Geology. — *Three geological sections across South Sumatra.* By J. WESTERVELD. (Communicated by Prof. H. A. BROUWER.)

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INTRODUCTION.

This paper is ment to give a short summary of the geology of South Sumatra as it has become known by the work achieved by the Sumatra party of the Geol. Survey of the Netherlands East Indies between 1927 and 1933, which methodical survey, the results of which have been published in the Explanations to the Geol. Map of Sumatra, scale 1 : 200.000 [1]), in a certain way may be considered as a continuation of the explorations made previously by A. TOBLER [2]) and others in Palembang and Djambi. The general geological structure of the region concerned, as it can now be conceived from the results of these explorations and besides from the mapping done by employees of oil companies, is illustrated by three sections across the entire width of the island and by two complementary cross-cuts. The writer wishes to thank Dr. H. M. E. SCHÜRMANN and Dr. J. K. VAN GELDER, both at the Hague, and Dr. J. ZWIERZYCKI, now at Warsav (Poland), for many valuable data concerning the oil region put at his disposal.

The area treated in this article covers the Residencies Palembang, Lampoeng Districts and parts of Djambi and Benkoelen [3]). Apart from the presumably pre-Carboniferous and possibly even pre-Palaeozoic crystalline schists and granitic gneisses of the Lampoeng Districts, which primarily belong to an old mountain system of unknown extension and still obscure connections with metamorphic rocks elsewhere in the East Indian Archipelago, the rock formations of South Sumatra outside the Neogene basin of Djambi, Palembang and the Lampoeng Districts are distributed over three main orogenetic units of major importance in the larger western half or "Asiatic" part of the East Indian Archipelago. The sediments of the oil basin were folded in subsidiary and later phases of movements, which culminated in late-Miocene time in the Barisan zone. From NE. to SW. the three main orogenetic stems may be distinguished as: 1. The late-Jurassic *Malaya orogene,* the chief exposures of which are found on the Malayan Peninsula, the Tin Islands (Riouw Archipelago, Banka, Billiton) and in West and Central Borneo (Kapoeas region, Schwaner Mts., upper Mahakam region), whereas on Sumatra it is only visible in the Bt. Batoe SE. of Palembang, the Bt. Iboel in E. Djambi and possibly also in the Tigapoeloeh Mts.; 2. The middle- or late-Cretaceous (or ev. Palaeocene) *Sumatra orogene* [4]), exposed in the

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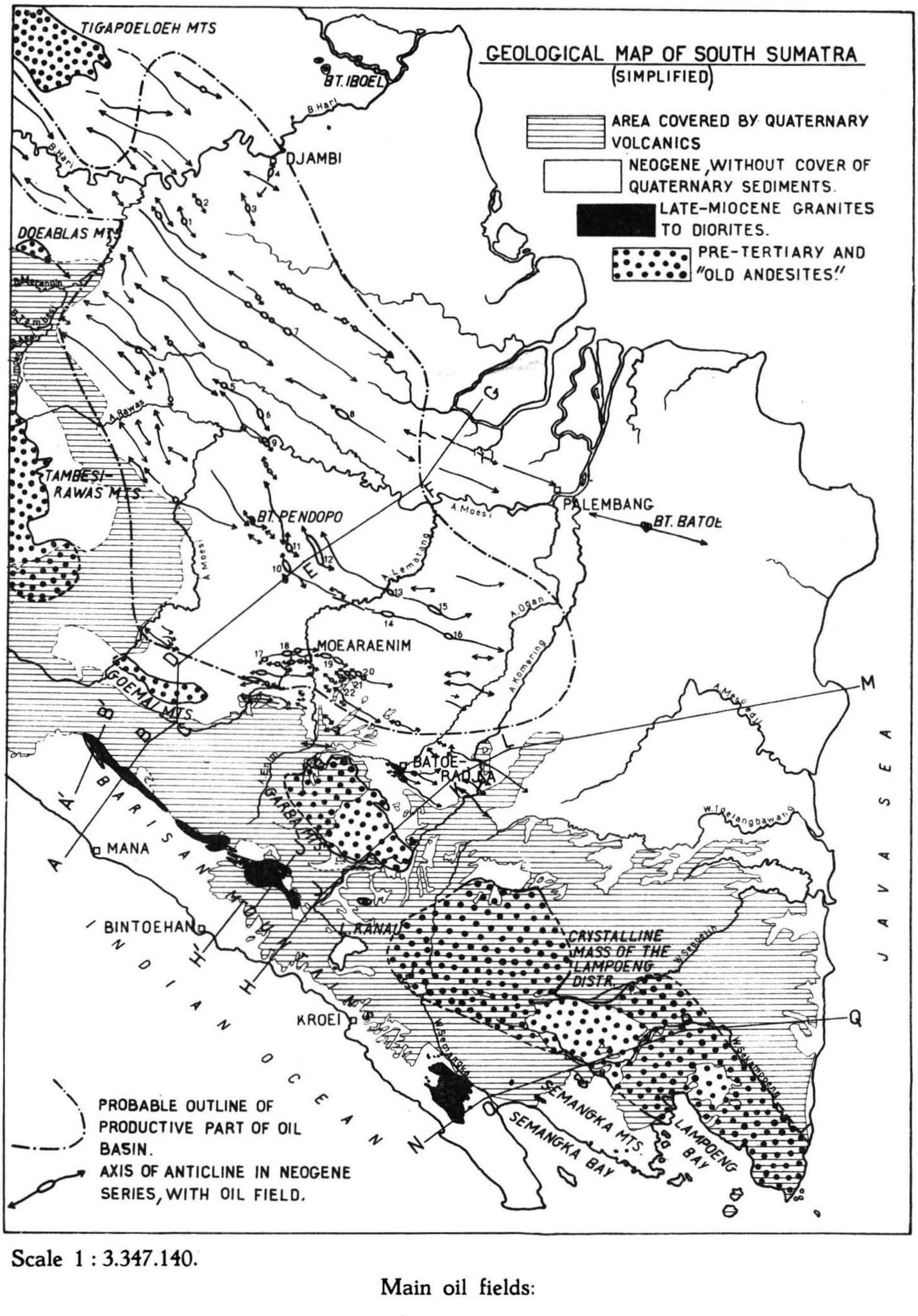
[1]) R. W. VAN BEMMELEN, Explanation (Toelichting) to sheet 10 (Batoeradja) and sheet 6 (Kroeï) of the Geological Map of Sumatra (1932, 1933); K. A. F. R. MUSPER, Do. to sheets 15 (Praboemoelih) and 16 (Lahat) (1933, 1937); C. H. VAN RAALTEN, Do. to sheet 7 (Bintoehan) (1937); J. VAN TUYN, Do. to sheet 4 (Soekadana), sheet 8 (Menggala), sheet 13 (Wiralaga) and sheet 9 (Gedongratoe) (1932, 1934, 1934, 1937); J. WESTERVELD, Do. to sheet 5 (Kotaboemi) and sheet 3 (Bengkoenat) (1931, 1933); J. ZWIERZYCKI, Do. to sheet 1 (Teloekbetoeng) and sheet 2 (Kotaägoeng) (1931, 1932).

