GEOLOGICAL INVESTIGATIONS IN N. E. NETHERLANDS TIMOR

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ACADEMISCH PROEFSCHRIFT

TER VERKRIJGING VAN DEN GRAAD VAN DOCTOR IN DE WIS- EN NATUURKUNDE AAN DE UNIVERSITEIT VAN AMSTERDAM, OP GEZAG VAN DEN RECTOR-MAGNIFICUS MR. P. A. J. LOSECAAT VERMEER, HOOGLEERAAR IN DE FACULTEIT DER ECONOMISCHE WETENSCHAPPEN, IN HET OPENBAAR TE VERDEDIGEN IN DE AULA DER UNIVERSITEIT OP DINSDAG 4 JULI 1939, DES NAMIDDAGS TE 3 UUR PRECIES

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AAN MIJN OUDERS
AAN MIJN VROUW

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SAMENVATTING.

In dit proefschrift zijn neergelegd de resultaten van mijn onderzoekingen op het eiland Timor, welke gedaan werden in het tijdvak van Juli tot November 1937.

Het terrein van onderzoek lag in hoofdzaak in de Onderafdeeling Beloe (O. Nederlandsch Timor), en wel in het N. en W. daarvan, waar het grootste deel der vroegere rijken Djeniloe en Lidak werd onderzocht. Ook een gedeelte van Harnenno, dat meer naar het Z.W. ligt en reeds tot de Onderafdeeling Noord-Midden-Timor behoort, werd in het onderzoek betrokken.

Tezamen met Prof. Dr. H. A. BROUWER werd bovendien nog een verkenningstocht ondernomen langs den juist gereed gekomen weg van Kefamenanoe naar Pante Makasar in de Portugeesche enclave Oeikoesi.

Kristallijne schisten werden in het onderzochte gebied weinig gevonden. Slechts werden in het kustgebied, in de omgeving van de grens tusschen Beloe en Noord-Midden-Timor, op eenige plaatsen amphibolieten gevonden, welke in hoofdzaak bestaan uit diopsied, plagioklaas en amphibool, terwijl ook spinel voorkomt. Zij worden als min of meer lensvormige lichamen door serpentijngesteenten omsloten. Of zij in het complex van serpentijngesteenten thuis behooren, of dat zij moeten worden opgevat als fragmenten, welke van een kristallijnen ondergrond werden afgerukt, kon niet worden uitgemaakt.

Afzettingen van permischen ouderdom komen zoowel in de Sonnebait-serie als in het Fatoe-complex voor.

Het Perm van de Sonnebait-serie vertoont groote overeenkomst met dat van de bekende vindplaats van permfossielen, bij Bitaoeni. Meestal is het een roode of donkerroode tot bruine kalk, soms nagenoeg zuiver, maar vaak ook mergelig, met veel vulkanisch materiaal. Naast een groote hoeveelheid steelleden van crinoïden, komen ook tallooze cephalopoden voor, en verder brachiopoden, lamellibranchiaten, koralen, bryozoën, een enkele gastropode en fragmenten van trilobieten.

Aan de basis van dit fossielhoudende perm, werd op verschillende plaatsen een conglomeraat van verweerde eruptief rolstukjes gevonden, dat plaatselijk door koralen verkit is. Veelal komen in de directe omgeving van deze permische afzettingen, basische stollingsgesteenten voor, welke

vaak amygdaloïdisch zijn en een enkelen keer ook „pillow" structuren vertoonen.

De permische afzettingen van het Fatoe-complex, welke een deel der fatoes van Lidak opbouwen, zijn meestal niet, of slecht gelaagd, en overwegend licht van kleur. Zij zijn veelal grof kristallijn en bevatten resten van crinoïden en vaak ook brachiopoden. Ammonieten werden in het Perm van het Fatoe-complex niet aangetroffen.

Afzettingen van triadischen ouderdom hebben in het onderzochte gebied een groote verbreiding. Zij werden aangetroffen in de Kekneno-serie, zoowel als in de Sonnebait-serie en in de afzettingen van het Fatoe-complex.

De Kekneno-serie bestaat in dit gebied hoofdzakelijk uit afzettingen in flysch-facies. Het overheerschende gesteente is een grijs-groenige of bruinige glimmer-zandsteen tot grauwacke, doch plaatselijk komen ook mergelige schalies en kalken voor, welke soms slecht bewaarde Halobiiden bevatten.

In de Sonnebait-serie is de Trias meer bathyaal ontwikkeld. Zoowel cephalopoden houdende afzettingen, als afzettingen met alleen Halobiiden werden aangetroffen. De eerstgenoemde zijn oranje-roodbruine kalken met weer mergelige gedeelten, nagenoeg geheel opgebouwd uit ammonieten.

De Halobiiden houdende afzettingen bestaan uit bonte kleischalies, mergelige kalken en kalken; ook kiezelkalken komen voor en vaak hoornsteenknollen of hoornsteenbanken met radiolariën. Dikwijls bevatten deze gesteenten in groote hoeveelheid, en dan haast altijd min of meer parallel gerangschikt, de fijne schaaltjes van Halobiiden.

De triadische afzettingen van het Fatoe-complex, welke een deel van de steile kalkrotsen van Lidak opbouwen, bestaan uit beige tot witachtige, zelden meer grijsgekleurde, meestal ongelaagde kalken, waarin plaatselijk koralen werden gevonden. De oöliet-structuur, welke in andere deelen van Timor voor deze kalken zoo karakteristiek is, wordt hier meestal verdoezeld door een begin van rekristallisatie.

Het jongere Mesozoicum is niet zoo goed vertegenwoordigd als de Trias. Slechts op één plaats werd een gesteente gevonden, grootendeels opgebouwd uit schaalfragmenten van Inoceramen, dat met eenige zekerheid tot de Jura, en wel meer speciaal tot het Oxfordien mag worden gerekend. Van onzekeren, doch mogelijk boven jurassischen of cretaceïschen ouderdom, zijn verschillende compacte, rose en roode, kalken met hoornsteenbanden.

Afzettingen, welke blijkens de Globotruncana-fauna welke zij bevatten, tot het Boven Krijt behooren, werden op verschillende plaatsen aangetroffen. Vooral de rossige, verwreven, mergelige kalken, zijn in het terrein steeds goed te herkennen.

Het *Eogeen* en het *oudere Neogeen* werden nergens als vast gesteente gevonden, doch gesteenten, welke tot het *Jong-Mioceen en/of Plioceen* mogen worden gerekend, hebben in het kustgebied in de omgeving van Batoepoetih en bij Pante Makasar in Oeikoesi, een vrij groote verbreiding. Zoowel vrij zuivere organogene kalken als zeer sterk kiezelige vulkanische tuffen komen voor, en tusschen deze beide uitersten zijn tal van overgangen aanwezig.

Zoowel in de omgeving van Batoepoetih als in Oeikoesi, kon geconstateerd worden dat deze jonge, meestal witte, gesteenten direct rusten op de bazaltische tot andesitische glaskorstgesteenten.

Het onderzoek der zware mineralen, welke zij bijna steeds in meerdere of mindere mate bevatten, wees uit, dat dit in hoofdzaak mineralen zijn, welke in de jonge vulkanische afzettingen van de eilanden ten N. van Timor, veelvuldig voorkomen.

Van de *oudere stollingsgesteenten* is een deel zeker van permischen ouderdom. Ook in het Mesozoicum komen zij voor, n.l. in de Sonnebait-serie, doch niet in de Kekneno-serie. Aangetroffen werden diabazen, bazaltische tot andesitische gesteenten en ook trachyten.

De *serpentijngesteenten* beslaan in deze streken uitgestrekte gebieden, vooral langs de kust. Zij zijn meestal sterk gebreccieerd en gemylonitiseerd, en vaak komen lensvormige massa's van sterk gewalste serpentijn voor met evenzeer gewalste gesteenten van de Sonnebait-serie. Zij zijn zeker ouder dan de glaskorstgesteenten, welke geen sporen dragen van een zoo intensieve tectonische beïnvloeding.

Van de *tertiaire stollingsgesteenten* hebben vooral de bazaltische tot andesitische glaskorstgesteenten een groote verbreiding. Vanaf de Oehawai bij Atapoepoe komen zij, met een geringe onderbreking, voor tot in het gebied bij Batoepoetih en nog verder naar het Z.W., waar ze ook in Oeikoesi uitgestrekte bergcomplexen vormen.

Behalve deze glaskorstgesteenten komen ook rhyolitische en dacitische tot kwartsandesitische gesteenten veelvuldig voor, vooral in het gebied tusschen Wehor en de F. Kadoea.

CONTENTS

INTRODUCTION.

As a member of the Geological Expedition of the University of Amsterdam to the Lesser Soenda Islands in 1937, under direction of Prof. Dr. H. A. BROUWER, I had the opportunity to study the geology of a part of N.E. Netherlands Timor, the results of which are to be found in the following pages.

I am very much indebted to all, who have given me their advise and help, when I was preparing this publication. In the first place I am very grateful to Prof. Dr. H. A. BROUWER, for giving me the opportunity to join the expedition, and for his support during the work in the field and the writing of this publication. I am grateful to Prof. Dr. H. GERTH, who was so kind as to give me his opinion on palaeontological and stratigraphical problems and to Prof. Dr. J. WANNER in Bonn for the trouble, he took in going through some of my slides. Dr. D. J. DOEGLAS had the kindness to give his time to discuss various problems of sedimentary petrography, and to check the results of my analyses. Ir. F. A. H. W. DE MAREZ OYENS was so kind as to determine some Triassic fossils, while Dr. C. O. VAN REGTEREN ALTENA examined some recent lamellibranchs and gastropods. Dr. TH. REINHOLD obliged me by his examination of a number of samples on diatoms. To the Government authorities of Timor and especially to Captain J. EEFTINK in Atamboea, who in every way gave me his valuable help, which contributed very much to the results I have obtained, I am greatly indebted.

My investigations, which commenced in the district of Djeniloe, comprised the district of Lidak and from there, went as far as Batoepoetih in Harnenno. In the beginning of October I had the opportunity to make a reconoitering, together with Prof. BROUWER, along the new road to Pante Makasar (in the Portuguese enclave of Oeikoesi) and in its vicinity. As far as our observations in Oeikoesi are connected with those I made in Beloe and Harnenno, they will be mentioned in this publication.

GEOGRAPHICAL OUTLINES.

The Subdivision Beloe [1]) is bounded in the north by the Sawoe-sea, in the south by the Timor-sea; its eastern boundary is the same as that between Netherlands- and Portuguese Timor and in the west it is adjoined by the Subdivisions North-, and South-Middle-Timor. The Capital, which is also the seat of the Government officer is Atamboea, situated at 330 m above the level of the sea on a plain, which bears the same name. Usually the commander of the garrison, quartered there, is charged with the government and assisted by a civil officer. Besides Atamboea is the centre of the Roman-Catholic Mission, which is under the direction of the Bishop of Atamboea. All this makes Atamboea, at any rate in these regions, a place of importance. In the immediate vicinity there is a landing-place for aeroplanes. There is a telephone-communication with Koepang and some villages lying in between, with Atapoepoe on the northern coast, with the Portuguese boundary and some other, more remote posts. The postal motorcar drives along the road to Koepang once a week in the dry season. It covers this distance of 279 km in two days.

Of the investigated regions Djeniloe includes the region north of Atamboea and Lidak that to the north-west and west of this place. Harnenno in the district Beboki, lies still farther in N.W. direction along the coast and belongs to the Subdivision of North-Middle-Timor.

Generally speaking the district in question is very hilly. Starting from the plain of Atamboea, which on an average lies 300 m above the level of the sea and entirely consists of young lake- and river-deposits, the first spurs of the Wehor complex of hills which continue towards the east as far as the Portuguese frontier and are connected towards the south-west with the Lidak mountains by a low ridge, are reached at a distance of over an hour, going from Atamboea in a northern direction.

The most striking are the serpentine hills, which form the highest top in this neighbourhood at a height of over 530 m; besides several basic and more acid igneous rocks occur. The road from Wehor to Atapoepoe itself, runs over a strongly folded, monotonous, calcareous mica-sand-

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[1]) In the following the Dutch orthography will be used for geographical names etc. (oe sounds like oo in "book").

stone formation, very poor in fossils, which at 420 m as a narrow flat ridge forms the waterdivide between the basin of Atamboea and that N.W. and W. of Wehor, the latter of which drains into the Motta [1]) Berloeli, which empties itself into the sea near the kampong which bears the same name. North of Wehor too, due east of the road to Atapoepoe, there is a basin, which forms the drainage-area of the Manoekakai river, which after having broken through a complex of basaltic to andesitic, glass-encrusted rocks stretching from the Fatoe Kadoea [2]) as far as the Oehawai, runs into the sea between the kampongs Fatoe Loeka [2]) and Abat, north-east of Atapoepoe.

The coastal mountains consist nearly entirely of sometimes more, sometimes less brecciated masses of serpentine rocks, only occasionally interrupted by broad alluvial valleys, ± diagonally placed on the shoreline.

Along a deep bay, surrounded on three sides by mountains, lies the port of Atapoepoe on the extension of the motorroad Koepang—Atamboea, which continues as far as the Portuguese frontier. According to WICHMANN (60) Atapoepoe is the first place of Timor, which was indicated on a map.

Once the seat of the government and long ago even protected by a fortress, Atapoepoe now only exists because a ship of the Royal Packet company touches at it on an average three times a month for export and import purposes. Europeans are no longer living here, only a native custom-house officer, a number of Chinese traders and natives suffer their chronic attacks of malaria.

Though the serpentine hills mostly show rather rounded forms, sharp and fantastic, often with vertical walls, the gloomily black masses of the glass-encrusted rocks are towering behind. In the shape of the Fatoe Kadoea-Oehawai-complex they separate the coastal area from the interior.

South-west of Atapoepoe the serpentine mountains also extend along the coast far into Harnenno. However not entirely without breaks, such as i.e. near Berloeli, where the motorroad, following the valley of the Motta-Berloeli, turns towards the south and separates the We Hedan-Boesamata massive from the mountain Makon. On the seaside from place to place between the spurs of the hills, there are little coastal plains,

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[1]) Motta, or abbreviated M. = river.

[2]) Fatoe (abbreviated F.) as in Fatoe Kadoea and Fatoe Loeka, is used by the natives to indicate a hill or a mountain, which may consist of any kind of rock; literally the word fatoe means stone. Moreover the word fatoe is used geologically to indicate the steep rocks of massive limestone, which are so characteristic of the Timorese landscape.

usually grown with coconut-trees and ending in mangrove swamps. The south side ends in an almost vertical decrease of 75 to 100 m in a plain, closely grown with gewangpalms, which runs parallel with the coast, locally widens out considerably (from 3 to 4 km) and continues as far as the eye can see, only interrupted occasionally and scarcely so by a string of hillocks, consisting of the above mentioned calcareous mica-sandstone formation. This formation is also found along a part of the southern side of this plain, accompanied however bij a large number of different limestones often rolled and crushed, apparently mixed up indiscriminately, which impression is still strengthened by the material of fluviatile origin, which is undoubtedly present here.

The hilly landscape towards the south consists principally of ridges of quartz-porphyry and other igneous rocks as in the neighbourhood of Wehor, but more towards the west along the motorroad to Atamboea and especially west of it we again find calcareous mica-sandstone and various limestones which here originate partly from the Lidak mountains proper. Gradually the country ascends in a southern direction till directly south of Toentoeni the first steep limestone rocks, which are so extremely typical of these mountains, rise up. North, east and south it is more or less enclosed by the situation of the kampongs Toentoeni, Sèsekoi, Wekatimoen, Tala, Weloerai, Tabéan and extends in a western direction including the curiously shaped somewhat spirally twisted Fatoe Fohomalas, on the boundary of Beloe and North-Middle-Timor.

Marked tops are the Fatoe Nanait, Fatoe Kaioena, Fatoe Toekoenénoe and Fatoe Manoeaman, which all consist of limestone of various colours and habitus, mostly however crystalline, often with trochites and all strongly veined with calcite. Though these tops lie 600 to 675 m above the sea, the highest summit is formed by the Fatoe Noireeoe, which is over 700 m high and unlike its surroundings consists of a basic igneous rock.

This region is drained in every direction.

South of the Fatoe Manoeaman, in the direction of Boeboerloelik and even past it, the shape of the country, though still very hilly even there, presents a milder character; Triassic limestones, radiolarian chert and other deposits of a more bathyal character, the age of which cannot always be determined, accompanied by Permian amygdaloid and other basic igneous rocks, prevail. West of Halitoekoe lies a locality of Permian fossils which is hardly second in richness to that of Bitaoeni.

