beds of the Eocene. These are followed by the purer marine sediments, in which the organogenous constituents predominate; but these are still reef limestones, sandy limestones and sandy marls, that is, all neritic deposits. It cannot be said with certainty whether the whole island sank below sea level; the absence of eocene rocks in some profiles may indicate that these spots remained as islands above the sea, but may equally well be due to the fact that erosion at a later period completely destroyed the eocene covering in these places. There is not much to be seen of *volcanic activity* in the Eocene. Whatever volcanic material may be found in Eocene deposits, KEMMERLING regards as erosion products from the effusiva of the original volcanic core of the island.

After the Eocene a *second folding* took place, which attacked the eroded core of folded sediments and eruptiva, as well as the eocene deposits lying unconformably upon it. The Eocene is found in a steep position

6) In 1929 WITKAMP's fossils were again examined by ROGGEVEEN. The *Lamellibranchs* then had to be determined as *Inoceramus*. In the same rock an *Ammonite* was found which showed that this deposit is of jurassic age.

in all sections, often with a dip of 30° or more. According to KEMMERLING this folding must have been completed previous to the Oldest Miocene, seeing that the Neogene is deposited upon these deeply folded beds unconformably and with the character of a distinct transgression. It does not seem as if there was any rising of new magma during this second folding; no contact metamorphosed eocene sediments were found. It does seem as if the superficial volcanic activity was stimulated by it, the Jawila and Lamboja Mountains in W. Soemba and a few peaks of the Massoe Mountains in E. Soemba, KEMMERLING believes to have their origin in this period, as they still retain the original shape of a volcano. The many tuff beds in the Neogene ("Kambaoni series", "Kananggar series") may be considered as due to this volcanic activity.

The deposit of the NEOGENE must have been proceeded by a period of erosion and sinking of the land. The neogene sea transgressed over the old core, levelled for a second time; but it did not take possession of all the land: the present Jawila, Lamboja, Tanah Daro and Djangga Prai Kaninggoe Mountains and the highest parts of the Massoe mountainland, remained above as islands. In the Massoe Mountains, for instance, up to a height of some 1.000 m. above sea level, remains are everywhere found of the marl series, but nowhere at a greater height. At these points, therefore, the neogene covering has not been destroyed by later erosion: it has never been present.

The absence of Neogene along the S. coast of W. and E. Soemba, on the contrary, must be attributed to tecktonic causes (faulting along the coast).

The many small unconformities, faults and local tilting of the strata in the neogene beds proves that during the neogene period the island was *constantly subjected to foldings*. This third folding must have been of greatest intensity about the middle of the Neogene. The lowest part of the "Waingapoe series" is suddenly much more deeply folded than the rock of the older part of the Neogene that lies beneath it; this, according to KEMMERLING, is due to a difference in plasticity in the strata. The *volcanic activity* was very great during these neogene foldings, as shown by the thick beds of tuff and pumice-stone, and the presence of older limestone blocks and boulders of eruptiva in the upper tertiary marl series points to erosion of the constantly rising mountain land.

This *third folding* was not confined to the Neogene; it *continues to the present day*. The later coral and gravel terraces, which are found up to

more than 600 m. above sea level, are the proof that even in SUB-RECENT and RECENT times the elevation of the island of Soemba by folding is still going on.

As far as can be traced, the axes of the three foldings in Soemba run parallel, about East to West.

The intensivity of the earliest folding was the greatest; the latest, with the exception of local dislocations, was slight. The dip of the neogene strata is usually only a few degrees; 10°—12° may be considered as the maximum (N.-limb).

In the *Neogene* of Soemba *two chief fold-axes* can be distinguished; a southern one on East Soemba and a northern one on West Soemba.

The *fold-axis in E. Soemba* culminates in the Massoe mountains. In these mountains and in the hill country lying east of them the surface is formed of the original body of the island; the neogene covering is only found as relics. To the East the axis pitches, and east of a line from Tg. Ngoendjoe to Kananggar the old core is concealed under an uninterrupted covering of neogene rock. In the upper reaches of the Wai Melolo, the Wai Rendi and the Wai Djeloe the foundation is found in the ravines, but further to the East it lies so deep under the thick deposits of the neogene shield, that even in the great cañons it is not revealed. To the W. of the Massoe mountains the fold-axis also pitches, but its prolongation in that direction is only partially concealed by Neogene, viz. only the northern flank. Further to the West the greatest part of the fold is sunk into the Indian Ocean along a system of faults.

The *fold-axis of W. Soemba* pitches to the West, and in the neighbourhood of Kodi (like the easterly end of the E. Soemba fold, in the district Rendi) is covered by a shield of Neogene. In contrast to E. Soemba this axis does not culminate in one central mountain land, but in four different groups, which form two parallel ranges from E. to W.; Jawila-Tanah Daro and Lamboja-Djangga Prai-Kaninggoe.

Towards Middle Soemba the fold-axis pitches under the neogene covering and only in an occasional river gorge (L. Kadessa, L. Kalamba, etc.) original foundation is exposed. *Middle Soemba is the region where the two pitching fold-axes interchange,* which explains why the Neogene is developed from North to South in a continuous sheet. In West Soemba only a part of the southern flank of the fold is missing, principally between Tg. Hoea and Tg. Marongi; here too a fault is the cause.

According to KEMMERLING these faults along the S. coast have mostly been formed in the latest Upper Tertiary, but this faulting still

goes on at the present time, like the folding. This is demonstrated by the absence of well developed terraces in the S. coast, by the steep boundary of the plateau on the N. coast and by local subsidences in the plateau itself. The slowly rising island, therefore, is bounded both on the N. and the S. side by faults and land slides which run parallel to the axis of the folds. These tectonic movements go on more slowly on the N. coast than on the S. coast, so that sea terraces have been able to form on the North.

No traces were found on Soemba of recent volcanic activity.

(See supplement, p. 197).

CHAPTER II

PALAEONTOLOGY

In this chapter only the foraminiferal fauna will be discussed at length. The other fossils were not determined, with the exception of a few molluscs, which could be compared with Javanese molluscs (MARTIN collection) in the collection of the Leiden Geological Museum.

In the larger foraminifera, specimens from washed samples, of which the habitus, horizontal and vertical section could all be examined, were determined down to species, as well as a number of foraminifera from hard rocks which had been prepared in tangential, horizontal and vertical sections. Occasionally a species determination could be made from slides, or a polished surface of hard rock, when a fortunate accident had given an orientated section which revealed a characteristic peculiarity of the foraminifer (e.g. an oblique section of reticulate *Camerinae*, a vertical section of *Assilina orientalis* or *Heterostegina borneënsis*, etc.). To avoid errors determinations of species were never made merely from unorientated accidental sections.

The smaller foraminifera from the upper tertiary marls were principally determined on the basis of the following publications:

BRADY, Challenger (1884).
CUSHMAN, North Pacific Ocean (1910—1916).
—— Atlantic Ocean (1918—1924).
—— Philippine and adjacent seas (1921).
—— Classification and economic use (1928).
HOFKER, Siboga I (1927).
SCHWAGER, Kar Nicobar (1866).
FISCHER, Seran und Obi (1927).
KOCH, Bulongan (1926).
—— Kabu (1923).
SCHUBERT, Bismarck-Inseln (1911), and a number of other works on foraminifera, all mentioned in the list of literature on p. 218, etc.

Generally speaking, the smaller foraminifera could be easily determined with the help of the reproductions given of recent foraminifera; deviations from the recent forms were in most cases, including the samples from the *Lepidocyclina*-containing Tertiary, so slight that they might be regarded as varieties. Besides these recent species, a few fossils were found which could be identified with the foraminifera of SCHWAGER, KOCH and FISCHER, and finally the material yielded a few new species (*Nonionina, Truncatulina, Polystomella, Sphaeroidina, Cristellaria*, etc.) two of which are described later; the rest are here not further noted, as they do not vary much from familiar species, and were met with in too small a number to be of any value for the stratigraphy [7]).

The problem of trimorphism (HOFKER) is left entirely out of consideration, in the first place because this phenomenon could not be sufficiently studied in material which, like ours, never contains large numbers of individuals of one species from the same locality, and in the second place because this purely biological problem can have no important influence upon the stratigraphic results which are the principal object of this research.

The fossil flora, formed by the numerous algae in the rock of Soemba would certainly repay a closer study, but they will not be dealt with here. We shall confine ourselves to a discussion of the animal organisms, while expressing the hope that there may be an opportunity later of giving a thorough systematic treatment of these algae. They are probably stratigraphically of no great importance, but it is not impossible that a minute research might yield important data (cf. p. 26).

GENERAL REMARKS ON THE FOSSILS OF THE SOEMBANESE TERTIARY

The post-mesozoic rock of Soemba is very rich in foraminifera, but with regard to other organisms the fossil fauna is poor. Fragments of

7) In the list of fossils the old nomenclature is used for all the smaller foraminifera, as it is given in BRADY's Challenger report. In 1932 a new nomenclature appeared for all these foraminifera from the hand of H. E. THALMANN (Eclogae geologicae Helvetiae, Bd. 25, No. 2, 1932, p. 293—312) in which the genus names of this standard work are changed in accordance with the modern nomenclature of CUSHMAN and others. As the examination of the Soemba material was completely finished by then, I left the old names stand; with the help of THALMANN's work the new names may be substituted if desired, as in general the Soembanese foraminifera exactly correspond to BRADY's reproductions.

echinoderms, corals, molluscs, and *bryozoa* are not uncommon in microscope preparations, but in samples the complete fossils are practically never found and in the Tertiary *foraminifera* almost always predominate over all other organisms. On the other hand foraminifera are not frequent in the subrecent terraces, which are often largely composed of corals and where molluscs are sometimes found, nor in the lowest tertiary deposits, in which molluscs may also be found (O.S. 302, 304, 305).

Rock that is principally composed of individuals of one species, (that is of a whole fossil population) are not very common, at any rate in the case of the larger foraminifera. Such rocks are found most frequently in Lower Tertiary; *Assilinae, Fasciolites, Discocyclinae,* small *Camerinae,* sometimes larger *Camerinae* in Tertiary a–b; *Camerina Fichteli* Mich. in Tertiary c–d; *Lepidocyclina* spec. in Tert. d. (O. S. 285). But generally speaking the fauna is characterised by the presence of a great number of species, each represented by a small number of individuals. The upper tertiary marls, for instance, often yielded a great variety of species, each of which was represented by one, or by a very few, specimens.

Typical *Cycloclypeus*-marls, such as are found in Java (CAUDRI 1931, TAN 1932) do not occur on Soemba; although this genus is sometimes the principal component of the harder marly limestones.

In the following pages we offer some remarks upon certain fossils successively.

Assilina and *Pellatispira* are both confined to typical *Assilina* or *Pellatispira* bearing rock, outside this they very seldom occur. Moreover in East Soemba these two genera invariably exclude one another. *Pellatispira* appears to be a typical inhabitant of reefs, it is found in marly algae-limes. *Assilina,* on the other hand is found in pure foraminiferous marls, marly limestones and limestone (for an explanation of this phenomenon see: Stratigraphy, p. 189). In West Soemba, however, they are found together in several limestones.

Spiroclypeus is not nearly so common in Soemba as in Borneo, and is only found in limestone and the harder kinds of marly limestone; the genus is represented by various species (see Pl. II, fig. 6, 7, 8) which, however, have not been further determined.

Fasciolitidae are found in great quantities in the Tertiary-a only of East Soemba (*Fasciolites ovicula* (Nutt.?)Bakx, *F. celebensis* Bakx, etc.); on West Soemba no *Fasciolites* is found. In the upper stages of the Tertiary *Fasciolitidae* are rather rare (cf. *Neoalveolina pygmaea* Hanz.) *Fasciolitidae* of the more complicated types (type *Alveolinella bontangensis* Rutten and type *Alveolinella Bosci* Defr.) are not found anywhere

in East and Middle Soemba; in West Soemba *A. bontangensis* Rutt. occurs, but is extremely rare. The very small, simply constructed *Alveolina* (resembling *A. melo* Ficht. et Moll) which is found so freely in Borneo, is almost unknown (found only in O.S. 411).

Regarding the *Lepidocyclinae* it should be noted that in the upper deposits (Tert. f) practically no miscrospheric forms are found, and in the somewhat lower layers (Tert. e) they also seem to be rather rare.

Miogypsina is found here and there in the marly limestones, but in the marls it is decidedly rare.

Of the smaller foraminifera the following may be said:

Miliolidae were hardly found at all in the washed samples of upper tertiary marls; on the other hand they are very plentiful in various hard rocks of the Lower Tertiary, where they sometimes form the entire ground mass of the deposit.

The *Lagenidae* are only represented in any quantity in the Upper Tertiary by the genus *Cristellaria*, usually the spirally coiled species. *Nodosaria* is rare. In O. S. 631 a single specimen of *Lagena* spec. was found; beyond this the genus was quite unrepresented in the marl samples.

Globigerinae and *Rotaliidae* often form the principal substance of the marly sediments and sometimes of the marly limestones in the Upper Tertiary. In many cases they are well preserved and yield good material for the study of the different species. The *Globigerinae* are almost all of the type without supplementary apertures. Of some *Globigerinae* and of *Orbulina universa* both pelagic and benthonic forms were found.

Rotaliidae are plentiful throughout the whole Tertiary. In the Upper Tertiary, from which they could be prepared out, *Pulvinulina Menardii* d'Orb (in some cases *P. tumida* Brady) proved to be the chief component. It is remarkable that the coiling of *Rotalidae* is not constant, specimens of *P. Menardii* were found both coiled to the dextral and sinistral, though the sinistral coiled ones were in the majority and were moreover larger than the dextral coiled specimens.

Carpenteria is found in great quantities in limestones and marly limestones, combined with algae. It was not found in the marls. The occurrence of *Rupertia* in this district, which was probably of a tropical nature during the whole tertiary age, indicates that this genus was not at that time entirely confined to temperate climates, as BRADY had concluded from the evidence of the Challenger-collection. In Soembawa also, *Rupertia* was found in tertiary rocks (V. D. VLERK, 1922).

Amphistegina appears in almost all slides and washed samples,

throughout all stages of the Tertiary. It is usually *A. Lessoni* d'Orb. but *A. Wanneri* Fischer is often found too.

Trillina, very common in Borneo, and an excellent index fossil for Tertiary-e, was not found at all in East and Middle Soemba, but it was met with in West Soemba.

Tinoporus, a genus of foraminifera which is very common in recent coast deposits of this group of islands, was repeatedly found in the subrecent terrace limestones of East and Middle Soemba, but not in large quantities. On West Soemba, on the other hand, *T. floresianus* (Schlumb.) forms whole rocks, which look like oöliths. Exactly the same rock, only formed of *T. baculatus* (Montf.?) Derv. (= *Baculogypsina neotetraedra* Tobl.) was recorded by VAN DER VLERK (1922) from West Soembawa, while TOBLER records a similar deposit (1918) on N. E. Soembawa (Sanggar Peninsula).

The Soemba collection yielded practically no abnormalities. The foraminifera must, therefore, have lived under quite normal circumstances. The only exception is a *Cycloclypeus* of the *neglectus* type (Tan 1930, CAUDRI 1931) with a symmetrically developed immature stage (O. S. 466). Further a *Fasciolites ovicula* from O. S. 136 and an *Assilina* from O. S. 300 give good examples of regeneration after a mechanical injury to the test, in the last case with a reversal of the direction of coiling.

In general there is a remarkable difference between the fauna of West Soemba and that of East and Middle Soemba, both in lower- and in upper-tertiary deposits.

In West Soemba the following genera and species are found, which seem to be entirely absent in East and Middle Soemba: *Linderina*, *Trillina*, *Alveolinella bontangensis* Rutten, *Camerina discoidea* nov. spec., while in the collection from West Soemba there was no single specimen of the *Fasciolites*-bearing rock so common in East Soemba.

Moreover in West Soemba *Assilina* and *Pellatispira* were found in combination with one another; in East Soemba they always occur separately and I have the impression that *Pellatispira* is absent in all rock from Tertiary-a age (see p. 189).

Nearly all limestones and marly limestones from Soemba are exceedingly rich in fossil algae, especially *Archaeolithothamnium*, *Lithothamnium*, *Lithophyllum* and *Corallina*, all four genera being represented by various species. There are some remarkably fine specimens of *Archaeolithotham-*

nium with sporangia. Some of the sub-recent rock is entirely composed of globular specimens of *Archaeolithothamnium* giving the rock an oölithic appearance. (O. S. 44, 192, 195).

Amphiroa was only seldom found and always in company with *Tinoporus baculatus*. It is worthy of note that the same peculiarity applies to W. Soembawa (v. d. Vlerk 1922; *T. baculatus* = *Baculogypsina neotetraedra*). *Amphiroa*, therefore, in contrast to the other algae, is a later species on these islands, and may be regarded, with *Tinoporus*, as index fossil for the sub-recent deposits.

In two samples *Halimeda* was met with (O. S. 234, W. S. 87).

LIST OF FOSSILS

In the following list all fossils of Soemba are mentioned, ranged according to their zoological classification.

Nearly all the smaller foraminifera are from the upper tertiary deposits from East and Middle Soemba, the only soft washable rock being found in the plateau of these regions.

In the slides of lower tertiary rocks some smaller foraminifera are found, which however could not be determined further than to the genus. They are: *Rotaliidae, Globigerinidae, Textulariidae, Miliolidae* (often very abundant), *Cymbaloporettidae* (confined to Tertiary b–c).

Gypsina globulus Rss. and *G. inhaerens* Schultze are found both in lower tertiary and upper tertiary rocks.

Tinoporus baculatus (Montf.?) and *T. floresianus* (Schumberger) (together with the sea-weed Amphiroa) are confined to subrecent ages.

The Molluscs are from the subrecent terraces; only a *Venus*(?) was found in Tertiary-a_1.

Foraminifera

Miliolidae

Quinqueloculina	spec. spec. indet.	
Biloculina	bulloides	d'Orbigny
	depressa	d'Orbigny
	spec. indet.	
Triloculina	spec. spec. indet.	

Pluriloculina	spec. indet.	
Spiroloculina	spec. indet.	
Trillina	Howchini	Schlumberger (confined to West Soemba)
Planispirina (?)		

TEXTULARIIDAE

Textularia	quadrilatera	Schwager
	spec. spec. indet.	
Gaudryina	subrotundata	Schwager
Verneuilina	pygmaea	Egger
Bolivina	spec. indet.	

LAGENIDAE

Lagena	c.f. quadricostulata	Reuss
Nodosaria	brevicula	Schwager
	communis	d'Orbigny
	crassitesta	Schwager
	insecta	Schwager
	obliqua	Linné
	c.f. setosa	Schwager
	spec. spec. indet.	
Vaginulina	spec. indet.	
Cristellaria	cultrata	Montfort
	italica	Defrance
	obliqua	Linné
	orbicularis	d'Orbigny
	rotulata	Lamarck
	vortex	Fichtel et Moll

Uvigerina	asperula	Czjzek
	crassicostata	Schwager
	javana (var.)	Koch
	nitidula	Schwager
	pygmaea	d'Orbigny
Sagrina	columellaris	Brady
	striata	Schwager
Bulimina	affinis	d'Orbigny
Cassidulina	calabra	(Seguenza) Brady
	subglobosa	Brady

PLANORBULINIDAE

Planorbulina	larvata	Parker et Jones
	spec. indet.	
Linderina	spec. indet.	(confined to W. Soemba)
Gypsina	globulus	Reuss
	inhaerens	Schultze
	plana	Carter
	vesicularis	Parker et Jones
Tinoporus	baculatus	(Montfort?) Dervieux
	floresianus	(Schlumberger) Hofker

GLOBIGERINIDAE

Globigerina	aequilateralis	Brady
	bulloides	d'Orbigny
	conglobata	Brady
	conglomerata (?)	Schwager
	dubia	Egger
	Kochi	(Koch) nov. nom.
	quadripartita	(Koch) nov. nom.
	sacculifera	Brady
	subcretacea	Chapman
	triloba	(Reuss)
	tripartita	(Koch) nov. nom.

Orbulina	universa	d'Orbigny
Sphaeroidina	bulloides	d'Orbigny
aff.	dehiscens	Parker et Jones
Pullenia	obliquiloculata	Parker et Jones
	quinqueloba	Reuss

ROTALIIDAE

Discorbina	allomorphinoides	Reuss
	isabelleana	d'Orbigny
	turbo	d'Orbigny
	spec. indet.	
Anomalina	ammonoides	Reuss
Carpenteria	spec. spec. indet.	
Rupertia (?)		
Truncatulina	culter	Parker et Jones
	Haidingerii	d'Orbigny
	margaritifera	Brady
	praecincta	Karrer
	pygmaea	Hantken
	refulgens	Montfort
	rostrata	Brady
	tenera	Brady
	Wuellerstorfi	Schwager
	nov. spec. (O.S. 462, 466, 537)	
Truncatulina (Siphonina)	reticulata	Czjzek
Pulvinulina	Berthelotiana	d'Orbigny
	crassa	d'Orbigny
	Menardii	d'Orbigny
	Micheliniana	d'Orbigny
	Partschiana	d'Orbigny

	c.f. pauperata	Parker et Jones
	procera	Brady
	repanda	Fichtel et Moll
	tumida	Brady
Rotalia	Beccarii	Linné
	Broeckhiana	Karrer
	calcar	d'Orbigny ?
	elphidioides	nov. spec.
	orbicularis	d'Orbigny
	papillosa	Brady
	Schroeteriana	Parker et Jones
	Soldanii	d'Orbigny
Calcarina	spec. indet.	
Nonionina	orbicularis	Brady
	umbilicatula	Montagu
	spec. indet.	
Polystomella	craticulata	Fichtel et Moll
	crispa	Linné
	macella	Fichtel et Moll
	spec. indet.	

AMPHISTEGINIDAE

Amphistegina	Lessonii	d'Orbigny
	Wanneri	(Fischer)

CAMERINIDAE

Assilina	aff. granulosa-exponens	
	orientalis	Douvillé
Camerina	bagelensis	Verbeek
	borneënsis	(Van der Vlerk) nov. nom.
	discoidea	nov. spec.
	djokdjokartae	Martin

		Fichteli	Michelotti
	aff.	irregularis	
		javana	Verbeek var. α and β
		Kemmerlingi	nov. spec.
		kelatensis	(Carter?) Douvillé
		pengaronensis	Verbeek
	aff.	taballarensis	(Van der Vlerk) nov. nom.
	c.f.	variolaria	Sowerby
		spec. indet. div.	
Pellatispira	aff.	irregularis	Umbgrove
		spec. indet. div.	
Operculina		complanata	Defrance
		complanata var. ammonoides	Gronovius
		spec. indet.	
Operculinella		venosa	Fichtel et Moll
Heterostegina	c.f.	borneënsis	Van der Vlerk
		spec. indet. div.	
Spiroclypeus		spec. indet. div.	
Cycloclypeus		annulatus	Martin
		annulatus Martin var. Martini	Van der Vlerk
		neglectus Martin var. indopacifica	Tan

ORBITOIDIDAE

Asterocyclima	aff.	pentagonalis	Deprat
Discocyclina		"dispansa"	Sowerby
		javana	Verbeek (gigantic and small forms)
		nov.? spec. (forma B)	

Orthocyclina	spec. indet.	
Lepidocyclina		
(Eulepidina)	tjendanensis	nov. spec.
	spec. spec. indet.	
(Nephrolepidina)	angulosa	Provale
	borneënsis	Provale
	Douvillei	Yabe
	Ferreroi	Provale
	Ferreroi-angulosa	Provale
	inflata	Provale
	c.f. isolepidinoides	Van der Vlerk
	Martini	Schlumberger
	parva	Oppenoorth
	aff. Rutteni	Van der Vlerk
	sumatrensis	Brady
	sumatrensis Brady	
	var. minor	Rutten
	var. inornata	Rutten
Lepidocyclina	glabra	Rutten
	and other, indeterminable, microspheric forms	
Miogypsina	complanata	Schlumberger
	Dehaarti	Van der Vlerk
	polymorpha	Rutten
	c.f. thecideaeformis	Rutten
	tuberosa (?)	Tobler (O. S. 537)
	spec. indet. (with heavy columns)	

ORBITOLITIDAE

Sorites ?

FASCIOLITIDAE

Fasciolites	celebensis	Bakx
	ovicula	(Nuttall?) East Indian form, flosculinised and unflosculinised
	Wichmanni	Rutten

	transition form from F. ovicula-F. javana	Verbeek
	transition form from F. ovicula-F. timorense	Verbeek
	transition form from F. Wichmanni-F. timorense	
	spec. indet. div.	
Neoalveolina	pygmaea	Yabe et Hanzawa
	spec. indet.	
Alveolinella	bontangensis	Rutten (confined to one place in West Soemba)
Coelenterata		
	CORALS	
	ALCYONARIA (spines)	
Porifera		
	spines of SPONGES	
Echinodermata		
	OPHIUROIDEA (plates)	
	ECHINOIDEA (plates and spines)	
	CRINOIDEA (plates and columnals)	
Mollusca		
	LAMELLIBRANCHIA	
Arca	spec. indet.	
Circe	c.f. gibba	Lamarck
Venus (?)		
Ostrea (?)		
	GASTROPODA	
Cerithium	aluco	Linné
Conus	spec. indet.	
Cypraea	spec. indet.	
Potamides	palustris	Linné
	sulcatus	Born
Turbo	spec. indet.	

Molluscoidea

BRYOZOA
BRACHIOPODA

Annelida (tubes)

Crustacea

BRACHYURA
OSTRACODA

Vertebrata

FISH OTOLITHS

Algae

Archaeolithothamnium	spec. indet.
Lithothamnium	spec. indet.
Lithophyllum	spec. spec. indet.
Corallina	spec. spec. indet.
Amphiroa	spec. indet.
Halimeda	spec. indet. (O.S. 234, W.S. 87)

DESCRIPTION OF THE SPECIES

FAMILY CAMERINIDAE

Genus Assilina

Compare: 1853 D'ARCHIAC et HAIME – Description des Animaux fossiles du groupe nummulitique de l'Inde, Paris 1853.

1896 VERBEEK en FENNEMA – Geologische beschrijving van Java en Madoera.

1908 HEIM, ARNOLD – Die Nummuliten- und Flyschbildungen der Schweizeralpen, Abh. Schweiz. Pal. Gesellschaft, Vol. XXXV.

1912 DOUVILLÉ, H. – Les foraminifères de l'île de Nias, Samml. des geologischen Reichsmuseums in Leiden, Ser. I, Bd. VIII.

1915 RUTTEN – in: VAN WATERSCHOOT VAN DER GRACHT, Bijdragen tot de geologie van Centraal Celebes, Jaarb. Mijnwezen 1914, Verh. 2de gedeelte (1915), p. 61—62, fig. 32—36.

1921 YABE – Note on some eocene foraminifera, Science Reports Tôhoku Imp. University, second series, Vol. V, No. 4.

1925 NUTTALL – The stratigraphy of the Laki Series (Lower Eocene) of parts of Sind and Baluchistan, with a description of the

larger foraminifera contained in those beds, Quarterly Journal Geol. Soc. of London, Vol. 81, pt. 3, p. 417—453.

1926 HARPE – Matériaux pour servir à une monographie des Nummulines et Assilines. D'après les notices laissés en manuscrits. Rédigé par P. Rozlozsnik. Annuaire de l'Institut géologique royal hongrois, Vol. XXVII, livre 1, p. 84—97.

1932 DOORNINK – Tertiary Nummulitidae from Java, Verh. Geol. Mijnbouwk. Genootschap v. Nederland en Kol., geol. serie, dl. IX, p. 301—303.

Assilinae are found in all the Greater Soenda-Islands; VERBEEK found them in Java, DOUVILLÉ has described them as found in Nias, RUTTEN in Celebes, YABE in Borneo and DOORNINK again in Java. But this does not mean that they have been properly classified. DOUVILLÉ defines a new species, *A. orientalis*, which, thanks to his excellent reproductions in which their distinctive characteristics can be clearly observed, is easily recognisable and was later re-found in Borneo and now again in Soemba (see below). RUTTEN's new species, *A. umbilicata*, on the other hand, is not well enough characterised, to be maintained without a reconsideration of the material from Celebes. The rest of the East Indian *Assilinae* are all more or less irresponsibly identified with the European species *A. spira*, *A. exponens* and *A. granulosa* and their varieties.

The species *A. spira* will not be referred to in the following pages as the Soembanese collection does not yield any forms that resemble this species, and which would form a basis for a discussion of the literature on the subject. On the other hand some suggestions are offered below on the question of *A. exponens*—*A. granulosa*, which has been raised several times recently, and which may prove to be of stratigraphic importance.

DESCRIPTION OF THE ASSILINAE OF THE GRANULOSA-EXPONENS-TYPE OF EAST-SOEMBA

These *Assilinae*, which are found as rock-forming fossils in the localities O. S. 62, 286, 299, 300, 315, 516, 517 and 780, are very variable in all respects. The best material was yielded by O. S. 300, in which a very perfect exterior has been preserved, with shiny prominent granulations. Fossils from the other localities are all more or less eroded, but it is evident that the difference in surface sculpture which they display, cannot be entirely ascribed to the degree of erosion.

We will here discuss the material from the various localities separately,

taking special note of the characteristics which NUTTALL used for distinguishing the *Assilinae* in British India (1925).

O. S. 62

Assilinae with sharp edge and distinct central depression. The greatest thickness of the shell lies nearer to the centre than to the periphery. Granulation sometimes well developed, but somewhat finer than in O. S. 300, sometimes on the other hand only little more marked than in O. S. 516 (see below). In the first case the granulation merges sooner into radial rows and ridges than in the specimens from O. S. 300.

The horizontal diameter varies from 7 to 10.5 mm. (average 9—10 mm.) and the thickness from 1½ to 4 mm. so that the vertical section varies between the forms given in fig. 3 and fig. 4.

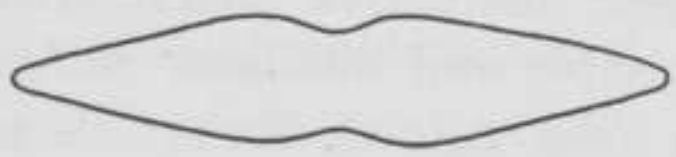

Fig. 3.

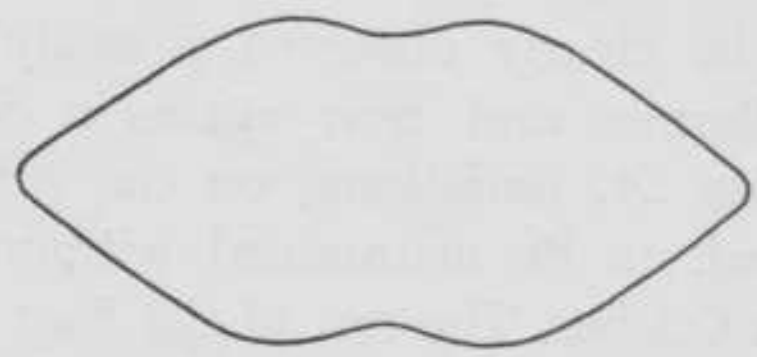

Fig. 4.

In this section the chambers are strictly triangular, with straight or almost imperceptibly curved walls (fig. 5). There are no signs of a specialiation of a portion of the wall immediately surrounding the lumina,as described and drawn by D'ARCHIAC and HAIME (1853) in *A. exponens* (p. 149, Pl. X, fig. 1*b*).

Fig. 5.

In horizontal section the shell is seen to be microspheric. The number of whorls on a radius of 5 mm. averages 10—11; the first 6 whorls occupy a good 1 mm. (± 1040 μ). The septa are as a rule quite straight, a little bent at the external angle and are slightly inclined backwards; often, however, they are arranged quite radially and, in the oldest coils especially, they are evenly curved. The initial chamber is about 30 μ in size.

For the number of chambers in the different whorls see table on p. 43.

O. S. 286, 315 and 517 are hard rocks from which the *Assilinae* could not be prepared out. The fossils could not therefore be accurately examined. In every case the shell remains equally thick from the centre to the periphery; there is no central depression. The shape of the vertical section varies therefore from fig. 6 to fig. 7, shapes which may certainly

be partly attributed to the rolling to which the foraminifera have been subjected. The number of whorls in these microspheric *Assilinae,* to a

Fig. 6.

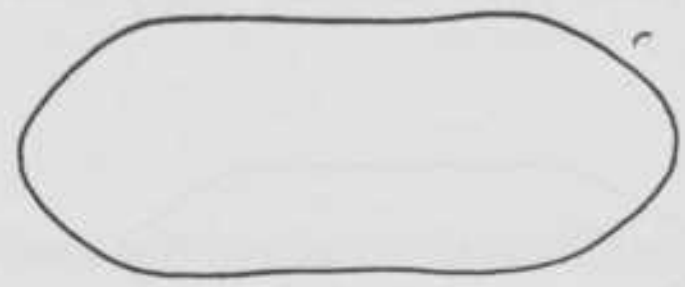

Fig. 7.

diameter of 10½ mm. is fully 10 (O. S. 315); the 4th whorl has about 17 chambers and the 5th about 22.

O. S. 299

Maximum horizontal diameter 12 mm.; shell with faint central depression. The shape of the vertical section is the same as fig. 8 or more flat. Granulations on the surface well marked, but not so large as in O. S. 300. On a horizontal diameter of 10½ mm. one of the specimens has 11 whorls; the first 6 occupy about 1.3 mm. The septa as a rule are not quite at right angles to the spiral lamina; they are straight, sometimes with a bend at the outside extremity (as in O. S. 516). For the number of chambers per whorl see table on p. 43. The initial chamber is very small, probably a little more than 15 μ. The vertical section of the chambers somewhat resembles the drawing which D'ARCHIAC and HAIME give for *A. exponens* (1853, Pl. X, fig. 1*b*).

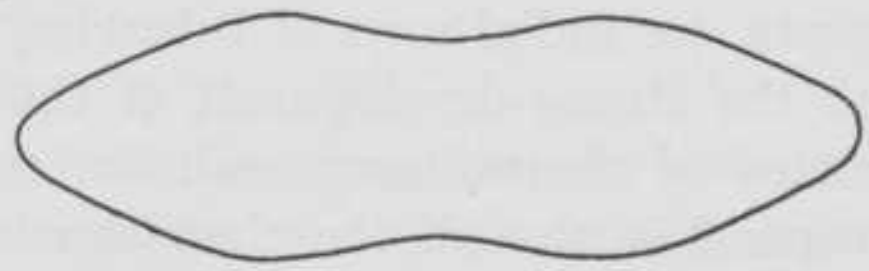

Fig. 8.

O. S. 300

This rock contains both forma A and forma B, many immature forms as well as adult ones. The shell of this *Assilina* is rather flat; in a microspheric specimen of 2.75 mm. thickness the horizontal diameter is 9 mm., while the smaller specimens are usually flatter. The edge in forma A is often formed by a well developed marginal cord; in forma B the edge is fairly sharp. There is no central depression or only a very slight one. This makes the vertical section like fig. 9 or fig. 10.

Granulation in both formae A and B is well developed and remarkably well preserved. The columns protrude a little above the surface in beautiful smooth round heads. In the centre they are very large (max. 150 μ) and arranged in a spiral of about 2 whorls, around the narrow central

depression (there is no central column). Later they are usually transformed into smaller tubercles, destroying the spiral line. In some spe-

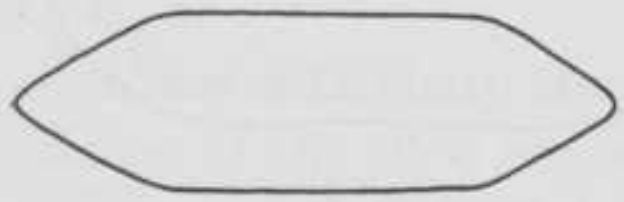

Fig. 9.

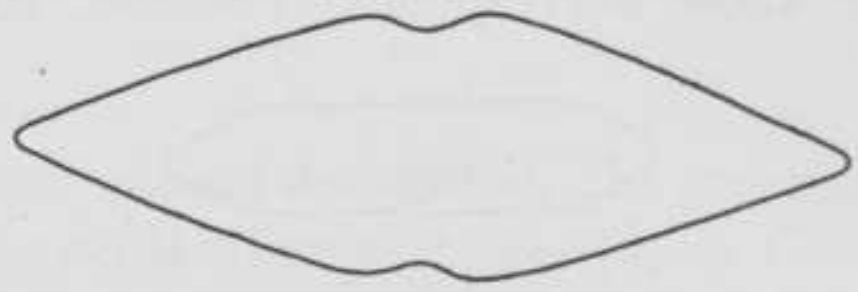

Fig. 10.

cimens, however, especially in forma A, the large tubercles, after these two whorls, elongate radially in a pear-shaped or rod-shaped manner and only after that disintigrate into detached granulations which usually also lie in radial rows. Through the last whorl the septa can be seen very clearly; sometimes these septa are thickened by the rows of granules or stick out as radial ridges. Occasionally there are columns between the septa (or radial rows of tubercles). Vertically broken specimens, owing to the strong development of the columns between which only small strips of the ordinary wall lie, sometimes resemble *Pellatispira*. The vertical section of the chambers is a tall triangle, with a rounded off apex and straight or sometimes even slightly concave walls.

The horizontal section of the microspheric form shows the total number of whorls to be 10—11, of which the first 6 coils occupy a radius of 1125—1275 μ. The initial chamber has a diameter of about 15 μ. The septa of the chambers are radial or slightly sloping backwards. As a rule, even in the last formed whorls they are well curved (as occurs in O. S. 62 only in the very oldest whorls). For the number of chambers per whorl see table on p. 43.

Forma A. is externally exactly the same as forma B., only smaller (max. 6 mm.), so that the columns and marginal rim are sometimes relatively more strongly developed. The number of whorls, in connection with the different diameters, is rather variable, which must be chiefly ascribed to the occurrence of immature forms in this rock; the maximum is 3½ to a good 5. The septa of the chambers are curved. The number of chambers for the various whorls is:

whorl	number of the septa				
1	6	—	6	—	6
2	12	—	12	—	13
3	15	—	15	—	16
4	19½	—	17	—	12 (on ½ whorl)
5	17½	—	10 (on ½ whorl)		
6	8 (on about $^1/_3$ whorl)				

The initial chamber, which is often slightly elongated, is only 200—270 μ in diameter (with wall) and is succeeded by a kidneyshaped second chamber of about the same width.

O. S. 516

This locality yielded microspheric *Assilinae* with a horizontal diameter of 10½ to 14 mm. and a thickness of 2½—3 mm. They have a sharp edge and are flattened or slightly depressed in the centre. The granulation is not much developed.

The shape of the vertical section is as fig. 11. The shape of the chamber lumina in this section is rigidly triangular, almost

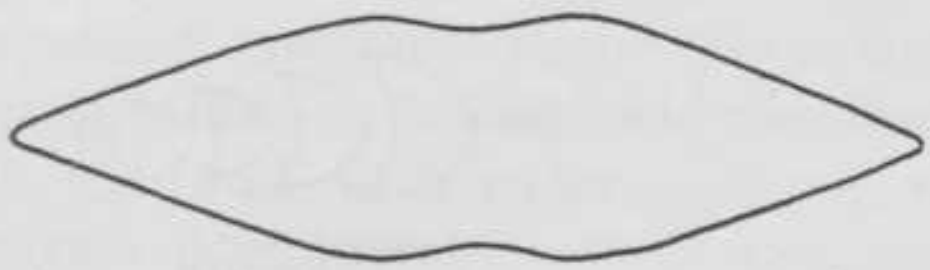

Fig. 11.

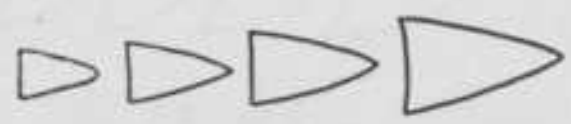

Fig. 12.

without curve in walls or basis, fig. 12. Nothing can be seen of a specialisation of the chamber wall, as given by D'ARCHIAC and HAIME for *A. exponens* (1853, p. 149, Pl. X, fig. 1*b*).

These *Assilinae*, in a radius of 5 mm. have 10 whorls, in a radius of 6 mm. 11 whorls. The first 6 whorls occupy a radius of about 1155 μ. The diameter of the initial chambers is 30—35 μ.

The septa are often quite straight, often also bent at the top corner. They are placed partly radially and partly sloping backwards. For the number of septa per whorl see table on p. 43.

O. S. 780

The *Assilinae* from this locality differ greatly in shape from all the others. They lie in a hard rock, of which only a small specimen is to be found in the collection, and have chiefly been examined on a very favourably eroded surface, from which their vertical section stands out in strong relief. A few specimens were polished horizontally.

The horizontal diameter of these foraminifera varies very greatly; possibly there are two different kinds mixed together, but it is more probable that we have formae A and B of the same species, as in O. S. 300, with immature and adult specimens. All specimens are very flat, in the middle thinner than at the periphery; the edge itself is rounded off or somewhat sharpened. The vertical section, especially in the larger specimens, is as shown in fig. 13, while the smaller specimens have more

resemblance to fig. 14. This is connected with the chamber lumina, which in the larger specimens are narrower and more pointed than in

Fig. 13.

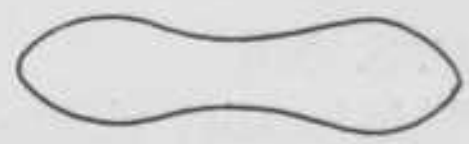

Fig. 14.

the smaller ones. This form is much more rounded off than the other *Assilinae* of East-Soemba. In the large individuals it is a fig. 15, in the small ones as fig. 16.

Fig. 15.

Fig. 16.

The columns, which have a greater power of resistance than the rest of the test, have been thrown into sharp relief by the process of erosion on a broken surface, thereby giving an appearance resembling *Pellatispira*.

Of the largest specimen from this rock, a microspheric form of 14 mm. diameter, a horizontal section was made. It proved to have 10½ whorls, the septa being generally straight, but bent or curved septa may also occur. The number of chambers per whorl is given in the table on p. 43.

The largest specimen of forma A. has fully 5½ whorls on a horizontal diameter of 6 mm. The initial chamber is again elongated (with wall about 200 ×300 μ) and is followed by an equally wide kidney-shaped 2nd chamber. The chambers of the spiral have sometimes straight and sometimes curved septa. The division of their number over the various whorls is as follows:

whorl	number of the septa
1	7
2	13
3	17½
4	19
5	4 (in $^1/_4$ of a whorl)
6	± 12 (in $^1/_2$ of a whorl)

If we now try to classify these Soembanese *Assilinae* by the characteristics usually applied to *Assilinae*, we encounter several difficulties.

In the first place these fossils appear to have no place in a species already existing, and in the second place the literature on the genus *Assilina* is so confused and contradictory, that we cannot determine upon a new species without reconsidering the whole of the literature.

A. spira de Roissy is out of the question at any rate, as no single specimen has the characteristic appearance of this species, a large flat shell where the whole spiral of evoluted whorls is visible. Neither do the *A. cancellata* and *A. papillata*, described by NUTTALL from the Middle Kirthar Series in British India come into consideration for a comparison with Soembanese *Assilinae*. The species to which these fossils can be compared and to which they have a great resemblance are *A. exponens* Sow. and *A. granulosa* d'Arch. These species are still not properly distinguished from eachother, and the Soembanese *Assilinae* cannot be quite identified with either.

In the older literature these two species are nowhere sufficiently characterised. H. DOUVILLÉ in 1919 made a revision of their characteristics (l'Eocène inférieur en Aquitaine et dans les Pyrénées, Mém. Carte Géol. détaillée de France). NUTTALL, who considered it of special importance for British India, that *A. exponens* and *A. granulosa* which characterise different stratigraphic niveau's, should be distinguished from one another, gave a new description of them in 1925, in which he suggested the following distinctions between the Indian representatives of the two species (both formae A. and B.):

Size: *A. exponens* (forma B.) usually 15—20 mm.
A. mamillata (forma A.) average 6—7 mm.
A. granulosa (forma B.) usually 7 mm., max. 15 mm.
A. leymeriei (forma A.) usually 2—3 mm.

Shape: *A. exponens* is more globular than *A. granulosa;* in *A. exponens* the shell begins to decrease in thickness at half the diameter; in *A. granulosa* the shell is more or less disc shaped with a suddenly turned rim (see HEIM 1908, p. 246, text fig. 24). Both kinds in British India have a central depression.

Granulations: In this respect the *A. granulosa* of British India shows a greater variability than the *A. exponens*. In the immature stage *A. granulosa* forms protruding granules along the outside of the spiral, while older individuals are smooth. (Pl. XXVI, fig. 1—2). *A. exponens* has the

same arrangement, but the columns are more delicate and remain the same at all stages of growth.

A. mamillata is usually fairly smooth; *A. Leymeriei* has large protruding columns (Pl. XXV, fig. 8).

Internal structure: In this respect the differences are very constant. In a typical *A. exponens* the whorls are narrower than in *A. granulosa*: in the former species the oldest 6 whorls occupy a radius of 1.75—2 mm., in the latter species 2.25—3.5 mm. In a radius of 5 mm. *A. exponens* has 10 whorls and *A. granulosa* only 8.

The number of septa, on the other hand, is greater in *A. granulosa* than in *A. exponens*, which may be seen from the following figures [8]):

whorls	*A. exponens*	*A. granulosa*
1	—	—
2	16—20	16—24
3	16—20	24—32
4	24	28—36
5	28	32—40
6	32	36—48
7	36	40—48
8	36—44	56
9	44—48	—
10	56	—

The shape of the septa also is different; *A. exponens* and *A. mamillata* have usually almost straight septa (rectangular chambers), the septa of *A. granulosa* and *A. Leymeriei*, on the other hand, have a marked bend near the outer rim of the whorl.

A. mamillata usually has 6—7 whorls and a single initial chamber with a diameter of 500 μ. In *A. Leymeriei* the embryonic apparatus is smaller and consists of two chambers [9]); this species has about 4 whorls.

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8) NUTTALL gives the number per $^1/_4$ whorl. For comparison with the Soembanese specimens, where for greater accuracy the chambers were counted by whole whorls, in the following table NUTTALL's figures have been multiplied by 4.

9) The difference between single and double embryonic chambers is left out of the question at present. The occurrence of either single chambered or double chambered nucleoconches is too essential a difference to be taken as a distinction between different species in the same genus. In my opinion it is probable that

If we now compare the phenomena of the Soembanese *Assilinae* we find as follows:

According to the size, which is max. 14 mm. these foraminifera should be counted as *A. granulosa*.

The shape of the shell (shown best in a vertical section) varies very greatly. In O. S. 62, 299 and 516 it is the *exponens*-shape; in O. S. 286, 315, 517 and 780 the shape of *A. granulosa* (especially resembling *A. granulosa var. minor* Heim, except O. S. 780, which resembles HEIM's *var. major*), while in the beautifully preserved specimens from O. S. 300 the *granulosa*-shape predominates, and every transition-form towards the gradually thinning out of the *exponens*-type is found. The granulation, which in the specimens from O. S. 300 and some from O. S. 62, is much coarser than in the *Assilinae* from British India, in most cases resembles *A. granulosa* as regards size and stages of development (O. S. 62, 299, 300, 780) but is sometimes as delicate as in *A. exponens* (O. S. 516).

The number of whorls on about 5 mm. radius varies in every case, varying from 10 to 11, which corresponds to NUTTALL'S *A. exponens* and the radius of the first 6 whorls is even smaller than NUTTALL gives for this species.

The number of chambers in the various whorls for certain specimens are:

whorl	O. S. 62				299	300		315	516	780	*A.exp.* (NUTTALL)	*A.gran.* (NUTTALL)
1	6	7	—	—	7	6	6	—	7	—	—	—
2	10	11	—	—	10	10	10	—	10	9	16–20	16–24
3	13	12	17	18	15	12	12	—	13	14	16–20	24–32
4	16	13	18	20	18	12	15½	17	16	17	24	28–36
5	18	17	19	24	22	16	±15	22	18	17	28	32–40
6	23	18	25	26	24	20	—	—	23	19	32	36–48
7	24?	24?	28	34	30	19	—	—	27?	24	36	40–48
8	—	—	—	38	30	23	26?	—	38?	26	36–44	56
9	—	—	—	41	32	28	28?	—	40	32	44–48	—
10	—	—	—	—	37	29	—	—	45	38	56	—
11	—	—	—	—	42	34	—	—	52	±40	—	—
12	—	—	—	—	±48	—	—	—	57	—	—	—
diam. initial-chamber	±30μ	30 μ	?	?	Slightly more than 15μ	15 μ	?	?	±35μ	?	?	?

normal formæ A. of all *Nummulitidae* begin with a double nucleoconch, and that a single chambered form exists in appearance only, viz. in those cases where the second chamber does not differ conspicuously from the chambers in the spiral.

From this table it may be seen that the number of chambers in the specimens from different localities are pretty much the same in the older whorls, but that later some differences occur. The fossils from O. S. 62 and O. S. 516 are exactly alike internally, while those from O. S. 299, 300 and 780 show a great resemblance to eachother and have rather fewer chambers than the first. The first group might possibly be brought under *A. exponens* although the number of chambers remains below that of the *A. exponens* from British India; the second group has far too few chambers for *A. exponens*, and none of the examined specimens corresponds internally to NUTTALL's *A. granulosa*.

It is possible that in Soemba there are two different species; there is a fairly distinct difference in the aspect of the horizontal section of O.S. 300 and O. S. 516 for instance (see Pl. I, fig. 1 and 2), while the initial chamber of O. S. 299—300 is also about half as large as in O. S. 62—516. As, however, these differences have only been observed in a very small number of individuals, and moreover do not correspond to differences in the external habitus, we will regard them for the present as variations within one species.

The Soembanese *Assilinae*, therefore, are, neither in their external nor their internal peculiarities, indentical with those of British India, although they often greatly resemble NUTTALL's *A. exponens* (especially O. S. 516). It follows that we should be cautious in drawing a parallel between the deposits in Soemba and in British India on the grounds of the presence of *Assilinae*, and at any rate there is no justification for regarding the Assilina-rocks of Soemba as an equivalent of the Laki Series (Lower Eocene) of which *A. granulosa* is the typical fossil (see also pag. 208, etc.).

Regarding the similarity of the Soembanese *Assinilae* with those from other localities in the East Indian Archipelago, the following may be said:

The "*Assilina granulosa*", wich DOUVILLÉ found in the material from Nias, as well as *A. orientalis*, may be exactly like that in Soemba (O. S. 780) in regard to granulations and in vertical section; of the rest of the peculiar characteristics nothing is known for certain, except that in the 7th. whorl there are about 30 chambers.

The same may be said of the *Assilina* in Borneo which was described and drawn by YABE, and was named *A. granulosa var. minor* Heim from the appearance of the vertical section.

On Soemba, as well as on Borneo and Nias this *Assilina* was found in company with *A. orientalis;* on Nias and Soemba it is moreover found

with *Camerina kelatensis*. We may therefore safely conclude that these Assilina rocks are completely equivalent on all three islands.

The *Assilinae* found in Java are somewhat better known, thanks to the excellent photographs that DOORNINK has made of them. Moreover I have had a personal opportunity of examining the material which he has described in the Geological Institution of Amsterdam University, and of comparing it with the Soemba material.

DOORNINK found "*Assilina granulosa*" in the material from four localities in Djiwo, G. Woengkal, Padasan, Batoe Goeha and Kali Dowo. The microspheric forms of all these *Assilinae* are much flatter than those from Soemba; they are more of the disc-shape of an *A. granulosa* but their edge is sharp. A central depression is nowhere distinctly to be seen. They resemble the flat form from O. S. 300 but are less thick.

The surface of the fossils is ill preserved; the arrangement of columns in the best examples is just like O. S. 300, but the granulations are smaller and are therefore further apart. The Javanese microspheric *Assilinae* are in general small (although DOORNINK gives as maximum diameter 19 mm.) and cannot, therefore, always be externally distinguished from the megalosperic forms, which may attain a maximum section of 9—11 mm. (Batoe Goeha, Padassan).

The number of whorls in the microspheric form, in a specimen from Padasan for instance, may be $8^3/_4$ in a radius of $3^1/_2$ mm., in one from Batoe Goeha about 10 in a radius of 6 mm. and for another from the same locality 9 in a radius of some 5 mm. The oldest 6 whorls occupy about 1.75 mm. The number of chambers in each whorl for these specimens is:

whorl	Padasan		Batoe Goeha	
1	± 5	8	—	8
2	10	14	—	12
3	16	17	14 ?	16
4	18	21	20	22
5	23	25	24	24
6	27	28	29½	32
7	29	35	32½	30
8	36	±34	—	±36

It will be seen that these figures correspond more to *A. exponens* than to *A. granulosa*.

The megalospheric forms belonging to these resemble *A. mamillata* more than *A. Leymeriei*. The diameter varies very much; in the material from Woengkal 4—7½ mm. (usually 6 mm.), from Batoe Goeha, Padasan and K. Dowo 2½—11 mm. The small specimens (up to 4 mm.) are lens-

shaped, the larger are flat discs, from the rapid thinning out of the lateral layers of the younger whorls. The columns can only be seen clearly in the smallest specimens; they are placed as in O. S. 300.

The vertical section of the chambers is a rather pointed triangle.

The number of whorls in a fairly large form is usually 4—5, sometimes 5½. The initial chamber is not globose and has a horizontal diameter of 275—450 × 425—570 μ; the second chamber is often considerably smaller.

The distribution of chambers in the various whorls is as follows:

whorl	Padasan		Batoe Goeha	G. Woengkal	K. Dowo
1	6½	6½	7.	8 ?	10
2	16	16	18	17	20
3	25½	26	23	29	32
4	±32	±34	±26	±32	± 36

On comparing these Javanese forms of *Assilina granulosa* with the Soembanese *Assilinae,* we see that both the formae A. and B. contain a larger number of chambers, that the test is of a more flat disc-shape and that the megalospheric initial chamber is much larger. It is therefore probable that these *Assilinae* should not be considered as equivalent.

A determination of the Javanese *Assinilae* as "*A. granulosa*" is however certainly indefensible; the vertical section of the chambers is more like *A. exponens,* and the number of chambers of the microspheric generation is even less than in NUTTALL's *A. exponens.*

In the above we have seen that the internal structure of the *Assilinae* from the East-Indian Archipelago is not the same as in those from British India. If we wish to see in how far the *A. exponens* and *A. granulosa* of British India resemble the European species, we find that there is not much to be gained from the European literature, because before NUTTALL made his studies (1925), little attention was paid to the internal characteristics; from illustrations (photos), however, some data may be gained.

ARNOLD HEIM (1908) made a sharp distinction between the two species and their varieties, based upon their external habitus. Besides the typical *A. exponens* with its gradually thinning-out thick shell, and the much more beautifully evolute disc-shaped *A. granulosa* with its lemniscate shaped vertical section, he distinguishes two transition forms: 1° *A. granulosa var. minor,* of which the lateral layers are somewhat

involuted so that the central depression is lost, and 2° *A. exponens var. tenuimarginata,* of which the central part exactly corresponds to the *A. exponens* type, but of which the later formed half of the spiral suddenly becomes evolute.

HEIM's specimens of both *A. exponens* and *A. granulosa* are much larger than those from either British India or the East Indies.

HEIM took no notice of the number of whorls or septa. Neither do the illustrations show much, except in the case of *A. granulosa var. minor. A. exponens* has a great number of whorls (about 22 in a radius of 13½ mm.) and many chambers (about 88 in the 17th whorl; ± 63 in the 12th?), but numbers which can be directly compared with the data from India cannot be ascertained. For *A. granulosa* (*var. major* Heim) no figures at all are known.

For *A. granulosa var. minor* (Pl. VIII, fig. 12 and 13) they are:

whorl	fig. 12	fig. 13
1	10	10
2	16	15
3	18	16
4	22	20
5	23	23
6	29	27
7	33	36
8	39	±34 (25 on ³/₄ whorl)
9	40	±52 (13 on ¹/₄ whorl)
10	±22 on ½ whorl	

This is less than NUTTALL gives for *A. granulosa,* but about the same as NUTTALL's *A. exponens* !

(Note. The determination of the *Assilinae* from Borneo as *A. granulosa var. minor* is therefore probably incorrect, at least if we assume that these *Assinilae* are identical with those from Soemba).

Further HEIM gives a number of good illustrations of the formae A, which belong to his *A. exponens* and *A. granulosa,* that is *A. mamillata* and *A. Leymeriei.* The size of the nucleoconch is very variable in both the megalospheric *Assilinae* (*A. mamillata* in the smallest of the specimens shown has also the smallest nucleoconch). Both *A. Leymeriei* and *A. mamillata* have 5—6 whorls; like the formae B., they are distinguished only by the shape of the vertical section.

The number of chambers per whorl is as follows:

A. mamillata (Pl. VII, fig. 35—37, resp.):

whorl			
1	7	6	7
2	14	14	16
3	17	20	23
4	21	22	29 (with small abortive chambers)
5	±25	22	25
6	±14 (on ½ whorl)	18 (on ¼ whorl)	± 6 (on ¼ whorl)

A. Leymeriei (Pl. VIII, fig. 16—18, resp.):

whorl			
1	7	8	8
2	15	16	14
3	22	22	13 (on ¾ whorl)
4	23	25	—
5	24	31	—
6	28	14 (on ½ whorl)	
7	22 (on ¾ whorl)		

number of whorls (by approximately the same hor. diameter!)	$7^1/_8$	$5^1/_2$	$2^3/_4$

It is evident, therefore, that no distinction can be made between these *A. mamillata* and *A. Leymeriei* according to internal characteristics. Moreover HEIM's *A. Leymeriei* probably includes specimens of different species; in the specimen of fig. 18 the whorls are almost twice as high as in fig. 16.

The number of whorls (except on Pl. VIII, fig. 18) corresponds more to NUTTALL's *A. mamillata* than to his *A. Leymeriei*.

(Heim's megalospheric specimens have rather more chambers than those from Soemba, but much fewer than the Javanese).

To conclude we may say that HEIM has not been able to establish an absolute distinction between the Swiss *A. exponens-mamillata* and *A. granulosa-Leymeriei*, and that the internal structure does not show the same differences that NUTTALL pointed out later.

One of the most recent writings on *Assilinae* from Europe and adjacent territories, are the notes by DE LA HARPE, published by ROZLOZSNIK (1926). Here, besides a series of new species (of which none correspond

to the fossils of Soemba) and the old *A. spira* of ROISSY, *A. exponens* and "*A. placentula* Desh. sp. vel. *A. granulosa* d'Arch" are described. Although this *A. exponens* is much larger and has many more whorls than the *Assilinae* NUTTALL distinguishes by that name in British India, it corresponds almost entirely in its internal characteristics, and *A. placentula* probably is the same as NUTTALL's *A. granulosa*. But between these two species DE LA HARPE's collection contains transitions (from one locality, La Mortala, *A. exponens* and *A. granulosa* are not to be distinguished from eachother), so that here, also, the boundary can not clearly be drawn and no general distinguishing characteristic can be laid down for these species.

CONCLUSION :

On the grounds of the results yielded by the above research in material and literature, we are brought to the same conclusion as BOUSSAC arrived at (1911, p. 104), namely that it is absolutely impossible to maintain a distinction between the two "species" *A. exponens* and *A. granulosa*.

The only objection, and that an important one, that can be raised against combining the two into one, very variable, species, is the fact that a few investigators (e.g. DOUVILLÉ in South France and NUTTALL in British India) found *A. granulosa* at a lower stratigraphic niveau than *A. exponens*. It appears to me therefore that a better way than combining all *Assilinae* of this habitus together, is to assume for the present that we are dealing with a great number of very similar species, which in some fields show sufficient differences to distinguish one from another. If this be correct, these *Assilinae* may be locally good guiding fossils, but they cannot under any circumstances be used for the correlation of deposits in territories lying far apart.

ASSILINA ORIENTALIS DOUVILLÉ

Pl. II, fig. 1.

1912 A. orientalis, DOUVILLÉ, H. – Les foraminifères de l'Ile de Nias, Sammlungen des geol. Reichsmuseums in Leiden, ser. I, vol. VIII, p. 263, Pl. XIX, fig. 6, 7, 8 en 9 (?).

1921 A. orientalis, YABE – Notes on some eocene foraminifera, Science Rep. of the Tôhoku Imp. Univ., Sendai, Japan, vol. V, No. 4, p. 105, Pl. XVII, fig. 11; Pl. XVIII, fig. 4—5.

This foraminifer, which up to now had only been found in hard rocks, was discovered in Soemba, besides in hard samples, in a comparatively soft marly limestone (O. S. 299), from which, with some difficulty,

a few specimens could be prepared out. There is now therefore rather more known about the exterior surface than DOUVILLÉ was able to reconstruct on the basis of an oblique section.

The test is $5^1/_2$ mm., measured horizontally, and 2.8 mm. thick, of a thick lens-shape with a sharp edge. The centre is occupied by a large umbo on which some 10 coarse granulations are to be seen. These columns are placed close together and arranged in a spiral; further towards the edge a few very fine granulations are seen. The surface is further quite smooth; in the last whorl only, the septa are faintly visible through the lateral wall.

The large megalospheric nucleoconch is followed by a spiral of 5—6 whorls. The convolutions are low and the height increases only very slowly during growth. The last whorl is (including the marginal cord) a good $^1/_2$ mm. high. The marginal cord varies over the whole spiral from 165 to 195 μ, but on the terminal whorl is often much less high (about 75 μ). The septa are arranged almost radially and are slightly curved. The last whorl contains some 30 chambers. The chambers are about 350 μ long, but their length is very variable; in a vertical section they are seen to have a maximum breadth of about 450 μ in the later whorls.

