

Citation:

L. Rutten, Modifications of the facies in the Tertiary Formation of East-Kutei(Borneo), in:
KNAW, Proceedings, 19 I, 1917, Amsterdam, 1917, pp. 728-736

Geology. — "*Modifications of the facies in the Tertiary Formation of East Kutei (Borneo)*" by Dr. L. RUTTEN. (Communicated by Prof. Dr. A. WICHMANN.)

(Communicated in the meeting of October 28, 1916).

The coast tract of Kutei is for a width of more than 100 km. occupied by a folded chain of mountains, chiefly built up by rocks of posteocone age. As far as it is hitherto known eocene strata occur only infrequently and in a tectonic connection, which has not yet been sufficiently explained.

It is not astonishing that no detailed stratigraphic subdivision that holds everywhere without modification can be given for the tertiary strata building up this chain of mountains of a length of more than 3000 km. A rough subdivision of the Posteocone into three sections, which will be briefly described below, can however be made for the greater part of the regions.

The oldest part of the posteocone deposits consists chiefly of grey, concretionary shales. Besides these pretty pure siliceous sandstones occur, which are — especially on the lower parts of the formation — thin-laminated. They often contain on the planes of stratification fine scales of coal. Very accessorially limestones are found. In the lower part of the formation they contain, besides small *Lepidocyclinae*, also large specimens of this species, in the higher parts of the formation occur only small *Lepidocyclinae*. The principal characteristic of the formation is of a negative nature: the great scarcity or the absence of coal seams.

This section, embracing the Oligocene and the greater part of the Miocene, is known in South Kutei to the west of the Balik Papan Bay. The entire Pamaluán group and the bottom part of the Pulu-Balang group with an estimated thickness of upwards of 1500 m. are to be considered as belonging to this section¹⁾.

In the neighbourhood of Samarinda the coal-free sandstones and shales to the West of Batu Panggal, which are free from coal, belong to the oldest part of the Miocene²⁾.

In the surroundings of Bontang and Santan only a small portion, valued at about 250 m, has been brought to the surface by the folding.

To the south of the river Sangatta we find at about 25 km. from the coast a deeply folded, domeshaped anticlinal, in which more

¹⁾ Tijdschr. Kon. Ned. Aardr. Gen. (2). 38. 1911, pp. 590 et seq.

²⁾ Jaarb. van het Mijnwezen in Ned. Indië Techn. Adm. Ged. 1887.

than 1000 m. of the older coal-free tertiary formation crops out, whilst in a still larger and deeper folded part between the rivers Sangatta and Bungalan nearly 1500 m. of this formation is to be seen.

In the region of the river Sekurau, where we find likewise a great dome-shaped anticlinal, about 800 m. of the older, coal-free tertiary formation have been brought to the surface.

The second section of the Postocene, consists again partly of hard, grey, concretionary shale and of sandstones which, as a rule, are less pure than in the lower formation. Limestone, and marl-banks occur now and then: they contain almost always corals and small *Lepidocyclinae*. Characteristic of this formation are especially the — most numerous — strata of black shining, scaly breaking coal.

Near Balik Papan this section is represented by the greater part of the Pulu-Balang group and the bottom part of the Mentawir group, together more than 1300 m. thick.

Near Samarinda the coal-bearing mountains of Batu Panggal and the inferior part of the coal formation of Tenggalung Ajam to a thickness of nearly 13000 m. are to be considered as belonging to this section.

Near Bontang the section embraces a complex of strata more than 1500 m. thick, near Bungalan the formation is nearly 1000 m. thick, near Sekurau over 1000 m.

The youngest section of the tertiary formation in East Kutei consists for the greater part of clays and sands with numerous seams of coal and local intercalations of limestones and marls. In contradiction to the two former groups the habitus of the rocks is however much younger. The hard, grey shales especially have been replaced by soft, grey clays, often with impressions of leaves into the planes of bedding. Instead of sandstones we usually find loose sands, and the shining, scaly breaking black coal of the older group changes towards the top gradually into dead black and brown coal, and at last even into peaty coal. The limestones and marls are in by far the most cases free from *Lepidocyclinae* and *Miogypsinae*, these fossils occur only in some places in the lower parts of the formation. The thickness of this section — embracing the younger part of the Miocene and the Pliocene — is very important.