The landscape in the vicinity of Tg. Batoepoetih in Harnenno makes a completely different impression. Though the eastern part of this region form the boundary of Beloe as far as about Maoebesi on the river of the same name, bears some similarity to the coastal district near Atapoepoe, from Maoebesi farther towards the S.W., the character is quite different. It is true, that there too the Fatoe Kadoea-rocks occur, but the serpentine rocks are absent. Besides a new element appears; young, partly organic limestones and marls, which sometimes lie on the glass-encrusted rocks, now again rise up as isolated hills from the plain, like the coastal hills, which form the Cape Batoepoetih proper, a little west of the village of Batoepoetih, which, except for a narrow strip of sand along the coast, is entirely enclosed by mangrove swamps.

Compared to the Fatoe Kadoea-ridge the glass-encrusted rocks are much lower here; no higher than about 10 to 100 m. They form two ranges, running nearly parallel with the coast, of which the most northern one ends close to the east of Batoepoetih and the other continues for many kilometers in a S.W. direction, separated by an elongated plain without a trace of drainage on the surface. Landward from the most inland chain, a plain runs parallel with it also. The shapes of these hills are much more flattened and in many places they are swamped in their own detritus, above which steeper peaks and ridges rise up here and there. Neither do they form one connected range, but often rise up in larger or smaller masses from the plain, by which they seem to be "washed".

The general impression is that of an old erosion-surface, uplifted and faulted by recent movements and once more exposed to the eroding forces. Not however to such a degree as in the neighbourhood of the Fatoe Kadoea.

In a landscape recently raised like that of Timor, fluviatile erosion plays an important part, however only during the wet season, from about December to May. In the East-monsoon all rivers are completely dried up, some bigger ones like the Talaoe except for a few dirty pools. For the greater part in this country most rivers are small mountain-streams, full of boulders and pebbly rocks of various kinds and sizes.

The *vegetation* is very poor, at any rate during the dry monsoon, to which the exhaustive cultivation, which for centuries was practised by the population, and by which large areas were often destroyed by fire, has certainly contributed. In order to oppose further disforestation the government has marked certain parts as forest reservations. Under no condition are the population allowed to cut down anything. In the examined region the Fatoe Kadoea-reservation, that of Lidak, which contains the steep limestonefatoes and of Haoe Roenat in Harnenno belong to them.

The absence of primeval forests is however no guarantee at all for the possibility of rapid travelling across the district. The many thorny plants, among which especially a bush, Lanterna, with long, thin and flexible stems and twigs, full of thorns is very prevalent, may form such dense screens across large distances, that to enable one to make the necessary observations, one has to cut one's way step by step. The thorny bamboo too may be especially annoying in this respect.

In the dry monsoon a luxurious roof of leaves is only found in the immediate vicinity of some *springs*, on which the population has to depend in this part of the year for its supply of water. The larger ones, which give several liters a minute, are however sporadic and in most cases the "we mata" (= spring) of the natives hardly deserves the name. It is often a hollow place in the rocks or a shallow hole in the ground, from which the water may be scooped up in very small quantities. In the plains, which lie on a lower level, water often can only be obtained by digging a shallow well in the bed of the river; such a "well" is not seldom found in the immediate surroundings of a venomously green kerbau-pool.

On the whole *the population* makes a docile impression, though great shyness is shown when a kampong is entered unexpectedly. The language is the Tettoem; along the W. boundary Dawan is also spoken and those who have attended the elementary school also know Malay. Their religion was originally a heathen one, but under the influence of the Mission many people have become Roman Catholics, which does not alter the fact that in their daily life all kinds of earthly spirits continue to play an important part.

The standard of life is very low. Their industry is on a very limited scale; their agriculture is primitive and principally exhaustive agriculture. Gardens with fruittrees and vegetables are only found sporadically. The food of the people is maize and also sago, which is obtained from the gewangpalm, which is very abundant especially in the plains and also supplies the building material and the thatching of their roofs. Cattle, horses and kerbaus are entirely left to nature; pigs and hens are domestic animals and dogs are only tolerated, because they bark, when there is any danger.

FORMER INVESTIGATIONS.

Comparitively little has been published so far on the geology of the districts to be discussed here. The first geological data were collected in 1829 by MACKLOT, who a.o. made an official investigation of the copper-ores in the neighbourhood of Atapoepoe. The specimens of rocks, collected by him, were described by WICHMANN (59) after JUNGHUHN and KLOOS [1]) had published something about them.

In 1872 an investigation was once more made into the presence of copper in these districts and that by the mining-engineer H. J. W. JONKER, who a.o. investigated the districts Djeniloe and Harnenno, principally the coastal region, from about the Portuguese boundary past Tg. Batoepoetih, with a few more inland reconnoitrings in the direction of the Lidak mountains. A report of his findings, together with a geological sketchmap is at our disposal in the "Jaarboek v. h. Mijnwezen 1873", while in that of 1895 J. W. RETGERS gave a short description of the rocks collected by JONKER.

In 1889 WICHMANN (60) also visited the neighbourhood of Atapoepoe and VERBEEK too made geological observations, which have been published in his Molukkenreport (54).

During the years 1910—1912 a 1st Netherlands expedition investigated the eastern part of Netherlands Timor. On this occasion the districts, to be described in this publication were also visited. H. A. BROUWER studied the collected rocksamples and described a large number of various types (2). The definite results of this expedition have not yet been published and in the different preliminary publications which MOLENGRAAFF caused to appear, the regions in the N.E. part of Netherlands Timor, investigated in 1937, are only mentioned in a more general connection. In 1916 the 2nd Netherlands Timor-expedition still exploited a locality of Lower Triassic fossils in Lidak and in the end the most recent data are those which were collected a.o. in the coastal district of Atapoepoe during the latest investigations which were made in Timor between 1919 and 1923 through the "Dienst van den Mijnbouw" after the copper- and chromium ores (24).

As far as *Djeniloe, Lidak* and *Harnenno* are concerned, the geological data which these expeditions produced, will be mentioned concisely below

[1]) WICHMANN, l.c., p. 1.

beginning with those of JONKER, for WICHMANN's description of MACKLOT's rocks was only published in 1887.

1873 The mountains in the vicinity of Atapoepoe all consist of serpentine rocks and serpentine "conglomerates" in different varieties and probably of different ages; they are separated from the inland by a heavy wall of volcanic conglomerate. More inland sedimentary rocks of unknown age are found, fragments of limestone (mostly dense, sometimes granular, honeycombed), of a grey, blue or reddish colour with many mica-particles and often very cleavable. They are partly metamorphosed and broken through by the serpentine rocks. Various eruptive rocks among which quartz-porphyry and diorite are also mentioned.

In Harnenno the serpentine rocks and the volcanic conglomerate are also found, beside new elements like micaceous slate and white, soft "chalks" were found.

Concerning the ores (*Cu* and *Cr*) JONKER concluded that where small and poor ore pockets occurred, there may also be larger and richer ones, but according to him the probability is against this and he considered it superfluous to look for them (24).

1887 Eight serpentine rocks and serpentine "conglomerates" were described microscopically. That they are the transformation products of olivine rocks (dunites) was looked upon as an established fact; also that most serpentine conglomerates must be considered as "friction conglomerates". Their age remained unknown. Other rocks which were described are amphibole-tonalite, diorite, augite-andesite, augite-andesite-breccia, and hyalomelan-breccia (59).

1892 This publication of WICHMANN's is principally a travelling record which however makes clear the geographical situation and the distribution of the rocks.

As a new rock a granular crystalline limestone is mentioned from the serpentine area. The contact metamorphically changed sandstone, mentioned by JONKER was not found and its presence doubted. After this visit the age of the serpentine rocks appeared rather Paleozoic than Tertiary to WICHMANN.

From the interior are mentioned: quartz-porphyry, sandstone, amphibolite, Permian deposits, Halobia-limestone and young coral-limestones (60).

1895 Of the rocks, collected by JONKER, a short description was given of: different serpentine rocks, biotite-granite, obsidian, augite-andesite, quartz-andesite, diorite, quartz-diorite, gabbro, diabase, hornblende-slate and enstatite rock (40).

1908 After intermediate landings at the capes Batoepoetih, where young, soft, white marly and foraminiferous limestones were found and near Cape Binnenmouw, where instead of JONKER's micaceous slate, schistose amphibolite was stated, VERBEEK also visited the surroundings of Atapoepoe and the interior as far as the Lakaän.

Though partly uncertain, VERBEEK considered the succession of the sedimentary and eruptive rocks as follows:

1. peridotite, amphibolite and diabase;
2. Permian and Triassic rocks, to which also belong the sandstone with limestones intercalating near Wehor;
3. quartz-porphyry and melaphyre (Fatoe Kadoea) as Mesozoic, eruptive rocks;
4. various Miocene and Pliocene coral-limestones and marls, in the neighbourhood of the Lakaän as high as 1283 m and the Quaternary deposits of the Talaoeriver (54).

1912—1917 Concerning his expedition to Timor MOLENGRAAFF gave various preliminary results during this period (31—35), from which we can infer the following data concerning Djeniloe, Lidak and Harnenno:

a. in de fatoe-group of Lidak rocks of Permian trochitic limestone and Upper Triassic reef-limestone are mixed up (31);

b. the Talaoe-basin is the eastern continuation of the Young Tertiary median basin in the vicinity of Niki-Niki in Middle Timor (34);

c. from Atapoepoe to Lidak four zones may be distinguished, viz: a zone of peridotite, serpentine rocks and serpentine "conglomerate", tuffs, basic and acid effusive rocks which lie unconformably on Mesozoic deposits of an oceanic type with a chaotic structure, forming a second zone in which on the surface Triassic and Permian fatoes are found as well also resting on the above mentioned Mesozoic oceanic deposits; more inland a 3d strip follows, the fatoe-group of Lidak, in the middle of a zone of amphibolites, schists and serpentine rocks, which zone adjoins the Young-Pliocene and Pleistocene deposits of the median basin in the south (cf. the geological sketch-map and the sections accompanying (34)).

The general part of these publications will be discussed more detailed elsewhere.

H. A. BROUWER (2) divided the rockmaterial of the MOLENGRAAFF-expedition into 25 groups. From Djeniloe, Lidak and Harnenno were described: amphibole-quartz-diorite, amphibole-diorite, serpentine rocks, microdiorite, quartz-porphyry, quartz-andesite and dacite, andesite, basalts (the Fatoe Kadoea rocks were discussed extensively; with respect to their "conglomeratic nature" their generation by submarine eruptions was accepted as the most plausible explanation (p. 136 l.c.)), besides diabases and coarsely crystalline limestones.

1922 WELTER (58) described a number of Lower Triassic ammonites from Lidak of WANNER's and MOLENGRAAFF's expeditions.

1925 The investigation during the exploration for minerals in the island of Timor during 1919—1923 produced no new data for Djeniloe, Lidak and Harnenno. On the geological map 1 : 250.000 added to the report (22) a strip is indicated along the coast of "serpentine rocks, diabase, gabbro, melaphyre, diorite and others, not specified more closely, Pretertiary", locally with copperores; near the Portuguese boundary and in Harnenno, east of Maoebesi "basaltic, andesitic and dacitic rocks with their tuffs, not further specified, Tertiary" are marked; also Pleistocene reeflimestone, and in the basin of the Talaoe, higher gravelterraces and Young Tertiary limestones.

It need not to be demonstrated, that publications on investigations in other parts of Timor are of great importance for a clear insight in the geology of these districts; they will be mentioned repeatedly.

THE GEOLOGICAL FORMATIONS.

Successively will be discussed:

I. Crystalline schists.

II. Permian.
   a. of the Sonnebait-series.
   b. of the Fatoe-complex.

III. Triassic.
   a. of the Kekneno-series.
   b. of the Sonnebait-series.
   c. of the Fatoe-complex.

IV. Younger Mesozoic.

V. Younger deposits.

VI. The igneous rocks.
   a. Permian and Mesozoic.
   b. The Serpentine rocks.
   c. Tertiary.

I. CRYSTALLINE SCHISTS.

Few crystalline schists occur in the explored region. In fact only amphibolites were found and even these in a few localities only. They are always accompanied by serpentine rocks, by which they seem to be enclosed in masses of a more or less lenslike shape (fig. 1). Macro-

Fig. 1.

View near Selawai, N.W. of Kampong Kanoe, looking to the S.W.

a. = amphibolites.

b. = serpentine rocks.

scopically observed they are hard, angularly fragmented, distinctly schistose, rather fine grained rocks of a dark green colour and mainly consisting of amphibole and plagioclase. These amphibolite bodies are mantled by a weathering zone of angular blocks, disintegrating into still smaller parts. The whole of these outcrops is marked by a characteristic red soil.

Rocks of this kind were mentioned from the Lakaän, near the Portuguese frontier and from some localities in West- and Middle Timor, where a.o. they form part of the Booi-mountains, the Mollo-mountains and the Moetis-mountains.

In the region of the Mollo-mountains the amphibolites are accompanied by other green-schists such as epidote-chlorite-schists, actinolite-schists, glaucophane-sericite-schists, etc., by mica-schists and gneises and by phyllites and quartzites (51).

The plagioclase-amphibolites are looked upon by most of the authors as metamorphosed basic igneous rocks. Concerning their age nothing can be stated. In view of their occurrence they may belong to the complex of serpentine rocks, in which case they may perhaps be considered as dikes and associated intrusives, but it is also possible that they represent parts of a crystalline substratum, torn off and carried along by the masses of serpentine rocks.

II. PERMIAN.

In this chapter the Permian deposits of the Sonnebait-series [1]) and those belonging to the Fatoe-complex will be discussed.

In view of the data resulting from the investigations, made in the surroundings of the Moetis-mountains (9) it is not impossible that in this region deposits of Permian age also occur in the Kekneno-series; proofs concerning this have not been found however.

Nearly all localities, where outcrops in the Permian of the Sonnebait-series were found, are situated in the Lidak district. Usually they lie rather scattered and the dimensions of the outcrops are on a small scale as a rule.

Hence the description of a complete sequence of Permian deposits is out of the question, the more so, as this formation was submitted to tectonic movements to a rather strong degree. Neither could the stratigraphic succession of the various strata in this region be established, partly owing to the isolated situation of the outcrops, partly through the covering layer of weathering-material. It is true that the latter made the collecting of a large quantity of fossils possible, but at the same time it hampered the immediate observation of the strata proper very much. By means of the fossils could be established once, that the outcrops did not all belong to the same stratigraphic level.

The Permian deposits which belong to the Fatoe-complex, are found in some of the steep limestone masses, which form the fatoe-complex [2]) of Lidak, a mountain-complex which even from the distance attracts the attention by its relatively high situation.

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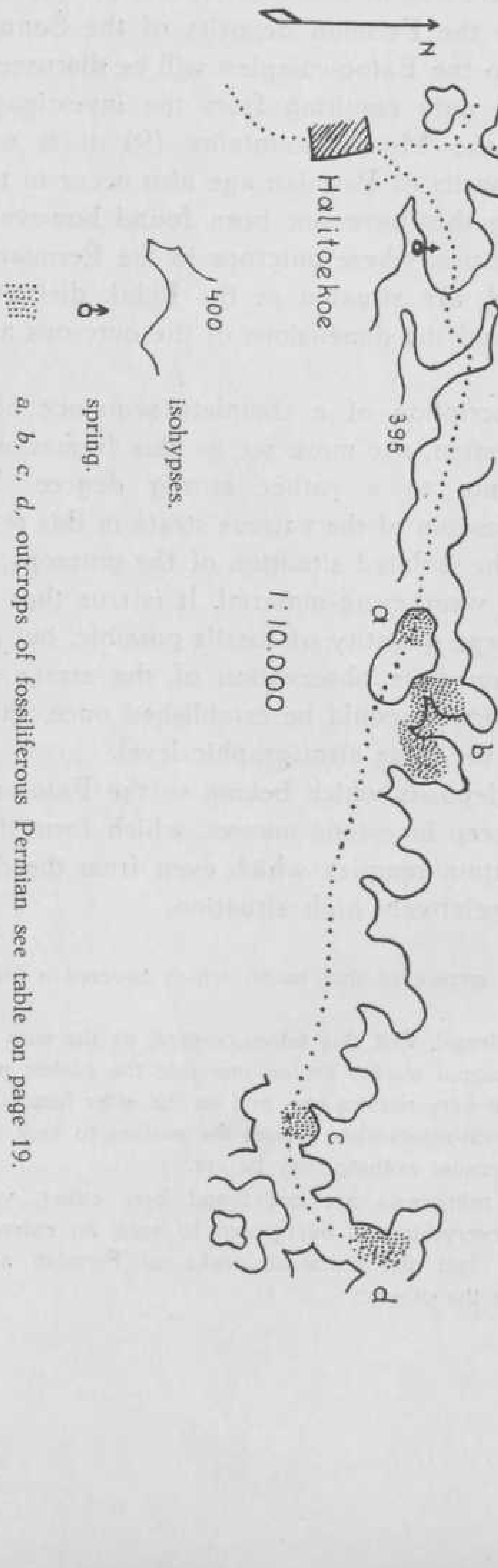
1) After the old empire of that name, which covered a large part of West- and Middle Timor.

