tischer Anwendung solcher Fette, z.B. bei der Behandlung des Diabetes, achten. In der vorigen Abhandlung wurde nachgewiesen, dass unter den bei den dort besprochenen Untersuchungen gegebenen Umständen der teilweise Ersatz von Nahrungsfett durch Undekafett eine sehr deutliche Verminderung der Ketosis zur Folge hat. Es besteht a priori keinerlei Grund zu der Annahme, dass dies bei Verabreichung von Triglyceriden anderer Fettsäuren mit ungerader Zahl von Kohlenstoffatomen nicht der Fall sein wird. Aus unseren hier beschriebenen Untersuchungen zeigt sich nun, dass die niedrigeren Triglyceriden in viel geringerem Grade als Undekafett und die höheren überhaupt nicht zu Disäureacidosis führen. *Aus diesem Grunde sind diese Produkte für therapeutische Anwendungen entschieden dem Undekafett vorzuziehen.* Auch in diesem Zusammenhange verweisen wir nach der Besprechung von Literatur über Intarvin und Diafett in der nächsten Abhandlung. In einem für medizinische Zwecke ins Auge gefassten derartigen Fett wird Undekansäure als Säurekomponente am liebsten fehlen müssen. Wir hoffen bald auch zu klinischen Untersuchungen mit hierfür am besten geeigneten Fetten Gelegenheit zu haben.

Gern entledigen wir uns schliesslich noch der Dankespflicht gegenüber der Verwaltung des „HOOGEWERFF-Fonds" und der „ERASMUS-Stichting" zu Rotterdam für die von diesen Seiten gewährte Unterstützung für unsere Untersuchungen.

Rotterdam. Laboratorium der Nederlandsche Handels-Hoogeschool.

Februar 1933.

Geology. — *The Malay double (triple) orogen.* By G. L. SMIT SIBINGA (Communicated by Prof. G. A. F. MOLENGRAAFF).

(Communicated at the meeting of March 25, 1933).

PART II.

The Australian double-orogen.

According to several geologists there exist geological relations and connections between the Halmaheira Archipelago, especially its Eastern part and New Guinea. Others have joined parts of the Pelew-orogen and of the Australian orogen to tectonical units. In the writer's opinion the available data, as far as they may be considered to be well established geological facts, do not support these views.

There exists a striking structural analogy in the main features between the Australian double-orogen, marginal to the Northern border of the Australian continent and the Asiatic double-orogen marginal to the Southern border of the Asiatic continent. The analogy is a principal one, though gradually there are great differences.

North of the Australian continent two orogens (the South- and the North-New Guinea-orogen) already well developed in Pretertiary time may be discerned. The S.-New Guinea-orogen may be pursued from the Louisiade Archipelago through whole New Guinea up to the group of islands: Salawati, Batanta, Waigeu. The Kumamba Is. and the Cyclope-Bougainville range belong to the N.-New Guinea-orogen, the prolongation of which is still uncertain. The available geological data neither allow to fix the orogenetic nor the magmatic cycles of these Australian orogens.

The geosyncline situated between the S.-New Guinea-orogen and the Australian continental border, which still existed in Miocene time has been very intensively folded during Post-miocene time. The most prominent element of this late Neogene orogenesis are the Snow Mountains. On account of analogy with the Himalayas and with regard to the exclusively Northern dip of the strata nearly up to their central part it has been suggested by several geologists (BROUWER, FEUILLETEAU DE BRUYN, ZWIERZYCKI, a.o.) that overfolding and overthrust sheets directed to the South occur in the Snow Mountains. If this view would appear to be right a strong Southward surface reaction would bear witness to a corresponding strong Northward continental action. This is an important gradual difference with the folding of the Neogene geosyncline between the Sunda-orogen and the Southern Asiatic continental border, which is much less intensively folded and which does not show strong surface reactions of any vigorous continental action.

The geosyncline between the S.- and N.-New Guinea-orogen has been strongly folded in Plio-pleistocene time only in its Northern part though less intensively than the Southern one. Overturned folds and small over-thrusts directed to the North however show a still distinct surface reaction of a Southward directed counteraction of the N.-New Guinea-orogen and the Pacific oceanfloor. Here we may also notice a great gradual difference with the geosyncline between the Sunda- and Molucca-orogen South of the Asiatic continent, which still finds itself in a geosynclinal stage.