[2]) A. TOBLER, Topografische und Geologische Beschreibung der Petroleumgebiete bei Moeara Enim (Süd Sumatra). Tijdschr. v. h. Kon. Ned. Aardr. Gen., 2nd series, **23**, 199—315 (1906); Do., Djambi-verslag. Jaarb. v. h. Mijnw. in Ned. O.-Indië, **48**, Verh. III, pp. 585 (1919). With Atlas.

[3]) "oe" of Netherlands orthography to be pronounced as "u".

[4]) In a previous paper (J. WESTERVELD, „De tektonische bouw van Zuid-Sumatra", Handel. v. h. 28ste Nederl. Nat.- en Geneesk. Congres, p. 264—267, 1941), the writer has



Scale 1 : 3.347.140.

Main oil fields:

1. Betoeng; 2. Badjoebang; 3. Tempino; 4. Kenali Assam; 5. Soeban Boeroeng; 6. Babat; 7. Sumpal; 8. Kloeang; 9. Mangoendjaja; 10. Benakat; 11. Djirak; 12. Talangakar-Pendopo; 13. Goenoengkemala; 14. Limau; 15. Talangdjimar; 16. Tandjoengmiring; 17. Soengei Ramok; 18. Tandjoeng Loentar; 19. Minjak Itam-Kampoeng Minjak; 20. Soeban Djerigi; 21. Batoekras; 22. Soengei Taham.

Tambesi-Rawas Mts., Goemai Mts., Garba Mts. and in the Crystalline Mass of the Lampoeng Districts, all cupolas forming part of a broad mountain system, which can be followed without interruption from the Tambesi-Rawas Mts. onward along the whole length of Sumatra between NW. Palembang and the north-point of Atjeh; 3. The late-Miocene *Soenda orogene,* represented by the folded Miocene sediments, effusive rocks and irruptives of the Barisan and Semangka Mts., which zone can be followed from S. Benkoelen until the SW.-part of the Government West Coast of Sumatra, where it evidently plunges below sea-level opposite the coast region of Tapanoeli, where the rocks of the Sumatra orogene are washed at various places by the Indian Ocean.

The Sumatra orogene forms the backbone of the island in Central and North Sumatra. On Java this late-Mesozoic mountain system is only exposed in the small pre-Tertiary cores of the South Serajoe Mts. and Djiwo Hills, while on the east-side of the area covered by the Malaya orogene equivalent structures of about the same age are very probably developed in the Meratoes and Bobaris Mts. of SE. Borneo.

The Soenda orogene, characterized by the occurrence of Miocene deposits in dominantly volcanic facies and by the development of Neogene, dacitic and dioritic to granitic intrusiva along its entire area of extension, can be traced from the Barisan Mts. in Benkoelen towards the southern ranges of Java, whence it takes its further course over the Lesser Soenda Islands as far as the Banda sea, from which region it proceeds with a sharp bend into the SW.-arm of Celebes and farther on into the western part of Central Celebes and the north-arm of this island. G. L. SMIT SIBINGA [5]) proposed the denomination "Soenda orogene" for the total assemblage of mountain structures developed on Sumatra, Java, the Lesser Soenda Islands and in the West Arc of Celebes. The name will be used here in a more restricted sense, applying it only to the Miocene magmatic zone indicated above.

STRATIGRAPHY AND IGNEOUS ROCKS.