2) It is not accidental, that this fatoe-complex, as the map shows, is more or less enclosed by the principal tracks, for on one side the easiest road is preferred to the somewhat shorter but very uneven one, and on the other hand the fact, that this region was made into a forest-reservation, causes the natives to look upon it more or less as a prohibited area, because nothing may be cut.

Though tropical rainforests are not found here either, yet the investigation is hampered because everything is overgrown to such an extent, that a general view is not possible. In fact the limestone rocks of Permian age seem to be mixed indiscriminately with the others.

a. The Permian of the Sonnebait-series.

The general character of these rocks shows a great similarity with that of the Permian of the well-known locality of Bitaoeni. It is usually a red or dark red to brown limestone, sometimes nearly pure, but often marly with much volcanic material. Beside large quantities of stem-ossicles of



a. b. c. d. outcrops of fossiliferous Permian see table on page 19.

Fig. 2.

Fossil localities near Halitoekoe (Lidak).

crinoids, among which an occasional calix is found, numerous cephalopods occur. Trilobite fragments were found too and moreover brachiopods, lamellibranchs, bryozoa and a few gastropods.

In the immediate vicinity of these fossiliferous Permian deposits basic, igneous rocks were usually found too, as in other parts of Timor. These rocks are often amygdaloidal; "pillow" structures may be observed locally.

The most E. locality (I) lies along a low ridge, which starts from Halitoekoe, runs in an E. direction and ends in the plain of Atamboea. In fact we are here concerned with four isolated outcrops, situated at small distances from each other (fig. 2). The rocks in question are red, sometimes slightly crystalline limestones full of columnals of crinoids; they were found at about 45 m E. of the spring and farther to the E. along the N. slope of the ridge, where beside stem-ossicles of crinoids, *Orthoceras*-fragments, corals, a few brachiopods and fragments of trilobites were also found in the desintegration product of these limestones.

Another group of two small outcrops lies S.W. of Halitoekoe near Haliren. Here too the red soil occurs with fragments of crinoidal limestone and some ammonites. (II)

In the gully due E. of this locality basic igneous rocks are again found, partly amygdaloidal, and at the base of the 2nd outcrop a conglomeratic bed was found, entirely built up of fragments of weathered, basic, igneous rocks, cemented with much calcareous material (fig. 3).

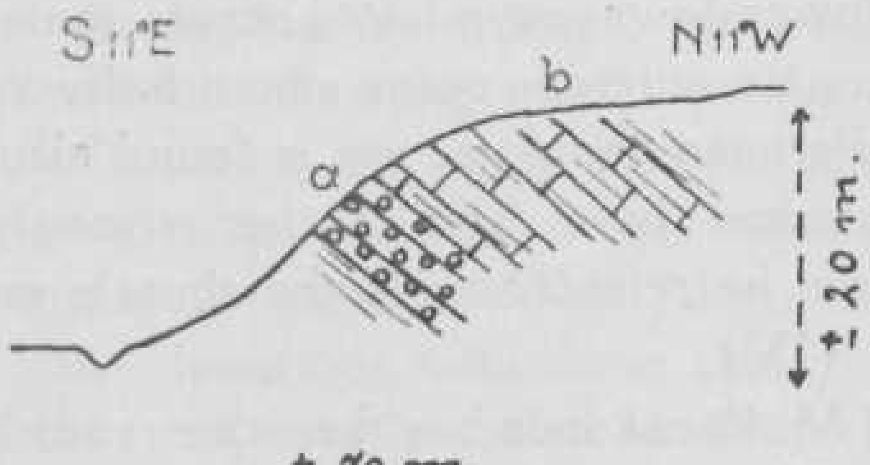


Fig. 3.

Detail of Permian near Haliren.

a. conglomerates rich in lime.

b. fossiliferous limestones and marls.

The locality Ai Té, W. of Halitoekoe, where a kampong is said to have been, has considerably larger dimensions than the preceding one. Across an area of about 125 × 200 m there are many fragments of the familiar red, marly limestone in its own desintegration material, so that the petrefacts have only to be taken up. (III)

Here too stem-ossicles of crinoids abound, occasionally a more or less damaged calix is found and beside many ammonites, bryozoa, corals, brachiopods and trilobite-fragments occur.

About the centre of this locality a hillock, where larger boulders are found, points to a fixed nucleus. As a matter of fact, it was possible to make out a certain degree of bedding there. Towards the margin of the outcrop the Permian becomes more and more mixed with all kinds of loose material, such as sandstone-fragments, basic, eruptive rocks and dense, lightly tinted limestones; in the two rivulets, which run E. and W. of this ridge, nothing can be observed at all on account of the covering

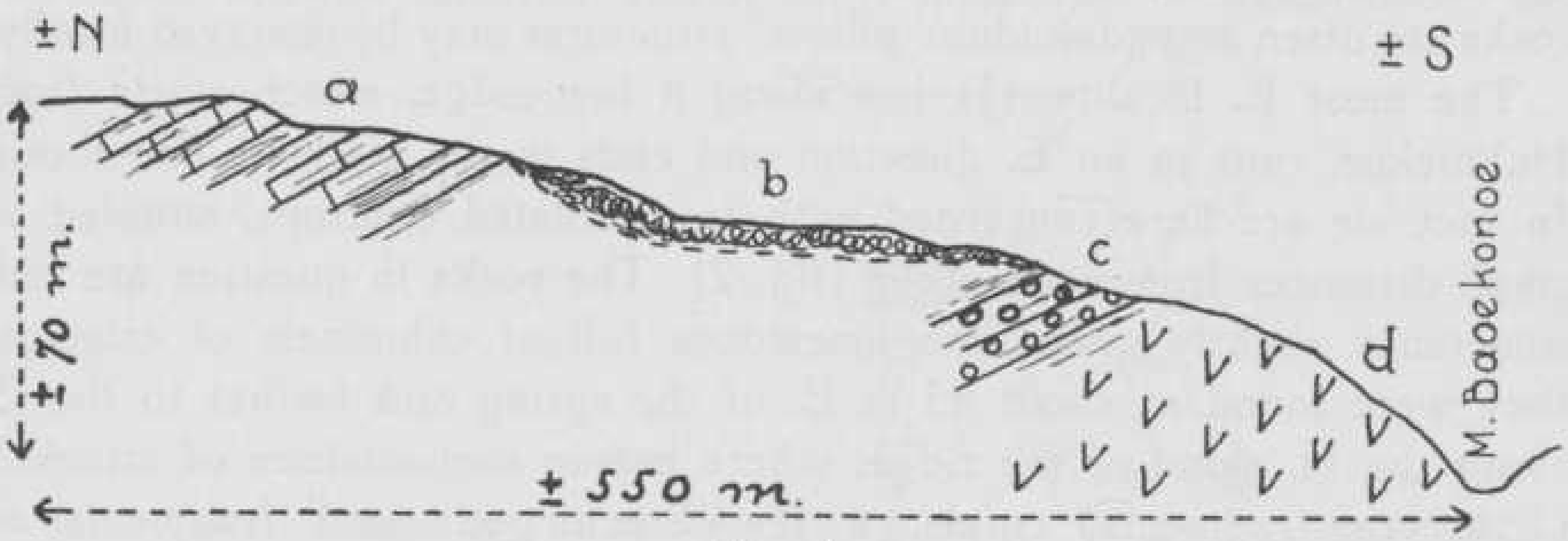


Fig. 4.

Section through Permian deposits W. of Halitoekoe.

a. red to brown fossiliferous limestones and marls.
b. young terrace deposits.
c. conglomerates, rich in lime.
d. amygdaloid with pillow structures.

detritus. On a lower level Permian conglomerate similar to that S.W. of Haliren was also found here and still lower down amygdaloid occurs again.

In the M. Baoekonoe too small Permian outcrops occur, about halfway between Weklosoen and Toebaten; Permian conglomerate is found also, however the deposits in these outcrops have been rather strongly influenced by pressure. This will again be referred to in the chapter on the structure of the explored region. (IV)

The Permian of the ridge S. of the M. Baoekonoe has the same reddish brown colour. It contains fewer columnals of crinoids, but more ammonites especially "brood". This brood sometimes builds up the entire rock, which then gets a white spotted appearance. *Orthoceras* and corals are also present. (V)

A further continuation of the zone of Permian rocks, which seems to run E.N.E. to W.S.W., is found in the M. Halilas. Strongly dynamically influenced, basic, igneous rocks occur here principally mixed with conglomerates and other sedimentary Permian, sometimes kneaded together. In the M. Wetaoe too, S. of its confluence with the M. Halilas these rocks are found across about 200 m, however once more in isolated outcrops, separated by younger terrace-deposits. (VI)

The Permian rocks which were found between Toebaten and Boeboerloelik and in the immediate neighbourhood of the last mentioned kampong, which itself was built on fossiliferous Permian, are of the same type as those near Ai Té. (VII)

N. of the zone described above, the Permian seems to form a second zone. The first two outcrops of this number lie S.W. of the Weklosoen kampong. Here too we are concerned with a red, more or less impure limestone with a beginning of recrystallisation. A difference with the outcrops, described so far, is formed however by the fact, that here only a large quantity of stem-ossicles of crinoids, sometimes of very large dimensions (Ø = 2 cm and more) was found, while there was not a trace of ammonites.

Farther W., somewhat S. of the F. Fohomalas, lies a group of Permian outcrops as well. The first of these runs from the small kampong of Babkaniem S.S.W. as far as the F. Toemoro. W. of it lies the spring We Alas, to the N. of which the Permian rocks appear over a pretty large surface.

W. of We Alas isolated patches of Permian rocks were also found a.o. once more the conglomerate of eruptive rock fragments, which is very much like the kind described above from the vicinity of Haliren, but much coarser and cemented here by *Lonsdaleia spec.* (16).

Near Babkaniem the rock is a brownish, semi-crystalline limestone, made impure by volcanic material, in which remnants of crinoids and brachiopods among which *Spirifer rajah* SALT. were found. Towards the F. Toemoro the rocks become more shaly; cherty limestone and even chert is found. These rocks are often crushed, and rolled out. This is also the case near We Alas, where the rock consists of a red brown, marly limestone with more cherty bands, in which remnants of crinoids occur and thickly scaled brachiopods, badly preserved owing to pressure, but in all probability belonging to the *Spirifer rajah* SALT. group. No trace of ammonites was found in this place either.

In general these rocks with their cherty character give the impression, that they were sedimented farther away from the land than the deposits from the neighbourhood of Halitoekoe, described above, which possess a more littoral-neritic character. It is true, that the conglomerate, found W. of We Alas, demonstrates, that littoral circumstances originally prevailed in this locality too.

N.W. of the fatoe-complex proper of Lidak, Permian rocks, approximately like the types described above, were also found. Finally in the M. Oboki there is a Permian outcrop across some distance in thick, light reddish brown beds of limestone with abundant columnals of crinoids and numerous brachiopods, among which *Martinia nucula* ROTHPLETZ. Ammonites are not found here.

In connection with what has been mentioned re the composition of the conglomerates that have been found, we must still mention, that about N.N.E. of the Lidak mountains, along the motorroad Atamboea-Atapoepoe over a distance of some km numerous eruptive rocks were found, most of them strongly pressed and weathered, which for the greater part may certainly be looked upon as of Permian age, because of Permian bryozoa, which were found in hardened tuffaceous to sandy and finely conglomeratic rocks from the above mentioned eruptive series.

Of the cephalopod-material, collected in the localities just mentioned (tabulated in the order in which they are mentioned) a tabular view is given on following page [1]).

As far as the number of species is concerned, it is possible, that during a quantitative investigation other species may still be added to those collected in 1937, but it seems hardly probable, that in this case the character of the fauna will be altered considerably. However allowance must be made for the fact, that the relations in the table inferred from the numbers of representatives of the various species, originating from different localities, can only give an impression of the real relations in this fauna. With respect to the badly represented species this impression will not deviate very much from reality in connection with what has been said above re the method of collecting, but as to the presence of the abundantly represented species, e.g. *Metalegoceras* [2]) the number which is mentioned, does not give the correct relation, as a selection was made in connection with the large quantity of individuals, and only the best specimens were taken. The prevalence of *Metalegoceras* is therefore much greater than is shown by the table. It may certainly be stated two or three times as great.

From the table it is evident, that here we are concerned with an ammonite fauna, entirely composed of the more primitive forms of Bitaoeni. The more developed forms of Bitaoeni such as *Medlicottia, Stacheoceras s. str., Popanoceras s. str., Adrianites* and the *Perrinites* with more strongly differentiated suture-elements, are entirely absent in the above

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[1]) Some points must be remembered. Firstly: the material in question was always (an occasional exception will be mentioned more precisely) collected under my own supervision, hence mystification by the natives was excluded. Secondly: though attempts were made to collect as many different species as possible, no time was available for quantitative exploiting in connection with the principal object of our activities.

[2]) *Metalegoceras sundaicum*, as meant by DE MAREZ OYENS (36).

	I				II	III	IV	V	VI	VII
	a	*b*	*c*	*d*						
Paralegoceras sundaicum HANIEL = *Metalegoceras* SCHINDEWOLF . . . . (45)	12	3	22	9	5	29	11	3	3	7
Paralegoceras pseudo-meneghinii HAN. = *Rhiphaeites* RUZENCEV . . . . . . (43)			1							
Pronorites timorensis HAN. = *Stenopronorites* SCHIND. . . . . (44)	1		3			2				
Propinacoceras simile HANIEL		1						1		
Nautilus wanneri HANIEL	1		1							
Marathonites gracilis SMITH = *Vidrioceras* BÖSE[1]) . . . . (1)			1							
Marathonites dieneri SMITH = *Martoceras* TOUM. . . . . (53)	1				1	8				2
Daraelites submeeki HANIEL		1								
Hyattoceras waageni SMITH = *Perrinites* BÖSE[2]) . . . . (1)			1							
Agathiceras sundaicum HANIEL	1					1	1	4		
Orthoceras spec. (s. l.)	*x*	*x*	*x*	*x*	*x*	*x*	*x*	*x*	*x*	*x*
Trilobites	*x*			*x*		*x*				

x = fragments.

mentioned Lidak-zone, hence we are compelled to compare these localities with the oldest zone of Bitaoeni.

A comparison with Somohole shows, that this Lidak-zone principally differs from it by the absence of the primitive genera *Eoasianites*, *Propopanoceras* and *Prosicanites*, while *Propinacoceras* and *Rhiphaeites* appear as new forms. Moreover in Lidak the genus *Metalegoceras*, which is considerably developed here, prevails, whereas in the locality of Somohole this genus plays only a subordinate part.

Among the fragments of trilobites found in Lidak there are some

[1]) Cf. also litt. (45).
[2]) Cf. also litt. (38).

very well preserved glabellas and other fragments of cephalons and pygidia, the first of which, according to a cursory identification, showed a striking similarity with that of *Phillipsia sicula* GEMM. and *Griffithides verrucosus* GEMM. (17) (15), curiously enough two forms, which, according to GHEYSELINCK, are recorded among the Sosio-fauna, but among that of Timor they have not been established so far. Concerning the last named form a confusion might be suggested with *Griffithides indicus* TESCH, if the glabellas in question did not show the identical, elongated transverse wrinkling, which GHEYSELINCK (p. 79) indicates as typical for *G. verrucosus* GEMM. Judging by the dimensions of the fragments, the specimens found in Timor, must have been considerably larger than the Sicilian forms.

Taking everything into consideration, it can only be said so far, that the Lidak-deposits are probably of the same age as the Artinskian of the Ural and the upper part of the Wichita-formation in N. Central Texas (30) (38). In connection with what was found in Lidak, it is not very probable, that a hiatus of any importance between Somohole and Bitaoeni (37) must be assumed.

In connection with the group of Permian outcrops in the vicinity of We Alas ten ammonites are interesting, which were brought to me shortly before I left for Koepang. In view of the approaching departure of the expedition there was no time to visit the locality, said to be at the S.W. foot of the F. Koekatoe, a mountain, consisting of eruptive rock, but the fact, that this species of ammonites had not yet been found in Lidak, was sufficiently interesting in itself to take them with us.

These ten ammonites, which at first sight showed great similarity, proved to belong to two genera, that of *Adrianites* and that of *Waagenoceras*, which latter even proved to provide a new species. They were studied by W. P. DE ROEVER, whose description is to be found in the palaeontological appendix.

b. The Permian of the Fatoe-complex.

The rocks of this unity are considerably different in appearance, habitus and the contents of their fossils from the Permian deposits of the Sonnebait-series, described above. While the Sonnebait-Permian rocks show a certain stratification and nearly always have a typical colour, running from red to brown, the Permian of the Fatoe-complex has a light colour, is massive and usually unstratified or badly so. Ammonites, which occur so frequently in the Sonnebait-series, are not found in the Permian rocks of the Fatoe-complex.