Apart from great principal analoga the Australian double-orogen especially the interjacent geosynclines show important gradual differences in their orogenetic evolution compared with the Asiatic double-orogen South of the Sundaland. That the orogenetic development of the Australian double-orogen has proceeded much further may be reasonably explained by the much stronger Australian continental action with Northward tendency during Tertiary time in contradistinction with the slight or perhaps entirely absent Asiatic Tertiary action with opposite tendency.

Crustmovements.

WEGENER [13]) considered the island arcs off the Eastcoast of Asia as marginal ranges separated from the continent and stuck in the simatic oceanfloor by the westdrift of Asia. This explanation of the origin of the Asiatic arcs is not adequate in the light of present knowledge, for it depends on the westward drift of Asia, which at present seems highly improbable.

TAYLOR [14]) e.g. showed conclusively that the distribution of the crustmoving forces is intimately related to latitude and to hemispheres. The continents in the Northern hemisphere moved in Southerly direction (disjunctive basins around the North Pole), while those in the Southern hemisphere moved in Northerly direction (antarctic disjunctions). The crustal movements were radial and dispersive from both polar regions and consequently the Asiatic continent slid Southward with a strong deflection to the East.

The inadequacy of the Asiatic westdrift has been stressed particularly by MOLENGRAAFF [15]) in connection with the nature and origin of the mid-atlantic ridge. The recent gravity measurements of VENING MEINESZ in the East Indian Archipelago (l.c.) also point to a Southeast instead of a West tendency of the Asiatic continent.

This conception seems to be contradictory to the Youngtertiary tectonic plan bordering on the Malay earthlobe (Sundaland), which shows no evidence in support of a strong Youngtertiary Asiatic earthmovement at all.

The tectonic processes at the crust's surface may be studied exactly in plan, in profile only approximately, whereas only a very thin surface layer is accessible to direct observation. Surface and subsurface structure may be quite incongruent, particularly in complicated area's as the East Indian Archipelago. This incongruity has still been emphasized by the recent maritime gravity survey.

We know that superficial folds originate through compressional stress. At the best we may ascertain its direction exactly in the surface layers. But we know also that the observed compressional stress at the surface has its seat in deeper layers of the earth's crust and that here the direction of stress may be quite divergent. For a definitely directed stress in the surface layers may be induced in the depth in a number of different ways: it may be an equally directed stress, an obliquely directed (differential shear) or even an inversely directed one (underthrusting). To the latter especially attention should be called.

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[13]) A. WEGENER. Die Entstehung der Kontinente und Ozeane. 4te Aufl. 1929. p. 201.

[14]) F. B. TAYLOR. Sliding continents and tidal and rotational forces. in: W. A. J. M. v. WATERSCHOOT V. D. GRACHT, etc. Theory of continental drift. 1928. p. 158.

[15]) G. A. F. MOLENGRAAFF. Wegener's continental drift. in: idem p. 90.

G. A. F. MOLENGRAAFF. The coral reef problem and isostasy. These Proceedings Vol. 19. 1916. p. 610.

A point of first-order importance in this connection is the actual movement of the crust being involved. It is usually assumed that the overthrust part is actually moving. The opposite or rather supplementary idea of underthrusting has been emphasized by MOLENGRAAFF [16]) and HOBBS [17]) and lateron by others.

If movement takes place along a thrustplane and the overriding (overthrust) part of the crust is assumed to be moved in space, there is as much reason to assume that the overridden (underthrust) part of the crust may be moved as well, but in the opposite direction. From a mechanical point of view however there is much more reason to assume that the underthrust mass, which is by far the main part of the orogenic body, actually moved than the relatively thin surface layer. Studying surface structures in the right proportion to their subsurface negatives even prominent features as extensive overfolds and overthrusts appear to be but surface reactions of the really deepseated action. Therefore the subsurface protuberance of an orogen should be more accurately called the negative orogen, realizing that this negative orogen from a geotectonic viewpoint is the most important part of the orogen, being actually the cradle of orogenetic action and evolution, of which the geologist only observes the surface reaction in the positive orogen.

Now predominant positive tectonic features as geanticlines and geosynclines, extensive overfolds and overthrusts require considerable relative movements and consequently a conspicuous negative action. Moreover they always will have their main trend more or less normal to the direction of the deepseated stress that gave rise to them. Consequently they are the most suitable to compute the intensity and the direction of the subsurface action of the negative orogen.

Reckoning with all these factors it will be possible to draw to a certain extent conclusions from the surface reaction with regard to the subsurface orogenetic action i.c. the continental crustmovement.