Crystalline schists and gneisses, which presumably must be of at least pre-Carboniferous age in view of the entirely non-metamorphic state of the Anthracolitic formations of Sumatra, constitute the frame-work of the Crystalline Mass of the Lampoeng districts (section N—Q), while smaller exposures are found between Lake Ranau and the Garba Mts. and between the old-Miocene rocks of the Barisan Mts. (districts Mana and Bintoehan, sections A'—B', H'—J'). This crystalline basement of S. Sumatra, which is partly covered by Miocene deposits and by products of Quaternary and pre-Neogene volcanism, can be traced from Lampoeng Bay in a NW.-direction until the Mana section of the Barisan Mts. It represents the only definite example of crystalline schists and gneisses on Sumatra and consists of an assemblage of orthogneisses (metamorphic granites, quartz-diorites, quartz-porphyrites and tuffs), biotite-, muscovite- and chlorite-schists, sericite-quartzites, graphitic zoisite-garnet-mica-schists, massive and schistose amphibolites, albite-sericite-schists and occasional marble beds; all rocks with a degree of crystallinity corresponding to the epi- to meso-zone of regional metamorphism as distinguished by U. GRUBENMANN.

Permocarboniferous rocks. A *Permian* rock suite of porphyrites and dark limestones with

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suggested a late-Cretaceous or ev. old-Eocene age for the Sumatra orogene and its post-orogenetic irruptive rocks. The lower age limit, however, has to be removed to the middle-Cretaceous, as all Cretaceous deposits of S. Sumatra presumably belong to the lower division of this formation.

The Malayan prefixes in this paper have the following meaning: Bt. = Boekit = Mountain top or hill; A. = Aer = River or water; B. = Batang = River; W. = Wai = River or water; S. = Soengei = River.

[5]) G. L. SMIT SIBINGA, The Malay double (triple) orogen. Proc. Kon. Akad. v Wetensch., Amsterdam, **36**, 202—210, 323—330, 447—453 (1933).

Glomospira, *Neoschwagerina* and *Fusulina* sp. is known from the pre-Neogene core of the Bt. Pendopo on the Talangakar anticlinorium in Central Palembang [6]). Late-Palaeozoic sandstones, conglomerates and liparitic to andesitic effusive rocks, together with limestones, which yielded a fauna of gastropods, brachiopods and Foraminifera of probably *lower-Permian* age, are developed at the Tambesi river on the NE.-side of the Tambesi-Rawas Mts. [7]). NW. of this locality *upper-Carboniferous* (to lower-Permian?) rocks in dominantly volcanic facies are developed in a broad syncline in Upper Djambi [8]). Pebbles of Permocarboniferous Fusulina limestone were besides found in a conglomerate bed between Middle Palembang beds NW. of Palembang town [9]), so that late-Palaeozoic rocks must form part of the pre-Neogene basement formations along the Palembang anticlinorium.

Trias (?). An indication to the existence of Triassic sediments in the Mesozoic slate formations of the Tambesi-Rawas Mts. is afforded by a find of *Thecosmilia* sp. in limestones along the Tambesi river [10]). Triassic sediments are probably to be expected in the Tigapoeloeh and Doeablas Mts., the sedimentary rocks of which consist largely of strongly folded slates, interbedded with sandy layers, calcareous phyllites, a few marble beds and occasional volcanic material [11]). Triassic are possibly also the quartz-sandstones exposed on Bt. Iboel.

Jurassic sediments are exclusively known with certainty from the Tambesi-Rawas Mts., where a small Dogger pelecypod fauna was found in sandy shales along the Temalang river N. of the Rawas river [12]). *The S. Temalang shales are the least disputable Jurassic beds thus far discovered on Sumatra.*

Cretaceous deposits are known from the NE.-margin of the Tambesi-Rawas Mts., the Goemai Mts., the Semangka Mts., and very probably also from the Garba Mts. In the Tambesi-Rawas Mts. dull shales and limestones on the B. Asai and B. Limoen yielded a Valanginian fauna of Ammonoidea (e.g. *Neocomites* and *Thurmannites* sp.), pelecypods, gastropods and echinids [13]). In the Goemai Mts. (section A—G), the pre-Tertiary rocks of which have all proved to be Cretaceous [14]), the late-Mesozoic deposits were divided into two apparently conformable series, distinguished resp. as the Saling beds or upper division (thickness at least 400 m.) and the Lingsing beds or lower division (thickness at least 3000 m.). The Saling beds are composed of volcanic breccias, tuffs and basaltic to andesitic lavas with a greenstone appearance, interbedded with fossiliferous limestone banks, which yielded a probably lower-Cretaceous fauna of Nerineas, Lovceniporas, Lof-

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6) Jaarb. v. h. Mijnw. in Nederl.-Indië, **60**, Alg. Ged., 25 (1931).

7) A. TOBLER, Op. cit., 195—200, 293, 294 (1919).

O. E. MEYER, Brachiopoden des Perm und Unter-Carbon der Residentschaft Djambi (Sumatra). Verh. v. h. Geol. Mijnb. Gen. voor Nederl. en Kol.; Geol. serie, **5**, 203—222 (1920—1922).

8) J. ZWIERZYCKI, Die geologischen Ergebnisse der Paläobotanischen Djambi-Expedition 1925. Jaarb. v. h. Mijnw. in Nederl.-Indië, **59**, Verh. II, 1—70 (1930).

9) Netherlands East Indies Mining Service; quarterly report (1932).

10) A. TOBLER, Op. cit., 78 (1919).

11) A. TOBLER, Op. cit., 206—212, 310—315, 416 (1919).

12) F. FRECH and O. E. MEYER, Mitteljurassische Bivalven von Sungi Temalang im Schieferbarissan (Residentschaft Djambi). Verh. v. h. Geol. Mijnb. Gen. voor Ned. en Kol.; Geol. serie, **5**, 223—229 (1920—1922).