Near Balik Papan — where the greater part of the Mentawir group and the Pliocene belong to it — it is more than 2000 m. thick, and near Bontang, Bungalan and Sekurau it has about the same thickness.

The post-eocene deposits between Balik Papan and Sekurau have consequently a thickness of over 4500 m. The facies of these deposits

which we shall call henceforward the *normal facies of the Kutei Tertiary formation*, remains nearly unchanged from the bottom to the top: sandstones and shales prevail greatly; coals can frequently occur among them; limestones and marls, which can locally sometimes become very important, have always a littoral character.

We give here a short scheme of the stratigraphy developed above:

Miopliocene. Sands, loose sandstones, soft, grey shales, very seldom hard clays and even shales, coralligenous limestones and marls, often with very fine fossils, coal from peaty brown to dead black, *Lepidocyclinae* only locally in the deeper parts of the formation. More than 2000 m.

Old-Miocene. Hard, grey shales, loose to hard sandstones black, scaly breaking glance coal (anthracite), coral limestones and marls with small *Lepidocyclinae*. Thickness over 1000 m. and under 2000 m.

Oldest Miocene and ? *Oligocene*. Hard, grey shales, rather pure, quartz-sandstones, which are thinplated in the lower parts of the formation, coal seams entirely or almost entirely absent, limestones and marls at the top with small *Lepidocyclinae*. Thickness about 1500 m.

Even when we stick to this scheme, there remains already abundant room for facial modifications, which are often met with indeed.

In the neighbourhood of Balik Papan e. g. banks of limestones and marls are entirely or almost entirely wanting in the miopliocene. Near Bontang they are plentiful and not bound to a definite level, near Bungalun they are again rare. To the West of the lower part of the river Sekurau littoral strata in the miopliocene are chiefly represented by a thick complex of coral limestones in the centre of the formation.

Coal seams are further exceedingly numerous in the miopliocene near Balik Papan; near Bontang and Bungalun they are much rarer, near Sekurau again very frequent.

Whilst with these facies modifications the general character of the formation remains intact, we find to the East and the North of the river Sekurau transitions of facies that lead us to quite different types of deposits. Guided by the annexed map, in which the principal geological structure lines of this region — the axes of the anticlinals — are indicated, we shall retrace these transitions of facies more particularly.

In a profile through the Sekurau anticlinal directly to the West

and of grey very sandy coral marls containing even sometimes gravel, towards the top they gradually change into the clays, sands and gravels, which constitute to the West of the river Sekuran the youngest part of the tertiary formation. Whereas the group of the calcareous rocks in the miopliocene westward of the river Sekuran has only a thickness of a few hundred meters — and still farther in a western direction quickly diminishes in thickness — it has become in the Sungei Narut, towards the Sekerat Mountains, 1000 m. thick or more. Traces of dead black coal between the coral sands and marls in the Sg. Narut and of transitions between glance coal (anthracite) and dead black coal in the deepest denudation of coral marls in the Sg. Mampang indicate that we have here to do with a modification of facies at a short distance, that the "younger coalbearing tertiary formation with limebanks" to the west of the river Sekuran is replaced by a system of sandy marls and coral limestones constituting a great part of the Sekerat Mountains.

A transition of facies of much inferior interest in the old-miocene containing glance coal (anthracite) takes place in the neighbourhood of the Sekuran anticline. Whereas in this formation coal strata are still numerous in the southern part of the Sekuran anticlinal, their number rapidly diminishes, so that the older miocene in the Northern part of the Sekuran anticlinal, on the Sembulu anticlinal and on the South and North Sampajau anticlinal is very poor in coal seams. The consequence of this modification of facies is, that in these regions we can no longer separate the "oldest coal-free posteocone" and the "old miocene containing glance coal" (anthracite) from each other in a satisfactory manner.