Characteristic is a compact, unstratified, white to light pink, coarsely crystalline limestone with many, often very large brachiopods, among which *Productus waageni* ROTHPLETZ, *Spirifer fasciger* KEYS. These rocks are partly built up of smaller and larger trochites, which give it its pink colour. When the crinoid-remnants prevail in the rocks, they cause the colour to become more reddish. Similar rocks are found in the Fatoe Kokoea near the spring E.N.E. of Sesekoi, which bears the same name, a rock complex with a naked, vertical wall on the east, running in an approximately N.-S. direction, which is 50 m high at a rough estimate.

The same rock forms a part of the Fatoe Nanait, one of the highest tops in Lidak and also between Sesekoi and Tala it was found in the Fatoe Koeak, where yellow tints were observed side by side with the reddish and white ones, probably a symptom of weathering. *Productus semireticulatus* MART. was also found here.

Further localities are the Fatoe Toekoenenoe and the Fatoe Fohomalas. The latter is isolated, fantastic in shape, and lies more towards the W. of the fatoe-complex proper on a lower level, and as if it had slid down from the company of the others. Here also occur some deviating types of rocks, viz. blacker kinds, which derive their darker tint from disseminated manganese ore, locally more accumulated in the rocks, and also types of a red colour. Together these rocks form the body of the Fohomalas, wound somewhat like a corkscrew.

Another variation was found along the S. and W. slopes of the Fatoe Nanait, viz. a limestone, which is also crystalline, it is true, and reddish with trochites and brachiopods (*Productus cancriniformis* TSCHERN.), but impure and sometimes finely conglomeratic by interspersed volcanic material.

III. TRIASSIC.

The Triassic is found in the same differing facies-types, as already described from other parts in Netherlands- and Portuguese Timor. We shall successively treat the deposits of the *Kekneno-series* [1]), those of the *Sonnebait-series* and those of the *Fatoe-complex*..

a. The Triassic of the Kekneno-series.

As we have remarked, when discussing the Permian, the possibility exists, that in this region too a part of this series is of Permian age, as in the neighbourhood of the Moetis-mountains Permian cephalopods were found in these deposits.

Generally these deposits show a great similarity with the series of rocks from the region between Moetis and Timaoe, mentioned by WANNER (55), which led him to use the term flyschfacies of the Upper-Trias.

In N.E. Netherlands Timor too we have apparently a very thick complex of strata, poor in fossils which, apart from variations on a small scale, shows great monotony, when taken as a whole. The predominating rock is a greyish green or brownish, mica-sandstone to greywacke, sometimes with more, then with less calcareous cement. Usually this rock is present in thick beds with many joints, here and there with a conglomerate layer, but it also occurs in thinner slabs, and then it is more fine-grained and of a pronounced limy character. Thin slabbed limestones, now and then with much sandy and/or argillaceous material, are intercalated, just as calcareous clay shales and shales, between which harder beds occur, containing much iron. Locally more clayey, to limy intercalations with badly preserved Halobiidae were found. Hence no definite age could be stated, except in general a Triassic one. Especially these last kinds of rocks cannot always be distinguished from similar ones of the Sonnebait-series. The essential difference between the two formations is however, that in the Kekneno-series sandstone prevails, owing to which the chiefly neritic-clastic character of this unity becomes

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[1]) Named after the highest top of the extensive region between the Mollo- and Moetis-mountains, which is built up of this formation; this series will be discussed more elaborately by W. P. DE ROEVER.

obvious, while in the Halobiidae-complex of the Sonnebait-series the slabby limestones and argillaceous, cherty limestones with shaly intercalations are entirely prevalent and on their side point to a deposition, farther from the land and in a deeper sea. However this does not prevent, that where the Kekneno-series with rocks containing Halobiidae and those of the same kind belonging to the Sonnebait-series, occur in each other's direct proximity, it is very difficult, if not impossible, to draw a sharp boundary between the two unities.

A more important point of difference is, that in the Kekneno-series *no eruptive rocks* occur, while in the Sonnebait-series they are found quite frequently. Special mention must be made of the Kekneno-sandstone, which was found in the wide valley of the M. Toebaten with its tributary rivers, about 1½ km down the river from Toebaten. Beside some conglomeratic strata, a great number of remnants of organisms was found there in the sandstone. These remnants are scaly; their significance could not be determined.

b. The Triassic of the Sonnebait-series.

1. *The rocks containing cephalopods.*

As early as 1909 WANNER (58) received information from a medical officer stationed at Koepang, concerning a locality of these deposits, where the river Manoemean, a branch of the Pono, crosses the path from Soefa to Hasfoeik. Natives, despatched by him for this purpose, brought samples with them containing Lower Triassic ammonites, which were described by WELTER (58) together with the specimens found by the MOLENGRAAFF-expedition from the neighbourhood of the Fatoe Toekoenenoe in Lidak.

The locality first mentioned does not belong to the district of Lidak, and as far as the second is concerned, owing to the institution of the forest-reservation, the local situation has changed completely. The bivouac Toekoenenoe ceased to exist long ago as well as the kampong of that name, while other kampongs, situated in the neighbourhood, have been moved or have disappeared. Hence it has not been possible to locate the deposits with Lower Triassic ammonites in the vicinity of the place, where according to the natives the kg Toekoenenoe used to lie; meanwhile they may have been completely concealed from the eye by the overgrowth.

It is true, that cephalopod bearing Triassic strata were found on the S.E. slope of the E. continuation of the Fatoe Manoeaman, close to

FACIES OF PERMIAN AN
IN N. E. NETHER

	KEKNENO-SERIES.		SON
TRIASSIC	↑ ? Predominating a grey-greenish or browny, mica-sandstone to greywacke, now less, then more calcareous, with some conglomeratic layers; besides limestones, and clay shales, calcareous shales and occasionally also siliceous limestones and shales, locally with badly preserved Halobiidae. ? ↓	Orange-red-brown limestones with more marly or dark brown, clayey parts, full of ammonites, a.o. *Xenodiscus, Meekoceras, Flemingites* and *Aspidites*. Locally manganese films occur. ↑ ?	M bl sh m w m lo bi ca
PERMIAN		Highly fossiliferous, slabby, red-brown limestones and marls (containing ammonites a.o. *Metalegoceras, Pronorites, Marathonites, Agathiceras,* other cephalopods and trilobites), conglomerates with calcareous cement and basic, effusive rocks. Locally more siliceous with chert-bands (no ammonites).	

AND TRIASSIC DEPOSITS, ERLANDS TIMOR.

	SONNEBAIT-SERIES.	FATOE-COMPLEX.
with aye a.o. nin- nan-	Multicoloured stratified or more slabby, calcareous clay-rocks, with interbedded blackish to dark ashcoloured and greenish shaly strata; also light coloured variegated, mostly finely crystalline, compact limestones with a conchoidal fracture, sometimes slightly marly, with chert-lumps and chertbanks; locally containing large quantities of Halobiidae; radiolaria also occur, sometimes causing the limestone to become siliceous. ? ↓	↑ ? Light coloured, usually beige to whitish, rarely more greyish, unstratified, compact limestones, mostly with oolitic structure which is blurred by an incipient recrystallisation (with corals).
red- arls *eta* *oni* alo- ates asic, ert-		Massive, unstratified, mostly white to light pink, occasionally also rather red or blackish coarsely crystalline limestones with many trochites and often brachiopods such as *Productus* and *Spirifer* (no ammonites); locally impure and granular to finely conglomeratic in consequence of interspersed volcanic material.

Berkase. Though it is only a small outcrop in this case and the situation of these layers is not very clear here, we may yet assume, that we have to do with rocks in situ, in view of the fact, that the same rock, though tectonically more strongly influenced, was found in the general direction of the strike more towards the W. somewhat S. of the Fatoe Kalitinloelik. They are orange-reddish-brown limestones, which show a beginning of recrystallisation, with more marly or dark brown clayey parts. The latter show clear traces of movement. Here and there manganese films may be noticed. The ammonites are often so close together, that hardly any room is left for the sediment proper, and the impression is given, that the rocks are entirely built up of cephalopods. They too show traces of being influenced by pressure; the shells are often bent or slightly telescoped. Next to ammonites some stem-ossicles of crinoids were found as well as fragments of *Orthoceras*.

We could identify here:

Xenodiscus lidacensis WELTER (1922)
,, cf. *rotula* WELTER (1922)
(=? *Pseudoflemingites rotuliformis*, SPATH 1934) (49)
,, cf. *lissarensis* DIENER (1897)
,, cf. *nivalis* DIENER (1909)
(= *Anakashmirites nivalis* SPATH 1934)
Meekoceras spec.
Flemingites cf. *rohilla* DIENER (1897)
,, *pulcher* WELTER
,, *guyerdetiformis* WELTER (1922)
(= *Euflemingites guyerdetiformis* (WELT.) SPATH 1934)
Owenites? egrediens WELTER (1922)
Aspidites cf. *evolvens* WAAGEN (1895)
(= *Clypeoceras evolvens* (WAAGEN) SPATH 1934)

Brachiopods and foraminifera were not found. Hence there is a rather great similarity with the material, described by WELTER, for which reason we can here suffice with a reference to his conclusions concerning age and resemblance to other localities in Timor.

The rock which was found S. of the Fatoe Kalitinloelik is undoubtedly identical with it. Locally even ammonites which have been entirely converted into calcite were found. However, as has been mentioned above, it was more strongly influenced by pressure, in consequence of which the recrystallisation has proceeded much further. Besides at different periods white calcite attached itself along cracks and fissures, and in a following stage was again kneaded with orange-red-brown limestone, so that locally a brown and white marbled rock was created [1]).

Therefore allowance must be made for the fact, that part of the other rocks in this region, also those of a different age, obtained a coarsely crystalline type, as it were by dynamo-metasomatic processes, so that at first sight the original rock is not recognized in it any longer.

2. *The rocks containing Halobiidae.*

In this region a distinction can be made between a predominating argillaceous development of these strata and a more limy one in the same way as KRUMBECK (25) did with the material, collected by the WANNER- and MOLENGRAAFF-expeditions. However in connection with the small size of the outcrops nothing can be stated with respect to their mutual relations. Moreover in the case first mentioned limestonebeds also occur, while shaly strata are by no means absent in the limy part of this series.

Roughly speaking rocks of this complex were especially found around the fatoe region of Lidak, but also in the centre of it, and in the region between the Fatoe Toekoenenoe and the Fatoe Nanait. Especially between the F. Toekoenenoe and the F. Manoeaman and in the continuation of that zone, towards the east as well as towards the west, these deposits were frequently found, and also towards the south of the mountain last mentioned, in the M. Baoekonoe and south of it with interruptions as far as Boeboerloelik. Basic igneous rocks were found in different places in this complex.

The clayey sequence usually shows variegated colours. They are principally light, yellow or purple-grey to grey or greenish, frequently also purple-reddish-brown to purple and brownish yellow, calcareous beds of clay-rocks, with interbedded blackish to dark ashcoloured and greenish shaly strata and occasionally a limestone-bed. Chert lumps occur as well as radiolaria, which sometimes cause the limestone to become siliceous. They are usually crossed by numerous cracks, often cemented again by calcite, which causes them to crumble down in angular pieces.

The limestone series is predominating of a light colour, usually beige or light grey, but also light violet, yellowish or greenish and occasionally slightly darker ashcoloured. They are often finely crystalline dense limestones with a conchoidal fracture, but granular crystalline limestones,

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[1]) The appearance of this rock may best be compared to that of "Saucisse de Boulogne".

with or without some argillaceous material are not rare either. They often contain lumps of chert in their own colours or alternate with slabs of chert and beds, as well as with calcareous shales. All these rocks often contain a large quantity of the thin shells of *Halobia, Daonella* or *Monotis*, nearly always arranged more or less parallel, which sometimes gives the rock a "feuilleté" character, then again are converted into a compact calcite mass. These extremely delicate shells are usually strongly pressed and crumbled, so that a complete specimen is hardly ever found, which makes identification extremely difficult.

Beside this fauna of lamellibranchs, which is monotonous but extremely rich in individuals, the above mentioned rocks contain radiolaria in varying quantities. These radiolaria are sometimes present in such large numbers, that together with an argillaceous and cherty substance they give the appearance of cherty limestones to rocks, otherwise built up of shells of Halobiidae. According to KRUMBECK (25) this is especially the case in the Karnian and Norian periods. The radiolaria have been badly preserved for the greater part; the internal part is recrystallised, hence structures can hardly ever be observed.

The chert level, mentioned above, (there may be several) gives a typical appearance to the country: over a large surface it is covered with fantastically formed angular fragments and waste of a rock which, at first sight, has nothing left in common with the glassy jellous chert from the limestone-complex. When treated with HCl, they do not show any trace of carbonate; their appearance is somewhat coarsely granular and completely opaque instead of smooth with a conchoidal fracture and more or less glassy like that of chert. That we are here nevertheless concerned with the chertlevel is proved by the nucleus of original chert, which still is to be observed in some pieces. This fact, as well as the strong infiltration with iron, which gives a yellowish brown colour to the rock, points to a weathering process as the most plausible explanation.

Beside the already mentioned clayey, limy and cherty rocks a greywacke-sandstone is found, usually in the neighbourhood of the *Monotis*-limestones, exactly like the sandstone of the Kekneno-series. However these sandstone intercalations are never very extensive, which does not prevent, that if the Kekneno-series also occurs in the same area, it is very difficult to draw a sharp boundary between the two unities in view of the possibility of tectonical complications.

Here and there a conglomeratic part, the components of which seem to originate from the same complex, was also found in this sandstone.

All the rocks, described above, are sometimes more, sometimes less intensively tectonically influenced, which usually becomes evident in a more or less intricate veining with calcite.

However, various of the multicoloured "earthslide-zones", where — in chiefly clayey, shaly disintegration masses — rolled and crushed limy and cherty fragments also occur, must be taken as very strongly tectonically influenced parts of the Halobiidae-complex.

Concerning the circumstances, under which these rocks were deposited, we refer to the elaborate considerations which KRUMBECK (25) devoted to them. The data, collected in this region in 1937 cannot shed a new light on this problem.

The age of these deposits was also subjected to an extensive analysis by KRUMBECK (25) at the hand of different representatives of the *Halobia, Daonella* and *Monotis* genera. His conclusion was: a *Ladinian* as well as a *Karnian-Norian* age.

In view of a *Pseudomonotis*, found in the outcrop at the S.W. foot of the F. Toekoenenoe, which most of all resembles KRUMBECK's pictures (27) of *Pseudomonotis* (*Claraia*) *subaurita*, a form of Skytian age, allowance must be made however for the possibility, that this complex also contains older deposits. In view of the fact, that among the deposits with flysch character some were found of Permian age (9) this is not improbable at all.

Except in the complex, described above, Halobiid-rocks were found in some other places. A purplish red, finely crystalline limestone of Under-Karnian age, full of shells of *Halobia styriaca* v. MOJS. from the neighbourhood of Korobaoe along the path from Wehor to Lidak and probably from the same locality as the specimen of the MOLENGRAAFF-expedition, mentioned by KRUMBECK (27), shows a type entirely different from the rocks described above. It probably belonged originally to the cephalopod limestone, though among the blocks in question no cephalopods were found.

An Upper-Karnian brownish red — partly blackish owing to manganese — finely crystalline limestone, with interbedded calcareous shales of the same colour, full of shells of *Halobia austriaca* v. MOJS., strongly influenced tectonically, found at some distance W. of km 292 on the motorroad to Atapoepoe, was not observed in the Halobiidae-complex proper. Where they belong stratigraphically, cannot be said with any certainty.

c. The Triassic of the Fatoe-complex.

Beside the fatoes of Permian age, already discussed, Triassic ones also occur in the limestone-complex of Lidak. In consequence of the overgrowth and the great quantity of detached limestone material, it is usually impossible to determine the relation of the fatoes to the surrounding and underlying rocks. Nearly the whole Lidak-region is fatoe or "fatoe-block-field".

Here the Triassic fatoes consist of lightly coloured, usually beige to whitish, rarely more greyish, compact limestones, which are usually unstratified, but in some places show a tendency to become coarsely bedded. The fresh fracture shows a beginning of recrystallisation, in consequence of which the characteristic oolitic structure, well-known from other parts of Timor is blurred. It is true, that locally oolites may be observed, but only after close observation and some searching. A coarser or finer brecciation often occurs; the rock is then veined with calcite.

A specific age could not be fixed for these limestones; corals (*Thecosmilia spec.*) occur, but on the whole these rocks are very poor in fossils, which does not prevent, that in view of the presence of similar rocks in other parts of Timor, to which a special age could be ascribed (25), we may assume, that here these deposits are also of an Upper-Triassic age (*Karnian, Norian*), while the possibility exists, that still younger deposits of this type are also present.