In vertical section the lumina of the chambers, as is already known, are seen to be sharply triangular with a concave base, and to have no alar prolongations round the earlier whorls. In this respect *A. orientalis* certainly belongs to the genus *Assilina*. But, on the other hand, this "*Assilina*" bears more resemblance to the genus *Camerina* if we take as criterion for distinguishing the two genera that the test of *Camerina* is involute up to the adult stage, while in *Assilina* the original involuted whorls are followed by evolute coils, and if we moreover consider not only the lumina of the chambers but the whole whorl including the lateral walls (which in connection with the growth of the living organism is a more logical method). The lamellae of these walls are continued with undiminished thickness to the centre of the test, in contrast to all other *Assilinae*, where the lamellae, even in the earliest formed parts, thin off towards the centre, while in the later whorls they do not even reach as far as the centre. The external shape, so unlike the other *Assilinae*, is connected with this, and is a thick, sharp edged lens without a trace of depression or flattering at the poles. This peculiar involuted build makes *A. orientalis* the morphologic transition form between *Assilina* and a non-operculinoid *Camerina*.

A direct relationship with other *Assilinae* cannot be ascertained. UMBGROVE (1931, p. 78) thought that there was a correspondence between *A. orientalis* and *A. ranikotensis* NUTTALL from the British Indian Ranikot beds. This cannot be the case, however. *A. ranikotensis* is smaller, and to judge by the reproductions, has a less pronounced umbo, is richly ornamented with more numerous and more scattered granulations besides having protruding ridges above the septa (NUTTALL, Ranikot, 1926, Pl. X, fig. 7—10; DAVIES, 1927, Pl. 8, fig. 16); but the most important difference is that *A. ranikotensis* is microspheric and has only 4 whorls (NUTTALL, Ranikot, 1926, p. 117, Pl. X, fig. 11), while *A. orientalis* is a megalospheric form with 5—6 whorls. The last characteristic prohibits the inclusion of the two fossils as different forms of the same species, and the absence of a description or reproduction of the vertical section of *A. ranikotensis* makes it impossible at present to investigate the relationship between these two species further.

Locality: O. S. 62, 299, 300, 517.
Age: Tertiary-a.

Genus Camerina

Camerinae are found in Soemba in great quantities and in great variety. Of all these *Camerinae* only a comparatively small number, and those mostly the larger species, have been minutely examined, while with the smaller fossils it has usually been considered sufficient merely to determine their genus. The reason of the neglect of the smaller species is twofold: in the first place the collection includes only a very few prepared out specimens, and in the second place the separate specimens that were present had been polished in Batavia, which had revealed great differences between the one and the other, but also made the co-ordinating of vertical and horizontal sections which belong together almost impossible. Moreover the surface of these small *Camerinae* was generally very ill preserved.

In a few cases it was possible to determine the species, or at any rate to ascertain to what known species these *Camerinae* were related. A few of the lowest fossiliferous tertiary rocks furnished specimens of "*C. thalica*" (see p. 59) while from the same ancient deposit a *Camerina* comes which is 2—3 mm. in diameter and $1^1/_2$—2 mm. thick, which might belong to *C. variolaria* Sow. (O. S. 302, 780) on account of its very thick, conical central column, the true diamond-shaped vertical section, with the 4—5

closely set walls of the coils and the comparatively few, only slightly curved lines on the surface.

The rest of the small *Camerinae* almost all resemble more or less the various forms of *C. bagelensis* Verb.; they often consist of little more than a large nucleoconch with only a few whorls, and not unfrequently accumulate into rock-forming material, making a compact mass of sediment, in which larger foraminifera also may be found.

Camerina cf. pengaronensis Verb., megalospheric form

See: 1929 Nummulites pengaronensis forma A, van der Vlerk – Groote foraminiferen van Borneo, Wetensch. Meded. v. d. Dienst v. d. Mijnb. in Ned. Indië, No. 9, p. 20, fig. 12, 35a—b.

1932 Camerina pengaronensis forma A, Doornink – Tertiary Nummulitidae from Java, Verh. Geol. Mijnbouwk. Genootsch. v. Nederl. en Kol., Geol. Serie, Dl. IX, p. 283, Pl. IV, fig. 2—3.

There is only one *Camerina* that has been prepared out from O. S. 299 (1 specimen) and which can be brought under this species; all the others, which probably also belong to the same species, were imbedded in hard limestone, and could only be determined by accidental sections, portions of the surface or impressions.

The specimen from O. S. 299 has a diameter of $5^1/_2$ mm. and is amply 2 mm. thick. From the small umbo some 35 straight lines radiate to the circumference. The vertical section is a pure diamond-shape. There are 6 coils, which have very thick walls, and lie very close together in the vertical section. All the whorls do not show the same perfect diamond-shape as the last one, so that here a transition can be seen between the *pengaronensis* type and the *nanggoulani* type, the latter having a more vaulted exterior.

The septa of the chambers in horizontal section are probably much curved.

It is probable that we have a megalospheric specimen; the nucleoconch can be seen distinctly at a small magnification and the number of whorls is small.

C. pengaronensis besides being found in O. S. 299, was found in O. S. 780 which is also Tertiary-a; on slides made of samples from Tertiary-b,a *Camerina* was to be seen which belongs also to this species. Further *C. pengaronensis* was found in several rocks together with reticulate *Camerinae*, which indicates Tertiary-c as the age of the deposits.

Camerina kelatensis (Carter?) Douvillé
Pl. I, fig. 4, 5 and 10.

1861? Nummulites kelatensis, Carter – Further observations on the structure of foraminifera, and on the larger fossilized forms of Scinde, Ann. and Mag. Nat. Hist., Tome VIII, p. 376, Pl. XV, fig. 6.

1912 N. kelatensis, N. très voisine à N. Lamarcki,

? N. pengaronensis, Douvillé – Les foraminifères de l'Île de Nias, Samml. des Geol. Reichsmuseums in Leiden, Ser. I, Bd. VIII, p. 262 etc., Pl. XX, fig. 1, 3.

non 1915 N. kelatensis, Dollfus – Paléontologie du Voyage à l'Île Célébes de M. E. C. Abendanon, in: E. C. Abendanon, Geol. en Geogr. doorkruisingen van Midden-Celebes, deel III, p. 975.

1929 N. kelatensis, van der Vlerk – Groote foraminiferen van N.O. Borneo, Wetensch. Meded. v. d. Dienst v. d. Mijnbouw, N° 9, p. 19, fig. 10, 32 a—b.

This *Camerina*, which is rather common in the lowest tertiary of East Soemba, is distinguished from all the other species of this genus there, by its gradually arched thick lenticular shape, and the characteristic pattern of the fine filament-lines on the smooth surface.

The marl O. S. 62 yielded some loose specimens; all the others were contained in hard rock and could not be prepared out.

The Soembanese specimens are relatively very thick; horizontal and vertical measurements in different specimens are 6 and $3^1/_2$ mm., 7 and 4 mm., $7^1/_2$ and 4 mm., 9 and $4^1/_2$ mm. The centre is sometimes slightly flattened; the edge is sharp in undamaged specimens. The number of lines on the surface at the edge is about 60, the course of these septal filaments is shown in the accompanying drawing (text fig. 17). As may be seen, some groups of lines reach the centre with a sharp curve, but many other end before they reach it and are either straight or only very slightly curved. The same form of growth is shown in the reproductions which Carter and van der Vlerk give of this species. The description and reproduction of the surface of the *N. kelatensis* from Nias, given by Douvillé, do not appear to me to correspond to the reality [10]). The

10) Both No. 11 and No. 38 (Eho river) of the Nias Collection, in Leiden, which Douvillé has worked up, contains a *Camerina*, which, so far as can be seen from the random sections on the polished surfaces of these hard rocks, exactly correspond to the Soembanese specimens of *C. kelatensis*, except that they are rather smaller than the specimens from O. S. 62. In my opinion Douvillé's *N. aff. Lamarcki* and *N. kelatensis* from Nias, which only differ by the occurence of white spots on the filaments of the former, belong to the same species, while the external cast of *N. pengaronensis* from No. 11 (of which Pl. XX, fig. 1 gives a very deceptive reproduction) probably belongs to a similar fossil. This would destroy Douvillé's argument for a difference of age between No. 11 and No. 38.

figure on p. 262 (1912) shows 54 deeply curved lines, all uniting in the centre, which is never the case in *C. kelatensis*. Moreover DOUVILLÉ says in the text: "Les filets sont fortement arqués et concaves en avant".

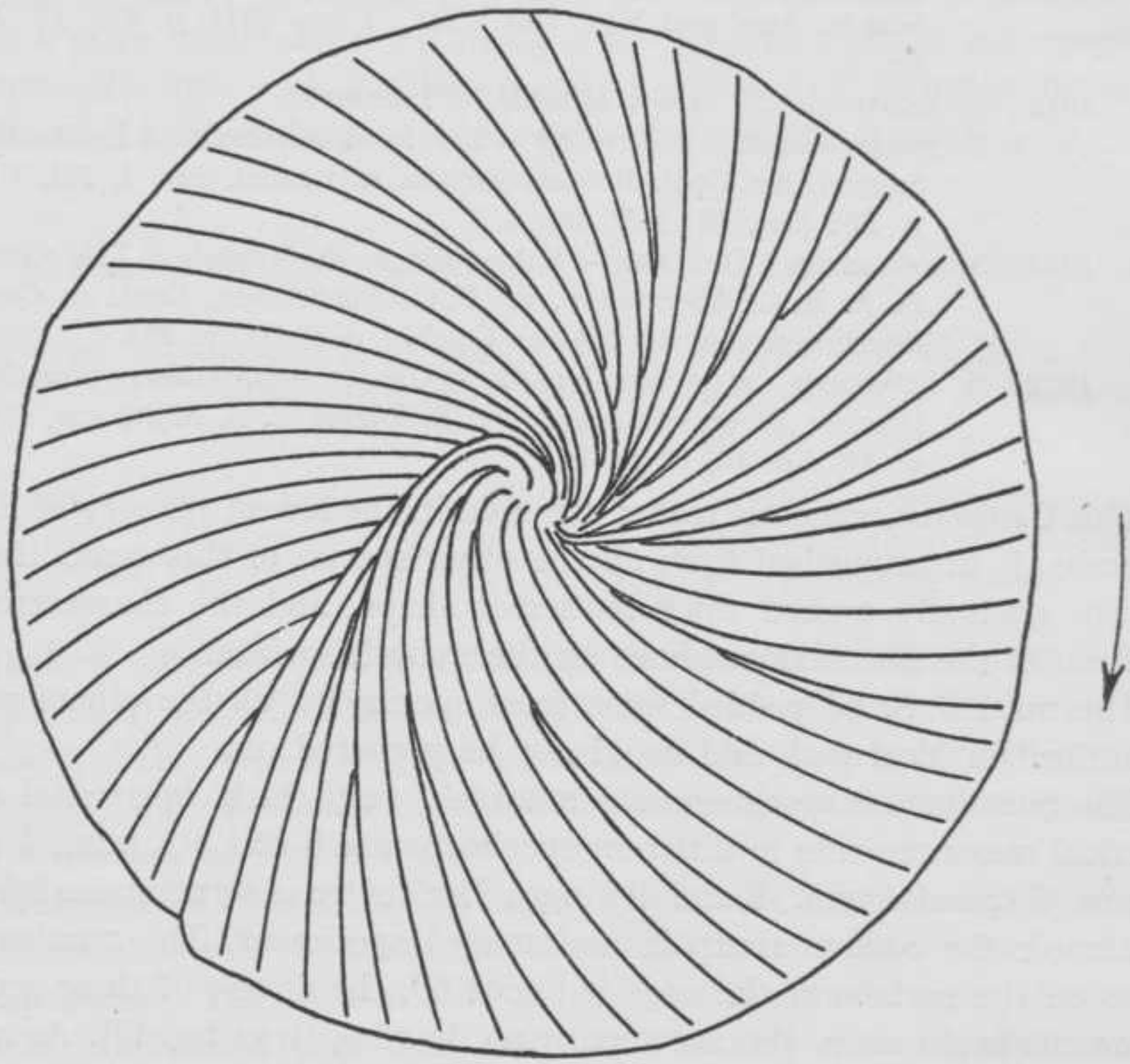

Fig. 17.

Examining the surface of *C. kelatensis* it will be seen that the groups of short, straight rays repeatedly come to an end up against the longer rays. This can only be accounted for by the longer lines being older than the short ones. The curved filament-lines should then be convex towards the front, which in fact has been clearly observed in the Soembanese specimens. It is a remarkable fact that the filament-lines of a new whorl are quite independant of the stripes upon the surface, which this whorl covers. A transparent specimen from O. S. 300, in which this phenomenon was observed, displayed an inextricable confusion of crossed lines. There are no granulations whatsoever in any of the specimens. (see below, vertical section).

The spiral of this microspheric *Camerina* is remarkably regular in

horizontal section; it consists of 11—12 whorls, is very narrow and built up from numerous small chambers. From about the 5th. whorl the height remains constant (300—375 μ); the manner of closing if the test could not be ascertained, but probably there are no low terminal whorls (cf. CARTER's description). The chambers in the oldest whorls are higher than they are long. Towards the end they increase somewhat in length; throughout the greater part of the spiral, the length is aproximately equal to the height, and in the outmost whorls the height is actually exceeded by the length. The spiral wall, which at first is as thick as the height of the chambers, becomes gradually thinner making the lumina of the chambers gradually higher. The septa are arranged almost radially and, except for a short curve at their distal end, are perfectly straight.

The vertical section shows that the central part of the test is occupied by a solid axis of about 0.8 mm. thickness, a group of numerous very fine columns, which however, cannot be seen from the outside. (In CARTER's material they form small irregular white dots on the surface, which can only be seen when the surface is polished). The highly arched alar prolongations of the chambers have a very low lumen (30—60 μ) which merges imperceptibly into the space of the real chamber, and at the other end as it approaches the axis gradually thins out completely. The wall on the other hand is very thick, but varies considerably in the different whorls (150—225 μ). The spiral wall is in general broad and rounded; but in the most external whorls, it is narrow and pointed. The marginal cord is not strongly developed.

The original *C. kelatensis* CARTER is a species from British India probably from the Middle Kirthar. The East Indian form, described above, corresponds in general with the description and lithograph of CARTER, but as CARTER's *C. kelatensis* has never been found in British India after his record and his material is lost (see NUTTALL, 1926, Kirthar), it is not certain that the form of the Malay region is absolutely the same species as the one from Western India.

This *C. kelatensis* from Soemba is identic with DOUVILLÉ's *C. kelatensis* from Nias, the material of which is kept in the Geological Museum at Leiden. Only the specimen from Nias have a smaller diameter. I had also the opportunity to study the types of VAN DER VLERK's *C. kelatensis* from the marl beds of the sandstone stage on the Upper Sg. Taballar (see p. 269). They are practically the same as the form from Soemba but as a rule they are slightly flatter. VAN DER VLERK says that there are 80 septa in the 10th whorl, but the very fine centre of the spiral being not clearly visible in his preparation, it is probable that the last whorl

of the specimen is not the 10th one, but about the 12th. So there is no important difference in the number of chambers, between the Soembanese forms and the specimens of Sg. Taballar. Very nearly related is the *C. densa* DOORNINK from the Tertiary-a of Djiwo, Java (see DOORNINK 1930, p. 295).

Locality: O. S. 62, 286, 300, 517, 780.
Age: Tertiary-a.

CAMERINA BORNEËNSIS (VAN DER VLERK) NOV. NOM.

1929 C. Nuttalli, VAN DER VLERK – Groote Foraminiferen van N.O. Borneo, Wetensch. Meded. v. d. Dienst v. d. Mijnbouw in Ned. Indië, No. 9, p. 19, fig. 11a—b, 34a—b.

In sample O. S. 62 a small *Camerina* was found which exteriorly was exactly like the *Camerinae* from the lowest marl bed from the river basin of the Sg. Taballar in N. E. Borneo, which VAN DER VLERK determined as *Camerina Nuttalli* Davies.

This *Camerina* from Borneo, of which I was able to examine the holotypes, is 5—8 mm. in diameter and in the centre about 2,3 mm. thick, the average proportion of diameter to thickness 3 : 1. The test runs out flat at the periphery and is surrounded by a well developed marginal cord, so that the edge is blunt. The central portion of the shell is occupied by an umbo with granulations, which are sometimes very numerous and are then arranged in a distinct narrow spiral. There are 35—40 septal filaments, which are only curved near the edge.

In horizontal section this *Camerina* is seen to be microspheric. The initial chamber is about 30 μ in size and is followed by a narrow fairly regular spiral of 7—$8^3/_4$ coils. The earliest whorls are very fine, the height of the spiral at the end of the first whorl is about 45 μ, and at the end of the second about 130 μ. The height increases regularly up to the last whorl but one, becoming about $^1/_2$ mm; the last whorl often spreads out into a flange of about one mm. width (see VAN DER VLERK, fig. 34 a-b). The septa of the chambers are as a rule only slightly curved and the tops of the lumina are not greatly rounded; in the last whorl only, the chambers may assume a very distinct, almost *Operculina*-like sickle form, with an obtusely rounded top. But in the normal coils the angle between the septa and the spiral wall, especially the posterior angle of the chambers, is very clearly marked (cf. *C. Nuttalli* of British India, see below). The number of chambers per whorl in different specimens is:

whorl:	Soengei Taballar			East Soemba O. S. 62:
	according to v. d. Vlerk's description	reproduced specimen	some other specimen	
1st	8	7	7–8	?
2nd	9	8	9	14
3rd	16	12	12	17
4th	20	19	20	17
5th	32	23	30	20
6th	35	28	35	26
7th	37	34?	38	30
8th	35–40 stripes on surface	36	—	31 on $^3/_4$ whorl
9th	—	29 on $^3/_4$ whorl	—	—

The specimen in O. S. 62 does not precisely correspond to the specimens from Borneo in horizontal section. Height and number of the whorls are about the same (in a diameter of 5 mm. the Soembanese form has $7^3/_4$ whorls, of which the last is 0,7 mm. high), but the number of chambers per whorl is somewhat less. From the above table it may be seen, however, that this difference is not very great, and as only a very limited amount of material could be examined (viz. one horizontal section) it is not certain whether we are dealing with a constant difference or only with an individual deviation. I will therefore, for the present assign the Soembanesian specimen, on the grounds of its great similarity, to the same species as those from Borneo.

This species is, however, not identical with *C. Nuttalli* (Nuttall) Davies (see Nuttall 1926, Ranikot, p. 114—115; Pl. X, fig. 1—2, text fig. 1; Davies 1927, p. 266—269, Pl. XVIII, fig. 3—4, Pl. XIX, fig. 1—9). It is true that the "*C. Nuttalli*" from Borneo has an analogous build to the British Indian species, which also has a group of pillars arranged in a spiral at the poles, 7—8 whorls which run out flat with a substantial marginal cord and slightly curved stripes on the surface, but *C. Nuttalli* is a large form, average 11,2 mm. (the diameter varies from 6,6 to 15,5 mm.; Davies regards the small individuals as immature forms). I received 9 specimens of Nuttall's material from Jherruck (Jhirak), Sind, from the Sedgwick Museum in Cambridge for comparison. At the very first sight it is clear that the form from Borneo and from Sind cannot be interchanged. The *Camerina* from the Sg. Taballar is exteriorly a miniature form of the British Indian *C. Nuttalli* with the central part

too large and too thick in proportion, a peculiarity which VAN DER VLERK had already noted. But the main difference between the two forms is shown in horizontal section. *C. Nuttalli*, with a larger diameter, has about the same number of whorls, which are therefore much higher; the height of the last coils is even about 1.5 mm. The spiral is very irregular with numerous depressions and in the centre, immediately after the initial chamber is very wide (at the end of the first coil about 220 μ, of the second nearly 400 μ). The chambers, which vary very much in height, and are divided by almost straight septa, have quite rounded tops with only a very faint tendency to form a distinct posterior angle; the inner margin of the spiral wall is comb-shaped under the influence of the septa, giving to the horizontal section a somewhat *Pellatispira*-like appearance. This peculiarity is a constant characteristic of the species; NUTTALL gives a drawing of the central part of the spiral (drawn by camera lucida), in which this can be seen. DAVIES has also recorded it and bases the connection between *C. Nuttalli* and the megalospheric *C. thalica* principally upon this peculiarity (1927, p. 269) and I myself found it also in the specimens from the Sedgwick Museum. But neither NUTTALL nor DAVIES have given a photograph of a horizontal section of *C. Nuttalli;* the omission is here corrected by a reproduction which confirms this very important characteristic beyond dispute (Pl. I, fig. 9). Such a marked rounding of the chambers has so far never been observed in East Indian *Camerinae.*

For the smaller *Camerina* from the Sg. Taballar, which proves to belong to another species I suggest the name *Camerina borneënsis.*

This new determination raises very important issues in stratigraphy. VAN DER VLERK, in the same early marls, found a small megalospheric *Camerina* as well, which is probably the forma A belonging to it and was determined as *C. thalica,* and on the ground of the occurrence of this pair *C. thalica-Nuttalli,* he parallelised the lowest marl beds on the Sg. Taballar with the British Indian upper Ranikot Series.

This parallel would now only rest upon the determination of *C. thalica.* But that *Camerina* is not precisely the same as the British Indian species, either. Between the East Indian "*C. thalica*" and the real *C. thalica* Davies there is a similar connection to that between *C. borneënsis* and *C. Nuttalli*: exteriorly and in vertical section they resemble eachother very greatly, but the form from Borneo is rather smaller and has not the typical comb-shaped spiral wall and rounded chambers, which is a characteristic of *C. thalica.* It seems to me best, therefore, to give this

Camerina another name too; it might be called *Camerina taballarensis*, for instance.

The parallelisation of the lowest marl beds on the Sg. Taballar with the British Indian Ranikot Series, falls through with this (see below p. 269—270).

Note: the megalospheric *C. c.f. Nuttalli* found by BAKX in hard limestones from Timor (see BAKX, 1932, p. 247) is not identical with *C. Nutalli* (Nuttall) Davies nor with *C. borneënsis* or its megalospheric associate. It must be left undetermined.

Occurrence of *C. cf. borneënsis* on Soemba:
Tertiary-a O. S. 62 (one loose specimen); O. S. 234 (vertical section in a slide).

CAMERINA C.F. TABALLARENSIS (VAN DER VLERK) NOV. NOM.

1929 N. thalicus, VAN DER VLERK – Groote foraminiferen van N.O. Borneo, Wetensch. Meded. v. d. Dienst v. d. Mijnbouw in Ned.-Indië, No. 9, p. 21, fig. 13, 36 a—b.

In the sandy limestone O. S. 61 which, according to its position in the field, belongs to the lowest tertiary deposits of the Rara Mata, one specimen of a small *Camerina* is found, which probably belongs to *C. taballarensis*. The horizontal diameter of the test is 4 mm. and the thickness is 2 mm. The centre is occupied by an abruptly rising umbo, formed by 6—7 closely set fairly massive pillars; around this central part of the test runs a smooth narrow band decorated by 24—25 short rays standing out in strong relief, with only a slight curve close to the margin. The whole is surrounded by a relatively very thick marginal cord.

The nucleoconch is megalospheric. The spiral increases very little in height during growth; after almost $3^1/_2$ coils it suddenly closes up, having first widened out. The number of chambers is:

in the 1st whorl	7
,, ,, 2nd ,,	17–18
,, ,, 3rd ,,	22
,, ,, 4th ,,	10 (in somewhat less than half a whorl)

The septa are only very gently curved, but diverge slightly from the radial line. In this respect, and possibly also by a somewhat less closely coiled spiral, this *Camerina* is distinguished from *C. thalica* of Thal (British India; see DAVIES 1927) to which in other respects it bears a

great resemblance, especially as regards the great development of the marginal plexus. It is however practically the same as VAN DER VLERK's "*C. thalica*" from Borneo, the name of which I changed into *C. taballarensis* (see above, p. 59).

It is, however, impossible to make a minute comparison between the two, owing to lack of material from Soemba.

This *C. c.f. taballarensis* is probably also contained in O. S. 60 and O. S. 302.

All these rocks belong to the lowest foraminiferous deposits in Soemba.

Besides this *Camerina* O. S. 61 contains a number of smaller forms one of which closely resembles it except that it is much flatter. Moreover the septal rays on the surface almost all show a tendency to form granulations at the same distance from the margin (except the central pillars). The number of chambers and the development of the whorls in this variety are practically the same as in the *C. c.f. taballarensis* from O. S. 61, described above.

CAMERINA KEMMERLINGI NOV. SPEC.

Pl. I, fig. 3 and 6

In the Tertiary-a of East Soemba a peculiar *Camerina* was found, which is unusually large and flat in comparison with the other *Camerinae* from these beds. It attains a horizontal diameter of $8^1/_2$—15 mm. and in the centre is about 2.1 mm. thick. It belongs to a still unknown species to which I will give the name of *Camerina Kemmerlingi*.

In all seven specimens of this species were found, all lying in hard rocks from which they could not be prepared out, so that no reproduction can be given of the exterior of the shell. A tangential section, however, revealed well developed pillars, placed at the internal angle of the septa in every whorl, thus forming a distinct spiral. The septal filaments are only slightly curved and sometimes bear a row of extremely delicate granulations. The marginal cord is very well developed. The exterior of the test must have been about the same as the microspheric "*C. orbignyi*", from Java that DOORNINK has shown (1932, Pl. VI, fig. 1—2).

C. Kemmerlingi is a microspheric form with $7^1/_2$—9 whorls, which are fairly regular, but at some spots may have a sudden depression. The initial chamber is about 20 μ in size; the height of the spiral at the end

of the first whorl is 75 μ, at the termination of the second 225 μ and in the 8th—9th whorl 1,5—1,7 mm.

The marginal cord in the youngest whorl is 200—225 μ thick. The septa are pretty nearly radial and near the external angle slightly, but distinctly curved. The number of septa in the various whorls is:

whorl	specimen reproduced (O.S. 237)	second (fragmentary specimen (O.S. 237):
1st	$7^1/_2$	?
2nd	$10^1/_2$	?
3rd	$11^1/_2$	?
4th	$21^1/_2$	?
5th	34	28
6th	34	33
7th	37	41?
8th	21	?
	on $^1/_2$ whorl	
9th	—	?

In vertical section it may be seen that the whorls in the median plane run out flat, and are surrounded by a well developed marginal cord. The whole aspect of this section greatly resembles *C. Nuttalli* Davies from Western India; except that in *C. Kemmerlingi* the columns are not so strictly confined to the centre of the test.

Camerina Kemmerlingi is closely related to the microspheric "*C. Orbignyi*" from Tertiary-b in Java; as has been said above the exterior corresponds exactly. But *C. Orbignyi* is smaller (4—5 mm.) and has loftier chambers. Further there is a great similarity between *C. Kemmerlingi* and *C. amakusensis-subamakusensis* Yabe and Hanzawa from the earliest Tertiary of the Amakusa Islands (Japan) (see YABE and HANZAWA, 1925, p. 78, Pl. XVIII, fig. 5; Pl. XIX, fig. 1, 3, 9; Pl. XX, fig. 1—5; Pl. XXI, fig. 5—7). This foraminifer also has the flat "*planulatus*"-like build with the high whorls and both in horizontal and in vertical section bears a striking resemblance to *C. Kemmerlingi*. But in *C. amakusensis* the spiral is probably more irregular and has a few more chambers and the surface of the test is quite different: it is absolutely smooth with numerous fine S-shaped filament lines, without a trace of granulation.

Finally, in vertical section especially, there is a resemblance between *C. Kemmerlingi* and the peculiar *Operculina*-like *Camerina* which RUTTEN found in material from Tg. Seilor, E. Borneo (1915, p. 9—10, Pl. II,

fig. 5—7), accompanied by *Fasciolites javana* and *Camerina Fichteli*. RUTTEN's *Camerina*, however, has loftier whorls which gives it a greater resemblance to *Operculina* than *C. Kemmerlingi* has.

C. Kemmerlingi was found in samples O. S. 61 (1 specimen), O. S. 126 (1 specimen) and O. S. 237 (5 specimens).

CAMERINA AFF. IRREGULARIS DESHAYES

Compare: Nummulites irregularis, D'ARCHIAC ET HAIME – Description des Animaux fossiles du groupe nummulitique de l'Inde, Paris, 1853, p. 138, Pl. VIII, fig. 16, 17 et 18.

N. irregularis, NUTTALL – The stratigraphy of the Lakiseries(Lower Eocene) of parts of Sind and Baluchistan, India, Quarterly Journal of the Geol. Soc. of London, vol. LXXXI, pt. 3, 1925, p. 446, Pl. XXVI, fig. 6, 7.

Synonym: Camerina irregularis, DOORNINK – Tertiary Nummulitidae from Java, Verh. Geol. Mijnbouwk. Genootschap v. Ned. en Kol. Geol. serie, dl. IX, 1932, p. 290, Pl. VI, fig. 10.

The marl sample O. S. 62 supplied a single specimen of a *Camerina*, which exterially bore a great resemblance to. *C. Kemmerlingi* nov. spec. It is of a flat shape with a horizontal diameter of 11 mm. and is fully 2 mm. thick. The exterior is not well preserved, but it was originally embellished with more or less straight lines and distinct irregularly placed granulations (not forming a distinct spiral as is typical of *C. Kemmerlingi*). The marginal cord is well developed, giving to the test a rather thick blunt edge.

In horizontal section however it proves to have more in common with *C. irregularis* Deshayes than with *C. Kemmerlingi*. The spiral, which begins with a microspheric embryonic apparatus, is very irregular and the septa are in general extremely curved, while there are a great number of abortive and hypertrophied chambers. Moreover the chambers occasionally leave a space open between their own walls and the marginal cord. The curve of the chambers gives them a very elongated shape, the length of the lumen (not the height of the coil) is frequently 3 times the width (= true length of the chamber). In consequence the number of chambers, although the septa lie close together, is not great.

The number of chambers in the various whorls is:

1st.	whorl	12
2nd.	,,	18
3rd.	,,	25
4th.	,,	31
5th.	,,	34
6th.	,,	37
7th.	,,	47 (on estimate)
8th.	,,	56

During growth the test has been thrice gradually closed, after which the height of the spiral gradually increased, which must probably be attributed to less fortunate periods in the growth of the animal; after $8^1/_2$ whorls the test was mature and was abruptly closed by a sudden inward turn of the spiral lamina. This method of closing, which seems to be usual in *C. irregularis* (D'ARCHIAC et HAIME, 1853, p. 139) points to a relationship with *C. planulatus* Lamk.

C. irregularis has so far only been known in the East Indies from Java (DOORNINK). Exteriorly the specimens from Java correspond exactly to NUTTALL's specimens from the Laki series in Baluchistan. But both the Soembanese and the Javanese forms differ from the European form (and from NUTTALL's specimens from British India) in the large number of whorls in the comparatively small radius. It cannot yet be said with certainty whether our specimen represents a special Indo-pacific variety.

Locality: O. S. 62.
Age: Tertiary-a.

CAMERINA DISCOIDEA NOV. SPEC.

Pl. I, fig. 7 and 8

A very peculiar *Camerina* was found in the slides of some rocks from the Tertiary-a from West Soemba.

It is a small fossil, resembling in its remarkably flat shell the *Assilinae* by which it is constantly accompanied. It is distinguished, however, by the convolutions being completely involute, as is shown in the reproduction. So it is the antipode of *Assilina orientalis*, which has the external appearance of a *Camerina*, but whose internal build is of the evolute *Assilina* type. This West Soembanesian *Camerina* does not belong to any known species; we give it the name of *C. discoidea*, in accordance with its form.

C. discoidea has a diameter varying from 2,9 to 3,9 mm. Its initial chamber is relatively very large (375—480 μ). There are about 3 whorls. We do not know any further particulars, the matrix being too hard to allow a closer examination.

Locality: W. S. 85, 87, 89, 99.

Camerina javana Verbeek

1896 Nummulites javanus, Verbeek and Fennema – Geologische Beschrijving van Java en Madoera.

1932 Camerina perforata, Doornink – Tertiary Nummulitidae from Java, Verh. Geol. Mijnb. Genootsch. v. Nederl. en Kol., geol. serie, Dl. IX, p. 273, Pl. I, fig. 1—5.

Two of Verbeek's varieties of this *Camerina* were found in the material from Soemba, viz. α and β.

Variety α

(see Verbeek and Fennema, p. 1096, Pl. III, fig. 45—47.
Pl. IV, fig. 58—59.
Pl. VII, fig. 94.

A large form, with pretty sharp edge.
Horizontal diameter: 23—26 mm.
Thickness: . 6—6$^1/_2$ mm.

This is a microspheric *Camerina*, of which the median plane is saddle-shaped, sometimes so much so, that in horizontal section the chambers can only be seen as narrow strips. This makes it impossible to count the exact number of chambers to a whorl. The spiral remains low (at half the radius not even ½ mm.) and the whorls are therefore numerous.

A radius of	12 mm.	there are	30	whorls	
	13 mm.	,, ,,	32	,,	
	14 mm.	,, ,,	39	,,	undulated specimen; diameter externally 25 mm.

The chambers (at half the radius) are usually as long or a little longer than they are high. The lumen is on an average 300 μ high and 300 μ to 450 μ long. The septa are more or less oblique and evenly curved (cf. *C. djokdjokartae* p. 68).

In vertical section also, the spiral is seen to be very closely wound. Outside the median layer the walls fit close to one another without much intermediate space, so that a broken specimen in the rock sample, may look like a delicately built *Orbitoid*, at first sight.

The exterior is not well preserved; the delicate filaments which wind irregularly backwards and forwards can only be seen here and there. These lines are occasionally thickened into minute knots, where pillars reach the surface; there are, however, no granulations whatever. In a somewhat sloping horizontal section filaments and pillars are seen much more clearly. The filaments meet a great many small pillars in their path, which stand either precisely in their course, or which they include by taking a sharp curve towards them; they repeatedly combine, and finally meet in the centre, greatly reduced in number, in a faint spiral. The innumerable pillars, many of which stand between the filaments and are untouched by them, can be seen even in this section to be more or less distinctly arranged along the edges of the whorls.

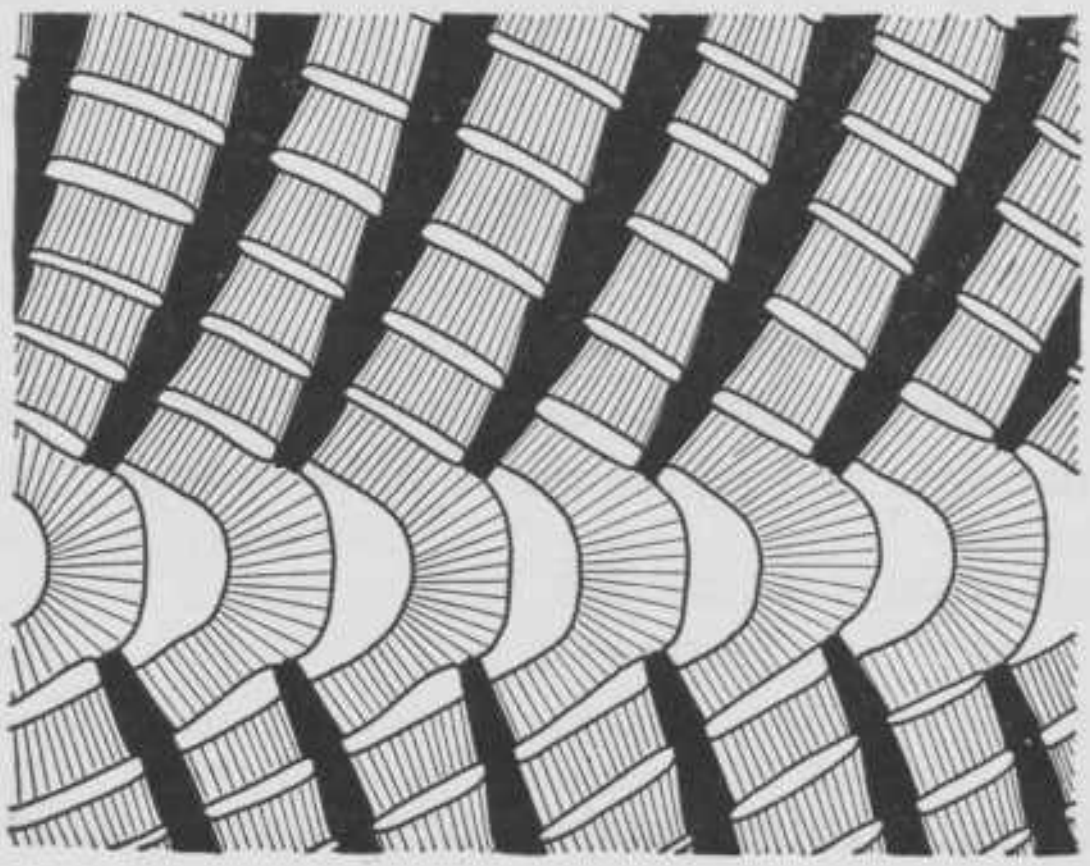

Fig. 18. *Camerina javana var.* a Verbeek (O. S. 112), detail of vertical section (schematic).

Their position and their manner of growth can beseen even better in a vertical section. The arrangement is very regular along the outside edge of each whorl. The pillars reach the edge of the vertical section, and must therefore theoretically end as a closely packed spiral at the surface. In many cases I observed that the pillars grew thinner towards the surface, as VERBEEK describes them, but some retain the same thickness up to the surface, so that I consider this phenomenon of wedging out is principally due to the section not having cut the pillar exactly through its axis. The pillars all stand at right angles to the whorl through which they pass, and curve slightly towards the axis of the shell, as shown in text fig. 18.

It should be noted that this vigorous development of the pillars was

only observed by VERBEEK in specimens of variety β. It now appears that the varieties α and β do not necessarily differ in this point and that the difference lies only in the construction of the whorls.

Locality: O. S. 107, 112, 164 and 768; C. c.f. javana in O. S. 511.
Age: Tertiary-b; perhaps also in Tert.-a.

VARIETY β

(see VERBEEK and FENNEMA, p. 1098, Pl. III, fig. 48—52, Pl. IV, fig. 60—68)

This variety is considerably smaller than the preceeding, and is characteristised by a relatively greater thickness and by the broad rounded edge.

The horizontal diameter varies between $11^1/_2$ and 13 mm., the thickness between $3^1/_2$ and 5 mm.

The number of whorls in a radius of $6^1/_2$ mm. is 16—17.

Here too nothing can be clearly seen of the exterior; in section the filaments and pillars prove to be exactly the same as in variety α.

Locality: O. S. 256.
Age: Tertiary-b.

Recently GERTH and DOORNINK have divided the *Nummulites javanus* of VERBEEK into various species, which they thought could be identified with *Camerinae* from Europe and adjoining territories. DOORNINK combines VERBEEK's var. α and β as *C. obtusa* Sow. (= forma B of *C. perforata* Montf.) and the var. γ and δ as *C. gizehensis* Forsk. (bibl. 21, p. 271—278). But DOORNINK does not seem to be absolutely certain of the complete identity of the Javanese form with these species: he says expressly that the characteristics of *C. perforata* and *C. gizehensis* are very variable, and in his summary (p. 304) when comparing Europe, British India and the East Indian Archipelago, he leaves the proposed alteration in the name of *C. javana* undecided.

As I myself have not been able to find any real correspondence between the first two territories and the East Indian Archipelago in regard to the further eocene foraminifera (see below, p. 676, etc.), I do not wish to introduce a European name for this *Camerina*, and prefer to continue to indicate the forms from Soemba as *C. javana var.* α and β.

CAMERINA DJOKDJOKARTAE MARTIN

1880 Nummulites Lamarcki and N. laevigatus, VERBEEK – Die Tertiärformation von Sumatra und ihre Thierreste, Palaeontographica 1880, Suppl. III, Lieferung 8 und 9, p. 24. Same in: Jaarb. Mijnw. 1881, dl. II, p. 39—40 (Java).

1881 N. djokdjokartae and N. spec. indet., MARTIN – Tertiär-Versteinerungen vom östlichen Java, Samml. des geol. Reichsmuseums in Leiden, Ser. I, Bd. I, p. 109—110. Pl. V, fig. 8—11.

1883 N. Lamarcki and N. laevigatus, VERBEEK – Die Tertiärformation von Sumatra und ihre Thierreste, Jaarb. Mijnw. 1883, dl. I, p. 18.

1892 N. Jogjakĕrtae and N. laevigatus, VERBEEK – Voorloopige berichten over Numm., Orbit. en Alveolin. van Java, Natuurk. Tijdschr. v. Ned. O.I., LI, p. 116—117.

1896 N. Jogjakartae and N. laevigatus, VERBEEK – Geologische beschrijving van Java en Madoera, p. 1104 and 1106, fig. 98, 100, 101, 103—110, 114—116.

1900 N. spec. indet., MARTIN – Die Eintheilung der versteinerungsführenden Sedimente von Java, Samml. des geol. Reichsmuseums in Leiden, Ser. I, Bd. VI, p. 214.

1905 N. Jogjakartae, DEPRAT – Les dépots éocènes néo-calédoniens, Bull. de la Soc. Géol. de France, sér. IV, T. 5, p. 495.

1912 N. Djokdjokartae and N. Vredenburgi, DOUVILLÉ, H. – Quelques foraminifères de Java, Samml. des geol. Reichsmuseums in Leiden, Ser. I, Bd. VIII, p. 281, Pl. V, fig. 1—9.

1915 N. Djokjakarta and N. laevigatus var. Vredenburgi, DOLLFUS – in: E. C. ABENDANON, Geologische en geographische doorkruisingen van Midden-Celebes, part III, p. 972—973, Pl. IV, 1760 (?).

1915 N. Djokdjokartae, formae A and B, MARTIN – Die Fauna des Obereocäns von Nanggulan auf Java, Samml. des geol. Reichsmuseums in Leiden, Neue Folge, Bd. II, Heft 5, p. 195.

1921 N. Vredenburgi, DOUVILLÉ, H. – Sur quelques foraminifères des Moluques orientales et de la Nouvelle Guinée, Jaarb. Mijnwezen, 1921, Verh. 2de deel, p. 110 (Rotti), Pl. I, fig. 1.

1926 N. acutus, pars, NUTTALL – The zonal distribution and description of the larger foraminifera of the Middle and Lower Kirthar Series (Middle Eocene) of parts of Western India, Rec. geol. surv. of India, vol. LIX, p. 134.

non 1926 N. djokdjokartae, loc.cit., p. 134.

1928 N. Djokjakartae, Java-karteering (Res. Bantam), Jaarb. Mijnwezen, 1928, alg. ged., p. 72.

1929 N. Djokdjokartae and N. Vredenburgi, GERTH – The Upper Nanggoelan beds (Palaeontology), Fourth Pacific Science Congress, Excursion Guide, D. I, p. 15; further cit. in BOTHÉ, Djiwo Hills and Southern Range, Excursion Guide, C. I, p. 6, 8.

1929 N. Djokdjokartae and N. Vredenburgi, GERTH – The stratigraphical distribution of the larger foraminifera in the Tertiary of Java, Proceedings of the Fourth Pacific Science Congress, p. 593, 598.

1931 N. Djokdjokartae and N. Vredenburgi, GERTH – Der geologische Bau Javas, Geologische Rundschau, Bd. XXII, Heft 3/4, Aufsätze und Mitteilungen, p. 192 (see also pag. 190).

1931 Camerina djogjokartae and C. acuta, UMBGROVE – Tertiary Foraminifera, Leidsche geol. Mededeelingen, Dl. V (Feestbundel Martin), p. 49.

1931 C. djokdjokartae and C. vredenburgi, LEUPOLD and VAN DER VLERK – The Tertiary (Stratigraphy), Leidsche geol. Mededeelingen, Dl. V (Feestbundel Martin), Tabel II behind p. 648 (Distribution of the most important larger Foram.)

1932 C. djokdjokartae, DOORNINK – Tertiary Nummulitidae from Java, Verh. Geol. Mijnbouwk. Genootsch. v. Nederland en Kol., Geol. Serie, dl. IX, p. 281, Pl. III, fig. 2—7.

From the section of Watoe Moendoe a few *Camerinae* have been washed out which are as large as *C. javana var. α*; but they are not the same as this species in other respects, more probably they belong to VERBEEK's "*Nummulites laevigatus*" from Nanggoelan. Unfortunately the only two specimens that I had at my disposal had already been made into slides (one horizontal and one vertical) in the preliminary examination of the rock in Netherlands India, so that very little is known to me of their exterior.

The horizontal diameter measures 21—22 mm., the thickness is 4 mm. The test is flat lenticular, with a fairly sharp edge; nothing could be seen of a central thickening.

The horizontal section shows a spiral which doubles itself repeatedly and keeps changing in width, sometimes even closes up completely and then begins again, in short is very irregularly coiled, but lies in one non-undulated plane. The height of the whorls is much greater than in *C. javana*, here it is on an average about 1 mm. (*C. javana* about $^1/_2$ mm.). This makes the number of whorls in the same radius smaller, viz. about 17—19. The chambers are in general much higher than they are long; at the half of the radius the lumen of a chamber averages $900 \times 675\ \mu$, much larger, therefore, than in *C. javana*. The number of chambers is also considerably smaller. The septa are placed radially and are straight except at the distal end where they are more or less distinctly bent over backwards.

The nucleoconch is microspheric.

In vertical section, also, the spiral deviates clearly from the type of *C. javana*. The circumference is an elongated shuttleshape, the whorls spread out in the median plane, which causes the great height of the spiral; outside the median plane the coils are also comparatively far from eachother. The marginal cord is well developed.

The test thus somewhat lightly built up, is provided with massive columns. These do not, as in *C. javana*, run regularly through all the whorls, but a column is developed in the wall of each convolution as a short, rapidly widening cone, after which it begins again narrow in the next whorl [11]) (see text fig. 19). In each whorl (and therefore on the surface

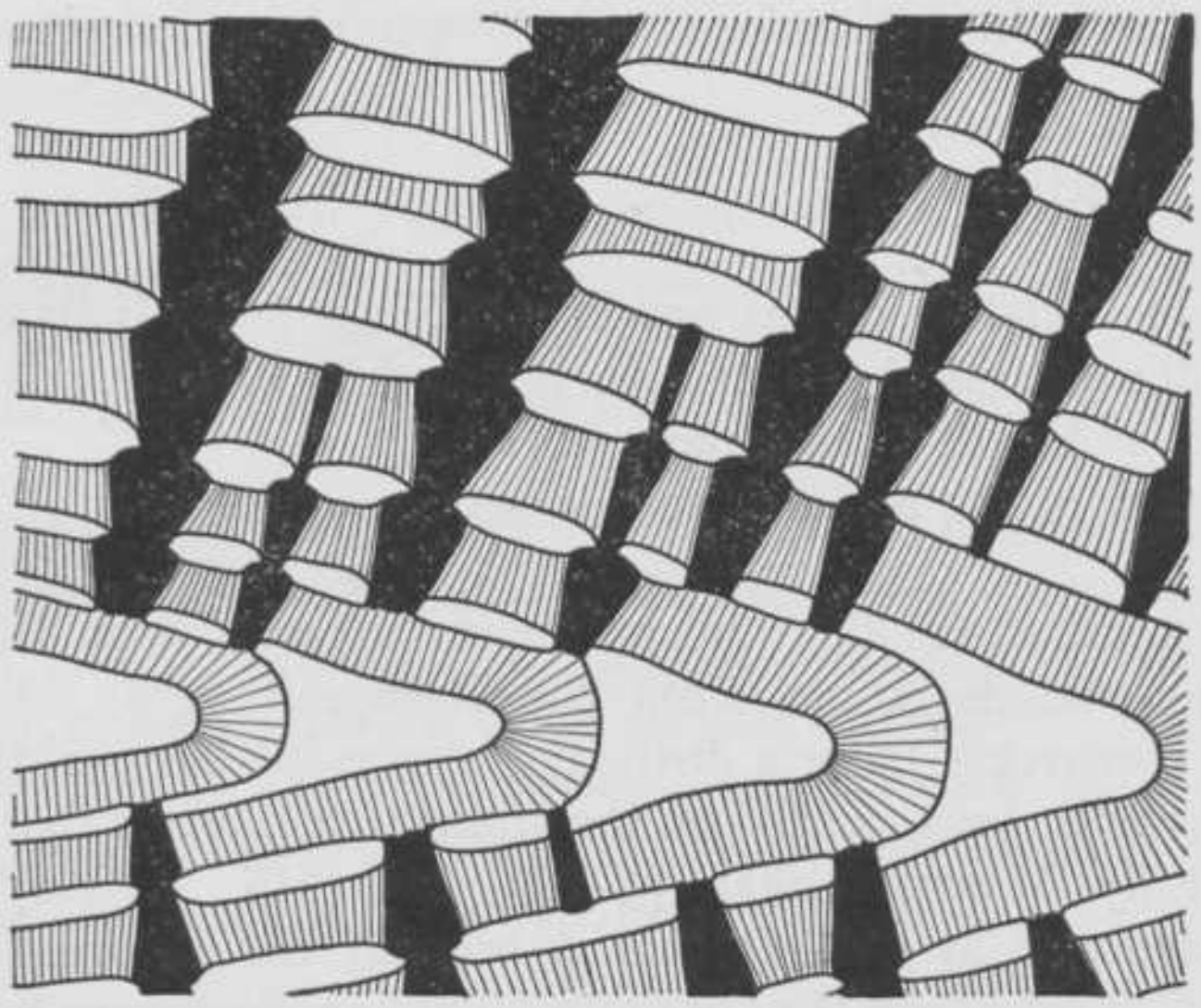

Fig. 19. *Camerina djokdjokartae* Martin, forma B, (O. S. 316), detail of vertical section (schematic).

in the adult stage), the columns have formed clearly protruding heads. At the periphery of the horizontally cut specimen the section has passed through the fossil in a somewhat oblique direction owing to a slight unevenness in the median layer; here, also, the sturdy columns can be seen, which however are not nearly so numerous and thickly set as in *C. javana*, and are joined by much less distinct septal filaments. In *C. javana* the filament-stripes predominate qualitatively, while the

11) VREDENBURG calls a similarly built column in *C. Vredenburgi* (= *C. Douvillei* Vredenburg) very strikingly: "a succession of cones" (1906, *N. Douvillei* etc., p. 82).

column sections appear more or less as thickenings of them; here, on the contrary, the columns predominate, and the filaments (as far as they can be seen on the slide) are only faint connections between them. It appears to me, therefore, probable that the surface has been exactly as shown in VERBEEK's reproduction Pl. VII, fig. 101 (Java en Madoera).

The Soembanese form is distinguished from *C. "laevigatus"* described by VERBEEK by a few small differences: the chambers are a little higher, and in consequence there are rather fewer whorls, viz. 17—19 to a radius of 10—11 mm. (against 19 to a radius of 9 mm. in the Javanese form). As, however, I was only able to examine one specimen and therefore could not tell if this was merely an individual peculiarity, for the present I include the forms in Soemba and in Java in the same species.

Locality: O. S. 316.
Age: Tertiary-b.

In the nomenclature of this well-known Netherlands Indian *Camerina* there is still a great deal of confusion, although in 1915 MARTIN discussed the subject at length (Manggulan, p. 194).

The history of the nomenclature is here recapitulated:

VERBEEK called the large microspheric *Camerina* from Nanggoelan, inspite of some deviations from the European form: "*Nummulites laevigatus* Lamarck". Later a distinction was made between the two by DOUVILLÉ (1912, Java, p. 281) on the grounds of external characteristics only, and by MARTIN (1900, p. 109 and 1915, p. 195) from the internal structure as well. DOUVILLÉ brought the Javanese *Camerina* under the *C. Vredenburgi* (VREDENBURG) PREVER [12])), known from British India. MARTIN opposed this identification and convincingly refuted it (1915, Nanggulan, p. 195—196): besides a few small differences on the surface, *C. Vredenburgi* and the Javanese *C. "loevigatus"* prove to deviate from eachother in their distinctive internal characteristics. In the first the whorl increases regularly and rapidly in height, by which the megalospheric forma A. especially may show a resemblance to an *Operculina* (see VREDENBURG's description); on reaching maturity the final whorl spreads out widely in the median plane, and then suddenly, sometimes after some irregular curves, is closed in a sharp bend. This has

12) *Nummulites Douvillei* Vredenburg (1906, p. 79). Later this name was changed by PREVER for reasons of priority to *N. Vredenburgi* (see Rec. geol. Survey of India, vol. XXXVI, part 3, 1908, p. 239).

been observed in both the megalospheric and microspheric forms.

C. "laevigatus", on the other hand grows in quite a different way; here the spiral is highest just about the middle of the radius, beyond that the height decreases and the test terminates gradually in some 4 to 6 very shallow whorls. In the megalospheric *C. djokdjokartae*, also, a similar build is found, only here the height does not increase from the centre, but the spiral begins directly after the large nucleoconch with the maximum height and gradually becomes steadily shallower.

These differences make it necessary, on the one hand, to make a specific distinction between *C. Vredenburgi* and the Javanese species; on the other hand the comparison of these forms brings us nearer to the convinction that *C. djokdjokartae* (*A*) and VERBEEK's *N. laevigatus* really belong in the same species.

In spite of this evidence against DOUVILLÉ's identification of the two species (in which moreover, the names are contrary to the accepted rules of nomenclature) the megalospheric *C. djokdjokartae* and *C. Vredenburgi-B* were still regarded after 1915 as the two generations of one pustulate species.

In 1926 the name *Nummulites Vredenburgi* was changed by NUTTALL into *N. acutus* Sowerby, but also on the grounds of an erroneous identification [13]), and the forma B. of *C. djokdjokartae* is given under this name in UMBGROVE's synonyma-list of the tertiary foraminifera (1931, Jubilee Vol. MARTIN, p. 49); LEUPOLD and VAN DER VLERK still call the forma B: *N. Vredenburgi* (Jubilee Vol. MARTIN, 2nd. table behind p. 648, strat. distribution of the most important foraminifera).

In the East Indian Archipelago *C. djokdjokartae* has no directly related forms. In regard to the exterior of the test *C. javana* Verbeek resembles it most closely, but I cannot agree with VERBEEK's hypothesis (Java en Madoera, p. 1005) that *C. "laevigatus"* may be a variety of *C. javana*, as the differences are too great for this (see above). There is a much nearer relationship to the European *C. laevigata* Lamk. (D'ARCHIAC et HAIME, 1853, p. 104; NUTTALL, 1926, Kirthar, p. 22—30, Pl. III and Pl. IV, fig. 6—8), and even more so to NUTTALL's *C. acuta* from the Middle-Kirthar Series of Western India. The last deviates from *C. djok-*

13) According to the reproduction of the horizontal section (1926, Kirthar, Pl. II, fig. 4) there is no correspondence in NUTTALL's *N. acutus* in the construction of the spiral with *N. Vredenburgi*. The test of this *C. acutus* closes gradually, in the same way as that of *C. djokdjokartae B*.

djokartae B only in the more massive build of the columns; the forma A. belonging to it was apparently not found, so that a comparison of the two species could not be pursued far enough. Moreover the deposits from Nanggoelan are probably a later formation than the Middle-Kirthar, in which *Assilinae* also are found. It is therefore advisable to keep the more recent name of *C. djokdjokartae* for the Javanese species.

DOUVILLÉ's hypothesis that the *Camerina* from Nanggoelan might be the representative in the Far East of *C. Brogniarti* d'Arch. & Haime is certainly incorrect. *C. Brogniarti* is characterised by unusually elongated chambers and has therefore nothing to do with this Netherlands Indian species. This also puts an end to the correlation of the Nanggoelan marls with the European Auversian, in so far as it was based upon the presence of these *Camerinae* (DOUVILLÉ, 1912, Java, p. 280 and 282).

CAMERINA FICHTELI MICHELOTTI

Reticulate *Camerinae*, both megalospheric and microspheric, occur in great quantities in East-Soemba, but in W. Soemba they are not found. The localities are given in the annotated list of ages of the rock samples, p. 160. Frequently the rocks are entirely composed of the shells of these *Camerinae* (O. S. 47, 533, etc.). Presumably deposits of this kind were once widely spread over the island, as besides in the limestones, in which these fossils are principally deposited, they are constantly found as derived material in the late tertiary rocks round about the Massoe mountains, mostly in marly limestones from Tertiary-e, by exception in a marly tuff from Tertiary-f (O. S. 537). Besides in this soft tuff a little loose material was found in one locality only (O. S. 173); beyond that both the original matrix and the heterogeneous sediments with *Camerinae* are comparatively hard limestones and marly limestones.

For the present I have determined all these *Camerinae* as *C. Fichteli* Mich. (forma B: *C. intermedia* d'Arch.); in two cases only specimens were found which correspond to *C. divina* Doornink (O. S. 472 and 537). The microspheric forms vary greatly in diameter and thickness in different localities, but no distinguishing pecularities could be observed.

The following remarks should be made on this identification:

In the group of the true reticulatae, in contrast to *Camerinae* from other groups, only a very few species are well described. Moreover the species are not always easy to recognise, so that they have been cancelled in part or identified with one another. Generally, at first sight, all reticulate

Camerinae are determined as *C. Fichteli-intermedia.* In literature an enormous geographic area is assigned to this species: Europe, N. E. Africa, Persia, the West of British India, the East Indian Archipelago, Bismarck Archipelago and even Florida. But it must not be forgotten that the determination is usually founded upon the most conspicuous characteristics which all *Camerinae* from this group have in common (network on the surface, shallow whorls, small number of septa per whorl, distinct "median chamber layer" in vertical section) and that the finer peculiarities, by which various species might be recognised, are often left unnoticed. It is quite possible that, after more minute examination, the *C. Fichteli-intermedia* could be divided into different species and that its distribution has not been nearly so cosmopolitan as is supposed. For instance, the megalospheric specimens from British India (NUTTALL 1925) prove to have a larger number of chambers per whorl than I found in material from Europe (Santander, Spain) and from the East Indies, and according to NUTTALL the large specimens of the microspheric form are confined to British India and the Dutch East Indies.

In the following list, some of the literature on reticulate *Camerinae* will be found, principally dealing with the Dutch East Indies.

MEGALOSPHERIC FORMS

1841 Nummulites Fichteli, MICHELOTTI – Saggio storico dei rhizopodi caratteristici dei terreni sopracretacei, Mem. Mat. e Fis. Soc. It. Sc. Modena, vol. XXII, Mem. Fisica, p. 296, n. 2, p. 302, tav. III, fig. 7a—b.

1847 N. Fichteli, MICHELOTTI – Description des fossiles des terrains miocènes de l'Italie septentrionale, Natuurk. Verhand. der Holl. Maatsch. v. Wetensch., Haarlem, ser. 2, vol. III, dl. 2, p. 15, Pl. I, fig. 9.

1853 N. Fichteli, D'ARCHIAC et HAIME – Description des animaux fossiles du groupe nummulitique de l'Inde, etc., p. 100, Pl. III, fig. 5a.

? 1871 N. sub-Brogniarti var. a, VERBEEK – Die Nummuliten des Borneo-kalksteines, Neues Jahrb. für Mineralogie, etc., p. 7, Taf. I.

? 1874 N. sub-Brogniarti var. a, VERBEEK – De nummuliten van den eoceenen kalksteen van Borneo, Jaarb. Mijnwezen, 1874, II, p. 154, Pl. II, fig. 13.

1905 N. subbrogniarti Forma A, similar to N. Fichteli, DOUVILLÉ – Les foraminifères dans le tertiaire de Bornéo, Bull. Soc. Géol. de France, ser. 4, T.V., p. 443.

1909 Bruguieria intermedia A, SILVESTRI – Nummuliti oligoceniche della Madonna della Catena presso Termini-Imerese (Palermo), Boll. Soc. Geol. Ital., vol. XXVII 1908—1909, p. 643, tav. XXI, fig. 9, 13—16. (with extensive list of synonyma)

1909 N. (Bruguieria) Fichteli, PROVALE – Di alcune nummulitine e orbitoidine dell' Isola di Borneo, Rivista Ital. di Pal., Vol. XV, p. 92.

1911 N. (Bruguieria) Fichteli, SCHUBERT – Die Foraminiferen des Bismarck-Archipels und einiger angrenzenden Inseln, Abh. d. k. k. geol. Reichsanstalt, Bd. XX, Heft 4, p. 93, Taf. IV, fig. 5—6.

1921 N. subbrogniarti A, YABE – Notes on some Eocene Foraminifera, Science Rep. Tôhoku Imp. Univ., Sendai, Japan, second series (geology), vol. V, no. 4, p. 103, Pl. XVII, fig. 1, 2, 5, 6, 7.

1922 N. Fichteli, RUTTEN – Vier Eocänvorkommen aus Ost-Borneo, Studien über Foraminiferen aus Ost-Asien, Samml. des geol. Reichsmuseums in Leiden, Ser. I, Bd. X, p. 9, Taf. II, fig. 2—3.

1925 N. fichteli, NUTTALL – Indian reticulate Nummulites, Annals and Mag. of Natural History, Vol. XV, ser. 9, p. 664 (with synonyma).

1929 N. Fichteli, VAN DER VLERK – Groote foraminiferen van N.O. Borneo, Wetensch. Meded. v. d. Dienst v. d. Mijnb. in Ned.-Indië, No. 9, p. 18, fig. 9, 30 a—b.

1929 N. Fichteli, HARTING – Tagogapoe, Fourth Pacific Science Congress, Excursion Guide C1, p. 9.

1931 Camerina intermedia, forma A, DOORNINK – Tertiary Nummulitidae from Java, Verh. Geol. Mijnb. Genootsch. v. Nederl. en Kol., Geol. serie, deel IX, p. 285, Pl. IV, fig. 4—10, text fig. a.

Camerina divina, DOORNINK, ibid., p. 299, Pl. IX, fig. 5—10.

Camerina absurda, DOORNINK, ibid., p. 299, Pl. IX, fig. 11—17, text. fig. 1.

1932 Camerina intermedia-fichteli, TAN SIN HOK – On the genus Cycloclypeus Carp., Wetensch. Meded. v. d. Dienst v. d. Mijnb. in Ned.-Indië, No. 19, p. 43, 47.

MICROSPHERIC FORMS

1846 Nummulites intermedia, D'ARCHIAC – Mémoires de la Soc. géol. de France, 2nde série, vol. II, p. 199.

1850 N. intermedia, D'ARCHIAC – ibid., vol. III, p. 416, Pl. IX, fig. 23, 24.

1853 N. intermedia, D'ARCHIAC et HAIME – Description des animaux fossiles du groupe nummulitique de l'Inde, etc., p. 99, Pl. III, fig. 3—4.