The tectonic plan of the Neogene geosyncline bordering on the Sundaland has recently be discussed by the writer, which here may be referred to [18]). The main phase of Young-tertiary orogenesis acted much less intensively at the Asiatic border than at the Australian. Conspicuous surface reactions as extensive overfolding and overthrusting directed towards the Sundaland, which could bear witness to an important Young-

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[16]) G. A. F. MOLENGRAAFF. Folded mountain chains overthrust sheets and blockfaulted mountains in the East Indian Archipelago. Compte Rendu du XII Congrès Géol. Intern. Toronto 1913, p. 689.

G. A. F. MOLENGRAAFF. l.c. [12]), p. 300.

[17]) W. H. HOBBS. Mechanics of formation of arcuate mountains. Journal of Geology XXII. 1914, p. 71.

[18]) G. L. SMIT SIBINGA. The Tertiary virgations on Java and Sumatra, their relation and origin. These Proceedings Vol. 35. 1932, p. 584.

G. L. SMIT SIBINGA. The interference of meridional and transversal stress in the Southeastern part of Borneo. Idem, p. 1090.

tertiary Asiatic action up till now have not been observed. However the Tertiary structures on Sumatra-Java are in the main directed towards the Sundaland. Though there is apparently no evidence for any strong Tertiary Asiatic action the minor tectonic features on Sumatra-Java do not speak against a Tertiary Asiatic action, be it a subordinate one (in the writer's opinion better called continental reaction).

On the other hand it may be emphasized that in Tertiary time the sphere of very strong Australian action reached up to the border of the Sundaland, overshadowing the influence of a perhaps feeble Asiatic action, so that it seems hardly possible to disconnect both actions.

During an earlier (Cretaceous) mountain building process however, as the Archipelago did not yet find itsef in the Australian sphere of action and an Asiatic crustmovement still found an unobstructed path, there seems to be more evidence for a strong Asiatic action as advocated by TAYLOR, MOLENGRAAFF and VENING MEINESZ. Cretaceous orogenesis acted very intensively on Sumatra-Java. Overthrust sheets are considered to be highly probable as well on Sumatra (TOBLER) as on Java (HARLOFF). If the existence of great overthrust masses on these islands, directed towards the Sundaland should be proved, there is indeed strong evidence for an important Young-cretaceous Asiatic crustmovement with Southern tendency.

A vigorous Young-cretaceous Asiatic action, perhaps followed by a feeble Tertiary one, the latter being overshadowed by an intensive Young-tertiary Australian action would give a reasonable explanation for the curious fact that Young-cretaceous orogenesis is much stronger along the Asiatic — and that Young-tertiary orogenesis is much more intensive along the Australian border. The writer therefore is still inclined to award a leading part to the Australian crustmovement in the Tertiary tectonic disturbance of the Archipelago. The following arguments may further support this view.

In a former chapter it has already been discussed that the much more advanced stage of Young-tertiary orogenetic evolution of the Australian double-orogen, especially of the interjacent geosynclines in comparison with the Asiatic double-orogen South of the Sundaland points to a strong Australian action with Northern tendency.

The surface reactions in the Molucca-orogen opposite the Sahulbank show likewise strong evidence for Australian action. On Timor extensive overfolding and overthrusting of alpine character directed towards the Southeast has been discovered by MOLENGRAAFF and WANNER. WEBER's observations on Jamdena and the Kei Is. seem to point to eastward directed overthrusts, therefore also towards the Sahulbank. On Ceram northward directed isoclinal overfolding and overthrusting has been determined by RUTTEN and HOTZ, likewise towards the Australian continent. From Timor up to Ceram thus strong centrifugal surface reactions prove decidedly strong centripetal subsurface action. Moreover the Australian action is shown conclusively by the Young-tertiary tectonic plan. The Molucca-orogen along the Australian border not only corresponds exactly with the continental contourline, but is entirely crushed and crumbled to pieces by the action of this continent. The writer already pointed out in a previous paper (l.c. 3) that the way in which the Molucca-axis has been disturbed and squeezed could only proceed from centripetal Australian action.

All these phenomena as extensive overfolding and overthrusting, squeeze and crush are totally lacking at the Asiatic continental border. Comparing the Young-tertiary tectonic plan of the Asiatic and the Australian marginal belts a sharper contrast is hardly conceivable.

Of argumentative force finally is the well established fact that the main phase of Tertiary orogenesis started with great intensity at the Australian border in the early Miocene, to be transmitted with diminishing force during the youngest Tertiary towards the Asiatic border, whose marginal belts have been folded much less vigorously in the Plio-pleistocene. This striding away of the Young-tertiary main orogenesis from the Australian to the Asiatic continent in time and space, recently clearly illustrated cartographically by UMBGROVE [19]), proves conclusively that the Australian crustmovement played a leading part in the Young-tertiary orogenesis of the Archipelago.