These rocks were found in various places in the fatoe-complex, a.o. W. of the Fatoe Toekoenenoe and the Faffi Noré, along and E. of the M. Oebaha, in the Fatoe Sakoe, the N. side of the F. Kakai, etc. etc.

The upper part of the F. Manoeaman also consists of these rocks as well as the S. part of its eastern extension. S. of the last named ridge it was still found as far as the Fatoe Oni. These limestones moreover form some smaller masses of rocks E. of the motorroad to Atapoepoe, N. of the F. Wemeko. They were also found as isolated boulders in the serpentine hills S. of Wehor, together with boulders of other rocks.

IV. YOUNGER MESOZOIC.

In the investigated area rocks occur of *Jurassic* as well as *Cretaceous* age.

Little can be said about those of Jurassic age. Deposits which with any certainty may be considered as Jurassic, were only found in one place, viz. in the We Koen, a left tributary of the M. Toebaten, which from a distance E. of the Kg. Toebaten leads up-stream in the direction of Boeboerloelik. In a strongly tectonically influenced zone, in which Triassic rocks occur too, a greyish rock was found, almost entirely composed of shellfragments of *Inoceramus*, with many light pink remains of echinoderms and some greenish, cherty inclusions. This rock may be placed in the *Oxford* period. It is interbedded with grey and reddish brown slabby, sandy limestones.

Of uncertain age, but most probably Jurassic or Lower Cretaceous are the rocks of the F. Maoepani, a fantastic mass of rocks formed by fluviatile erosion, situated at some distance S. of Wehor, which consists of greyish white, light green and red to pink limestones, alternating with chertbands full of radiolaria, which are red in the lower parts, but higher up exclusively green to white.

The whole is rolled out: the chertbands are more or less drawn out in lens-shaped fragments and full of cracks, along which recrystallisation of the quartz occurs and infiltration of calcite takes place.

To this same complex belong most probably the strongly folded strata of pink to red limestones with red chertbands, some hundred meters E. of the F. Wemeko. Here too the chertbands are mutilated and more or less drawn out lenticularly. The limestone which has become plastic under high pressure, has clearly moved in thin layers like the cards in a pack which is bent.

The mass of rocks of mostly light coloured limestones with chertbands S.S.E. of the F. Wemeko also seems to belong to the rocks that have just been described.

Along the motorroad to Atapoepoe, N.N.W. of the mountain Manoeba, rocks were found not only of Triassic age, but also deposits containing Globotruncanae, hence certainly of Upper Cretaceous age and besides several rocks, whose age could not be established and which may be partly

Jurassic, partly Cretaceous. In the neighbourhood of km 291 they are light red. compact limestones with brown, radiolarian chert, purple to pink, marly slabby limestones with somewhat redder, radiolarian chert, flesh-coloured-mixed-with-white chert containing foraminifera, among which *Globotruncana* cf. *linnei* (D'ORB.) are found, and besides thick, compact, white and mauve *Globigerina*-limestone with a more or less conchoidal fracture. Everything was influenced tectonically to a high degree; concerning the mutual relations of these rocks nothing can be said. However it is certain, that the flesh-coloured-white-chert is of Upper Cretaceous age, in view of the Globotruncanae it contains.

The age of the rocks in the neighbourhood of km 288—287 is once more uncertain; beside red, fine-grained radiolaria-rocks, compact red radiolarian chert with white spots, and greenish grey cherty-calcareous-radiolaria-rocks, thinly laminated, finely crystalline, violet limestones are found.

The age of a number of rocks which form the F. Manoeaman cannot be determined any more either. They are principally very light flesh-coloured to rather light-brickred, very fine, compact limestones with a conchoidal fracture and a peculiar indentation which is accentuated by films of reddish clay, with interbedded red-brown marly limestones, red to brown chert with radiolaria and a red-brown more or less granular rock which chiefly consists of radiolaria with some calcareous and argillaceous material. The compact fleshcoloured limestones, which contain some badly preserved organisms (probably foraminifera) strongly resemble the Biancone limestones from the Apennines and it is not impossible, that the complex of layers described just now, also belongs to the Cretaceous.

More details can be given about the Younger Cretaceous deposits, which are characterized by the well-known Globotruncana-fauna. THALMANN (52) and RENZ (39) have demonstrated during the last few years, that this fauna can be used with great certainty to establish an Upper-Cretaceous age. According to them *Globotruncana* and its species are autochthonic Upper-Cretaceous fossils; those found in Tertiary and Recent deposits are usually of an allochthonic character and a recent appearance of this genus has not been recorded. Moreover RENZ (39) succeeded by a close survey of the Cretaceous part of the Scaglia complex of the Central Apennines in dividing it into different zones, in connection with different *Globotruncana* species. Hence the following rocks are of Upper-Cretaceous age on the ground of the Globotruncana-fauna which they contain.

Light reddish, marly limestones, with little white, partly flattened, dense limestone fragments, with badly preserved Globigerinidae as well as some rolled out fragments of brown, greyish green or olive-green argillaceous rocks.

Microscopically seen this rock proves to contain Globotruncanae as well as numerous Globigerinidae. It was found in several localities, generally S., W. and N. of the Lidak fatoe-complex, viz. between the F. Oni and Halitoekoe, in the M. Baoekonoe, S.W. and N.W. of the F. Fohomalas, N.W. of Hofehan, in the M. Oebaha and in various other localities N. of the Lidak mountains.

Another rock largely built up of Globotruncanae, was found in a hill, conspicuous by a certain bedding, about S.W. of the F. Maoepani and E. of the F. Wemeko.

It is a finely conglomeratic, granular limestone, purple to brown, with more or less flattened brown and greenish fragments of clayey rocks. Microscopically this rock proves to contain a multitude of Globotruncanae, while some angular grains of quartz are also present beside fragments of dense limestone, chert with radiolaria and weathered, eruptive rock.

This rock is interbedded with beds of 4 to 5 m thick of a similar rock, which however is much more finely grained, less conglomeratic and has also a lighter colour. Besides with marly limestones of a somewhat purplish brown colour, which were clearly moved and evidently absorbed the forces to which the whole complex, which is strongly inclined, was submitted.

A similar rock as far as its number of Globotruncanae is concerned, was found directly S. of the W. spur of the serpentine rocks near Halitoekoe. However there the colour is not purplish brown, but beige, and it cannot exactly be said that it is conglomeratic, but it contains some inclusions of green, soft argillaceous rocks.

A rock, which was found between Obenani and Sesekoi is of an entirely different type. It is brownish and conglomeratic with many fragments (as large as about 2 cm) of brown, yellowish brown and greenish, weathered eruptive rocks and siliceous clay rocks. Most fragments are angular, some however more rounded off, and situated in a calcareous matrix, in which light beige oolite components occur. Higher up it passes into a reddish brown, finely conglomeratic rock of the same type as the preceding one, with a great many beige oolitic components. Microscopically it proves to consist of many fragments of weathered, eruptive rocks and cherty material in a groundmass of partly damaged oolites and rounded fragments of dense oolitic limestone, which show a striking resemblance with the beige oolitic limestones of the Triassic fatoes. Besides a considerable quantity of angular quartz grains occurs. In the calcareous cement and only there, many Globotruncanae were observed.

Finally we have to mention a light grey to beige finely conglomeratic limestone with fragments of a fine, dense limestone, weathered eruptive rocks and chert. Moreover some occasional oolites may be noticed and when the rock is moistened, Globotruncanae become visible in large quantities. Microscopically this rock too proves to contain numerous Globotruncanae, while a considerable number of angular quartz grains occur. Besides, some isolated oolites were observed, as well as fragments of dense oolitic limestone. This rock was found in various localities, a.o. in the serpentine hills near the Laisahé in larger and smaller boulders.

Concerning the age of these rocks, according to THALMANN (52) *Globotruncana* only attains a stronger development in the Cenomanian.

The oldest representatives of this genus were found in the Aptian of the Pyrenees; the greatest development is attained in the Senonian and especially in the Santonian, during which period *Globotruncana* nearly forms 100 % of the microforaminifera-fauna in Mexico. From the Upper-Senonian and especially in the Maestrichtian this genus disappeared rapidly and had entirely disappeared even prior to the sedimentation of the Danian.

In connection with this and with what is published so far about the Cretaceous in the E. part of the Indian Archipelago (42, 57) the flesh-coloured-white chert described above with a few Globotruncanae among which *Globotruncana* cf. *linnei* (D'ORB.) occurs, might be placed at the base of the Upper Cretaceous. The light reddish, marly limestones with a larger number of Globotruncanae might be a little younger, while the rocks with a multitude of Globotruncanae might belong to the Senonian.

As far as the last rocks are concerned, may be pointed out, that SCHUBERT (46) on account of rocks from the island of Letti containing Globotruncanae came to the conclusion, that similar rocks must be considered as deposits in quiet bays where large quantities of plankton are washed together.

V. YOUNGER DEPOSITS.

Deposits of Eocene age were nowhere found as solid rock in the investigated area. Only, in one place near the Fatoe Hai S.S.W. of Wehor a lump was found of an ash-coloured marly limestone with *Nummulites*. The Older Neogene was not found as solid rock anywhere either. However in different localities rocks containing Lepidocyclinae (20) were found in larger or smaller lumps, which very much resemble the finely conglomeratic light coloured Cretaceous rocks.

They are also finely conglomeratic, mostly beige limestones, sometimes multicoloured by the numerous components of various colours. The rock principally consists of numerous rounded fragments of coarsely and finely oolitic, beige limestone and other dense limestones, while a great many isolated, often damaged, larger oolites also occur. In this calcareous mass rounded fragments of strongly weathered, igneous rocks, sometimes rich in quartz, usually angular pieces of chert and rather large grains of quartz, sometimes more or less rounded off, occur.

Only deposits, which can be considered as belonging to *Upper Miocene* and/or *Pliocene* with a tolerable degree of probability were found in situ in various localities; in the Batoepoetih region and between that district and F. Kabélak they have an extensive distribution, just as in the vicinity of Pante Makasar in the Portuguese enclave of Oeikoesi.

Pretty pure organic limestones, as well as decidedly siliceous volcanic tuffs occur, and between these two extremes there are countless transitions. Even in the organic limestones of the purest type some volcanic material is always present, mostly in the form of fine isotropic fibres of glass, but ash-particles and interspersed mineral fragments are also present, which will be referred to below.

The rock which builds up the most E. part of Cape Batoepoetih proper, is a pretty soft, very porous chalk, which comes off white. The numerous Globigerinidae, which the rock contains are visible in the shape of small, milky white globules. It contains many small inclusions of light beige, very fine clay, and is interbedded with thin, somewhat harder, beds of a clayey, marly substance. The W. part of this steep wall, which is about 50 m high and faces the sea, also consists of a similar rock. The strata lie horizontally in the E. part; in the W. part they have a slight inclination, about 3° to 4° to the west. On the seaside at the foot of the precipitous wall, large blocks were found of a coarsely conglomeratic rock, a younger deposit of boulders, which lies like a terrace, about 10 m thick, on the white organic limestones. The boulders principally consist of dense limestones and the whole is cemented together by calcareous material. A dip of this conglomeratic bed was not observed.

The rocks, gathered on the isolated hill about S.W. of Batoepoetih are much more compact. In these too the Globigerinidae can be detected by means of a magnifying glass.

Even more compact is the rock (*a.* of fig. 5) (*b.* of fig. 6) with a somewhat conchoidal fracture, with Globigerinidae of the Hill-complex Haoe Roenat, situated between Batoepoetih and F. Kabélak.

In this complex of hills can be observed how the young, white rocks are resting with a horizontal stratification on a foundation of the glass-encrusted rocks. In connection with the uneven surface of these glass-encrusted rocks the boundary between the two rocks lies on the W. side at a height of about 70 m and on the N. side 20 m higher (see fig. 5). The flat top lies at about 130 m above the level of the sea, consequently these young limestones have a

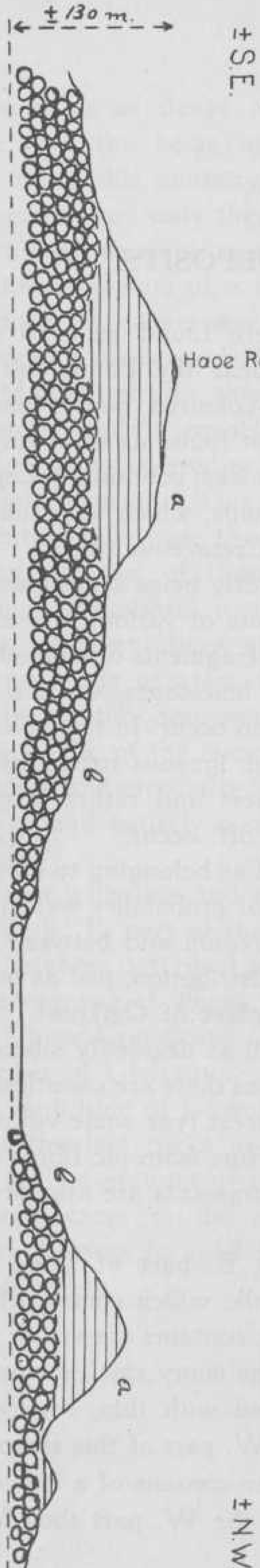

Fig. 5.
Section through the ranges between Batoepoetih and F. Kabélak.
a. limestones and marls with Globigerinidae, Radiolaria and Diatoms.
b. pillow lavas.

thickness of about 60 m in this locality. A basal conglomerate was not observed. In the ridge of hills N. of the path Batoepoetih —F. Kabélak the boundary between the two rocks on the S. side lies at about 50 m; on the seaside however about 25 m high. The highest part of this ridge is situated at about 100 m above sea-level. (Fig. 5.)

The rocks c., of fig. 6 are sandy and more or less stratified, in consequence of the large quantity of volcanic material. Very dense,

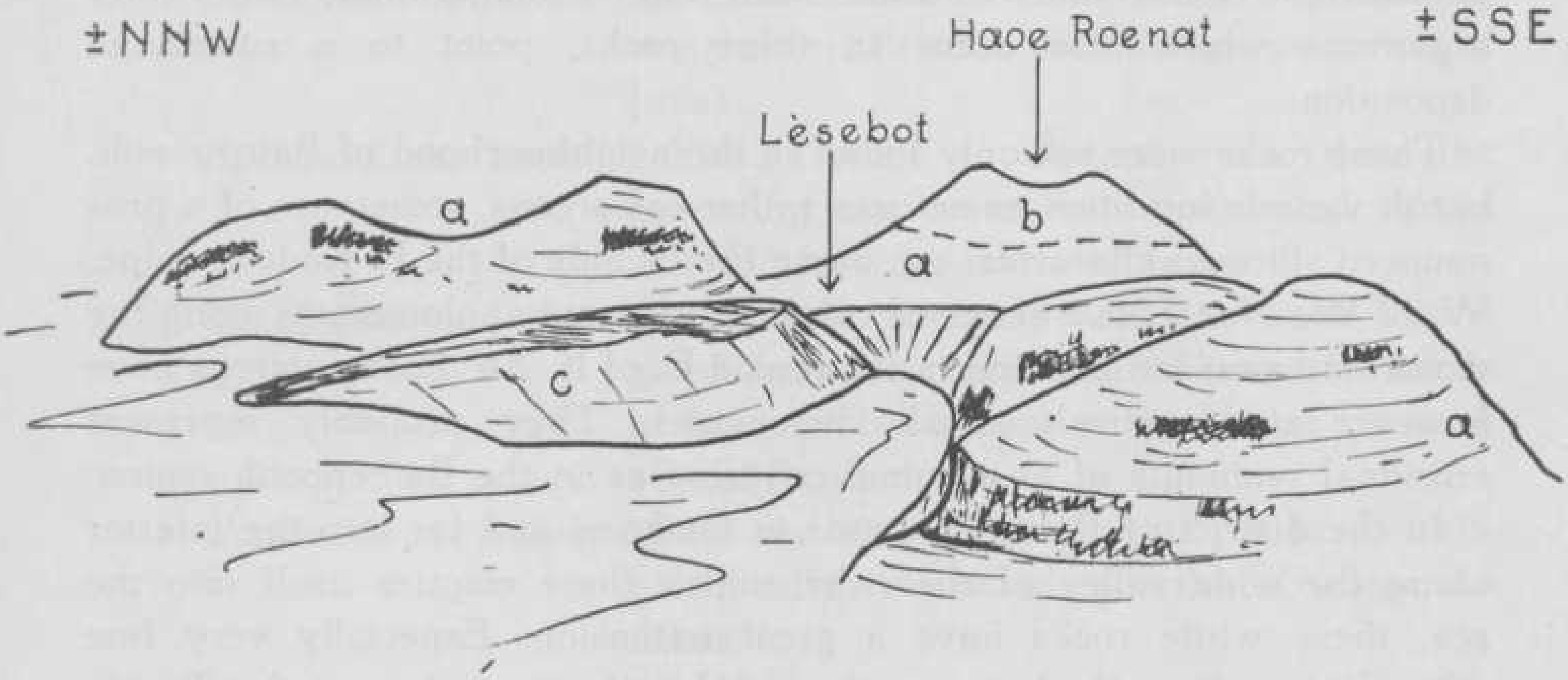

Fig. 6.

