HOOFDSTUK III.

DE STRATIGRAPHIE VAN NEDERLANDSCH OOST-INDIË.

18. PALEOZOIC

BY

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(with 1 illustration).

INTRODUCTION.

Our knowledge of the stratigraphy of the young-paleozoic and particularly of the post-paleozoic rocks of the Netherlands East Indies is fairly extensive. Very little is known about the older paleozoic.

Older paleozoic sediments are mentioned on various occasions, but the determination of the age of the rocks is mostly based on an assumption, that is made more ore less probable by the stratigraphic relation to younger fossil-bearing rocks, and not by the actual fossils, which are typical for that formation. The metamorphic rocks, which are exposed over large areas, were considered by early investigators as to belong to a very early epoch of geologic history: mostly pre-cambrian. A few fossils proved the presence of younger metamorphic rocks since. Part of these metamorphic rocks are of paleozoic age.

PRE-CARBONIFEROUS.

FEUILLETAU DE BRUYN (*17*, 18) reports brown ferruginous mica-sandstones from the area East of the Noord-West river in New Guinea; these sandstones contain brachiopods *(Spirifer bifidus, Spirifer ? ziczac, Atrypa)*, gastropods, bivalves and a trilobite *(Phacops)*, which could be upper-devonian.

STEHN (*42*, 25) found the devonian fossil *Atrypa reticularis* var. *disquamata* in a similar sandstone, collected by HELDRING in the Setakwa river. This fossil is known from devonian sediments in adjacent regions (south-eastern Asia, Queensland). The *Atrypa* from the area near the Noord-West river might be identical to that from the Setakwa river. This would point to a great extension of this formation (*63*). MARTIN (*30*, 101) describes fossils in sandstones (boulders collected by HELDRING in the Noord West- and the Noord river. He mentions *Proëtus* or *Philipsia*, *? Actinoceras, Rhynchonella, ? Spiriferina, ? Orthis.* Part of these rocks might have carboniferous or permian age. A specimen of *Spirifer verneuilli* was found in a collection of fossils, made by VERSTEGE in southern

Central Celebes (*12*); it is not, however, generally accepted that this fossil really occurs in this region.

Part of the metamorphic rocks of the archipelago might belong to older-paleozoic sediments, but no fossil evidence is available.

CARBONIFEROUS AND PERMIAN.

Young-paleozoic sediments have a widespread occurrence in the archipelago and characteristic fossils are found in large quantities on the different islands. In many cases the exact determination of the age is difficult, in some cases doubt exists whether the rocks under consideration are of carboniferous or of permian age.

We shall deal with each island separately. If the age determination is not based on the occurrence of typical fossils and only made probable by stratigraphical relations, the sediments will not be dealt with separately.

North-Sumatra.

KLEIN (*27*, 1080) found fossils in Atjeh near Kaloë (Tamiang) in a red limestone, weathering to a peculiar grey rock and bearing resemblance to a tuffaceous rock. These fossils and the ones, that were collected on later occasions, were considered originally to be of devonian age. TESCH (*43*, 610) describes them as of permian age. Corals, crinoids, brachiopods and gastropods *(Euomphalus)* occur in these rocks, besides two trilobites *(Neoproëtus indicus* and *Phillipsia aff. sumatrensis)*.

On the Besitang BÜCKING (*15*) collected fossils in a dense red limestone, which TORNQUIST (*15*, 13, 99) considers to be upper-carboniferous: *Lopophyllum vermiforme, Zaphrentis sp. indet., Martinia glabra.*

At various other localities fossils of presumably permian age have been found by PORRO, VOLZ, HIRSCHI, LINDBERG, VAN ES, OPPENOORTH, ZWIERZYCKI (*61*, 20), TOBLER (*46*, 318). We mention specially the occurrence of corals stromatopores, stems of crinoids, brachiopods and *Orthoceras* near Al. Pineuëng south of Tapa Toean, and of *Fusulinidae* (a. o. *Schellwienia*) on the Al. Oento.

It is supposed by ZWIERZYCKI (*61*, 21) that to the carboniferous and permian of North Sumatra belong a. o.: grey and black, sometimes silky, slates with lenticular quartz, sandstones, siliceous slates, conglomerates and greywackes, and also grey, black and red limestones. As to the stratigraphical relation of the limestones with the other rocks, there has been noticed in different places a stratification in the lower part of the massive limestones, and an alternating of the limestones and slates. This proves that the slates are of the same age as the limestones. As far as information goes, the limestones nowhere rest unconformably on the slates. In the same formation are also found diabase — and porphyrite — like lava's and the tuffs, that presumably are derived from the same eruptions. Finally ZWIERZYCKI thinks it possible, that serpentines and serpentine-schists also belong to this series. Metamorphosed sediments are common, mostly in the vicinity of granite- and diorite intrusions. The largest area of the above mentioned formation lies probably south of the Tripa-river. In various other places it has a wide distribution along the west coast as well as in the central- and eastern mountain chains of northern Sumatra.

Central- and South Sumatra.

Fusulina limestones have rarely been found in North Sumatra; in Central Sumatra they are very common and known for a long time. VERBEEK (*48*, 143) originally doubted, whether the young paleozoic limestones which he found in the highlands of Padang, were of carboniferous or of permian age, but after the studies of fossil collections by BRADY (*4*), WOODWARD (*60*) and ROEMER (*37*) these rocks have long been considered as belonging to the lower-carboniferous. A renewed and more detailed investigation of the fauna by FLIEGEL (*18*) led him to assume an upper-carboniferous age. He described foraminifers, corals, crinoids, brachiopods, bivalves, gastropods, cephalopods and a trilobite.