In the centre of the domeshaped Sembulu anticlinal, which is less strongly folded than the Sekuran anticlinal, we find hard shales and sandstones, belonging certainly to the old-miocene containing glance coal (anthracite), though the coal is entirely wanting, — with the exception of a few unimportant seams only some centimeters thick and numerous traces of coal on the planes of the strata of the sandstones. On the Northwestern limb limestones with small *Lepidocyclinae* occur besides the typical sandstones and argillaceous shales. On the South-eastern limb we find — still in the old-miocene and alternating with the hard shales — exceedingly fine strata of usually grey clayey sands and sandy clays which often contain shales. In the Northern part of the Eastern wing these clayey sands change towards the top gradually into a thick system of *Globigerina* marls, sandy and even gravel-containing limestones and grey, clayey sandy marls rich in fossils of a littoral origin. The *Globigerina* marls are

grey to blue, clayey and clayey-sandy, and the strata are for the greater part very imperfect; they often contain bulbs and strata of dense, grey, yellowishly disintegrating marl-limestones. The limestones are partly coralligenous rocks, partly very remarkable lime-sandstones poor in fossils; quartz conglomerates of hornstone with a very abundant cement of calcite; analogous rocks occur likewise in the above described coralligenous limemarl-facies of the Sekerat Mountains. The marls which are very rich in fossils are grey, often very sandy and can easily be separated; they contain besides Globigerinidae many littoral Foraminifera (*Amphistegina*, *Operculina*, *Cyclocypens* and in lower strata also *Lepidocyclina*) and numerous fragments of Corals, Echinids and Molluscs. We shall by-and-by distinguish marls of analogous habitus — though they may partly be of a different age — especially on the Batu Hidup and the Gunung Batu anticlinal, in the river basin of the Lower Sampajau. We shall hereafter indicate these facies constantly as *Sampajau marls*.

On the Northern part of the Eastern limb of the Sembulu anticlinal the superposition of the described strata is thus, that the Globigerinacmarls, with a few banks of limestones and Sampajau marls lie deepest; then follows a rather thick complex of limestones, limesandstones and gravellimestones, whilst typical Sampajau marls lie on the top. The total thickness — from the lowest Globigerinacmarls to the axis of the synclinal between Sembulu and Maluwi anticlinal — is here about 1200 m.

In this formation occur moreover on the Upper Lemudjau and the Upper Lindak banks of a very remarkable rock — for East Kutei, — which we shall meet afterwards on the Southern limb of the Maluwi anticlinal in the river basin of the Sungei Mangenai, in about the same stratigraphical level. They are white clayey — sometimes sandy — very light volcanic tufas, most likely deposited in an aeolic way. Where the rock is fresh, we see in microscopical preparations, that the principal mass consists of an entangled conglomerate of glass threads, between which mineral splinters of biotite, green hornblende not or little twinned feldspar and most likely also quartz are found. With the naked eye one recognizes from these minerals as a rule only the numerous, idiomorphous biotite scales. The result of a determination of siliceous acid that Mr. MOM, assistant at the agro-geological laboratory at Buitenzorg, was kind enough to make for me, was that a sandy tufa of the Upper Lemudjau contains 72.2% SiO_2 .

We saw that the described limy- (calcareous) marly- tuffaceous formation in the North of the Sembulu anticlinal rests on the old miopliocene; it must consequently be synchronous with part of the

miopliocene that we saw already so remarkably facially modified in the Sekerat Mountains. Perhaps it embraces also still the youngest parts of Old-miocene.

The study of the Maluwi anticlinal gives us still more information in this direction. We saw above, that the vertical distance from the deepest Globigerinaemarls in the Northern part of the Sembulu anticlinal to the youngest Sampajan marls in the synclinal lying eastward, amounts to about 1200 m. From the synclinal to the culmination point of the Maluwi anticlinal there is however over 1700 m. Consequently we should expect, to see in the centre of the Maluwi anticlinal the shales appear again. This is however not the case: the whole of the Maluwi anticlinal is composed of monotonous, grey-blue, clayey sometimes glauconitic marls of Globigerinae and of blue, plastic clays, containing but few layers of quartz sand, and in one spot an extremely thin stratum of glance coal (anthracite). An important part of the old-miocene strata, which occurred on the Sembulu anticlinal still almost exclusively in normal facies, has consequently been developed as Globigerinaemarls in the Maluwi anticlinal lying towards the sea. In the synclinal between Sembulu and Maluwi anticline we discovered still true Sampajan marls; more E.N.E.-ward they are however modified, because the Globigerinae come much more to the front, and at the same time the other fossils recede more backward. In this way we find in the region of Pulu Sangkuwang and Godang marly rocks representing as it were a penetration of the Sampajan marl-facies and the Globigerinaemarlfacies. W. STAUB¹⁾ has described a small fauna of most likely pliocene age. The youngest strata of this region are coralligenous limestones, which come to light at the mouth of the Sungei Tungkap and between the lower course of the rivers Kauli and Lindak.