The writer fully agrees with VENING MEINESZ that the principal strip of negative anomalies, i.e. for the greater part the still highly uncompensated Molucca-orogen, which also in his opinion reasonably may be expected to continue along all Eastasiatic orogens up to the Aleutians is of Asiatic origin, caused by a Southeast tendency of the Asiatic continent. However the Asiatic crustmovement already set in during Pretertiary times. We know that Cretaceous orogenesis has been very strong in Eastern Asia. The gigantic Eastasiatic geosyncline has been subjected to compression since at all events late Mesozoic time. It appears that an intimate relation existed between the Pretertiary Asiatic crustmovement, the intensive Cretaceous Eastasiatic orogenesis and the compression of the active geosyncline bordering on the Asiatic eastcoast, almost all in the same period. It goes without saying that all these intensive and extensive processes gave rise to strong and widespread gravity anomalies. The gravity measurements have taught that orogenetic activity may take place without maintenance of isostatic equilibrium which implies the discernment of the temporal permanence of isostatic anomalies (c.f. last chapter). In the writer's opinion the strip of strong negative anomalies in question is one of them and must likewise be of Pretertiary origin, though in the Malay Archipelago during the Tertiary period modified and intensified by strong Australian action.

This conception harmonizes with all observed and well established geological facts.

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[19]) J. H. F. UMBGROVE. Het neogeen in den Indischen Archipel. Tijdschr. Kon. Ned. Aardr. Gen. Dl. 49. 1932, p. 769.

Tertiary structural plan of the Molucca-orogen.

As stated above the main phase of Youngtertiary orogenesis started in the Molucca-orogen at the Australian continental border (Sahulbank) after the sedimentation of the Oligocene. As a rule the Youngtertiary main trends both in the Sunda-orogen and in the Molucca-orogen generated originally more or less parallel to the trends of the orogenetic axes and deviated lateron through the fracturing and bending of the latter. The writer recently pointed out that the complementary branching of trend lines (virgations) on Sumatra-Java may be explained by the bending and subsequent fracturing and faulting of the orogenetic axis (l.c. 18). But it may also have happened that the trend of the orogenetic axis could not adapt itself to the direction of compressional stress (Sumba), in which case the trends originated more or less divergent to the axis.

Considering the present structural plan it is clearly visible that the positive orogenetic axis opposite the Sahulbank is often cut obliquely by the negative axis, indicated by the general course of the island arc. The divergency may be considerable as e.g. on Babber, where the Youngtertiary trend and the positive orogenetic axis run nearly perpendicular to the negative axis. Such apparently abnormal trends are essentially not abnormal if we realize that the disturbing crush of the continental crust-movement has subsequently broken and has bent the more rigid positive orogen in several places to a much greater extent than the more plastic negative orogen. One always has to conceive the position of both axes during the main phase of Tertiary folding in question with regard to the prevailing direction of stress.

The divergent trends in the Molucca-orogen opposite the Sahulbank may reasonably be explained by subsequent fracturing and bending of the positive orogenetic axis, the axis of the more plastic negative orogen remaining still fairly undisturbed. Imagining the positive axis in its original position, still more or less indicated by the negative axis, the trend appears to be quite normal to the direction of stress.

In this complicated area the directions of stress and movement in both parts of the orogen have to be sharply discerned to get a clear notion of the whole tectonic process. As already pointed out in a previous chapter the direction of stress may be different to the direction of movement in the positive orogen, while it may be quite different too in the negative orogen. Moreover the direction of stress and movement in both parts of the orogen may be divergent to each other. Consequently at least four different factors with regard to stress and movement in an orogenic body have to be reckoned with, apart from the continental crustmovement. To simplify the matter as much as possible the minor tectonic features are to be left out of account for the time being and considerations are confined to predominant tectonic features, which always have a trend more or less normal to the direction of stress so that the directions of stress and movement pretty well coincide, though they may be opposite to each other in the positive and the negative orogen.

As already stated above, the positive Molucca-orogen from Timor up to Ceram has been moved centrifugally towards the Australian continent, it being the surface reaction of a centripetal movement of the negative orogen due to centripetal continental stress induced by continental action with northward tendency. The centripetal continental stress is suggestively demonstrated by the tectonic plan, particularly by the shape of the crushed positive orogenetic axis.