View in the neighbourhood of Lesebot.

a. = pillow lavas.
b. = limestones and marls with Globigerinidae, Radiolaria and Diatoms.
c. = sandy, tuffaceous rocks.

hard, brownish white limestones with incipient "Karren" formation were found in a hill between Lèsebot and Halimanèëk. A large number of lamellibranchs and gastropods were found, distributed on this hill, which according to Dr. VAN REGTEREN ALTENA all proved to belong to recent species. This points to foodremnants, left behind by the inhabitants of a former kampong, which is also indicated by fragments of crockery. The hill about S.S.E. of this locality, which, with its top at about 140 m above sea-level, constitutes the highest point of the neighbourhood, again consists of *Globigerina*-limestone, which crumbles down in fantastic lumps.

Under the microscope these rocks principally show (the sandy ones are left out of account here) a dense and somewhat marly matrix, which when strongly magnified (300—500 ×) proves to consist for the greater part of fine calcite grains, which with fine, isotropic glass-particles, often showing lines resembling the cleavage of mica, form a thick fabric, in which here and there an occasional fragment of quartz, feldspars or ferro-magnesian minerals occur. Calcosphaerolites, coccolites, discoasters, (50) sponge-needles, radiolaria, and also diatoms occur. Of the foraminifera the Globigerinidae predominate while Pulvulinae also occur pretty frequently.

The sandy limestones correspond to the rocks, described just now, but they contain much more volcanic material in the shape of angular fragments of quartz, feldspars, ferro-magnesian minerals and also particles of isotropic glass and volcanic ash. The Globigerinidae and other organisms which also occur in these rocks, point to a submarine deposition.

These rocks were not only found in the neighbourhood of Batoepoetih, but in various localities, sometimes rather calcareous, sometimes of a pronounced siliceous character, e.g. along the N. side of the F. Kadoea-ridge, W. of We Noeoe, in a series of volcanic tuffs and agglomerates along the motorroad near km 290 and in the region E. of it. All those outcrops have however comparatively small dimensions. They probably represent erosional remnants of an original covering as in the Batoepoetih-region.

In the district of Pante Makasar in Oeikoesi and far into the interior along the wide valley of the river, which there empties itself into the sea, these white rocks have a great extension. Especially very fine siliceous, sandy and also coarse-grained tuffs occur frequently. Beside these however, beds were found of a hard, compact, white to light pink limestone with a somewhat conchoidal fracture and many manganese-dendrites and mangenese films along cracks.

From the hill F. Soeba behind the old fortification of Pante Makasar there is a good view of the coastal area. Here these white rocks occur once more together with the glass-encrusted rocks, on top of the latter.

In the level coastal region they have a slight inclination towards the sea, which increases to 20° N.W. towards the lava-hills. Often these white rocks have a black surface in consequence of a thin film of desiccated vegetation, but from place to place, parallel with the stratification-planes a white colour may also be seen, which makes the impression from a distance, that white rocks alternate with black ones.

After an investigation of the diatoms in the rock (S 134), from the Haoe Roenat hillcomplex in the district of Batoepoetih, collected immediately above the glass-encrusted rocks, Dr. TH. REINHOLD was kind enough to give me the following particulars:

> "These diatoms have been preserved very badly; they are mostly recrystallised and moreover distorted.

However the following forms are still recognizable:

Actinoptychus aster, BRUN, known from the Upper Miocene of Japan and from the *Globigerina* marls of Java.

Cestodiscus peplum, BRUN, known from the Neogene of different localities e.g. Trinidad, Spain, etc. also from the *Globigerina* marls of Java.

Coscinodiscus excentricus EHR. Eocene to Recent, occurs abundantly everywhere, (also in the *Globigerina* marls of Java).

Coscinodiscus lineatus EHR. Eocene to Recent, rarer than the preceding one; extensively distributed also in the *Globigerina* marls of Java.

Coscinodiscus vetustissimus, PANT. var. *javanicus* REINHOLD, stratigraphically restricted to the *Globigerina* marls of Java; probably also in the Under Pliocene of California.

Coscinodiscus radiatus EHR, var. *nodulifer* REINHOLD, in Java stratigraphically restricted to the *Globigerina* marls.

Hemidiscus cuneiformis, WALL (var. *nivea* HANNA and GRANT) known from the Miocene of California and from the *Globigerina* marls of Java.

Synedra formosa, HANTZSCH. var., Young Neogene of Java.

Moreover in this rock radiolaria occur of which it is not certain, whether they have any stratigraphical importance.

Besides a siliceous sponge occurs, *Erylus mamilaris,* OSC. SCHM., which occurs frequently in the lower part of the *Globigerina* marls of Java and in the Miocene, situated below; also in the Oligocene? of New-Zealand.

These fossils lead to the conclusion, that the rock must be considered as *the equivalent* of the *Globigerina* marls of Java, which are classified by various authors, either in the Upper Miocene, or in the Lower Pliocene, but in any case in the young Neogene.

The species which were found (*Synedra* perhaps excepted) might point to a pelagic facies, but the small number of species — exactly the strongest have been preserved — points to a destructive selection, which makes an inference with respect to the facies uncertain."

VI. THE IGNEOUS ROCKS.

a. Permian and Mesozoic.

Extensive petrographical descriptions have been given by WICHMANN (59), BROUWER (2) and IMDAHL (23). WANNER (55), MOLENGRAAFF (34) and BURCK (11) stated, that various effusives and tuffs are of a Permian age, and in the district discussed here the presence of different diabases and amygdaloidal rocks of a Permian age could be established also. E.g. in the complex of igneous rocks which extends along the motorroad to Atapoepoe, from the mountain Manoeba to the plain of Atamboea, tuffs and finely conglomeratic rocks also occur, the Permian age of which is proved by bryozoa, which have been identified as *Fenestella spec.* (fig. 7).

In other localities in Lidak basic eruptive rocks also occur together

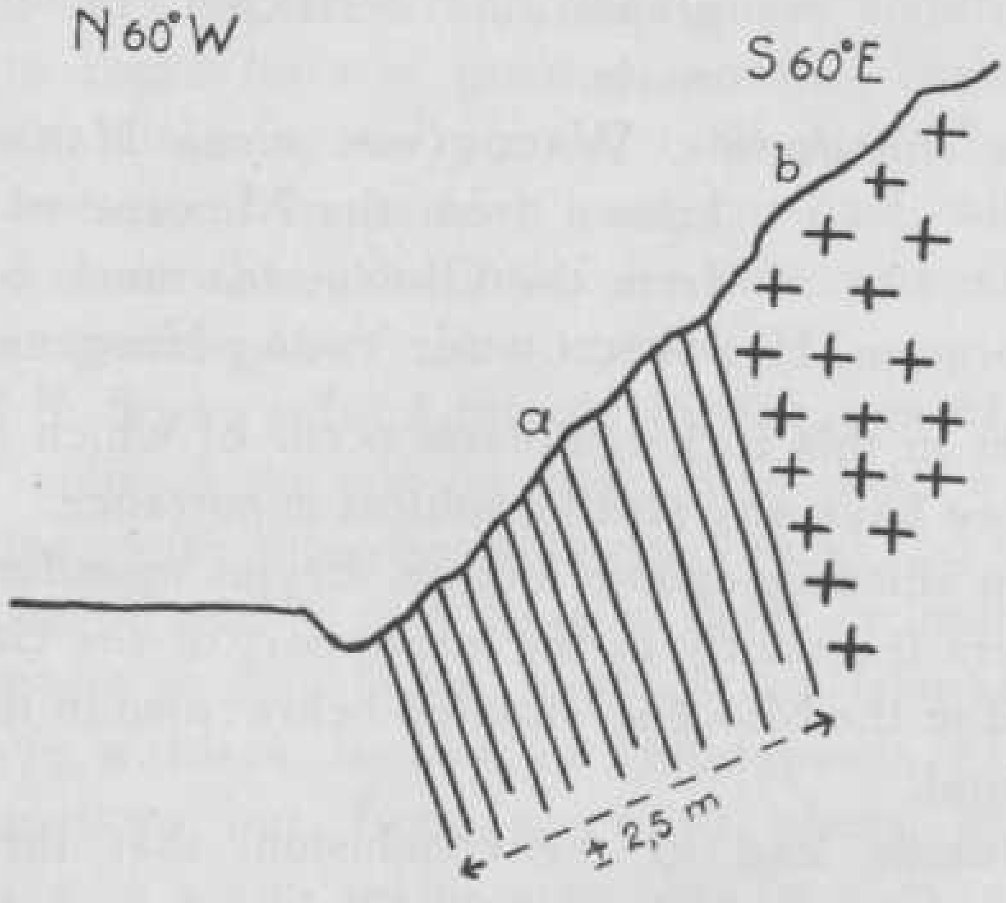

Fig. 7.

Detail of Permian deposits near km 286 on the motorroad to Atapoepoe.

a. sandy tuffs and finely conglomeratic rocks.

b. weathered, basic eruptive rock.

with Permian sediments containing ammonites. They are mostly amygdaloidal and usually strongly altered. The infillings of the cavities consist of calcite.

Occasionally pillow structures can be distinctly observed, e.g. in the

M. Baoekonoe S.W. of Halitoekoe, where between each two pillows a red finely crystalline limestone was found. There is not a trace of a glassy crust with these rocks.

Igneous rocks also occur in the Mesozoic, except in the Kekneno-series. Some of these apparently belong to the rocks containing Halobiidae and are therefore probably of a Triassic age. Others were looked upon by BROUWER (4) as decidedly post-Triassic. Among this group of rocks augite-diabases, andesitic to basaltic rocks and also trachytes were found, a description of which will be given below. In the field no definite age could be established, but probably the rocks, last mentioned, are of Permian age (7).

b. Serpentine rocks.

The serpentine rocks cover extensive areas in the investigated districts. Nearly the entire coastal range, from some km N.E. of Atapoepoe as far as the neighbourhood of Maoebesi in Harnenno is composed of them and also more into the interior this rock is found in several places.

In 1873 JONKER (24) gave some particulars respecting the conditions in which these rocks occur.

WICHMANN (59) described serpentine rocks from the surroundings of Atapoepoe; VERBEEK (54) and BROUWER (2) also described similar rocks afterwards.

A first inspection gives the impression that there are two types of serpentine rocks, a "conglomeratic" kind and a non-conglomeratic one, but a closer investigation shows, that there is a much greater diversity. The "conglomerate" is very irregular and contains fragments with a section of some cm to some dm. Occasionally these fragments are strongly rounded off, as in the case of a genuine conglomerate, but mostly they have a more or less angular shape. The cement is always serpentine too. However it usually shows another structure than the "inclusions" and is apparently more subject to weathering, hence the "inclusions" become more conspicuous and give to the rock its "conglomeratic" appearance. Sometimes a fresh fracture shows, how the "inclusions" are surrounded by a zone of crushed serpentine material, from which by means of transitions may be seen, that originally it was identical with that of the "inclusions". However "conglomeratic" rocks in which not the slightest similarity can be detected between the serpentine of the "inclusions" and that of the matrix, also occur. Fragments of the most diversified types of serpentine rocks are then enclosed in completely pulverised serpentine material.

Among the apparently compact serpentine rocks genuine breccias and even entirely mylonitised rocks prove to be present. As such they are not always conspicuous, because the "conglomeratic" character is absent, which absence is probably due to a slighter difference in resistance to weathering of "inclusions" and cement. A fine specimen of this may be seen at the N. point of the F. Loeka along the motorroad a little outside Atapoepoe. In the naked wall of serpentine rock, which is 15 to 20 m high, apparently compact parts form a marked contrast with the surrounding highly "conglomeratic" serpentine rock. At a closer inspection however these too are brecciated (cf. fig. 8 and 9).

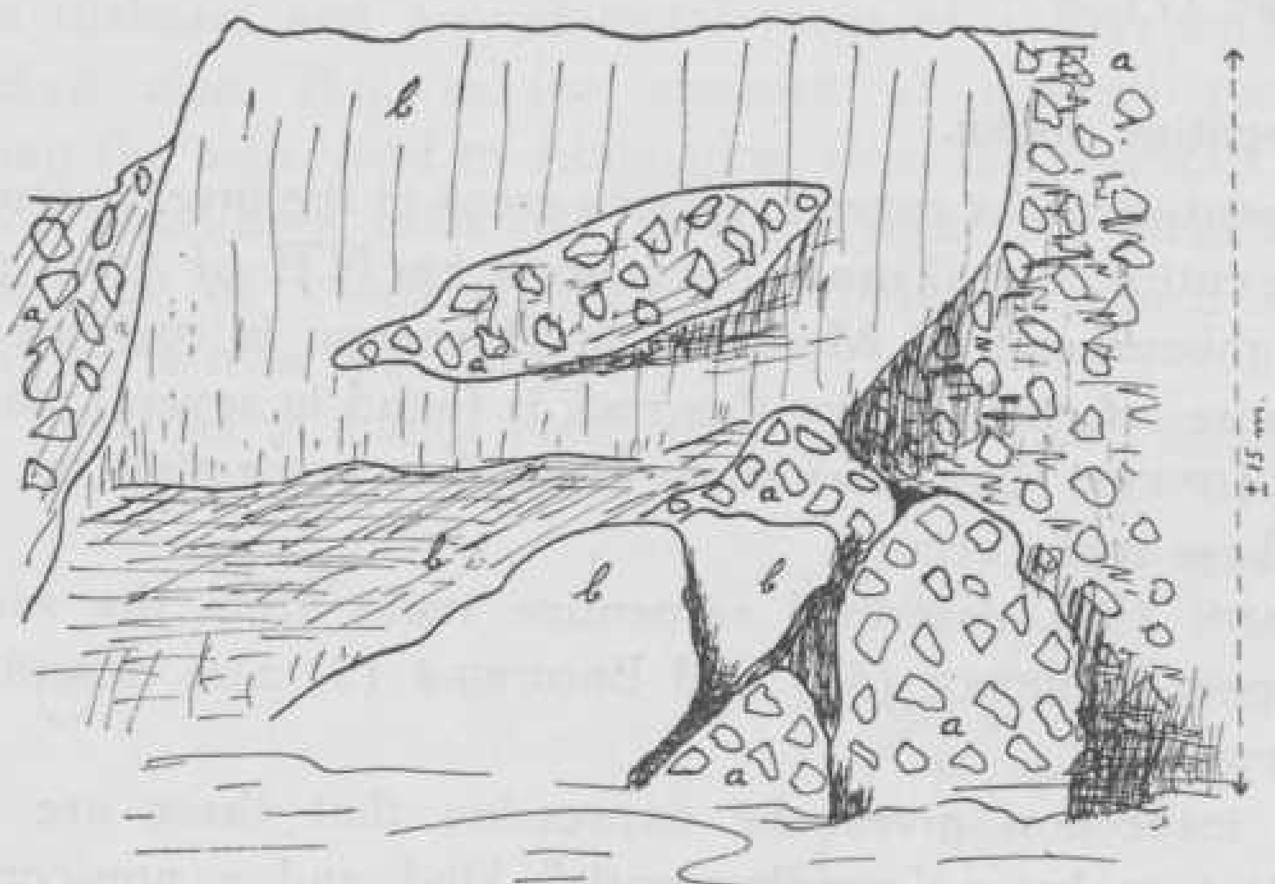

Fig. 8.

Fatoe Loeka, near Atapoepoe.

a. "conglomeratic" serpentine rocks.

b. apparently not "conglomeratic" serpentine rocks.

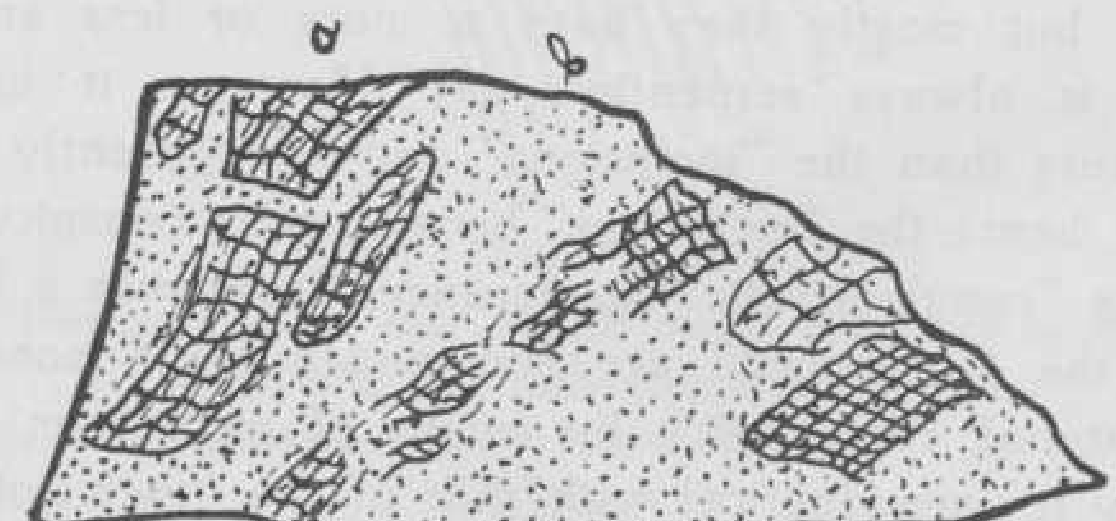

Fig. 9.