In 1906 DOUVILLÉ (*16*) expressed the opinion the limestones with fusulinids of Central Sumatra to be of permian age. The age of several of the young-paleozoic sediments from these areas is still uncertain and additional stratigraphical and paleontological information is necessary to give more light on several unsolved questions, as may become evident from the following summary.

The localities from which fossils have been mentioned by VERBEEK (*47*, 247 a. f.) are classified by TOBLER (*46*, 315) in several groups, which are supposed to belong to different stratigraphical horizons.

They are:

1. five localities with verbeekines, among which the locality Goegoek Boelat, which has been investigated later by several others.
2. four localities with productides.
3. three localities with fusulinids and trilobites; one of these is specially rich in fossils (Soengei Balam).
4. one locality with crinoids.

Collections of fossils from Goegoek Boelat which were collected by VOLZ in 1901 and TOBLER in 1909 have been described later. VOLZ (*51*, 23) mentions 9 species of foraminifers and also corals, crinoids, brachiopods and gastropods. He sticks to FLIEGEL's age determination and considers these sediments to be upper-carboniferous. As stated above, DOUVILLÉ referred to these limestones with fusulinids as permian, and LANGE (*29*), who studied TOBLER's collections, agrees with DOUVILLÉ on this matter. LANGE describes 18 species of *Fusulinidae*, belonging to the genera *Fusulinella, Schubertella, Schellwienia, Verbeekina, Doliolina* and *Neoschwagerina*, 61 other species of foraminifers and some sponges, corals, brachiopods and gastropods. Because *Verbeekina verbeeki* and *Doliolina lepida* occur together, LANGE considers these rocks to have a middle permian age.

Supplementary investigations were carried out by MUSPER (*33*, 289) near Goegoek Boelat and he also furnished new data from other parts of Central Sumatra. He mentions the occurrence of carboniferous sediments besides the permian ones. For in limestones of the Ngalau Sariboe mountains fossils were collected near Moeko-Moeko, among which *Syringopora, Endothyra* and *Bigenerina* were identified by GERTH (*33*, 266); in addition the absence of the large fusulinids from the upper-carboniferous leads him to the conclusion that this limestone is of lower-carboniferous

age or perhaps belongs to the lower part of the upper-carboniferous. According to MUSPER there is a large difference in facies too between these rocks and the more western sediments near the lake of Singkarak. In the eastern part the limestones are interbedded with slates to phyllitic slates and sandstones to quartzitic sandstones; in the western part, where the limestones are supposed to be permian, they are more thinly bedded and much richer in fossils; we find them accompanied by clayshales and marlshales, siliceous slates, porphyrites, porphyrite tuffs and arkose-like rocks.

In Djambi too much is known with regard to the occurrence of young-paleozoic rocks. MEYER (*31*, 219) thinks a slaty limestone, found by TOBLER near Soengei Landak to be of lower-carboniferous age, *Strophomena analoga* ?, *Chonetes variolata* and *Spirifer urii* ?, occurring in this rock. TOBLER (*46*, 317) considers the fossils from the numerous other localities as to be of permian age. He distinguished two facies of the permian: a marine diabase-formation (porphyrite, porphyrite-tuff formation), containing thick limestone masses, and a more acid porphyry-formation, deposited near the shore or on the continent (quartz free and quartz bearing porphyry, porphyrytuff and conglomerate formation), containing very little limestone.

TOBLER divides (*46*, 317) the localities, where permian fossils were found in the following groups:

1. some rests of crinoids and brachiopods in the tuffs of his diabase formation.
2. numerous localities with a fauna closely resembling that from the above mentioned locality Goegoek Boelat with many *Fusulinidae (Schellwienia, Verbeekina, Sumatrina)*, corals, brachiopods and gastropods in limestones of the diabase formation. The fauna from S. Selajau (*45*, 168) belongs in this group and is according to TOBLER of younger lower-permian age.
3. Rests of *Fenestella* in limestones and tuffs of the porphyry formation.
4. limestones and siliceous slates with much *Productus sumatrensis*, occurring with a total thickness of ± 30 M. in the porphyry formation. MEYER (*31*, 88) thinks the brachiopods to be younger permian.
5. Many leaves of *Pecopteris* and *Cordaïtes* in tuffaceous clayshales in the porphyry formation.
6. Some fragments of *Dadoxylon* in tuffs of the porphyry formation.

According to TOBLER the porphyrite facies forms mainly the older part of the permian (paleo- and meso-dyas), while the younger permian (neo-dyas) is formed by the porphyry-facies (Fig. 1).