13) E. BAUMBERGER, Die Kreidefossilien von Dusun Pobungo, Batu Kapur Menkadai und Sungi Pobungo (Djambi, Sumatra). Verh. v. h. Geol. Mijnb. Gen. voor Ned. en Kol.; Geol. serie, **8**, 17—47 (1925).

14) K. A. F. R. MUSPER, Nieuwe fossielresten en de ouderdom der kalksteenen in het Pretertiair van het Goemaigebergte. De Ing. in Ned.-Indië; IV. Mijnbouw en Geologie, **1**, 521—531 (1934).

Do., Explanation to sheet 16 (Lahat) (1937).

tusias, echinids, small Foraminifera and corals. The Lingsing beds are a series of thin-bedded shales, tuffaceous marls with Radiolaria and sponge spicules, Radiolaria-bearing hornstones, and an occasional limestone bed with small Foraminifera and *Orbitolina* sp. of a presumably lower-Cretaceous type. In the Semangka Mts. a strongly folded series of black shales, tuffaceous sandstones, beds of coral limestone and of black limestone with *Orbitolina* sp., also of a presumably lower-Cretaceous type, was found abutting on the crystalline rocks of the Lampoeng Mass (section N—Q). The Cretaceous age of the Upper and Lower Garba beds (section H—M), into which the pre-Tertiary deposits of the Garba Mts. were divided, is suggested by their great lithological similarity to the Cretaceous rocks of the Goemai Mts. The Upper Garba beds, only preserved in a few steep synclines, consist of tuffaceous marls with Radiolaria and of diabase tuffs. Similar beds are also exposed in the cores of some anticlines near Batoeradja. The Lower Garba beds are a strongly folded series of hydrothermally altered, andesitic, basaltic and dacitic tuffs and lava flows, interbedded with shales and limestone beds.

Although definite evidence is still lacking, *a transgressive position of the lower-Cretaceous* is suggested by the side-by-side occurrence of Cretaceous rocks and crystalline schists in Palembang and the Lampoeng Districts, apparently without any intercalation of Permocarboniferous and old-Mesozoic formations, which play such an important part in Central and North Sumatra.

Pre-Tertiary intrusive rocks, granites to diorites and allied types, are known from all the pre-Tertiary ranges. In the Tambesi-Rawas Mts., Goemai Mts., Garba Mts., the Crystalline Mass of the Lampoeng Districts, and possibly also in the Doeablas Mts. and the pre-Tertiary core of Bt. Pendopo, they probably all belong to one post-orogenetic family, intimately connected with post-lower-Cretaceous folding in the zone of the Sumatra orogene. Their period of intrusion has to be located between the lower-Cretaceous and the Neogene, but a pre-Eocene age seems most probable in view of the fact that in Atjeh (N. Sumatra) the already deeply eroded Sumatra orogene is locally covered unconformably by Oligocene strata. The granites of the Tigapoeloeh Mts. and the granosyenite of Bt. Batoe probably belong to the late-Jurassic Malaya orogene; almost certainly the rock of Bt. Batoe, which by its high content of potash and rare earths [15]) shows unmistakable relationship to the eruptive rocks of the Tin Islands. Still older epochs of magmatic activity are represented by the undatable granite-gneisses of the Lampoeng Districts and by detached bodies of granitic rocks, which occur together with the Permian deposits of the B. Tambesi in an overthrust mass above Mesozoic slates [16]). A homologue of this overthrust granite is found in the B. Merangin-B. Mesoemai region in Upper Djambi, where a pre-upper-Carboniferous granite of analoguous tectonic position occurs at the base of the volcanic upper-Carboniferous series described by J. ZWIERZYCKI [17]).

The plutonic bodies of the Tambesi-Rawas Mts. are intrusive into Mesozoic slates and Jurassic (to Cretaceous?) limestones (pyrometasomatic iron and Cu-Pb-Zn ores!), while those of the Goemai and Garba Mts. are resp. intrusive into the Lingsing-Saling beds and the Garba beds (sections A—G, H—M). The Crystalline Mass of the Lampoeng Districts contains many intrusive granites (pyrometasomatic iron ores!), the most extensive body of which is exposed between the upper courses of W. Sekampoeng and W. Sepoetih (section N—Q). Dominant rock types in all these cupolas are granite to diorite, with on a minor scale gabbro and dikes of aplite, pegmatite, pyroxenite, porphyrite, dolerite, spessartite and kersantite. In the Doeablas Mts. the pre-Tertiary slate formation is in-

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15) W. VAN TONGEREN, Mineralogical and chemical composition of the syenite-granite from Boekit Batoe near Palembang, Sumatra, Netherlands East Indies. Proc. Kon. Akad. v. Wetensch., Amsterdam, **39**, 670—673 (1936).

Do., On the occurrence of rare elements in the Netherlands East Indies, etc. Dissertation, Utrecht; analysis, p. 148 (1938).

16) A. TOBLER, Op. cit., 195—200, 293, 294 (1919).

17) J. ZWIERZYCKI, Op. cit. (1930).

truded by granite, augite-syenite, essexite and dikes of diorite-porphyrite, hornblende-syenite, porphyry, aplite, tourmaline-bearing pegmatite and spessartite, while the plutonics of the Tigapoeloeh Mts. consist of granite to diorite, joined by veins of aplite and pegmatite [18]).