N. sublaevigata, D'ARCHIAC et HAIME – ibid., p. 106, Pl. IV, fig. 8.

1871 N. Sub-Brogniarti, VERBEEK – Die Nummuliten des Borneokalksteines, Neues Jahrb. f. Mineralogie, etc., p. 6. Taf. I, II.

1874 N. Sub-Brogniarti, VERBEEK – De nummuliten van den eoceenen kalksteen van Borneo, Jaarb. Mijnwezen, 1874, II, p. 152, Pl. II, fig. 10—12, 14—27.

1896 N. sub-Brogniarti, VERBEEK and FENNEMA – Geologische Beschrijving van Java en Madoera, p. 1107.

1905 N. subbrogniarti, DOUVILLÉ – Les foraminifères dans le tertiaire de Bornéo, Bull. soc. géol. de France, ser. 4, T. 5, p. 442—444.

1909 Bruguieria intermedia B. SILVESTRI – Nummuliti oligoceniche della Madonna della Catena presso Termini-Imerese (Palermo), Boll. soc. geol. ital., vol. XXVII, 1908—1909, p. 632, tav. XXI, fig. 8, 10—12. (with synonyma).

1909 N. (Bruguieria) intermedia, PROVALE – Di alcune nummulitine e orbitoidine dell' Isola di Borneo, Rivista Ital. di Pal., vol. XV, p. 93.

1911 N. (Bruguieria) intermedia, SCHUBERT – Die Foraminiferen des Bismarck-Archipels und einiger angrenzenden Inseln, Abh. d. k. k. geol. Reichsanstalt, Bd. XX, Heft 4, p. 94.

1921 N. subbrogniarti, YABE – Notes on some Eocene Foraminifera, Science Reports Tôhoku Imp. Univ. Sendai, Japan, second series (Geology), vol. V, No. 4, p. 103, Pl. XVII, fig. 1, 2, 3, 4.

1925 N. intermedius, NUTTALL – Indian reticulate Nummulites, Annals and Mag. of Natural History, vol. XV, ser. 9, p. 662, Pl. XXXVII, fig. 1 (with synonyma).

1929 N. intermedius, VAN DER VLERK – Groote Foraminiferen van N. O. Borneo, Wetensch. Meded. v. d. Dienst v. d. Mijnbouw in Ned. Indië, No. 9, p. 18, fig. 31 a—b.

1929 N. intermedia, HARTING – Tagogapoe, Fourth Pacific Science Congress, Excursion Guide C1, p. 9.

1932 Camerina intermedia, DOORNINK – Tertiary Nummulitidae from Java, Verh. Geol. Mijnb. Genootsch. v. Nederl. en Kol., geol. serie, deel IX, p. 285, Pl. IV, fig. 11, Pl. V, fig. 1.
C. subbrogniarti, DOORNINK – ibid., p. 269.

The first reticulate *Camerina* that was found in the Dutch East Indies (S. E. Borneo) was described by VERBEEK (1871, 1874) under the name of *Nummulites sub-Brogniarti*. It is a fairly large form with a small nucleoconch and more than 50 whorls in a radius of 14 mm. The chambers of the spiral are long, the length being $1^1/_2$—2, maximum 3 times as great as the height. The same *Camerina* was again recorded by DOUVILLÉ (1905, p. 442) as "forme réprésentative" of *C. intermedia*. YABE (1921) determined reticulatae from Boeloengan (forma A and B) as *N. subbrogniarti*, but the species is not recorded by other authors and it was usually tacidly identified with *C. intermedia*. DOORNINK (1932), however, again disputed the identification of *C. subbrogniarti* with *C. intermedia*. As most important points of difference he mentions the aspect of the vertical section, the shape of the chambers in equatorial section and the size of the initial chamber. The difference in the vertical section was not further specified by him and we will leave it out of consideration. The shape of the chambers may form a good characteristic. The ratio of length to breadth of the chambers, according to DOORNINK, is in *C. intermedia* 1 : 1. The chambers are therefore considerably shorter

than in *C. subbrogniarti* Verb. and if this is a constant difference it would indeed be an insuperable objection to combining the two species. The last point of difference, that of the size of the initial chamber, is not so sound. DOORNINK points out that the initial chamber in *C. subbrogniarti* is much larger than in *C. intermedia*, so much so, that *C. subbrogniarti* must be regarded as a megalospheric form (p. 269). In my opinion DOORNINK has relyed much too much on VERBEEK's illustrations (1874, P. II, fig. 13 and 25) in this respect, which appear to me quite untrustworthy. Fig. 13 reproduces an abnormal specimen, which according to VERBEEK is dinstinguished from the other specimens by having a much larger initial chamber (VERBEEK's var. α); but even the var. α is not necessarily a megalospheric form, as in this figure the enlargement is not mentioned and the nucleoconch is single, which points more to a microspheric than to a megalospheric form. Fig. 25 represents the horizontal section of a youthful normal *C. subbrogniarti* enlarged 16 ×. The initial chamber in this drawing is about 1.5 mm. in size, which in reality would be about 100 μ. But in the centre the lithograph is not good; it has probably been retouched and spoiled (note the inaccurate reproduction of the septa in the earliest whorls, being concave towards the proximal end of the spiral). These reproductions, therefore, teach us nothing concerning the size of the initial chamber. We only know that the centre, according to VERBEEK's description, is "small, but perceptable", while in *C. intermedia* a very small initial chamber is always found. But this difference is not exact enough to be used as a distinction.

At the same time it was DOORNINK who noticed and brought forward the existance of important differences in the reticulate *Camerinae* to which far too little attention had been paid in the previous literature. He observed a variability in the megalospheric forms as well which induced him to institute two new species, *C. divina* and *C. absurda*.

C. divina, so called because of the divine regularity in the height of the spiral, according to the description (p. 299) is distinguished from *C. Fichteli* principally by the much greater length of its chambers (in the outside whorls 2 to 5 times as long as they are high) and by the coarser structure of the network of filaments. This network may be of importance in the determination, NUTTALL has used it in British India for the distinction of *C. intermedia-Fichteli* and *C. clypeus-subclypeus* (1925, Indian reticulate Nummulites). Unfortunately DOORNINK has not given the size of the meshes in numbers either for *C. Fichteli* or his new species *C. divina* and a reliable comparison cannot be made from the photos,

as he gives a superficial tangential section of *C. divina* only (of *C. intermedia* there is only a median section on which a portion of the network can be seen). But the difference cannot be very great. According to the reproduction (Pl. IX, fig. 5 and 6) the meshes of *C. divina* near the surface average about 200 μ, sometimes as much as 325 μ. A part of DOORNINK's material of *C. intermedia* is in the Leiden Museum; in 5 specimens of forma A and 3 of forma B of this material I found a rather irregular network with meshes of 150—300 μ diameter, usually larger than 250 μ. Before this network has been minutely studied in a large amount of material, it cannot be depended upon as a characteristic distinction.

The second new species, *C. absurda*, according to DOORNINK is distinguished from *C. divina* and *C. Fichteli* by the greater flatness of the test and by the irregularity of the abnormally large nucleoconch and of the spiral. It appears to me a somewhat dubious species; it is only known from one locality in a small number of specimens, so that it is not impossible that the abnormal growth is not a specific peculiarity, but that it originates in external influences. The network seems to be very fine (DOORNINK, p. 310); but for the rest this species is not yet sufficiently characterised.

If we leave *C. absurda* out of account, we may expect the following species in the East Indies: *C. subbrogniarti* Verb., *C. divina* DOORNINK and *C. Fichteli-intermedia*.

The first two are distinguished from *C. Fichteli-intermedia* by having longer chambers. There may be distinct differences in the height of the whorls also; *C. subbrogniarti* which has 50 whorls in a radius of 14 mm, cannot possibly have such high coils as the *C. intermedia* (forma B) from DOORNINK's material, whose spiral after the immature stage is 400—700 μ high, and *C. divina*, to judge by the photos, has more shallow coils than the javanese *C. intermedia* (forma A). But this characteristic, like the meshes of the network, must be confirmed by further research. We will only discuss the question of the length of the chambers.

The reticulate *Camerina* with short chambers, DOORNINK's *C. intermedia*, seems to be most common in the East Indies. The few photographic reproductions that appeared before DOORNINK's publication, never show the peculiarly long chambers characteristic of his *C. divina;* even in the reproduced specimens of YABE's *C. subbrogniarti* (forma A) the chambers are too short (1921, see fig. 6a in particular). SCHUBERT's material (Bismarck Archipelago) and RUTTEN's (Borneo) and by far the most of my own specimens (E. Soemba) belong without any doubt to the shortchambered type. But there are some cases in which the chambers

are longer than in DOORNINK's *C. intermedia,* but shorter than DOORNINK's measurements for *C. divina* and *C. subbrogniarti* Verb. Such specimens are found for instance in VAN DER VLERK's material (1929) from the Brantan and Seilor beds in Boeloengan (Tert.-c) and in all probality it is the same with YABE's *C. subbrogniarti* (1921) of which only badly orientated sections are given. Transitional forms of this kind were also found in E. Soemba (O. S. 537) together with specimens that could unhesitatingly be determined as *C. divina.* Moreover the chambers in the earlier whorls are often short, but in the last two coils they attain dimensions equal to *C. divina.*

From all this it may be seen that at present the determination of different species in the East Indian reticulate *Camerinae* is far from simple. Even the vertical section, which shows so clear a difference between *C. divina, C. absurda* and *C. Fichteli* (*C. intermedia A*) in DOORNINK's photographs is not sufficient help. The thick evenly vaulted vertical section of *C. divina* for instance contrasts strongly with the much flatter, somewhat bi-conic specimens of *C. intermedia* A from DOORNINK's material, but it cannot be distinguished from the vertical section of VAN DER VLERK's *C. Fichteli* which, as regards the length of the chambers, certainly does not belong to *C. divina.*

It is evident that we should be very cautious in drawing stratigraphic conclusions from the presence of these species. DOORNINK, in his tables on p. 305, 306 gives the following data on the distribution of these *Camerinae*: *C. intermedia* in Tertiary-c(d), *C. divina* in Tertiary-d and *C. absurda* in Tertiary-c. This would lead us to regard *C. divina* as index fossil for Tertiary-d and the abnormal *C. absurda* as index fossil for Tertiary-c. But both these species are only known from one locality, in a limited number of individuals, and their stratigraphic value must certainly be first tested on more ample material.

Not much is known stratigraphically about the Soembanese rocks with reticulate *Camerinae.* These *Camerinae* are found in various combination with other foraminifera:

1. with *radiate Camerinae,*
2. with *Lepidocyclinae,*
3. without *radiate Camerinae* and without *Lepidocyclinae,*
4. as derived material in upper tertiary rocks.

As far as could be ascertained for these usually hard rocks, the *Camerinae* also in the beds where they combine with *Lepidocyclinae,* belong to the type of *C. intermedia* (DOORNINK). The only specimens which might

be assigned to *C. divina*, were found in O. S. 472 and 537. In a slide from O. S. 472 besides this *C. c.f. divina* there is a section of another *Camerina* that looks very much like *C. pengaronensis* Verb., which indicates that this rock should belong to Tertiary-c. O. S. 537 is a marly tuff from the upper tertiary plateau, where the reticulate *Camerinae* are secondarily deposited. This sample also contains a small irregular specimen with an abnormally large nucleoconch, thus belonging to *C. "absurda"*.

The material from Soemba could therefore not supply the necessary confirmation of the stratigraphic value of DOORNINK's species.

We here give a short description of the Soembanese specimens.

The megalospheric forms attain a horizontal diameter of 2.5—5.5 mm. (occasionally even 5 mm.) and a thickness of 1—1.5 mm. The ratio of diameter to thickness is not constant, but varies from 2.2 : 1 to 3.6 : 1. The network of filament-lines is fine; generally the meshes are 150—200 μ in size, maximum up to 240 μ. There are no granulations whatever, but the filament-lines converge in the centre in a distinct spindle which becomes visible in polishing. The meshes are pretty regular up to the edge (in contrast to what NUTTALL says of the Indian reticulate Nummulites, 1925, p. 663, of the network of British Indian *C. intermedia*) and almost isodiametric. As these *Camerinae* were almost all found in hard rocks there were only a few orientated sections to be examined. The nucleoconch in every case where it could be observed is double. This in itself is nothing special in a megalospheric form, but it must be mentioned here because NUTTALL says of the British Indian *C. Fichteli* that the protoconch is single (loc. cit., p. 665). As the chambers of the spiral in *C. Fichteli* are frequently rounded, it is not always easy to make out which chambers belong to the nucleoconch and which form the beginning of the spiral [14]). But there is every reason to believe that NUTTALL's statement is not quite correct; in the first place, in by far the majority of cases, if not all, the nucleoconch in the Nummulitidae consists of two chambers and in the second place in the same publication NUTTALL calls the nucleoconch of *C. subclypeus* single, while to judge from the photo (Pl. XXXVII, fig. 5) it seems to be double-chambered. The British Indian *C. Fichteli* may perhaps be different to the European and East

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14) SILVESTRI includes even 3 chambers in the nucleoconch (1909, p. 646), but probably he was deceived by the sections not being made exactly through the equatorial plane, by which in the centre of the spiral the horizontal walls of the chambers were cut through as well (cf. Pl. XXI, fig. 14—15).

Indian species as regards the number of chambers per whorl, but the occurrence of an essential difference as this in the nucleoconch seems to me improbable.

The chambers of the spiral in the Soembanese specimens are as a rule comparatively short, as in DOORNINK's *C. intermedia;* in the outside whorls chambers which are twice as long as they are high are not uncommon, however.

The vertical section of reticulate *Camerinae,* as they may be seen in slides of the rock may resemble either DOORNINK's *C. intermedia* A or *C. divina.*

The specimens from the washable tuff O. S. 537 could be minutely examined. Amongst these there were several belonging to the *C. divina* type. The horizontal diameter is 2.6—4 mm. and the thickness 1—1.5 mm. The ratio of diameter to thickness varies from 3 : 1 to 4 : 1. The meshes of the net-work on the surface are 150—225 μ in size, as large, that is, as in the specimens with short chambers.

The horizontal section, in most cases, yields a surprisingly regular appearance. In the first place the spiral, which consists of 6—9 whorls, except for slight deviations, remains during the whole process of growth of the same height: about 150 μ, in a few individuals as much as 240 μ. In the second place, the position of the septa lends great regularity to the appearance; the septa of each new whorl lie almost exactly in the line of those of the preceeding coil, so that these divisions often form distinct slightly curved lines from out the centre, which continue almost without interruption through all the whorls. The number of chambers, that constantly becomes a little larger in the oldest whorls at a later period remains the same in all the whorls, so that the chambers become longer and longer. The earliest chambers are about as long as they are high, while in the later whorls they may be more than three times as long as their height. This great regularity is often found in reticulate *Camerinae,* as can be seen from the reproductions of *C. divina* (DOORNINK 1932) and *C. Fichteli* (VAN DER VLERK 1929) although it may not be so striking as in the material from O. S. 537. The septa are only slightly curved, but slope backwards considerably. The marginal cord is not much developed.

The microspheric forms from Soemba have a maximum diameter 13 mm., being a good 2 mm. in thickness. These figures are usually not more than 8 mm. and 2 mm.

The meshes of the superficial net-work are of the same size as in the

megalospheric forms, and equally regular. There are absolutely no columns here either.

The initial chamber could not be accurately measured, but in any case it is very small. The spiral increases in width somewhat rapidly at first, but after a few coils it reaches its maximum height and with the exception of fairly numerous irregularities it remains further almost the same during the whole period of growth. The height in some cases does not exceed 375 μ. In the largest specimens, however, the whorls may attain to 500 μ. The number of normal whorls is usually 17. The shell is then closed by a few very shallow whorls (in the Soembanese material at most 4) which are barely 50 μ high and in which the lumina at certain points may be squashed quite flat. The chambers of the spiral are relatively short; sometimes (e.g. the specimens from O. S. 537) however they are longer than in DOORNINK's *C. intermedia*-B and are then just the same as VAN DER VLERK's reproduction of *C. intermedia* (1929). The number of chambers per whorl cannot be properly counted, owing to undulations in the median plane; in the 8th coil it is about 20, but increases somewhat in the later coils. The closing whorls consist of numerous abnormally small chambers.

Genus Pellatispira

Pellatispira was only found on Soemba in compact limestone and sandy or marly limestones, from which they usually could not be prepared out. The only samples from which a few specimens could be obtained are the somewhat soft marly limestones O. S. 151 and 152 from Lalokoe. These specimens all belong to one species, which is very closely related to P. irregularis Umbgr. if not identical with it.

PELLATISPIRA AFF. IRREGULARIS UMBGROVE

Pl. II, fig. 2 and 3

Compare: 1928 Pellatispira irregularis, UMBGROVE – Wetensch. Meded. v. d. Dienst v. d. Mijnb. in Ned.-Indië, No. 10, p. 65, fig. 69—74.

The horizontal diameter of these Pellatispira varies from $2^1/_2$ to $3^1/_2$ mm. (average 3 mm.) and the thickness from 1.25 to 1.75 mm. The test is lenticular with rounded blunt margin and sometimes a slight vaulting of the central portion. The shape is not always circular, in some specimens it is even distinctly eliptical, but whether this is the case in an uninjured

condition I am doubtful, considering the regularity of the median spiral.

The surface, magnified 10 times, shows a regular mesh of wide transparent canal openings and white pseudo-pillars; real pillars are entirely absent.

The nucleoconch is megalospheric. In horizontal section the diameter of the initial chamber (including wall) is 180—225 μ. It is remarkable that the initial chamber in vertical section proves to be oval, so that the chamber cannot be spherical, but is ellipsoid; the height is greater than the horizontal measurement, viz. 240—270 μ (with wall). The thickness of the wall is variable.

The remaining chambers form a spiral of 3—4 whorls. The height of the coil in the 3rd whorl is 375—450 μ; of this the lumen of the chamber occupies in general rather more (about 270 μ) than the compact wall of the chamber + the spiral comb (160—200 μ). The number of chambers in the last whorl is 25—26.

The lateral calcareous wall on either side of the spiral, as seen in vertical section, is 400—500 μ thick, and riddled with numerous radial canals. Even on the exterior, but especially in a tangential section, it can be clearly seen that these canals are not circular in cross-section, but in general obtuse quadrilateral; they are all of about the same width, viz. measured in diagonal direction about 60 μ, and along the sides about 45 μ, and lie close together in alternating rows. Pl. II, fig. 2, shows that a vertical section, that cuts the canals in a diagonal direction, may present an appearance very greatly resembling *P. glabra* Umbgr.: the very broad canals are separated by extremely thin walls (minimum 15 μ). In reality the pseudo-pillars are in cross section about the same size as the canals and also more or less square. Moreover the Soembanese specimens are distinguished from *P. glabra* by the chambers having distinct perforations, which, strangely enough, does not seem to be the case with *P. glabra* (UMBGROVE, 1928, p. 22).

The shape of the canals in cross section and their whole arrangement correspond to those of *P. irregularis* but there is a slight deviation which forbids the inclusion of the Soembanese form in this species except under reservation. This is, that the canals in the Soembanese specimens are not constricted at the surface by a club-shaped thickening of the "pillars", they continue of the same width to the very end. In two specimens, however, it could be observed that all the canals, at the same height close below the surface, are closed by a calcareous lamel of 15—20 μ thickness, in which numerous evenly distributed perforations of 5—7 μ maintain the connection with the outer world (Pl. II, fig. 3). This phenomenon is

entirely absent again in other specimens. It is remarkable that this closing up of the canal openings, which probably is of importance in the life cycle of the foraminifer, in these two forms, *P. irregularis* Umbgr. and the Soembanese specimen, in other respects corresponding completely to one another, takes place in essentially differing ways. It is therefore not impossible that we here have two separate species after all.

Locality: near Lalokoe.
Age: Tertiary-b.

Pellatispira was found in East Soemba in Tertiary-b (see discussion on p. 189). In general the sections of *Pellatispirae* in the slides of those rocks resemble the *Pellatispirae* from Celebes reproduced by VAN DER VLERK and DOZY (1934); sometimes they seem to represent quite unknown species (Pl. II, fig. 9.

In West Soemba *Pellatispirae* were found in Tertiary-a as well (see Pl. II, fig. 4 and 5).

Genus Heterostegina

Heterosteginae are rare in the marls of Soemba; they are found more frequently in the limestones. As I have not a sufficient number of prepared out specimens of this genus insufficiently studied in Netherlands India, I have as a rule refrained from species determination, and will here confine myself to a short description of a few of the forms which are found on the island.

1. A Heterostegina with a diameter of amply 3 mm. Exterior unknown. The primary spiral is very narrow, only a little wider than that of *H. glabra* Osimo (cf. OSIMO, 1908, p. 34, Tav. I, fig. 5—6), and the septa of the chambers are, as in this species, very much curved. The embryonic portion of the test is primitively constructed; the first secondary septum does not appear until the 24th chamber. This construction leads to the surmise that we are dealing with a microspheric form, but it is not certain that this really is the case. The initial chamber has a diameter of 75 μ, which would be unusually large for a microspheric form, while the second chamber is somewhat kidney-shaped (cf. CAUDRI, 1932, p. 195—196). It is therefore also possible that this *Heterostegina* is megalospheric, in which case it would be a very primitive species. The fossil has been found in the marl O. S. 537, which is of the age of Tertiary-f. If it has been originally deposited in this marl, the find would

throw a very curious light upon the origin of *Heterosteginae;* but it is not impossible that it has been washed into the rock from an older deposit, as *Camerinae* are also found in this marl. And as these *Camerinae* are of the reticulate type, it is probable that the *Heterosteginae* derive from Tertiary c—d.

2. In the same marl another *Heterostegina* is found, of which the spiral gradually increases in height, but is not so narrow as in the above form. The horizontal diameter of this fossil is 4 mm. The middle of the test is occupied by a large central mamelon and the edge (with marginal cord) is very thick. The central mamelon bears distinct granulations, while the primary septa are also faintly granulated. These primary septa, which are not visible on the exterior, are much curved and lie rather far apart. The secondary divisions are not very numerous and the chamberlets are therefore large. This Heterostegina has a comparatively small nucleoconch, but is megalospheric; the chambers are soon divided into chamberlets. This species is therefore probably less primitive than the former.

3. The sample O. S. 537 yields a third species of an entirely different type to the first two. The test, which is barely 4 mm. large, has a fairly thick central mamelon, surrounded by a broad very thin collar. The central part bears extremely delicate granulations, but these are entirely absent from the remainder of the test. Primary and secondary septa are clearly visible from the exterior. The primary whorl increases rapidly in height; the number of both chambers and chamberlets is large, so that the whole median plane is much more delicately constructed than in the other two Heterosteginae from the same rock. The nucleoconch is megalospheric and the number of undivided chambers is small.

4. Slides of the breccious limestones O. S. 357 and 534 contain numerous sections of a foraminifer which must be counted as a *Heterostegina*, but which very much resembles a *Spiroclypeus* by its distinctly involuted build. A vertical division of the alar prolongations into lateral chambers, the characteristic of the true *Spiroclypei* however could not be observed anywhere. We are probably dealing with a *H. borneënsis* Van der Vlerk, a species which was also found on Borneo in deposits of the Tertiary-e age (that is of the same age as the heterogenous limestone O. S. 357 and 534). Probably it lies therefore in its primary deposit and has not been washed in simultaneously with the *Camerinae* which are

found in it. The *Heterostegina* of O. S. 534 has large chamberlets and the whole equatorial layer corresponds well with the reproduction which VAN DER VLERK gives of *H. borneënsis* (1929, fig. 25a). The large initial chamber is succeeded by a kidney-shaped second chamber, and in one of the sections of the rock it could be observed that the first three sickle-shaped chambers are not yet sub-divided into chamberlets. The fossil probably possesses a large central tubercle, while in the later formed parts of the test also well developed columns are found.

It is remarkable that this *Heterostegina* is here accompanied by a small *Lepidocyclina* which (with some reservations) I have determined as *L. isolepidinoides* Van der Vlerk. In the original locality, S. Oema, N. E. Borneo, these two foraminifera were found, which VAN DER VLERK regards as guiding fossils for the very oldest parts of Tertiary-e (1929, p.8).

FAMILY ORBITOIDIDAE

Genus Discocyclina sensu lato

The genus *Discocyclina* s. lat. is found in many lower tertiary deposits on Soemba. The *Discocyclinae* are comparatively few in number in the marls and marly limestones of Tertiary-a, where they only form an important part of the rock in O. S. 511 and 514. In Tertiary-b there are innumerable representatives of the genus both in the lime-sandstones and the deposits of the reef facies. Both stages are rich in species. The size of these foraminifera differ greatly; to the larger species belong *D. javana* Verbeek and the somewhat smaller species from O. S. 316; various species from 6—10 mm. are very general, while the ground mass of the rock of Tertiary-b often contains numerous *Discocyclinae* of scarcely 3 mm. in diameter.

The rocks from which fossils could be prepared out, are never washable marls, but generally more or less coarse grained lime-sandstones. The specimens obtained from these rocks were seldom uninjured, and in most cases grains of the rock stick so fast to the surface of the fossils, that nothing could be seen of their finer moulding. I shall therefore confine myself to the description of a few forms, which were detached by natural influences from the matrix in which they had been imbedded or which in slides, or on polished surfaces of the samples, could easily be recognised by striking characteristics.

1. Discocyclina s. str.

Discocyclina javana Verbeek

1875 Orbitoides discus, Verbeek – Geol. beschrijving der distrikten Riam-Kiwa en Kanan, Z. en O. afd. van Borneo, Jaarb. Mijnw. 1875, dl. I, p. 119.

1880 Orb. papyracea var. nov., Verbeek – Tertiärformation von Sumatra, I Theil, Palaeontographica, Suppl. III, Lfg. 8, p. 24 (Java).

1881 Orb. dispansa, Martin – Tertiär von Ost-Java, Samml. des geol. Reichsmus. in Leiden, Ser. I, Bd. I, p. 112, Pl. VI, fig. 1—2.

1891 Orb. papyracea var. javana, Verbeek – Voorl. Bericht over Num., Orb. en Alveolinen van Java, Natuurk. Tijdschrift voor Ned. Oost-Indië, Dl. LI, 1892, p. 107, 119; fig. 8.

1896 Orb. papyracea var. javana, Verbeek – Geol. Beschr. van Java en Madoera, p. 1124, 1127, Pl. IX, fig. 144—147, Pl. X, fig. 155—157.

Orb. papyracea var. javana minor – ibid., p. 1119, 1127, Pl. IX, fig. 136—137, Pl. X, fig. 150—151.

1900 Orb. dispansa, Martin – Die Eintheilung der Versteinerungsführenden Sedimente von Java, Samml. des geol. Reichsmus. in Leiden, Ser. I, Bd. VI, p. 209.

? 1903 Orthophragmina dispansa (forma B), Schlumberger – Troisième note sur les Orbitoides, Bull. Soc. géol. de France, Sér. IV, Tome 3, p. 286, Pl. XII, fig. 51—52.

? 1905 Orth. javana, Douvillé – Quelques Foraminifères dans le Tertiaire de Bornéo, Bull. Soc. géol. de France, Sér. IV, Tome 5, p. 440.

non 1905 Orth. javana, minor, Deprat – Les Dépôts éocènes néocalédoniens, Bull. Soc. géol. de France, Sér. IV, Tome 5, p. 502, Pl. XVII, fig. 13—14.

? 1912 Orth. javana, Douvillé – Quelques Foraminifères de Java, Samml. des geol. Reichsmus. in Leiden, Ser. I, Bd. VIII, p. 287, P. XXIII, fig. 1—2, Pl. XXIV, fig. 1.

1912 Orth. javana, Rutten – Over Orbitoiden van Soemba, Verslagen Kon. Akad. van Wetensch., Amsterdam, Dl. XXI, p. 393.

(pars ?) 1915 Orth. dispansa (forma B), Martin – Die Fauna des Obereocäns bei Nanggulan, Samml. des geol. Reichsmus. in Leiden, Neue Folge, Bd. II, Heft. V, p. 197—198, Textfig. 1.

1915 Orth. javanensis, Dollfus – Paléontologie du voyage à l'île Célébes de M. E. C. Abendanon, in: E. C. Abendanon, Geol. en geogr. doorkruisingen van Midden-Celebes, Dl. III, p. 979, Pl. IV, fig. 323 B and C.

(1915 Orth. javana, forma A, RUTTEN – Studien über Foraminiferen aus Ost-Asien, Samml. des geol. Reichsmus. in Leiden, Ser. I, Bd. X, p. 7).

? 1921 Orth. javana, YABE – Notes on some foraminiferal limestones from D. E. Borneo, Science Rep. Tôhoku Imp. Univ. Sendai, sec. series (geology), vol. V, No. 4, p. 105, Pl. XVIII, fig. 2—3.

non 1926 Discocyclina javana var. indica, NUTTALL – Larger foraminifera of the Middle- and Lower Kirthar Series of Western India, Rec. geol. Survey of India, vol. LIX, pt. I, p. 147, Pl. VII, fig. 4, 6, 7; Pl. VIII, fig. 4.

(1928 D. javana, UMBGROVE – Het genus Pellatispira in het Indo-Pacifische gebied, Wetensch. Meded. v. d. Dienst v. d. Mijnbouw, No. 10, p. 23, 24.)

(1929 D. javana, BOTHÉ – Djiwo Hills and Southern Range, Fourth Pacific Science Congress, Java 1929, Excursion Guide C_1, p. 6, 8.)

1931 D. javana, UMBGROVE – Tertiary Foraminifera, Leidsche geol. Mededeelingen, Dl. V (Feestbundel Martin), p. 80, 81.

Judging from the number of *Discocyclina javana* Verbeek recorded from all parts of the Archipelago, one would be inclined to think that this *Discocyclina* was an easily determinable species. Nothing is further from the truth. It is true that VERBEEK has given an almost complete description and good reproductions of it, but almost all other writers, in the determination of the *Discocyclinae* (as in the *Lepidocyclinae*) attach far too much importance to the size of the granulations, while neglecting VERBEEK's careful description, and various large *Discocyclinae* have been determined as *Orthophragmina javana* merely on account of this entirely inadequate distinction.

The island of Soemba yields two forms of large *Discocyclinae*, which each by itself might be determined as *D. javana*, as regards the absence of a central mamelon and the even distribution of the small columns. The great difference between them in habitus and size, however, gave rise tó a close examination of the internal characteristics, which showed that they belonged to two separate species. One of these forms I determined as *D. javana* Verbeek; the other, considering the confusion reigning in the nomenclature of the *Discocyclinae*, I prefer not to indicate by a particular species name. A description of this will be found on p. 113; a description of *D. javana* follows immediately.

From the locality O. S. 768, I received 6 *Discocyclinae* prepared out

by erosion, with a horizontal diameter of some 37—50 mm. and 6—7 mm. thick. The test, which sometimes shows a very faint vaulting in the centre, gradually decreases in thickness, towards a thin, fairly sharp edge. This periphery, from about the middle of the radius, is sometimes faintly saddle-shaped, but sometimes deeply undulated radially, which increases the appearance of thinness in the test. The surface is completely smooth, but when polished it is seen that there are innumerable regularly scattered small columns, all of equal size (about 75 μ) and as a rule only separated from eachother by one circle of lateral chambers of about 100 μ. The walls of these lateral chambers, which are about 20 μ thick, are not curved and lie radially between the columns, so that the chambers are almost triangular and the whole surface of the test is covered by symmetrical figures.

The equatorial plane is built up of rather large thin-walled chambers. The test is microspheric and in the centre lie very small, broad equatorial chambers; but even within a distance of 5 mm. from the centre some of the chambers attain a length of 150 μ, while others are not more than 100 μ long. This diversity persists up to the periphery, rows are constantly wedging out, or there are rings of 100 μ height between those of 150 μ. The chambers are usually 30—50 μ wide and their radial wall is only about 10 μ in thickness.

The vertical section also clearly reveals the delicate construction of this *Discocyclina*. The lateral chambers (of which in an individual of $7^1/_2$ mm. thickness about 95—110 lie one above the other on either side of the equaterial layer) are 25—40 μ high and are separated by very thin horizontal walls (12—16 μ). These walls are almost straight, which makes the lumina of the chambers practically rectangular. The columns in the earlier formed parts of the test seem to be much more massive than at the surface or nearer to the periphery (up to 160 μ thick) and have a tendency to divide [15]). The equatorial layer in the exact centre is extremely low (4 μ; with horizontal walls 24 μ), but the height increases constantly outwards, so that it averages 75 μ (with walls) and at the periphery is even 110 μ. The vertical walls of the equatorial chambers are slightly convex outwards, but this peculiarity is not strongly pronounced.

If these Soembanese foraminifera are compared with VERBEEK's

15) See NUTTALL's explanation of a similar phenomenon in *D. dispansa* (1926, Kirthar). Possibly in *D. javana* it should also be considered more as an irregular form of the columns than as a division.

description and reproductions of the two varieties of *Discocyclina javana* (which in all probability may be combined into one species), it can be seen that in the Soembanese form the columns are somewhat smaller, the equatorial layer somewhat higher, and the periphery more deeply undulated. But conspicuous differences are not observable, so that I feel justified in determining them as *Discocyclina javana* Verbeek. VERBEEK gives no reproduction of the exterior, which in this case is very characteristic, with its triangular lateral chambers; the drawing of the vertical section (Pl. X, fig. 151) seems to indicate that the horizontal walls of the lateral chambers in VERBEEK's specimens are also nearly straight and very thin. We may therefore, under reservation, add to VERBEEK's description our observation of the shape and wall-thickness of the lateral chambers.

If we now consider in how far the *Discocyclina javana* mentioned in the literature can be included in this species with certainty, we find that, besides VERBEEK's material, only RUTTEN's (Soemba) and DOLLFUS's (Celebes) come into consideration [16]). RUTTEN had smaller specimens to examine than I had, but otherwise it must have been precisely the same species; the megalospheric form that he found amongst them (see Samml., Bd. X, p. 7) we will for the present leave out of account.

DOLLFUS, like myself, had very large, sometimes deeply undulated specimens; the vertical sections, of which he gives reproductions, show lateral chambers with almost straight horizontal walls, which makes them practically the same as my *D. javana* from O. S. 768.

Of all the other authors it is uncertain whether they have described *Discocyclinae* which are completely identical with those from O. S. 768 (and therefore with VERBEEK's types); with some, e.g. MARTIN, there is a possibility that they have included a mixture of material under this name.

The *D. javana* from Borneo found by Yabe, corresponds in many respects, but is much smaller and belongs to a different stratigraphic stage (see below. p. 91—92).

DOUVILLÉ, in his description of the species, only notes external characteristics. The size of diameter, columns and distance of the columns, which he records in 1905, might apply to a real *D. javana*, but he says

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16) In the list of synonyms above, all articles, in which *D. javana* is simply mentioned without any further particulars, are included in brackets.

that the specimens are megalospheric [17]). Concerning his reproductions of Javanese forms in 1912 we can only say that Pl. XXIII, fig. 2 might represent a *D. javana* with the radially placed walls of the lateral chambers; the other photographs show nothing decisive whatever in this respect. Both publications contain too few data to establish the identity of the specimens.

MARTIN has made several attempts to correct the nomenclature of this *Discocyclina* which he regards as the microspheric generation of *Discocyclina dispansa* Sow. In 1900, however, he left the possibility open that there might be another large *Discocyclina* besides VERBEEK's *D. javana* which would belong as microspheric form to the megalospheric *D. "dispansa"*. In my opinion this is certainly possible: on East Soemba (O. S. 316), in company with *Nummulites djokdjokartae B* (also known from Nanggoelan), large *Discocyclinae* are found, which are not quite the same as the *D. javana* Verbeek (see below, p. 92); MARTIN gives no description or reproduction of the internal structure, but in the material from Kali Progo which is kept in Leiden, there are two microspheric forms which in my opinion are not the same, and the photographs by SCHLUMBERGER (1903), to whom a small part of the material was sent for examination, do not entirely correspond to the *Discocyclinae* from O. S. 768.

A definite decision as to the limits of the different species, however, must be postponed until an extensive specialized study of the East Indian *Discocyclinae* has given us a firmer basis on which to found our regional and stratigraphic conclusions.

Although, for the above reasons, we cannot always say with certainty which of the recorded specimens are identical with VERBEEK's *D. javana*, in some cases it can be proved that one or other of the *Discocyclinae* included in this species do not belong to it. Deprat's determination of specimens from New Caledonia as *D. javana*, for instance, is certainly not correct (at least so far as it concerns the specimens reproduced). The vertical section (Deprat, 1905, pl. XVII, fig. 13) has much more massive columns, which clearly diverge from two centres; moreover the growth lines show in the earlier parts of the shell a distinct umbilicus, which disappears at a later stage. Fig. 14 gives a horizontal section, where here and there lateral parts of the test are visible; here it may be seen

17) It does not, however, seem very probable that this should have been the case with all his specimens, the maximum diameter being 55 mm.

that the thick columns are surrounded by a circle of lateral chambers, much smaller than the pillars. Deprat himself remarks that this surface very greatly resembles *Orth. umbilicata* Deprat, from the same locality; taken in connection with the vertical section, it is more probable that in this case he has described a flat, not typically developed, *Orth. umbilicata* rather than a *D. javana* corresponding to the Java form.

NUTTALL's *D. javana var. indica* has also probably nothing to do with the Java species. It is a smaller form with rather highly arched centre and sharp edge, bearing in this respect much similarity to the Orbitoids described as immature forms of *D. javana;* but the equatorial chambers are only 60 × 30 μ and moreover the columns are rather more distinctly developed.

DISCOCYCLINA JAVANA VERBEEK

SMALL FORM

Cf. Orth. javana, YABE – Note on some eocene foraminifera, Science Rep. Tôhoku Imp. Univ. Sendai, Sec. Series, Vol. 5, No. 4, p. 105, Pl. XVIII, fig. 2 and 3.

The marl from O. S. 62 yields one specimen of a small microspheric *Discocyclina* which shows no reliable characteristics to distinguish it from *D. javana*, and which I will therefore discuss under that name. The specimen does not correspond to VERBEEK's description of an immature form of *D. javana*, viz. a thick lenticular test with a thin edge which approaches to *D. dispansa*, this specimen being very flat and deeply undulated with no inflation in the centre. The horizontal diameter is fully 10 mm. The pillar-heads which are spread over the entire surface are some 90 μ thick, the lateral chambers (like the larger forms from O. S. 768) are almost triangular with a diameter of 90—100 μ. Each pillar is surrounded by a single circle of lateral chambers.

The median chambers have very thin radial walls (about 10 μ) but their lumina are smaller than those of the above described large *D. javana*, viz. 75—120 μ. It should, however, be remembered, that these measurements apply here to chambers within a distance of 5 mm. from the centre.

Nothing is known to me of the vertical section.

This small form seems to me to correspond exactly to Yabe's *Orthophragmina javana* from E. Borneo. If this is really the case, there would be another important correspondence to record, that they are both

found in company with *Assilinae* (and probably with the same two species of *Assilina*). Caution should therefore be observed in associating this *Discocyclina* with the large *D. javana*, which is never found together with *Assilinae* and may be confined to a higher niveau. On the other hand, the small microspheric form from O. S. 62 is accompanied by a few megalospheric specimens, which have a great resemblance to the *D. dispansa* from the Nanggoelan beds (see below p. 95). Difference in the facies and other external factors may also have influenced the growth of the test.

Discocyclina nov. spec. (?) Forma B

The locality O. S. 316 yields some fossils that have been washed out of the Lower Tertiary section of the Watoe Moendoe. Besides some specimens of *Camerina djokdjokartae* (forma B) a lenticular *Discocyclina* was found. The measurements of the 6 specimens that I had for examination are:

Horizontal diameter	$23^1/_2$	25	24	19	21	24	mm.
Thickness	$5^1/_2$	5	$5^1/_2$	4	$5^1/_2$	$5^1/_2$	mm.

The test is evenly vaulted, without umbo or thin rim and is often curved into a saddle-shape. The surface was quite smooth in most of the specimens, but a superficial tangential section revealed closely set pillars of 90 μ distributed over the entire test, separated by 1—2 circles of very irregular lateral chambers. The walls of these chambers are about 30 μ thick, they run quite irregularly and are often curved. This gives the lumina of the chambers often an elongated reniform appearance (see text fig. 20), making the size very variable. The maximum is 150 μ measured lengthwise; usually they are much smaller. The chambers, in deeper tangential sections are shown to remain completely irregular up to the equatorial layer (compare *D. dispansa*).

The equatorial chambers are as usual close to the nucleoconch wider than they are long, but within $^1/_2$ mm. from the centre the length already exceeds the width. At a radius of 5 mm. they are (with wall) 90—100 μ long and 30—45 μ wide. These measurements also apply to the later rings, except that right at the edge the length may be as much as 150 μ (especially with irregularities in growth). The median chambers of this *Discocyclina* are therefore on an average shorter than in *D. javana* Verbeek and moreover they have much thicker walls, the thickness of the radial wall being here 20—30 μ.

The vertical section, also, shows probably constant deviations from the *D. javana* from O. S. 768. The median layer is low, the wall being 30 μ in the centre, at the periphery increasing to some 100 μ, the average being 60 μ. A remarkable phenomenon is that the vertical walls of the median chambers, in this section, are much curved outwards, especially in the latest parts of the test. Taken in combination with the lateral-chamber walls attached to them, this growth gives some resemblance to a *Camerina*. In a total height of the shell of $5^1/_2$ mm. there are about 70—80 lateral chambers in a vertical pile. These chambers are rather low and thick-walled. As a rule the height of the lumina is about 30—40 μ (sometimes less; occasionally 45 μ), while the horizontal walls in one specimen are 20—25 μ thick, and in another 12—25 μ (average 16 μ). In the first, thick-walled specimen all the walls are more or less convex towards the exterior, so that the lumina are somewhat rounded in form; in the second individual this peculiarity is not so pronounced and there are chambers with almost straight horizontal walls as well as with curved ones.

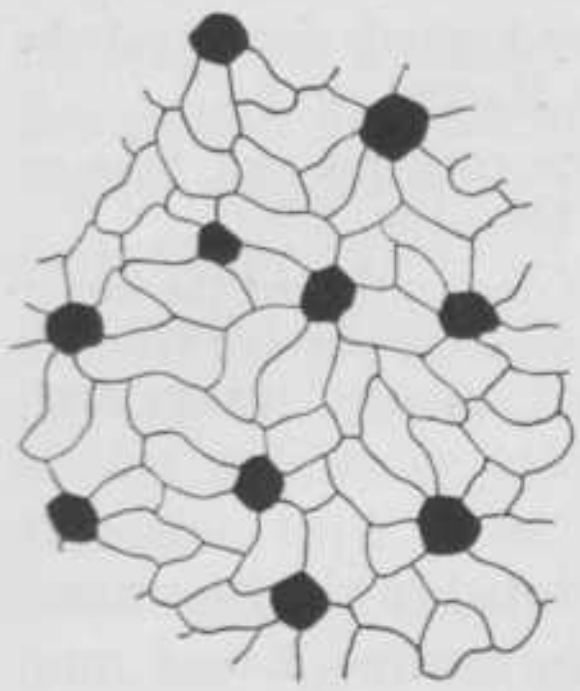

Fig. 20.

Amongst the *Discocyclinae* described from Netherlands India there is none that I could directly compare to this, with its peculiar irregular lateral chambers and its thick-walled median chambers. Therefore, for the present, I regard it as a separate species. I wish only to point out that in MARTIN's material from Kali Progo I found a microspheric specimen with exactly the same irregularity in the shape of the chambers, while DOUVILLÉ (1912, Java, Pl. XXIII, fig. 3) gives a reproduction of a megalospheric form with similarly built chambers. Soemba itself also yields similar megalospheric forms, but from a lower stratigraphic niveau (O. S. 62, Tert.-a_2).

DISCOCYCLINA "DISPANSA" (SOWERBY)

Bibliography:

D. dispansa and D. decipiens, UMBGROVE – Tertiary Foraminifera, Leidsche geologische Meded., dl. V, 1931, (Feestbundel Martin), p. 65.

Orbitoides dispansa, VERBEEK – Geol. en geogr. Beschrijving van Java en Madoera, 1896, p. 1125, 1127, fig. 148—149, 158—160.

D. dispansa, NUTTALL – The zonal distribution and description of the larger Foraminifera of the Middle and Lower Kirthar Series of parts of Western India, Rec. Geol. Surv. of India, Vol. LIX, Pt. I, 1926, p. 145, Pl. VII, fig. 1, 2, 3 and 5.

As typical for this "species" we repeatedly see noted in the literature: Test up to 10 mm. in diameter, well arched in centre (3 to 4 mm. thick), decreasing in thickness towards the periphery to an extremely thin edge. Pillars distributed over the whole surface, but more strongly developed in the centre. Nucleoconch megalospheric.

In the East Indian Archipelago, *Discocyclinae* have been collected from various localities, which answer to this description, and which therefore have been almost all included in SOWERBY's species. DOUVILLÉ was the only one who distinguished two species in the very rich and well preserved material from Nanggoelan, to one of which he left the name of *Orthophragmina dispansa*, while he identified the other with *Orthophragmina decipiens* v. Fritsch. MARTIN (1915), very rightly, made objection to this determination, as DOUVILLÉ there identified a megalospheric form with massive pillars with the large *Orth. decipiens* which probably has only slightly developed pillars and possesses an extremely small nucleoconch (forma B ?). MARTIN further makes an effort to clear up the whole confusion between *D. dispansa, decipiens* and *javana*, by combining in one species all specimens from the Nanggoelan beds (formae A and B from the different beds and from different localities) into one species which he called *O. dispansa*. SCHLUMBERGER, also, regarded forma A and forma B from Nanggoelan (Kali Progo, from which a small amount of material was sent him) as one species, *O. dispansa* (1903). NUTTALL, on the other hand, collected new material from one of the original localities of Sowerby's *Lycophris dispansus* in British India, and came to the conclusion that none of the materials from the East Indian Archipelago could be identified with *D. dispansa* (1926, Kirthar). VAN DER VLERK (1928), again, identified a *Discocyclina* from N. E. Borneo with *D. dispansa* as redescribed and re-illustrated by NUTTALL.

In my opinion it is impossible to make an end of the series of con-

fusions and erroneous interpretations, of which the literature on these *Discocyclinae* is full, without a renewed and very minute study of the original material from Nanggoelan. The discovery of two different microspheric *Discocyclinae* on Soemba, which both might fall under the description of VERBEEK's *D. javana*, and both of which, moreover, I believe to have recognised in the material from Kali Progo [18]) in Leiden, makes it probable that in megalospheric forms too there will be distinctly observable differences. It seems to me even possible that in Nanggoelan more than two species occur, viz. one species with a small number of almost triangular lateral chambers round each pillar ("*O. dispansa*", Douvillé, 1912, Java, Pl. XXIII, fig. 3), one with a large number of small rounded chambers round the pillars in the centre ("*O. decipiens*" ibid., fig. 4 and 5), and one with very irregular elongated to reniform lateral chambers, especially in the central part ("*O. decipiens*" ibid., fig. 6) [19]). Moreover it is not absolutely proved that VERBEEK's *D. javana* must necessarily be the microspheric form of MARTIN's *D. dispansa*: both DOUVILLÉ (1905) and RUTTEN (1912, 1915) found "megalospheric forms of *Orth. javana*" which they kept apart from *Orth. dispansa*. Decisions about the nomenclature must therefore be postponed until a thorough study has been made of all the forms of *Discocyclina* which occur in the East Indies.

The only prepared out Soembanese *Discocyclinae* of this "*dispansa* type" are 3 specimens from the marl O. S. 62 coming, therefore (together with *Assilinae* and flosculinised Fasciolites ovicula NUTTALL) from an earlier deposit than that of Nanggoelan. They closely resemble the *Discocyclinae* from the last named locality and can probably not be distinguished from them. Their horizontal diameter is 10, $8^1/_2$ and $5^3/_4$ mm. respectively, the thickness about 3 mm. The whole surface is covered with evenly distributed granulations of about 90—150 μ, which do not increase much in thickness towards the centre. In the two largest specimens the external surface is not well preserved; as far as could be seen the lateral chambers are 100—150 μ large and are only slightly elongated to kidney-shaped. The smallest specimen, on the other hand, shows very

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18) In any case this material contains two different kinds of forma B; one very large specimen with delicate pillars and small lateral chambers, and one smaller specimen with larger, irregular, very clearly kidney-shaped lateral chambers.

19) It should here be specially pointed out, however, that I have only superficially examined the material from K. Poeroe and K. Progo (Nanggoelan) as an extensive study is outside the scope of the present work.

distinctly large kidney-shaped lateral chambers of 150—240 μ, in which it completely corresponds to DOUVILLÉ's fig. 6 (loc. cit.). It is remarkable that this irregular form only seems to exist in the latest layers of lateral chambers, and therefore can only be seen well on the exterior and in a superficial tangential section. In the deeper layers, more triangular chambers are found in the centre so that it presents almost the regularity of a superficial section of *D. javana*.

The specimen of $8^1/_2$ mm. was cut in half; the one half was made into a horizontal preparation, the other gave a vertical section. The place of the nucleoconch, which must have been rather low, as is usual in these *Discocyclinae*, was replaced by an irregular cavity, without a proper wall, caused by erosion. The median chambers are small (max. 75 μ) and relatively wide, their radial wall is about 10—12 μ thick. The vertical section is exactly the same as the drawing that VERBEEK gives of *O. dispansa* in his "Beschrijving van Java en Madoera". The median layer is very shallow and is covered on both sides by about 40 thin-walled, rounded lateral chambers. These chambers are 40—50 μ high, and their horizontal walls are only 10—12 μ thick.

These megalospheric *Discocyclinae* were found in company with the small form of *D. javana* (see p. 91). They are perhaps related to *D. undulata* Nuttall, which is known from the Middle Kirthar Series of Western India (Nuttall, 1926, Kirthar, p. 150, Pl. VIII, fig. 5), but they are certainly not identical with it.

2. Asterocyclina

The *Asterocyclinae*, like the *Discocyclinae*, are imbedded in rather hard rock from which they could not be got out uninjured and with a well preserved exterior. It was only in a few specimens that the star-shape could be recognized externally, and as a rule the radial plan could not be seen until a horizontal section had been made. The material is therefore not suitable for a thorough study of the genus, so we shall here confine ourselves to a description of one species, which is found fairly generally in the neighbourhood of Lalokoe.

Asterocyclina aff. pentagonalis Deprat

Pl. III, fig. 1 and 9

Cf. 1905 Orthophragmina pentagonalis, Deprat – Les dépôts éocènes néo-calédoniens, Bull. soc. géol. de France, sér. IV, T. 5, p. 507, Pl. XVIII, fig. 24, 25; Pl. XIX, fig. 27.

The diameter of this fossil varies from 4 to 6 mm. and the thickness is about $1^1/_2$ mm. The centre is only faintly inflated and the collar sometimes has indistinct radiating elevations. The surface is covered by a net-work of lateral chambers, which are 90—100 μ in diameter, except close to the centre, where they are somewhat smaller. The specimens of O. S. 114 are entirely deficient in pillars, on the other hand in those of O. S. 256, which in other respects cannot be distinguished from them, the walls in the central part are thickened at every angle, a thickening which sometimes develops into pillars of max. 100 μ thickness.

The construction of the equatorial layer is seen in the reproduction (fig. 1, 4). The chambers are unusually variable, both in shape and size. There are 4—6 rays, which begin narrow and only at the margin broaden out in a fan-shape. These rays are composed entirely of elongated chambers. In the interradial field, especially near the centre, there are very shallow rows in which the chambers are almost square (minimum about 25 μ), and which in the latest formed part of the test are often compensated by rows of extremely long chambers (180 $\times$ 36 μ). Sometimes one chamber in the radius corresponds to two rings of smaller chambers in the inter-radius. The embryonic apparatus is about 350 μ in diameter, and consists of 2 chambers, which practically do not embrace eachother and are surrounded by an almost closed regular polygonal ring of a few very low chambers. The rays run out from the angles of these chambers, one of the rays always runs in the direction of the axis of symmetry of the embryonic apparatus, on the side of the largest (second) chamber. This nucleoconch and the polygonal ring have fairly thick walls (about 20 μ), while the equatorial chambers are very thin-walled.

In the largest (reproduced) specimen of my material it often occurs that the radial septa of the median chambers are not fully developed; it is remarkable that it is almost always the proximal portion of the septa that is absent. This gives the impression that in the growth of this *Asterocyclina*, and probably in the Orbitoids in general, first the tangential wall calcifies and then the radial divisions from without, inwards.

In the vertical section the median layer is everywhere about 40 μ. The aequatorial chambers embrace one another to some extent. On both sides of this layer lie about 17 lateral chambers, the lumina of which are about 25 μ high. The lateral chambers seem to accompany the median layer up to the edge.

The material is insufficient for an exact determination of species. The peculiar embryonic apparatus is very similar to *A. pentagonalis* Deprat from New Caledonia, but in that species the circular chamber entirely surrounds the nucleoconch, and is no longer subdivided. Moreover *A. pentagonalis* is much smaller, and the median layer seems to be more regularly built and to have thicker walls. The vertical section of the Soembanese fossil greatly resembles Deprat's species, especially in the reproduction Pl. V, fig. 25 (1905) except that the pillars are much less developed.

Considering all these differences, I think it is better not to identify the form from Soemba with *A. pentagonalis*.

Regarding the *Asterocyclina* here examined the following observations should be made:

besides elongated and short rectangular chambers which were in far the greater majority, distinctly hexagonal chambers were observed. On this ground, the Orbitoid might be assigned to the genus *Orthocyclina* Van der Vlerk: but for the present I regard it as an Asterocyclina, for the following reasons:

1st the rectangular shape of chambers in foraminifera is probably never primary, (thin-walled *Cycloclypei* usually have clearly hexagonal chambers: in *Discocyclinae* s. lat. it is repeatedly observed that the ring-shaped walls are extra thickened.) The hexagonal chambers in this *Asterocyclina* are confined to the interradial fields, where the walls are conspiciously thinner than in the radiants, it may therefore be supposed that they have retained their primitive form through the absence of secondary wall-thickening.

2nd it is a question whether the occurrence of hexagonal chambers is really such an exceptional phenomenon in an *Asterocyclina* (cf. Deprat, 1905, Pl. XIX, fig. 29, *A. cf. lanceolata*). This can only be decided by the examination of good and ample material.

3rd the same rocks from Lalokoe contain an even smaller Orbitoid, which is undoubtedly an *Orthocyclina*, and in comparison with which

the *Discocyclina*-like qualities of this *Asterocyclina* are seen to predominate.

Locality: O. S. 114, 152, 256; W. S. 417?, 418?
Age: Tertiary-b.

Genus Orthocyclina

The definition that VAN DER VLERK gave of this genus is: "this genus name may be given to the foraminifera from the family of the *Orbitoididae* in which the median chambers in horizontal section are partly pure rectangular (and even usually almost exactly square) and partly hexagonal-rounded" (1923, p. 93).

After what has been said above regarding the Soembanese *Asterocyclina*, I wish to lay special stress upon the words "usually almost exactly square" in this definition. In comparing our Pl. III, fig. 9 with the reproduction that VAN DER VLERK gives of *Orthocyclina soeroeanensis*, het difference between the equatorial layer of this species and that of the *Asterocyclina* is very clearly seen. The latter, even within a radius of $1^1/_4$ mm., has, both in radius and interradius, numerous elongated chambers beside the almost isodiametric ones, while in the *Orthocyclina* the chambers, even in the radius, are never much longer than they are broad and in the greatest number the tangential and radial measurements are about the same.

In this respect a very small Orbitoid from the Soembanese collection belongs to the *Orthocyclinae*, a description of which follows:

ORTHOCYCLINA SPEC. INDET.

Pl. III, fig. 2 and 3

The horizontal diameter of this fossil, which is fairly frequent in the lime-sandstones near Lalokoe, is max. 2—$2^1/_2$ mm. The circumference in uninjured state is probably clearly polygonal, while on the surface radiating elevations were observed. The lateral chambers are at most 75 μ in size, usually not more than 40—50 μ. In the centre relatively thick pillars are developed (max. 90 μ in tangential section).

The equatorial layer is also much more delicately built than in the *Asterocyclinae* from this rock. The chambers are about 30 μ wide and at most 60—70 μ long; they are arranged in polygons, the angles of which are connected with the embryonic apparatus by 6 distinct rays. The

nucleoconch is about 240 μ in diameter, it consists of a round initial chamber, a much larger 2nd chamber and sometimes there are some large rounded chambers surrounding it. These may form a complete ring, but in other specimens there are only a few scattered about against both embryonic chambers. The 2nd chamber of the nucleoconch is large and irregular and, especially when the extra chambers are absent, may surround the initial chamber to a large extent (like the trybliolepidine type in the *Lepidocyclinae*). The wall of the nucleoconch is 15—20 μ thick, the ordinary median chambers have an extremely thin wall (about 4 μ). It is perhaps in connection with this (see above p. 98) that the shape of these chambers is preponderately hexagonal; rectangular chambers are found only in the rays and quite at the edge.

I know nothing with certainty of the vertical section, as I did not have a single well authenticated section. Possibly a vertical cut specimen found by chance in a slide of the rock belongs to this species, which was distinguished from all other *Discocyclinae* known to me by its very loose structure. On either side of the median layer there lie about 9 lateral chambers, of which the highest is max. 30 μ, and the thickness of the horizontal wall about 10 μ.

This *Orthocyclina* greatly resembles *O. soeroeanensis* Van der Vlerk, but deviates from it by a much larger nucleoconch, thinner median chamber walls, rather broader rays, and by having pillars. For the present we will give no further determination.

Locality: O. S. 110, 114, 146, 147, 310?, 311?; W.S. 418?
Age: Tertiary-b (and perhaps Tert.-a).

Genus Lepidocyclina

Almost all the harder limestone beds of the Upper Tertiary on Soemba are principally composed of *Lepidocyclinae;* in the washable deposits these foraminifera are much more rare and were only found in any quantity in the coarsest marly tuffs (O. S. 327; O. S. 537). In the finer marls they sometimes occur sporadically, but only as very small individuals (*L. parva, L. Martini*), this providing a good example of how the occurrence of benthonic foraminifera may be dependant upon the milieu in which the sedimentation has taken place.

Eulepidinae could not be prepared out from any of the samples, and so were not further studied except in one case. This exception is the

Lepidocyclina from O.S. 47 and O.S. 285, which, being found in Tertiary-d is of special interest in Soemba as well as in the archipelago in general, and to which we shall therefore devote a brief discussion. The other *Lepidocyclinae* described here all have a different type of nucleoconch (nephrolepidine, trybliolepidine and pliolepidine) and belong to smaller and later species. One microspheric form will also be described.

There is one striking peculiarity, for which I can find no explanation, that must be mentioned here, namely that in the whole of East Soemba there is a remarkable scarcity of microspheric *Lepidocyclinae*. O. S. 537 yielded one specimen of *L. glabra;* beyond this no single microspheric form was found in the washable samples. In the slides, too, it was only quite occasionally that a microspheric form could be recognised (O. S. 285, 329, 379, 542, 544, 549); most of the larger individuals in these accidental sections are coarsely built with a high median layer and coarse perforations between the median chambers, and are probably tangentially or obliquely cut megalospheric *Eulepidinae*.

Lepidocyclina (Eulepidina) tjendanensis spec. nov.
Pl. III, fig. 5—7

In 1925 van der Vlerk gave an account of the stratigraphy of the Tertiary of East Borneo (Tidoengsche Landen). Here we see that the *Lepidocyclinae* first make their appearance in the Tempilan-beds, where they are found together with the last *Camerinae*.

The species by which the genus *Lepidocyclina* is represented in the Tempilan-beds (= Tertiary-d) are, according to this table: *L. papuaensis* Chapm. and *L. dilatata* Mich. The *L. papuaensis* was determined by van der Vlerk himself in a sample from Sg. Mesaloi; the determination of the *L. dilatata* by Douvillé appears to be incorrect and has been constantly changed. Originally Douvillé did not give a specific name to this *Lepidocyclina* found in limestones from Rantau Boedjoer and Wajau (S. E. Borneo) but he considered them to be about equal to a *Lepidocyclina* in an overlying bed, which he determined as *L. formosa* Schlumb. (1905, p. 443—445); it is probably a generally saddle-shaped, columnless *Lepidocyclina* with small, regular median chambers. In 1908 (see Verbeek: Molukken-verslag, Jaarb. Mijnw., p. 692—693), he changed the name to *L. dilatata*, and finally this name was abandoned by van der Vlerk (1928), at any rate in his stratigraphic notations. Here van der Vlerk gives only Tertiary-e as stratigraphic distribution of *L. dilatata*

Mich., while amongst the localities for this species the place in Borneo is no longer mentioned [20]).

On the other hand, the occurrence of *L. papuaensis* Chapm. in Tertiary-d is constantly confirmed by VAN DER VLERK (1928, p. 28; 1929, p. 22; 1931, Feestbundel MARTIN, p. 626). Not only is this species never found in a higher niveau, so that it may be regarded as a good index fossil for Tertiary-d, but it is moreover (besides *Isolepidina boetonensis* Van der Vlerk, which was once found in company with *Camerina*) the only *Lepidocyclina* which is recorded from deposits of his age. It might be concluded from this that *L. papuaensis* is the only forerunner of the numerous *Eulepidinae* which appear in Tertiary-e. But this conclusion would be incorrect. In the first place the *Lepidocyclina* mentioned by DOUVILLÉ cannot be brought under this species, in the second place the original *L. papuaensis* of CHAPMAN was found together with two other species of *Lepidocyclina* and in the third place the *Lepidocyclinae* which are found in Soemba in company with *Camerina Fichteli*, do not belong to *L. papuaensis* Chapm. [21]).