ZWIERZYCKI (*62*, 79 a.f.), who carried out investigations in this area afterwards, does not admit such a great difference between the two facies, as TOBLER does. Quartz porphyries occur scarcely, according to him, and several of the diabases are more or less porphyrites or andesites. In addition to this his opinion about the age of the formations is also differing a great deal from the one TOBLER was advocating. He mentions the occurrence of five different horizons of limestones with fusulinids along the rivers Mesoemai, Merangin and Mengkarang. The distance

between the first and the last horizon measured perpendicular to the stratification being 1750 M., GERTH (*62*, 84) nevertheless did not find in all these limestones more than one species closely affiliated to *Fusulina alpina*; this species only occurs in the ouralian and the lowermost artinskian, which could make the above-mentioned sediments more probably upper-carboniferous than lower-permian. So this volcanic formation, in which fossil plants and thin coal-seams occur, must have been deposited in a relatively short period of time. It is most peculiar, that the fossil plants are of distinct European character and do not resemble the Gondwana-types from India and Australia. Among the fossil plants. JONGMANS and GOTHAN (*26*) mention several *Pecopteris* species, *Lepidodendron sp., Stigmaria sp., Sphenophyllum oblongifolium, Calamites suckowi, Cordaites borassifolius, Tobleria bicuspis,* which indicate upper-carboniferous (stephanian) and not permian as the age of the strata, because of the presence of *Lepidodendron* and *Stigmaria* and the absence of forms that are typical for the permian. POSTHUMUS (*36*) mentions some more species; after him the Djambi flora shows the greatest resemblance to the oldest part of the *Gigantopteris* flora of Eastern Asia. Even if the boundary between carboniferous and permian is drawn as high as possible, there are, according to POSTHUMUS, some reasons to assume a permian age, and he thinks it justified to conclude to lowermost permian or to the transitional strata between permian and carboniferous. JONGMANS, who has not yet finished his study of an extensive collection

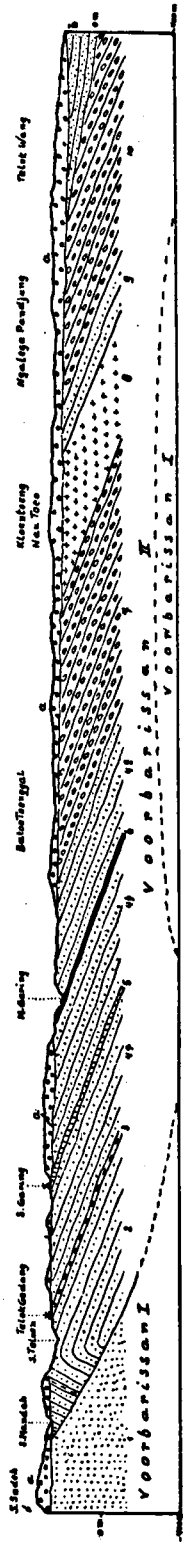

Fig. 1.

Section through the porphyry-formation on the B. Merangin between S. Sadeh and Telok Wang. (After TOBLER, Djambi report)

a. Quarternary tuffs and agglomerates.
b. Miocene tuffs and tuff-sandstones with silicificated Dicotyl-wood and marine fossils.
1. Quartzbiotitehornblendediorite.
2. Quartzporphyry tuff.
3. *Productus* slates with limestone and coal seam.
4*a* en *b*. Quartzporphyry tuff, conglomerate, sandstone-like.
4*c*. Porphyry tuff.
5. *Pecopteris*-shale.
6. Coal-layer.
7. Porphyry conglomerate.
8. Quartzkeratoporphyre.
9. Porphyry tuff, sandstone-like.
10. Porphyry conglomerate.

of the Djambi flora told me, that a closer observation of the material did but confirm his opinion on it being of upper-carboniferous age.

OZAWA (*34*, 52) found *Schwagerina princeps* in *Productus* limestones of TOBLER's group 4 (see above), and states it to be generally accepted as typical for the upper-carboniferous in Asia. We already mentioned above MEYER's opinion about these limestones being upper-permian with regard to the characteristics of the brachiopods.

As we have seen, later investigations did not bring the kind of evidence to make accept TOBLER's opinion. The sediments, belonging to TOBLER's porphyry-formation carry fossils that point to an upper-carboniferous rather than to an upper-permian age. In that case the strata with *Productus sumatrensis*, occurring underneath the strata with fossil plants would not be younger than carboniferous, and in case the diabase-formation really is older than the porphyry-formation, as is assumed by TOBLER, the limestones with fusulinids in the diabase-formation would have to be carboniferous too. In view of the above-mentioned controversies it must by clear, that there still exists much doubt about the age of the different young-paleozoic sediments in Sumatra and that as yet it is impossible to make an accurate stratigraphical subdivision.

Finally we may mention ZWIERZYCKI's (*62*, 80 a.f.) statements about differences in facies in his explanation to sheet VIII of the Geological Map of the Netherlands East Indies, covering a large part of Central- and South Sumatra. He separates three zones: 1. the Goemanti-Liki area in the western part, mainly consisting of pelitic rocks. 2. a volcanic facies in the central part consisting of eruption- and denudationproducts of acid to basic extrusive rocks, alternating with tuff-sandstones, conglomerates and breccias and also with plant-bearing clayshales and limestones with fusulinids. This facies was deposited in a marine basin on a short distance from the centra of eruption of the above-mentioned extrusive rocks. Some of the sandstones and breccias might still show evidence of them once having been a lahar or volcanic mud-flow. 3. the Kampar-Batanghari area in the eastern part with a prominent psammitic facies.

Savoe.

Traces of the permian basement of the island Savoe are found in the alluvial plain of Meba; some loose corals: *Amplexus coralloides* and *Zaphrentis beyrichi* (*50*, 312, 662) have been described from this locality.

Rotti.