Our present knowledge of Tertiary tectonis on Buru and the Tukang Besi Is. is still too scanty to determine the directions of movement and stress. Some more data are available about the Buton Archipelago and Eastern Celebes.

BOTHÉ's[20]) representation of the geological structure of North Buton points to eastward directed isoclinal overfolding and overthrusting. According to BROUWER (l.c. 11) Eastern Celebes may be considered as a Tertiary folded range with its convex side to the West and with a general trend, which bends approximately in the direction of the present Northeastern and Southeastern peninsulas. In this Tertiary folded range imbricated structures with "schuppen" of partly brecciated ultrabasic rocks and of limestones thrust one over the other seem to prevail, though a general direction of thrusting could not yet be determined exactly.

In the Northern part of Eastern Celebes KOOLHOVEN[21]) discovered likewise overthrusts of alpine character. KOOLHOVEN's information for two reasons is of great importance, firstly as he had at his disposal the still unpublished results of L. V. LÓCZY and his fellow-workers, who investigated the most complicated adjoining territory and secondly as he was able to determine for the first time the position of the root of the overthrust due to the favorable circumstance that in the Northern part of Eastern Celebes the overthrust mass still coheres with its root. Up till now the roots of the overthrust sheets in the Molucca-orogen have been unknown and nowhere observed. In the part bordering on the Australian continent, on account of the direction of thrusting, the region of the roots has been presumed to be situated at the inner (Asiatic) side. This presumption has now been confirmed, as in the part of the Molucca-orogen which now forms the Northeastern peninsula of Celebes the root really has been observed to be situated on the Asiatic side of the orogen. This seems to apply to Buton too, the Southern prolongation of Eastern Celebes.

On account of its marginal position at the Asiatic side of the Molucca-orogen it seems reasonable to expect the root to be continued from the

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20) A. CHR. D. BOTHÉ. Voorloopige mededeeling betreffende de geologie van Z. O: Celebes. De Mijningenieur. 1927, p. 97.

21) W. C. B. KOOLHOVEN. Verslag over een verkenningstocht in den Oostarm van Celebes en den Banggai-Archipel. Jaarb. Mijnwezen 1929. Verh. p. 187.

Northern part of Eastern Celebes through the Southern part of Eastern Celebes up to Buton.

The direction of thrusting on East Celebes and Buton — where it could be determined — appeared to be the same as in the part of the Molucca-orogen bordering on the Australian continent, namely towards the outer (Australian) side of the orogen. The positive Molucca-orogen from Buton up to the peninsula of Bualemo of Northeastern Celebes thus shows a strong surface reaction indicating a corresponding vigorous action of the negative orogen directed towards the Asiatic continent.

The main phase of Tertiary orogenesis on Buton took place as in the part of the Molucca-orogen bordering on the Australian continent after the deposition of the Oligocene, in the Northern part of Eastern Celebes somewhat later, namely after the sedimentation of the Lower-miocene.

Our present knowledge of Western Halmaheira does not yet allow us to determine any direction of stress nor movement.

The part of the Molucca-orogen Southwest of Sumatra (Mentawei Is.) seems to be developed quite normally.

Geology. — *The formation of the atolls in the Toekang Besi-group by subsidence.* By PH. H. KUENEN. (Communicated by Prof. G. A. F. MOLENGRAAFF).

(Communicated at the meeting of March 25, 1933).

The present author in preparing a report on his investigations on coral reefs, as geologist of the oceanographical expedition to the East Indies on board Hr. Ms. Willebrord Snellius, came across a number of arguments in favour of the formation of atolls through upgrowth, during slow sinking of the substratum, on which they grow. It remains probable, that glacial control influenced the upper story of these great buildings, especially in aiding the levelling and regulation of the depths of the lagoon-bottoms. In this respect the classical study of MOLENGRAAFF on the influence of pleistocene lowering of sealevel in the East Indies (bibl. 4) remains untouched. In the production of the deeper mass below the living reefs and lagoons, however, the sinking of the substratum has played the principle part in the manner advocated by DARWIN, DANA and DAVIS. The group of atolls in which this can be most clearly demonstrated is the Toekang Besi-group to the south-east of Celebes. In the following paper a short summary will be given of the reasons for favouring this theory. For a detailed argumentation the reader is referred to the shortly forthcoming publication in the reports of the Snellius expedition.

ESCHER showed in 1920 (bibl. 1) that the atolls and the islands in the Toekang Besi-group are situated in rows. The first row in the south-west