It seems clear, therefore, that besides *L. papuaensis* (and *L. boetonensis*) there must have been other Lepidocyclinae in Tertiary-d.

On E. Soemba only two samples were found belonging with certainty to Tertiary-d, O. S. 47 and O. S. 285.

O. S. 47 is chiefly composed of *Camerina Fichteli* (formae A and B) and contains comparatively few *Lepidocyclinae*. There was one megalospheric specimen of these Lepidocyclinae, precisely in vertical section, on a polished surface. This individual is 14 mm. in diameter, and 1.5 mm. thick. The nucleoconch is flattened, and very large, in this section about 1700 μ. The number of lateral chambers on either side of the nucleoconch is 12; these chambers are about 20 μ high and are separated by horizontal walls of some 20 μ thickness. Pillars were not observed, neither were they found in specimens in other accidentel sections of the rock.

In contrast to this sample, in O. S. 285 the *Lepidocyclinae* are in the

20) In Western India and Persia *L. dilatata* was found associated with *Camerina intermedia* (see NUTTALL 1926, Three species of Lepidocyclines from Western India and Persia, p. 332).

21) The statement by TAN SIN HOK (1932, p. 47, table VI) that *Nephrolepidina isolepidinoides* Van der Vlerk is found with *Camerina Fichteli* in marls collected along the Tjiapoes, S. Bantam, Java, we will not discuss here. The matter is of too great stratigraphic importance to be only casually mentioned, as TAN does, and must first be thoroughly investigated. The possibility that these Camerinae have been derived from older deposits must not be neglected.

majority; it is a true Lepidocyclina lumachelle, in which only here and there a few *Camerinae* are found. Most of the *Lepidocyclinae* are microspheric, but megalospheric specimens are not rare. Those of forma B are very large; they may attain to a diameter of 40 mm. with relatively very little thickness (1—$1^1/_2$ mm., max. 3.75 mm. in the central knob). They have a very small, scarcely protruding central knob and the test is quite flat or slightly undulated. The surface of most of the specimens in this rock is smooth and structureless; in a few specimens erosion has laid bare the lateral chambers. These lateral chambers, with a diameter of 150—200 μ, and walls of about 20 μ, are all rounded polygonal in shape and are joined together irregularly. In vertical section some 38 can be seen one above the other. The lumina close to the surface in the middle of the shell are 20—40 μ high and the horizontal walls are 15—20 μ thick. In this section, in the oldest portion of the test, pillars can be seen, which, however, do not reach the surface so that there are absolutely no granulations, not even in the umbo. The megalospheric form is much smaller (12—14 mm.) and has a nucleoconch of about 1200—1700 μ. It is remarkable that this nucleoconch in horizontal section is sometimes of exactly the same nephrolepidina-like type as VAN DER VLERK found in *L. papuaensis* (1925, fig. 25; 1928, fig. 7a; 1929, p. 22). The arrangement of the median chambers as far as could be seen both in the megalospheric and the microspheric generation is in circles, at any rate not in polygons. In vertical section 10—12 lateral chambers can be seen one above the other, of which the lumina are 20—25 μ high, the horizontal walls being 15—20 μ thick. This megalospheric form has no columns whatever.

Probably the *Lepidocyclina* from O.S. 47 and those from O. S. 285 belong to the same species. This species, which I cannot identify with any known species, and to which I should like to give the name of *L. tjendanensis* (after Tjendana = Soemba) resembles in some respects *L. papuaensis*, in others *L. dilatata* (to which the vertical section shows at first sight a great similarity, cf. VAN DER VLERK 1929, fig. 39b); but both these species show distinct columns at the surface. This *Lepidocyclina* differs moreover from *L. papuaensis* by its larger diameter, flatter shape, the smaller number of lateral chambers in vertical section and above all by the smaller height of the lateral chambers. The principal difference from *L. dilatata* consists in the shape of the lateral chambers at the surface: *L. dilatata* has very irregular, rounded, often oblong lateral chambers with thick somewhat meandering walls, the *Lepidocyclina* from Soemba has comparatively regular, thin walled polygonal chambers. Moreover the height of the lateral chambers is also too small

for *L. dilatata*. Amongst the pillar-less *Eulepidinae* the only ones that could be compared with this, are *L. formosa* Schlumb. and *L. planata* Opp. *L. formosa*, however, has too high and too numerous lateral chambers and moreover its vertical walls are too thick; *L. planata* gives quite a different general impression and according to VAN DER VLERK's table (1928) its lateral chambers are about three times too high.

It cannot be ascertained whether our species is the same as DOUVILLÉ's *Lepidocyclina* from the Tempilan beds; but we can say at any rate that in the material from Soemba no saddle-shaped specimens were found.

LEPIDOCYCLINA PARVA OPPENOORTH

1918 Lepidocyclina parva, OPPENOORTH – Foraminiferen van de Noordkust van Atjeh, Verh. Geol. Mijnbouwk. Gen. v. Ned. en Kol., geol. serie, dl. 2, p. 255, Pl. 8, fig. 11—12, Pl. 9, fig. 9.

1928 Lepidocyclina parva, VAN DER VLERK – Het genus Lepidocyclina in het Indopacifische Gebied, Wetensch. Meded. v. d. Dienst v. d. Mijnbouw in Ned.-Indië, No. 8, p. 28, fig. 24a—b.

1929 Lepidocyclina parva, VAN DER VLERK – Groote foraminiferen van N.O-Borneo, Wetensch. Meded. v. d. Dienst v. d. Mijnbouw in Ned.-Indië, No. 9, p. 24, fig. 22, 47a—b.

Excellent reproductions of this species were given by VAN DER VLERK in 1929, both as regards the external habitus and the internal structure. The specimens from Soemba conform to these exactly. *Lepidocyclina parva* is a small *Lepidocyclina*, which is characterised by the generally rhomboid form of the median chambers. This form gives the median layer the appearance of being composed of chambers arranged in a fan-shape, a characteristic which *L. parva* shares with *L. atjehensis* Opp., *L. isolepidinoides* Van der Vlerk and the *Lepidocyclinae* of the *sumatrensis*-group, and which distinguishes it from *L. Martini*, the small unradiated forms of which sometimes look exactly like *L. parva*.

L. parva was found on Soemba with certainty in the marl O. S. 327; but it is rare. The horizontal diameter of these specimens is 1—$1^1/_4$ mm. and the thickness about $^3/_4$ mm. The embryonic apparatus is very small, about 170—210 μ and is nephrolepidine; in one of the specimens the second chamber embraces the initial chamber so slightly that it approaches the isolepidine type. The wall is 20—30 μ thick. The median chambers, the walls of which are some 15 μ thick, are about 30—45 μ long (at the periphery up to 60 μ). The vertical section is less pointed at the edge than

in *L. Martini* and is slightly heavier in build. There are 6—8 lateral chambers one above the other, of which the lumen is 45 μ high, while the horizontal walls are about 12 μ thick (never thinner than 10 μ). The median layer is everywhere about 60 μ high (with wall).

Locality: O.S. 327, 537, and some other marl samples.
L. parva, here as on N. E. Borneo, is found in Tertiary-f.

Lepidocyclina Ferreroi Provale

1909 L. Ferreroi, Provale – Di alcune Nummulitine e Orbitoidine dell' isola di Borneo, Riv. Ital. di Paleontologia, Anno 15, p. 70, Pl. II, fig. 7—13.

1911 L. polygona, Rutten – Over Orbitoiden uit de omgeving der Balik Papan-baai, Verslagen Koninkl. Akad. v. Wetensch. te Amsterdam, Wis- en Natuurk. Afd., p. 1155.

1914 L. Ferreroi, Rutten – Studien über Foraminiferen aus Ost-Asien, Samml. des geol. Reichsmuseums in Leiden, Serie I, Bd. IX, p. 293, Pl. XXII, fig. 2—5 (non fig. 1).

1922 L. Ferreroi, van der Vlerk – Studiën over Nummulinidae en Alveolinidae, Verh. Geol. Mijnb. Genootsch. v. Nederland en Kol., Geol. Serie, Dl. V, p. 253, Pl. I, fig. 5 (?).

1928 L. Ferreroi, van der Vlerk – Het genus Lepidocyclina in het Indo-pacifische gebied, Wetensch. Meded. v. d. Dienst v. d. Mijnbouw in Ned.-Indië, No. 8, p. 20, fig. 20a—c.

1931 L. Ferreroi, Caudri – De Foraminiferen-fauna van eenige Cyclo-clypeus-houdende gesteenten van Java, Verh. Geol. Mijnb. Genootschap v. Nederland en Kol., Geol. Serie, Dl. IX, p. 173, 174.

? 1931 L. Ferreroi, Hanzawa – Tertiary foraminiferous Rocks from the Kwantô Mountainland, Science Rep. Tôhoku Imp. Univ., Sec. Series (Geology), Vol. XII, No. 2, p. 153, Pl. XXIV, fig. 8.

Further synonyma (not checked) are to be found in the publications of van der Vlerk (1922, 1928) and in: Umbgrove – Tertiary Foraminifera, Leidsche geol. Mededeelingen, Dl. V (Feestbundel Martin), p. 68.

This peculiar species was represented in O. S. 327 by numerous specimens which displayed a remarkable variety in their exterior form and the position of the columns. All these different forms may be arranged in a continuous series of gradually transmitting terms, so that there is no necessity to divide them into separate species.

At the beginning of the series are forms of the stellariform outline, typical for *Lepidocyclina Ferreroi;* the very broad column-heads (up to 900 μ diam.) lie in the points of the star, sometimes standing so far from

the central portion of the shell, that the last, in individuals with 4 pillars, acquires the shape of a cross. The number of columns is variable. There is no flange whatever.

Throughout the whole series the columns become smaller (down to some 500 μ diam.) and move more and more towards the centre. The number of columns remains inconstant; while in some individuals there are only 3 columns, there are occasionally a great many more than are usual in *Lepidocyclina Ferreroi* (as many as 7). In the last case especially, the columns often combine into an umbo. This makes the test thicker and thicker in the centre while the points in the circumference become less distinct, the outline being polygonal. The edge is sometimes surrounded by a thin narrow flange.

The series is terminated by almost globular individuals, measured through the column heads the proportion of diameter to thickness is: 1.8 by 1. The columns are usually numerous (in one specimen even 10, see below), are about 500 μ in diameter and in the centre of the test lie close together in a ring, in the middle of which erosion has often caused a depression. The outline is almost round; and there is again no flange. The shell thins out abruptly from umbo to edge.

The thick specimens, from the large number of pillars that combine into an umbo, might be regarded as a transition form from *Lepidocyclina Ferreroi* to *Lepidocyclina angulosa* Provale. But the umbo always occupies much more than a quarter of the total diameter of the test, the proportion originally given by PROVALE for the *Lepidocyclina angulosa.*

Similar transition forms have already been described elsewhere:

VAN DER VLERK (1923, p. 138) found them in material from the locality Goenoeng Mlendong (Koetei, E. Borneo), besides typical representatives of *L. Ferreroi* and *L. angulosa*. As this material is kept at the Geological Museum in Leiden, I was able to compare the Soembanese forms with it. The transition forms from Borneo display a great variety amongst themselves and the fossils from Soemba, just described, only correspond to those specimens from Borneo which are relatively close to the typical *Lepidocyclina Ferreroi* in the possession of a very large umbo surrounded by a ring of pillars. But by far the greater number of specimens from Borneo approach more or less in habitus to *Lepidocyclina angulosa,* as the umbo is smaller and the peripheral part much broader, gradually decreasing in thickness to the very thin edge. (In this material no gradual transition can be followed). This thin edge, gradually growing into the

thicker portion of the shell, is never absent in the typical *Lepidocyclina angulosa*.

Judging by their external appearance, therefore, all specimens from Soemba should be considered as belonging to the *Ferreroi* type.

As regards the internal structure, on the other hand, the position of the pillars in the material from Soemba represents every stage of transition from the one type to the other.

The only essential difference between the position of the columns in *Lepidocyclina angulosa* and in *Lepidocyclina Ferreroi* is that in the former they are formed immediately, in the first development of the test after the embryonic stage, so that in vertical section they are seen to diverge from out the centre, while in the latter they appear at a later stage of growth, so that the central portion of the test has no pillars, and originate in, or above the median layer, at some distance from the embryonic apparatus.

In the fossils from Soemba, the same gradual transition could be observed internally as externally. The flat forms, in which the columns stand far apart, proved to correspond completely to the typical *Lepidocyclina Ferreroi*. In the centre of the test, on either side of the median layer there are 6—7 lateral chambers, which are sometimes remarkably wide at the surface (width about 200 μ, sometimes even 320 μ, height 60—100 μ) and which, also just in the centre, often lie very irregularly one above the other. There are no pillars in the shell, except at the angles, where they are collected in bundles under one great common tubercle. In the following stages of the transition series the large composite columns originate more and more closely to the embryonic apparatus, so that some stages further they commence directly beside it. The number of lateral chambers on either side of the median layer is greater (7—9), and as a rule these chambers, especially in the peripheral portion of the test, lie in regular vertical rows, which are occasionally divided by very tenuous columns. The central portion of the shell within the circle of large pillars is again built up of very wide lateral chambers (at the surface some 200 μ wide and 75—100 μ high), which do not always lie regularly one above the other, and between which there are no traces of wall-thickening to be found. As is only natural, this part of the shell, which is the most lightly built, is the first to succomb to erosion, which is the cause of the frequently observed umbilicus.

Finally, in one of the last stages of the series, the true *angulosa* type appears: the columns diverge from the embryonic apparatus itself. The

relatively large umbo in this specimen is surrounded by a circle of 10 pillars, within again ample lateral chambers lie; where these are placed in more or less regular rows one above the other, the vertical walls show a tendency here and there to thicken at the angles. The number of lateral chambers on either side of the median layer, may be as many as 14.

In the material from G. Mlendong also there are specimens in which the columns diverge from the centre, and others in which they only originate at some distance from the embryonic apparatus.

There is no close connection between the exterior form of the shell and the place of origin of the pillars. The specimen from O. S. 327, where the pillars spring from the centre, exteriorly resembles *L. Ferreroi* more than *L. angulosa*, while in the material from Borneo specimens were found, on the other hand, with the habitus of *L. angulosa* but in which the columns did not proceed from the embryonic apparatus.

From all this it can be seen that it is very difficult to draw an exact line between *L. Ferreroi* and *L. angulosa* if we keep to the apparently distinctive characteristic of the position of the pillars and the form of the test connected with it.

Yet we here have two different species which are well distinguished from eachother by other characteristics. *L. angulosa*, in vertical section, has everywhere regular rectangular lateral chambers which are about 50 μ high. The lateral chambers of *L. Ferreroi*, on the other hand, are usually rounded and especially in the peripheral portion of the test, and in the centre, within the ring of pillars, may be very high and large and lie quite irregularly one above the other.

If this characteristic is taken as criterium in defining the species, all the specimens in O. S. 327 belong to *L. Ferreroi*, and all the transition forms from G. Mlendong to *L. angulosa*.

Localities of *L. Ferreroi:* O. S. 327 and several other marl samples.

Lepidocyclina Martini Schlumberger

1900 Lepidocyclina Martini, Schlumberger – Note sur deux espèces de Lepidocyclina des Indes néerlandaises, Sammlungen des geol. Reichsmuseums in Leiden, Ser. I, Bd. VI, p. 131, Pl. 6, fig. 5—8.,

1909 L. Martini, R. Douvillé – Lepidocyclines et Cycloclypeus malgaches. Ann. Soc. Royal zoologique et malacologique de Belgique, vol. XLIV, p. 134, Pl. VI, fig. 3—4.

? 1909 L. Martini, PROVALE – Di alcune Nummulitine e Orbitoidine dell' isola di Borneo, Rivista italiana di Paleontologia, vol. XV, p. 76, Tav. III, fig. 4 ?

1910 L. Martini, CHAPMAN – A study of the Batesford Limestone, Proc. Royal Soc. of Victoria, vol. 22, (new series), part 2, p. 263.

1916 L. (Nephrolepidina) Martini, H. DOUVILLÉ – Les foraminifères des couches de Rembang, Samml. des geol. Reichsmuseums in Leiden, Ser. I, Bd. X, p. 28, Pl. IV, fig. 3—7.

1916 L. Martini, NEWTON – Organic Limestones from Dutch New Guinea, Rep. on the collections made by the British Ornitologists' Union and the Wollaston Expedition in D. New Guinea 1910—1913, vol. 2, Rep. No. 20, p. 12.

1925 Amphilepidina Martini, H. DOUVILLÉ – Revision des Lépidocyclines, Mém. Soc. géol. de France, Nouvelle série, T. II, Fasc. 2, p. 113.

1928 L. Martini, VAN DER VLERK – Het genus Lepidocyclina in het Indo-pacifische gebied, Wetensch. Meded. v. d. Dienst v. d. Mijnb. in Ned.-Indië, No. 8, p. 33, fig. 23a—c.

1930 Trybliolepidina Martini, TAN SIN HOK – Enkele opmerkingen over de stratigrafische verspreiding van Trybliolepidina Van der Vlerk, De Mijningenieur, Jaarg. 11, No. 7, p. 145.

1931 L. Martini, CAUDRI – De foraminiferenfauna van eenige Cycloclypeus-houdende gesteenten van Java, Verh. Geol. Mijnb. Genootschap v. Ned. en Kol., geol. serie, Dl. IX, 1932, p. 172, 173.

The marl sample O. S. 327 yielded numerous prepared out *Lepidocyclinae* which belonged to the following species: *L. Martini*, *L. Douvillei*, *L. Ferreroi*, *L. parva*, *L. borneënsis*, *L. sumatrensis*, *L. sumatrensis var. minor* and *L. aff. Rutteni*. The *L. Martini* that we shall describe here is a small *Lepidocyclina* (hor. diameter about 3 mm.) with a comparatively thick central portion (vertical 0.8—1.0 mm.) highly vaulted and rapidly changing into the thinner rim. In most of the specimens from this locality the rim runs into a few more or less linguiform points and is somewhat undulated in a vertical direction. Sometimes these points are wel developed and give the shell a stellate shape, but in some cases they are only abortive, so that the circumference is almost polygonal.

Besides this form there is another, in which a number of radial ridges run out from the centre, continuing over the thin flat flange. In well preserved fossils the extremities of these ridges form the points of the star. A reproduction of this type has been given by DOUVILLÉ (1916, Rembang, Pl. 4, fig. 3—7), and probably SCHLUMBERGER's specimens in an uninjured state conform to it. It seems certain that the two forms belong to the same species, from the fact that in some cases the one side

of the test shows distinctly protruding ridges, while the other side runs out into gently undulating points; the internal structure is exactly the same in all respects.

The number of points in the star is 7—8.

The surface is not very well preserved, but here and there something can be seen of the structure. In the central portion in particular, a great number of granules can be seen, with a diameter of about 60 μ. In the first mentioned form there are no granules on the smooth tongue-like points, while in the second form they are continued upon the ridges of the flange.

In almost all cases the horizontal section has the familiar appearance of *L. Martini*. The median chambers are often, as SCHLUMBERGER described them, more or less arranged in circles in the inter-radial fields, while in the radius itself the circles bulge out suddenly from the marked radial elongation of the chambers. In exceptional cases the chambers are very little elongated; then they lie in slightly undulated circles, which gives rise to the external polygon, mentioned above.

The nucleoconch, which both in form and size is very variable (see below) is always surrounded by an extra thick wall (about 45 μ, exceptionally even more than 60 μ) of which the calcite ususally has a distinctly fibrous structure (PROVALE, 1909, p. 77).

For the determination of *L. Martini* the vertical section is indispensable. The species is distinguished from all other radiate *Lepidocyclinae* by having only 7—8 high, very thin walled lateral chambers in a vertical row. These chambers, which in the centre may be 150 μ wide at the surface, with an average height of 45, occasionally amply 60 μ, only gradually become smaller towards the periphery, so that they remain wide even in the flange. The horizontal walls are extremely thin (about 8—10 μ) and the lumina are not rounded. Owing to the high vaulting of the centre the chambers from the median layer up to the surface increase rapidly in size. The whole plan of this section with the globular central portion and the much thinner flange may to a certain extent be taken as typical, although this form has also been observed in other *Lepidocyclinae* (amongst others *L. Rutteni*, CAUDRI, 1932, p. 200).

To give an idea of the variability of form and size of the nucleoconch I give a reproduction of some types to be found in the material of O. S. 327. These figures, which were drawn with the camera lucida and are all on the same scale, give a good impression of the "polymorphie

initiale" in this species (textfig. 21, **a-m**). As we see the second chamber varies, within one species from very slightly embracing (**a**) to horse-shoe shaped (**f**), so: *L. Martini* forms a transition from *Nephrolepidina* to *Trybliolepidina*. The pure trybliolepidine type with rounded square initial chamber was not found amongst the specimens from O. S. 327, but it was found in SCHLUMBERGER's original material from Madoera, which is kept at Leiden (fig. 21, **n**). Fig. 21, **e** and **g** show two abnormal forms of the embryonic apparatus. One of them, **e** has a second chamber that surrounds the initial chamber to such a great extent and the wall of which is joined to that first chamber with such sharp angles that the nucleoconch comes to resemble an *Eulepidina;* **g** represents an embryonic apparatus, unfortunately not complete, that has consisted of more than two chambers.

Besides these comparatively large specimens of O. S. 327, in other rocks, such as the loose marl O. S. 631, some extremely small, polygonal to stellate *Lepidocyclinae* were found, with a diameter of only 1 mm. which according to their internal structure certainly belong to *L. Martini* also. In this minute form a trybliolepidine nucleoconch is found in which the second chamber is divided in two by a partition which proceeds from one of the angles of the square initial chamber.

Localities: O. S. 327, 537, 631 and several other marl samples.

LEPIDOCYCLINA DOUVILLEI YABE AND HANZAWA.

? 1912 Lepidocyclina angulosa, DOUVILLÉ – Les foraminifères de l'île de Nias, Samml. des geol. Reichsmuseums in Leiden, Ser. I. Bd. VIII, p. 270, Pl. XXI, fig. 4—5.

1914 L. angulosa RUTTEN – Studien über Foraminiferen aus Ost-Asien, Samml. des geol. Reichsmuseums in Leiden, Ser. I, Bd. IX, p. 291, Pl. XXI, fig. 1—4.

1922 L. Douvillei, YABE and HANZAWA – Lepidocyclina from Naka Kosaka, Jap. Journal of Geology and Geography, Vol. I, No. 1, p. 49; non Pl. V, fig. 4, Pl. VII, fig. 1 and 7.

pars 1928 L. Douvillei, VAN DER VLERK – Het genus Lepidocyclina in het Indo-pacifische Gebied, Wetensch. Meded. v. d. Dienst v. d. Mijnbouw in Ned.—Indië, No. 8, p. 25, fig. 18b; non fig. 18a and c.

1932 L. Douvillei, CAUDRI – De foraminiferenfauna van eenige Cycloclypeus-houdende gesteenten van Java, Verh. geol. mijnb. Gen., Dl. IX, 1932, p. 175.

The specimens of this species, from O. S. 327, have an average horizontal diameter of a good 3 mm. and are 1—2 mm. thick. They are only slightly vaulted. The test is polygonal and has no flange; the number of angles in the polygon is 4—6. In a few specimens the surface is well preserved and shows distinct, relatively large columns; usually the exterior of the specimens from this material is very ill preserved, so that the foraminifera may easily be confused with much weathered flat polygonal forms of *L. Ferreroi*. The latter, however betray their true nature immediately on polishing, as the large pillars always stick out a little above the rest of the shell, so that they are the first thing to come to light when the fossil is being ground. As the specimens of *L. Douvillei* with a better preserved surface are thicker in proportion than the rest, the thinness of the majority may be due to erosion.

The median layer proves, in horizontal section, to be composed of small chambers, which may vary in shape (hexagonal to spatuliform; often somewhat longer than they are wide, in the inter-radial space sometimes wider than they are long), but of which the majority are hexagonal and in which the radial and tangential diameter never differ much. These chambers, which at first sight seem to be of the same size, are arranged in regular polygons, with here and there slightly concave sides, so that the total appearance of the median layer is one of great regularity. The wall thickness varies from 15 tot 20 μ.

The average maximum diameter of the nucleoclonch is amply 400 μ, and like in *L. Martini*, it is entirely surrounded by a thick fibrous wall (wall thickness 45 μ). Here too, as in *L. Martini*, distinct *Trybliolepidinae* are found besides specimens with an embryonic apparatus of the nephrolepidine type (text fig. 21, **q** and **r**).

I had no good preparations of the vertical section; so I shall not attempt to give a minute description of it, especially as some excellent material from Java will shortly, I hope, give me the opportunity of returning to the subject. The section is characterised by the great number of rounded lateral chambers (on either side of the median layer, in the centre about 16); the height of these chambers is in the central rows about 30—40 μ. The pillars are very distinct in this section, sometimes they are much thicker at the surface than the width of the lateral chambers and diverge from the centre of the test.

Localities: O. S. 327, 537 and other marl samples.

Lepidocyclina borneënsis Provale

1909 L. Tournoueri var. borneënsis, Provale – Di alcune Nummulitine e Orbitoidine dell' isola di Borneo, Rivista italiana di Paleontologia, vol. XV, p. 74, Tav. III, fig. 16—19.

? 1922 L. Tournoueri var. borneënsis, van der Vlerk – Studiën over Nummulinidae en Alveolinidae, Verh. v. h. Geologisch Mijnb. Genootsch. v. Ned. en Kol., geol. serie, dl. V, p. 369, Pl. II, fig. 2.

non 1925 Amphilepidina borneënsis, Douvillé – Revision des Lépidocyclines, Mem. Soc. geol. de France, nouvelle serie T. II, fasc. 2, p. 111.

1925 L. Tournoueri var. borneënsis, van der Vlerk – A study of the foraminifera from the "Tidoengsche landen" (E. Borneo), Wetensch. Meded. v. d. Dienst v. d. Mijnbouw in Ned.-Indië, No. 3, p. 29, fig. 8, 33, 56.

1928 L. borneënsis, van der Vlerk – Het genus Lepidocyclina in het Indopac. gebied, Wetensch. Meded. v. d. Dienst v. d. Mijnbouw in Ned.-Indië, No. 8, p. 17, fig. 16a—c.

1929 L. borneënsis, van der Vlerk – Groote foraminiferen van N.O. Borneo, Wetensch. Meded. v. d. Dienst v. d. Mijnbouw in Ned.-Indië, No. 9, p. 22 and table.

1929 L. borneënsis, Musper – Beknopt verslag over de uitkomsten van nieuwe geologische onderzoekingen in de Padangsche Bovenlanden, Jaarb. Mijnwezen, Verh. 1929, p. 327.

? 1929 L. transiens, Umbgrove – Lepidocyclina transiens nov. spec. van Sumatra, Wetensch. Meded. v. d. Dienst v. d. Mijnbouw in Ned.-Indië, No. 9, p. 109.

? 1930 L. transiens, Tan Sin Hok – Enkele opmerkingen over de stratigrafische verspreiding van Trybliolepidina Van der Vlerk, De Mijningenieur, Jaarg. 11, No. 7, p. 145.

1931 L. borneënsis, Caudri – De foraminiferenfauna van eenige Cyclo-clypeus-houdende gesteenten van Java, Verh. v. h. Geologisch Mijnbouwk. Genootschap v. Ned. en Kol., dl. IX, 1932, p. 175, 179, 199.

In sample O. S. 327 a few *Lepidocyclinae* are found which have exteriorly so little in common, that it is only after being polished that they can be seen to belong together. I determined them as *Lepidocyclina borneënsis* Provale. The outline of these foraminifera is (principally owing to damage) very irregular, sometimes even seeming to form rounded off points. The horizontal diameter varies from 1.5 to 3.25 mm. (the small specimens are probably only fragments) and the thickness is about 1 mm. There is no flange. The surface, as in all fossils from this rock, is not well preserved. It is an exception to find any distinct sculpturing; in these cases the very large, thin walled lateral chambers and the delicate evenly distributed granulation, so typical of this species, can be seen.

The median chambers are arranged in irregular circular rings with larger and smaller swellings and depressions. Usually these irregularities are compensated during growth by the chambers in a later ring above a swelling being very low and those above a depression being much elongated. Thus the edge of an individual remains more or less circular: The shape of the median chambers is elongated hexagonal to spatuliform, but the hexagonal chambers form by far the majority. The size is variable: there is not only a variability in the size of chambers in the same circle, but at some periods of growth the animal may build up some circles which consist entirely of low chambers around the older parts of the shell, where the chambers are all much larger. The size does not, therefore, increase or decrease in a regular way during growth. Moreover in one individual all chambers are much larger than in another; some specimens have chambers with an average radial and tangential diameter of 150 μ and 75 μ respectively, or 165 μ and 90 μ; in others these measurements average 105 μ and 55 μ. The vertical walls of the median chambers are remarkable thin (about 7 μ, sometimes even less; maximum 10 μ).

The nucleoconch is strikingly large (about 700 μ in the more regular specimens; up to 945 μ in the abnormal forms) and thin walled. This wall is not of the same thickness everywhere, the average is about 15 μ, but it may be much thinner in places ($< 7\ \mu$) or much thicker (22—30 μ). In one case the nucleoconch is entirely surrounded by a fibrous wall, 45 μ thick. Measuring the thickness of the walls is in many places made difficult by crystaline calcite having been precipitated against the walls during fossilization, often not easily to be distinguished from the original calcareous wall of the foraminifer. The shape of the nucleoconch is extremely variable. Fig. 21 **s**—**w**, copied by means of the camera lucida, gives a few examples of this. **u** and **w** represent abnormal individuals with more than two chambers, **u** bears a striking resemblance to one of PROVALE's specimens (1909, pl. III, fig. 18). Besides these abnormal multilocular forms the nucleoconch in this species may be both of the trybliolepidine (**s**) and the nephrolepidine type (**t**).

The vertical section corresponds well with the reproduction that PROVALE gives of it. On both sides of the median layer lie about 7 lateral chambers, which attain considerable proportions in the centre (tangential diameter at the surface up to 255 μ; height 60—70 μ). The large lateral chambers are strictly confined to the middle of the test; more towards the edge they immediately become much smaller. No pillars could be seen in vertical section (which is no proof of their entire absence, see below). Both the horizontal walls of the lateral chambers and the division

wall between median and lateral chambers are about 15 μ thick. The median layer embraces the nucleoconch to some extent and is there very high; the normal height (with wall) is close to the centre 60—75 μ and does not increase much towards the edge (about 90 μ).

PROVALE records from Borneo only the occurrence of the quite abnormal monstrous form of *L. borneënsis* besides the normal nephrolepidine type; she does not seem to have found the very large nephrolepidine nucleoconch in her material. UMBGROVE, on the other hand, in 1929 describes a *Lepidocyclina* from S. Sumatra with a circular arrangement of the median chambers and a huge thinwalled nucleoconch as a new species, under the name of *L. transiens*, a name which was intended to indicate the transition from *Nephrolepidina* to *Trybliolepidina* which was here noticed for the first time. This *L. transiens* now proves to be practically identical with *L. borneënsis* Prov. and should perhaps be eliminated as a separate species. It is true that the description of the two species does not tally in several particulars (cf. UMBGROVE's table of the characteristics of *L. transiens* with VAN DER VLERK's for *L. borneënsis* 1928), but on a closer examination the differences do not appear to be sufficient to form a sharp distinction. Exteriorly *L. transiens* looks exactly like the weathered specimens of *L. borneënsis* from the Soembanese material; the irregular outline should be regarded as an erosion phenomenon, as the arrangement of the median chambers cannot give rise to an angular external shape of this kind. The small diameter, at any rate in part, must also be attributed to weathering, as is clearly shown in some vertical sections of *L. transiens* [22]). The characteristics to which the writer attached most importance, viz. the peculiarly large, thinwalled nucleoconch, which was sometimes of the nephrolepidine and sometimes of the trybliolepidine type entirely looses its importance after the study of the new material from Soemba. The vertical section of *L. transiens* shows the characteristic phenomenon of *L. borneënsis*, the large lateral chambers in the centre. The height of these chambers is certainly small in comparison with what L. borneënsis may attain to, viz. an average of about 45 μ, according to UMBGROVE 40 μ, on the other hand in many cases it rises to 60 μ [23]). Moreover, in some prepa-

22) The Leiden Geological Museum possesses ample material of this species for study, from the original locality, Batoe Radja.

23) The number of 120 μ that VAN DER VLERK gives for the height (1925, p. 29 and 1928, table 2) seems to me, at any rate for an average, undoubtedly too large. Cf. the reproduction that is given with it (1925, fig. 56).

rations distinct pillars could be seen, so that the absence of these cannot be regarded as a characteristic distinction.

A second more obvious difference remains between *L. transiens* and *L. borneënsis*, in the median chambers. In the first they are on an average much smaller and less elongated (by which they give the impression of being thicker walled), and the spatuliform shape is much more common than in *L. borneënsis*. But even in this respect there is no essential difference. The specimens of *L. transiens* that I had to examine, all seemed to have existed under unfavourable circumstances and to have been frequently hindered in their growth. Their chambers are on an average 75—80 μ long, but chambers of 105 μ are not unfrequent. The fact that the average size of these chambers in specimens from the Soembanese locality is of such great individual variety, and also the probability that the shape and size of the median chambers is very dependant upon the circumstances in which the organism is placed as well as on its specific character, makes a distinction between the two species extremely difficult. Taking all this into consideration, it seems to me that even if *L. transiens* should prove to be a separate species, it is not suitable for use as an index fossil for deposits of the age of the Batoe Radja limestone (see UMBGROVE, p. 145); it is much too difficult to recognise.

Localities of *L. borneënsis* on Soemba: O. S. 327, 537, and some other marl samples.

LEPIDOCYCLINA AFF. RUTTENI VAN DER VLERK

Pl. III, fig. 4.

Cf. 1924 L. Rutteni, VAN DER VLERK – Foraminiferen uit het Tertiair van Java, Wetensch. Meded. v. d. Dienst v. d. Mijnbouw in Ned.-Indië, No. 1, p. 17, Pl. 3, fig. 1—4.

1928 L. Rutteni, VAN DER VLERK – Het genus Lepidocyclina in het Indopacifische Gebied, Wetensch. Meded. v. d. Dienst v. d. Mijnbouw in Ned.-Indië, No. 8, p. 29, fig. 12 a—c.

1931 L. Rutteni, CAUDRI – De foraminiferen-fauna van eenige Cycloclypeus-houdende gesteenten van Java, Verh. v. h. Geol. Mijnbouwk. Genootschap v. Ned. en Kol., dl. IX, 1932, p. 175, 200, Pl. 111, fig. 5—6.

In the marl sample O. S. 327 a few *Lepidocyclinae* were found, which bear a great resemblance to the numerous specimens of *L. Martini* from this rock, but can not be assigned to this species. They are stellate foraminifera with 4 or 6 points, maximum size $3^1/_2$—4 mm. and about 1 mm. thick (Pl. III, fig. 4). The whole surface is rendered granular

by the presence of numerous slender pillars, which are slightly better developed in the centre than at the points. The test is not like *L. Martini* with a well arched, more or less globular, central part, but from the centre towards the periphery it gradually decreases in thickness, while no flange is formed. Thus at first sight the fossil has more resemblance to the stellate variety of *L. Rutteni* than to *L. Martini*.

The median chambers are arranged in polygons with comparatively broad rays, but the median layer is in general indistinguishable from that of the *L. Martini* in the same sample. The chambers may be as much as 120 μ long and 50—80 μ broad even quite near to the centre. The nucleoconch in the few preparations which were examined was very large and irregular; it was multi-chambered or trybliolepidine (540—760 μ max. section; see text fig. 21, **o** and **p**, on the same scale as the drawings of the nucleoconch of *L. Martini*).

A vertical section, which greatly resembles *L. Rutteni* in having a larger number (12) of lateral chambers on each side of the median layer, probably comes from the same organism as this horizontal section which has so much in common with *L. Martini*. The lumen of the lateral chambers is max. 45 μ high and the horizontal walls are 15 μ thick; but they are not rounded at the corners, like the true L. Rutteni, neither has this specimen a true flange, though it has a thinner rim, which however has been caused by regeneration. The median layer in the normal part of the shell is low (60—75 μ), after the regeneration it suddenly increases to 120 μ and at the edge it is 225 μ high.

It would certainly be interesting to know from a stratigraphical point of view whether the above described *Lepidocyclinae* belong to *L. Rutteni* or not. Unfortunately the material at my disposal (3 specimens) was not sufficient to ascertain this. At all events these specimens are nearly related to the well known index fossil of the Tji Lanang beds, so I feel justified in using the designation *L. aff. Rutteni*.

The "Subgenus" Trybliolepidina Van der Vlerk

The foregoing descriptions of *Lepidocyclina Martini*, *L. Douvillei* and *L. borneënsis* show that on Soemba there are various species of *Lepidocyclina* in which both a nephrolepidine and trybliolepidine embryonic apparatus may occur. The same phenomenon has been frequently recorded in recent years in material from other districts and in other species besides those mentioned above. This fact leads to a reconsideration

of the division of the genus *Lepidocyclina* into various subgenera.

At first when after DOUVILLÉ's subdivision of the genus, attention was attracted to the shape of the nucleoconch, it was thought that the far-embracing shape of the second chamber in small *Lepidocyclinae* was a transition from *Eulepidina* to *Nephrolepidina*. VAN DER VLERK was the first to question this hypothesis, principally on stratigraphic grounds: the species in which he found the pure "bowl-shaped" second chamber could not be placed chronologically between the *Eulepidinae* and the

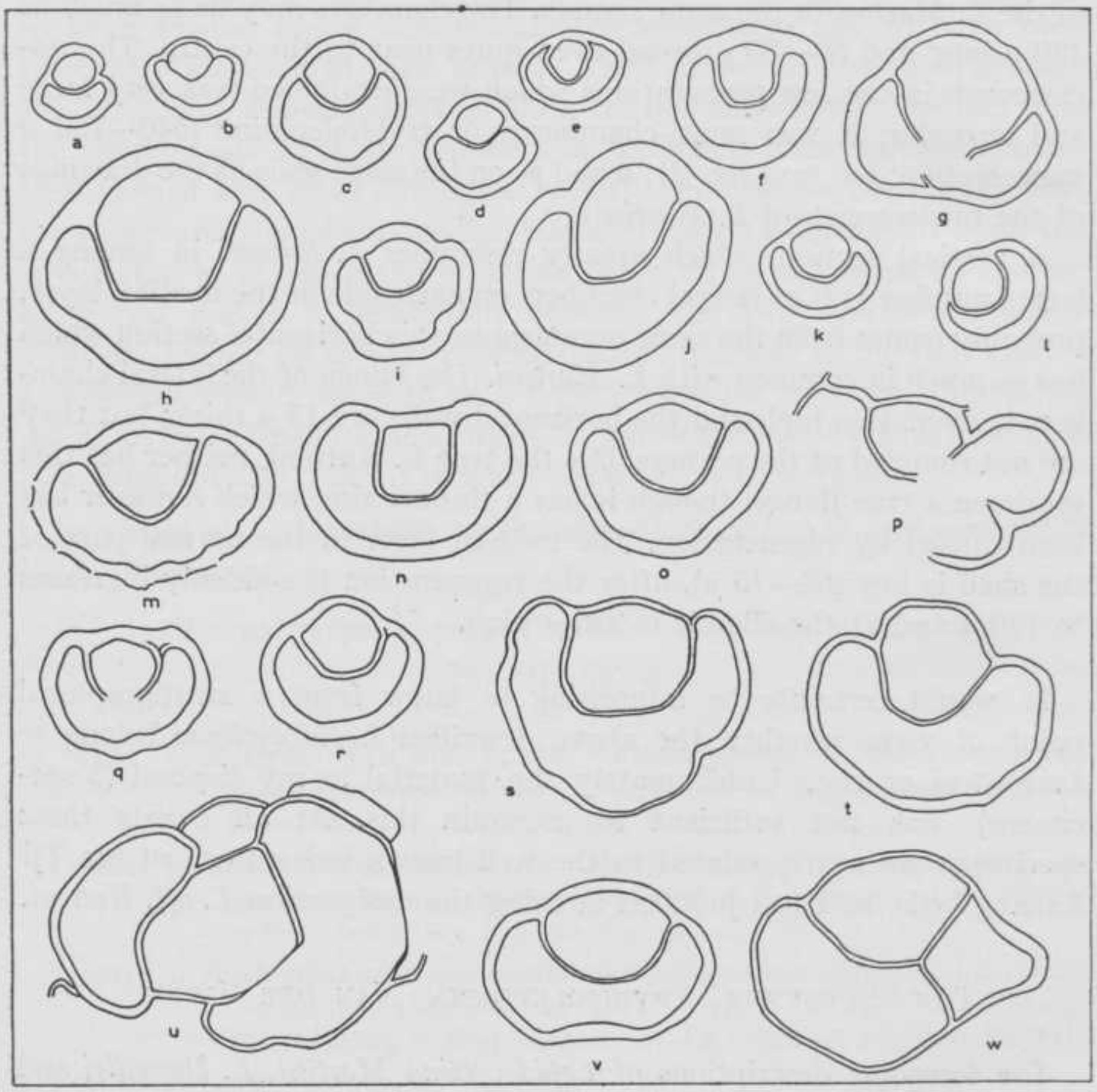

Fig. 21. Nucleoconchs of some *Lepidocyclinae* from O. S. 327 and one of *L. Martini* from SCHLUMBERGER's original material from Madoera. Drawn by camera lucida, all on the same scale.

a-m *L. Martini* (O. S. 327) **o-p** *L. aff. Rutteni* (O. S. 327)
n *L. Martini* (Madoera) **q-r** *L. Douvillei* (O. S. 327)
s-w *L. borneënsis* (O. S. 327)

Nephrolepidinae, but were characteristic of the latest Lepidocyclina-bearing part of the Tertiary (Njalindoeng- and Tji-Lanang-beds). Moreover this type was almost constant in the specimens examined of these late species (especially *L. Rutteni*, Van der Vlerk, 1924) and it was then not yet known that it might be found in *Lepidocyclinae* from earlier beds as well. All this led VAN DER VLERK in 1928 to propose a new sub-genus, *Trybliolepidina*, which he considered to be of great importance as index group for the uppermost part of Tertiary-f (Genus Lepidocyclina, p. 4, Introduction).

Since then it has been convincingly proved that the occurrence of the trybliolepidine type of nucleoconch cannot in itself be used for age determination (VAN DER VLERK, 1929, p. 24; UMBGROVE, 1929, p. 110; GERTH, 1930, Larger foraminifera, p. 597; TAN, 1930, Trybliolepidina; LEUPOLD and VAN DER VLERK, 1931, p. 639; CAUDRI, 1932, p. 178, 199; SCHEFFEN, 1932).

However, both TAN and VAN DER VLERK still regard the form of the nucleoconch as an important characteristic, on which the classification may be based, in other words, they both maintain *Trybliolepidina* as a subgenus. TAN's classification of subgenera is very loose as he lets the decision as to whether a particular *Lepidocyclina* belongs to the *Nephrolepidinae* or to the *Trybliolepidinae* depend upon the numerical majority of specimens with nephrolepidine or trybliolepidine nucleoconch within the species (1930). It seems to me, apart from the want of accuracy of such a method of determination, that it is undesirable to make use of such undecided characteristics in classification, especially when it is not a question of species or variety, but of a subgenus. A systematic unity of a larger order should be more easily recognisable and more distinctly defined than the species, while in this case it would be just the reverse. For this reason it is preferable — as SCHEFFEN does (loc. cit.) — only to speak of a nephrolepidine and a trybliolepidine type of nucleoconch, and then, if possible, to state as an additional peculiarity which of these types predominates in a species (e.g. *L. Rutteni* usually trybliolepidine, *L. sumatrensis* in general only slightly embracing nephrolepidine, etc.). In my opinion all the smaller nephrolepidine or trybliolepidine *Lepidocyclinae* from the Dutch East Indies belong to one group, the subgenus *Nephrolepidina sensu lato*, as against the *Eulepidinae* and *Pliolepidinae*.

In connection with the above, I wish to say a few words about an article of recent date on the subject.

In 1931 HANZAWA (Kwantô Mountains, Izu and Bôsô peninsulas)

made an attempt to reorganize the subdivision of the genus *Lepidocyclina*. This attempt is a failure: instead of giving a good solution of the difficulties it introduces still further confusion into the subject. After having discarded DOUVILLÉ's distinction of *Nephrolepidina* and *Amphilepidina*, following WAYLAND VAUGHAN, he returns to this distinction later after the study of reproductions in the works of other writers, because he thinks he recognises in VAN DER VLERK's *Trybliolepidina* the *Amphilepidina* of DOUVILLÉ. This is an entirely wrong standpoint. DOUVILLÉ's division into *Nephrolepidina* and *Amphilepidina* is based upon completely different characteristics to VAN DER VLERK's distinction of *Nephrolepidina* and *Trybliolepidina* and so it is not only a question of priority, for which the name "Trybliolepidina" should retire before the older "Amphilepidina". *Nephrolepidina* and *Amphilepidina* are distinguished by the form of the median chambers, while their nucleoconch is the same; in *Nephrolepidina* and *Trybliolepidina* the median layers correspond to one another, but the distinction is made on the type of nucleoconch.

By confusing these two principles, HANZAWA looses all firm ground for his classification. He abolishes VAN DER VLERK's nephrolepidine *L. japonica* from N. E. Borneo as synonym of this species because of an unspecified difference in the nucleoconch and median chambers (p. 163); on the other hand he has no objection to DOUVILLÉ's summing up of the *Amphilepidinae*, in which *L. sumatrensis* is included. *L. Ferreroi*, which according to his express statement (p. 153) has hexagonal chambers and which in PROVALE's own type-figure shows a nephrolepidine nucleoconch, he assigns to the *Amphilepidinae;* on p. 164 he even speaks of the "amphilepidine nucleoconch" of *L. angulosa*. All this makes it clear that HANZAWA's reasons for reinstating the subgenus *Amphilepidina* are worthless and for the present we must refrain from making any further sub-division of the *Nephrolepidinae s.l.*

What the relation is between the nephrolepidine and the trybliolepidine type from a genetic point of view it is at present impossible to say. The supposition that the difference in form of the second chamber should arise from a different position with regard to the median layer of the whole embryonic apparatus, does not seem to me probable, as in horizontal section a tilted nucleoconch is practically never found; a section made not entirely through the median layer certainly gives a different (more nephrolepidine) figure, but in well levelled preparations the differences are great, so that we are driven to the conclusion that the

two types have stereometrically a different form. Probably the nephrolepidine and the trybliolepidine type in their purest form have a different method of origin. In the true trybliolepidine embryonic apparatus with the rounded quadrilateral initial chamber the large horseshoe-shaped second chamber (if not always, at any rate in many cases) has been formed by an open ring of 3 chambers, of which two radial septa have been absorbed. Occasionally the original multichambered stage has been more or less preserved (e.g. in a specimen of *L. Martini* from O. S. 631); sometimes traces of the walls can still be found, or dents in the external wall of the horseshoe chamber correspond to the angles of the initial chamber. But as a rule there are no traces left of the divisions and all discontinuity in the thick exterior wall of the second chamber has been obliterated. In these cases it is also very possible that the second chamber has never been divided, as no sharp lines can be drawn between all the cases, which gradually pass from only slightly to very definitely embracing second chambers, and a normal *Nephrolepidina* usually makes the impression of there having been only one "second chamber" from the outset. I cannot guess at the cause of this difference in the embryonic chambers. It cannot well be due to faciel factors, as the various types are all found side by side in the same rock.

The smaller *Lepidocyclinae* usually have a comparatively small nephrolepidine or trybliolepidine embryonic apparatus; other types are quite exceptional and in my opinion should be regarded as an accidental deviation in the ontogenetic development of the organism. *L. borneënsis*, however, fills a peculiar place in the classification as in it the abnormal nucleoconch is the rule. Sometimes a normal small nephrolepidine nucleoconch is found (PROVALE, 1909; VAN DER VLERK, 1925; CAUDRI, 1932), but frequently there is a gigantic embryonic apparatus of the nephrolepidine or trybliolepidine type, or all sorts of irregular multichambered nucleoconches which resemble a *Pliolepidina* or a *Polylepidina*. Moreover this species in all its characteristics, merges almost imperceptably into the true regular *Pliolepidinae*, a matter to which I hope to be able to return before long. *L. borneënsis* is a transition form, which cannot be brought into any of the sub-genera of the genus *Lepidocyclina*.

LEPIDOCYCLINA GLABRA RUTTEN

1911 Lepidocyclina glabra, RUTTEN – Over Orbitoiden uit de omgeving der Balik Papan-baai, Kon. Akad. van Wetensch. te Amsterdam, 1911, p. 1159.

1914 Lepidocyclina glabra, RUTTEN – Studien über Foraminiferen aus Ost-Asien, Samml. des geol. Reichsmuseums in Leiden, Ser. I, Bd. IX-p. 290, Pl. XXI, fig. 5—8.

1922 Lepidocyclina glabra, YABE and HANZAWA – Lepidocyclina from Naka-Kosaka, Jap. Journ. of Geol. and Geogr., vol. I, No. I, p. 50. Pl. V, fig. 5, Pl. VI, fig. 1—2.

1926 Amphilepidina glabra, DOUVILLÉ – Révision des Lépidocyclines, Mém. Soc. géol. de France, nouvelle série, T. II, No. 2, p. 106.

1928 Lepidocyclina glabra, VAN DER VLERK – Het genus Lepidocyclina in het Indo-pacifische gebied, Wetensch. Meded. v. d. Dienst v. d. Mijnbouw in Ned.-Indië, No. 8, p. 24, fig. 45.

1931 Lepidocyclina glabra, CAUDRI – De foraminiferen-fauna van eenige Cycloclypeus-houdende gesteenten van Java, Verh. Geol. Mijnb. Genootsch. v. Ned. en Kol., geol. serie, Dl. IX, 1932, p. 173.

The only microspheric *Lepidocyclina* that I was able to prepare out from the upper tertiary rock from E. Soemba, was a specimen of *L. glabra,* coming from the marl O. S. 537. It is an uncommonly large individual (8 mm. hor. diam.; about 2 mm. thick) with a smooth surface, on which no pillars are visible. When polished, however, 6 well developed internal pillars of 120—140 μ thickness came to light in the centre, arranged in a circle. The lateral chambers are small (75—90, max. 120 μ). The median chambers are very small in the centre, increasing gradually towards the edge; in connection with the abnormally large diameter of the test, the chambers at the margin are also much larger than is usual (up to 150—190 μ long with a width of 75 μ). The chambers, at a certain distance from the nucleoconch, are all elongated hexagonal to spatuliform and are arranged in polygons.

Genus Miogypsina

The limestones and marly limestones of Tertiary-e contain, sometimes in large quantities, *Miogypsina Dehaarti* Van der Vlerk, which is easily recognised on slides by the unusually high median layer, which is enclosed on both sides by the very thick vaulted layers of the lateral wall, between which no chambers are left open.

These limestones also contain sections of *Miogypsinae* with large thick-walled lateral chambers and massive pillars.

A conglomerate from the same age contains the primitively constructed *M. complanata.*

Loose *Miogypsinae* are extremely rare in the collection from Soemba.

Most of these are small and ill preserved, and in habitus and horizontal section somewhat resemble *M. thecideaeformis* Rutten; they have not been further determined. Besides these small Miogypsinae a single good specimen of *M. polymorpha* Rutten was found in East Soemba (O. S. 631). It is a very thin foraminifer with a smooth exterior, its broad apex is shell-shaped, and its deeply undulated margin runs out in some six projections. Length and breadth of this specimen are both 5 mm.

On West Soemba limestones were collected which were almost entirely composed of *Miogypsinae*. The vertical section of these fossils greatly resembles *M. thecideaeformis*, and sometimes *M. polymorpha* Rutten or *M. bifida* Rutten.

Miogypsina complanata Schlumberger

1900 Miogypsina complanata, Schlumberger – Note sur le genre Miogypsina, Bull. Soc. Géol. de France, série 3, Tome XXVIII, p. 330, Pl. II, fig. 13—16; Pl. III, fig. 18—21.

1905 Miogypsina complanata, Chapman – Notes on the older tertiary foraminiferal rocks on the West Coast of Santo, New Hebrides, Proc. Linnaean Soc. of New South Wales, vol. 30, p. 270.

? 1911 Miogypsia complanata, Schubert – Die fossilen Foraminiferen des Bismarckarchipels, Abh. der K. K. geol. Reichsanstalt in Wien, Bd. 20, Heft 4, p. 120.

1913 Miogypsina complanata, Schubert – Beitrag zur fossilen Foraminiferenfauna von Celebes, Jahrb. der K.K. geol. Reichsanstalt in Wien, Bd. 63, p. 120.

1922 Miogypsina complanata, van der Vlerk – Studiën over de Nummulinidae en Alveolinidae, Verh. Geol. Mijnbouwk. Genootsch. voor Nederl. en Kol., geol. serie, Dl. V, p. 379.

1931 Miogypsina complanata, Umbgrove – Tertiary Foraminifera, Leidsche Geol. Meded., Dl. V (Feestbundel Martin), p. 70, 83.

M. complanata, which is characterised by the particularly well developed, completely excentric embryonic spiral, forms the chief component of the ground-substance in the conglomerate of the Tandoela Djangga, combined with *Spiroclypei* and small *Nephrolepidinae* (O. S. 520).

The specimens from Soemba are megalospheric, the initial chamber is fairly constant in size 110—120 μ. The embryonic spiral consists of 20—22 chambers (including the initial chamber), which together form about 2 whorls. The chambers first increase in size (up to about the 16th. chamber), in the last portion they become smaller again. The whole

spiral, measured in the length of the fossil is 525—600 μ. The rest oft he chambers are of an obtuse diamond-shape, between the spiral and the margin of the test the greatest number counted was 6 (in slides of the rock). The maximum length of the whole test measures 1.7 mm. (measured on the slide). The vertical section is very flat, lateral chambers were not observed, but it is possible that this section only cut the periphery, where no more lateral chambers develop.

This primitive *Miogypsina* may be confused with *Heterostegina* or *Spiroclypeus* if the preparations are not good, but they are distinguished from these by less regularity in the chambers and by the large number of un-subdivided chambers in the spiral.

FAMILY FASCIOLITIDAE

Genus Fasciolites

The determination of *Fasciolitidae* is a very difficult matter for those who have not made a special study of the subject. For the determination of the *Fasciolitidae* from Soemba I have, therefore, used only the recent monograph by BAKX (1930) relying almost blindly upon the results of his research and I shall content myself with stating a few facts which may be of value for specialized research later on.

BAKX says on p. 217 of his publication:

"The distinction of species is particularly difficult in the genus *Fasciolites*. The "most important characteristics are:

1st size of the chambers (this decides the rule of coiling),
2nd number of whorls,
3rd ratio of length to breadth.

"As characteristics of secondary importance we name:

4th size
5th diameter of the initial chamber

"These characteristics are in the nature of the case fairly variable. The age of "the individual has a great influence upon the number of whorls for instance. "Moreover the genus *Fasciolites* forms an orthogenetic gens. The different species mer- "ge almost imperceptably with one another. The species and varieties that I give "here, must, therefore, be regarded more as a sort of average of the individuals "during a special stage of the series. It is not impossible that in a more accurate "examination and with a very large amount of material more constant variations "could be recognized."

BAKX distinguishes two series of development for Netherlands India, both springing from *Fasciolites oblonga* [24]), viz.:

1°. Fasciolites oblonga . . .Fasc. ovicula . . . Fasc. javana.

2°. Fasciolites oblonga . . . Fasc. celebensis . . . Fasc. Wichmanni.

The great variability to which the characteristics are subject in different individuals of one species (or, as regards the size of the chamberlets, even in one individual) makes it impossible to lay down more than a mean value for a large number of specimens.

It is almost impossible to make an exact determination of a limited number of fossils, by the characteristics laid down by BAKX.

The reproductions which BAKX gives in his publication for the various "stages" in the series, clearly show different types, however. Besides the size of the chamberlets in many cases the mean thickness of the normal basal layer (not the flosculinisation) and the attachment of the whorls to the axis (index; form of the test) have a great influence upon the aspect of the longitudinal section. There is, for instance, a great difference between *Fasc. celebensis*, with its rows of chamberlets always lying far apart, and *Fasc. javana*, which has about the same index, but the whorls of which (except sometimes in the points) are closely packed together. This difference cannot be expressed in the number of whorls, as *Fasc. javana* is much larger and therefore almost as a matter of course has more whorls. The thickness of the concentric walls is shown to some extent in the tables which Bakx gives for the rule of coiling ("wet van oprolling"), but it seems to me that the differences would be shown more clearly if these characteristic qualities could not only be gathered from variable numbers, but could be expressed in words in the description of a species. The same applies to the general form of the test, which is very important for the recognition of the species, but which is not sufficiently expressed in the number for the index only.

The general aspect, in determining the species of a limited number of specimens may be of more practical value than the precise numbers of average measurements. As, however, for a reconsideration of the species a large amount of material is necessary, especially with such a difficult genus as *Fasciolites*, this is not the place to attempt a reorganisation of the different species on there lines; for this we must wait for the continuation of the monographic work begun by Bakx.

My determination of the Soembanese *Fasciolites* is principally based upon the resemblance in general aspect between the BAKX's material

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24) See note on page 132.

and the material from Soemba; on being checked the whole series of measurement and figures proved to be about the same as the data in BAKX's publication.

A special note must be made here on the phenomenon of flosculinisation. BAKX, in continuation of research by NUTTALL, found that the old classification of all thick-walled *Fasciolitidae* into the genus *Flosculina* as distinct from the narrow-whorled genus *Alveolina* (*Fasciolites*) was untenable, as various species include both thinwalled specimens and specimens with extremely thick coils. BAKX proposes, therefore, to combine them all in the genus *Fasciolites*, and to talk of "flosculinised forms" in the case of thick-walled specimens (loc. cit. p. 212).

The *Fasciolitidae* from the Soembanese Eocene have convinced me that this is the right plan.

BAKX considers it probable that the flosculinisation is due to a reaction of the animal to the greater or lesser quantity of calcium in the water. This seems to me to be improbable. It is impossible to imagine, when we regard the Fasciolites rocks from Soemba, that during the formation of these beds there can have been any such variations in the composition of the water; the mixture of flosculinised and unflosculinised individuals in the innumerable quantity of *Fasciolitidae* in the same bed is too intimate. Moreover this theory does not account for the flosculinised forms being confined to the Tertiary-a.

It is not easy to say for the present, what the explanation of the flosculinisation may be; at the same time, it should be noted that all the older species are not flosculinised in the same way. According to the reproduction *Fasc. subpyrenaica* has about 3 abnormally thick-walled coils, *Fasc. ovicula* has 2 and *Fasc. elliptica* $3^1/_2$—$6^1/_2$. For the *Fasc. ovicula* from the Dutch Indies the appearance of only 2 flosculinised coils is fairly constant (see below); perhaps this could be proved for other species by further research. In *Fasc. oblonga, Fasc. timorense, Fasc. celebensis* and *Fasc. lepidula* true flosculinisation has never been formed. I consider it therefore probable, that the possibility of flosculinisation is in close connection with the specific qualities of the different species and that the stratigrafic question can be explained as follows: the flosculinised forms are confined to Tertiary-a simply because the species in which flosculinisation was possible, died out at the end of Tertiary-a.

Finally we must discuss one remarkable phenomenon here, which was found in both my own material and in BAKX's viz. the occurrence of concentric "canals". In longitudinal section, between the fibrous transparent covering layer of one whorl and the more or less opaque basal

layer of the following one a narrow very bright line was seen, which seemed to form a whole system. That this is really an open space and not an extra-hyaline intermediate layer in the wall of the coil, is proved by the peculiar fossilized *Fasciolites* in sample O. S. 780, in which the lumina are clothed by ferrugenous precipitate, while the walls are changed into structureless transparent calcite; the "canal" is seen in this as a dark line. There is a "canal" round every whorl and here and there distinct "connecting canals" between the "canals" of different whorls are to be seen. These "connecting canals" run between the chamberlets.

All the same this is not a true canal system. In cross section this "canal" may also be seen here and there as a line round the whorls. REICHEL, who observed this phenomenon very clearly in a cross section (1931, Pl. XVI, fig. 2) explained it as the splitting of the shell. The combination of longitudinal and cross section yields proof, that it is due to concentric cracking. But it is still remarkable that the connecting cracks should keep clear of the chamberlets. This cracking of the shell cannot be brought into direct connection with pressure in the rock, as in some shattered specimens it is not found and in externally uninjured ones it is, so that probably the cracks did not come after fossilization, but have been caused by erosion previously.

FASCIOLITES OVICULA (NUTTALL?)

Pl. IV, fig. 1 and 4

1912 Alveolina javana, DOUVILLÉ, H. – Les foraminifères de l'île de Nias, Samml. des geol. Reichsmuseums in Leiden, Ser. I, Bd. VIII, p. 266, pl. XIX, fig. 3 (large form).

? 1925 Alveolina ovicula, NUTTALL – The stratigraphy of the Laki series etc., Quart. Journ. Geol. Soc., Vol. LXXXI, p. 439. pl. XXXV, fig. 9—10.

1929 Alveolina elliptica, UMBGROVE – Tertiary sea connections between Europe and the indopacific area, Proc. of the 4th Pan Pacific Science Congress, Physical papers, Vol. II, A, p. 92.

1932 Fasciolites ovicula, BAKX – De genera Fasciolites en Neoalveolina in het indopacifische gebied, Verh. Geol. Mijnbouwk. Genootschap voor Ned. en Kol., Geol. Serie, Dl. IX, p. 225, pl. II, fig. 11—14.

The large *Fasciolites*, which have often built up entire portions of the rock of the hill-country of East Soemba (O. S. 62, hard portion; 134, 236, 237, 243, 790; together with *Assilina* O. S. 286, 300, 780), almost all belong to *Fasciolites ovicula*, as described and reproduced by BAKX

from the East Indies. It cannot yet be said with certainty whether this East Indian *Fasciolites ovicula* may be regarded in all respects as the same as NUTTALL's original *Fasc. ovicula*, a very rare foraminifer from the Ghazij shales (Laki series) in Western British India.