The permian basement of this island is mentioned by WICHMANN (*59*), ROTHPLETZ (*38*) and afterwards by VERBEEK (*50*, 320), fragments of it being found among the extrusives of mud volcanoes on the Landoe peninsula. They mentioned the occurrence of corals *(Dibunophyllum australe, Clisiophyllum, Zaphrentis beyrichi)*, bryozoans *(Fenestella virgosa)*, crinoidal limestones and loose stems of crinoids. Afterwards BROUWER (*14*, 42) found some other corals and brachiopods in the same region. The permian was found in place by BROUWER (*14*, 39) east of

Meoain in the district Thie, and boulders of limestone with crinoids were found at different places on the island. The permian east of Meoain consist of reddish and greenish shales and mostly reddish limestones, partly containing much tuffaceous material and often being rich in fossils. Underneath this shale horizon occurs in a not quite clear relation a basic, camptonitic eruptive rock. These strata contain stem fragments of crinoids, many brachiopods and some corals and bryozoans. Among the eleven species of brachiopods (*7*, 226) we find some, that are of no stratigraphical value, such as *Productus cf. semireticulatus, Retzia radialis var. grandicosta, Spirifer fasciger* and *Notothyris nucleolus*. Other fossils only occur in the permian or the permo-carboniferous: *Derbya beyrichi, Camarophoria purdoni, Rhynchonella timorensis* and *Notothyris minuta*. According to BROILI it is impossible to make an exact determination of the age of the rocks by means of the brachiopods, but in any case they belong to the permian. Among the bryozoans were found (*1*): *Hexagonella turgida, Batostomella spinigera, Rhombopora graciosa, Streblotrypa germana, S. biserialis, Fenestella rottiensis, F. aspratilis, Thamniscus gracilis, Pinnatopora scalaris.*

Timor.

The first paleozoic fossils of the East Indian archipelago were collected on Timor and afterwards the richest known fauna of marine permian deposits has been found on this island.

Several investigators have collected permian fossils on Timor; they are mentioned in the publications of BEYRICH (*2*), WICHMANN (*59*), ROTHPLETZ (*38*), VERBEEK (*50*), HIRSCHI (*25*) and WANNER (*52*). Extensive paleontological collections and important stratigraphical data were gathered by a German expedition (WANNER, WELTER and HANIEL) in 1911 and a Netherlands expedition (MOLENGRAAFF, BROUWER and WECKHERLIN DE MAREZ OYENS) from 1910 to 1912. The paleontological results of the two expeditions were mainly published by J. WANNER in the „Palaeontologie von Timor". In 1915 a second Netherlands Timor expedition took place (JONKER, BURCK and VAN ES), and afterwards some other collections have been made on the island. The paleontological results of the second Netherlands Timor expedition are being edited by H. A. BROUWER and published in the Jaarboek van het Mijnwezen voor Ned. Indië.

The young-paleozoic fauna of Timor (*56*) is specially rich in echinodermata (*53, 54, 55*), these being about one half of all the genera and species. Then follow the corals (*19, 20, 28*), cephalopods (*23, 24, 35*), brachiopods (*6, 22*), gastropods (*57, 22*) bivalves (*57, 22*), bryozoans (*1*), foraminifers (*40*), sponges (*21*) and trilobites (*44*). Among the echinoderms the crinoids are specially well represented, the formely known number of all paleozoic crinoids being increased with 12 % by the study of the Timor fauna. We mention among the many other genera the remarkable *Timorocrinus*, the forms with reduced arms *(Hypocrinus)*, the ones with one arm *(Metasycocrinus* and *Monobranchiocrinus)* and the ones without arms *(Lageniocrinus, Embryocrinus)*. Very extensive collections of blastoids, mainly belonging to *Schizoblastus* have been made. Like the echinoderms, the corals show many new and often aberrant forms. Here

too its has become evident, that many representatives of different groups occur in a period. when they were formely supposed to be nearly extinct. The tabulate corals are well represented a. o. by *Favosites, Pseudofavosites, Stylonites, Pachypora, Michelinia* and *Aulopora.* The tetracorals are in many respects related to the triassic hexacorals. Solitary forms are predominating, almost all of the solitary corals belong to the families of the *Axophyllidae* and *Zaphrentidae.*

The cephalopods are very numerous, but in contradistinction to the echinoderms and corals and like the other groups, that are represented, they do not show many new forms. Still we find some new genera, but they include less then 10 % of all the species. Most of the genera belong to the *Cyclolobidae, Agathiceras* being by far the most abundant with regard to the number of species as well as to the number of individuals present. As for the rest, the genera on Timor do not show very many species. *Paralegoceras sundaicum* has many representatives, and among the other ones we may mention *Pronorites uralensis var. timorensis, Popanoceras indoaustralicum* and *Stacheoceras timorense* as being fairly abundant. All the other species are rare compared with those which have been mentioned above. The ammonite-fauna of Timor shows marked affinities to the fauna in the russian an silician permian areas. The permian age of the sediments is proved mainly by the cephalopods and the stratigraphical subdivision of the permian on Timor is made principally with the aid of the cephalopods. The development of the auxiliary lobes of *Popanoceras timorense* points to an uninterrupted sedimentation of the permian on Timor.

The very numerous brachiopods have hardly any stratigraphical value; only a few species are restricted to Timor and they still are intimately related to other common and well known forms. The *Productidae* and the *Spiriferidae* are among the most important ones with regard to the number of genera and species as well as with regard to the number of individuals. It is remarkable, that rather those species, that already appeared in the lower- or upper-carboniferous, mostly show a large number of individuals. Taken as a whole, the character of the fauna is permian and in this connection the occurrence of a few specimens of *Richthofenia* and *Lyttonia* is worth mentioning. About the other groups of animals may be mentioned the widespread occurrence of bryozoans; some limestones consist almost entirely of bryozoans, which are very much like those in the permian deposits of the Salt Range. The sponges, just like the corals, still show a mainly paleozoic character. Several forms show an external habit that is different from all the known types. Two species of trilobites, *Neoproetus indicus* and *Pseudophillipsia sp.* have been described. Among the foraminifers the genus *Fusulina* is represented by four species and at several localities limestones have been found, which consist nearly exclusively of shells of these foraminifers. The younger *Fusulinidae* with a complicated shell-structure lack entirely.