"Old andesites" [19]). The general transgression of the lower-Miocene sea over the eroded structures of the Sumatra orogene was preceded in Eocene or early-Miocene time by a stage of terrestrial, dominantly andesitic volcanism, the frequently propylitized products of which still cover wide areas over the NW.-section of the crystalline Lampoeng Mass, the NW.-part of the Garba Mts. and the S.-part of the Tambesi-Rawas Mts. The Lower Kikim tuffs around the Goemai Mts. and andesitic rocks which occur between the pre-Tertiary rocks of the Bt. Pendopo (Permian and intrusive granite) and their Miocene cover also belong to these effusives. Part of the Tertiary andesites, breccias and tuffs of the Barisan and Semangka Mts. may probably be correlated with these "old andesites", but it is hardly possible to distinguish them from the old-Miocene volcanics of these mountain ranges. The "old andesites" are sometimes cut by Au-Ag veins of an epithermal type (NW.-section of the Lampoeng Mass, Tambesi-Rawas Mts. S. of the A. Rawas, in the latter region apparently associated with dacites and liparites).

Neogene sediments and volcanics. The following stratigraphical scheme applies in a general way to the Neogene formations of S. Sumatra (oil basin and Barisan zone):

Oil basin in SW. Palembang.			Barisan and Semangka Mts.
Upper Middle Lower	Palembang beds (younger-Miocene and Pliocene).		Marine Pliocene of the Benkoelen coast and Semangka valley. ∿∿∿ unconformity. "Intermediary Neogene" of Benkoelen (Lower Palembang beds?). ∿∿∿ local unconformity or stratigraphical gap?
	Telisa or Goemai beds.	Batoeradja-Telisa series (older Miocene)	Batoeradja — Telisa series (at many places chiefly in volcanic facies).
Batoeradja stage	Batoeradja limestone. Basal beds (quartz-sandstone horizon(s), shales, layers of black lignite or wood horizons, sometimes volcanic deposits).		

The Neogene deposits of the oil basin attain their greatest thickness in the region E. of the Goemai Mts., where the Telisa and Palembang beds alone together measure about 7600 m. (Telisa beds ± 4800 m.; Lower Palembang beds 700—1000 m.; Middle Palembang beds 650—800 m.; Upper Palembang beds 500—1000 m.), which figure ought to be augmented with that for the Batoeradja stage, which around the Goemai Mts. consists of a basal quartz-sandstone horizon (75—200 m.), covered by a volcanic series of andesitic breccias, tuffs and lavas (the Upper Kikim tuffs) with an aggregate thickness of 2000—2500 m. on the S.-side of the range and 300—950 m. on its N.-flank. Along the northern margin of the Goemai Mts. the Telisa and Palembang beds show a very reduced thickness and the same phenomenon can be observed in the area of the Batoeradja folds and in the Lampoeng Districts, where the Neogene series covers a relatively stable region of slow former subsidence. In the case of the Goemai anticline its rather thin cover of Neogene deposits, especially on the N.-side, can be explained as a consequence

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[18]) A. TOBLER, Op. cit., 379—381, 388, 389 (1919).

[19]) The term has also frequently been used to denote all Tertiary andesites.

of its early rising in a initial stage of the process of young-Tertiary folding. The Neogene stratigraphy of the Moearaenim region also applies more or less to Central and North Palembang and Djambi. Along the E.-side of the Tambesi-Rawas Mts., however, the entire Neogene series shows a little differentiated, tuffaceous development, while E. and SE. of the Garba Mts. the Neogene beds are developed in sandy, tuffaceous and conglomeratic facies. The Telisa series wedges out between its pre-Neogene basement and the Palembang beds along the Palembang anticlinorium (section A—G), so that the Lower Palembang beds in this region are lying immediately above pre-Tertiary rocks.

The *Batoeradja stage* is especially well-developed around the Goemai and Garba Mts. and in the anticlines near Batoeradja. Its basal beds are of less importance in the latter region, where the old-Miocene Batoeradja limestone (Tertiary e4—e5 according to W. LEOPOLD and I. M. VAN DER VLERK's scheme for the East Indian Tertiary [20]), characterized by Eulepidinas, Spiroclypei, *Miogypsina dehaarti* V. D. VLERK and *Trillina Howchini* SCHLUMB. as guide fossils, acquires a maximal thickness (up to 300 m.). In small basins along the upper courses of W. Sekampoeng and W. Sepoetih on either side of the Lampoeng Mass the basal beds consist of some hundreds of meters of quartz-sandstones and quartz-conglomerates with a few coal beds and capped by Batoeradja limestone. SW. of the Crystalline Mass this basal Miocene series passes side-ways into the volcanic old-Miocene of the Semangka Mts. (section N—Q). The Batoeradja stage merely represents a facial type of the lowest division of the Telisa series. On the Talangakar anticlinorium, where the Telisa beds have a thickness of 1000—1200 m., it is developed as a sandy deposit and contains an important oil horizon (oil fields Talangakar-Pendopo, Benakat etc.). In the Barisan and Semangka Mts. the old-Miocene, the Telisa beds inclusive, is largely developed as a series of andesitic lavas, tuffs and breccias with some sedimentary intercalatations, e.g. shales and limestones with Batoeradja guide fossils. Only near Mana the Telisa beds show their normal sedimentary development.

The Telisa beds (upper part of Tertiary e and T. f) are a monotonous series of Globigerina marls and shales with intercalations of andesitic tuffs and breccias, beds of glauconitic sandstone, platy or concretionnary limestones and occasional layers with plant remains. Spyroclypei were still found in the lower part of the series in association with Lepidocyclinas and other genera. In the Barisan Mts. near Mana the Telisa beds are developed in normal sedimentary facies (thickness 3000—4000 m.), but in the districts Bintoehan and Kroei and in the Semangka Mts. the series is almost entirely replaced by andesitic volcanics (see sections). The Telisa beds contain important oil horizons in Central Palembang and Djambi.