Not counting the small "immature form", which is found in some rocks, the length of the Soembanese fossils varies from 4,8 to 10 mm. (average 6,7 mm.). The ratio of length to breadth is often smaller than given by BAKX: the maximum index is 2, but indices of 1,4—1,5 are not infrequent, the average index is 1,6.

The size and shape of the chamberlets is very variable. This variability rests chiefly on the shape of the chambers in three dimensions (cf. REICHEL, 1931); it depends upon where they are cut by the longitudinal section, in what form (oval or rounded rectangular) and how large they will appear in the preparation. In the outside coils the chamberlets are usually 60—75 μ in height, sometimes as much as 90 μ; the chambers are measured exclusively on the short axis of the shell (in the points they are usually considerably higher) and only in the normally developed whorls (the last whorl is often for a great part abnormal). The number of chamberlets per mm. measured tangentially in the middle of the youngest whorl is $14^1/_2$—19, average 17. There is no constant connection between this number and the thickness of the radial walls between the chamberlets; both the width of the lumina and the thickness of the walls is very variable.

The number of whorls is 15—26. The flosculinization has less influence upon this number than the size of the shell; the greatest number of whorls was found in a flosculinised specimen of 10 mm. length.

Flosculinisation in this species shows the following peculiarity: around the nucleoconch lie first 3 or 4 very thin-walled coils, in which the basal layer is scarcely developed; these are followed by the very thick flosculinised whorls (usually the 4th or 5th coil, occasionnally only the 5th), and then, in most cases again with hardly any transition, by ordinary coils which have at the same time a well-developed basal layer. It is remarkable that this method of flosculinisation seems to be pretty constant; it was observed in BAKX's material too. When, by exception, a *Fasciolites* from Soemba shows another kind of flosculinisation, the fossil is in other respects (index, size of chamberlets) not entirely identical with the East Indian *Fasc. ovicula* (NUTTALL found in the British Indian fossils sometimes more than two flosculinised coils). According to BAKX unflosculinised forms are not frequent (loc. cit. p. 227); in Soemba, however, they are in the majority.

In the specimens from Soemba the nucleoconch is 150—270 μ in diameter, measured on the long axis; in this they differ from the 6 original specimens of NUTTALL, where the initial chamber was not more than 100 μ. In sample O. S. 136 three specimens were found with an initial chamber of about 90 μ; but it is not certain that they are exactly the same as the other *Fasc. ovicula* from Soemba (see below).

The *Fasciolites* from Soemba, like the material on which BAKX bases his monograph, do not form a group of uniform individuals, but rather a series: there are finer and more coarsely built specimens amongst them. Although the impression of fineness or coarseness that a *Fasciolites* makes depends very much upon the manner of fossilization, there are differences that can be actually measured. The differences between the terms of the series which follows one another are very slight, but the two extremes display a striking difference. The large specimen in O. S. 237 in the last coils (24th—26th coil) has chamberlets of an almost constant 75—90 μ (but in the older parts it is exactly the same as smaller specimens of *Fasc. ovicula*), while on the other hand in a *Fasciolites* from O. S. 299 the chambers in the 25th coil, measured on the short axis of the shell, are as a rule only 60 μ in hight. The latter should be regarded as a transitional form to *Fasc. javana* Verb. but it is larger than the transitional forms that BAKX found between these two species (loc. cit. p. 233). The length of this, unflosculinised foraminifer is 8,3 mm., the index 1,9; there are 25 whorls and the initial chamber is 150 μ in diameter (see Pl. IV, fig. 4).

Fasciolites ovicula could be determined with certainty in samples O. S. 62, 136, 236, 237, 299, 300 and 780; moreover in rough and polished surfaces or in slides of the samples O. S. 125, 130, 134, 211, 223, 243, 286, 511 and 790, *Fasciolitidae* were found, which appear to the eye to be exactly the same and which most probably belong to the same species.

DOUVILLÉ's "*Alveolina javana*" from Nias (1912), which is preserved in the Leiden Museum, is just the same as the *Fasc. ovicula* from Soemba; this is, therefore, yet another point of resemblance between the deposits on Soemba and Nias, which already have in common *Camerina kelatensis* and 2 species of *Assilina*.

The marl sample O. S. 136 yielded, besides ordinary specimens of *Fasc. ovicula*, 3 fossils of a somewhat different construction (Pl. IV, fig. 2). These have a nucleoconch of only 90 μ in diameter and seem somewhat more delicately built. The measurements and number of

whorls correspond to the other *Fasciolites*: length 6—7 mm., index 1,5—1,9 and number of whorls 19—23. But the chamberlets are perhaps as a rule slightly smaller: in 2 of the specimens they were 60—75 μ (usually 60 μ) while 16—18 chambers per mm. lay beside eachother; in the 3rd the chamberlets are almost constantly 60 μ, sometimes smaller and 20—21 per mm. were counted. None of these specimens are flosculinised.

This may be a different species, or it may be only another form of the same species. BAKX assigns specimens of *F. Wichmanni* (loc. cit., p. 234—235) with small initial chambers like this to the microspheric generation. An initial chamber of almost 100 μ seems to me, however, somewhat large for a microspheric form.

As regards the size of the nucleoconch, the abnormal individuals in O. S. 136 correspond to NUTTALL's British Indian *Fasc. ovicula*, but that fossil has not a particularly delicate appearance.

TRANSITIONAL FORM FROM FASCIOLITES OVICULA (NUTTALL?) TO FASCIOLITES JAVANA VERBEEK

Pl. IV, fig. 3

Two more transitional forms between *F. ovicula* and *F. javana* were found besides the transition form described on page 129.

In contrast to that specimen those forms are flosculinised. They are 7 and 7,2 mm. long and have an index of 2 and 2,2 respectively. The first specimen has 19 to 20 whorls, of which the 7th and 8th are greatly flosculinised (see reproduction); thus it will be seen that in comparison with the other specimens of *F. ovicula* from Soemba, this fossil has an extraordinarily large number of narrow whorls in the centre. The second individual has 17 whorls of which the 5th and 6th are highly flosculinised, the thickness only gradually decreasing through the 7th and 8th whorl.

The nucleoconch in the first specimen is 150 μ and in the second 180 μ in size; the chamberlets in the last whorl are in both 60—75 μ, maximum 90 μ.

This form is nearer to *F. ovicula* than to *F. javana*.

Locality: O. S. 511.

FASCIOLITES SPEC. INDET., RELATED TO F. OVICULA (NUTTALL?)

Pl. IV, fig. 5

A strongly flosculinised specimen from O. S. 511 is nearly related to *F. ovicula*. This fossil has an elliptical shell of 5,2 mm. length and 2,9 mm.

thickness (index 1,8). The nucleoconch is 195 μ, and there are 12 whorls. The chamberlets in the last whorl are only 50—60 μ, that is somewhat smaller than the chamberlets in *F. ovicula* with a corresponding radius. The manner of flosculinisation of this organism is again different to what has so far been found in by far the greatest number of specimens of *F. ovicula*. The whorls, from the 4th coil, become gradually thicker, the maximum thickness is reached in the 5th and 6th whorl, after which it gradually decreases. The same kind of flosculinisation is found in a specimen in BAKX's collection, under the name of *F. ovicula*. The combination of this unusual flosculinisation and the somewhat more delicate chamberlets makes me, however, hesitate to determine this form as *F. ovicula*.

FASCIOLITES CELEBENSIS BAKX

1921 Alveolina c.f. oblonga, DOUVILLÉ, H. – Sur quelques foraminifères des Moluques orientales et de la Nouvelle Guinée, Jaarb. Mijnw. 1921, Verh. dl. 2, 1923, p. 110, pl. II, fig. 1.

1932 Fasciolites celebensis, BAKX – De genera Fasciolites en Neo alveolina in het indopacifische gebied, Verh. Geol. Mijnbouwk. Genootsch. voor Nederl. en Kol., geol. serie, dl. IX, p. 228, pl. I, fig. 9—10.

This *Fasciolites* can be immediately recognised in longitudinal section by its thick-walled coils. With the exception of the oldest whorls, which are still narrow, the basal layer is remarkably well developed, so that the rows of chamberlets, on the short axis as well, lie far apart. At the same time there is no flosculinisation, the thickening proceeds quite regularly, and sometimes decreases equally gradually in the outermost whorls, the thickness being invariably greatest in the points. The shape of the test is about half-way between cylindrical and elliptic. The measurements of the specimens from Soemba vary a good deal; most of the fossils are very small (possibly immature forms?) the largest specimens are 3,6—5 mm. long. The index on the whole is smaller than BAKX found, in large individuals 2—2,25. The number of whorls varies, again in the large forms, from 8 to 11; in the smaller specimens the number is less. The chamberlets in the last whorl are between 60 and 75 μ in size, average 60 μ. The nucleoconch is about 240 μ in maximum diameter, in some specimens however, it is much smaller (i.e. 180 μ).

Fasc. celebensis was found in O. S. 126, 130, 223, 235 and perhaps in O. S. 134 as well. This species was not as numerous as *Fasc. ovicula;* in O. S. 130 only, in which no large *Fasc. ovicula* are found, it is very amply represented, especially in the small form.

Fasciolites Wichmanni Rutten

Pl. IV, fig. 7 and 8

On the Watoe Moendoe and at Kakaha a few *Fasciolites* were found, which, especially for their large index must be assigned to *F. Wichmanni*. They are comparatively small specimens, from 6—6,6 mm. long, with an index of 2,3—2,7. They are not flosculinated and have 15—16 whorls with thickwalled chamberlets, of which the radial diameter in the last whorl is only 50—60 μ, sometimes reaching 75 μ. This form corresponds to the thick specimen that Bakx has reproduced (1932, fig. 28); it is therefore not a typical *F. Wichmanni*, but a form which, from its comparatively small index very greatly resembles *F. javana* Verb. (cf. Bakx, p. 235). The whorls in two specimens are regular, the third specimen (O. S. 134) is irregular, a deformation which, however, is caused by pressure.

The nucleoconch of one specimen is 145 μ, in another (O. S. 511) it is 180 μ, and clearly consists of more than one chamber.

Locality: O. S. 134?, 511 and 512 (altogether 3 specimens were examined).

Transitional forms from Fasciolites Wichmanni Rutten to Fasciolites timorense Verbeek

Pl. IV, fig. 9 and 10

In O. S. 512, besides this small *F. Wichmanni*, there is a very peculiar larger *Fasciolites*, which has a large index in its immature stage corresponding to *F. Wichmanni*, but which becomes thicker at a later stage and by its distinctly cylindrical shape very much resembles *F. timorense* Verb. [25]). In one specimen (Pl. IV, fig. 10) the chamberlets of the last whorl are too small for *F. timorense*, viz. 75 μ. A second specimen (Pl. IV, fig. 9) has an even larger index in the immature stage (about 3.75), but at a later stage assumes the appearance of *F. timorense* in every

25) *F. timorense*, under the name of *F. oblonga* d'Orb was included in Bakx's monograph (1932, p. 218, fig. 1, 4). Bakx had the goodness to point out to me that this name is not correct. Unpublished research under Prof. Wanner, who collected the Timor material have shown the points of difference between *F. oblonga* and the cylindrical *Fasciolites* from Timor more clearly than they appeared to Bakx. It is, therefore, better to preserve the old name of F. timorense Verb. for these *Fasciolites* from Timor.

respect having an index of more than 2, and the large chambers typical of this species, 90 μ or more in radial diameter.

Both specimens, however, are larger than the true *F. timorense*, 7,4 and 8,5 mm. long respectively and have more whorls (19—21). In both the nucleoconch is 180 μ in size and they are unflosculinated.

Transitional form from Fasciolites timorense Verbeek to Fasciolites ovicula (Nuttall?)

Pl. IV, fig 6.

Like Bakx, I found a *Fasciolites*, which may be regarded as a transitional form from *F. timorense* (*F. oblonga* Bakx, see note on page 132) to *F. ovicula*, but while Bakx's transitional forms are small and unflosculinated, mine is very large (8,4 mm. long) and has about $1^1/_2$ flosculinised whorls, principally the 6th. There are 18 whorls and the chamberlets in the last are 75 μ. All this corresponds more to *F. ovicula* than to *F. timorense*, but the index is 2,3 and the shape is pretty clearly cylindrical, so that the general appearance, again, is more like *F. timorense* than like *F. ovicula*.

Locality: O. S. 511.

Fasciolites spec. indet. (flosculinised form)

In sample O. S. 514 there is a greatly flosculinised form, which does not conform to the flosculinised *F. ovicula* from the other localities. The fossil, which has been a good deal damaged by pressure, is 5 mm. long and 2,8 mm. thick. The number of whorls is at least 12 (probably 15, the central thin-walled coil around the nucleoconch cannot be well distinguished); $3^1/_2$—4 of these are strongly flosculinisated, the remainder are thin and closely packed together. The strong flosculinised coils, which have remained intact, are completely circular in longitudinal section; the shell in undamaged condition must therefore have had a smaller index than now. The chamberlets are very small, in about the 10th—12th coil they are not even 40 μ. The total impression made by the longitudinal section is more delicate than in F. ovicula.

Locality: in the basal beds of the section of the Tandoela Djangga (see p. 187).

SMALLER FASCIOLITIDAE SPEC. DIV.

Besides the large *Fasciolitidae* described here, in various samples from East Soemba smaller specimens were found of 1—4 mm. length, with smaller chamberlets (about 50 μ) and a smaller number of whorls and sometimes a different index. These smaller forms probably belong partly to the genus *Neoalveolina*, but in part they resemble the forms of *Fasciolites* so much that they must be assigned to the same genus, as immature forms. In *Fasc. celebensis* the transition from the large to the small form is easy to follow; other small forms are somewhat rounder and sometimes have a few more coils, the walls of which are not thick and therefore are more like the oldest part of *F. ovicula*.

Sample O. S. 134 contains small *Fasciolitidae* which seem undoubtedly to be very youthful specimens. Amongst these fossils there are some which are only about 1 mm. in size and do not consist of much more than a nucleoconch with the first three very thin-walled coils, in which the chamberlets have not reached more than 25 μ.

Immature forms of this kind were found in samples O. S. 62, 134, 236, 300, 315, 514. From Nias, too, a small form is reproduced beside the large *Fasc. ovicula* (DOUVILLÉ, 1912, Pl. XIX, fig. 3). It is remarkable that in O. S. 300, both in the *Fasciolites* and the *Assilinae*, numerous small specimens are found, which cannot well be regarded as anything but immature forms.

Genus Neoalveolina

Neoalveolina pygmaea Hanz. can be recognised by its larger index, the shape of the shell with its pointed extremities and the small chamberlets, which everywhere, even in the outside whorls, are almost entirely round. The maximum is 10—12 whorls and the chambers are 30—40 μ large. This species could be identified on Soemba in Tertiary-a in the samples O. S. 134, 310, 311 and further in a number of later rocks from the Tertiary-c age (O. S. 226, 366) and Tertiary-e (O. S. 611).

On many slides of O. S. samples from these stages undeterminable sections of *Neoalveolinae* occur; in the W. S. samples only one case was met with (W. S. 16).

Perhaps besides *N. pygmaea* there may be other species of *Neoalveolina* on Soemba; very occasionally on slides of upper tertiary rocks sections are found of specimens which are apparently too small, too delicate and too round to be *N. pygmaea* (O. S. 411).

No *Neoalveolina* could be prepared out.

Genus Alveolinella

Of this genus the species *A. bontangensis* Rutten was found on Soemba. It is abundant in W. S. 392 and is probably present in the sample W.S. 50, the localities of this fossil being strictly confined to the neighbourhood of Tg. Lamboja in West Soemba.

General Remarks upon the Fasciolitidae of Soemba

As the above shows, the genus *Fasciolites* was only found in East-Soemba; I did not find it at all in the collection from West-Soemba.

By far the majority of the specimens belong to the species that BAKX (1932) has called *F. ovicula* Nuttall (Dutch-Indian form), while in smaller quantities *F. celebensis* Bakx is also often found. This fauna occurs in various places, Rete Balaroe in the upper valley of the Liang Malip, the range of hills to the East of that valley (Rara Mata, Tandoela Dangga) and the surroundings of Kakaha. The rocks from Watoe Moendoe, however, (O. S. 511, 512) contain a very remarkable *Fasciolites* fauna, which deviates considerably from the fauna in the other localities. Besides *F. Wichmanni* Rutten, of which in other places only one doubtful specimen was found near Kakaha, this fauna includes a series of peculiar transitional forms, which are difficult to place in known species.

The lines of development instituted by BAKX, which rest entirely upon palaeontological grounds, could not be tested by the material from Soemba, as I could not command sufficiently detailed stratigraphic data. All Soembanese localities of *Fasciolites* belong to Tertiary-a_2.

There is no complete profile exposed in the deposits of this stage, so that we can only guess at the stratigraphic relation of the various localities.

Amongst the *Fasciolites* of the (stratigraphic) lowest locality Rete Balaroe (O. S. 299, 300) and those of the range of the Tandoela Djangga lying some hundreds of meters higher (topographically and in all probability also stratigraphically) no difference was found that could account for a development series of this kind.

The deviating forms in O. S. 511 and 512 come from the top of the Watoe Moendoe, 200 m. above sea level. This locality probably lies high in the profile, as just to the south of this hill Tertiary-a_2 is found at sea-level and the dip of the strata not being very steep this topographic difference of height may be taken to indicate an important difference in stratigraphic level.

The transion from *F. ovicula* to *F. javana* and the appearance of *F. Wichmanni* at this level would be in agreement with BAKX's hypothesis on the stratigraphic distribution (BAKX, p. 254), but a transition form from *F. ovicula* to *F. javana* was also found at Rete Balaroe and the great resemblance to *F. timorense* Verb. (*F. oblonga* Bakx) seen in some of the specimens from the Watoe Moendoe in the full grown state would lead to just the opposite conclusion as regards the phylogenie.

All this warns us, that we must still be very cautious with a detailed age determination on the ground of the *Fasciolites*, as long as the vertical distribution of the different species has not been tested by sound stratigraphic data.

FAMILY TINOPORIDAE

Genus Tinoporus

TINOPORUS BACULATUS (MONTFORT?) DERVIEUX

? 1808 Tinoporus baculatus, DE MONTFORT – Conchyliologie systématique, vol. I, p. 146.

non 1884 Tinoporus baculatus, BRADY – Rep. Voy. Challenger, Zoology, vol. 9, p. 714—716, Pl. CI, fig. 4—7.

1893 Tinoporus baculatus, DERVIEUX – Atti R. Acad. Sci. Torino, vol. 29, p. 6, fig. 19, 26, 34.

1918 Baculogypsina neotetraedra, TOBLER – Notiz über einige foraminiferenführende Gesteine von der Halbinsel Sanggar, Soembawa, Zeitschrift für Vulkanologie, Bd. IV, p. 190—192, Pl. XXXV, fig. 3—5.

1922 Baculogypsina neotetraedra, VAN DER VLERK – Studiën over Nummulinidae en Alveolinidae, Verh. Geol. Mijnbouwk. Genootsch. voor Nederl. en Kol., geol. serie, Dl. V, p. 397, 423, 454.

1927 Tinoporus baculatus, HOFKER – The Foraminifera of the Siboga Expedition, Part. I, p. 12, Pl. IV, fig. 2, 7, 8, 10; Pl. VI, fig. 4, 12, 13, 14, 19.

1930 Tinoporus baculatus, YABE and HANZAWA – Tertiary foraminiferous rocks of Taiwan (Formosa), Science Reports Tôhoku Imp. Univ., sec. series (geology), vol. XIV, No. 1, p. 44.

non 1933 Tinoporus baculatus, GALLOWAY – A manual of Foraminifera, Bloomington 1933, p. 310, Pl. 28, fig. (16 ?), 17 a—c.

In some sub-recent reef-limestones of East Soemba a many-chambered tetrahedral foraminifer was found, which completely corresponds to the organism which in Soembawa forms the principal substance of the sub-

recent reefs and tuffogene limestones and of the recent shore deposits, viz. TOBLER's "*Baculogypsina neotetraedra*" (TOBLER, 1918; VAN DER VLERK, 1922). It is a foraminifer with a tetrahedral arrangement of the megalospheric nucleoconch, surrounding which are a great number of later chambers, at first irregularly grouped, then built up one above the other in regular rows. Between the embryonic apparatus and a surface plane of the tetrahedron lie about 13—14 chambers. The whole test attains the size of 1—2 mm.

TOBLER's description and photographs characterize this remarkable fossil very well, so that it can easily be recognised. But the name "*Baculogypsina neotetraedra*", which TOBLER gave to it, cannot be justified. The characteristics of this organism are not the same as those typical of *Baculogypsina*, which is related to the *Rotalidae*. It is not, however, so easy to find a new, correct name; it seems to me that it would be best to substitute "*Tinoporus baculatus*", "*Baculogypsyna neotetraedra*" being exactly the same as *Tinoporus baculatus* as described by HOFKER. But there is still a great deal of confusion in the nomenclature of this group of foraminifera, although lately many experts have given their attention to it. CUSHMAN (1928) has eliminated the genus *Tinoporus*, and distributed the various species in the literature over the genera *Gypsina* and *Baculogypsina*, while he includes the latter, together with *Siderolites* in the family *Calcarinidae*. HOFKER (1927) makes a sharp distinction between *Tinoporus*, which he considers to be a genus closely allied to *Gypsina* (family *Tinoporidae*), and *Baculogypsina* which he includes in the family *Rotalidae*, together with *Calcarina*. HOFKER and CUSHMAN, thus, only differ in that HOFKER still allows the deviating genus *Tinoporus* to stand beside *Gypsina*. GALLOWAY (1933) again, mentions *Tinoporus* as a link in the chain of development between *Calcarina* and *Baculogypsina*, which he unites in the family of the *Tinoporidae*. Thus the *Tinoporidae* in HOFKER's classification embrace entirely different foraminifera than GALLOWAY's *Tinoporidae*.

The basis of this confusion lies in the original drawing of *Tinoporus baculatus* by DE MONTFORT (1808) which combines characteristics of both *gypsinoid* and *rotalid* nature, and which therefore may be variously interpreted by one author or the other. GALLOWAY lays stress upon the spiral development of the median chambers, HOFKER looks upon this as the central portion of a microspheric form, and adds DE MONTFORT's foraminifer, as forma B, to the megalospheric *Tinoporus baculatus* of DERVIEUX, which bears a *Gypsina*-like character. In how far HOFKER's

nomenclature is correct I will not here discuss, but be it said that his classification is based upon extensive personal research and therefore certainly deserves preference to classifications only based upon a study of literature.

HOFKER's research on the internal construction of his *Tinoporus* and *Baculogypsina* brought to light very remarkable differences between them, whilst these foraminifera sometimes bear externally a confusing resemblance to one another. As distinction HOFKER gives the following points:

Tinoporus in the immature stage of the megalospheric generation has a "raspberry" shaped embryonic apparatus, around which at first a mass of irregularly (*Gypsina*-like) arranged chambers form, this arrangement suddenly changing into regular rows; in *Baculogypsina*, the earlier formed chambers lie, as in all *Rotalidae*, in a distinct spiral, and on both sides of the median layer rows of chamberlets develop beside them. The "spines" of the test in tetrahedal *Tinoporidae* are caused by a special manner of growth of the chamberlets round a calcareous axis, which contains no canal system; in *Baculogypsina* the spines are solid formations of the supplementary skeleton and possess a very highly developed canal system [26]).

In connection with HOFKER's results we are driven to the conclusion that "*Baculogypsina neotetraedra*" belongs to HOFKER's *Tinoporidae*, and is probably identical to the A_2-generation of his *T. baculatus*. The only thing to remark is that it is a little smaller (the specimens of the Siboga material attain the size of max. 3 mm. from point to point) and the points are less pronounced, to judge by TOBLER's photographs. The section reproduced by him, corresponds exactly to this A_2-form. We shall, therefore, for the present call this foraminifer *T. baculatus* (assuming, thus, that HOFKER's *T. baculatus* actually is identical with DE MONTFORT's).

TOBLER's views on the relationship of "*B. neotetraedra*" to other species of foraminifera must be so far revised, that this foraminifer cannot be a special form of *Baculogypsina sphaerulata*, as this belongs to the true *Baculogypsinae* (Hofker); at the same time it remains undeniable that the species is very nearly related to *B. floresiana* (HOFKER: *Tinoporus floresianus*).

Tinoporus baculatus was found in great quantities by the Siboga Expedition, in the Nangamessi bay (N. Soemba) and in the roadstead

26) See for the related genera *Siderolites* and *Baculogypsinoides* YABE and HANZAWA, 1930, p. 44.

of Bima (N. E. Soembawa); PANNEKOEK VAN RHEDEN found this species as the principal component of the recent sand of the Saleh bay (N. Soembawa). In other places in this region it was found in lesser quantities. Further it is a rock-former in the sub-recent deposits of N.W. Soembawa (TOBLER, 1918; VAN DER VLERK, 1922); in East Soemba it is also found here and there in sub-recent reef limestones (O. S. 1, 7, 257).

TINOPORUS FLORESIANUS (SCHLUMBERGER) HOFKER

1896 Baculogypsina floresiana, SCHLUMBERGER – Mém. Soc. Zool. de France, vol. IX, p. 88, Pl. III, fig. 1, 2, 3; Pl. IV, fig. 7.

1918 Baculogypsina floresiana, TOBLER – Notiz über einige foraminiferenführende Gesteine von der Halbinsel Sanggar, Soembawa, Zeitschrift für Vulkanologie, Bd. IV, p. 191.

1927 Tinoporus floresianus, HOFKER – The Foraminifera of the Siboga Expedition, Part. I, p. 17, Pl. IV, fig. 1, 3, 4, 5; Pl. VI, fig. 1, 2, 3, 5, 6, 7, 9, 20, 21.

This usually globular *Tinoporus*, which is rather more delicately built than the former, often greatly resembles *Gypsina globulus* (according to HOFKER *G. globulus* is a special form of a *Tinoporus* species) but is distinguished from it by its solid radial pillars.

Tinoporus floresianus is very common in the recent coast deposits in these regions. The Siboga expedition dredged this species in great quantities on the coast of Flores and near Savoe; WITKAMP (1912, p. 625) found them as the principal component of shore sand on the reef west of Saloera (a small island to the south of East Soemba; determination by WICHMANN). On W. Soemba a sub-recent limestone was found (W. S. 334, 335) which is entirely composed of these almost spherical *Tinoporidae*, which lends it an almost oölithic appearance; in the reef-limes of East Soemba however, this species was seldom found (O. S. 7).

STRATIGRAPHIC VALUE OF THE GENUS TINOPORUS

As we have seen *T. floresianus* and *T. baculatus* are very common recent foraminifera in the region round Soemba. In older formations (tertiary) on the other hand, they do not seem to occur anywhere. They may therefore justly be regarded as indicators of very late deposits, and especially the tetrahedral form of *T. baculatus*, being easily recognisable, may be safely used in these islands as guide fossil for rocks of sub-recent age. According to HOFKER these two species are endemic in these regions.

FAMILY GLOBIGERINIDAE

Globigerinidae are very plentiful in the upper tertiary marls, particularly the genus *Globigerina*. Almost all these *Globigerinae* belong to the compactly built type, without supplementary apertures on the sutures (*Globigerina* s. str. Cushman); in the washed samples occasionnally *G. conglobata* or *G. sacculifera* were found, which belong to the type of *G. rubra* (*Globigerinoides* Cushman), with supplementary apertures.

It is remarkable that *G. bulloides* s. str. which is so general in the recent *Globigerina* ooze, is extremely uncommon in the Upper Tertiary of Soemba; it was only in O. S. 631 that it could be found in any quantity. Most of the fossil *Globigerinae* from this island are less lightly coiled; *G. bulloides var. triloba* Rss. was found in quantities, as well as a much coarser form of the same type of construction (possibly a *Sphaeroidina*?, see below), which here and there predominated over the rest. Further the *Globigerinae* were found, to which Koch gave the name of *G. bulloides var. quadripartita* and *var. tripartita*, and which differ from the *forma typica* by a much more closely coiled test. Of these last two forms, which may be prone to be index fossils of great value, we will supplement Koch's observations with a minute description, as the Soembanese material is much better preserved than Koch's was, so that more details could be observed.

Orbulina universa d'Orb. was found in almost all the upper tertiary marl samples; the form, in which two chambers can be observed externally, was also present.

Sphaeroidina aff. dehiscens (see below) was found in a large number, while on the other hand *S. bulloides* is rather uncommon. The genus *Pullenia* is not often met with.

Genus Globigerina

GLOBIGERINA QUADRIPARTITA KOCH (NOV. NOM.)

Pl. V, fig. 1, 2, 6, 11 and 12

1926 Globigerina bulloides var. quadripartita, Koch – Mitteltertiäre Foraminiferen aus Bulongan, Ost-Borneo, Eclogae geologicae Helvetiae, Bd. XIX, No. 3, p. 745, fig. 20 a—c.

Koch describes this *Globigerina* as follows:

Test spirally coiled, but more compact in form than *G. bulloides* s. str.

The last coil consists of 4 chambers, the last 2—3 chambers are elongated downwards and cover the very deep umbilicus to some extent. Ventral and dorsal side of the test are convex. The aperture could not be observed. In the reproductions fig. 20 b and c can be seen that the last two chambers are not only elongated downwards but at the same time flattened at the outer side.

In the upper tertiary marls of Soemba the same *Globigerina* was found, and in much better condition than KOCH's material from Borneo. In the typical representatives of this remarkable *Globigerina* the entire spiral can be seen from the dorsal side, the earlier formed chambers are well developed and almost globular. From the ventral side only four chambers are visible, they are grouped around a deep umbilicus and are all of much the same size. In specimens such as those shown in fig. 1, 2, it should be noticed that 3 of the four chambers gradually flatten out. These specimens correspond pretty well to KOCH's reproduction; in contrast to most cases where three of the chambers are more or less normally globular, while the 4th. is flattened and elongated and placed on the other side of the umbilicus symetrically opposite the 3 other chambers (fig. 11, 12). The last chamber is further distinguished from all earlier chambers, in both cases, by the wall having a different structure: while the earlier chambers are somewhat transparent and have distinct perforations, the wall of the last chamber is smooth, opaque white and more finely perforated. It is remarkable that this specialisation of the wall of the last chamber does not appear in the specimens that are not typically developed, for instance a specimen in which a 5th chamber tries to insert itself into the last whorl (fig. 10) or in transitory forms from *G. quadripartita* to *G. tripartita*, the last of which usually shows the specialisation in an even stronger degree. (This transition form, which seldom appears, should probably be regarded as an incompletely developed *G. tripartita*, in spite of the 4 chambers in the last whorl.) Specialisation of the last chamber, both as regards the shape of the chamber and the structure of the wall, is therefore confined to the typical specimens, showing that there is no regular gradual transition from the typical *G. quadripartita* to the typical *G. tripartita*. As moreover the connection between these two forms and *G. bulloides* s. str. is not clear, I here prefer to regard *G. quadripartita* and *G. tripartita* as separate species and not as varieties of *G. bulloides*.

No signs of an aperture could be observed in the Soembanese specimens either. Probably the chambers open out very deep in the umbilicus, but this was always stopped up with detritus which I was not able to

remove without destroying the delicate fossil. Thus it was impossible to determine whether each chamber had a direct outlet into the umbilical cavity, as in *G. bulloides;* supplementary apertures along the sutures are completely absent, so that these *Globigerinae* certainly do not belong to the genus *Globigerinoides* Cushman.

The typical *G. quadripartita* is an easily recognisable species. The most important characteristic, however, is not the number of four chambers in the last whorl, which is found in other forms as well (*G. conglobata, G. conglomerata* Schwag., *G. pachyderma, G. "bulloides"* Stache, *G. bulloides* d'Orb., etc.) but rather the flattening of the last chamber(s), the deep umbilicus and above all the convexity of the test both above and below. In recent material from the Kei islands, there was a small specimen of *G. bulloides,* in which the last whorl was composed of only 4 chambers. Seen from below this test greatly resembled *G. quadripartita,* but from the side it was seen to have the ordinary *bulloides* construction, in which the earlier formed spiral scarcely protrudes above the top of the latest chambers. In this recent *G. bulloides,* therefore, the spiral lies much more in one plane. The same difference makes it also possible to distinguish the five-chambered form of *G. quadripartita* from a normal *G. bulloides.* It is more difficult to find a distinct difference between *G. quadripartita* and *G. conglobata.* When we have small specimens of the latter, with four chambers in the last whorl, and when these are not well enough preserved to show the supplementary apertures in them, we might easily be lead to determine them as *G. quadripartita; G. conglobata* also has a fairly high test and a somewhat flattened last chamber. But *G. quadripartita* can be distinguished from such specimens by its deep umbilicus, which is never found in *G. conglobata.*

As in the recent *Globigerinae,* in the Soembanese *G. quadripartita* a distinction can be made between the rather coarse benthonic and the much smaller and more delicate pelagic form (Pl. V, fig. 6); the former, which is far the most frequent, is 0,55—0,9 mm. in size, the latter is only 0,35 mm. The second is usually found in fine grained fossil-poor marls (e.g. O. S. 12) and shows also the specialisation of the last chamber.

G. quadripartita, which was found in great quantities in Soemba, is here used as a guide fossil in the determination of the age of deposits; see for this p. 193—194.

GLOBIGERINA TRIPARTITA KOCH (NOV. NOM.)

Pl. V, fig. 3, 4 and 5

1926 Globigerina bulloides var. tripartita, KOCH — Mitteltertiäre Foraminiferen aus Bulongan, Ost-Borneo, Eclogae geologicae Helvetiae, Bd. XIX, No. 3, p. 746, fig. 21 a—b.

KOCH gives as typical characteristics:

Shape, similar to *G. bulloides var. quadripartita*, but with only 3 chambers in the last whorl. The last three chambers are so large that they occupy almost 5/6 of the whole height of the test. The earlier formed chambers lie in a flat spiral which rises only a little above the last whorl. Umbilicus very deep. Sutures between the last 3 chambers deeply cut and open.

In the reproduction (fig. 21a) may further be seen that the earlier chambers are not well rounded, but flattened against each other to some extent. KOCH was unable to find the aperture.

In the upper tertiary marls of Soemba this *Globigerina*, which is fully 1 mm. in size, was frequently found. The material is much better preserved than KOCH's; we may therefore supplement his description by the following notes:

Of the three chambers visible from the ventral side, only the first formed is externally almost globular, the other two are flattened on the outside and below elongated into a point (cf. KOCH' "open sutures"). This gives to the whole test, seen from the side, something the appearance of a flowerbud. The ventral edge of these two chambers is fairly sharp and covered with bosses and blunt spines, a peculiarity which in KOCH's specimens had been quite lost through fossilization. The perforations of the earliest of the three chambers is rather coarse and corresponds completely to that of the earlier whorls of the test; but the two later chambers have a much more finely perforated wall, which is smooth and opaque white. In this fossil there is a specialisation, thus, similar to that in *G. quadripartita*.

The whorls of *G. tripartita* are somewhat involute, that is to say: the later whorls surround the earlier ones to some extent on the ventral side. The last three chambers enclose a narrow deep umbilicus. As no aperture was observed, it could not be decided whether this *Globigerina* belongs to the *bulloides* type, where every chamber opens separately into the umbilicus. As, moreover, no distinct transition forms towards *G. bulloides* s. str. were found, it seems to me better to divide *G. tripartita* from *G.*

bulloides, as a separate species (see also *G. quadripartita*). Supplementary apertures on the sutures are not found in this species.

I can hardly believe that, as KOCH says, *G. tripartita* seen from below could be confused with *Sphaeroidina dehiscens*, at least if the material is good. Occasionally, however, *G. conglobata* may resemble *G. tripartita*. This is the case with small very compactly built specimens of *G. conglobata*, in which only three chambers can be seen ventrally. But even when the large gaping chief aperture and the supplementary apertures are stopped up with detritus, these specimens could not be mistaken for *G. tripartita*, as they have no umbilicus, and have not the distinct spiral of earlier chambers visible on the upper side.

G. tripartita is an even better defined species than *G. quadripartita*. It is not known in the earlier literature; STACHE's *G. angipora* (see CHAPMAN 1926, fig. 36a) resembles it to some extent but is probably not identical with it.

For the value of *G. tripartita* as index fossil see p. 193—194.

GLOBIGERINA KOCHI NOV. SPEC.

1923 Globigerina spec., KOCH – Die jung-tertiäre Foraminiferen-fauna von Kabu (Res. Surabaja, Java), Eclogae geologicae Helvetiae, Bd. XVIII, No. 2, p. 355, fig. 8 a, b.

This *Globigerina*, considered by KOCH a good guide fossil for the deposits of Kaboe, was also found here and there on Soemba in the upper tertiary marls. The fossils were not good enough to supply further details to KOCH's original description.

It is a small, flat *Globigerina*, on the upper side of which a close somewhat excentric spiral is seen of small chambers, not easily to be distinguished one from another, while on the other side only 4 chambers are visible. These 4 chambers gradually increase in size from the earliest to the latest and the last chamber is slightly elongated horizontally which gives the test something the appearance of a strongly compressed *G. sacculifera*. There are, however, no supplementary apertures on the sutures. The four latest formed chambers lie round an undeep umbilicus; no aperture was observed.

For the value of this *Globigerina* as guide fossil, see p. 194. It was found in samples O. S. 263, 457, 499, 537, 631 and 753.

Genus Sphaeroidina

Sphaeroidina aff. dehiscens Parker et Jones

In the upper tertiary globigerina marls an organism is very frequently found which I have, under reservation, determined as a form related to *Sphaeroidina dehiscens*. It is a fairly large *Globigerina*-like fossil, in which externally only 3 closely joined chambers are visible. The latest formed of these chambers occupies about half of the entire test, and the two earlier ones a quarter each. The chambers are attached to eachother along straight sutures, without the deep open cuts between them, which are characteristic of the *Sphaeroidina dehiscens*. Neither is there any trace of the characteristic jagged edge bent outwards, differing in sculpture from the rest of the test, and it cannot be supposed that these two peculiarities have here been lost by fossilization. The exterior is well preserved and presents a regular rough net-work moulding, without spines. An aperture could not be observed.

In regard to general habitus the fossil greatly resembles the *Globigerina seminulina* from Kar Nicobar, that Schwager has reproduced; except that the last chamber is slightly wider, which gives the general shape of the test a rather more rounded cylindrical form. According to Brady (Challenger) this *G. seminulina* is identical to *Sph. dehiscens*. Fischer found *Sph. dehiscens* in a fossil state in various places on Ceram and gives as further localities: Pliocene from the Nicobar Islands, Bismarck Archipelago, Solomon Islands and New Guinea.

Whether the forms from Soemba may also be attributed to this species, seems to me very doubtful owing to the absence of the split and the jagged edge. But to judge by the extremely compact build of the test, it seems probable that we are dealing with a species of the genus *Sphaeroidina*.

VARIOUS OTHER SMALLER FORAMINIFERA

Uvigerina javana Koch

1923 Uvigerina javana, Koch – Die jung-tertiäre Foraminiferenfauna von Kabu (Res. Surabaja), Eclogae geologicae Helvetiae, Bd. XVIII, No. 2, p. 353, fig. 7.

Koch describes *Uvigerina javana*, which he regards as a good guide fossil, as follows:

Test round-egg-shaped, with truncated apex. Chambers fairly large, the last three, which are highly inflated, constitute the greater part of the test. The sutures are shallow. A number of widely separated sharp ridges run over the lowest part (earliest chambers); the last three chambers are smooth, or only underneath show the first beginning of ridges. The aperture, which is surrounded by a flat rim, lies at the end of a short neck. This neck is planted in a depression in the last chamber, and in the reproduction it can be seen that it does not lie in the continuation of the axis but slightly to one side.

KOCH gives as the most closely related species: *Uvigerina crassicostata* Schwag. and notifies further, that there were also forms amongst his material which were relatively longer than the specimen reproduced.

The soft marl sample O. S. 263 provided a *Uvigerina* which is probably identical with these more slender forms of *U. javana*. The test shows the same sculpture as KOCH's reproduction, but is conspicuously less thick at the upper end, as the later chambers are much less inflated. The general shape, therefore, is about the same as *U. crassicostata*. But there is a difference, viz. that in the last named species the aperture springs from the last chamber without a depression and lies more or less in the direction of the axis of the test. (SCHWAGER, Kar Nicobar, fig. 94), while the neck in the Soembanese specimens corresponds exactly to *U. javana*.

KOCH bases his belief in the close relationship between *U. javana* and *U. crassicostata* entirely upon the sculpture, which shows a great resemblance in the two species. But in my opinion the position of the aperture is a more important characteristic and therefore I do not regard *U. crassicostata* as the most nearly related form, but *U. nitidula* Schwag., which has also been found on the Nicobar Islands. *U. nitidula* differs from *U. javana* by its much more slender shape and by the presence of continuous ridges over all the chambers.

For the value of *U. javana* as guide fossil see p. 194.

ROTALIA CALCAR D'ORB.?

Pl. V, fig. 7, 8 and 9

1846 Rotalina aculeata, D'ORBIGNY – Les foraminifères fossiles du bassin tertiaire de Vienne, p. 159, Tab. VIII, fig. 25—27.

1866 Calcarina Nicobarensis, SCHWAGER – Die fossilen Foraminiferen von Kar Nicobar, Novara Exp., geol. Theil, Vol. II, p. 261, Taf. VII, fig. 114 and fig. 3.

1915 Rotalia calacar, CUSHMAN – A monograph of the Foraminifera of the North Pacific Ocean, Smithsonian Inst. U. S. Nat. Mus., Bull. 71, pt. 5, p. 69, pl. 28, fig. 2.

1921 Rotalia calcar, CUSHMAN – Foraminifera of the Philippine and adjacent seas, Smithsonian Inst. U. S. Nat. Mus., Bull. 100, vol. 4, p. 350, pl. 71, fig. 3 a—b.

Compare also: 1927 HOFKER – The foraminifera of the Siboga Expedition, part. I, p. 34, etc.

SCHWAGER records a foraminifer from Kar Nicobar, which he calls *Calcarina Nicobarensis*, and of which he gives a detailed description and three beautiful illustrations.

The same fossils, but in a less perfect form than shown in SCHWAGER's reproductions, were found on Soemba in various upper tertiary marls and this find gives rise to a discussion of SCHWAGER's determination.

SCHWAGER describes his "*Calcarina*" about as follows:

Test spirally coiled; the last whorl is formed of 10—12 chambers, which at the outside run out in points. The chambers are only slightly vaulted on the dorsal side; on the ventral side the vaulting is more marked, so that the chambers there have an obtuse roof-shape and are separated by deep sutures. This vaulting is practically constant in all specimens.

The large umbilicus is usually covered by an umbilical plug which is surrounded by an irregular groove.

The surface is rough, with grooves and nodules. Even when the foraminifera deviate in form from the regular type (which often happens), they can always be recognized by this peculiar surface.

All that could be seen distinctly of the canal system was radial canals between the chambers. SCHWAGER thinks it probable that these branch and become narrowed at the end and finally open out on the surface.

Further SCWAGER records that this *Calcarina Nicobarensis* is also found in great quantities in recent deposits on the coast of the Nicobar Islands. As the most nearly related species he names *Rotalina aculeata* d'Orb.

SCHWAGER's description is entirely applicable to the above mentioned fossils from Soemba. These are also very diverse in shape, but they can always be recognized by their peculiar rough surface. Good specimens are rare, they have only been found in samples O. S. 5, 9 and 462. The fossils from Soemba are, generally speaking, somewhat thicker than SCHWAGER's specimens.

Nevertheless this fossil should not be called *Calcarina Nicobarensis*. It is not a *Calcarina* but a *Rotalia*, as the following particulars will prove:

there are no traces of spines, formed by the supplementary skeleton; the protruding points at the circumference are extensions of the chambers themselves, in which the lumen runs into the very extremity;

the umbilical plug is surrounded by a fairly distinct groove, while on the upper side of the shell the spiral coiling can be followed to the very centre; the supplementary skeleton, therefore, does not overgrow the test, as it does in *Calcarina;*

in the canal system a straight radial canal runs between the septa of the chambers, in the outside wall of the test dividing into two equal branches, which according to HOFKER is typical of the genus *Rotalia* (Siboga I, p. 38—39, Pl. XIX, fig. 2—3; Pl. XXI, fig. 2).

On closer examination this *"Calcarina Nicobarensis"* proves to be identical with a certain form of *Rotalia calcar*, and it is remarkable that it has never been named as a synonym of this species. *Rotalia calcar* is a species which is rather variable in external form. HOFKER distinguishes a "hispid" and a "calcarine" form, which correspond to BRADY's *R. hispida* and *R. calcar* respectively, but which both deviate considerably from the fossils from Soemba and the Nicobar Islands. These fossils, resemble a third form, viz. the spineless variety, which CUSHMAN reproduces in his description of material from the Northern Pacific Ocean and the Philippine Seas. D'ORBIGNY's fossil *Rotalina aculeata* from the Basin of Vienna, which SCHWAGER regards as very closely related, is probably identical with them.

ROTALIA ELPHIDIOIDES NOV. SPEC.

Pl. V, fig. 13, 17.

The marl O. S. 631 yielded a great number of small foraminifera, among which a very peculiar rotaloid organism was found that does not belong to any known species.

The horizontal diameter of this fossil can be very large, viz. max. 3,5 mm., but varies a great deal. In the 8 specimens that were found diameter and thickness are (in mm.):

diameter	3,5	2,6	2,9	2,8	1,9	1,8	1,3	1,2.
thickness	1,8	1,6	?	1,8	1,2	1,1	1,1	1,0.

Both dorsal and ventral side of the test are convex. The vertical section reveals a rotaloid build, beginning with a microspheric initial chamber in the larger specimens (and probably also in the smaller ones, which seem to be immature forms).

In the large specimens practically nothing can be seen of a spiral on the dorsal side, nor of radiating sutures on the ventral side, because of a covering mass of secundary shell material, which is ploughed with innumerable fissures. The smaller (immature) specimens are very instructive in showing different stages of development of this complicated structure. Originally only the umbilical area and the depressed sutures of the chambers were covered by clear shell material. The umbilical mass is perforated by very coarse canals, while at the periphery of the shell it is clearly seen that the narrow bands covering the sutures are flanked on both sides by a row of, probably alternating, pores (Pl. V, fig. 13). In a later stage the sutural bands, having developed into protruding ridges, are segmentated by a great number of fissures, each of which connects a pair of pores lying on either side of the ridge. In the larger specimens the secundary material occupies a greater part of the surface, so much so, that the internal structure of the shell is indicated only by the arrangement of the fissures (see Pl. V, fig. 15—17).

The aperture in the smaller specimens is a narrow elongated pear-shaped opening at the inner margin of the septum.

The horizontal section shows numerous chambers, arranged in 4—5 whorls. The septa are double; the thick outer wall of the chambers is very finely perforate. No real canal system could be observed, but between the two lamina of a septum there is often a very conspicious space, which opens, sideways of the wedge of clear shell material in the sutures, into the pores of the superficial fissures (see Pl. V, fig. 14).

It is somewhat difficult to ascertain the correct place in classification for this remarkable organism.

At first sight one is apt to include it in the genus *Polystomella* (or *Polystomellina*) because of the fine rows of fissures over its sides. But the bridges between the fissures are formed of massive shell material instead of being processes of the protoplasma. The highly developed covering of secundary shell material would lead to the conclusion that it is a *Calcarina*. To this classification, however, there are two objections: in the first place our fossil lacks spines, and in the second place the pores of the chambers are very fine and do not melt together before opening at the surface (cf. HOFKER, Siboga I, p. 35—39, 44). Thus it appears best to place it among the true *Rotaliae* and I will give it the name of *Rotalia elphidioides*, which name indicates its remarkable resemblance to the genus *Elphidium* (= *Polystomella*). The prototype of this fissured rotaloid organism is to be found in *Rotalia Beccarii* Linn., the "central species

of the genus" (BRADY), which often shows open sutures with lateral incissions on the ventral side, but in which there is no secundary material along the sutures (see BRADY, Challenger, Pl. CVII, fig. 3; CUSHMAN, North Pacific Ocean, Part. V, Pl. 30, fig. 3; CUSHMAN, Atlantic Ocean, Part. 8, p. 58—59, Pl. 12, fig. 5—7, Pl. 13, fig. 2).

Occurence: O. S. 631.

Age: Tertiary-f.

AMPHISTEGINA WANNERI FISCHER

1910 Amphistegina sp. nov., WANNER - Beiträge zur Geologie des O. Arms der Insel Celebes, Neues Jahrb. für Mineralogie, etc., Beilage Bd. 29, p. 761.

1927 Amphistegina Wanneriana, FISCHER - Beitrag zur Kenntnis der Pliozänfauna der Molukken-Inseln Seran und Obi, Palaeontologie von Timor, Lief. XV, p. 170, Pl. CCXVII (6), fig. 131 a—c.

This small usually flat *Amphistegina* can be distinguished from *A. Lessoni* d'Orb. by the stripes on the surface being represented by rows of fine hyaline dots, while between these rows two or three shorter rows of dots lie. FISCHER did not find any transitory forms between this and *A. Lessonii*. As a matter of fact the difference between these two species is considerable. There is more similarity between *A. Wanneri* and *A. radiata* Ficht. et Moll. Most of the specimens of *A. Wanneri* which were found on Soemba in the Upper Tertiary, correspond exactly to FISCHER's illustration; at the same time more deviating forms were found, which had fewer granulations, or in which septa, although discontinuous, could be more clearly traced.

CHAPTER III

STRATIGRAPHY

AGE DETERMINATION OF THE ROCK SAMPLES

The stratigraphic results of the field work on Soemba did not prove to give so much support for the palaeontologic research of the collection of samples as the first chapter of the report would lead one to expect. In most cases it is impossible to group the samples according to their localities and then study the fauna of the bed as a whole.

This method could only be applied to a certain number of the least interesting samples. The first group that can be distinguished is formed of the subrecent rocks in which the label usually says "found in the 1st, 2nd, 3rd etc. sea terrace" and which, moreover, in the first general examination were annoted by KEMMERLING as "sub-recent". In so far as these rocks belong to the unbroken bank of terraces along the coast, which form a well defined element in the field, these samples may safely be united as sub-recent deposits, even though they have not nearly all been microscopically examined, and although they contain extremely few index fossils. On the other hand the terrace relics from the inland can only be attributed to this under reservation as these reef limestones, may easily be confused with tertiary reefs (which in fact has frequently been done) while here and there terraces occur of a different origin which cannot be distinguished from them. The terraces near Kakaha, for instance, which according to KEMMERLING are probably fluviatile, contain rocks of various age, including some from the lowest layers of Lower Tertiary.

A second group contains the sediments very poor in fossil content from the base of the Tertiary which KEMMERLING has marked "Lowest Eocene".

A third group was distinguished according to the lithologic habitus, i.e. the light-coloured, principally white, marl deposits. Generally speaking, the nature of the sediment, at any rate in a superficial macroscopic examination, is an untrustworthy basis for stratigraphy. As, however we know from the field geologic examination of Soemba, that the "white

marls series", the upper tertiary plateau, here stands as a sharply defined unity, as against the usually darker and more yellowish lower deposits, and that moreover in numerous marl samples an upper tertiary fauna is found, it may be assumed for all these marls, that they originate from this plateau. At the same time, too much reliance should not be placed on classifications by colour, as white rocks are also found containing an eocene fauna; these, however, are not marls.

The age of the rest of the samples, on the other hand, had to be determined separately for each rock specimen, by palaeontologic methods, without the help of stratigraphic data. This was partly because in the field no more could be done than to divide the deposits into Upper and Lower Tertiary, while in the examination of the foraminifera it was our purpose to make a further subdivision. But the difficulties of this task are chiefly caused by the inexplicable carelessness with which the collection has been put together. Although it is evident from the reports of the field work that locally the deposits could be well distinguished and that here and there a good section was exposed, the labels on the rock samples hardly ever say from which layer they come, while in the neat drawings of such sections belonging to the reports there is hardly ever a number indicating one of the samples, nor yet in the accompanying descriptions.

The definition of the age in the greater part of the collection was therefore necessarily made from the fossil content, that is, the foraminiferal fauna. Our knowledge of the stratigraphic value of tertiary foraminifera has been constantly increasing during the last years through the work of various experts, so that there are plenty of index fossils amongst this order. At the same time the deposits of Soemba are extremely rich in foraminifera; so at first sight it does not seem a difficult task to determine the age of the rocks. Nature, however has thrown her own difficulties in our way.

In the first place we encounter the difficulty caused by the washing in of derived foreign fossils. Anyone who has walked along a coast where the sea exercises its destructive powers on a moderately hard fossil bearing rock and has noticed how fossil and recent shells may lie comfortably side by side on the shore and be buried in the same sediment, will be able to understand how it is that sometimes in a rock two kinds of index fossils may be found, each indicating a different stratigraphic layer. In unstable districts, where the coast-line is constantly changing, it will be by no means an uncommon occurrence that fossils are washed away from the disintegrating rocks in which they have lain imbedded,

to find a secondary asylum in a new sediment; the surprising thing is that it is not more frequently found than has been done so far. The foraminifera, which by their smal size and resistant build are in general better able to endure a transportation of this kind than larger fossils, are peculiarly apt to cause confusion. In defining the age of a foraminiferous rock it should always be remembered that it may be of a later formation than would seem from the presence of some particular index fossil. In such complicated cases there is fortunately usually some indication of washing in; bits of crumbled rock are found in which the older fossils may be enclosed, or here and there a piece of the original matrix will still adhere to the fossils, easily distinguished from the new groundmass. Again the earlier fossil may have been fossilized in a different way to the later ones which are inherent in the rock under examination. But we are not always so fortunate as to find these indications, in which case we might doubt the value of such index fossils. All the same the stratigraphic distribution of the foraminifera, at any rate as regards the most important index genera, has been so firmly established in the course of time by constant checking, that even in these cases its value need not be questioned.

In Soemba the Upper Tertiary began with a great transgression by which apparently considerable masses of earlier rocks were broken up. As VAN DER VLERK immediately found in his preliminary survey of a part of the collection, *Camerina Fichteli* often occurs on East Soemba as derived fossil in the neogene deposits.

Not only the sea, but fresh water as well, may cause the presence of misleading guide fossils. This must be the case with an *Assilina* which was found in a sub-recent terrace limestone on N. E. Soemba. This *Assilina* is probably derived from the neighbourhood of the Massoemountains, where *Assilina* bearing rock is exposed, and must have been carried by river to the N. coast across the island that had risen above the sea-level in subrecent times.

It is possible to imagine a case in which early fossils might be secondarily deposited in later sediments which of themselves are without fossils. In that case an erroneous age definition is unavoidable, unless the state of preservation of the fossils, or the stratigraphic position of the rock proves that the locality is secondary. On Soemba a few rocks of this kind were found, which suggested the idea that their fossil content was entirely secondary. These are the sandy samples O. S. 235, 310, 311 and to a lesser degree O. S. 64, in which the lower tertiary foraminifera are all very much waterrolled, and in the slides contrast

clearly to the groundmass of the rocks, having a sharp black contour. This suggests that the weathering has taken place during the disintegration of the rock in which the fossils were originally imbedded in an undamaged state. Their position in the field (locality, dip of the strata) renders all doubt impossible that we are, in fact, dealing with early deposits. The foraminifera must, therefore, have been reduced to this deplorable state by some other cause, previous to the fossilization, and a glance at any recent reef-sand, with its almost unrecognisable organic constituents, makes it evident that a similar phenomenon in fossil sediments must have been caused by the action of breakers.

A second difficulty, which, being much more common, may lead to more serious consequences, is the absence of definite index fossils. A definition of age by negative data is naturally always dangerous and should never be made without a certain reservation. In the first place it should never be forgotten that in the laboratory only a very minute portion of a deposit can be studied and it must be very much a matter of chance whether we get specimens of the whole fauna or only a small part of it. It may also occur that owing to various external circumstances one or more of the index fossils are actually lacking in the whole deposit; we can easily imagine that the nature or the surroundings in one spot will be more favourable to the growth of an organism than in another spot, or that the empty shells have been passively transported by water currents, causing a differentiation in the sediment according to shape or weight, or again that in rough water it was only the most resistant forms that could endure for later fossilization. In any case, the chance is great, that the elements of a chronologically connected fauna will be separated from one another in the deposit. When the fauna is incomplete, therefore, in determining the age of the sediment it is generally speaking necessary to look for support in the stratigraphy of the locality. In the course of this chapter we shall discuss in what manner and in what degree of accuracy the definition of age can be made in the case in point, where the mutual position of the various rocks is very insufficiently known.

Subdivision of the Tertiary used here

The most convenient way of marking the age in the Soemba collection was the letter method which van der Vlerk and Umbgrove (1927) instituted for the subdivision of the Tertiary in the Dutch East Indies on the basis of their study of foraminifera, and which was later more completely worked out by van der Vlerk and Leupold (1931).

I do not agree with DOORNINK in his idea (1932, p. 304) that this arrangement is of a very preliminary character, and that after a study of the Javanese *Camerinae* we can immediately proceed to a parallelization of the tertiary beds in the Malay Archipelago with the subdivisions of the Tertiary in Europe and Western India. DOORNINK's research by no means proves that these widely separated territories may be directly and in all details compared to one another. In my opinion VAN DER VLERK and UMBGROVE's arrangement does not bear a temporary character but a purely local one; it has the advantage that the data gained can all be easily fitted into the stratigraphy of the Archipelago without chance of confusion, and is therefore to be preferred, even for the Lower Tertiary, to the introduction of all sorts of terms from the classical European districts.

ANNOTATED LIST OF AGE DETERMINATIONS

1. East- and Middle-Soemba

Rocks without index fossils, but belonging to the "Lowest Eocene" (TERTIARY–a_1 ; see p. 212):

O. S. 144. Greyish-blue eruptive sandstone.
271 ? Grey calcareous sandstone, underlying O. S. 270 (label: Lowest Eocene).
279. Heterogeneous sandstone containing feldspar and mica, cementated with clay and chlorite.
280. Grey conglomeratic calcareous sandstone.
281. Same as O. S. 280.
284. Calcareous clayey sandstone containing *vegetable remains*.
292. Coarse greyish-blue calcareous eruptive sandstone containing a few *molluscs* and *Globigerinae*.
293. Clayey sandstone.
294. Cement of the conglomeratic sandstone O. S. 292.
296. Limy concretions in O. S. 292.
297. Calcareous sandstone containing *molluscs;* same as O. S. 292.
304. Greyish-blue calcareous sandstone containing *molluscs*.
305. Same as O. S. 304, containing *molluscs* and *vegetable remains*.
307. Cristallized limestone with layers of hornstone.
312. Greyish-blue calcareous conglomerate.

TERTIARY–a_2 (see p. 204).

Characterised by the presence of the index fossils *Assilina* and *Fasciolites ovicula*:

O. S. 62. With *Assilina orientalis, Camerina kelatensis, C. irregularis, C. borneënsis* and *Discocyclina javana* (small form).
223. With *Fasciolites celebensis.*
236.
286. With *Camerina kelatensis.*
299. With *Assilina orientalis* and *Fasciolites ovicula-javana.*
300. With *Assilina orientalis* and *Camerina kelatensis.*
780. With *Camerina c.f. kelatensis.*

With *Assilina* and *Fasciolites celebensis:*

O. S. 126. With doubtful *Assilina* and with *Camerina Kemmerlingi.*
130.
235. With *Discocyclina.*

With *Assilina, Fasciolites Wichmanni* and *F. Wichmanni-timorense:*

O. S. 512. With *Discocyclina.*

With *Assilina* and undeterminable *flosculinised Fasciolites:*

O. S. 315.

With *Assilina* (*Fasciolitidae* absent):

O. S. 64. granit régénéré.
302. With *Camerina aff. tabalarensis.*
310.
516a.
517. With *Assilina orientalis* and *Camerina kelatensis.*

With *Fasciolites ovicula* or other *flosculinised Fasciolites* (*Assilina* absent):

O. S. 109. With *Discocyclina.*
125. With doubtful *Assilina.*
134. With *Fasciolites c.f. Wichmanni, F. c.f. celebensis* and *F. spec. indet.*

136.
211.
237. With *Camerina Kemmerlingi*.
243. With *Discocyclina*.
511. With *Fasciolites Wichmanni* and other species, *Camerina c.f. javana* and *Discocyclina*.
514. With *Discocyclina*.
790. With *Discocyclina*.

With *Camerina Kemmerlingi* and *C. aff. taballarensis* with its smaller variety:

O. S. 61.

With *Camerina borneënsis* (other guide fossils absent):

O. S. 234.

With *Camerina aff. taballarensis* (other guide fossils absent):

O. S. 60. Locality near O. S. 61.

Without index fossils, but for other reasons determined as Tertiary-a:

O. S. 301. With *vegetable remains* (lignite), somewhat similar to O. S. 302; of the same locality and height as O. S. 300.
311. As O. S. 310 (*Assilina* absent in this sample).
516. Fine marly sandstone enclosing a layer full of large *Assilinae* (O. S. 516a).
518. Rock similar to O. S. 512; locality same as O. S. 517 (containing dubious *Assilinae*).
519. Dark brown calcareous sandstone with only few fossils (*Miliolidae, Camerina, Fasciolites*), forming the highest bed of the Lower Tertiary in the section of the Tandoela Djangga, overlying O. S. 517 and 518.
796. Rock and locality as O. S. 519.

According to the macroscopic appearance of the rock, the following samples represent the same stage:

O. S. 133. Fine greyish-brown calcareous sandstone containing small *Camerinae;* rock similar to O. S. 234.

137. Coral limestone containing many *Miliolidae;* locality: fluviatile terrace near Kakaha.
221? Dark brown conglomeratic sandstone, similar to O. S. 519.

TERTIARY-b.