The above-mentioned permian fossils originate from a thick series of sediments, mainly consisting of limestones (often crinoidal limestones), marls, tuffaceous marls and tuffs. Conglomerates occur in small quantities and diabase and amygdaloidal melaphyre are also found in the series.

According to the opinion of most of the investigators these sediments are exclusively permian, but some of them doubt this statement. SCHUBERT (*40*) thought the foraminifers to be carboniferous, while the forms with a complicated shell-structure are lacking, and SPRINGER (*41*) stated the fact, that a large percentage of the types present formerly only were known from pre-permian formations. WANNER (*56*) summarized the different reasons, that point to an exclusively permian age. The older features of the fauna are specially striking for the echinoderms and corals, and to a smaller extent for the sponges. Several genera of crinoids, that were not supposed to be younger than carboniferous, also occur in the Timor fauna; *Schizoblastus* and *Orbitremites* are two blastoids that were only known from the carboniferous. Specially notable is the ordovician-devonian coral genus *Cystiphyllum* and the *Favosites gotlandica* group, which is mostly confined to the silurian-devonian. The older features are not prominent in those groups, that were known to have yielded already many permian representatives; they come into prominence in the groups, that were only sporadically known from the permian, according to WANNER. After him it is a mere accident that so many fossils, which seem to be carboniferous had not yet been discovered in the permian. Besides several mesozoic types occur and would probably be still more numerous, if our knowledge of the lower-triassic marine faunas was not so incomplete. The work done on the permian fauna of the island Timor undoubtedly proved the abrupt change from the paleozoic to the mesozoic fauna to be much more gradual than formerly had been supposed.

The above-mentioned permian series of sediments can be subdivided by means of the fossils, that were collected from several localities, and mainly with the aid of the cephalopods (*56*, 35), in:

1. Somohole-beds, the cephalopod fauna shows a marked resemblance to that of the Wolfcamp formation of the Glass-Mountains in Texas. The Somohole beds represent the lowermost permian and have been found with certainty only near mount Somohole in the eastern part of Netherlands Timor.

2. Bitauni-beds, which enable us, on account of their rich cephalopod fauna, to make a good comparison with sediments of the same age in other areas. The fauna is very much the same as the one, occurring in the Leonard-formation in western Texas, fits in fairly well between the Sosio fauna of Sicily and the Artinsk fauna of the Urals, but includes parts of both of them. The main area of its distribution is the eastern part of Netherlands Timor and Portuguese Timor.

3. Basleo-beds, which yielded most of the permian fossils of Timor. The main area of its distribution is Central-Timor, especially near Basleo, East of Niki-Niki. The fauna corresponds with those from Sosio in Sicily and from the Wood formation in Texas[1]).

[1]) Lately J. WANNER (Centralblatt f. Min. etc., 1931, p. 539—549) has discussed the age of the Basleo-beds, which according to him are younger (upper-permian).

4. Amarassi-beds, which are only known in the western part of Netherlands Timor. The fauna nearly has not any point of resemblance with the fauna of the Bitauni beds.

In the following stratigraphical table after PERRIN SMITH (*35*, 7) the stratigraphy of the permian in Timor is compared with formations of the same period in other parts of the world.

	Sicily	Urals	Armenia	India	Timor	Texas
Neo-Dyas			Djulfa beds with *Otoceras*	*Episageceras* and *Xenodiscus* beds		
				Cyclolobus zone	Amarassi beds with *Cyclolobus*	
				Xenaspis beds		
Paleo-Dyas	Sosio beds with *Waagenoceras*				Basleo beds [1]) with *Waagenoceras*	Word formation with *Waagenoceras*
		Artinsk			Bitauni beds with *Perrinites*	Leonard formation with *Perrinites*
						Hess formation
					Somohole beds with *Marathonites*	Wolfcamp formation with *Marathonites*
		Uralian		Coal Measures		Cisco = Uralian

Letti.

Several fossils were collected from this island by MOLENGRAAFF and BROUWER (*32*), the presence of permian crinoidal limestones already having been stated by VERBEEK (*50*, 440). The brachiopods of this collection

[1]) See note on p. 560.

were studied by BROILI (*5*), the ammonites by HANIEL (*23*) and the foraminifers by SCHUBERT (*39*). The brachiopods belong to the *Productidae, Spiriferidae* and *Terebratulidae*. Six of the eight species of brachiopods, that have been determined, occur in carboniferous and permian and two *(Chonetes strophomenoides* and *Martinia nucula)* are only known in the permian. The three ammonites, belonging to the genera *Paralegoceras, Agathiceras* and *Propinacoceras*, point to the same age as the Bitauni beds of Timor (paleo-days) and *Doliolina lepida* in a limestone, of which only a loose fragment has been found, points also to a lower-permian age. Besides crinoids, corals, gastropods, fusilines and trilobites have been found. The fossils, which were collected from the rock in place, came from the southern part of the island, where greywackes, shales with iron-bearing concretions, sandstones and some thin limestone beds alternate. To the north we find a zone of metamorphosed sediments, consisting of phyllitic shales and phyllites, quartzites and quarzitic schists, cristalline limestones and lime-bearing phyllites, amphibolitized diabases, amphibolites and epidote-chloriteschists. The permian age of these rocks is proved by the stems of crinoids in the laminated limestone-beds. Still further north we find a zone, mainly consisting of amphibolitized diabase rocks, amphibolites and epidote-chloriteschists and less metamorphic sediments, among which the cristalline limestones are considered to be metamorphosed permian rocks (*32*, 21). On the northern coast lies a serpentine mass of which the stratigraphical relations are not quite certain. The above-mentioned succession of beds, which as a rule dip steeply to the north, should not be considered as the normal one though. The facies is something like the facies of the Somohole beds of Timor, which belong to the paleo-days as do the Bitauni beds and the fossiliferous permian beds of Letti. Perhaps the sediments of Letti belong to the lowermost part of permian.