The *Lower Palembang beds* (late-Miocene) are a series of bluish green or gray, frequently glauconitic marls and claystones, interbedded with tuffaceous sandstones and glauconitic, concretionnary, marly limestones. The formation contains abundant molluscs and Foraminifera (Lepidocyclynas, Miogypsinas, Cycloclypei, rotalides and other genera) and corresponds more or less to the upper-Miocene Badoei, Bodjongmanik, Njalindoeng and Tjilanang beds in W. Java [21]). The L. P. beds contain oil sands practically over the whole extension of the oil basin in Palembang and Djambi.

The *"intermediary Neogene"* of the Benkoelen coast region (distr. Mana and Bintoehan) presumably represents a stratigraphical equivalent of the L. P. beds, to which they correspond facially. NE. of Mana this series (thickness $\pm$ 1500 m.) apparently succeeds in

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20) W. LEUPOLD and I. M. VAN DER VLERK, De Palaeontologie en Stratigrafie van Nederlandsch Oost-Indië; "The Tertiary". Leidsche Geol. Meded., **5**, 611—648 (1931).

21) Guide fossils of the Bodjongmanik and Badoei beds in Central Bantam, W. Java (C. H. OOSTINGH, Mollusken als gidsfossielen voor het Neogeen in Nederlandsch-Indië. Hand. v. h. 8ste Ned.-Ind. Natuurw. congres, 508—516 (1938)), also found in the L. P. beds are: *Turritella subulata* MART., *Amusium hulshofi* MART., *Apolymetis grimesi elongata* (HAANSTRA and SPIKER), *Cultellus dilatatus* MART., *Siphocypraea caput-viperae* (MART.).

conformable succession to the Telisa beds, although the mutual relations are obscured by a reverse fault (sect. A'—B', A—G). Near Bintoehan this series, which is generally rich in shell fragments, contains also pumice tuffs, silicified wood and silicified dacite tuffs, while it is probably separated from the Telisa beds in this district by a stratigraphical gap. The marine fauna of these beds mainly consists of molluscs and Foraminifera (Lepidocyclinas, Miogypsinas, Cycloclypei, e.g. *Cycloclypeus* ex. gr. *guembelianus* BRADY and *C. (Katacycloclypeus) annulatus* MART., which two species according to TAN SIN HOK [22]) are resp. restricted to the upper-Miocene to Pliocene and to the upper-Miocene).

The *Middle Palembang beds* near Moearaenim (late-Miocene to lower-Pliocene) consist of claystones, tuff-sandstones, interbedded with marly or glauconitic concretions, glauconite sands and several groups of brown-coal beds (total thickness of coal beds up to 47—90 m., but strongly variable). Marine horizons with molluscs, echinoderms, shark teeth and small Foraminifera are found in the lower part of this formation near the Goemai Mts. Oil horizons are known mainly on the Moearaenim anticlinorium.

The *Upper Palembang* beds (Pliocene to Pleistocene?) consist principally of acid pumice tuffs, tuff sands and kaoline-like clays, practically without marine horizons and with few coal strings. The formation contains no oil.

The *Pliocene of Benkoelen* and the Semangka valley lies unconformably above all older Neogene formations and shows a monoclinal, sea-ward dip of 5—10°, only locally interrupted by faults, in the coast region of Benkoelen. The formation is of marine-tuffaceous origin, contains abundant mollusc remains and consists of greenish, tuffaceous marls, calcareous marls, tuffaceous claystones, layers of pumice tuff, sometimes massive dacitic-liparitic tuffs, andesitic ocnglomerates and occasionally also andesitic lavas (total thickness of the series 800—1000 m.). Plant remains and layers of impure brown-coal are also frequently found. The series corresponds more or less to the upper-Pliocene Tjimantjeuri, Tjilegong, Bodjong, Kaliglagah and Sondé beds in W. and Central Java [23]).

During the Batoeradja-Telisa epoch the Neogene sea of the oil basin stood in close connection with the Indian Ocean through wide passages around the Goemai and Garba Mts., which condition still persisted, albeit perhaps on a reduced scale, during the Lower Palembang and even locally — NW. of the Goemai Mts. — during the Middle Palembang epoch. Before the Upper Palembang epoch, however, all connections were apparently cut off by the rise of the Barisan zone and the Lampoeng Mass; the marine Pliocene of the west coast possibly corresponds to the terrestrial-volcanic U. P. beds on the E.-side of these structural units.

Late-Miocene intrusive rocks. The old-Miocene sediments and volcanics of the Barisan and Semangka Mts. are penetrated at many places by granitic to dioritic (on a minor scale also gabbroic) and dacitic rocks in bosses or batholithic bodies. The largest of these intrusions are found in the southern peninsula of Benkoelen, NE. of Bintoehan and NE. of Kroei, while similar intrusions are also found in the coast range of N. Benkoelen and in the region SE. of Padang (Gov. West Coast of Sumatra). The late-Miocene granites to diorites are responsible for extensive propylitizations and silicifications of the old-Miocene volcanics in the Barisan zone, while they have also to be considered as the parent rocks of the epithermal Au-Ag veins in N. Benkoelen (Lebong region) and near Padang. The massive dacites are intimately associated with the holocrystalline rocks, but in most cases seem to be slightly older.