Detail of the parts marked with b in fig. 8.

a. fragments of serpentine rock, drawn out, but still showing a distinct pattern.

b. completely pulverised serpentine material.

Another type, which I look upon as a genuine mylonite, was collected from the left wall of the We Soemak valley, near the little cascade. It is a compact rock, which however has a peculiar appearance for a serpentine rock; it has a light greenish colour and is quite dull. At a more careful investigation it appears, to consist of a dense fabric of fine serpentine fibres, cemented by fully pulverised serpentine material. Locally some so-called "eyes" were observed consisting of harder parts. Considered as a whole it is a typical rock for a zone of strong movements.

Next to these peculiar kinds of serpentine rocks normal types, which are connected with the above mentioned rocks by various transitions, were also found. Their colours have different shades of greyish green or olive-green to darkbrown or bluish-black-green. Often tiny glittering, black crystals of chromite may be noticed and in many rocks the schillerisation of bastite is noticeable. Sometimes fine veins of ore form a kind of network in the serpentine mass.

These more normal serpentine rocks nearly always show traces of strong tectonical influence too. They are coarsely or finely laminated and are intersected in all directions by gliding planes. Phenomena as described above were mentioned from Celebes by BROUWER (8). Concerning the origin of these masses of serpentine rock, WICHMANN (59) was of opinion, that they originated from dunites. VERBEEK (54) mentioned however partly serpentinised peridotite from this region as well and BROUWER (2) also described serpentine rocks, which owe their existence to an original olivine-pyroxene mixture. The factors, which play a part in the serpentinisation process and the circumstances, under which this transformation takes place have long formed a serious point of contention and continue to do so to a certain extent.

In the last few years however various authors (13, 21, 29) have come to the conclusion that large masses of serpentine rocks can only be formed by autometamorphosis of peridotites.

Relations to other rocks. Many investigators (3, 24, 54, 60) have so far published their views about the probable age of these serpentine rocks.

The strongly tectonical influence, to which these rocks have been subjected according to the foregoing, combined with observations which will be discussed afterwards, make it very likely that the contact with their surroundings is of a tectonical nature.

So, if they occur once in a while together with sedimentary deposits of an established age, no conclusion concerning the age of the serpentine rocks can be made. Respecting the phenomena, observed by JONKER

(24) and by the MOLENGRAAFF-expedition (3) in the coastal region of Atapoepoe, which were ascribed to contact metamorphic effects of the serpentine rocks, the same objections obtain as RITTMANN (41) raised against the "contact"-phenomena (silicification) which RUTTEN and HOTZ thought, they had detected in sediments adjoining serpentine rocks in the islands of Kellang and Manipa. For according to him this silicification, which phenomena corresponds entirely with that, described by JONKER (24), must be ascribed not so much to contact-effects as to an infiltration of colloidal SiO_2, which may be formed during the weathering of serpentine rocks.

So even now we cannot fix a definite age for the serpentine rocks. The possibility concerning their age may however be restricted to a certain extent. They are undoubtedly older than the glass-encrusted rocks of the F. Kadoea, which do not show traces of such an intensive tectonical influencing as the serpentine rocks. Moreover owing to their mylonitic character these rocks must have been present as early as the great overthrust-movements.

c. Tertiary.

1. The glass-encrusted rocks.

Samples of these rocks were collected by MACKLOT (59), JONKER (24) mentioned them too, and added a number of particulars concerning the characteristics of this "volcanic conglomerate". Elaborate descriptions were afterwards given by WICHMANN (59), VERBEEK (54) and BROUWER (2), consequently a general description will suffice here.

They are basaltic to andesitic rocks with a grey to ashcoloured groundmass, in which here and there an occasional tiny plagioclase phenocryst may be detected. In the groundmass small and somewhat larger cavities occur, entirely or partly filled with a secondary substance of a lighter colour.

The fragments of medium size often have retained part of their glassy crust, a lustrous, black obsidian (about 0.5 cm thick), which exfoliates when struck with a hammer. In consequence of this property many of the larger fragments have a more or less rounded shape and the presence of fragments without any hyaline crust is explained thereby. They are enclosed in a mass of smaller fragments, among which pieces of obsidian also occur, cemented by a whitish or greyish material, and thus make the impression, that they are conglomeratic.

On the strength of comparisons with similar phenomena in other districts BROUWER (2) came to the conclusion, that for the Fatoe

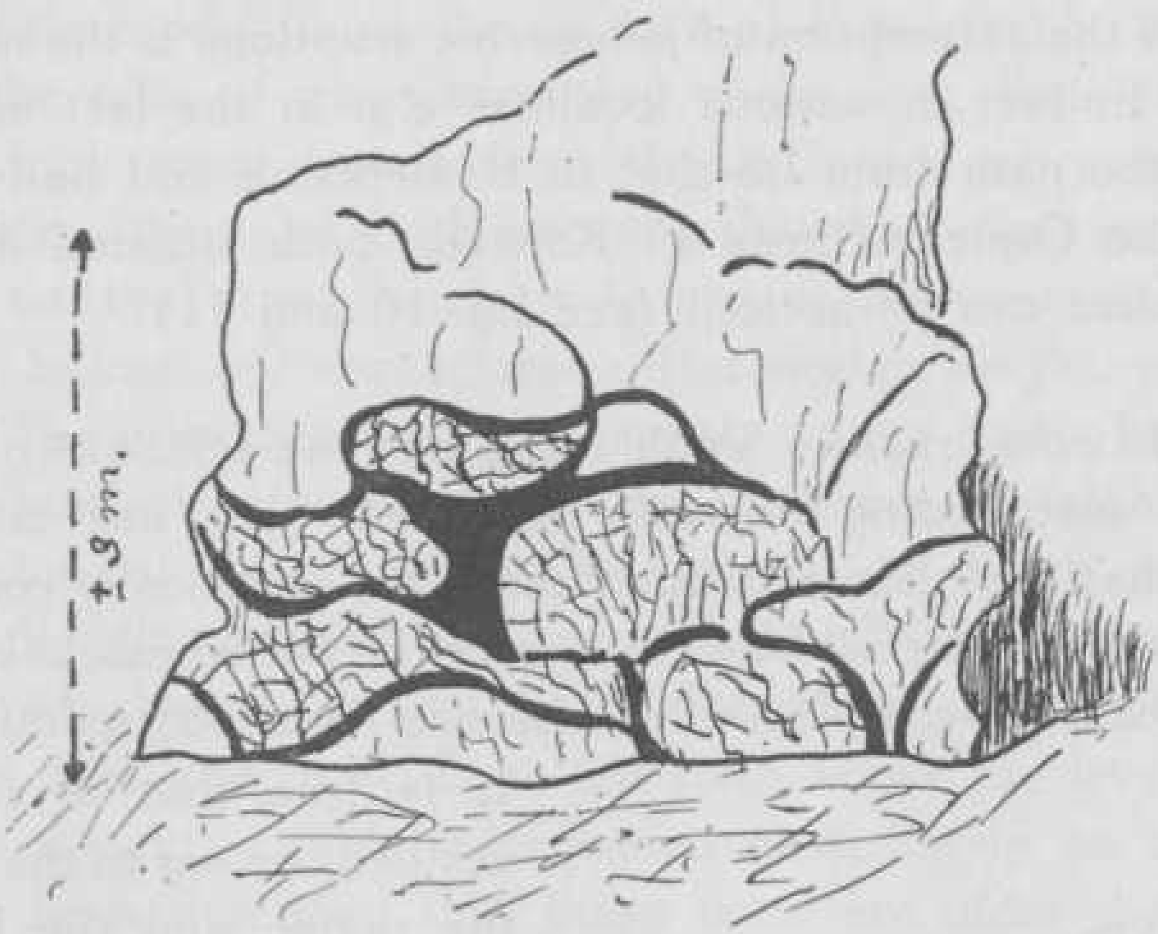

Fig. 10.

Pillow-structures in lavas near Lèsebot (Harnenno).

The black zones represent the hyaline parts.

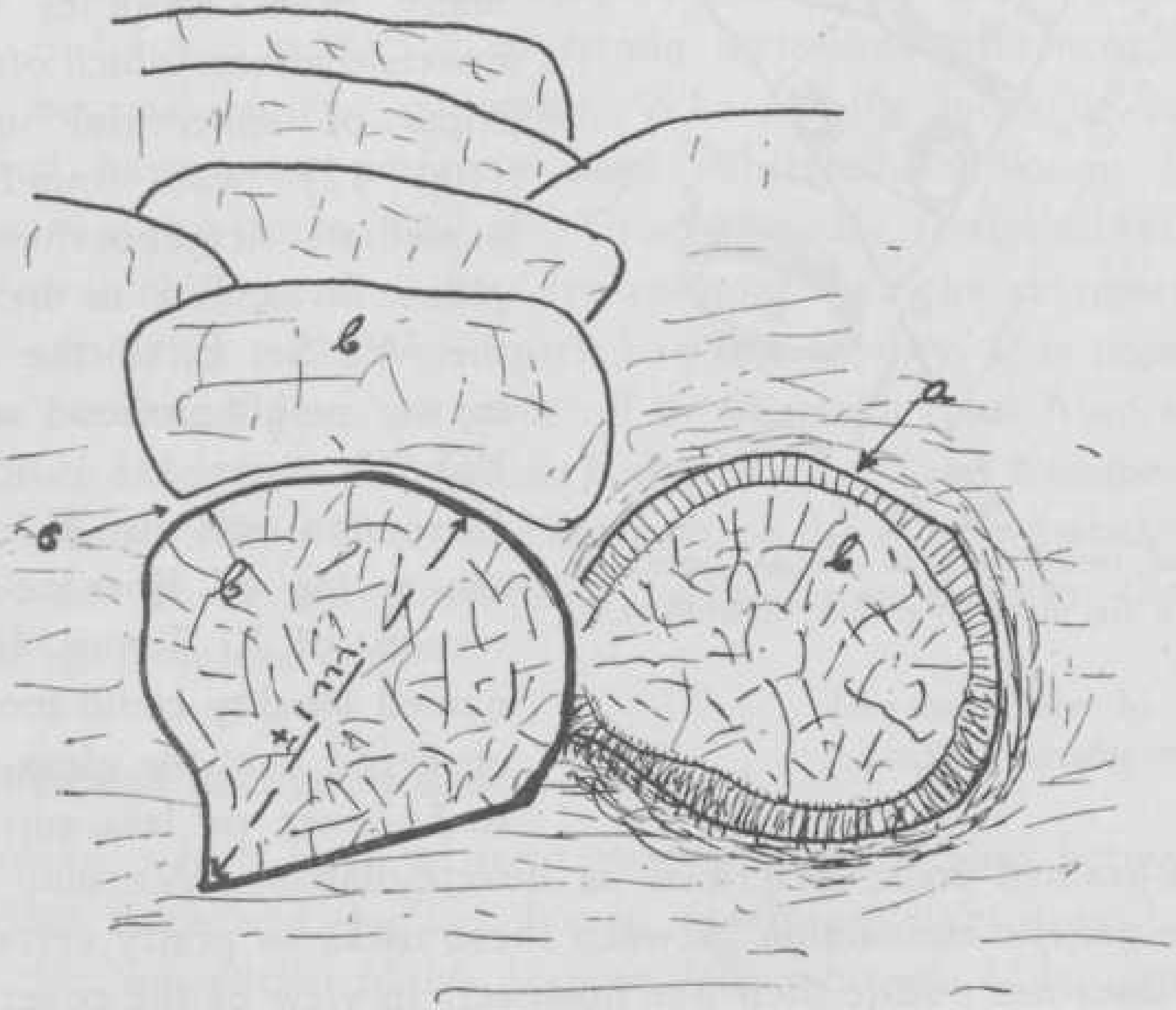

Fig. 11.

Pillow-structures in the W. part of the Oipiekan (Harnenno), some distance below the top.

a. hyaline crust.

b. irregularly fractured lava.

c. zone of yellowish weathered material.

Kadoea-rocks the assumption of submarine eruptions is the most plausible explanation. In fact in various localities e.g. in the last mass of these rocks along the path from Lèsebot to Batoepoetih and halfway towards the top of the Oipiekan near F. Kabélak, both situated in Harnenno, pillow-structures can be noticed (see fig. 10 and 11).

Relations to other rocks. With respect to the relations of these rocks towards the surrounding deposits, BROUWER (2) has mentioned the probability, that the glass-encrusted rocks are genetically connected with the rock near the waterfall We Ro, where the M. Manoekakai leaves the F.-Kadoea-Oehawai-complex, which he has described as quartz-diabase. It is true that it could not be verified, owing to the steepness of the ravine and the large masses of detritus of the pillow lava, which builds up the higher part of this mountain-complex, but in many other localities the same quartz-diabase, which often shows signs of spheroidal weathering (fig. 12) was found in the immediate neighbourhood of the pillow lavas. E.g. in the ravine of the We Se, E. of the Oehawai, in the neighbourhood of Kg. F. Kabélak near the Oipiekan in Harnenno, and also E. of it, near the spring of Boentoeka in the vicinity of Ai Toean. In the last named locality could moreover be observed, that the glass-encrusted rocks more or less surround the medium-grained rock, described as quartz-diabase. We may therefore take the genetic connection between these rocks as pretty certain.

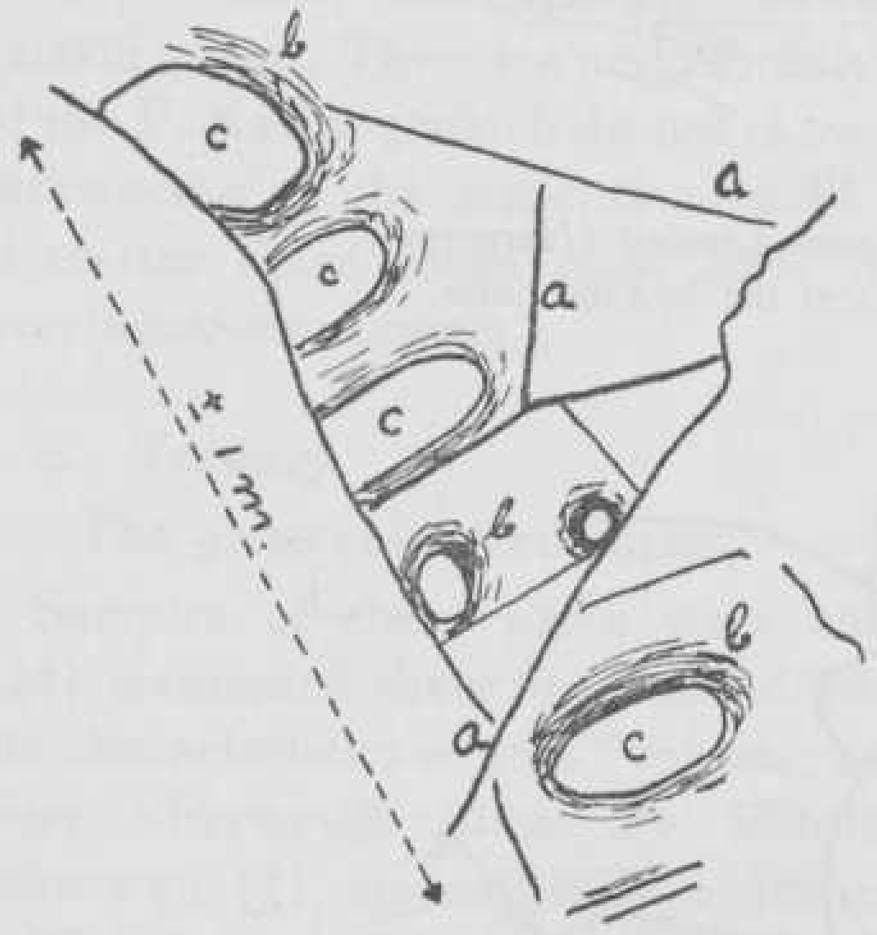

Fig. 12.

Spheroidal weathering in diabase rocks in the We Se, near We Ain (Djeniloe).

a. joints.
b. zones of weathered rock.
c. less weathered rock.