Loeang.

BROUWER (*13*) mentions permian crinoidal limestones and marls to have a wide distribution on Loeang. Besides stems of crinoids several brachiopods *(Derbyia spec., Productus spec., Camarophoria purdoni, ? Spirigera timorensis)* and bryozoa *(Fenestella spec., Acanthocladia cf. dubia, Fenestella cf. geinitzi)* are common, but usually badly preserved.

Besides quartz sandstones and calcareous sandstones alternating with shales and tuffaceous rocks of doubtful age have been found on the island.

Babber.

WECKHERLIN DE MAREZ OYENS (*58*) found boulders of crinoidal limestones in most of the rivers of Babber. These limestones resemble the permian crinoidal limestones of the island of Timor.

In two localities these limestones have been found in place. In one of them their permian age is moreover proved by the occurrence of typical bryozoans.

New-Guinea.

We mentioned already under the pre-carboniferous the possible permian or carboniferous age of sandstones from the Noord- and the Noord-West river. According to HUBRECHT (*10*, 186) sandstones, marls, shales and limestones occupy a large area in the central mountains, south of the Snow mountains. The limestones of the Hellwig mountains would be of permian age, the brachiopods in the sandstones point to a presumably paleozoic age.

In the Vogelkop rests of brachiopods have been found in dark grey marls. BROILI (*8*) studied this fauna. He mentions *Discina, Chonetes* and *Martinia*, which indicate permo-carboniferous age. *Amplexus coralloides*, a coral common in the european carboniferous and also occurring in the permian of Timor, has been found in a greyish yellow limestone (*8*, 2).

Information about the other islands.

A permian *Popanoceras* (*11*) occurs in VERSTEGE's collection from southern Central Celebes, mentioned already above under the pre-carboniferous. Several authors doubt, whether this fossil has been found in the area mentioned.

Young-paleozoic sediments are liable to occur on some of the islands not yet mentioned. One should bear in mind, that many mountainous regions, which are covered with thick jungle, hardly have been subject to any serious study; thus the fact, that fossils have not been found, can by no means be a reason to assume their total absence. Besides the original fossil-content may have been destroyed by subsequent metamorphism. We refer to the partly metamorphic rocks, mentioned above from Sumatra and Letti. Rocks similar to those, which are undoubtedly young-paleozoic on other islands occur on Borneo and Celebes and on several smaller islands as Ceram and Boeroe.

A series of schistose, partly calcareous phyllitic rocks, interbedded with more or less cristalline limestone, occur on the island of Moa (*9*). The age is not exactly known. It shows some resemblance to the central zone of metamorphic permian rocks on the island of Letti, but the beds of cristalline limestone are more numerous on Moa, and the basic eruptive rocks from Letti were not found yet on Moa.

From islands of the Riouw-archipelago (*3*, 135) are mentioned some rocks which resemble rocks of the Pahang volcanic series on Malakka and rocks of the volcanic facies of the permo-carboniferous on Sumatra.

These few examples may illustrate, that there might be a much larger distribution of permo-carboniferous sediments, than has been mentioned in describing the sediments from the different islands.

BIBLIOGRAPHY.