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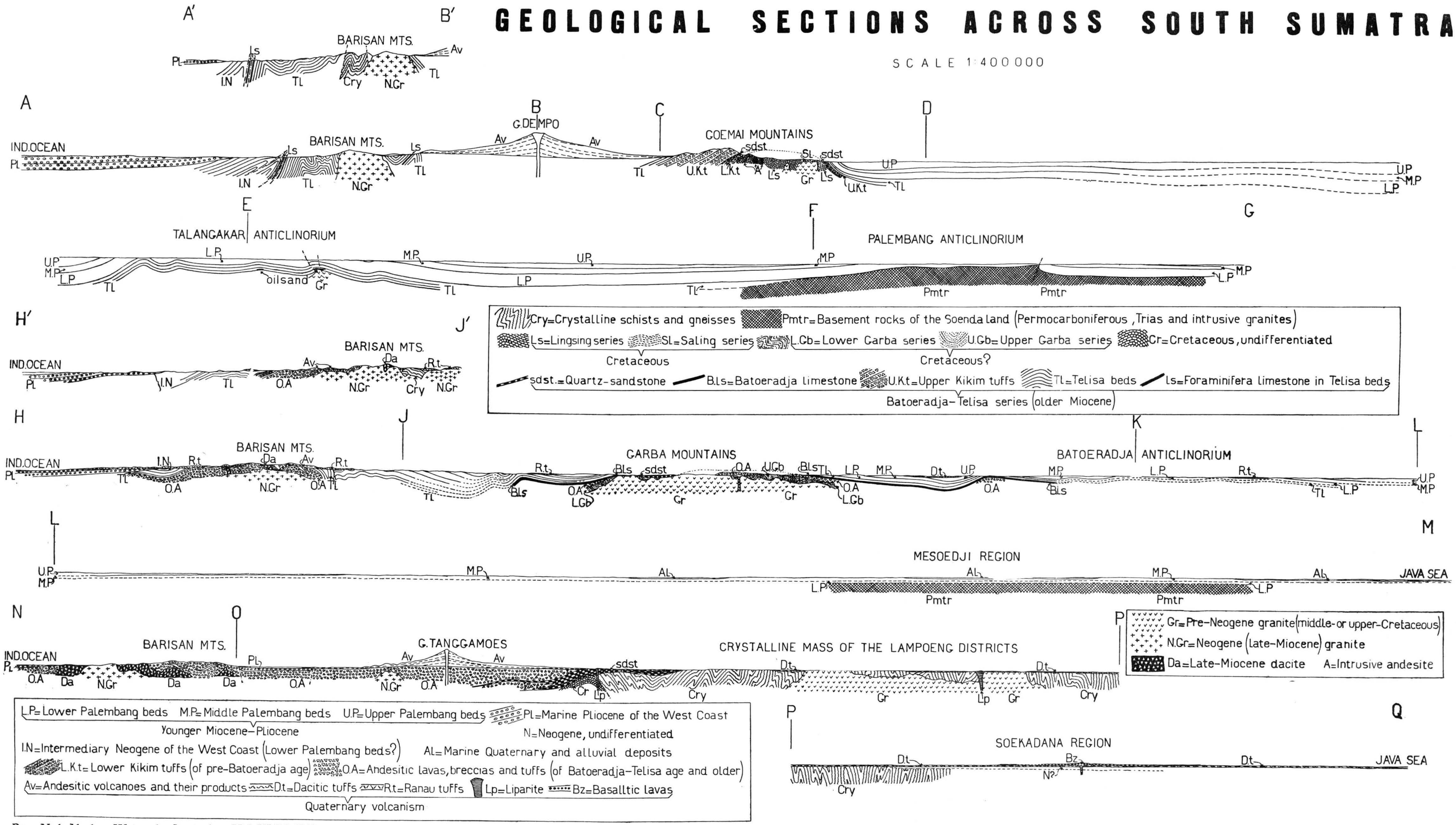
[22]) TAN SIN HOK, On the genus Cycloclypeus Carpenter. Dienst v. d. Mijnb. in Ned.-Indië; Wetensch. Meded., **19** (1932).

[23]) C. H. OOSTINGH, Op. cit. (1938); also: Note on the stratigraphical relations between some Pliocene deposits in Java. De Ing. in Ned.-Indië; IV. Mijnb. en Geol., **6**, 140—141 (1939). Guide fossils of the Tjilegong and Bodjong beds (Bantam, W. Java) also found in the Benkoelen Pliocene are: *Terebra insulindae* P. J. FISCHER, *Nuculana praeradiata* (O. BOETTG.), *Turritella angulata bantamensis* MART., *Polinices (Neverita) sulcifer* (MART.), *Pecten javanus* MART., *Cardita javana* MART.