On the southern limb of the Maluwi anticlinal, lying towards the sea, we do not find back anything of the Sampajan marl-facies; as far as the central part of the Sungei Mangenai exclusively Globigerinaemarls occur here, which contain towards the top banks of the Biotite bearing tufas described above. The Globigerinaemarls are then succeeded at the Sungei Mangenai by coralligenous limestones, which in their turn are covered with a series of sands and gravels — the youngest part of the tertiary formation or perhaps already of quaternary age. These limestones suggest, that towards the end of the tertiary formation the sea slowly receded, a conclusion, which had already been arrived at by W. STAUB (l. c.) on other grounds.

¹⁾ Vierteljahrsschrift der Naturf. Gesellschaft in Zürich. 61. 1916, p. 128 et seq. (The thickness of the Sadgkulirang marls is indicated here too small.)

Now we leave South Sangkulirang and repair to the more northern anticlinals, where we shall likewise find remarkable modifications of facies.

The nuclei of the Southern and Northern Sampanju anticlinals are formed by the Old-Miocene, that contains here remarkably little coal and limestone, but for the rest it is built up of the normal sandstones and shales. On the Western limb of these anticlinals we meet with the Miopliocene, in the South in entirely normal development, in the North with indications of Sampajau marls.

On the Eastern limb we find on the strata of old-miocene likewise miopliocene, partly in the normal development with soft clays, sands, gravel and dead black to brown coal.

In higher parts follow then — in the neighbourhood of Sungei Labuan — between the normal rocks banks of Sampajau marls. In Baŕu and Batu Hidup anticlinal, rising more towards the East the types of the Sampajau marls and limestones obtain a much greater development, though they alternate in the Western limbs still with rather numerous seams of coal. On the Eastern limbs the development of the marly facies is still greater. Sandy clays and sands occur here still in fact, but the coal has almost disappeared. The youngest parts of the tertiary formation consist here of a complex of sands and gravels, — as is likewise the case in the Sembulu anticlinal dipping down towards the North, near Sekurau and southward from the Sungei Mangenai. — We must mention that the miocene Gastropoda, which K. MARTIN¹⁾ described a few years ago from Sangkulirang were collected on the Batu Hidup anticlinal, whilst the fossils described by me from Sankulirang were found on the Gunung Batu anticlinal²⁾. Whilst for these two faunas the age was determined as young miocene, or as transition between old and young miocene, W. STAUB (l. c.) determined the age of the facial analogous fauna of Godang as pliocene. To a certain height these determinations of age are supported by the representation on the map: the strata of fossils of Gelingsch are situated on the farthest anticlinals of the Sangkulirang region, the fauna of Godang was found in the deep synclinal region between the anticlinals of Maluwi and Sembulu and the anticlinals of North Sangkulirang.

We have come to the end of our descriptions and give on the annexed table another geographical-stratigraphical sketch of the facial modifications in the tertiary formation of Sangkulirang.

A few short considerations may be added to the facts described above.

¹⁾ Samml. Geol. Reichsmus, Leiden. (l). 9. 1914, p. 325 e. s.

²⁾ Samml. Geol. Reichsmus, Leiden. (l). 9. 1914, p. 383 e. s.