Characterised by the presence of the guide fossils *Camerina, Pellatispira* and *Discocyclina,* and the absence of *Assilina* and *flosculinised Fasciolites:*

O. S. 65. Sandy limestone full of *Discocyclina; Pellatispira* doubtful.
107. Same as O. S. 65.
114.
116. Rock similar to O. S. 64 (Tert. -a), but with larger foraminifera; *Pellatispira* doubtful.
117. Same as O. S. 65.
146. Same as O. S. 65; *Pellatispira* doubtful.
147. Same as O. S. 146; *Pellatispira* doubtful.
152.
160.
169.
170.
174.
182.
207.
433.
508. With doubtful *Camerina.*
509.
513.
761.
765.
766.
773.

With *Pellatispira* and *Discocyclina,* accidentally devoid of *Camerina:*

O. S. 35. *Pellatispira* doubtful.
151.
510.

With *Pellatispira* and *Camerina,* devoid of *Discocyclina:*

O. S. 148.

165.
185.

With *Pellatispira*, accidentally devoid of *Camerina* and *Discocyclina:*

O. S. 767. Same as O. S. 765, somewhat more compact.

With *Camerina* and *Discocyclina* (*Pellatispira* absent):

O. S. 106. Same as O. S. 65.
110. Same as O. S. 147, but more sandy and very poor in large foraminifera.
112.
120.
131. Same as O. S. 65.
138. Same as O. S. 65, but accidentally devoid of *Camerinae.*
228.
229.
241.
256.
316.
764. Boulder in subrecent terrace-limestone.
768.

Without the typical combination of foraminifera, but for other reasons determined as Tertiary-b:

O. S. 132. With *Camerina* only, but rock and locality practically the same as O. S. 131.
163. Rock and fauna of smaller foraminifera exactly the same as O. S. 151, but accidentally devoid of guide foraminifera.
164. With large *Camerinae* only; rock and locality practically the same as O. S. 110.
207a. Rock and locality same as O. S. 207.
246 ? With *Neoalveolina c.f. pygmaea;* appearance of rock like that of lower tertiary deposits, locality near O. S. 241 and 243 (Tert. a-b).

TERTIARY - C.

Characterised by the presence of *reticulate Camerinae* (*C. Fichteli* and *C. intermedia*) in combination with *radiate Camerinae* (in most cases *C. c.f. pengaronensis*):

O. S. 29.
168.
173.
287. With *Neoalveolina*.
328. With *Cycloclypeus*.
430. (*reticulate Camerinae* somewhat doubtful).
472.
484.
533.
535.
536.
771.
774.

With *reticulate Camerinae*, without *radiate Camerinae* and without *Lepidocyclina*:

O. S. 226. With *Neoalveolina*.
270.
336.
366. With *Neoalveolina*.
367. With *Neoalveolina*.
426. With *Neoalveolina*.
428. With *Neoalveolina*.
431.
467.
473.
479. With *Neoalveolina*.
490a. Boulder in O. S. 491.
602.
677.

Without *reticulate Camerinae*, but nevertheless probably belonging to this stage:

O. S. 538. } With *C. c.f. pengaronensis*, rock like O. S. 535; locality
539. } practically the same as O. S. 535 and 602.

Without *Camerinae* or other index fossils, but for other reasons determined as Tertiary-c:

O. S. 27. Rock and locality same as O. S. 29.
428. Rock and locality same as O. S. 426.
429. Rock and locality practically the same as O.S. 431.
434. Rock and locality same as O. S. 428.
471. Rock practically the same as O. S. 467; locality near O. S. 472 and 473.

TERTIARY-d.

Tertiary-d is characterised by the occurence of both *Camerina* and *Lepidocyclina* (*Eulepidina*).

In East Soemba finding this combination does not absolutely prove the presence of Tertiary-d, as in many cases it is due to the washing in of *Camerinae* into upper tertiary deposits containing *Lepidocyclinae*.

Genuine Tertiary-d is extremely rare; it was met with only twice in the collection O. S., viz.:

O. S. 47. Rock a yellow limestone entirely composed of *reticulate Camerinae*, here and there in combination with *Lepidocyclina* (*Eulepidina*) *tjendanensis* nov. spec.
285. Grey *Lepidocyclina*-lumachelle (*L. tjendanensis*) with scattered *reticulate Camerinae*.
(See discussion of the age determination of Tert. c-d on p. 190.)

TERTIARY-e.

Characterised by the combined presence of *Eulepidina, Nephrolepidina* (amongst others *L. c.f. isolepidinoides*) and *Heterostegina c.f. borneënsis* as TERTIARY-e_{1-2} (probably e_1):

O. S. 534, containing derived *Camerinae*.

Probably the same, but with *Nephrolepidina* and *Heterostegina c.f. borneënsis* only:

O. S. 357, containing derived *Camerinae*.

Characterised as TERTIARY-e_5 by the presence of *Spiroclypeus, Nephrolepidina* and *Miogypsina complanata:*

O. S. 520. Transgression conglomerate, forming the base of the upper tertiary covering in the Liang Malip district (Tandoela Djangga).

Characterised as TERTIARY-e_{4-5} by various guide fossils, in connection with O. S. 520 probably belonging to TERTIARY-e_5:

O. S. 214. With large megalospheric *Lepidocyclinae* (*Eulepidina* ?), *Nephrolepidina* and *Miogypsina*.
217. With *Spiroclypeus, Nephrolepidina, Miogypsina Dehaarti* and *Miogypsina spec. indet.*, and derived *Camerinae*.
218. With *Nephrolepidina, Miogypsina Dehaarti* and *M. spec. indet.*
233. With *Eulepidina, Nephrolepidina* and *Miogypsina;* same as O. S. 217, with derived *Camerinae*.
419. With *Spiroclypeus, Eulepidina, Nephrolepidina, Miogypsina Dehaarti* and *M. spec. indet.*
558. With *Lepidocyclina, Miogypsina Dehaarti* and an undetermined species of *Miogypsina* with lateral chambers.
611. With doubtful *Spiroclypeus*, with *Miogypsina* and *Neoalveolina c.f. pygmaea*.
612. With *Spiroclypeus, Eulepidina, Nephrolepidina, Miogypsina Dehaarti*.

In connection with these the following samples represent the same stage (TERTIARY-e_{4-5}, probably e_5):

O. S. 515. Boulder from the conglomerate O. S. 520, containing *Eulepidina, Nephrolepidina* and derived *Camerinae*.
521. *Globigerina* limestone bank in the conglomerate O. S. 520.
522. Sample from the same conglomerate as O. S. 520, containing *Spiroclypeus* and *Eulepidina*, and derived *Camerinae*.
523. Locally developed reef deposit connected with the conglomerate O. S. 520.
610. Rock and locality same as O. S. 611.
614. Rock and locality same as O. S. 612.
793. Sample from the conglomeratic covering of the Tandoela Djangga, as O. S. 520.
794. Idem; containing *Spiroclypeus* and small *Lepidocyclinae*.
795. Idem.

Characterised by the presence of *Spiroclypeus* as TERTIARY-e_{2-5}, in connection with the above (O. S. 520) probably TERTIARY-e_5:

O. S. 26. With *Eulepidina* and *Nephrolepidina*.
282. With *Eulepidina, Nephrolepidina* and derived *Camerinae*.

283. With *Eulepidina, Nephrolepidina* and derived *Camerinae.*
334. With *Eulepidina.*

And in connection with these:

O. S. 332 ? Containing *Lepidocyclinae;* rock as O. S. 334.
333. Rock and locality as O. S. 334.
335. Rock and locality as O. S. 334.
347. With small *Lepidocyclinae* and *Miogypsina spec. indet. div.* (with and without lateral chambers), locality as O. S. 26 and 334; therefore probably Tertiary-e_5.
378. Rock and locality as O. S. 26 and 334; containing derived *Camerinae.*

Characterised as TERTIARY-e by the occurence of *Eulepidina* and *Nephrolepidina* (or small *Lepidocyclinae*):

O. S. 232. Rock as O. S. 217.
329. With many microspheric *Lepidocyclinae* and derived *Camerinae.*
379. With many microspheric *Lepidocyclinae* and derived *Camerinae.*
490. Boulder in O. S. 491.
590. With derived reticulate Camerinae.

Without the typical guide fossils, but for other reasons probably belonging to TERTIARY-e:

O. S. 411 ? White marly limestone with *Neoalveolina c.f. pygmaea* and smaller *Neoalveolinae;* without fossils indicating an earlier stage.
487. } 488. } Rock similar to O. S. 490; boulders in O. S. 491.
589 ? With reticulate Camerinae. Rock identical with O. S. 590; locality practically the same as O. S. 590.

TERTIARY-e or TERTIARY-f.

O. S. 230. White limestone containing *Lepidocyclina,* collected near O. S. 232 and 233.
264. With large and small *Lepidocyclinae,* but not showing genuine *Eulepidinae* or other index fossils from Tertiary-e; judged by the locality belonging to Tertiary-f.

358. Reef limestone, stratigraphically situated between O. S. 357 (Tert.-e) and O. S. 359 (Tert.-f).

TERTIARY-f.

(See discussion of the age determination and remark on the subdevision of this stage on p. 192—195).

Containing the complete foraminiferal fauna typical of the Tertiary-f in Soemba (*Nephrolepidina, Miogypsina, Cycloclypeus annulatus, C. annulatus var. Martini, C. neglectus var. indopacifica* and *var. transiens, Globigerina quadripartita, G. tripartita* and in some cases *G. Kochi*):

O. S. 98. Rock similar to O. S. 327; *Miogypsina* absent in this sample.
327. With *Lepidocyclina borneënsis* and *L. sumatrensis*, therefore probably Tertiary-f_1.
420.
466. Containing abnormal symmetric *Cycloclypeus;* accidentally devoid of *Globigerina tripartita.*
537. Same as O. S. 327, containing *G. Kochi*, derived *Camerinae* and *Lepidocyclina glabra.*
631. With *G. Kochi.*

Containing *Nephrolepidina* and large *Lepidocyclinae*, probably microscopic forms:

O. S. 542.
544. With *L. sumatrensis*, therefore probably Tertiary-f_1.
549. With *L. sumatrensis*, therefore probably Tertiary-f_1.

Containing *Nephrolepidina* and *Miogypsina:*

O. S. 25. With *L. sumatrensis*, therefore probably Tertiary-f_1.
71. With *L. sumatrensis*, therefore probably Tertiary-f_1.
339. *Lepidocyclina* doubtful.
351. Containing some doubtful microspheric forms and *L. sumatrensis*, therefore probably Tertiary-f_1.
359.
581.
617.

Containing *Nephrolepidina* (or small *Lepidocyclinae*), devoid of *Miogypsina:*

O. S. 6.
9. With *Globigerina quadripartita.*
10.
56. With *Globigerina quadripartita.*
58. Rock same as O. S. 46 (see below).
79.
88. With *L. sumatrensis,* therefore probably Tertiary-f_1.
101.
113.
188.
386.
458.
459.
462. With *L. sumatrensis,* therefore probably Tertiary-f_1.
491. With *Cycloclypeus neglectus var. indopacifica.*
543.
545.
546. With doubtful *Lepidocyclina;* rock as 542.
547.
552.
575.
576.
584.
588.
758.
759.
775.

Containing *Miogypsina thecideaeformis* and *Globigerina quadripartita,* accidentally devoid of *Lepidocyclina:*

O. S. 756.

Containing *Miogypsina,* deposit situated at the top of the marl series:

O. S. 619.

Devoid of larger foraminifera, but containing the additional *Globigerina* fauna typical of Tertiary-f (*G. quadripartita, G. tripartita* and in some cases *G. Kochi*):

O. S.	5.	O. S.	267.
	12.		272.
	24.		309.
	78.		457.
	86.		494.
	96.		499.
	167.		753.
	263.		762.

Without index fossils, but for other reasons determined with certainty as Tertiary-f:

O. S. 11. Tuffoid marl from the same locality as O. S. 10.
46. Basal conglomerate forming the boundary between the red tuff series and the white marl series (containing debris of a *Lepidocyclina*-bearing marly limestone similar to O. S. 56).
57. Same as O. S. 56.
72. Similar to O. S. 71, but marly.
73. Idem.
81. Basal deposit of the marine transgression over the igneous foundation in the section of the Middle Soemba plateau; overlain by O. S. 79.
84. Idem; cf. O. S. 86.
95. Coral limestone, perhaps with *Spiroclypeus* but according to the field explorations situated at a considerable stratigrafic height above the transgressional base of the upper tertiary section of Middle Soemba (O. S. 79 and 81).
97. From the same locality and height as O. S. 98.
153. Globigerina marl, overlying unconformably the Eocene (O. S. 146—152).
154. Rock as O. S. 537, overlying unconformably the Eocene.
155. *Globigerina* limestone, overlying unconformably the Eocene.
156. Calcareous *Globigerina* sandstone, overlying unconformably the Eocene.
273. Basal conglomerate intercalated in the marl series, containing debris of the earlier Upper Tertiary (fragment of *Eulepidina*).
338. Reef limestone same as O. S. 339.
352. Conglomeratic pumice-stone-tuff sandstone, overlain by O. S. 351.

360. Rock same as O. S. 339, overlying O. S. 359 and overlain by the white marl O. S. 362.
361. Same as O. S. 360.
541. Globigerina marl enclosing the hard limestone bank O.S. 542.
548. Rock and locality practically the same as O. S. 545.
553. Rock and locality as O. S. 552.
587. Reef limestone same as O. S. 581 (*Miliolidae* perhaps derived from earlier deposit; cf. O. S. 581).
618. Like O. S. 617 and 619 forming the highest bed in the marl section.
759. Same as O. S. 758.
760. Idem, identical with O. S. 759.

Besides these, the greater part of the white or very pale coloured marls, tuffoid marls and tuffoid sandstones of the upper tertiary plateau in E. Soemba, and the reddish tuffoid "Kambaoni Series" equivalent to them, most probably belong to the Tertiary-f, as they bear a great similarity to the above mentioned fossiliferous deposits (see discussion of the age determination on p. 192, etc.).

Determined as Tertiary-f from the appearance are:

1rst Fine chalky or sandy marls with or without *Globigerinae*, similar to O. S. 12, 20, 78, 86, 267, 272 or 762 (without tuffoid constituents):

O. S. 14.	O. S. 100.	O. S. 158.	O. S. 416.
17.	102.	161.	418.
18.	103.	162.	421.
20.	104.	186.	456.
22.	111.	189.	461.
48.	119.	196.	464.
49.	122.	199.	468.
51.	124.	362.	681.
52.	139.	368.	683.
87.	140.	377.	
94.	141.	380.	

2nd. Sandy tuffoid marls, tuffoid calcareous marls pumicestone tuffs, pumicestone tuffoid sandstones or conglomerates, similar to O. S. 5, 327 or 537:

O. S. 19.	O. S. 175.	O. S. 385.	O. S. 684.
36.	205.	404.	685.
38.	206.	415.	686.
92.	208.	417.	688.
105.	222.	463.	689.
118.	165.	469.	690.
121.	266.	470.	691.
123.	277.	495.	769.
145.	349.	497.	776.
157.	350.	678.	
166.	374.	682.	

In connection with these marls and tuffoid deposits the following samples should probably be included in Tertiary-f:

O. S. 21. Marly limestone from the same locality and height as O.S. 22.
142. Coral limestone overlain by the subrecent terraces; locality same as O. S. 140, 141 and 145.
198. Nodular white marly limestone overlain directly by the subrecent terraces.
274., 275., 276. Claystones from the marl section near Kananggar.
375. Calcareous sandstone from the same locality as O. S. 374.
376. Idem.
564. Limestone bank intercalated in the white marl series.
566., 567. Gravel limestones intercalated in the white marl series.
692. Marly limestone, collected from the white marl series on the Wai Melolo (O. S. 681—692).

SUBRECENT.

Characterised as very late deposits by the presence of *Tinoporus baculatus* (Montf.?) Derv. (see p. 138, 139):

O. S. 1. Containing *Amphiroa*; collected from coral terrace.
7. Conglomeratic coral reef limestone, containing *T. floresianus*, *Amphiroa* and derived *Assilina*.
257. Terrace limestone.

Without *Tinoporus;* fauna of smaller foraminifera not identical with the earlier deposits from East and Middle Soemba:

O. S. 74., 75., 76., 77. — With *Rotalidae* and *Globigerinidae* in a much better state of preservation than in all marls from Tertiary-f. O. S. 74 and 75 somewhat loose marly deposits high in the profile, probably locally replacing the coral covering.

89. Reef limestone, containing *molluscs;* situated at a greater height than O. S. 88.

406 ? Reef limestone, containing a recent fauna; situated on top of the profile.

Collected from the subrecent sea terraces (see general map, fig. 1, p. 6) or the relics of coral limestones overlying the upper tertiary marls:

O. S. 13.
15.
16.
39., 40., 41., 42., 43., 44. — Overlying the marl series with an evident unconformity; O. S. 44 a peculiar "*Archaeolithothamnium oölith*".
53.
54.
55.
68. At sea level.
159. With many *Miliolidae.*
192. Same as O. S. 44.
195. Same as O. S. 44.

O. S. 200.	O. S. 569.	O. S. 623.	O. S. 680.
240 ?	570 ?	624.	750.
258.	571.	625.	752.
259.	572.	626.	755.
260.	573 ?	627.	757.
261.	574 ?	628.	764.
262 ?	578.	629.	With boulders
278.	616.	630.	from Tert.-b.
563.	620.	632.	
565.	621.	676.	
568.	622.	679.	

2. West Soemba

TERTIARY-a.

Characterised by the presence of *Assilina:*

W. S. 85.
89. With *Pellatispira, Discocyclina, Camerina spec. indet.* and an unknown very peculiar *Camerina, C. discoidea* nov.spec.
87.
99. With *Camerina spec. indet.* and *C. discoidea.*

TERTIARY a–b, probably-b.

Characterised by the presence of *Camerina, Pellatispira* and *Discocyclina* and the absence of *Assilina:*

W. S. 20.
208.
213.
417. With *Asterocyclina.*
418. With *Asterocyclina* or *Orthocyclina.*

With *Pellatispira* and *Camerina:*

W. S. 416.

With *Pellatispira* and *Discocyclina:*

W. S. 388.
488.

With *Camerina* and *Discocyclina:*

W. S. 43.

The following samples are probably to be assigned to TERTIARY-b:

W. S. 136. With *Discocyclina* ?
415. With fragments of *Discocyclina.*

TERTIARY-c and -d are not found in West Soemba.

TERTIARY-e.

Characterised as TERTIARY-e_5 by the presence of *Miogypsina Dehaarti* Van der Vlerk and *Miogypsinae* with lateral chambers:

W. S. 16.

Characterised as TERTIARY-e_5 by the presence of *Trillina, Neoalveolina,* small *Lepidocyclinae* and *Miogypsinae* with lateral chambers:

W. S. 373.

Characterised as TERTIARY-e_5 by *Nephrolepidina, Eulepidina* and *Miogypsina* with lateral chambers:

W. S. 169.

Characterised as TERTIARY-e_{2-5} by the presence of *Spiroclypeus* and *Eulepidina:*

W. S. 92.

Proved to belong to TERTIARY-e by the presence of various index fossils:

W. S. 22. With *Trillina.*
164. With *Trillina* and small *Lepidocyclinae.*
199. With *Eulepidina* and *Nephrolepidina.*
368. According to KEMMERLING belonging to the upper tertiary plateau; with *Eulepidina.*

Probably belonging to TERTIARY-e:

W. S. 12. With small *Lepidocyclina* and *Trillina* (?).
128. With *Lepidocyclina c.f. sumatrensis* Brady and *Trillina* (?).
160. } Full of *Operculinella;* rock and locality same as W. S. 164.
161. }
165. With small *Lepidocyclinae;* rock and locality same as W. S. 164.
174. Upper tertiary rock with large *Lepidocyclinae.*
187. With small *Lepidocyclinae, Miogypsina* without lateral chambers and *Trillina* (?).
202. According to KEMMERLING same rock as W. S. 199.
402. With small *Lepidocyclinae* and *Eulepidinae* (?).

Characterised as TERTIARY e_5 — f, probably e_5:

W. S. 49. With large *Lepidocyclinae* (probably *Eulepidina*), *Nephrolepidina* and *Miogypsinae* with and without lateral chambers.

190. With large and small *Lepidocyclinae* and *Miogypsina* with lateral chambers (same species as in W. S. 169).

419. With small *Lepidocyclinae* and *Miogypsinae* with and without lateral chambers; according to KEMMERLING belonging to the basal deposits of the upper tertiary plateau.

454. With large *Lepidocyclinae, Nephrolepidina, Trillina* (?) and *Miogypsina* with lateral chambers (same species as in W. S. 169).

TERTIARY-f.

With certainty belonging to TERTIARY-f:

W. S. 392. With *Alveolinella bontangensis* Rutten.

Most probably belonging to TERTIARY-f:

W. S. 146. With *Cycloclypeus* (*C. annulatus* Martin and other species), and small *Lepidocyclinae* (*L. c.f. Martini* Schlumb., *L. c.f. Douvillei* Yabe, etc).

242. With *Lepidocyclina Ferreroi* Prov. and other *Nephrolepidinae* and *Miogypsina c.f. polymorpha* Rutten or *bifida* Rutten.

265. Marl bed in which boulders are found containing *Miogypsinae* with lateral chambers.

387. According to KEMMERLING same rock as W. S. 392.

The following samples are all from TERTIARY-e-f, probably-f:

With small *Lepidocyclinae* (probably *Nephrolepidinae*) and *Miogypsinae* with lateral chambers:

W. S. 42.
62.
138.
178.
214. With *L. c.f. sumatrensis* Brady.
222.
338.
364.

386.
421.

With small *Lepidocyclinae* (in part genuine *Nephrolepidinae*):

W. S. 1.	W. S. 152.	W. S. 201.
4.	168	229.
10.	170.	232 .
15.	183.	240.
118.	195.	328.
121.	196.	468.

With *Miogypsina* with lateral chambers:

W. S. 376.
378.

With some doubtful *Alveolinella:*

W. S. 50.

(Further the great number of samples of globigerina limestones (such as W. S. 234, 363, 384), tuffoid limestones, pale coloured marly limestones, forming the greatest part of the collection from West Soemba are probably deposits from TERTIARY-f. They come from the upper tertiary plateau and are of the same age as the more marly and tuffoid deposits from the plateau in Middle and East Soemba. On the plateau some clayey lignite was found: W. S. 193, 236, 237, 238, which must be of UPPER TERTIARY or SUBRECENT age.)

SUBRECENT.

All rocks from the zone of sea terraces along the North and West coast of West Soemba (see general map, fig. 1) are of subrecent age. Besides this uninterrupted zone scattered relics of subrecent reefs are found inland and along the South coast. Such relics are for instance:

W. S. 31, 32 (with *Amphiroa*), 35, 38.

Only very few deposits are characterised as subrecent by their fossil contents; they are:

W. S. 219. With *Tinoporus* and *Amphiroa*.
334. } Oöliths formed by innumerable specimens of *Tinoporus*
335. } *floresianus* (Schlumb.).

SUMMARY OF THE AGE DETERMINATIONS

1. East- and Middle-Soemba

O. S.	1.	subrecent	
	5.	Tertiary	f
	6.	—	f
	7.	subrecent	
	9.	Tertiary	f
	10.	—	f
	11.	—	f
	12.	—	f
	13.	subrecent	
	14.	Tertiary	f
	15.	subrecent	
	16.	—	
	17.	Tertiary	f
	18.	—	f
	19.	—	f
	20.	—	f
	21.	—	f
	22.	—	f
	24.	—	f
	25.	—	f_1
	26.	—	e_{2-5}
	27.	—	c ?
	28.	?	(later than c)
	29.	—	c
	35.	—	b
	36.	—	f
	38.	—	f
	39.	subrecent	
	40.	—	
	41.	—	
	42.	—	
	43.	—	
	44.	—	
	46.	Tertiary	f
	47.	—	d
	48.	—	f
O. S.	49.	Tertiary	f
	51.	—	f
	52.	—	f
	53.	subrecent	
	54.	—	
	55.	—	
	56.	Tertiary	f
	57.	—	f
	58.	—	f
	60.	—	a_2
	61.	—	a_2
	62.	—	a_2
	64.	—	a
	65.	—	b
	68.	subrecent	
	71.	Tertiary	f_1
	72.	—	f
	73.	—	f
	74.	subrecent	
	75.	—	
	76.	—	
	77.	—	
	78.	Tertiary	f
	79.	—	f
	81.	—	f
	84.	—	f
	86.	—	f
	87.	—	f
	88.	—	f_1
	89.	subrecent	
	92.	Tertiary	f
	94.	—	f
	95.	—	f
	96.	—	f
	97.	—	f
	98.	—	f

O. S.	100.	Tertiary	f
	101.	—	f
	102.	—	f
	103.	—	f
	104.	—	f
	105.	—	f
	106.	—	b
	107.	—	b
	109.	—	a_2
	110.	—	b
	111.	—	f
	112.	—	b
	113.	—	f
	114.	—	b
	116.	—	b
	117.	—	b
	118.	—	f
	119.	—	f
	120.	—	b
	121.	—	f
	122.	—	f
	123.	—	f
	124.	—	f
	125.	—	a_2
	126.	—	a_2
	130.	—	a_2
	131.	—	b
	132.	—	b
	133.	—	a
	134.	—	a_2
	136.	—	a_2
	137.	—	a_2 ?
	138.	—	b
	139.	—	f
	140.	—	f
	141.	—	f
	142.	—	f
	144.	—	a_1
	145.	—	f
	146	—	b

O. S.	147.	Tertiary	b
	148.	—	b
	151.	—	b
	152.	—	b
	153.	—	f
	154.	—	f
	155.	—	f
	156.	—	f
	157.	—	f
	158.	—	f
	159.	subrecent	
	160.	Tertiary	b
	161.	—	f
	162.	—	f
	163.	—	b
	164.	—	b
	165.	—	b
	166.	—	f
	167.	—	f
	168.	—	c
	169.	—	b
	170.	—	b
	171.	—	f
	172.	—	?
	173.	—	c
	174.	—	b
	175.	—	f
	177.	?	
	182.	Tertiary	b
	185.	—	b
	186.	—	f
	187.	—	?
	188.	—	f
	189.	—	f
	192.	subrecent	
	195.	—	
	196.	Tertiary	f
	198.	—	f
	199.	—	f
	200.	subrecent	

O. S.	205.	Tertiary	f
	206.	—	f
	207.	—	b (boulder)
	208.	—	f
	211.	—	a_2 (boulder)
	212.	—	?
	214.	—	e_5
	217.	—	e_5
	218.	—	e_5
	221.	?	
	222.	Tertiary	f
	223.	—	a_2
	224.	—	?
	226.	—	c
	228.	—	b
	229.	—	b
	230.	—	e or f
	232.	--	e
	233.	—	e_5
	234.	—	a_2
	235.	—	a_2
	236.	—	a_2
	237.	—	a_2
	240.	subrecent	(?)
	241.	Tertiary	b
	243.	—	a_2
	246.	—	a or b ?
	256.	—	b
	257.	subrecent	
	258.	—	
	259.	—	
	260.	—	
	261.	—	
	262.	—	
	263.	Tertiary	f
	264.	—	e or f
	265.	—	f
	266.	—	f
	267.	—	f
	270.	—	c

O. S.	271.	Tertiary	a_1 ?
	272.	—	f
	273.	—	f
	274.	—	f
	275.	—	f
	276.	—	f
	277.	—	f
	278.	subrecent	
	279.	Tertiary	a_1
	280.	—	a_1
	281.	—	a_1
	282.	—	e_{2-5}
	283.	—	e_{2-5}
	284.	—	a_1
	285.	—	d
	286.	—	a_2
	287.	—	c
	288.	—	?
	292.	—	a_1
	293.	—	a_1
	294.	—	a_1
	296.	—	a_1
	297.	—	a_1
	299.	—	a_2
	300.	—	a_2
	301.	—	a_2
	302.	—	a_2
	304.	—	a_1
	305.	—	a_1
	307.	—	a_1
	309.	—	f
	310.	—	a_2
	311.	—	a_2
	312.	—	a_1
	315.	—	a_2
	316.	—	b
	321.	subrecent	
	327.	Tertiary	f_1
	328.	—	c
	329.	—	e

O. S.	332.	Tertiary	e_{2-5}?
	333.	—	e_{2-5}
	334.	—	e_{2-5}
	335.	—	e
	336.	—	c
	338.	—	f
	339.	—	f
	347.	—	e_5?
	349.	—	f
	350.	—	f
	351.	—	f_1
	352.	—	f
	357.	—	e_{1-2}?
	358.	—	e or f
	359.	—	f
	360.	—	f
	361.	—	f
	362.	—	f
	366.	—	c
	367.	—	c
	368.	—	f
	374.	—	f
	375.	—	f
	376.	—	f
	377.	—	f
	378.	—	e_{2-5}
	379.	—	e
	380.	—	f
	383.	—	e
	384.	—	?
	385.	—	f
	386.	—	f
	391.	—	?
	404.	—	f
	406.	subrecent	?
	411.	Tertiary	e ? (earlier than f)
	415.	—	f
	416.	—	f
	417.	—	f

O. S.	418.	Tertiary	f
	419.	—	e_5
	420.	—	f
	421.	—	f
	426.	—	c
	428.	—	c
	429.	—	c
	430.	—	c
	431.	—	c
	433.	—	b
	434.	—	c
	456.	—	f
	457.	—	f
	458.	—	f
	459.	—	f
	460.	?	
	461.	Tertiary	f
	462.	—	f_1
	463.	—	f
	464.	—	f
	465.	—	f
	466.	—	f
	467.	—	c
	468.	—	f
	469.	—	f
	470.	—	f
	471.	—	c
	472.	—	c
	473.	—	c
	479.	—	c
	480.		
	484.	—	c
	487.	—	e
	488.	—	e
	489.	—	f
	490.	—	e
	490a.	—	c
	490b.	—	? (earlier than f)
	491.	—	f

O. S.	494.	Tertiary	f
	495.	—	f
	497.	—	f
	499.	—	f
	508.	—	b
	509.	—	b
	510.	—	b
	511.	—	a_2
	512.	—	a_2
	513.	—	b
	514.	—	a_2
	515.	—	e_5
	516.	—	a_2
	517.	—	a_2
	518.	—	a_2
	519.	—	a_2
	520.	—	e_5
	521.	—	e_5
	522.	—	e_5
	523.	—	e_5
	533.	—	c
	534.	—	$e_{1\text{-}2}$, prob. e_1
	535.	—	c
	536.	—	c
	537.	—	f
	538.	—	c
	539.	—	c
	541.	—	f
	542.	—	f
	543.	—	f
	544.	—	f_1
	545.	—	f
	546.	—	f
	547.	—	f
	548.	—	f
	549.	—	f_1
	552.	—	f
	553.	—	f
	558.	—	e_5
	563.	subrecent	
O. S.	564.	Tertiary	f
	565.	subrecent	
	566.	Tertiary	f
	567.	—	f
	568.	subrecent	
	569.	—	
	570.	—	?
	571.	—	
	572.	—	
	573.	—	?
	574.	—	?
	575.	Tertiary	f
	576.	—	f
	578.	subrecent	
	584.	Tertiary	f
	587.	—	f
	588.	—	f
	589.	—	e ?
	590.	—	e
	602.	—	c
	610.	—	e_5
	611.	—	e_5
	612.	—	e_5
	614.	—	e_5
	616.	subrecent	
	617.	Tertiary	f
	618.	—	f
	619.	—	f
	620.	subrecent	
	621.	—	
	622.	—	
	623.	—	
	624.	—	
	625.	—	
	626.	—	
	627.	—	
	628.	—	
	629.	—	
	630.	—	
	631.	Tertiary	f

O. S.	632.	subrecent	
	676.	later than	c; probably subrecent
	677.	Tertiary	c
	678.	—	f
	679.	subrecent	
	680.	—	
	681.	Tertiary	f
	682.	—	f
	683.	—	f
	684.	—	f
	685.	—	f
	686.	—	f
	688.	—	f
	689.	—	f
	690.	—	f
	691.	—	f
	692.	—	f
	750.	subrecent	
	752.	—	
	753.	Tertiary	f
	755.	subrecent	
	756.	Tertiary	f
	757.	subrecent	
	758.	Tertiary	f
	759.	—	f
O. S.	760.	Tertiary	f
	761.	—	b
	762.	—	f
	763.	—	f
	764.	subrecent	(with boulders)
	765.	Tertiary	b
	766.	—	b
	767.	—	b
	768.	—	b
	769.	—	f
	771.	—	c
	772.	—	?
	773.	—	b
	774.	—	c
	775.	—	f
	776.	—	f
	778.	—	?
	780.	—	a_2
	782.	—	?
	784.	?	
	790.	Tertiary	a_2
	793.	—	e_5
	794.	—	e_5
	795.	—	e_5
	796.	—	a_2

2. West-Soemba

W. S.	1.	Tertiary	f
	4.	—	f
	10.	—	f
	12.	—	e?
	15.	—	f
	16.	—	e_5
	20.	—	b
	22.	—	e
	31.	subrecent	
	32.	—	
W. S.	35.	subrecent	
	38.	—	
	39.	Tertiary	f?
	42.	—	f
	43.	—	b
	49.	—	e_5
	50.	—	f?
	62.	—	f
	85.	—	a_2
	87.	—	a_2

W. S. 89.	Tertiary	a_2
92.	—	e_{2-5}
99.	—	a_2
112.	—	e-f
118.	—	f
121.	—	f
128.	—	e?
136.	—	b?
138.	—	f
146.	—	f
152.	—	f
160.	—	e?
161.	—	e?
164.	—	e
165.	—	e
168.	—	f
169.	—	e_5
170.	—	f
174.	—	e?
178.	—	f
183.	—	f
187.	—	e?
190.	—	e_5-f
193.	—	f (or later)
195.	—	f
196.	—	f
199.	—	e
201.	—	f
202.	—	e?
208.	—	b
213.	—	b
214.	—	f
219.	subrecent	
222.	Tertiary	f
229.	—	f
232.	—	f
234.	—	f
W. S. 236.	Tertiary	f (or later)
237.	—	f (or later)
238.	—	f (or later)
240.	—	f
242.	—	f
265.	—	f
273.	—	?
328.	—	f
334.	subrecent	
335.	—	
338.	Tertiary	f
363.	—	f
364.	—	f
368.	—	e
373.	—	e_5
376.	—	f
378.	—	f
384.	—	f
386.	—	f
387.	—	f
388.	—	b
392.	—	f
402.	—	e?
412.	?	
413.	?	
414.	?	
415.	Tertiary	b
416.	—	b
417.	—	b
418.	—	b
419.	—	e_5-f
421.	—	f
454.	—	e_5-f
468.	—	e-f
476.	—	?
488.	—	b

NOTES BY THE LOCALITY MAPS

On Map I the localities are given of the rocks from E. Soemba, deposited previous to the great land period (that is, in Tertiary-a—e_{1-2}); on Map II the localities of rocks from East and Middle Soemba which were deposited after the great upper tertiary transgression (Tertiary-e_{4-5}—subrecent) are found.

As it is impossible on these small scale maps to mark all the localities, which often lay very close together, a quantity of samples which were found in almost the same locality and which are moreover of the same age, are included under one number.

The samples which come from the continuous upper tertiary plateau and the late sea-terraces (Tertiary-f—subrecent) are not given separately: Map II gives the routes on which these samples were collected (see below). This gives a good idea of the extensiveness of the region, where it is only in the deepest ravines of the rivers that anything other than Upper Tertiary is found (e.g. eruptiva etc.).

Map III gives the localities of all the rocks I have determined from the West Soemba collection (Tertiary-a—subrecent).

No localities are given in these maps of eruptiva, and the pre-tertiary sediments and metamorphosed rocks which are confined in the mountainous regions, parts of the south coast of East and West Soemba and the deep ravines of the large rivers (see Chapter I).

1 - Combination of numbers on Maps I and II

Number of the sample:	Number on map:	Map
O. S. 27	29	I
36	497	II
64, 65, 106, 107, 110, 112, 114, 116	neighbourhood of Lalokoe	I
118	111	II
119	111	
120	neighbourhood of Lalokoe	I

Number of the sample:	Number on map:	Map:
O. S. 130	243	I
131	132	
137	136	
140	139	II
146 } 147 }	neighbourhood of Lalokoe	I
152	151	
154	155	II
156	155	
161	159	
164	neighbourhood of Lalokoe	I
166	155	II
167	175	
171	175	
186	175	
205	208	
206	208	
212	208	
214	217	
218	217	
229	228	I
230	232	II
233	232	
235	234	I
236	134	
237	134	
256	neighbourhood of Lalokoe	
264	263	II
265	267	
266	267	
270	479	I
274	273	II
281	280	I
297	296	
299	302	
301	300	
304	305	
339	338	II
347	332	

Number of the sample:	Number on map:	Map:
O. S. 358	419	II
359	420	
360	420	
367	366	I
386	385	II
391	404	
416	415	
417	415	
467	29	I
468	470	II
484	479	I
495	494	II
510	509	I
521	520	II
523 (boulder)	522	
536	535	I
539	538	
610	612	II
611	612	
679	678	
680	678	
681	678	
682, 683, 684, 685, 686, 688, 689, 690, 691, 692	267	
761	768	I
765	768	
766	768	
767	768	
772	769	II
776	775	
793	794	
795	794	

2 - Numbers of the routes traversing the upper tertiary plateau and the subrecent sea terraces (Map II)

Number of the rock:	Route:
O. S. 1	35
5, 6, 8	34
9, 10, 11, 12, 13, 14	33
15, 16	24
17, 18, 19	20
20, 21, 22	18
24, 25	25
38, 39, 40, 41, 42, 43, 44	27
46, 48	surroundings of Kambaoni
49	34
51, 52, 53, 54, 55	27

Number of the rock:	Route:
O. S. 56, 57, 58	surroundings of Kambaoni
68, 71, 72, 73, 74, 75, 76, 77, 78, 79, 81	1
84, 86, 87	5
88	9
89, 92, 94	10
95, 96, 97, 98, 100, 101, 102	11
172, 177, 187	neighbourhood of Wai Rara (upper reaches of the Wai Melolo)
188, 189, 192	38

Number of the rock:	Route:
O. S. 195, 196	38
257, 258, 259, 260, 261, 262	37
275, 276, 277	neighbourhood of Kambaoni
349, 350, 351, 352	26
456, 457, 458, 459, 460	17
461	23
462, 463, 464, 465, 468, 469, 470	28
541, 542, 543, 544, 545, 546, 547	14
548, 549, 552	21

Number of the rock:	Route:
O. S. 553	21
563, 564, 565, 566	30
567, 568, 569, 570	18
571	15
572, 573, 574	19
575, 576	16
578	22
584, 587, 588	29
617, 618, 619	10
620, 621, 622, 623, 624, 625, 626, 627, 628, 629, 630	32
631	8
632	6
750, 752, 753	36

Number of the rock:	Route:
O. S. 755, 756, 757, 758, 759, 760, 762, 763, 764	36

SYSTEMATIC SURVEY OF THE ROCKS

In this chapter the rocks we have examined will be grouped together according to age and a short description of them given beginning from the earliest.

"Lowest Eocene" (Tertiary-a_1).

The rocks from E. Soemba given on p. 155 under this name, form the basis of the Tertiary according to Kemmerling's annotations. They are the debris from the older island deposited during the transgression of the eocene sea (Lowest "Tanah Roong" beds). They are grey or blue-grey lime-sandstones or conglomerates, sometimes made up of elements of varying origin, containing few or no fossils. Remains of molluscs, however, may be found (including *Venus spec.*), some fragments of *echinoderms* (*crinoids*), an occasional *Serpula* and, extremely scarcely, *foraminifera*. Foraminifera can only be identified with certainty in O. S. 292, viz. a few *Globigerinae*.

This "Lowest Eocene" must be assigned to Tertiary-a_1 on account of the fossil-containing rocks by which these deposits are covered.

"Lowest Eocene" is known on East Soemba from the river sources of Loko Maneta, Loko Loboeng and Lai Melolo, also from the valley of the Liang Malip and the sharp elbow of the Wai Maoendjara, that is in an arc surrounding the whole eastern side of the Massoe Mountains. What the localities of this "Lowest Eocene" are on West Soemba I am not aware. (Note: O. S. 307, a crystaline limestone with thin layers of hornstone, although annotated as "Lowest Eocene" probably does not belong to this deposit, but to the pretertiary sediments).

TERTIARY-a_2.

The strata which follow stratigraphically upon the "Lowest Eocene", according to their fossil content probably all belong to the upper part of Tertiary-a (Tertiary-a_2; see below, p. 204).

At Rete Balaroe (upper valley of the Liang-Malip, East Soemba), the unconform position of the Tertiary over the pre-tertiary foundation is clearly observed. Besides the fossil-poor deposits mentioned above, there are found here as earliest tertiary sediments: grey foraminiferous marls (O. S. 299), claystone with vegetable remains (O. S. 302), lignite (O. S. 301) and blue-grey conglomeratic lime-sandstone (O. S. 300). The marl (O. S. 299) lies at the base of the section, above it follow O. S. 300—302, all on the same level. The other lower tertiary rocks from this district, coming from the ridge east of the Liang Malip (Rara Mata, Tandoela Djangga and Watoe Moendoe), are probably more recent than those from Rete Balaroe, even if this cannot be said with certainty, as the folds of the lower tertiary beds make it almost impossible to correlate them in the field for any distance. They are yellowish-brown to red-brown, or pale-grey or sometimes pale-yellow marls, marly limestones, sandy limestones and pure compact limestones, which in general contain an extremely rich foraminiferous fauna. Some rocks from East Soemba are entirely built up of closely packed *Fasciolitidae* or *Assilinae* (or a combination of the two) with only a few other fossils amongst them; others consist chiefly of small *Camerinae*, while the mass of the compact rock is often formed of innumerable *Miliolidae*. *Discocyclina* is seldom found as rock former (O. S. 511, 514). Large *Discocyclinae* and *Camerinae* are distinctly rare, *Pellatispira* is found in West Soemba, but in the East Soembanese Tertiary-a it is entirely absent.

The whole series of deposits from the fossiliferous part of Tertiary-a must be of a thickness of at least a few hundred meters, even if the folding of the strata is taken into consideration. This can be seen in the undisturbed section of the Tandoela Djangga and the Watoe Moendoe; the section of Tandoela Djangga which does not even contain the whole of Tertiary-a_2 (with an inclination of 24°) is 200 meters in height. Yet the difference in age between the basal and uppermost strata of the complete section (including Rete Balaroe) cannot be very great, as no palaeontologic distinction can be made between the fauna of O. S. 299 (in the valley, Rete Balaroe), O. S. 62 and 780 (Rara Mata), and O. S. 517 (fairly high up in the Tandoela Djangga); throughout the whole section *Fasciolites ovicula*, *Assilina orientalis*, *Assilina aff. exponens-granulosa* and *Camerina kelatensis* are found. The deposits must therefore have been

made within a relatively short period. With the exception of Rete Balaroe, the lowest deposits in this section and also in other localities indicate their formation to have been in a shallow sea, or rather as a littoral formation with much terrigenous and little zoogenous material: the earliest rock from Rara Mata (O. S. 60, lying on an eruptive foundation) is a lime-sandstone; the transgression rock in the section of Lalokoe is a fine grey lime-sandstone which still clearly betrays its deviation from the granite foundation (O. S. 64, 116, "granit régénéré"). Sometimes in these sandy sediments very small *Assilinae* and *Camerinae* are found (O. S. 64, 302). Above these follow purer limestones of more organogenous origin and at the top of the section lie again fossil-poor sandy deposits (highest lower tertiary strata of the Tandoela Djangga, O. S. 519, 796; the top of the hill is formed by a transgression conglomerate from Tertiary-e). The neighbourhood of Kakaha is very much dislocated, so that no continuous section could be recorded. Here, as in the above places, the basis is formed of sandy or conglomeratic rock, while this locality yields numerous rock samples (mostly boulders) of Fasciolites-limestones. In the undisturbed section of Lalokoe, the fossil-bearing zone is not represented.

The rocks of Tertiary-a_2 all bear the character of bottom deposits; in this period no real reefs are formed. It is true that a few rocks contain many algae (O. S. 234, 315, 790 and especially 109) and here and there shell banks or bryozoa are found. But there are practically no corals; only in O. S. 315 minute fragments of corals are found.

Tertiary-a_2 was found on E. Soemba in the upper valley of the Liang Malip and in the whole range of hills east of the valley; further at the mouth of the Wai Maoendjara and at the spot where the river is crossed by the road from Lalokoe to Tanah Roong. Further east again it is found in the neighbourhood of Kakaha, at a locality about half-way down the Wai Djeloe, at the base of the section of Lalokoe and as a boulder in the neighbourhood of Tandjong Ngoendjoe. The Tertiary-a is, therefore, here enclosed between the Massoe Mountains and the Wai Djeloe. In West Soemba Tertiary-a_2 was found on the Loko Lomoe and on the peninsula to the East of the Sendikiri Bay.

TERTIARY-b

The limestones, lime-sandstones and marly limestones of East Soemba which are determined by their fossil content as Tertiary-b may be divided into two main groups, viz. deposits from a sandy facies and from a reef facies. The limes and lime-sandstones are of a grey-green,

yellowish-green or grey-brown colour and are often chiefly composed of *Discocyclinae;* sometimes large *Camerinae* predominate.

The majority of the marly limestones of the reef facies are white and consist chiefly of reef organisms; *Corallina, Carpenteria* and *Pellatispira.* Besides these *Discocyclina* and *Camerina* also are found, but seldom in large quantities; the ground mass often contains *Cymbaloporettidae.*

The age of these rocks was in most cases determined by the presence of eocene foraminiferous genera and the simultaneous absence of forms typical of Tertiary-a, so it has been determined partly by negative characteristics. This method of determination is in general insecure and may easily lead to errors; the absence of certain forms may be due to various facial causes, so that it is not a more recent fauna that we have to deal with, but only an impoverished one. In all probality, however, the b-rock in Soemba is actually younger than the rocks which according to their fauna belong to Tertiary-a. Sometimes the same kind of deposit from the two stages may be very different in habitus and fossil content. For instance we may find in East Soemba a yellowish marly limestone containing *Assilinae* and the earlier species of *Fasciolites* and *Camerina,* but without *Pellatispira,* and on the other hand the white marly limestone with *Pellatispira,* in which these old index fossils are not found at all. In the lime-sandstones this difference is also found; there are brown lime-sandstones with the *Assilina-Fasciolites* fauna and beside them grey-green ones without this fauna. This is an example of how rocks with the same lithologic factors may yet contain different faunas, which can only be satisfactorily accounted for by a difference in age. The *Camerinae* and the *Discocyclinae* seem in general to be different in the rock with typical a-fauna and in rock where there is no *Assilina* and *Fasciolites;* the rock from Tertiary-b contains a predominance of large *Discocyclinae* and *Camerinae,* while these large forms are extremely rare in the guaranteed Tertiary-a rock.

Although the differentiation into Tertiary-a and Tertiary-b can nowhere be illustrated by a good section, it remains probable therefore that the rock we have classified as Tertiary-b really does belong to a later stage. The presence of Tertiary-b on Soemba can be proved in one case with certainty, viz. by finding *Camerina djokdjokartae* Mart. (O. S. 316, south of the Watoe Moendoe).

Tertiary-b was found on East Soemba principally in the neighbourhood of Lalokoe and on the upper Wai Rendi; further in the disturbed district by Kakaha, on the slopes of the Watoe Moendoe and in a few scattered localities: at the mouth of the Wai Maoendjara, by the mountain rivers

of the Loko Loboeng and finally as boulder near Tandjong Ngoendjoe, thus again on the E. side of the Massoe Mountains.

The most easterly localities on the Wai Rendi and near Lalokoe do not really belong to the field of the foot-hills, where the whole landscape consists of lower tertiary deposits, but are disconnected inliers where the earlier foundation of the upper tertiary plateau is seen, sometimes over a considerable distance, laid bare by the erosion of recent rivers. The discovery of one reef-rock from Tertiary-b amongst the samples from the high lying reef between Ramoek and Pr. Kareha seems to me so peculiar, that I cannot help thinking it must be due to a confusion in the samples of the collection; this sample (O. S. 433) that in locality and height above sea level deviates so greatly from all the other samples of the same stage, macroscopically exactly resembles the other samples from the reef, which are characterised by reticulate *Camerinae* as Tertiary c-d.

In West Soemba Tertiary-b is represented by the same rock as in East Soemba, also in a sandy and a marly facies. Tertiary-b was here found in the surroundings of the Loko Lomoe and in the region between Waigale and Tg. Lamboja, and perhaps in the gorge of the L. Memboro.

TERTIARY-C.

What we have said of Tertiary-b, namely that it was determined with the help of negative characteristics, is applicable to a great many of the rock samples we have determined as Tertiary-c. Tertiary-c is characterised by the simultaneous occurrence of reticulate *Camerinae* and radiate *Camerinae*, without any *Orbitoids*. This condition is only fulfilled by a comparatively small number of rocks from East Soemba (see p. 160), which can with certainty be classified as Tertiary-c. In a number of other samples, however, only reticulate *Camerinae* were found, without radiate *Camerinae* and without *Lepidocyclina*. Reticulate *Camerinae* are typical of both stages -c and -d, and the samples which have only yielded reticulate *Camerinae* may equally well represent rocks of the Tertiary-c age, where the radiate *Camerinae* are locally absent, as deposits from Tertiary-d in which it happens that no *Lepidocyclina* is to be found.

The rocks with reticulate and radiate *Camerinae*, that is, with the complete fauna of Tertiary-c are white or very lightly coloured foraminiferous limestones, sometimes granular and porous, and white to light yellow marly limestones. Most of them are chiefly composed of *Camerinidae* (*Camerina, Heterostegina, Operculina*). Many of the samples in which only reticulate *Camerinae* are found, are very similar to these; for instance in the samples coming from the reef between Ramoek and Marenja, no

distinction can be made macroscopically between the deposits with and without the complete -c fauna (O. S. 426 etc.; O. S. 533 etc.). In most cases the determination of these rocks as Tertiary-c will be correct. But a warning should be given, as the reticulate *Camerinae* in East Soemba have built up a rock in almost exclusive population in Tertiary-d as well. The sample O. S. 47, also a pale yellow *Camerina* limestone, is a good example of this, showing how in a later stage large parts of the sediment may be quite free from *Lepidocyclina*, giving a habitus which cannot be distinguished from rocks from the Soembanese Tertiary-c.

Tertiary-c on East Soemba is again represented by neritic deposits, principally reefs; sandy constituents are extremely rare. The reefs can often be recognised as such in the field, e.g. at Ramoek, where they can be clearly seen stuck onto the original igneous body of the island. All lower tertiary rocks between Ramoek and Praing Kareha belong to this reef [24]). Tertiary-c was also found near Lalatang, on the upper L. Loboeng and L. Maneta, on the upper reaches of the L. Melolo between Kambaoni and Lai Tokoe, in the disturbed district on the upper reaches of the Wai Rendi, at the mouth of the Wai Maoendjara, in the southern slope of the Rara Mata and finally as boulder in the red tuff series near Kananggar.

In the collection from West Soemba no samples from Tertiary-c were found. It is possible, therefore, that there are no deposits of this stage in West Soemba.

TERTIARY-d.

Only two of the samples of the O. S.-collection can be ascribed to this stage with certainty, O. S. 47 and O. S. 285. The first sample is taken from comparatively small boulders in the late marly tuffs in the neighbourhood of Kambaoni, the second is taken from the landslip in the valley head of the Liang Malip, where it was knocked off an enormously large block. It is possible that in this neighbourhood Tertiary-d is in situ, although it was not recognised as such in the field.

O. S. 47 is a compact light yellow limestone, chiefly composed of reticulate *Camerinae*, but in some places *Lepidocyclinae* (*Eulepidina*) are found in it. The rock may easily be confused with some of the rock from Tertiary-c. The sample O. S. 285, on the other hand, represents an entirely different deposit: it is a light grey *Lepidocyclina*-lumachelle, quite unique in the collection.

On West Soemba no Tertiary-d is found.

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24) See remark on O. S. 433 on p. 190.

TERTIARY-e and -f.

In general the rocks from Tertiary-e in Soemba are of a clearly transgressional character. They are fine calcareous conglomerates and marly limes, which contain fragments of eruptiva and limestone, and often derived *Camerinae* from earlier stages. The majority of these *Camerinae* are reticulate, but we also find a few radiate specimens, both indicating that the fragments are chiefly erosion products from Tertiary-c and -d. Its transgressive character is shown not only by the composition of the rock, but from the position of the deposits in the field. Tertiary-e in most places forms the basis of the neogene cover and is severed by a distinct unconformity from the lower tertiary or pre-tertiary foundation. The lower limit of this stage can thus be sharply drawn. The upper limit, on the other hand, is very difficult to define, for upwards we have a series of constantly wedging out layers, alternating with one another and merging into eachother horizontally, in which no clear subdivisions can be made. Occasionally in the middle of this white or reddish marl series a conglomerate will be found containing *Lepidocyclinae* (O. S. 46, 273) and it is possible that this forms the lower limit of the following stage, Tertiary-f. How far these conglomerate banks extend horizontally is not known; they may also be due to a relatively sudden elevation of the sources of rivers and have no connection with a marine transgression (cf. the subrecent gravel terraces).

All rock of the upper tertiary marl series, which is not characterised by its fauna as Tertiary-e, has been classified as Tertiary-f. This Tertiary-f consists of marly limestone banks and of the great mass of marls, tuffoid marls, pumice-stone tuffs, tuffoid limestones (W. S.), tuff-sandstones and conglomerates from the upper tertiary plateau. In the limestones small *Lepidocyclinae* and sometimes *Miogypsinae* are found; amongst the marls and marly tuffs there are also several which certainly belong to the *Lepidocyclina*-containing part of the Tertiary, while others contain no larger foraminiferae or are even entirely free from fossils.

It is naturally not impossible that amongst these rocks determined as Tertiary-f there are some of the age of Tertiary-e. The f-fauna on Soemba is as a rule nothing but an impoverished fauna from Tertiary-e: typical index fossils from Tertiary-f are extremely rare (only once or twice *Alveolinella bontangensis* and *Miogypsina* c.f. *polymorpha* were found; *Lepidocyclina Rutteni* seems to be entirely absent). It is dangerous to define the age of these marls by a negative characteristic especially because they seem to be here a bad milieu for larger foraminifera. It is not impossible that it is just the larger foraminifera that are typical of

Tertiary-e, *Eulepidinae* and *Spiroclypei*, that are absent owing to the unfavourable surroundings. In the same way, the absence of *Trillina* among the smaller foraminifera cannot be taken as an absolute proof for the age of Tertiary-f as this genus seems in general to prefer a calcareous milieu and is moreover rare in this region; on East Soemba *Trillina* is entirely absent, even in rocks that certainly belong to Tertiary-e.

At the same time, as we know from other districts, *Eulepidinae* and *Spiroclypei* may be found in a marly facies as well, so it is not likely that the absence of these foraminifera in the marls is only due to a difference in surroundings. This makes it more probable that all these rocks should be classified as Tertiary-f (partly by their fossil contents and for the rest by their lithologic likeness to the fossiliferous samples), than as Tertiary-e.

In connection with this subject it may be as well to say a few words about the stratigraphic distribution of certain smaller foraminifera which I have used in the Soemba collection as index fossils for Tertiary-f, viz. *Globigerina quadripartita* (Koch), *Globigerina tripartita* (Koch) and, in combination with these, *Globigerina Kochi* (Koch) nov. nom. and *Uvigerina javana* Koch. These *Globigerinae* which, usually together, are found in a great many marls from E. Soemba and which have never been found in recent *Globigerina* ooze, are certainly very useful as index fossils owing to their easily recognisable appearance. But which stage exactly they indicate is not yet certain. On Soemba they are found together with *Nephrolepidinae* and *Miogypsinae* or without larger foraminifera and no sections are known from which it could be ascertained whether their stratigraphic distribution runs from Tertiary-e into the beds that are later than the *Lepidocyclinae*-containing Tertiary, or is only confined to the Tertiary-f. For the reasons mentioned above it was assumed that all the marls are Tertiary-f and that this *Globigerina*-fauna here begins in Tertiary-f. But this does not agree with all records in literature. Koch put the age of the localities of the rocks from which *G. quadripartita* and *G. tripartita* were originally described, Boeloengan [25]), with some reservation, on a level with the lowest part of the *Globerina*-marls from Beraoe, which lies to the south of it. These *Globigerina* marls again are placed by Leupold and van der Vlerk without hesitation in Tertiary-e (Middle to Lower Tertiary-e; see Feestbundel Martin, 1931, p. 622) and Umbgrove also assigns Koch's *Globigerinae* to Tertiary-e (Feestbundel Martin, p. 63). Personally I am not acquainted with the situation on the spot, but as Koch had three marl samples to examine, which did not

25) On the map of fossil localities by Krijnen in the Feestbundel Martin these localities are marked by the number 152.

come from a distinctly observed section, I do not consider it as absolutely proved that these marls must be correlated with the *Globigerinae*-marls from Beraoe.

The accompanying fossil fauna from KOCH's marls does not guarantee the age as Tertiary-e, either; larger foraminifera did not occur in the two samples with *G. quadripartita* and *G. tripartita*, while in the third, in which these *Globigerinae* are absent but which is probably of the same age, only *Lepidocyclina cf. angulosa* Prov. and *Miogypsina cf. thecideaeformis* Rutten were found, but no *Eulepidinae* and *Spiroclypei*. It appears to me more probable that the marl samples from Boeloengan are derived from stage f, than that all marls from Soemba, judging by these *Globigerinae*, should be determined as Tertiary-e.

Globigerina Kochi was described by KOCH from samples from Kaboe (E. Java), which he assigns to Lower Pliocene or Upper Miocene [26]). He estimates these deposits as being of the same age as the fauna that SCHWAGER described from Kar Nicobar and in any case earlier than the largely recent foraminiferal fauna from deposits on E. Ceram, the age of which has been determined by FISCHER as Pliocene on the ground of its *Mollusca*. In E. Soemba this *Globigerina* was found in two places in company with small *Lepidocyclinae* (even with *L. sumatrensis*) and *Miogypsinae*, and in the other samples which contain no larger foraminifera always accompanied by *G. quadripartita* and *G. tripartita* (or one of the two). It cannot, therefore, be an index fossil exclusively for this latest Miocene to early Pliocene, but it certainly appears as early as the lower boundary of Tertiary-f. The same conclusion is applicable to *Uvigerina javana* which was likewise considered as a good guide fossil for the beds of Kaboe.

The occurrence of these comparatively late *G. Kochi* and *Uvigerina javana* in the marls of E. Soemba is another argument for the probability of these marls belonging to Tertiary-f and not to Tertiary-e. Careful examination of *Globigerina* marls from other districts, stratigraphically well known, in the Archipelago will be needed to prove which stages or parts of stages are characterised by the presence of *G. quadripartita*, *G. tripartita* and *G. Kochi;* on Soemba these fossils can certainly be of use to show that the various marls are of the same age, and that age is in all probability Tertiary-f.

Tertiary-f, on E. Soemba, like Tertiary-e, is represented principally

26) VAN ES assigns these *Globigerina* marls from Kaboe to the uppermost Miocene, called Tertiary-g by UMBGROVE (see: UMBGROVE, 1932, p. 784).

by white and yellowish white rocks, except where the tuffoid constituents predominate over the marly elements, giving a darker tint to the rock. On W. Soemba some rocks were found of a slightly more lively colour, including some yellow and bright-pink *Miogypsina* limestones, but the colours are always very light. The only exception to the rule is sample O. S. 10, a compact dark-brown limestone containing small *Lepidocyclinae;* according to KEMMERLING this rock, in which the walls of the fossils are dissolved, so that they can only be recognised by the dark filling of the lumina, has probably acquired its peculiar "lower tertiary" colour from hydro-thermal activity. This rock shows a great resemblance to another, eocene, sample, O. S. 780, in which the *Fasciolites* is also only negatively preserved.

In the collection from Soemba there is not much to be seen of the subdivisions of Tertiary-f given by LEUPOLD and VAN DER VLERK. In eight samples *Lepidocyclina sumatrensis* (and its varieties) was found; in one of them *L. borneënsis* (including the pliolepidine form) occurs (O. S. 327). These samples, thus, probably belong to Tertiary-f_1. All the other *Lepidocyclina*-containing samples might equally well belong to Tertiary-f_1 as to -f_2. The highest zone, Tertiary-f_3, is nowhere met with. *L. Rutteni*, which characterises this stratum was not found in a single sample and the only *Lepidocyclina* that resembles it (in the fossil list and the palaeontological description it is called *L. aff. Rutteni*) comes from O. S. 327, which must be assigned to -f_1. Of course this does not prove that this zone does not exist in Soemba, it may be represented by *Globigerina* marls, in which the larger foraminifera for some reason and other are not present, and which could not be recognised as Tertiary-f_3.

The upper limit of Tertiary-f is probably just as indistinct as the lower boundary. From the stratigraphic observations in the field we should be inclined to suppose that the lowest deposits of the neogene covering, the "Kananggar series" (or in other places the "Kambaoni series"), represent the *Lepidocyclina*-containing Tertiary (Tertiary-e-f) and the "Waingapoe series" overlying it with a clear unconformity represents the Pliocene with the plio-miocene transitory beds (Tertiary-g-h) and perhaps up to the Pleistocene [27]). This may be so in a few places, e.g. in Middle-Soemba (Maka Minggit, G. Oentoe Manoek) and in East-Soemba in the neighbourhood of Kananggar, where this marl section is well developed, but this "Waingapoe series" is by no means always so clearly drawn in the field, and what is called "Waingapoe series" in other parts of the

27) Especially in connection with what is known of the rest of the islands in the East of the Archipelago (see UMBGROVE 1932, 1934).

island is sometimes no more than a locally tuff-less deposit of the same age as the coarser marly tuffs and marly limestones of the "Kananggar series". In a section to the North of Ramoek, for instance, in the so-called "Waingapoe deposits", *Lepidocyclina, Miogypsina* and even *Spiroclypeus* was found. It remains an open question, therefore, whether the entire upper tertiary marl series belongs to Tertiary-f or whether the uppermost strata were deposited in Tertiary-g or even Tertiary-h (see p. 201).