1. BASSLER, R. S. The permian bryozoa of Timor. Palaeontol. v. Timor, VII, p. 37—90.
2. BEYRICH, E. Ueber eine Kohlenkalkfauna der Insel Timor. Abh. d. k. Akad. d. Wiss. zu Berlin, 1864, S. 61—98.
3. BOTHÉ, A. CH. D. Geologische verkenningen in den Riouw Archipel en de eilandengroep der Poelau Toedjoeh. Jaarb. Mijnw. 1925, Verh. II, blz. 101—152.
4. BRADY, H. B. On some fossil foraminifera from the West Coast District, Sumatra. Jaarb. Mijnw. 1878, I, blz. 157—169 en Geol. Magaz. 1875, blz. 532—539.
5. BROILI, F. Permische Brachiopoden der Insel Letti. Jaarb. Mijnw. 1914, Verh. I, blz. 185—207.
6. BROILI, F. Die permischen Brachiopoden von Timor. Palaeontol. v. Timor, VII, 1916, S. 1—104.
7. BROILI, F. Permische Brachiopoden von Rotti. Jaarb. Mijnw. 1920, blz. 223—227.
8. BROILI, F. Zur Geologie des Vogelkop. Wet. Meded. Dienst van den Mijnb., I, 1924, blz. 1—15.
9. BROUWER, H. A. Geologie van een gedeelte van het eiland Moa. Jaarb. Mijnw. 1916, Verh. I, blz. 37—56.
10. BROUWER, H. A. Geologisch overzicht van het oostelijk deel van den Oost-Indischen Archipel. Jaarb. Mijnw. 1917, Verh. II, blz. 147—447.
11. BROUWER, H. A. Fossielhoudende palaeozoische afzettingen op Celebes. De Ingenieur 8 Nov. 1919.
12. BROUWER, H. A. Devonische afzettingen in den Oost-Indischen Archipel. De Ingenieur 29 Nov. 1919.
13. BROUWER, H. A. Geologische onderzoekingen op de eilanden Loeang en Sermata. Jaarb. Mijnw. 1920, Verh. II, blz. 207—222.
14. BROUWER, H. A. Geologische onderzoekingen op het eiland Rotti. Jaarb. Mijnw. 1920, Verh. III, blz. 35—106.
15. BÜCKING, H. Zur Geologie von Nord- und Ost-Sumatra. Samml. Leiden, VIII, 1904, S. 1—101.
16. DOUVILLÉ, H. Les calcaires à Fusulines de l'Indochine. Bull. Soc. Géol. de France, 4e sér., VI, 1916, p. 576—587.
17. FEUILLETAU DE BRUYN, W. K. H. Contribution à la géologie de la Nouvelle-Guinée. Diss. Lausanne 1921.
18. FLIEGEL, G. Ueber oberkarbonische Faunen aus Ost- und Süd-Asien. Palaeontographica, XLVIII, 1901—1902, S. 91—136.
19. GERTH, H. Die Anthozoen der Dyas von Timor. Palaeont. von Timor, IX, 1921.
20. GERTH, H. Die Korallenfauna des Perms von Timor und die permische Vereisung. Leidsche geol. Med., II, 1926.
21. GERTH, H. Die Spongien aus dem Perm von Timor. Jaarb. Mijnw. 1926, Verh. I, blz. 93—134.
22. HAMLET, B. Permische Brachiopoden, Lamellibranchiaten und Gastropoden von Timor. Jaarb. Mijnw. 1927, Verh. II.
23. HANIEL, C. Ammoniten aus dem Perm der Insel Letti. Jaarb. Mijnw. 1914, Verh. I, blz. 161—166.
24. HANIEL, C. Die Cephalopoden der Dyas von Timor. Palaeontol. von Timor, III, 1915, S. 1—153.
25. HIRSCHI, H. Zur Geologie und Geographie von Portugeisch-Timor. Neues Jahrb. f. Min. etc., Beil. Bd. 24, 1907, S. 460—474.

26. JONGMANS, W. u. GOTHAN, W. Beiträge zur Kenntniss der Flora des Obercarbons von Sumatra. Verh. Geol. Mijnb. Gen., Geol. Ser., VIII, 1925, blz. 279—303.

27. KLEIN, W. C. Een vermoedelijk devonische trilobietenfauna in Nederlandsch-Indië. Versl. Kon. Akad. v. Wet., XXIV, 1916, blz. 1080—1084.

28. KOKER, E. M. J. Anthozoa uit het Perm van Timor. Jaarb. Mijnw. 1922, Verh. blz. 1—50.

29. LANGE, E. Eine mittelpermische Fauna von Guguk Bulat. Verh. Geol. Mijnb. Gen., Geol. serie, VII, 1925, blz. 213—295.

30. MARTIN, K. Palaeozoische, mesozoische und kaenozoische Sedimente aus dem südwestlichen Neu-Guinea. Samml. Geol. Reichsmus. Leiden, Ser. I, Bd. IX, 1911, S. 84—107.

31. MEYER, O. E. Brachiopoden des Perms und Unter-Carbon der Residenzschaft Djambi. Verh. Geol. Mijnb. Gen., Geol. Ser., V, 1922, blz. 203—222.

32. MOLENGRAAFF, G. A. F. en BROUWER, H. A. Geografische en geologische beschrijving van het eiland Letti. Jaarb. Mijnw. 1914, Verh. I, blz. 1—87.

33. MUSPER, K. A. F. R. Beknopt verslag over de uitkomsten van nieuwe onderzoekingen in de Padangsche Bovenlanden. Jaarb. Mijnw., Verh. 1929, blz. 265—331. (Vgl. ook Jaarb. Mijnw., Verh. 1927, I, blz. 101—114).

34. OZAWA, Y. A new occurrence of Schwagerina princeps in Sumatra. Eclogae. Geol. Helv., XXII, 1929, p. 51—52.

35. PERRIN SMITH, J. Permian ammonoids of Timor. Jaarb. Mijnw. 1926, Verh. I, blz. 1—58.

36. POSTHUMUS, O. Eenige opmerkingen betreffende de palaeozoische flora van Djambi, Sumatra. Verh. Kon. Akad. v. Wet., XXXVI, 1927, blz. 428—434.

37. ROEMER, F. Ueber eine Kohlenkalkfauna der Westküste von Sumatra. Palaeontographica, XXVII, 1880, S. 1—11. Hetzelfde in Jaarb. Mijnw. 1881, I, blz. 289—305.

38. ROTHPLETZ, A. Die Perm-, Trias- und Juraformation auf Timor und Rotti im Indischen Archipel. Jaarb. Mijnw. 1894, Wet. Ged., blz. 5—98 en Palaeontographica, XXXIX, S. 57—106.

39. SCHUBERT, R. Ueber Foraminiferengesteine der Insel Letti. Jaarb. Mijnw. 1914, Verh. I, blz. 167—174.

40. SCHUBERT, R. Die Foraminiferen des jüngeren Palaeozoikum von Timor. Palaeont. v. Timor, II, 1915, S. 49—60.

41. SPRINGER, F. A remarkable fossil echinoderm fauna in the East-Indies. Amer. Jour. of Science, 5 Ser., VIII, Nr. 46, 1924.