The normal facies of the Kutei Tertiary formation is undoubtedly for a great part of terrestrial origin; the limestones and marls, which, in proportion to the entire mass of the formation, are always very insignificant, point only to a temporal intrusion of a very shallow sea into the land. The different facies of Sangkulirang (Sekerat facies, Sampajau marl facies and Globigerinaemarl facies) are on the contrary decidedly of a marine origin. Now it is highly remarkable, that the boundary between terrestrial and marine facies in Sangkulirang constantly nearly follows the normal N—S coastline of Kutei. The supposition is suggested that already in great periods of the tertiary formation the present, normal coastline of Kutei — allongated towards the North through Sangkulirang — formed the boundary between land and sea. Exclusively the terrestrial deposits were seized by the “normal” folding, which laid afterwards the tertiary formation into the anticlinals extending from SSW.—NNE. Only in Sangkulirang, where — for reasons that have not yet been sufficiently explained — the direction of the foldings is abnormal i. e. from SW to NE to W—E, also part of the sediments deposited towards the sea were upheaved through the formation of the mountains.

From the fact that in the “normal” coast margin of Kutei terrestrial deposits and in more easterly regions marine deposits of old miocene age are found, we may conclude, that, even if in the old miocene the isles of Borneo and Celebes rose above the level of the sea, they must already have been separated by a sea, so that already in the Old Miocene the Strait of Makassar was extant in design. VERBEEK ¹⁾ has likewise — by other considerations — come to the same conclusions.

We still find an inclination in literature to regard extensive Globigerin marls as being of a pelagian origin. This conclusion would certainly be incorrect for the very thick Globigerinaemarls of Sangkulirang. For in the first place we could observe how very near the coast these sediments have been deposited. In the second place W. STAUB has described a collection of gastropoda from Globigerinaemarls of Godang which contain besides true marine forms also forms of brackish and of fresh water. At last I could state in Globigerinaemarls on the west coast of the isle of Senumpa and in glauconitic Globigerinaemarls in the island of Serai, lying to the East of Senumpa, that they show cross-bedding, a phenomenon that totally excludes their being deposited into deep water,

Buitenzorg, August 1916.

¹⁾ Jaarb. Mijnw. Ned. Indië, 37. 1908. Wetensch. Ged., p 806.

SEKURAU ANTICLINAL (Southern part)	SEKURAU ANTICL. (Eastern part)	SEKURAU ANTICL. (Northern part)	SEMBURU ANTICL.	MALUWI ANTICL. (Northern part)	MALUWI ANTICL. (Southern part)	SAMPAJU ANTICL.	BATU HIDUP ANTICLAL	Gg. BATU ANTICL. (Western limb)	Gg BATU ANTICL. (Eastern limb)
<i>Miocene.</i> Sands, gravel, clays. Coral limestone. Sands, gravel, clays, brown to black coal.	Sands, gravel, clays. Coral limestones and marls with traces of coal.		Sands, gravel, clays Sampajau marls. Limestones, sandy and gravelly Biotite tufas. Globigerina marls, traces of lime-rock and Sampajau marls, finely stratified clayey sands.	Coral limestones Sampajau marls with Globigerinae and Biotite tufas. Globigerina marls.	Sands, gravel, clays. Coral limestone. Biotite tufas. Globigerina marls.	Sands, gravel, clays, brown to dead black coal, in the North traces of Sampajau marls.	Sands, gravels, clays, brown coal (lignite). Sampajau marls, limestones.	Sands, gravels, clays, brown coal (lignite). Sampajau marls, limestones.	Sands, gravels. Sampajau marls, limestone, sands, clays, clayey sands.
<i>Old Miocene,</i> in normal facies coal-bearing.	Shales, sandstones, black glance coal (anthracite), separate strata of coralligene, Lepidocyclus limestone.	Shales, sandstones, separate strata of coralligene, Lepidocyclus limestone.	Shales, sandstones, traces of coal. Limestone banks with Corals and Lepidocyclus, finely stratified, clayey sands, traces of Globigerina marls on the upper parts.	Globigerina marls, traces of sand and glance coal (anthracite).	Globigerina marls, traces of sand.	Shales, sandstones, traces of coal and limestone.			
<i>Oldest Miocene, ? Oligocene.</i> (coal-free).	Shales, traces of sandstones and limestones.	Shales, traces of sandstones.							