The thickness of the upper tertiary covering is very variable, which is due principally to the unevenness of the older land, over which is transgressed. Probably the thickness may be some hundreds of meters. At the G. Datoe Sasar (in middle Soemba) it was estimated to be about 400 m. but possibly this only included the upper part of the plateau, the Waingapoe series.

The geographic distribution of upper tertiary rocks in East and Middle Soemba is given in Map II. The numbers on this map in so far they do not lie in the zone of sub-recent terraces along the coast (see general map, p. 6) almost all belong to the neogene plateau; only an occasional relic of older sub-recent terraces further inland are marked amongst them. On West Soemba the Upper Tertiary forms the whole covering also, leaving only the mountains and the region along the south coast between Tg. Mamba and Tg. Marongi free and which in its turn is covered at the W. and N. coasts by the subrecent sea terraces (see p. 8 and Map III). In the region between Tg. Mamba and Tg. Marongi there are, however, numerous relics of the upper tertiary plateau.

SUBRECENT TERRACES.

The latest deposits on Soemba are coral limestones, gravel limestones and marls. Sometimes these marls, which form the basis of each terrace (the reef bank is only very narrow) have a grey tint, which distinguishes them from the Upper Tertiary. The terrace limestones themselves are white to pink and are in general harder, coarser porous and less marly than the reef limestones of tertiary age. They contain chiefly *corals* and *algae*, as a rule the foraminiferous fauna is very poor. There are, however, occasionally foraminiferous limestones, such as the *Tinoporus*-"oöliths" from the extreme western point of the island (near Kodi). Similar "oöliths" are also found on E. Soemba, which however consist entirely of globular specimens of *Archaeolithothamnium*.

The geographic position and the extensiveness of the uninterupted zone of terraces which surround the island can be seen on the general map (text fig. 1), copied from a working map by KEMMERLING. Within

this zone, farther inland, there still lie the innumerable relics of older terraces, which have been to a large extent eroded away again; the localities of the samples from this district are given on Map II and Map III (c.f. p. 168 and 173).

CONCLUSIONS SUPPLEMENTARY TO THE FIELD WORK HISTORY OF THE ISLAND

Generally speaking, we may say that the palaeontological research on Soemba confirms the results arrived at from the field examination.

Disregarding some slight corrections in the age determination, especially of reef-limestones in the interior, research amongst the foraminifera has only lead to two important modifications of the stratigraphy of the island.

In the first place it has shown that the lower tertiary "Tanah Roong Series" is not one formation but includes 3—4 different stages of the Tertiary. VAN DER VLERK, in his preliminary determination, demonstrated Tertiary-a, -b, -c and -d, and stated further that the upper tertiary rocks often contained derived *Camerinae*. I myself, in the final examination of the whole collection came to the following conclusions:

Tertiary-a and Tertiary-b, both in West and in East Soemba are represented by marine deposits (Tertiary-a is particularly well developed in East Soemba, with *Assilina* and *Fasciolites*).

Tertiary-c is common in East Soemba, but has not been found in West Soemba.

Rocks from Tertiary-d seem to be extremely rare and are also found only in East Soemba.

The number of cases in which *Camerinae* are washed into upper tertiary sediments containing *Lepidocyclinae* is very considerably greater than was at first thought; these *Camerinae* come from Tertiary-c—d.

The second important conclusion is that the vast upper tertiary transgression which spreads over the whole island took place in Tertiary-e_{4-5}, probably Tertiary-e_5. At the basis of the upper tertiary covering there often lie conglomerates or heterogenous marly limestones which contain *Nephrolepidinae, Eulepidinae, Spiroclypei* and *Miogypsinae*. This extensive transgression therefore coincides with the Beboeloeh transgression which has been recorded from so many places, all over the Indian Archipelago (see LEUPOLD and VAN DER VLERK, 1931).

The time that elapsed between the deposit of lower tertiary sediments and the upper tertiary covering may be computed as follows.

It must have been during this period that the folding took place which tilted the lower tertiary beds, and which raised the island above sea-level, thereby exposing it to the influences of erosion.

In East Soemba rocks of Tertiary-c are found at the height of more than 1000 meters in the mountains (Ramoek-Pr. Kareha), while in the upper tertiary plateau boulders are found derived from Tertiary-d. Thus we must assume that the folding did not reach its maximum effect until after the Tertiary-d. The great scarcety of rocks from Tertiary-d suggests that the region at that time was already for the most part land and that the folding began towards the end of Tertiary-c. This is confirmed by the profile at Ramoek, where Tertiary-c in the form of distinct reefs clings to the andesitic foundation of the island at various levels (reef Ramoek-Pr. Kareha; see p. 191).

It may, of course, be due to an unfortunate accident in collecting the samples, that we have no Tertiary-c and -d from West Soemba, and it is also possible that erosion during the land-period has entirely destroyed all deposits of that stage. Neither of these are very probable, however, as no derived reticulate *Camerinae* are found here in the Upper Tertiary either. If these stages are really absent from the island, in all probability this would indicate that West Soemba had already become land by that time, that the folding began in West Soemba and during Tertiary-c and -d spread to East Soemba.

In the earlier part of Tertiary-e (Tertiary-e_{1-4} or -e_{1-5}) the whole of Soemba was land. A few rare finds in East Soemba of littoral sediments, which must be determined as Tertiary-e_{1-2} (probably e_1) according to their fossil content, make it probable however, that at first some spots of the land were accessible to the sea. One of these rocks (O. S. 534, near Pr. Kareha) is a grey coral limestone, which according to a verbal report from Dr. KEMMERLING, can be as clearly recognised in the field as being a reef on the andesitic substratum as the c-reefs in this region can be, and is lifted up in the same way, so that it lies higher than the flat upper tertiary covering, which has left this high part of the Massoe free. Although we must be somewhat cautious in accepting this representation of the situation, which is based upon recollection and not upon notes taken directly on the spot, it is at any rate an indication that the raising of the land continued into the Tertiary-e.

The denudation of the upraised land was not very great. This can be inferred from the fact that the washed-in foraminifera in the basal

beds of the Upper Tertiary of East Soemba are derived exclusively from the Tertiary-c—d, probably Tertiary-c (see p. 191). At the time of the great transgression erosion chiefly effected the highest points of the eruptiva (small boulders of igneous rocks in the basal beds) and the latest and most highly situated sediments of the Lower Tertiary, by which it is evident that the surface of the island was then only slightly above sea-level.

The great folding between Tertiary-c and -e_5 is probably not the only motion to which Soemba was subject in the Lower Tertiary. No continous profile of all lower tertiary beds has been found (Tertiary-a—c); Tertiary-a is found transgressive upon the Pre-Tertiary; in other places Tertiary-a + -b, or Tertiary-c lie unconformably over the pre-tertiary foundation. Unconformities between Tertiary-a and -b, or -b and -c have not been recorded, no doubt due principally to the fact that the Lower Tertiary used to be regarded as one formation so that they were never looked for. Palaeontologic research, however, has brought one very remarkable succession of beds to light, which might be an indication of considerable vertical motion during Tertiary-a—b. This is the section of Watoe-Moendoe, which was investigated by KEMMERLING and is only briefly mentioned in an uncompleted sketch on the Liang Malip valley (April 1925).

The Watoe Moendoe is the most southerly hill of the range that borders the Liang Malip valley in the East. The broad table-shaped top lies about 200 m. above sea-level. Between this hill and the south coast lies a plane, which is often submerged at high water and from which small elevations rise, erosion-remains of harder rock. Now both on the top of the Watoe-Moendoe (O. S. 511, 512) and on the small elevations in the plane (O. S. 315) Tertiary-a has been found in situ, while halfway up, on different sides of the hill, Tertiary-b lies. That it is really Tertiary-b relics and not an impoverished Tertiary-a-fauna is proved by finding loose foraminifera (*Camerina djokdjokartae* Mart.) in the plane, which must have come from this profile. Here, therefore, we find Tertiary-b deposited against a hill of Tertiair-a-rock which must have assumed its steep shape as early as Tertiary-b. This phenomenon can be best accounted for by an upraising of the district after Tertiary-a. (An other explanation would be that the Tertiary-a-rock originated as an irregular steep reef, and during Tertiary-b was covered by a bottom sediment. But this is not probable, considering that the rocks from Tertiary-a do not as a rule give the impression of being reefs: they contain few algae and practically no coral.) The profile of the higher, more northerly

Tandoela Djangga, also found in KEMMERLING's description, strengthens the idea of a raising above the sea. This hill, which is about 440 m. high, consists of well stratified sediments from Tertiary-a (O. S. 514, 516, 519, 796) with a dip of 24°, while the flat top is formed by a conglomerate bank formed in Tertiary-e_5, which is 5 m. thick and lies almost horizontal (O. S. 520—523, 793—795). The lower tertiary series contains alternately compact foraminiferous limestones and fine sandy foraminiferous marls, but merges upwards into a very sandy well stratified limestone (O. S. 519, 796), which points to the sea having grown shallower. Tertiary-b is not recorded in the whole neighbourhood of the Tandoela Djangga; it is possible that this stage is really absent here. Perhaps in Tertiary-b the Tandoela Djangga had become completely land and the south coast lay where the Watoe Moendoe now is. Tertiary-c is practically not found in the Liang Malip region, but has probably lain there at one time (O. S. 287). This would indicate a sinking motion after Tertiary-b. In the great folding-phase after Tertiary-c—d perhaps the raising was not uniform. It is difficult to reconcile the profiles of the Liang Malip region where the lower tertiary land has been denuded down to the deposits of Tertiary-a during that land period, with the profile at the much greater altitude of the Massoe Mountains between Ramoek and Pr. Kareha, where the remains are still found of Tertiary-c, even after a much longer denudation period (viz. Tertiary-c—recent times; this part did not come below sea level during the upper tertiary transgression), unless we assume that East Soemba has been block-faulted and that the different parts moved independently.

The conclusion to be drawn from these various data is that Soemba must have been in motion during the whole of the Lower Tertiary, and that sea and land were constantly at strife. Considering the neritic and littoral character of the lower tertiary deposits it is probable that the highest points of the Pre-Tertiary were never entirely below sea level.

The upper tertiary covering is only slightly folded. There are certainly signs of some local vigorous disturbances: steep inclination of the strata (max. 27°), local crumpling of the epidermis (lowest beds of the "Waingapoe Series" at Kananggar), faults, conglomerate banks, denuded surfaces and unconformities; but a distinct folding which can be traced for some distance horizontally and which includes a considerable part of the section has nowhere been recorded. The covering lies flat or with a faint incline over the distinctly folded Pre-Tertiary and Lower Tertiary. In this respect Soemba corresponds to what Rutten says of the small island

Rotti, S. W. of Timor (Voordrachten over de Geologie van Ned. Oost-Indië, 1927, p. 677).

The only important problem that arises in connection with the upper tertiary covering, is the place occupied by the so-called "Waingapoe Series". A view of the islands in the neighbourhood, especially of the "Outer Banda Arc" shows that frequently on the more or less folded "Lower Neogene" there is an almost horizontal deposit of *Globigerina*-marls or -limestones (sometimes conglomeratic or with a slight admixture of clay), which is usually covered unconformably by coral limestones and which is designed to the "Pliocene" (see UMBGROVE 1932—1934; BOTHÉ 1932). In analogy with this it would be tempting to find an equivalent of this "Pliocene" in the "Waingapoe Series". But it must be insisted upon, that nothing is known with any certainty of the "Waingapoe Series" on Soemba. KEMMERLING's statement "that two divisions can be distinguished everywhere in the Neogene" is too optimistic. It is only in Middle Soemba (Maka Minggit, G. Oentoe Manoek) that the unconformity (with a denudation surface) could be traced for some distance between a lower series of beds with a dip of 6—20° and an upper series with a dip of 0—5°. Everywhere else there are only local disconnected sections reported, in which the upper part is formed by level marls, usually poor in tuffs. Palaeontologic research has shown that the "Waingapoe beds" here and there contain *Lepidocyclinae* and in some places are not more recent than the transgressional rocks which form the base of the upper tertiary plateau covering (see p. 196). Even for the section of Middle Soemba I could not find a good palaeontologic distinction between the lower and the upper series. Thus we are still unable to say what the exact age of these level beds may be, and it is by no means impossible that the distinct unconformity, which seemed to occur in the middle of the Upper Tertiary, on this mobile island, largely consists of a series of small local unconformities which are not synchronous. But one thing is obvious from the occurrence of the almost horizontal covering beds of the plateau that were found in so many different places over the whole island; that the principle phase of the upper tertiary folding was concluded before the end of the Tertiary, as the covering beds all belong obviously to the tertiary plateau. As, moreover, several of the limestones and marls which we now assign to Tertiary-f have clearly been influenced by the folding, we must assume that the principle phase occurred after the deposit of the earliest portion of Tertiary-f. Probably therefore the most intensive folding took place in the Middle to Upper Tertiary-f. The folding was always accompanied by

marine sedimentation, which would account for the numerous small unconformities in the Upper Tertiary. This leads to the conclusion that the sedimentation of the upper tertiary covering must have taken place in a somewhat shallow sea, which would even account for the *Globigerina* marls [31]).

The period in which we have placed the principle phase of the slight upper tertiary folding agrees with the period that UMBGROVE assumes for the last intensive folding of the island arc which is the continuation of the Nicobars, via Nias, Mentawei Islands, Rendjoewa, Timor, Tenimber Islands, Kei Islands, Ceram, Boeroe up to E. Celebes (1934, p. 21—22). According to UMBGROVE these islands are the only part of the Indian Archipelago in which an intensive miocene folding (which in many places gave rise to the formation of nappes) is known. Moreover the gravimetric research carried out by VENING MEINESZ has shown that this series lies in a belt of some 100 Km. in which strongly negative anomalies of gravity could be recorded, anomalies which he connects with folding phenomena (see UMBGROVE 1932, p. 769). It has been shown by palaeontologic research, that there is a remarkable similarity in the Lower Tertiary (Tertiary-a) between Nias and East Soemba (of the lower tertiary beds of the other islands practically nothing is known palaeontologically). Moreover, on many of the islands of this series a considerable folding of the Lower Tertiary has been recorded, or at all events has been surmised; a second folding took place in Tertiary-f (probably -f_2). After that the islands were submerged and the formation of "pliocene" and "pleistocene" marine sediments was followed by late elevation above sea level, accompanied by the formation of reefs (see UMBGROVE 1932, 1934; BOTHÉ 1932). Considering that its geographic situation is not in conflict, it might therefore be supposed, that Soemba belonged to this series. But there is one difference between Soemba and the islands examined by UMBGROVE (1934), namely that on most of them the miocene folding was very intensive, even causing an overthrust structure (e.g. on Timor), while on Soemba the second tertiary folding in about the same period had only a slight influence and was of much less importance than the folding between Tertiary-c and Tertiary-e_5. It is a very remarkable coincidence that the belt of negative anomalies of gravity is interrupted precisely at Soemba; the negative effect diminishes or possibly even dis-

31) A *Globigerina* marl from the Soemba collection containing a number of fairly large boulders indicates that these marls may be formed close to the coast as well.

appears in the vicinity of the island. This would indicate that Soemba, after Tertiary-e at any rate, has not formed a part of the arc in a structural sense.

CORRELATION OF THE DEPOSITS IN SOEMBA WITH THOSE IN OTHER REGIONS

A - COMPARISON WITH REGIONS IN THE DUTCH EAST INDIES

For a comparison of the different deposits in Soemba with data from other regions of the East Indies, see in the first place the stratigraphic essay on the Tertiary by LEUPOLD and VAN DER VLERK (1931). To this we can now add a few particulars, especially with regard to the Lower Tertiary.

1. **Lower Tertiary.**

The lower tertiary localities which are of the greatest importance in connection with Soemba, and which we shall discuss in turn, are Nias, Boeloengan (Soengei Marah, E. Borneo), the peninsula of Mangkalihat (N. E. Borneo), Java (especially Middle Java), Central Celebes and Timor. The Tertiary-a of East Soemba contains the following important larger foraminifera: *Assilina aff. granulosa-exponens* nov. nom., *A. orientalis* Douv., *Camerina kelatensis* (Carter ?) Douv., *C. aff. irregularis* Desh., *C. pengaronensis* Verb., *C. c.f. borneënsis* (Van der Vlerk) nov. nom., *C. aff. taballarensis* (Van der Vlerk) nov. nom., *C. c.f. javana* Verb. *var.* α and β, *C. c.f. variolaria* Sow., *Fasciolites Wichmanni* Rutten, *F. celebensis* Bakx, *F. ovicula* (Nuttall ?), transitory forms of *F. Wichmanni* to *F. timorense* Verb. and of *F. ovicula* to *F. javana* Verb., *F. spec.* (small forms), *Discocyclina c.f. dispansa* and *D. javana* (small form).

NIAS.

The fauna from the eocene rocks on Nias which DOUVILLÉ described in 1912 (especially in the samples from Hili Badaloe and from Eho, but probably from locality No. 11 as well; see p. 53) is to a remarkable extent the same as from the East Soembanese Tertiary-a. Nias and Soemba have here the following foraminifera in common: *Assilina aff. granulosa-exponens, A. oriëntalis, Camerina kelatensis, Fasciolites ovicula, F. spec.* (small form) and perhaps *Camerina c.f. javana* and a species of *Discocyclina*. There can be no doubt that the deposits on Nias and Soemba are equivalent. The great similarity of these two islands, which lie far apart,

but which both form part of the outside arch of the Soenda islands, is so interesting that it should certainly be mentioned here.

SOENGEI-MARAH (Boeloengan, E. Borneo).

The foraminifera of this region have been described by Yabe (1921). The oldest organogenous deposits, the Orang beds, here contain *Assilina aff. granulosa-exponens*, *A. oriëntalis*, *Camerina c.f. pengaronensis*, and *Discocyclina javana* (small form), showing that these deposits, also, correspond to the Soembanese Tertiary-a.

Both localities, Nias and Soengei Marah, were placed in Tertiary-a_2 by LEUPOLD and VAN DER VLERK; so we may certainly assign the oldest fossil-bearing beds in Soemba in Tertiary-a_2 as well.

PENINSULA OF MANGKALIHAT (N.E. Borneo).

The oldest beds which have yielded tertiary fossils in this locality, are placed by LEUPOLD and VAN DER VLERK in Tertiary-a_1. The stratigraphy of this locality follows from their report of the Indian Tertiary (1931, p. 614) in which LEUPOLD's latest, unpublished field geologic data are contained. The classification of the Taballar marls, as it was given in the first publication on this district (see VAN DER VLERK, 1929) proved later to be incorrect. The Lower Taballar marls of 1929 became in 1931 marl beds in the sandstone stage, and the Middle Taballar marls (1929) were called in 1931 Lower Taballar marls. From the marl beds in the sandstone VAN DER VLERK determined in 1929 *Camerina Nuttalli*, *C. thalica*, *C. kelatensis* and *C. variolaria*. On the strength of the presence of *C. Nuttalli* and *C. thalica*, he correlated this deposits with the Upper Ranikot Series of British India, so that in 1931 they were placed at the base of the Tertiary, that is in Tertiary-a_1. In a further research which I conducted (see p. 57) it was shown that neither the *C. Nuttalli* nor the *C. thalica* of Borneo corresponds completely to the British India *C. Nuttalli* and *C. thalica*, so that the fauna from Sg. Taballar has not really sufficient in common with the fauna from the Ranikot Series to justify such a weighty correlation. On the other hand the *C. Nuttalli* from Borneo (*C. borneënsis* nov.nom.) is extremely like a Camerina from Soemba (O. S. 62), the *C. kelatensis* is almost exactly the same as the Soembanese *C. kelatensis* (O. S. 62) and probably the *C. variolaria* from both islands is the same. There is therefore, good reason to assume that the fossil beds in the sandstone stage of the Sg. Taballar are of the same age (Tertiary-a_2) all the more because they do not lie quite at the bottom

of the profile. Below the sandstone stage there lies a red sandstone and a basal conglomerate, to which the name of Tertiary-a_1 might be given and which can be correlated to the "Lowest Eocene" of Soemba. We shall return later in this chapter to the parallelisation with British India; here it is enough to remark that the presence of these fossils in Borneo is no reason for supposing that there is an older fauna in the East Indies than that found in Soemba.

MIDDLE JAVA.

A comparison with the lowest Lower Tertiary of Java is not easy to make, because the fauna from Tertiary-a in Java is very different in species to the Soembanese. In the Djiwo hills GERTH found two Camerina limestones both of which he assigned to Tertiary-a_2. The oldest of these, the Woengkal limestone, which transgresses over the Pre-Tertiary, contains *Assilinae* (but other species than are found on Soemba), further *C. javana Verb. var.* β and γ (= "*C. perforata obtusa*") and *C. bagelensis* Verb. and two species of *Discocyclina*, which, with the present knowledge of the genus, we cannot compare with Soemba. The uppermost limestone is found both in the Djiwo hills and in the Loh-Oeloh mountains where it lies transgressionally upon the Pre-Tertiary and where it is moreover replaced horizontally by a Fasciolites limestone. This Camerina limestone contains according to GERTH and DOORNINK: *C. javana var.* β and γ (= "*C. perforata*" and "*C. gizehensis*"), *C. bagelensis, C. laevigata* Brug., *C. densa* Doornink, *Discocyclina javana* Verb., *D.* "*dispansa* Sow." and *Pellatispira orbitoidea* (Prov.); *Assilinae* are absent. The Fasciolites-limestone of Loh Oeloh yielded *F. ovicula* and *F. javana* (with some transitional forms), *Camerina javana var.* β, *C. bagelensis, Discocyclina ephippium* and *D. javana* (see BAKX 1932, p. 242). According to BAKX, the Soembanese specimens of *Fasciolites ovicula*, which sometimes show a great inclination towards the *javana*-type, may be placed in the same stage of the development series of the *Fasciolitidae* as the fauna from Loh Oeloh. Perhaps the Fasciolites beds in Java and Soemba may be correlated, therefore, but the stratigraphic value of this development series is not established with certainty and moreover in one rock from Soemba (O. S. 512) *F. aff. timorense* was found, which would indicate a somewhat greater age.

The limestones of Goenoeng Gamping near Djokja and of S. Bantam (W. Java), which GERTH (1930) with some reserve placed in Tertiary-a_1, yield no points in common with the beds from Tertiary-a from Soemba (see below).

The later beds in Java, the Nanggoelan beds in Djokja and the Gamping beds in the Djiwo hills, which both belong to Tertiary-b, have a few foraminifera in common with Soemba. In the first place *Camerina djokdjokartae* Martin, further *C. pengaronensis* Verb., *C. irregularis* (see DOORNINK), *Discocyclina javana* and the smaller *Discocyclina* of the *dispansa*-type; the *C. variolaria* of Java (see DOORNINK) is not the same as the *C. c.f. variolaria* from the Soembanese Tertiary-a. The presence of *C. djokdjokartae*, which is typical of the earliest part of the Nanggoelan beds, proves there are deposits on Soemba from the Lower Tertiary-b; the stratigraphic value of the other foraminifera must be studied further before correlations can be founded upon them. *C. irregularis*, for instance, was found by DOORNINK only in the uppermost part of the Nanggoelan beds, while they are found in exactly the same form in Soemba in the company of *Assilinae*, that is in Tertiary-a.

"Oligocene" was only found in Java in the west of the island. TAN SIN HOK (1932) made a distinction between stages c and d, the first of which contained reticulate *Camerinae* and a few radiate *Camerinae* and the second only reticulate *Camerinae* and *Lepidocyclinae*. In GERTH's material, which came from different localities to TAN SIN HOK's, DOORNINK found only reticulate *Camerinae*, sometimes in company with *Lepidocyclinae* and sometimes not. DOORNINK states that in the lowest division (= Tertiary-c, without *Lepidocyclinae*) *C. intermedia* d'Arch. and *C. absurda* Doornink are found, while in the uppermost (= Tertiary-d, with *Lepidocyclinae*) only *C. divina* Doornink (forma A exclusively) is found. On E. Soemba forms were found which corresponded to DOORNINK's *C. intermedia* as well as specimens of the "*divina*" type. As far as can be seen, there is no reason to regard this "*C. divina*" as an index-fossil for Tertiary-d as it seems to occur sometimes in company with radiate *Camerinae*. *C. absurda* is still a dubious species to which not much stratigraphic value can be attached (see p. 77, 79).

CENTRAL CELEBES.

The Lower Tertiary from Central Celebes has not many points in common with Soemba. This may be due to the fact that little is known of the species that occur in Celebes. DOLLFUS (in ABENDANON, Middle Celebes 1915) has determined *Fasciolites javana, Camerina djokdjokartae, C. laevigata, C. bagelensis, C. kelatensis, Pellatispira Madaraszi* and *Discocyclina dispansa* in the material of ABENDANON, a combination that is unknown in Soemba, but which is probably partly due to erroneous determination. His description of *C. kelatensis*, for instance, is very

cursory and the *C. djokdjokartae* is insufficiently typified and compared to DOUVILLÉ's material from Nias, in which guaranteed no *C. djokdjokartae* is contained, while no good reproductions are given. This publication is thus no guide as to whether we are dealing with Tertiary-a or -b; these deposits are usually assigned to Tertiary-b, but this is no proof against the stratigraphic value of *C. kelatensis*, which in Soemba, Nias and Borneo is so typical of Tertiary-a. The presence of *Assilina*, recorded by DOLLFUS, RUTTEN (Jaarboek Mijnw. 1914) and VAN DER VLERK-DOZY, proves that on Celebes Tertiary-a is also present; but as there are no definitions of species, or only inadequate ones, it is impossible to draw a comparison with Soemba. Further the following foraminifera are known from Tertiary-a and -b in Celebes: *Fasciolites Wichmanni, F. celebensis, F. ovicula, Camerina javana var. δ, C. c.f. globula, C. elegans, C. gizehensis, C. Heeri, Discocyclina umbilicata, Pellatispira crassicolumnata, P. glabra, P. Rutteni, P. c.f. inflata, P. c.f. irregularis* and *Lacasina Wichmanni* (see: OSIMO 1908, BAKX 1932, VAN DER VLERK-DOZY 1934). Of these species, some of which moreover are untenable, only *F. ovicula* and *F. celebensis* are of importance for a comparison with Tertiary-a in Soemba (the localities may be found in BAKX's publication), while the *Pellatispirae* (see VAN DER VLERK-DOZY) will be largely the same as those in the Soembanese Tertiary-b.

TIMOR AND OTHER LOCALITIES IN THE EASTERN PART OF THE ARCHIPELAGO

Finally the age of some localities for *Fasciolites timorense, F. ovicula* and *F. celebensis* may probably be ranged with the Tertiary-a of Soemba. All these localities can be found in BAKX's publication. The most important of them is the Lower Tertiary of Timor, which probably in respect to the Fasciolites-fauna corresponds exactly to E. Soemba and perhaps even forms the direct continuation of the deposits on E. Soemba.

2. Upper Tertiary

The Upper Tertiary in Soemba is a comparatively thin, almost unfolded sediment series. The small depth of the strata indicates that it is not a geosynclinal region. In some places it begins with a distinct transgressional conglomerate, which contains *Nephrolepidina, Spiroclypeus* and *Miogypsina*, and belongs, therefore, to Tertiary-e_{4-5} (probably e_5). This transgression corresponds to the Beboeloeh-transgression which has been recorded in several places in the East-Indies (see LEUPOLD and VAN DER VLERK). Subsequent to the Beboeloeh-transgression there must have been other brief interruptions in the sedimentation, for instance

before the deposit of the so-called "Waingapoe-series". But it is by no means proved as yet that this interruption came after the *Lepidocyclina*-bearing part of the Tertiary and that the following deposits belong directly to Tertiary-h as LEUPOLD and VAN DER VLERK assume (loc. cit., p. 645; see above, p. 201). The coral limestones mentioned by these writers as Tertiary-h or Quarternary were all assigned to the Quarternary by KEMMERLING.

B - COMPARISON WITH REGIONS BEYOND THE EAST INDIAN ARCHIPELAGO

We will now consider whether the new data yielded by the examination of the Soembanese collection can throw any light upon the old problem of how far the Tertiary of the East Indian Archipelago can be correlated with the Tertiary of Europe, or even with that of Western India, which has often been regarded as intermediate between the two. It is always dangerous to make a correlation of territories at such great distances from eachoter; when we see how complicated the zoogeography of our own time is, we can understand that it is impossible to make a truly just comparison between widely separated territories, at a time of which practically nothing is known as regards the geographic and ecologic conditions. In the following, therefore, the relative value of correlation and limits must never be forgotten.

The first investigators who worked in the East Indies were inclined to apply the classifications of European Tertiary to Indian Tertiary. MARTIN, however, pointed out on the strength of the *molluscs* in Java (1914, 1915) that the East Indies must have been a region confined to itself, which, at least during the Upper Eocene and the Neogene was not connected with the Mediterranian Sea, and where a characteristic indigenous fauna could be developed. As regards the Lower and Middle, Eocene and the Oligocene a study of the *molluscs* gives no grounds for assuming either the existance of a sea communication or of land barriers as no mollusc faunas sufficient for a comparative study are known from these periods.

The differences between the East Indies and Europe has gradually become increasingly evident, in part through the study of foraminifera, so that it is now certain that since the Upper Eocene there has been no direct open sea connection between these two regions. A clear account of the conclusions to which the earlier and later research has lead, is given by UMBGROVE in 1929 and MARTIN in 1931.

UMBGROVE comes to the final conclusion that at latest in the Middle

Eocene age there could have been an open sea connection between Europe and the Malay Archipelago (Tethys). During the Upper Eocene there was no communication. In the Oligocene there came a connection with Europe, perhaps not a direct one, but varying during the course of this age and indirect, with Western India as intermediary, by which an intermittant migration of European animal organisms to the East Indies was possible. The character of the fauna in the Archipelago indicates that the entrance of new forms must have taken place during that period. This theory is supported by VREDENBURG's research on oligocene *molluscs* in Western India, which correspond exactly to the European forms and by the wide distribution of *reticulate Camerinae* in Europe, Western India and the East Indies. During the whole Neogene the sea-way to Europe must have been again closed (except that, according to VREDENBURG, there may have been an incomplete and temporary communication in the Lower Miocene); but is was easy for animal forms to pass between Western India and the East Indies as is evident from the corresponding forms of *molluscs*.

UMBGROVE's theory is a very attractive one for the period following the Middle Eocene. But as regards the Lower and Middle Eocene in which the possibility of an open connection between the Malay Archipelago and Europe is left undiscussed, we are of opinion that the subject deserves further research. Here the new data that we have gained from Soemba will be of use. UMBGROVE places the Tertiary-a of the East Indies on a line with the Upper Ranikot, the Laki and the Lower and Middle Kirthar Series in Western India, on the authority of GERTH, who correlated these deposits entirely on the strength of the *foraminifera* (from Tertiary-a no other organisms have been described from which a comparison would be possible). GERTH's theory is found in various stages of development in his publications from 1929 to 1932; in 1932 (Geologie en Mijnbouw) DOORNINK's latest research on *Camerinae* in Java is taken up in it.

On Java, according to GERTH, there are no strata which can be with certainty correlated with the Ranikot and Laki series (Lower Eocene). The limestones of Djiwo and Loh Oeloh he regards as equivalents of the Kirthar (Middle Eocene), the Tertiary-b (Upper Eocene) corresponds with a hiatus in Western India. The similarity between the foraminifera of Western India and Java would be so striking, not only in general line of development but in a number of common species, that it might well form the basis of a correlation of the Archipelago with Western India and even with Europe.

But on a minute comparison between the foraminifera of Java and of India it appears that the excellent classification of British Indian eocene stages, with their characteristic index fossils can by no means be applied to Java. Not only has GERTH identified species which probably have no connection with eachother (e.g. *Alveolina elliptica* with *Alveolina javana*) and made use of decidedly erroneous determinations for certain Javanese foraminifera (e.g. *Assilina granulosa*, DOORNINK), but the index fossils do not even follow in the same order as in British India. GERTH places *Assilina spira* in the lowest part of the Middle Eocene and *Alveolina elliptica* (= *A. javana*) in the uppermost, while NUTTALL's *Assilina spira* appears for the first time in the uppermost part of the Middle Kirthar, and *Alveolina elliptica* is found from the lowest part onwards. *Discocyclina Sowerbyi*, according to GERTH, was only found in the lowest beds of the Javanese Middle Eocene, in which there was no *D. dispansa;* in 1932 *D. dispansa* was even considered typical for Tertiary-b (Upper Eocene). The British Indian *D. Sowerbyi* is found however throughout the whole Middle Kirthar, while *D. dispansa* typifies only the lower half of it. *Assilinae* are confined, in Java, to the lowest middle eocene beds; in Western India they are found from the Upper Ranikot up to the Upper Kirthar. Finally GERTH places the pustulate *Camerina djokdjokartae*, the microspheric form of which he calls *C. Vredenburgi*, as the typical index fossil for Tertiary-b, Upper Eocene therefore, while in British India it is almost certain that the Upper Eocene is completely absent (at any rate in Sind and Cutch) and *C. Vredenburgi* is a species from the Middle Kirthar.

It follows from this that it is impossible to correlate the two divisions in Javanese Middle Eocene with synchronous niveaus in British India. The foraminifera from Tertiary-a from Soemba, Borneo and Nias, also, cannot be found in the fauna from Sind. *Assilina orientalis* is a typically East-Indian species, *Assilina aff. granulosa-exponens* does not correspond to any of NUTTALL's *Assilinae*. *Camerina kelatensis* is originally a British Indian species, probably from the Kirthar, but after CARTER who discovered it, this *Camerina* has never been found and CARTER's material is lost. This species is therefore very little known. Perhaps it is not identical with the East Indian form indicated by this name and cannot be used for a correlation. *C. aff. irregularis* of the Malay Islands is not the same as the Western Indian *C. irregularis*. *C. pengaronensis* has so far been found only in the East Indies. "*C. Nuttalli*" and "*C. thalica*" (= *C. borneënsis* nov. and *C. taballarensis* nov.) are not the same as the well known *C. Nuttalli* and *C. thalica* from the Upper Ranikot in Sind

and Thal. Neither are the *Fasciolites* the same. There is a slight difference between the Western Indian and the East Indian *F. ovicula*, which is particularly evident in the transitional forms from *F. ovicula* to *F. javana*, and the true *F. oblonga* and *F. timorense*, though they very closely resemble eachother, do not belong to one species. *F. celebensis* and *F. Wichmanni* have no related forms in British India. Finally the East Indian forms of *Discocyclina "dispansa"* do not correspond to *D. dispansa* Sow. (see NUTTALL, Kirthar) and there is a distinct difference between the British Indian *D. javana var. indica* and the true *D. javana* Verb. or its small variety.

If to this we add the fact that the Eocene of the East Indies contains numerous species of the genus *Pellatispira*, while this genus is absent in British India, and that on the other hand the genus *Dictyoconoides* which plays such an important part in British India is not found in the East Indies, we see that the foraminifera in British India and the East Indies, especially in regard to species, have more points of difference than of similarity, so that it must not be too readily assumed that there was an open sea communication between the two regions in Lower and Middle Eocene.

Before going further in the construction of a theory on a possible sea communication in those periods we must briefly discuss the question of the age to be assigned to the beds reckoned as Tertiary-a in the East Indies.

Although it has been shown that it is impossible to carry out a minute correlation over those regions by means of index fossils, an attempt may be made at a rough estimation of the age of the earliest tertiary deposits in the Archipelago from the general impression made by the whole fauna (in this case the foraminifera). As MARTIN and GERTH have pointed out several times, the development of the foraminifera in Europe, Western India and the Malay islands from Eocene to Oligocene, displays a remarkable similarity especially as regards *Camerinae*. If the a-fauna from Soemba be compared with the stages of development of the eocene foraminifera as given by NUTTALL (Geol. Mag. 1926) it is seen that this fauna is no longer very primitive and that the niveau of Soemba may be considered about equal to the boundary between the Laki and the Kirthar Series, that is between the Lower and Middle Eocene. This applies also to the Orang beds of Boeloengan and the Eocene of Nias. The deposits of Djiwo give the impression of being later, from the large

Assilinae (*A. spira*) in the lower division and the *C. javana var. γ* (resembling *C. gizehensis*) in the upper division. They might represent about the Middle Kirthar, and are at any rate not earlier than Lower Lutetian. As, however, the Fasciolites limestone of Loh Oeloh which corresponds to the upper division of Djiwo, is probably of the same age as the beds on Soemba, it will be better to place these limestones, also, at about the base of the Middle Eocene. In this connection the question of age of the *Pellatispira*-reef-limestone at Goenoeng Gamping (near Djokja) found by GERTH in 1930 (Kon. Acad. v. Wetensch.), which he supposes to be of greater age than the Woengkal limestone, must be touched upon. He bases this determination upon the fact that the reef limestone of G. Gamping lies geographically between the clays, tuffs and marly sandstones of the Upper Eocene of Nanggoelan and the Camerina limes and Discocyclina marls of the Middle and Upper Eocene of Djiwo, and that a very remarkably varying facies must be assumed within this short distance unless the exceptional appearance of this reef limestone is partly attributable to a difference in age. Judging by the presence of a *Camerina* that considerably resembled *C. Wadiai* Davies, GERTH, under reservation, placed this limestone on a level with the Ranikot of British India. But seeing that the subject in question is a reef with which a sudden change of facies in the direct surroundings may easily be expected and that the *Camerina* (described later by DOORNINK as *C. Gerthi*, 1932) is not identical with *C. Wadiai*, there is no reason to assume that the deposit is so much older. When we consider how very seldom *Pellatispira* has been found in Tertiary-a so far, it becomes probable that the Pellatispira limestone from Gamping (and the one from S. Bantam which is equivalent to it) does not belong to Tertiary-a at all, but to Tertiary-b.

Thus we come to the conclusion that the age of Tertiary-a_2 which contains the earliest tertiary foraminifera of the East Indies is about equivalent to the boundary between Laki and Kirthar or perhaps even to the Middle Kirthar. Whether Tertiary-a_2 may be regarded as an equivalent of the whole Kirthar series, which reaches a thickness of some thousands of meters, cannot yet be ascertained, as we do not know enough of the thickness and of the nature of the deposits of Tertiary-a_2. So far no hiatus has ever been found between Tertiary-a and -b, so that it is probable that Tertiary-a continues up to the Upper Eocene.

The only deposits that can be regarded on stratigraphic grounds as older than this fossil-bearing Tertiary-a_2 and which might be combined as Tertiary-a_1, are the sandstones and conglomerates which form the basis of the Tertiary on Mangkalihat, in the southern peninsula of Celebes,

on Soemba and perhaps in the Tidoeng Lands (N.E. Borneo) (comp. LEUPOLD and VAN DER VLERK). These beds probably belong to the Lower Eocene considering the presumable age of Tertiary-a_2, but it is a question whether they represent the whole of that age. Their character seems to indicate that they are formed by comparatively rapid sedimentation. In British India the Lower Eocene is represented by a thick series of deposits: Lower Ranikot 500 m., Upper Ranikot about 360 m., Laki (in Sind, where the highest horizon, the Ghazij shales, is absent) about 160 m., Ghazij Shales (Baluchistan) 500 m. With the exception of the Lower Ranikot which in Sind consists of estuarine sandstone and shales, it is principally sandstone and shales of marine origin, the deposit of which has probably occupied a much longer time than the formation of the East Indian Tertiary-a_1. Moreover between the Ranikot and Laki series there lies a very important stratigraphic hiatus and between the beds of the different series less considerable unconformities exist. From this we should conclude that in the Tertiary the sedimentation began earlier in the Indus region than in the Malay Archipelago. Even if the Lower Ranikot, which has some marine deposits in Thal, is left out of consideration, it is probable therefore that the first marine transgression in the Tertiary took place earlier in Western India than in the East Indies and that the latter region remained land almost to the end of the Lower Eocene.

We can now make the following (approximate) correlation:

EUROPE:	WESTERN INDIA	BURMA	MALAY ARCHIPELAGO
Pliocene	Mekran Series	↑	Tertiary e—h
Miocene	Gáj Series		
Oligocene	Nari Series	Pegu Stage	Tertiary c—d
Upper Eocene	Stratigraphical break (Sind); limestone of the Mula-pass (Baluchistan)	Yaw Stage Pondang Stage	Tertiary-b
Middle Eocene	Kirthar Series	"Eocene"	Tertiary-a_2
			Tertiary-a_1
Lower Eocene	Laki Series Stratigraphical break Upper Ranikot Lower Ranikot		

(For Burma c.f. VREDENBURG 1921, Burma and Garo Hills).

Following the above conclusion and some publications on the stratigraphy of the intermediate countries, we will attempt to reconstruct the history of the sea communication between the Archipelago and Europe during the Tertiary. The following publications, all given in detail in the bibliography, should be consulted: VREDENBURG 1906 Nummulites Douvillei and Classification, 1909, 1921 Burma and Garo Hills; COSSMANN and PISSARRO 1909 (see VREDENBURG); MARTIN 1914, 1915, 1931; COTTER 1912, 1914, 1923; NOETLING 1895; DAVIES 1927; NUTTALL 1925 Laki, 1926 Ranikot, Kirthar and Eocene of Western India, 1931; UMBGROVE 1929.

WESTERN INDIA.

Here the Tertiary begins with the Lower Ranikot, which is principally an estuarine or fluviatile deposit, but contains some marine sandstone in Thal. It is covered by the marine Upper Ranikot. Both NUTTALL and DAVIES tried to draw a parallel between these beds and Europe, which brings them to somewhat different conclusions, but they both regard the whole Ranikot as older than Ypresian. Between Ranikot and Laki there is a distinct unconformity and a hiatus (with laterite formation in Sind) after which follows the Laki Series, which represents the Ypresian. The Laki merges upwards, probably without unconformity, into the immensely thick Kirthar Series, which is also marine and corresponds to the Lutetian and Anversian of W. Europe. This is followed, probably with a barely evident disconformity and hiatus, by the oligocene Nari Series, which represents the Bartonian and the Ludian, and after that follow the neogene Gáj and Mekran Series.

The Upper Ranikot, especially the uppermost part, contains a very rich fauna; the study of *foraminifera, gastropoda, cephalopoda* and *echinoidea* has shown that in species these groups do not at all correspond to the W. European.

The *foraminifera* from the Laki and Kirthar series, according to NUTTALL (1925), show a great resemblance to the European in their species and in the order in which they are found in the different niveaus; DAVIES on the other hand considers that a good correlation can only begin with the Lutetian. The *echinoids* described by DUNCAN and SLADEN from the Laki and Kirthar are, like those from the Ranikot, all typically British Indian species (see VREDENBURG 1906, Classification etc.). According to NUTTALL a *gastropod* is found in the Laki Series (*Velates Schmideli* Chemn.) which is also known in Europe, but beyond this practically nothing is known of the *molluscs* from these two series. As

may be seen the similarity of the fauna in Europe and British India is not so obvious as to prove with certainty that these two regions formed one great sedimentation basin during that period. As has been said, the existance of an open sea connection between this region and the East Indies is equally doubtful.

The Nari series, according to VREDENBURG (see MARTIN 1931) contain more than 40 species of *molluscs* in common with Europe and not a single species in common with Java (nor from other stages). There is not as yet much known about the foraminifera. NUTTALL described a few reticulate *Camerinae* and *Lepidocyclinae*, of which the species can not yet be stated with certainty to correspond to either Europa or the East Indies.

From the later strata practically no *foraminifera* are known, but innumerable *molluscs*. In the Gáj Series the molluscan fauna resembles the Javanese very much, but includes many European species; in the Mekran Series the European species have almost entirely disappeared and the fauna is of a completely Malay character.

BURMA.

There are only a few publications on the Early Tertiary of Burma, that we could use for a comparison with the East Indies. From the Eocene, that was early distinguished in the region, COTTER (1912) had determined the following foraminifera: *Camerina Beaumonti*, *Camerina Vredenburgi* and *Orthophragmina omphalus*. In the last COTTER thought he recognised a form from Borneo, but the *Camerinae* and also the few *other fossils* dealt with, are all comparable to the Kirthar in Western India. NOETLING (1895, p. 6) compares this Eocene with the Indian Kirthar and with Europe on the grounds of the mollusc *Velates Schmideli* Chemn. [32]). VREDENBURG (1906, Classification, p. 177) mentions that TIPPER found both Laki and Kirthar beds in Burma. Moreover three *gastropods* known from the Ranikot Series have been found in the lowest beds of the Laungshe Shales in Burma (see DAVIES 1927, p. 260). It would seem, thus that the similarity of the fauna was greater with Western India than with the East Indies during the whole of this "Eocene".

The beds which follow this "Eocene", COTTER's Yaw Stage (1914),

32) This must probably not be understood as a correlation with the Kirthar but with the Laki series. In 1895 no distinction had been made between Kirthar and Laki, and NUTTALL found the *Velates Schmideli* later in the Laki series (1925, p. 431).

contain a pecular *Camerina* which is most nearly related to a form known from Europe; but on the other hand they yield a number of *molluscs*, whose correspondence with the molluscs of Nanggoelan (Java) brought COTTER to the conclusion that Burma and the East Indies belonged to one faunistic province which was strictly divided from Western India (1923).

The oldest profile from the post-eocene Pegu Series seems to correspond to the Nari Series of British India.

From VREDENBURG's work (1921) we know that stages of the Upper Tertiary, in so far as they are marine, can be well correlated with the Neogene of Western India and the East Indian Archipelago. Burma was also inhabited at that period by an Indo-Malayan fauna.

From these data we can make a conception of the history of the sea connections during the Tertiary:

In the earliest Eocene the sea transgressed in Europe, in British India and in Burma. British India and Burma belonged to one sea-basin, but between India and Europe — at least if we assume that the climate was the same — a land barrier must have lain, which made the interchange of sea animals impossible.

In the Upper-Landenian the sea retired and there was a land period. In the Ypresian the sea again took possession of these regions; whether there was still a land barrier or whether it was partially or entirely submerged during the whole or a part of the Ypresian cannot be said. Burma was flooded by this Indian sea, while the East Indies remained land.

Towards the end of the Ypresian a regression began in Europe. It cannot yet be said with certainty if this took place in British India too. VREDENBURG assumes a hiatus here, both in Sind and Baluchistan, but NUTTALL thinks there is a gradual transition from the Ghazij Shales to the Lower Kirthar (Baluchistan). The Malay land about this period gradually sank below sea-level.

In the Lutetian Europe, Western India, Burma and East India were all covered by the sea. The first three territories perhaps then stood in open communication with eachother, but probably Burma was the extreme east end of the sea and there was a confining tongue of land between Burma and the west of the Malay region. The sea in the Malay region was shallow, it is not impossible that it only occupied the edge of the ancient Soenda land, as GERTH suggested (1931, Geol. Rundschau, p. 190; Geologie en Mijnbouw, 1932, p. 226).

In the Upper Eocene probably the Malay sea was more extensive and, at any rate in a part of the Upper Eocene, was in connection with Burma. The communication with Europe was entirely cut off, partly by Western India, which was then above sea level.

The oligocene sea again broke down the barrier, making Western India and Europe into one sea province. The communication to the East is very dubious, probably during this period there was an intermittant and incomplete communication as Umbgrove suggests. The immigration of various genera to the Indopacific regions can be best accounted for in this way, but the *reticulate Camerina* cannot contribute much as proof of an open sea connection, as there is as yet too little exact knowledge of the species in this group to determine their geographic distribution.

According to VREDENBURG (see MARTIN 1931, p. 3) in the Upper Nari the communication between India and Europe was perhaps again completely broken.

The Neogene finally established the unity between British India and the East Indies, including Burma. The communication with Europe, according to Vredenburg, must have existed to some extent in the beginning of the Miocene, but after that been finally closed. From then onwards the typical Indo-pacific province developed, which extends from East Africa to the Philippine Islands and exists to the present day.

Of course the foregoing sketch is only made on general lines. A more accurate and extensive study of the interlying regions is necessary to arrive at a complete reconstruction of the palaeogeography. But two conclusions may be definitely drawn from the data:

1° From the earliest Lower Eocene there is no possibility of a Tethys.

2° The East Indies have been an independant region during the whole Tertiary inhabited by an indegenous marine fauna (into which in the Oligocene a few new forms from Europe were introduced, which developed independantly further) and the stages in the East Indian Archipelago can never be directly correlated in detail and with accurate synchronous limits, with the classic Western Europe.

LEIDEN, National Museum of Geology
and Mineralogy, April 1934.

BIBLIOGRAPHY

ARCHIAC, A. D' and J. HAIME – Description des Animaux fossiles du groupe nummulitique de l'Inde, précédée d'un résumé géologique et d'une monographie des Nummulites, Paris 1853.

BAKX, L. A. J. – De genera Fasciolites en Neoalveolina in het indo-pacifische gebied, Verh. Geologisch-Mijnbouwkundig Genootschap voor Nederland en Kol., Geol. Serie, Dl. IX, 1932, p. 205–266, Pl. I–IV.

BOEHM, G. – Posidonomya Becheri in Niederländisch Indien?, Centralblatt für Min. Geol., Pal., 1911, p. 350–352.

BOETTGER, O. – Die fossilen Mollusken der Eocänformation auf der Insel Borneo, Palaeontographica, Supplement III, 1875, p. 9–59, Taf. I–X.

BOTHÉ, A. CHR. D. – Over phasen van gebergtevorming in het Neogeen van den Indischen Archipel (with table), De Mijningenieur, 13th Jaargang, 1932, p. 71–77, 88–92.

BOUSSAC, J. – Études paléontologique sur le Nummulitique alpin, Mémoires pour servir à l'explication de la carte géologique detaillée de la France,Paris 1911.

BRADY, H. B. – Report on the Foraminifera dredged by H. M. S. Challenger. Report on the scientific results of the voyage of H. M. S. Challenger during the years 1873–'76, Zoology, Vol. IX, 1884.

CARPENTER, W. B. – On the microscopic structure of Nummulina, Orbitolites and Orbitoides, etc. Quaterly Journal of the Geol. Society of London, Vol. VI 1850, p. 21–39, Pl. III–VIII.

CARTER, H. J. – Further observations on the structure of Foraminifera, and on the larger fossilized forms of Scinde, etc., including a new genus and species, Annals and Magazine of Natural History, T. VIII, 1861, p. 309–333, 366–382, 446–470, Pl. XV–XVII.

CAUDRI, C. M. B. – De foraminiferen-fauna van eenige Cycloclypeus-houdende gesteenten van Java, Verh. v. h. Geol. Mijnb. Genootsch. v. Ned. en Kol., Geol. serie, Bd. IX, 1932, p. 171–204.

CHAPMAN, F. – Cretaceous and tertiary foraminifera of New Zealand, New Zealand Geological Survey, Palaeontological Bulletin, n° 11, 1926, p. 1–116, Pl. I–XX.

COTTER, G. DE P. – The Pegu-Eocene succession in the Minbu District near Ngapoe Records of the Geological Survey of India, Vol. XLI, 1912, p. 221–238.

COTTER, G. DE P. – Notes on the value of Nummulites as zone fossil, with a description of some Burmese species, Records of the Geological Survey of India, Vol. XLIV, 1914, p. 52–84, Pl. 1–3.

COTTER, G. DE P. – The Lamellibranchiata of the Eocene of Burma, Memoirs of the Geological Survey of India, Palaeontologia Indica, New series, Vol. VII, Mem. n° 2, 1923, p. 1–24, Pl. I–VII.

CUSHMAN, J. A. – A Monograph of the Foraminifera of the North Pacific Ocean, Smithsonian Institution, U. S. National Museum, Bull. 71, parts 1–6, 1910–1916.

CUSHMAN, J. A. – The Foraminifera of the Atlantic Ocean, Smithsonian Institution, U. S. National Museum, Bull. 104, parts 1–5, 1918–1924.

CUSHMAN, J. A. – Foraminifera of the Philippine and adjacent seas, Smithsonian Institution, U.S. National Museum, Bull. 100, vol. 4, 1921.

CUSHMAN, J. A. – Foraminifera, their Classification and economic use, Sharon, Massachusets, 1928.

DAVIES, L. M. – The Ranikot Beds at Thal, Quaterly Journal of the Geological Society of London, Vol. 83, pt. 2, 1927, p. 260–290, Pl. XVIII–XXVI.

DEPRAT, J. – Les Dépots Éocènes Néo-Calédoniens, leur analogie avec ceux de la région de la Sonde. Bull. de la Soc. Géol. de France, Serie IV, T. 5, 1905, p. 485, Pl. XVI–XIX.

DOLLFUS, G. F. – Paléontologie du voyage à l'île Célébes de M. E. C. Abendanon, in: E. C. ABENDANON, Geologische-geogr. doorkruisingen van Midden Celebes, deel III, 1915, p. 959.

DOORNINK, H. W. – Tertiary Nummulitidae from Java, Verh. Geol. Mijnb. Genootschap v. Ned. en Kol., Geol. serie, dl. IX, 1932, p. 267–315, 10 Pl. and 11 textfig.

DOUVILLÉ, H. – Les foraminifères dans le tertiaire de Bornéo. Bull. soc. géol. de France. 4e série, tome V, 1905, p. 435–464, Pl. XIV.

DOUVILLÉ, H. – Les foraminifères de l'île de Nias, Samml. des Geol. Reichsmuseums in Leiden, Ser. I, Bd. VIII, 1912, p. 253–278, Pl. XIX–XXI.

DOUVILLÉ, H. – Quelques foraminifères de Java, Samml. des Geol. Reichsmuseums in Leiden, Serie I, Bd. VIII, 1912, p. 279–294, Pl. XXII–XXIV.

DOUVILLÉ, H. – Les foraminifères des couches de Rembang, Samml. des Geol. Reichsmuseums in Leiden, Serie I, Bd. X, 1916, p. 19–35, Pl. III–VI.

DOUVILLÉ, H. – Sur quelques foraminifères des Moluques orientales et de la Nouvelle Guinée, Jaarboek Mijnwezen, 1921, Verhandelingen 2e deel, p. 107–116. Pl. I–II.

DOUVILLÉ, R. – Lépidocyclines et Cycloclypeus malgaches, Annales de la Societé Royale zoologique et malacologique de Belgique, Vol. XLIV, 1909, p. 125–139, Pl. V–VI.

FISCHER, P. J. – Beitrag zur Kenntnis der Pliozänfauna der Molukkeninseln Seran und Obi, Palaeontologie von Timor, Lief. XV, 1927.

FRITSCH, K. VON – Einige eocäne Foraminiferen von Borneo, Palaeontographica, Supplement III, 1875, p. 139–146.

GALLOWAY, J. J. – A Manual of Foraminifera, James Furman Kemp Memorial Series, publ. n° 1, Bloomington, Indiana, 1933.

GERTH, H. – Ein neues Eocän-Vorkommen bei Djokja auf Java, Koninklijke Akademie van Wetenschappen te Amsterdam, Proceedings Vol. XXXIII, n° 4, 1930, p. 392–395.

GERTH, H. – The stratigraphical distribution of the larger foraminifera in the Tertiary of Java, Proceed. 4th Pacific Science Congress, 1930, p. 591–597.

GERTH, H. – Der Geologische Bau Javas, Geologische Rundschau, Bnd. XXII, 1931, p. 188–201.

GERTH, H. – De geologische bouw van Java, Geologie en Mijnbouw, 1932, p. 226–230.

HANZAWA, S. – Notes on Tertiary Foraminiferous Rocks from the Kwantô Moun-

tainland, Japan, Science Reports Tôhoku Imp. Univ., sec. series (Geology), Vol. XII, n° 2A, 1931, p. 141–157, Pl. XXIV–XXVI.

HANZAWA, S. – On some Miocene Rocks with Lepidocyclina from the Izu and Bôsô peninsulas, Science Rep. Tôhoku Imp. Univ., second series (Geology), Vol. XII, n° 2A, 1931, p. 159–170, Pl. XXVII–XXVIII.

HARPE, P. DE LA – Matériaux pour servir à une monographie des Nummulines et Assilines. d'Après les notices laissés en manuscrits. Rédigé par P. Rozlosznik, Annuaire de l'Institut géologique Royal Hongrois, vol. XXVIII, livre I, 1926, p. 1–102.

HEIM, A. – Die Nummuliten- und Flyschbildungen der Schweizeralpen, Abh. Schweiz. Pal. Ges., Vol. XXXV, 1908.

HOFKER, J. – The Foraminifera of the Siboga Expedition, Siboga Expeditie, Monografie IV, Part I, 1927; Part II, 1930.

KOCH, R. – Die jungtertiäre Foraminiferenfauna von Kabu (Res.Surabaja), Eclogae geologicae Helvetiae, Bd. XVIII, n° 2, 1923, p. 342–361.

KOCH, R. – Eine jungtertiäre Foraminiferenfauna aus Ost Seran (Kasuma), Eclogae geologicae Helvetiae, Bd. XIX, n° 1, 1925, p. 207–213.

KOCH, R. – Mitteltertiäre Foraminiferen aus Bulongan, Ost Borneo, Eclogae geologicae Helvetiae, Bd. XIX, n° 3, 1926, p. 722–751.

LEUPOLD, W. and I. M. VAN DER VLERK – The Tertiary, Leidsche geol. Meded., n° V, Feestbundel K. MARTIN, 1931, p. 604–648 (with 2 tables).

MARTIN, K. – Tertiär-Versteinerungen vom östlichen Java, Samml. des Geologischen Reichsmuseums in Leiden, Ser. I, Bd. I, 1881–1883, p. 105–130, Pl. V (pars), VI, VII and VIII.

MARTIN, K. – Die Eintheilung der Versteinerungsführenden Sedimente von Java, Samml. des geol. Reichsmuseums in Leiden, Ser. I, Bd. VI, 1900.

MARTIN, K. – Wann löste sich das Gebiet des Indischen Archipels von der Tethys? Samml. des Geol. Reichsmuseums in Leiden, Serie I, B. IX, 1911–1914 (1914), p. 337–355.

MARTIN, K. – Die Fauna des Ober-Eocäns von Nanggulan auf Java (mit 8 Tafeln), D. Rhizopoda, Samml. des Geol. Reichsmuseums in Leiden, *Neue Folge*, Bd. II, Heft V, 1914–1915, p. 195.

MARTIN, K. – Wann löste sich das Gebiet des Indischen Archipels von der Tethys? (Eine Fortsetzung), Leidsche Geologische Mededeelingen, Deel IV, 1931' p. 1–8.

NOETLING, F. – The development and subdevision of the tertiary system in Burma, Rec. Geol. Survey of India, Vol. XXVIII, pt. 2, 1895, p. 59–86, Pl. 2.

NUTTALL, W. L. F. – Indian reticulate Nummulites, Annals and Magazine of Natural History, Ser. 9. Vol. XV, 1925, p. 661–667, Pl. XXXVII–XXXVIII.

NUTTALL, W. L. F. – Two species of eocene foraminifera, Alveolina elliptica and Dictyoconoides cooki, Annals and Mag. of Natural History, ser. 9, 1925. Vol. XVI, p. 378–388, Pl. XX–XXI.

NUTTALL, W. L. F. – The stratigraphy of the Laki-series (Lower Eocene) of parts of Sind and Baluchistan (India), with a description of the larger foraminifera contained in those beds, Quaterly Journ. Geol. Soc. of London, vol. LXXXI, part 3, 1925, p. 417–453, Pl. XXIII–XXVII.

NUTTALL, W. L. F. – Three species of Lepidocyclina from Western India and

Persia, Annals and Magazine of Natural History, Ser. 9, Vol. XVII, 1926, p. 330–337, Pl. XIII.

NUTTALL, W. L. F. – The Upper Ranikot Series of Sind, India, Geological Magazine, Vol. LXIII (63), 1926, p. 112–121, Pl. X–XI.

NUTTALL, W. L. F. – The Zonal Distribution and Description of the Larger Foraminifera of the Middle and Lower Kirthar series (Middle Eocene) of parts of Western India, Rec. Geol. Surv. of India, Vol. LIX, 1926, p. 115, Pl. I–VIII.

NUTTALL, W. L. F. – The Zonal Distribution of the larger foraminifera of the Eocene of Western India, Geological Magazine, Vol. LXIII, 1926, p. 495–504.

NUTTALL, W. L. F. – The stratigraphy of the Upper Ranikot series (Lower Eocene) of Sind, India, Records of the Geol. Survey of India, Vol. LXV, pt. 2, 1931, p. 306–313.

ORBIGNY, A. D' – Foraminifères fossiles du Bassin tertiaire de Vienne, Paris 1846.

OSIMO, GIUSEPPINA – Di alcuni Foraminiferi dell' Eocene superiore di Celebes, Rivista Italiana di Paleontologia, Vol. XIV, 1908, p. 28–54, Tav. I–III.

PROVALE, I. – Di Alcune Nummulitinae e Orbitoidine dell' isola di Borneo, Rivista Italiana di Paleontologia, Vol. XIV, 1908, p. 55–80, Vol. XV, 1909, p. 65–96.

REICHEL, H. – Sur la structure des Alvéolines, Eclogae geologicae Helvetiae, Vol. XXIV, n° 2, 1931, p. 289–303, Pl. XIII–XVIII.

ROGGEVEEN, P. M. – Jurassic in the Island of Sumba, Koninklijke Academie van Wetenschappen te Amsterdam, Proceedings, Vol. XXXII, n° 4, 1929, p. 512–514.

ROZLOSZNIK, P. – Einleitung in das Studium der Nummulinen und Assilinen, Mitteilungen aus dem Jahrbuche der Kgl. Ungarischen Geologischen Anstalt, Bd. XXVI, Heft 1, 1927, p. 1–154, Pl. I.

ROZLOSZNIK, P. – Studien über Nummulinen, Geologica Hungarica, series geologica, fasciculus 2, 1929.

RUTTEN, L. – Over Orbitoiden van Soemba, Verslagen Kon. Acad. v. Wetensch. te Amsterdam, Deel XXI, 1912, p. 391.