42. STEHN, CH. E. Devonische Fossilien von Holländisch-Neu-Guinea. Wetensch. Meded. Dienst Mijnb. No. 5, 1927, blz. 25—27.

43. TESCH, P. Permische Trilobieten van Atjeh. Tijdschr. Kon. Ned. Aardr. Gen., XXXIII, 1916, blz. 610—611.

44. TESCH, P. Trilobite aus der Dyas von Timor und Letti. Palaeont. von Timor, XII, 1923, S. 121—132.

45. TOBLER, A. Djambi-Verslag. Jaarb. Mijnw. 1919, Verh. III.

46. TOBLER, A. Unsere palaeontologische Kenntnis von Sumatra. Ecl. Geol. Helv. XXIII, 1923, p. 313—342.

47. TORNQUIST, A. In H. Bücking, Samml. Leiden, VIII, 1904, S. 13—14 und 99—100.

48. VERBEEK, R. D. M. Over den ouderdom der steenkolen van het Ombilien kolenveld in de Padangsche Bovenlanden en van de sedimentaire vormingen van Sumatra in het algemeen. Jaarb. Mijnw. 1875, I, blz. 135—146.

49. VERBEEK, R. D. M. Topografische en Geologische beschrijving van een gedeelte van Sumatra's Westkust, 1883.

50. VERBEEK, R. D. M. Molukken-verslag. Jaarb. Mijnw. 1908, Wet. Ged.

51. VOLZ, W. Zur Geologie von Sumatra. Geol. u. palaeontol. Abhandl., herausgeg. von E. Koken, N. F., VI, 2, S. 87—196, 1904.

52. WANNER, J. Einige geologische Ergebnisse einer im Jahre 1909 ausgeführten Reise etc. Centralbl. f. Min. 1910, S. 137—147.

53. WANNER, J. Die permischen Echinodermen von Timor. I. Palaeont. von Timor, VI, 1916. Id. II. Pal. v. Timor, XIV, 1924.

54. WANNER, J. Die permischen Krinoiden von Timor. Jaarb. Mijnw. 1921, Verh. III.

55. WANNER, J. Die permischen Blastoiden von Timor. Jaarb. Mijnw. 1922, Verh., blz. 161—230.

56. WANNER, J. Die marine Permfauna von Timor. Geol. Rundschau, XVII, a, 1926, S. 20—48.

57. WANNER, C. Die Gastropoden und Lamellibranchiaten der Dyas von Timor. Palaeont. v. Timor, XI, 1922, S. 1—82.

58. WECKHERLIN DE MAREZ OYENS, F. A. H. De geologie van het eiland Babber. Handel. Nat. Geneesk. Congr. 1913, blz. 463—468.

59. WICHMANN, A. Bericht über eine im Jahre 1888—1889 ausgeführte Reise nach dem Indischen Archipel. Tijdschr. Kon. Ned. Aardr. Gen. 1892, blz. 161—276.

60. WOODWARD, H. Notes on a collection of fossil shells etc. from Sumatra. Geol. Magaz. 1879. Hetzelfde in Jaarb. Mijnw. 1880, I, blz. 203—259, met naschrift van R. D. M. Verbeek.

61. ZWIERZYCKI, J. Geologische overzichtskaart van den Nederlandsch-Indischen Archipel, Toelichting bij Bl. I en Id. Toel. bij Bl. VII. Jaarb. Mijnw. 1919, Verh. I.

62. ZWIERZYCKI, J. Geologische overzichtskaart van den Nederlandsch-Indischen Archipel. Toelichting bij Bl. VIII. Jaarb. Mijnw. 1929, Verh., blz. 73—157.

63. ZWIERZYCKI, J. Geologische overzichtskaart van den Nederlandsch-Indischen Archipel. Toelichting bij Bl. XIV en XXI. Jaarb. Mijnw. 1927, Verh. I, blz. 248—300.


MAP OF THE MORE IMPORTANT FOSSIL LOCALITIES
IN THE NETHERLANDS EAST INDIES
SCALE 1:6.000.000.
COMPILED BY W. F. KRIJNEN.
ALSO SHOWING THE SUBDIVISION FOR THE SHEETS
OF THE MAP 1:100.000 OF THE TOPOGRAPHICAL SURVEY
OF THE NETHERLANDS EAST INDIES.
ZUID-CHINEESCHE ZEE
MALAKA
BRITSCH
NOORD-BORNÉO
SERAWAK
SELEBES-ZEE
BORNÉO
SELEBES
MOLUKSCHE
HALMAHERA
STILLE OF GROOTE OCEAAN
SERAN-ZEE
NIEUW GUINÉ
JAVA-ZEE
BANDA-ZEE
FLORES-ZEE
ARAFOERA-ZEE
INDISCHE OCEAAN
SAVOE-ZEE
TIMOR-ZEE
MADOERA
LOMBOK
BALI
SOEMBAWA
FLORES
SOEMBA
TIMOR
BANGKA
BELITOENG
GOLF VAN TOMINI
GOLF VAN BONE
GOLF VAN TOLO
STRAAT MAKASSAR
STRAAT MALAKA
STRAAT KARIMATA
MENTAWAI-EIL.
Meridiaan van Batavia = 106° 48' 27".79 O. v. Greenwich.