GEOLOGICAL SECTIONS ACROSS SOUTH SUMATRA
SCALE 1:400000
A' B' BARISAN MTS.
A B C D
G.DEMPO
COEMAI MOUNTAINS
IND.OCEAN
BARISAN MTS.
E F G
TALANGAKAR ANTICLINORIUM
PALEMBANG ANTICLINORIUM
oilsand
H' J'
H J K L
BARISAN MTS.
CARBA MOUNTAINS
BATOERADJA ANTICLINORIUM
L M
MESOEDJI REGION
JAVA SEA
N O P
G.TANGGAMOES
CRYSTALLINE MASS OF THE LAMPOENG DISTRICTS
P Q
SOEKADANA REGION
Cry=Crystalline schists and gneisses
Pmtr=Basement rocks of the Soenda land (Permocarboniferous, Trias and intrusive granites)
Ls=Lingsing series
SL=Saling series
Cretaceous
L.Gb=Lower Garba series
U.Gb=Upper Garba series
Cretaceous?
Cr=Cretaceous, undifferentiated
sdst.=Quartz-sandstone
B.ls=Batoeradja limestone
U.Kt=Upper Kikim tuffs
Tl=Telisa beds
ls=Foraminifera limestone in Telisa beds
Batoeradja–Telisa series (older Miocene)
Gr=Pre-Neogene granite (middle- or upper-Cretaceous)
N.Gr=Neogene (late-Miocene) granite
Da=Late-Miocene dacite
A=Intrusive andesite
L.P=Lower Palembang beds
M.P=Middle Palembang beds
U.P=Upper Palembang beds
Younger Miocene–Pliocene
Pl=Marine Pliocene of the West Coast
N=Neogene, undifferentiated
I.N=Intermediary Neogene of the West Coast (Lower Palembang beds?)
AL=Marine Quaternary and alluvial deposits
L.Kt=Lower Kikim tuffs (of pre-Batoeradja age)
O.A=Andesitic lavas, breccias and tuffs (of Batoeradja–Telisa age and older)
Av=Andesitic volcanoes and their products
Dt=Dacitic tuffs
Rt=Ranau tuffs
Lp=Liparite
Bz=Basaltic lavas
Quaternary volcanism

Quaternary sediments and volcanics. Marine Quaternary sediments are represented by upheaved coral reefs along the Benkoelen coast, especially near Bintoehan (up to 50 m. above sea-level); furthermore by extensive blankets of clay deposits with marine shells, which form large embayments between the Neogene hills of E. Palembang and E. Djambi. The marine Holocene beds on the eastern outskirts of the oil basin were formed during the post-Pleistocene period of partial submergence of the eastern coast region. Only in very recent time the sea again receded over a height of 5—10 m. [24]). *Quaternary stages of volcanism* produced the following five groups of effusive rocks, tuff mantles and volcanic cones: 1°. *Liparitic-perlitic lavas of fissure eruptions in the Pasoemah region* (SW. of the Goemai Mts.) *and along the Semangka valley*; 2°. *Dacitic pumice tuffs and dacitic-liparitic necks of the Lampoeng Districts*; 3°. *Andesitic to basaltic volcanoes* within and NE. of the Barisan zone; 4°. *Liparitic-dacitic pumice tuffs of the Ranau eruption*, deposited around Lake Ranau and E. of the Garba Mts.; 5°. *Basaltic lavas of the Soekadana fissure eruptions* in the eastern Lampoeng Districts. Groups 1 and 2 are the oldest and connected with longitudinal fault zones as channel ways. The acid necks of the Lampoeng Districts NW. of Lampoeng Bay (two of them indicated on section N—Q) are probably the eruption points of the acid Lampoeng tuffs. The Ranau tuffs, connected with the formation of the volcano-tectonic L. Ranau depression, are older than the youngest andesitic volcanoes, but younger than the oldest andesitic cones. The andesitic volcanoes are mainly located on diagonal or transverse fault zones.

TECTONICS.

The rocks of the Sumatra orogene, which were folded in the middle- or late Cretaceous (or ev. Palaeocene) epoch, are strongly, but not excessively folded; dynamo-metamorphism or regional metamorphism are apparently not developed on an intensive scale. Overthrusts of presumably not very large horizontal displacement are known from the NE.-flank of the Tambesi-Rawas Mts., where Permian rocks and detached masses of granite were thrown in a SW.-direction upon Mesozoic slates; furthermore from the SW.-flank of the Lampoeng Mass W. of Lampoeng Bay, where crystalline schists are separated by a NE.-ward dipping, reverse fault from the Cretaceous rocks of the Semangka Mts. (section N—Q). The Neogene deposits were strongly folded and also cross-faulted in the Barisan section of the larger Soenda orogene in late-Miocene time before the intrusion of the late-Miocene granites (to diorites) and dacites. Later movements mainly affected the Mio-Pliocene deposits of the oil basin, which were warped into three main anticlinoria in South and Central Palembang: the Moearaenim-Batoeradja anticlinorium, the Talangakar anticlinorium and the Palembang anticlinorium. In N. Palembang the Talangakar and Palembang anticlinorium unite into one broad system of folds. In the oil region the most complicated structures are found in the oil fields of the Moearaenim anticlinorium, which are segmented by cross faults (Soeban Djerigi oil field) or even struck by overthrusts (Batoekras and Minjak Itam-Kp. Minjak oil fields). Reverse faults (with NE.-ward dip), however, are also known from the folds on the Talangakar anticlinorium, as for instance on the Talangakar-Pendopo oil field (secion A—G), along the SW.-flank of Bt. Pendopo, along the SW-side of the Karangringin oil field (S. of the Mangoendjaja oil field) and on various folds between the A. Moesi and A. Rawas. A steep flexure or even reverse fault is besides found on the NE.-flank of the Palembang anticline (secion A—G). The arcual shape of the Moearaenim fold system may be explained as the result of the strong NE.-ward push exerted upon the mighty succession of poorly consolidated, Neogene beds in the former area of subsidence NE. of the Goemai Mts. through the tectonic depression between the Goemai and Garba Mts. The Barisan zone only underwent a gradual uplift and dissection into longitudinal fault blocks during the Pliocene and afterwards.

Amsterdam, Geological Institute of the University.

[24]) J. VAN TUYN, Over een recente daling van den zeespiegel in Nederlandsch Oost-Indië. Tijdschr. v. h. Kon. Ned. Aardr. Gen., 2nd series, 49, 89—99 (1932).