RUTTEN, L. – Studien über Foraminiferen aus Ost-Asien, 1–7, Samml. des Geol. Reichsmuseums in Leiden, Ser. I, Bd. IX–X, 1913–1915.

RUTTEN, L. – Foraminiferenführende Gesteine von Niederländisch Neu-Guinea, Nova Guinea, Résultats de l'expedition scientifique néerlandaise à la Nouvelle-Guinée en 1903, Vol. VI, Géologie, livraison II, 1914, p. 21–51, Pl. VI–IX.

RUTTEN, L. – in: W. A. J. M. VAN WATERSCHOOT VAN DER GRACHT, Bijdragen tot de geologie van Centraal Celebes, Jaarb. Mijnw. 1914, Verh. 2e ged. (1915), p. 60–62, fig. 32–36.

SCHEFFEN, W. – Zur Lepidocyclinen-Bestimmung, De Mijningenieur, 1932, n° 5, p. 97–99.

SCHLUMBERGER, CH. – Notice sur deux espèces de Lepidocyclina des Indes Néerlandaises, Samml. des Geol. Reichsmuseums in Leiden, Serie I, Bd. VI, 1900, p. 128.

SCHUBERT, R. J. – Die fossilen Foraminiferen des Bismarckarchipels und einiger angrenzender Inseln, Abhandl. d. k. k. Geol. Reichsanstalt, Bd. XX, Heft 4, 1911, p. 1–130, Taf. I–VI.

SCHWAGER, C. – Fossile Foraminiferen von Kar Nicobar, Reise der Österreichischen Fregatte Novara, Geol. Theil, Bd. 2, 2e Abth., 1866, p. 187–268, Taf. IV–VII.

SILVESTRI, A. – Nummuliti Oligoceniche della Madonna di Catena Presso Termini-Imerese (Palermo), Bollettino della Societa geologica Italiana, Vol. XXVII, 1908 (1909), p. 593, Pl. XXI.

TAN SIN HOK – Over Spiroclypeus, met opmerkingen over zijn stratigrafische verspreiding. (Summary in English), De Mijningenieur, 1930, p. 180–184.

TAN SIN HOK – Enkele opmerkingen over de stratigrafische verspreiding van Trybliolepidina Van der Vlerk, De Mijningenieur, Jaarg. 11, n° 7, 1930, p. 144.

TAN SIN HOK – Over Cycloclypeus. Voorloopige resultaten eener biostratigraphische studie, De Mijningenieur, 1930, p. 233–242.

TAN SIN HOK – On the genus Cycloclypeus Carpenter, Part I, And an appendix on the Heterostegines of Tjimanggoe, S. Bantam, Java, Wetensch. Meded. v. d. Dienst v. d. Mijnbouw in Nederl.-Indië, n° 19, 1932, p. 3–194, 24 plates, 7 tables, 4 textfig.

TOBLER, AUG. – Notiz über einige foraminiferen-füherende Gesteine von der Halbinsel Sanggar (Soembawa), Anhang in: J. J. PANNEKOEK VAN RHEDEN, Geol. Notizen über die Halbinsel Sanggar, Insel Soembawa, Zeitschrift für Vulkanologie, Bd. IV, 1918, p. 189–192, Pl. XXXIV–XXXV.

UMBGROVE, J. H. F. – Het genus Pellatispira in het Indo-pacifische gebied (with summary in English), Wetensch. Meded. v. d. Dienst v. d. Mijnbouw in Ned. Oost-Indië, n° 10, 1928.

UMBGROVE, J. H. F. – Lepidocyclina transiens nov. spec. van Sumatra, Wetensch. Meded. v. d. Dienst v. d. Mijnbouw in Ned. Indië, n° 9, 1929, p. 109, fig. 1–5.

UMBGROVE, J. H. F. – Tertiary Sea-connections between Europe and the Indo-Pacific Area, Proc. Fourth Pacific Science Congress, 1929.

UMBGROVE, J. H. F. – Tertiary Foraminifera, Leidsche Geol. Mededeelingen, deel V (Feestbundel K. MARTIN), 1931, p. 35.

UMBGROVE, J. H. F. – Het Neogeen in den Indischen Archipel, Tijdschr. v. h. Kon. Nederlandsch Aardrijkskundig Genootschap, Deel XLIX, afl. 6, 1932, p. 769–834.

UMBGROVE, J. H. F. – Tijd en type der tertiaire plooiïngen binnen de zone van sterk negatieve afwijkingen der zwaartekracht in den Indischen Archipel, Tijdschrift van het Koninklijk Nederlandsch Aardrijkskundig Genootschap, Vol. XLIX, 1934, p. 20–34.

VERBEEK, R. D. M. – Die Nummuliten des Borneo-kalksteines, Neues Jahrbuch für Mineralogie, etc., 1871.

VERBEEK, R. D. M. – De nummuliten uit den eoceenen kalksteen van Borneo Jaarb. Mijnwezen, 1874, Verh. dl. II, p. 133, 2 plates.

VERBEEK, R. D. M. – Die Tertiärformation auf Sumatra, Palaeontographica, Supplement III, Lieferung 8 und 9, p. 24 (Java), 1880; also: Jaarb. Mijnwezen, 1881, Verh. II, p. 39–40 (Java); 1883, Verh. I, p. 18 (Java).

VERBEEK, R. D. M. and R. FENNEMA – Geologische Beschrijving van Java en Madoera, Amsterdam, 1896. Description geologique de Java et Madoura, Amsterdam, 1896.

VLERK, I. M. VAN DER –, Studiën over Nummulinidae en Alveolinidae, Dissertation, Leiden, 1922; Verhandelingen v. h. Geologisch Mijnbouwkundig Genootschap v. Nederl. en Kol., Geol. serie, dl. V, 1922, p. 329, Pl. I–II.

VLERK, I. M. VAN DER –, Een nieuwe Cycloclypeussoort van Oost-Borneo, Samml.

des geologischen Reichsmuseums in Leiden, Serie I, Bd. X, 1923, p. 137–140, Pl. I–II.

VLERK, I. M. VAN DER – Een overgangsvorm tusschen Orthophragmina en Lepidocyclina uit het Tertiair van Java, Verhandelingen v. h. Geol. Mijnb. Genootsch. voor Nederland en Koloniën, Geol. serie, Deel VII, 1923, p. 91–98 (with 1 plate).

VLERK, I. M. VAN DER – Foraminiferen uit het Tertiair van Java I, Wetensch, Meded. v. d. Dienst v. d. Mijnbouw in Nederl.-Indië, n° 1, 1924, p. 17–36, Pl. III–V.

VLERK, I. M. VAN DER – A study of tertiary foraminifera from the "Tidoengsche Landen" (E. Borneo), Wetensch. Meded. v. d. Dienst v. d. Mijnbouw in Ned.-Indië, n° 3, 1925, p. 13, Pl. I–VI.

VLERK, I. M. VAN DER – The genus Lepidocyclina in the Far East, Eclogae geologicae Helvetiae, Vol. 21, n° 1, 1928, p. 182–211, Pl. VI–XXIII.

VLERK, I. M. VAN DER – Het genus Lepidocyclina in het Indopacifische Gebied Wetensch. Meded. v. d. Dienst v. d. Mijnbouw in Ned.-Indië, n° 8, 1928, p. 1–80, fig. 1–58.

VLERK, I. M. VAN DER – „Groote" Foraminiferen van N.O. Borneo (with summary in English), Wetensch. Meded. v. d. Dienst v. d. Mijnbouw in Ned.-Indië, n° 9, 1929.

VLERK, I. M. VAN DER and DOZY, J. J. – The Tertiary Rocks of the Celebes-Expedition 1929, Verhandelingen v. h. Geol. Mijnbouwk. Genootschap v. Nederl. en Koloniën, Geol. serie, Dl. X, 1934, p. 183–217, Pl. I–II.

VREDENBURG, E. – Nummulites Douvillei, with remarks on zonal destribution of Indian Nummulites, Rec. Geol. Surv. of India, Vol. XXXIV, part 2, 1906, p. 79, Pl. VIII, fig. 1–8.

VREDENBURG, E. – The classification of the Tertiary system in Sind, with reference to the zonal distribution of the Eocene Echinoidea described by Duncan and Sladen, Record of the Geol. Survey of India, Vol. XXXIV, 1906, p. 172–198.

VREDENBURG, E. – Nummulites Vredenburgi Prever nom. mut., Rec. Geol. Survey of India, Vol. XXXVI, pt. 3, 1908, p. 239.

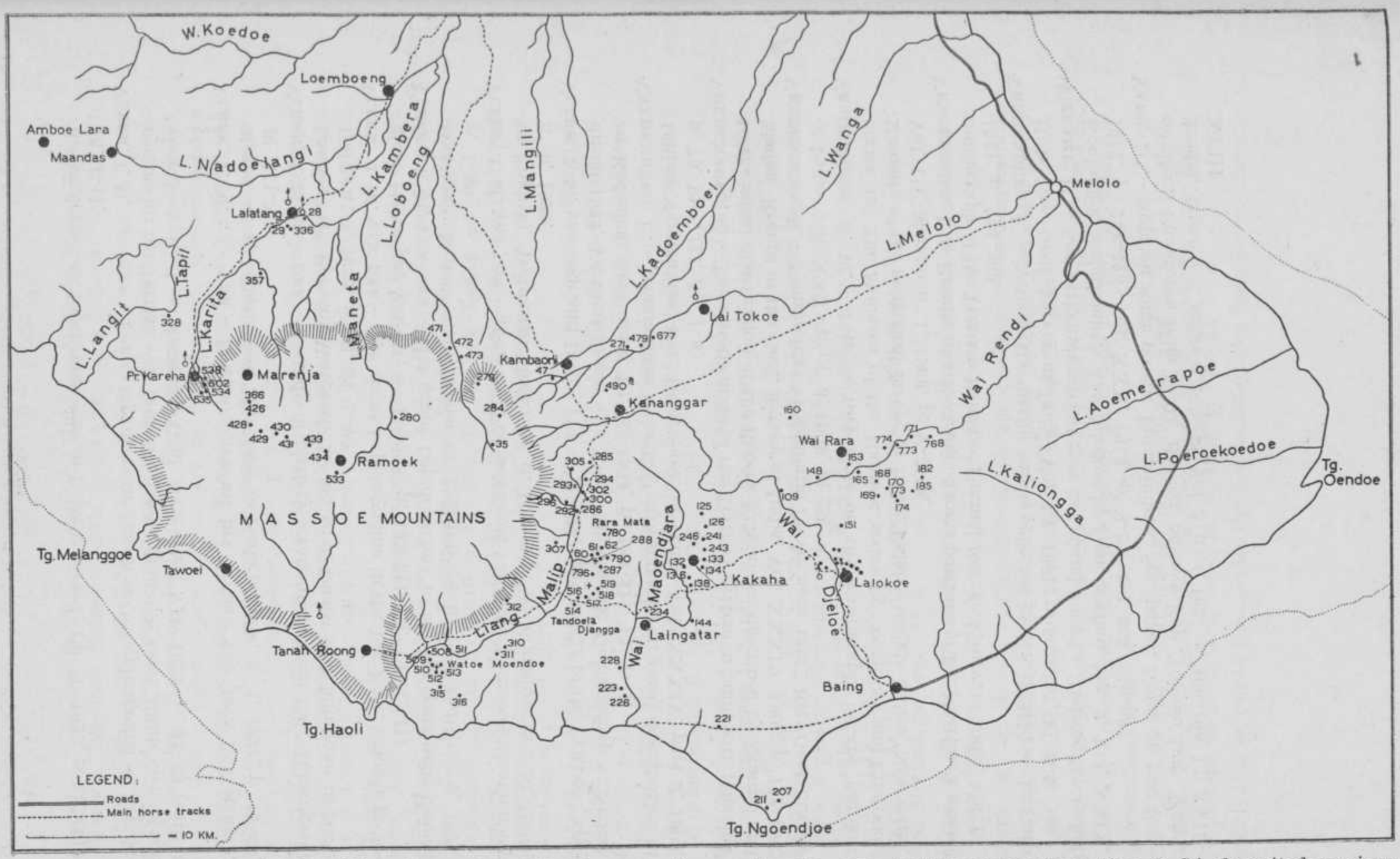
VREDENBURG, E. W. – Introductory Note on the Stratigraphy of the Ranikot Series; in: The Mollusca of the Ranikot series, by COSSMANN and PISSARRO. Memoirs of the geological survey of India, Palaeontologia Indica, New series, Vol. III, Memoir n° I, 1909, p. V–XIX.

VREDENBURG, E. – Results of a Revision of some portions of Dr. Noetling's second monograph of the Tertiary Fauna of Burma, Rec. geol. surv. of India, Vol. LI, 1921, p. 224–302.

VREDENBURG, E. – Note on the marine fossils collected by Mr. Pinfold in the Garo Hills, Rec. Geol. Survey of India, Vol. LI, 1921, p. 303–337, Pl. 8–9.

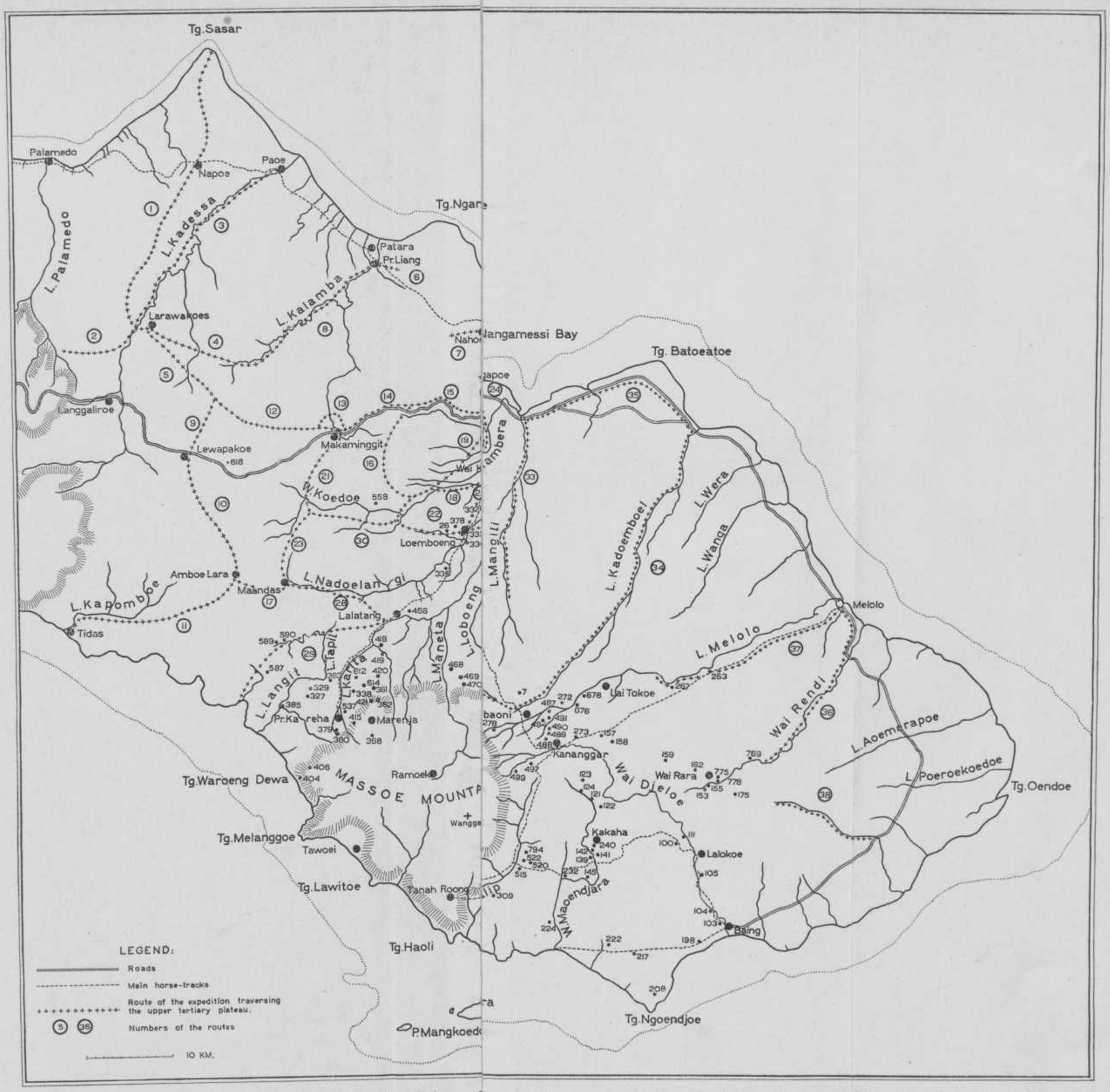
WITKAMP, H. – Een verkenningstocht over het eiland Soemba, Tijdschrift van het Koninklijk Nederlandsch Aardrijkskundig Genootschap, Ser. 2, Vol. XXIX, 1912, p. 744–775; Vol. XXX, 1913, p. 8–27, 484–505, 619–637.

YABE, H. – Note on some eocene Foraminifera. Sec. paper: Notes on two foraminiferal limestones from E. D. Borneo, Science Rep. Tôhoku Imp. Univ., Sendai, Japan. sec. series (Geology), Vol. 5, n° 4, 1921, p. 100–106, Pl. XVII–XVIII.

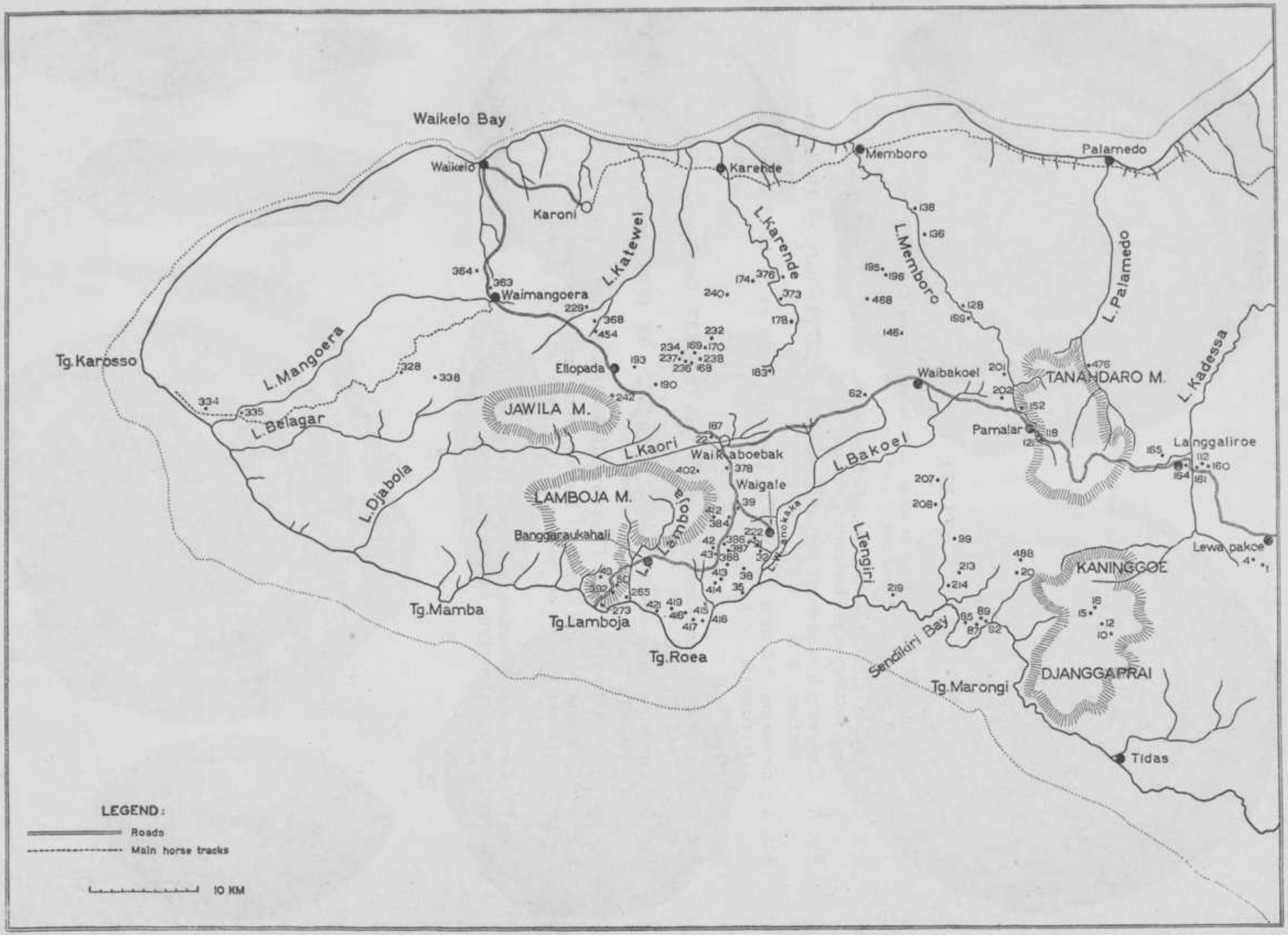


MAP I. East Soemba, with localities of samples of the lower tertiary and some upper tertiary rocks (collection O. S.), deposited previous to the great transgression in Tertiary-e_5.

♂ Wells of cold sulphurous water (H_2S) springing forth from *Camerina-limestones*.



Map II. East and Middle Soemba, with localities of the upper tertiary rocks (collection O.S.), deposited after the great sion in Tertiary-e_5



Map III. West Sumba, with localities of samples from the upper and lower tertiary deposits (collection W.S.)

PLATE I

Fig. 1. *Assilina* aff. *exponens-granulosa* nov. nom., from O.S. 516 (upper beds of Tertiary-a_2). Horizontal section, × 6.

Fig. 2. *Assilina* aff. *exponens-granulosa* nov. nom., from O. S. 300 (lower beds of Tertiary-a_2). Horizontal section, × 6.

Fig. 3. *Camerina Kemmerlingi* nov. spec., from O. S. 237 (Tertiary-a_2). Horizontal section, × 6.

Fig. 4. *Camerina kelatensis* (Carter ?) Douvillé, from O. S. 62 (Tertiary-a_2). Horizontal, × 6.

Fig. 5. *Idem*, × 6.

Fig. 6. *Camerina Kemmerlingi* nov. spec., from O. S. 237 (Tertiary-a_2). Vertical section, × 6.

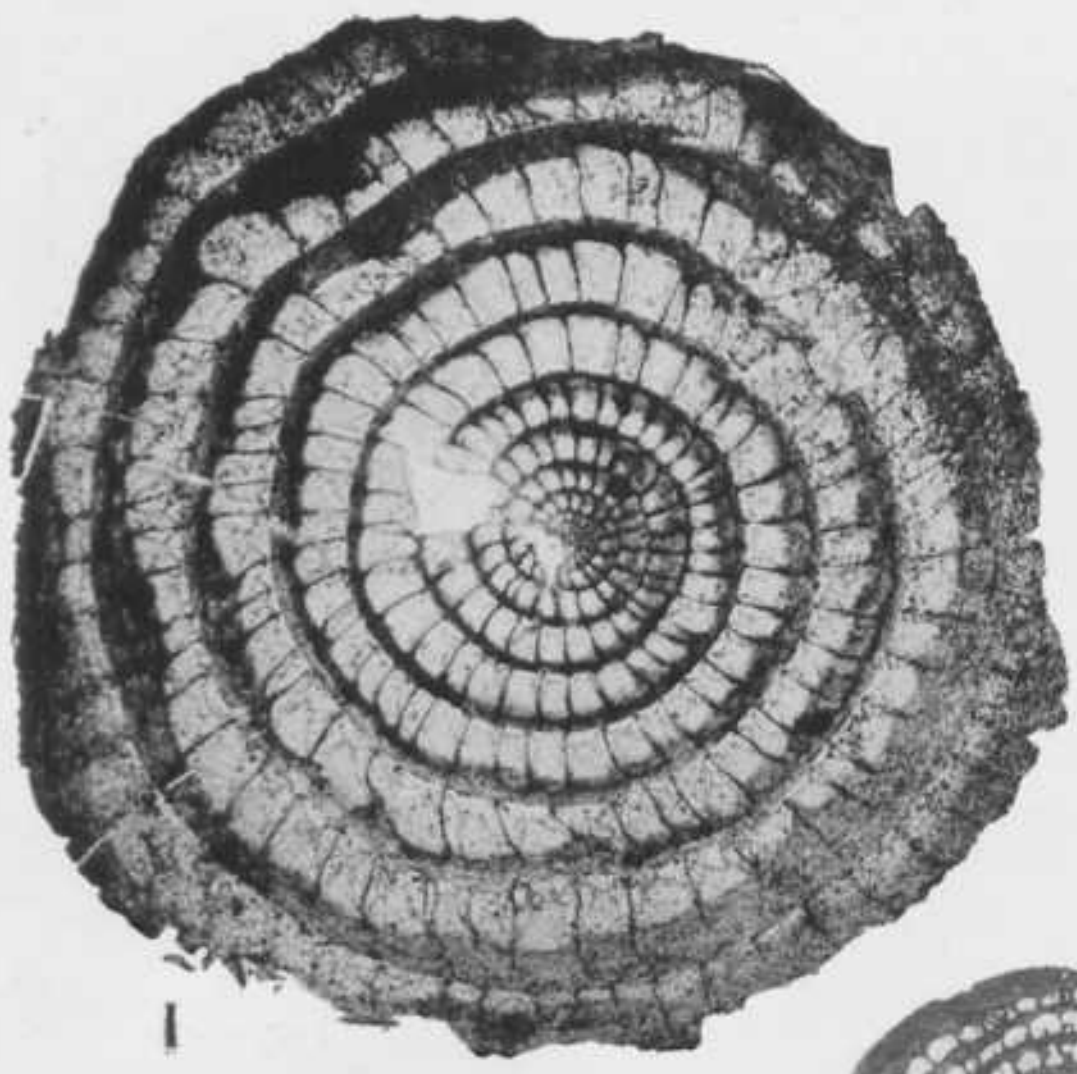
Fig. 7. *Camerina discoidea* nov. spec., from W.S. 89 (Tertiary-a_2). Vertical section, × 15.

Fig. 8. *Idem*, from W. S. 99 (Tertiary-a_2). Vertical section, × 15.

Fig. 9. *Camerina Nuttalli* (Nuttall) Davies, from the Uppermost Ranikot beds (Lower Eocene) of Jherruck, Sind (see p. 57—58). Horizontal section, × 6.

Fig. 10. *Camerina kelatensis* (Carter ?) Douvillé, from O. S. 62 (Tertiary-a_2). Vertical section (polished), × 6.

PLATE I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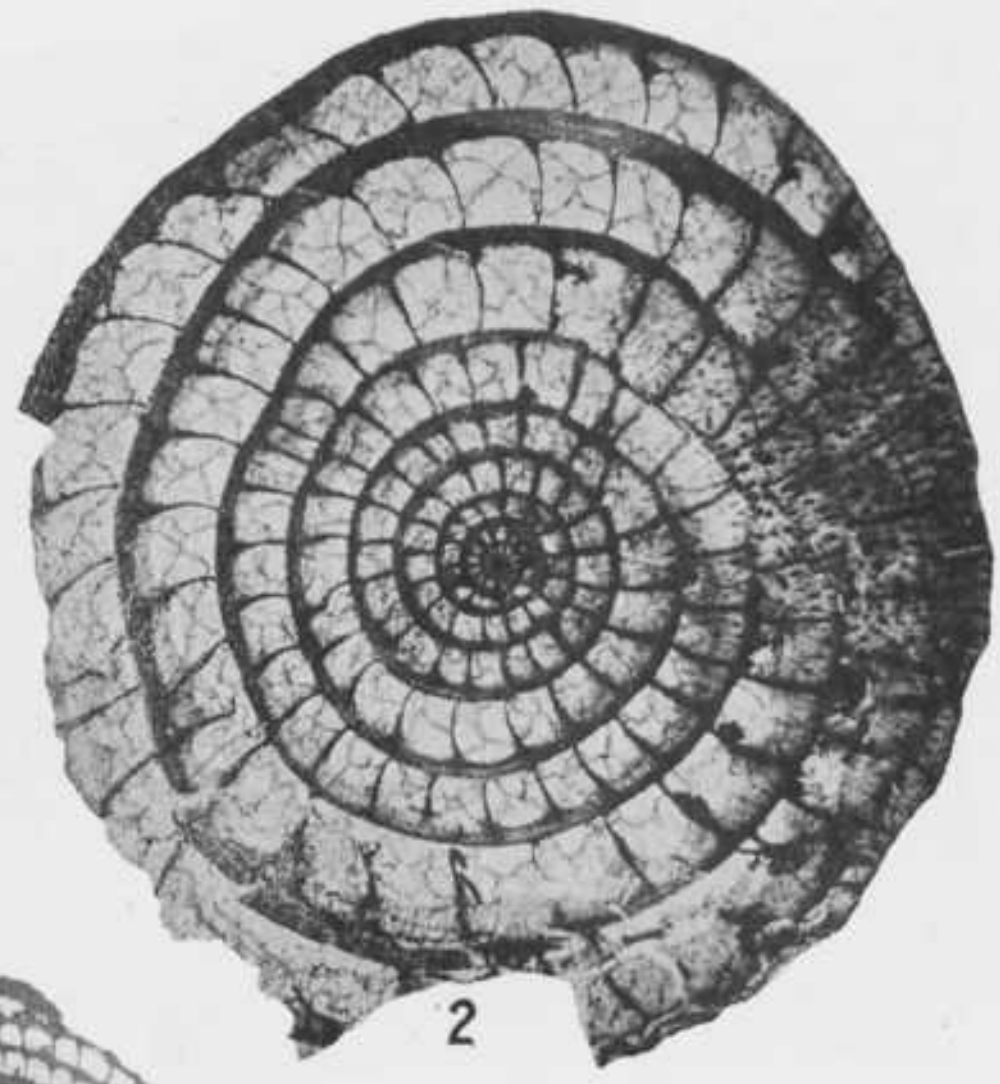
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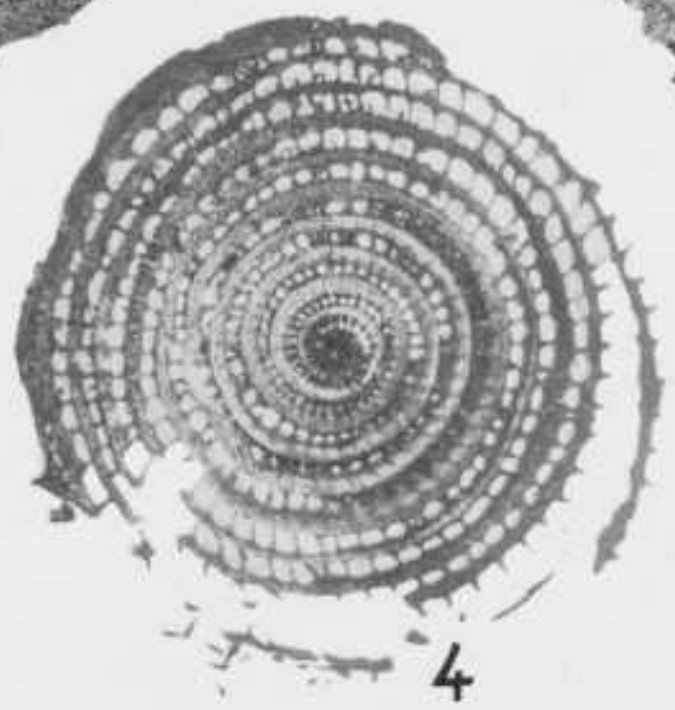
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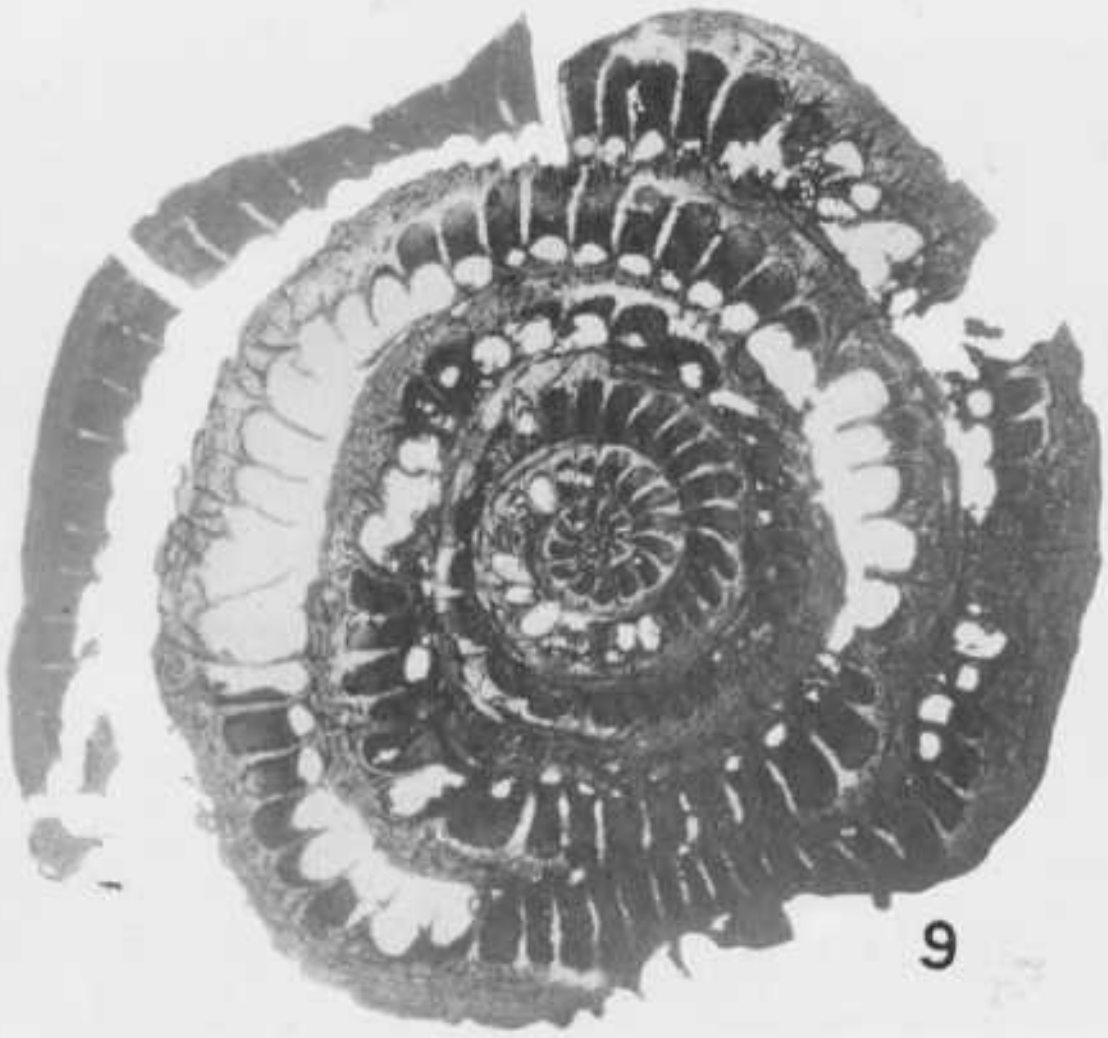
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PLATE II

Fig. 1. *Assilina orientalis* Douvillé, from O. S. 299 (basal beds of Tertiary-a_2). Exterior, × 6.

Fig. 2. *Pellatispira* aff. *irregularis* Umbgrove, from O. S. 151 (Tertiary-b). Vertical section, × 15.

Fig. 3. *Idem*, detail of the same specimen as fig. 2, showing the peculiar closure of the lateral canals by a thin perforated calcareous lamel (upper left corner of the photograph; the upper edge of the preparation consists of attached rock-material), × 125.

Fig. 4. *Pellatispira spec.*, from W. S. 89 (Tertiary-a_2). Vertical section, × 15.

Fig. 5. *Idem*, × 15.

Fig. 6. *Spiroclypeus spec. indet. div.*, from O. S. 419 (Tertiary-e_5). Occasional section on slide, × 25.

Fig. 7. *Idem*, × 25.

Fig. 8. *Idem*, × 25.

Fig. 9. *Pellatispira spec. nov.?*, from O. S. 185 (Tertiary-b). Occasional, practically vertical, sections on slide, × 15.

PLATE II

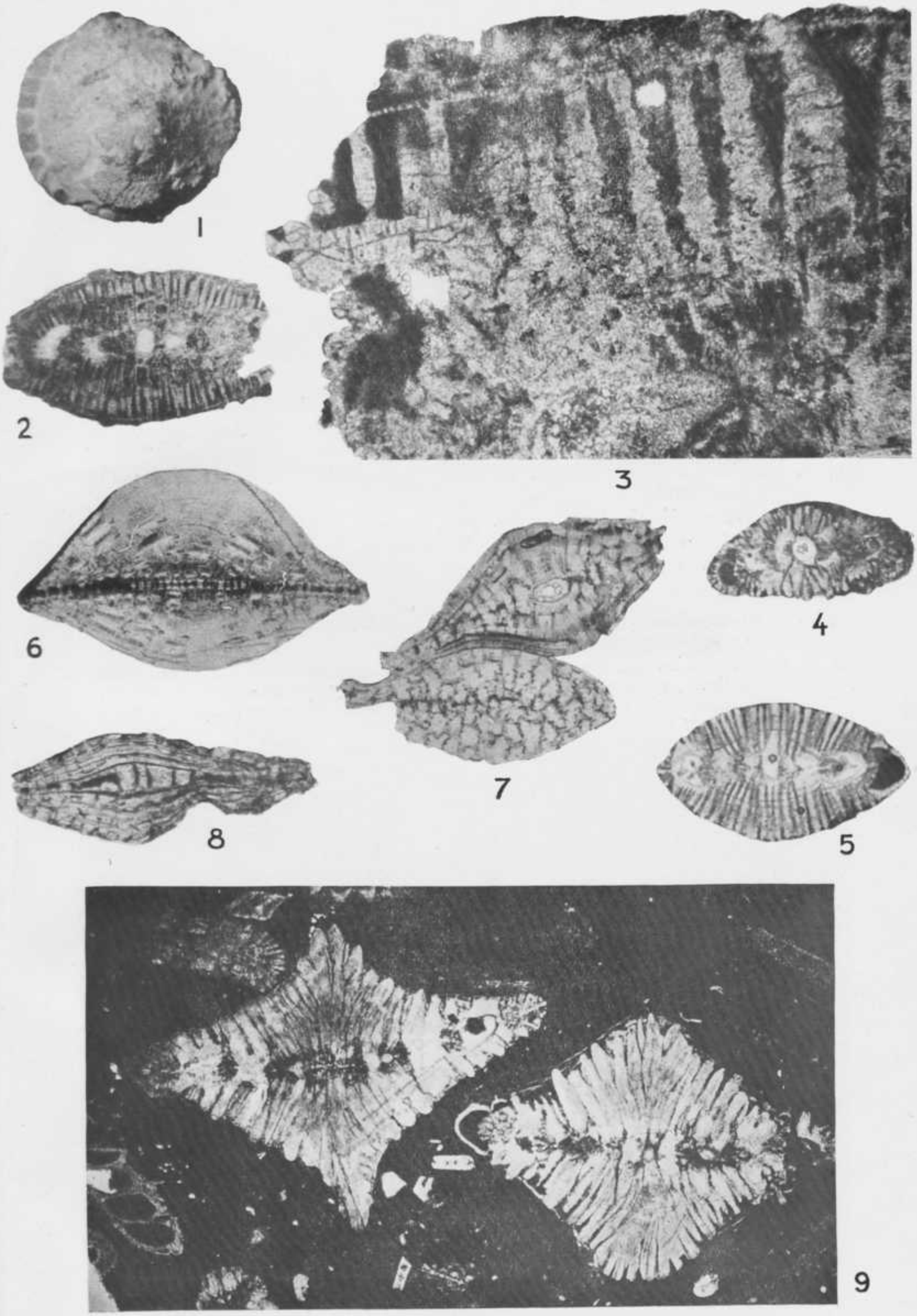


PLATE III

Fig. 1. *Asterocyclina* aff. *pentagonalis* Deprat, from O. S. 114 (Tertiary-b). Horizontal section, × 10.

Fig. 2. *Orthocyclina* spec., from O. S. 114 (Tertiary-b). Horizontal section, × 10.

Fig. 3. *Orthocyclina* spec., detail of the same specimen, showing the almost isodiametric hexagonal chambers, × 54.

Fig. 4. *Lepidocyclina* aff. *Rutteni* Van der Vlerk, from O. S. 327 (Tertiary-f_1). Exterior, × 8.

Fig. 5. *Lepidocyclina tjendanensis* nov. spec., forma A, from O. S. 285 (Tertiary-d). Vertical section on slide, × 6.

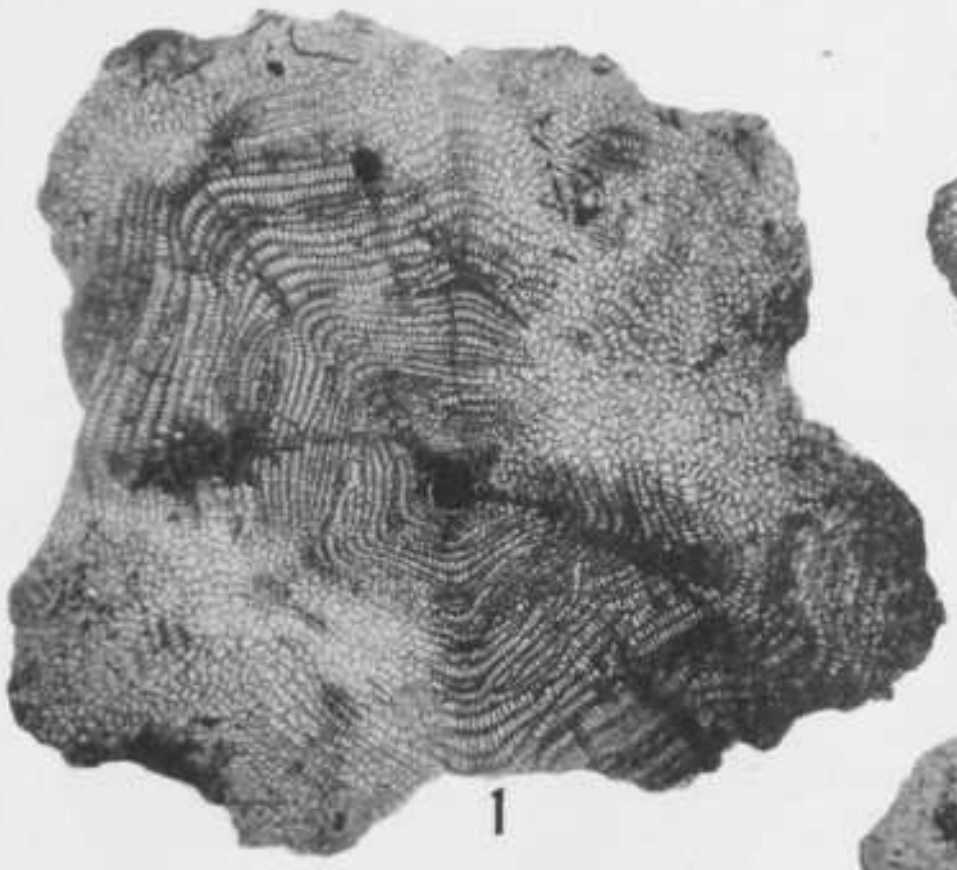
Fig. 6. *Idem*, × 6.

Fig. 7. *Idem*, × 6.

Fig. 8. *Lepidocyclina tjendanensis* nov. spec., forma B, from O. S. 285 (Tertiary-d). Vertical section on slide, × 6.

Fig. 9. *Asterocyclina* aff. *pentagonalis* Deprat, detail of the specimen reproduced in fig. 1, showing the pentagonal ring of very low chambers round the nucleoconch, and the unfinished radial walls of several median chambers, × 54.

PLATE III



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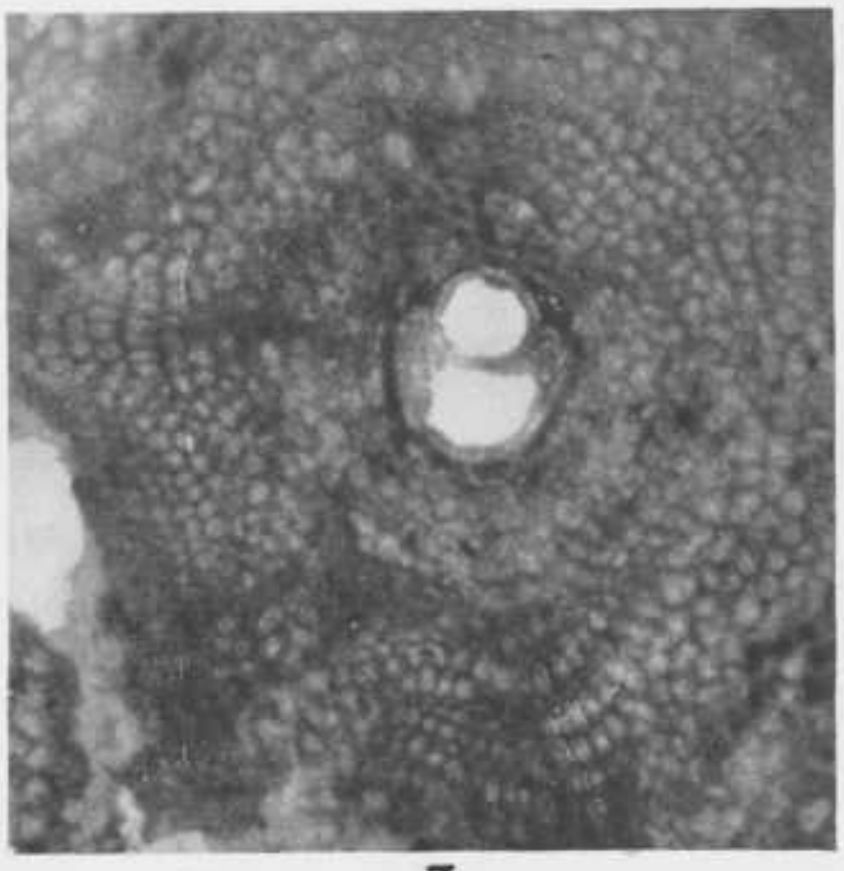

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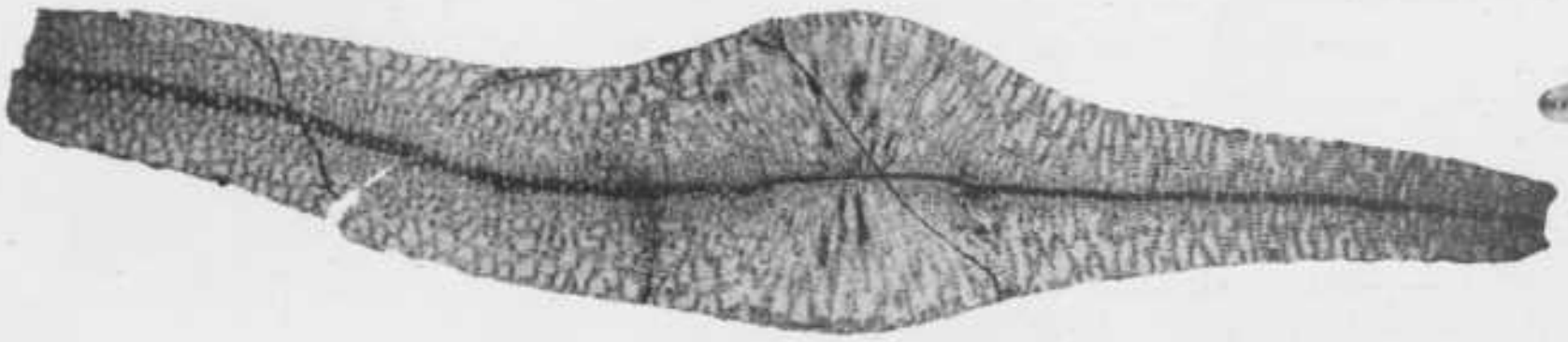

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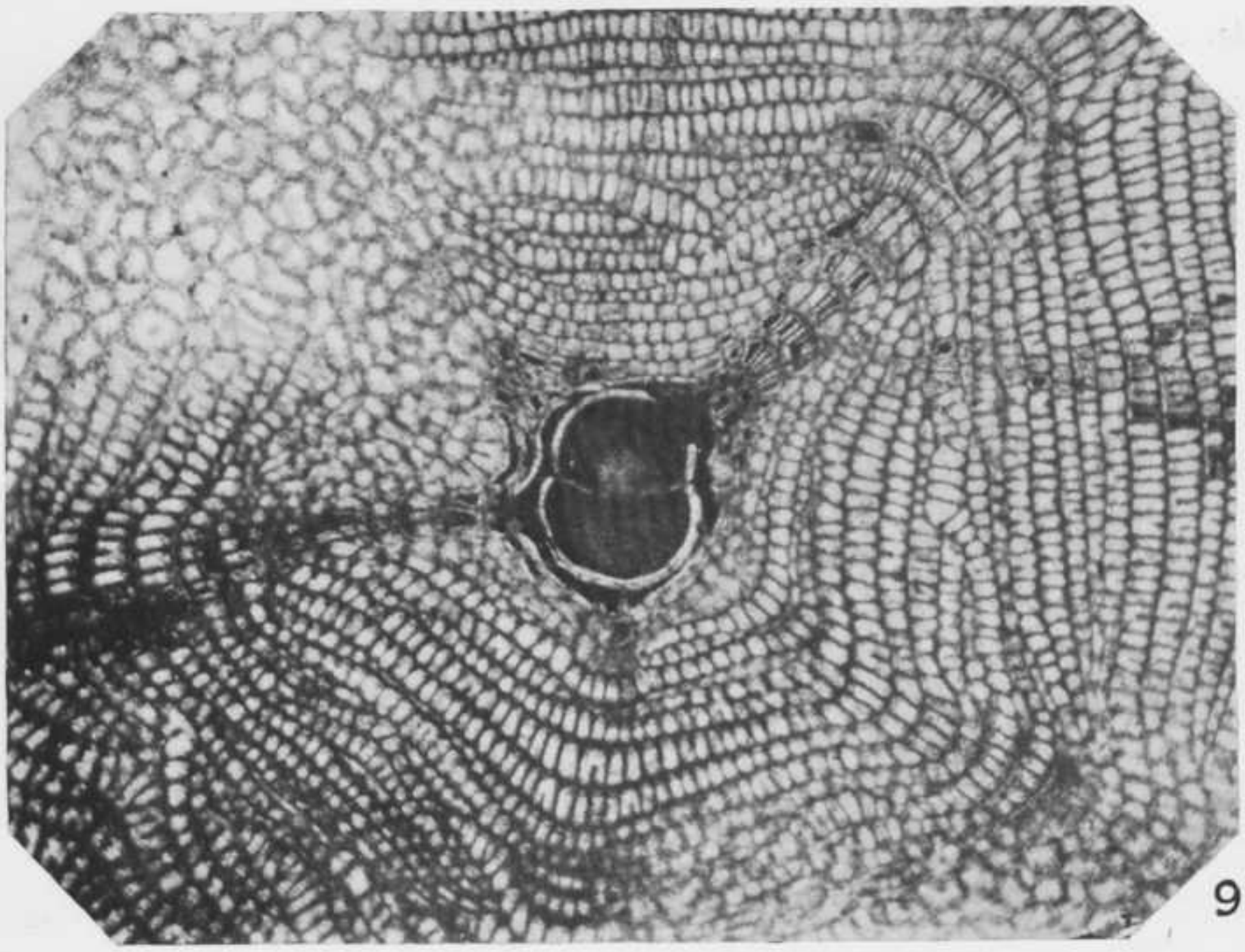

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PLATE IV

Fig. 1. *Fasciolites ovicula* (Nuttall ?) Bakx, normal flosculinised specimen, from O. S. 62 (lower beds of Tertiary-a_2), showing pseudo-canals round each whorl, × 10.

Fig. 2. *Fasciolites ovicula* from O. S. 136 (Tertiary-a_2), deviating form with smaller chamberlets and a small nucleoconch (see p. 129), × 10.

Fig. 3. *Fasciolites ovicula* from O. S. 511 (uppermost beds of Tertiary-a_2), abnormally flosculinised transition form to *Fasciolites javana* Verbeek (see p. 130), × 10.

Fig. 4. *Fasciolites ovicula* from O. S. 299 (basal bed of Tertiary-a_2), unflosculinised transition form to *Fasciolites javana* Verbeek (see p. 129), × 10.

Fig. 5. *Fasciolites spec.*, from O. S. 511 (uppermost beds of Tertiary-a_2), flosculinised form related to *Fasciolites ovicula* (Nuttall ?) Bakx (see p. 130), × 10.

Fig. 6. *Fasciolites spec.*, from O. S. 511 (uppermost beds of Tertiary-a_2), transition form from *Fasciolites timorense* Verbeek to *Fasciolites ovicula* (Nuttall ?) Bakx (see p. 133), × 10.

Fig. 7. *Fasciolites Wichmanni* Verbeek, from O. S. 512 (uppermost beds of Tertiary-a_2), × 10.

Fig. 8. *Fasciolites Wichmanni* Verbeek, from O. S. 511 (uppermost beds of Tertiary-a_2), showing multilocular nucleoconch, × 10.

Fig. 9. *Fasciolites spec.*, from O. S. 512 (uppermost beds of Tertiary-a_2), transition form from *Fasciolites Wichmanni* Verbeek to *Fasciolites timorense* Verbeek (see p. 132), × 10.

Fig. 10. *Idem*, × 10.

PLATE IV

PLATE V

Fig. 1. *Globigerina quadripartita* (Koch), specimen from O. S. 5 with highly flattened chambers in last coil. Ventral view (pencil drawing), × 50.

Fig. 2. *Idem*, same specimen. Side view (pencil drawing), × 50.

Fig. 3. *Globigerina tripartita* (Koch), from O. S. 5. Ventral view (pencil drawing), × 35.

Fig. 4. *Idem*, same specimen. Dorsal view (pencil drawing), × 35.

Fig. 5. *Idem*, same specimen. Side view (pencil drawing), × 35.

Fig. 6. *Globigerina quadripartita* (Koch), small pelagic form from O. S. 5. Ventral view (pencil drawing), × 50.

Fig. 7. *Rotalia calcar* d'Orbigny ? from O. S. 5, Dorsal view (pencil drawing), × 75.

Fig. 8. *Idem*, same specimen. Ventral view (pencil drawing), × 75.

Fig. 9. *Idem*, same specimen. Side view (pencil drawing), × 75.

Fig. 10. *Globigerina quadripartita* (Koch), abnormal form with 5 chambers in last coil, from O. S. 5. Ventral view (pencil drawing), × 50.

Fig. 11. *Globigerina quadripartita* (Koch), specimen from O. S. 5 with only slightly flattened chambers in last coil. Ventral view (pencil drawing), × 50.

Fig. 12. *Idem*, same specimen. Side view (pencil drawing), × 50.

Fig. 13. *Rotalia elphidioides* nov. spec., from O. S. 631, immature specimen. Side view, showing sutural bands of secondary shellmaterial flanked by alternating pores, × 12.

Fig. 14. *Idem*, adult specimen. Horizontal section, showing interseptal spaces in the upper half of the photograph (sometimes opening into the sutural pores) and sutural fillings of clear shellmaterial, × 20.

Fig. 15. *Idem*, adult specimen. Side view, showing covering of secondary shellmaterial with rows of fissures, × 12.

Fig. 16. *Idem*, same specimen. Dorsal view, showing covering of secondary shellmaterial conceiling the spiral growth, with fissures, × 12.

Fig. 17. *Idem*, same specimen. Ventral view, showing umbilical mass of secondary shell-material with canals, × 12.

PLATE V


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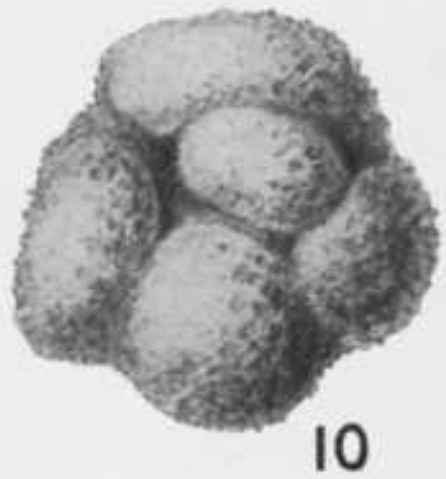
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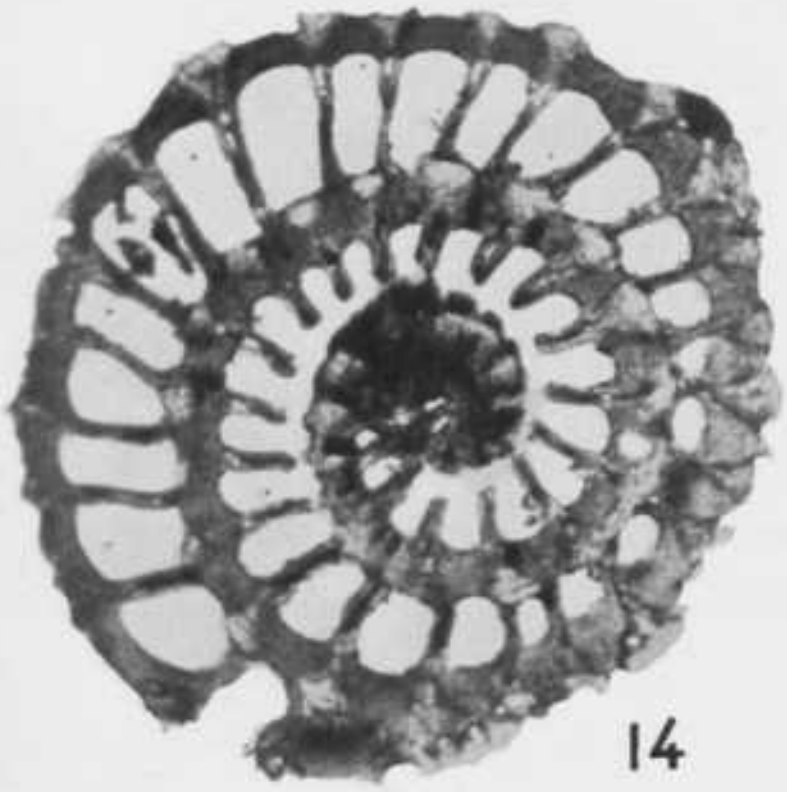
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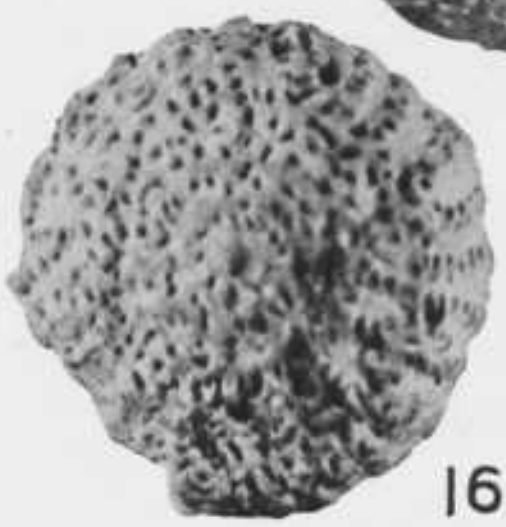
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STELLINGEN

I

De stratigrafie van Soemba levert geen bevestiging van de opvatting van LEUPOLD en VAN DER VLERK, dat de grens tusschen Oud- en Jong-Tertiair getrokken moet worden tusschen het Tertiair-*d* en het Tertiair-*c*.

II

De systematische plaats van het genus Orthocyclina is nog zeer onvoldoende bekend; parallelisaties op grond van dit genus zijn nog niet veroorloofd.

III

De familie der Orbitoididae is geen natuurlijke familie; het zoeken naar een phylogenetische reeks in deze groep zal geen bevredigend resultaat opleveren.

IV

De monografie over het genus Cycloclypeus van TAN SIN HOK is van grooter belang voor de genetica dan voor de stratigrafie.

Wetensch. Meded. v. d. Dienst v. d. Mijnbouw in Ned.-Indië, No. 19, 1932.

V

De kwestie van de trimorfie bij foraminiferen is een zuiver biologische kwestie. Zij heeft geen practische beteekenis voor de palaeontologie en het heeft geen zin naar bewijzen vóór of tegen het bestaan van trimorfie te zoeken in fossiel materiaal.

C. M. B. CAUDRI

VI

Aan het ontstaan van een instortings-caldera behoeft geen uitblazing van de magma-haard of het eruptie-kanaal of uitlooging van het vulkaanlichaam door gassen te zijn voorafgegaan. De noodige ondergrondsche holte kan op andere wijze verklaard worden dan met behulp van één der genoemde drie theorieën.

WING EASTON, Verh. v. h. Geol. Mijnbouwk. Genootschap voor Nederland en Koloniën Geol. serie, Dl. III, 1916.
ESCHER, Leidsche Geologische Mededeelingen, Dl. II, 1927; Dl. III, 1929.
v. BEMMELEN, De Mijningenieur, 1929.
v. D. BOSCH, Natuurk. Tijdschr. v. Ned.-Indië, 1930.

VII

Zwevende zijdalen zijn geen bewijs voor glaciale erosie.

VIII

Het vomer der Mammalia kan worden afgeleid van het parasphenoid der overige Vertebrata.

IX

De opvatting van WARBURG, dat de vergiftige werking van een zuivere NaCl-oplossing op zeeëgel-eieren berust op een abnormale verhooging van de ademhalingsfunctie, wordt door de proeven van SCHLIEPER niet weerlegd.

WARBURG, Hoppe-Seylers Zeitschr., 1910.
SCHLIEPER, Biol. Centralblatt, 1931.

X

De grens tusschen alpine en sub-alpine gordel moet worden getrokken op de hoogte van de klimatische boomgrens.

SCHRÖTER, Das Planzenleben der Alpen, 1926.