This does not decide their age however. In view of the covering white *Globigerina*-limestones, marls and tuffaceous rocks, for which a Young Miocene and/or Pliocene age could be established (p. 39) the pillow lavas, lying underneath, must be pre "Young Miocene-Pliocene". Whether there was any space of time between the outflow of the pillow lavas and the deposition of the soft white rocks, could not be determined.

On the one side especially in the vicinity of Batoepoetih, but also near Atapoepoe, the hills of glass-encrusted rocks with their striking level and equally high tops, (apart from the influence of young faulting-movements) strongly make the impression that they mark an old erosion-surface, but on the other hand, it is not at all impossible, that this lava-complex lacked any appreciable difference in height, even when it was formed. The absence of a conglomerate at the base of the deposits, lying above, may also be explained in two ways. It might point to a previous, prolonged period of erosion, owing to which no supply or formation of detritic material, or hardly any, had taken place, but it may also be inferred, that the pillow lavas after their submarine outflow at some distance from the coast, have not risen above the level of the sea, so that the sediments could be deposited immediately on top of them.

Above has been described that these lavas are older than the white Globigerina-limestones, marls and tuffaceous rocks, but on the other hand they must be younger than the great overthrusts in Timor and more especially younger than the movements, which brought the serpentine masses along. We have found that this complex of serpentine rocks was subjected to strong tectonical influences, locally they even became genuine mylonites. Whereas the lavas in question, though they have most certainly been subjected to young faulting movements, show no traces at all of such an intensive, tectonical influence, the inference is obvious, that they are younger than the movements, by which the serpentine rocks were carried to this locality. It is improbable that similar masses of lava, as occur all the distance from Atapoepoe to the vicinity of Lelogama (W. Timor) should have been transported on the crest of an overthrust sheet, the more so, as the quartz-diabases, with which they are connected genetically, make the impression, that they spring directly from the deep.

2. Rhyolites and dacites to quartz-andesites.

These rocks, which have a great extent in the region between the Fatoe Kadoea ridge and the Tapobòten, mostly are light greyish white; sometimes they are darker bluish grey or yellow-brown. Macroscopically they show in a dense groundmass, which makes a glassy impression, tiny feldspar phenocrysts and occasionally large, idiomorphic crystals of quartz. Often there are traces of hydrothermal after-effects, in consequence of which they are intersected by veins of chalcedony; often there are cavities as large as an egg, entirely filled with chalcedony.

Beside different ridges and complexes of hills these rocks often form large "block-fields".

The problem of their age has been considered by VERBEEK (54) who placed these rocks among the "old-mesovolcanic rocks" and by BROUWER (4), who gave several arguments in favour of a Tertiary age. Though in the field the closest attention was given to this problem no conclusive data could be collected. We received the impression however that they are older than the lavas of the F. Kadoea-ridge and that a Tertiary age is the most likely one, as the character and the position of these rocks is difficult to understand if a pre-overthrust age is assumed.

PETROGRAPHY.

The following rocks will be described:

1. Crystalline schists (amphibolites).
2. Granites.
3. Tonalite-aplites.
4. Trachytes.
5. Rhyolites to Quartz-andesites.
6. Basic Andesites.
7. Diabases.
8. Serpentine rocks.
9. Sandstones of Triassic age.

1. CRYSTALLINE SCHISTS. (Amphibolites).

In the explored region, only diopside-plagioclase-amphibolites were found. They are confined to a few localities only (see map). Concerning these diopside amphibole rocks, in his publication on the Moluccas VERBEEK (54) mentioned, with regard to an amphibolite from the cape E. of Binnenmouw, described by him, that it was not to be doubted, that the amphibole of the rock in question was of secondary origin and formed at the expense of the diallage.

In the samples, described below, beside amphibole and plagioclase, diopsidic augite was found also, besides spinel. The amphibole certainly originated in part at the expense of pyroxene, but there is also another pyroxene generation.

Although VERBEEK looked upon these amphibolites as dynamo-metamorphic gabbros, the problem of the origin of rocks of this kind seems not yet solved entirely.

In connection with the "Landewednack Hornblende schists" of the Lizard, e.g. HARKER (19) mentioned a plagioclase-amphibolite, containing colourless diopside, which partly or wholly has taken the place of hornblende, which rock is found especially in close association with intrusions of peridotite (now serpentine).

Concerning the same "Landewednack Hornblende schists" FLETT and HILL (14) thought it "in every way probable, that the pyroxene of the hornblende schists is due to contact alteration, or to their metamorphism and folding having taken place at high temperatures".

In 1938 SCRIVENOR (47) wrote about the same rocks: "If these rocks are the result of metamorphism of pre-existing basic lavas and sills, we may reasonably expect to see in sections traces of the original pyroxene from which the hornblende has been derived by uralitization and also traces of original ophitic structure.

With regard to the latter, I have seen nothing convincing. With regard to the former, I have not, as already stated, seen any augite such as one expects in basic lavas and sills, but in a few slides, I have seen diopside and hornblende associated in such a manner that it might be argued that the hornblende is uralitized diopside".

Thus, the origin of diopside bearing plagioclase-amphibolites is not always certain. On Timor, rocks of this kind occur together with large masses of serpentine rocks.

S 146. *Diopside-plagioclase-amphibolite from the Cape N.W. of Kg. Kanoe,* close to the boundary of Beloe and N. Middle Timor.

The sample shows a hard, dark green, medium-grained rock rich in amphibole with a more or less schistose structure. The texture is granoblastic. Owing to an arrangement in zones with predominating amphibole and zones with predominating plagioclase, which sometimes wedge out or pass into each other, a certain schistosity is developed which is still intensified by the fact that the amphibole is mostly situated with the columnar axis parallel to the planes of schistosity. This mineral shows a pleochroism from light bluish green ($n\gamma$) to light yellowish green ($n\beta$) and very light yellow ($n\alpha$), in which $n\gamma \geqq n\beta > n\alpha$. The maximal birefringence is about 0.02. The extinction ($n\gamma/c$) is 20° maximal.

Abundant plagioclase is also present. Polysynthetic twinning occurs frequently. The extinction is sometimes somewhat undulatory. The composition is approximately that of labradorite. Locally incipient alteration may be observed. Beside these two minerals, a pretty large quantity of diopsidic augite in irregular grains, conspicuous owing to its lack of colour and its refraction, also occurs. Pyroxene-cleavage may be observed occasionally.

Locally this pyroxene occurs as a nucleus in amphibole, in the same way as described by VERBEEK, but most of it is present in grains of another generation. As an alteration-product, an iddingsite-like mineral occurs, which shows parallel extinction and a pleochroism from red-brown to yellow-brown. Usually it is intergrown with ore.

Beside ore as accessory component was found, an isotropic mineral with the refraction and the dull green colour of hercynite or pleonaste.

S 141. *Diopside-plagioclase-amphibolite from the vicinity of the Oipiekan (Harnenno).*

Macroscopically as well as microscopically this rock resembles the preceding one.

However it exhibits to a much greater extent primary augite. The amphibole, which has the same pleochroism of light bluish green to yellow-green and light greenish yellow as that of the preceding rock is mostly lenticularly elongated.

Diopsidic augite of the other generation is present in smaller quantities. Quartz could no more be recognized here than in the preceding rock.

2. GRANITES.

The granite, described below, is probably the same as that mentioned by RETGERS (40), who described the samples collected by JONKER. It was found in one locality only, viz. on the E. Side of the valley of the M. Manoekakai, where it forms a hillock S. of the coarsely crystalline limestones of unknown age of the F. Kai, which like those of the F. Soehoen farther East, are strongly dynamically influenced limestones.

Where as this granite is more or less brecciated and effects of contact-metamorphism in the limestones adjoining it were not observed, it probably must be looked upon as a "rider", carried along by the masses of serpentine rocks.

S 90*. *Granite. Hillock S. of the F. Kai,* on the E. Side of the valley of the M. Manoekakai near Atapoepoe.

This coarse-grained holocrystalline rock chiefly consists of feldspar, quartz and some altered dark minerals; it was strongly influenced by cataclasis in consequence of which the minerals are locally completely crushed.

The quartz is xenomorphic and usually shows a strong undulatory extinction. Locally there is incipient recrystallisation. The appearance is not entirely clear owing to numberless very tiny inclusions of liquids, which are often arranged in fine, more or less straight veinlets. Apatite prisms and grains also occur as inclusions in the quartz.

Among the feldspars, potash-feldspar, distinguishable by its very low refraction is predominant. However some acid plagioclase also occurs, with fine, polysynthetic twins, which are occasionally curved and show a small angle of extinction.

The feldspar has generally been rather strongly altered; beside fine, sericite-scales, a brownish, earthy kaolin substance was formed in large quantities. Notwithstanding these alteration effects, locally an indication of a structure was still observed, which very much resembles the so-called "grating structure" of microcline. Hence beside orthoclase, microcline is also present.

The dark minerals, which were present in small quantities, have also been altered for the greater part. Yet it may still be ascertained, that biotite predominated; however it has been altered nearly entirely to chlorite, owing to which some ore was formed, though originally some ore was present too; locally it was altered to a limonitic substance. Besides some grains which belong to the epidote-zoisite group, also occur.

Apatite is present in pretty large quantities. Zircon too was observed.

3. TONALITE-APLITES.

From the region treated here, rocks of this kind have not been mentioned so far, although plutonic rocks of this type were described by WICHMANN (59) and BROUWER (2). The sample in question was found in one locality only and the outcrop, in a zone of weathered serpentine rocks, was not a good one, so it can only be said, that in all probability this rock occurs in the serpentine rocks as a dike, especially, as this aplite does not show traces of movements.

S 142*. *Tonalite-aplite. Between F. Kabélak and the Oipiekan.*

The rock is light coloured, medium-grained and holocrystalline. Dark minerals are distributed throughout the rock in small quantities, but locally they have accumulated, in consequence of which darker patches occur.

The thin section shows a rock, essentially composed of quartz and feldspar, which minerals are more or less equigranular. Only the plagioclase has a slightly hypidiomorphic boundary. Carlsbad twins as well as polysynthetic twin lamellae occur; potash-feldspar plays a subordinate part.

The twin lamellae of the plagioclase show only small extinction angles. The refraction is usually higher than, but sometimes nearly equivalent to that of the Canada balsam; however it is always lower than that of quartz. The composition is that of oligoclase to andesine.

Many feldspars show an incipient alteration by which sericite scales and also larger folia of muscovite were formed. Frequently a greenish chlorite and a brown, limonitic substance are present too, possibly formed from originally enclosed dark minerals.

These dark minerals, which occurred in rather small quantities, have been almost completely altered. The majority of them must have been biotite; some hornblende or augite may also have been present. What remains still distinctly shows the pleochroism of biotite and parallel extinction. As an alteration-product chlorite occurs, and moreover a strong leaching of iron has taken place, which has been infiltrated as limonite and has given a brown colour to the entire alteration-product.

This leaching, so-called Baueritisation, caused the biotite to lose its colour, in consequence of which it came to resemble muscovite very much, which last mineral, is not only present as an alteration-product of feldspar, but also primary. Beside some ore, zircon and apatite were also found accessorily.

4. ALKALI-TRACHYTES.

Rocks of this type were found in the F. Monoe-bot and in the F. Monoe-kiiek in Lidak; two hills on the W. side of the plain of Atamboea, showing a topography, strongly resembling that of an area consisting of schists.

The same rock was found in the Faffinoré. When fresh it is greenish, which passes into a slightly reddish brown by processes of weathering.

At the N. foot of the F. Monoe-bot a basaltic to andesitic rock also occurs, which will be described together with the rocks of group 6. An alkali-trachyte, found on the path from Atapoepoe to Lahoeroes where the Talaoe basin begins, was described by BROUWER (2).

S 203. *Alkali-trachyte. Fatoe Monoe-kiiek (Lidak).*

The sample shows a light greyish green, finely crystalline rock, with a somewhat schistose structure which becomes reddish through weathering.

The structure is trachytic; the rock chiefly consists of mostly very fine laths of feldspar, orientated owing to fluxion; the spaces between them are filled with a brown to black, finely distributed substance.

The laths of feldspar have a refraction, which is always considerably lower than that of the Canada balsam. We are here concerned with a potash-feldspar. It is developed thin tabular parallel to (010), in consequence of which, the laths in this thin section approximately correspond to sections perpendicular to (010), which have a parallel or almost parallel extinction.

The brownish substance, mentioned above, contains the dark minerals in very tiny grains and rods. Some are greenish and show almost parallel extinction; their elongation is negative, which points to *aegirine*. Others, which are slightly brownish, show the pleochroism of biotite; they show a rather high birefringence and parallel extinction. Their elongation is positive. Chlorite is also present, as well as ore; the latter mostly in tiny grains, but also occasionally as a large, cubic crystal, which has been altered locally to red-brown limonite. Another colourless, clear mineral occurs among the other minerals, usually filling small cavities. It has a refraction which is much lower than that of the feldspar. The birefringence is very low too; with crossed nicols the mineral has a somewhat spotted appearance and sometimes seems almost isotropic. In the cavities quartz also occurs.

5. RHYOLITES TO QUARTZ-ANDESITES.

BROUWER (3) mentions that effusive rocks cover a large area in the region S. of Atapoepoe; among them dacitic rocks are quite numerous.

Below a description is given of the rhyolitic rock forming the Medamori-ridge, S. of the F. Kadoea and of some quartz andesites to dacites, which were found, not only between Wehor and Atapoepoe, but also more to the W., as far as the neighbourhood of Haoediak in Harnenno.

Concerning quartz andesites to dacites, LACROIX pointed out in his publication on the rocks of M. Pelée (28) that dacites, rich in idiomorphic quartz phenocrysts and andesites without those phenocrysts occur, with no perceptible difference in their chemical compositions. He also succeeded in establishing the connection between rocks with a groundmass rich in quartz and those without any visible quartz, by means of various transitions. The fact whether quartz will crystallise or not, depends upon the circumstances of chilling of the lava. In these rocks the quartz will mostly be formed by hydatogenous effects, after the solidification of the principal part of the rock, e.g. under a thin crust which chilled rapidly, in which case a high temperature mineral like tridymite is formed first, and the other quartz minerals afterwards.

S 52. *Dacitic rhyolite. Medamori-ridge S. of the F. Kadoea.*

In the mostly microcrystalline groundmass phenocrysts occur of quartz and feldspar. The quartz phenocrysts are very clear and often show beautiful idiomorphic boundaries. They are frequently surrounded by a zone of an infiltrated limonitic substance. Fragments of the groundmass occur as inclusions in which sericite and chlorite scales may be recognized.

The feldspar phenocrysts mostly show idiomorphic boundaries too. However they are very turbid, owing to alteration and hence are much less conspicuous than the quartz individuals. They sometimes show Carlsbad twins and sometimes polysynthetic twins. Their composition is about that of acid andesine.

In the case of the feldspars, which do not show polysynthetic twinning, it cannot be decided any more, whether they are potash-feldspar or plagioclase, owing to the alteration. However phenocrysts occur with a refraction which is considerably lower than that of the Canada balsam.

In view of this and of the alteration effects, owing to which a brownish, earthy kaolin substance is frequently formed beside sericite scales, it is probable, that potash-feldspar is present too.

Tiny, very finely fibrous aggregates occur, enclosed in the feldspars. They consist of a substance with a low birefringence of a secondary origin.

The groundmass consists of a microcrystalline mass of a turbid, brown colour, owing to the alteration products. It consists of quartz and feldspar, irregularly intergrown. Secondary quartz is also present e.g. along the cracks. Traces can only be found of the dark minerals. Occasionally an altered biotite individual may still be recognized. The rest is represented by yellow-brown ferriferous alteration-products, among which finely fibrous chlorite is often present, distributed through the rock or locally accumulated. Only here and there some non-limonitic ore is found.

S 15*. *Quartz-andesite to dacite. Top of the Tapobòten near Wehor.*

In this light grey rock irregular fragments are cemented by zones of a dark brown, isotropic, locally cryptocrystalline, hyaline substance, in which many smaller fragments of the same rock occur. The larger fragments have a microcrystalline groundmass, in which tiny feldspar phenocrysts are conspicuous, owing to the absence of microlitic inclusions of dark minerals. They are strongly attacked by alteration processes and in polarized light it appears that they contain many fine and often fibrous mineral-aggregates, among which sericite scales occur. Irregular, colourless, nearly isotropic patches occur sometimes. Here and there twinning according to the Carlsbad law may be detected.

The groundmass, in which locally a flowstructure may still be observed, consists of a partly altered, microcrystalline mass of irregularly intergrown feldspar and quartz, with dark specks of countless microlites of dark minerals.

Among these microlites there are many, which in spite of their small dimensions, are still distinctly pleochroitic, from nearly colourless to brown-green. Moreover they show parallel extinction and may certainly be regarded as biotite.

Sericite, chlorite and kaolin occur as alteration-products.

S 21. *Quartz-andesite to dacite. Hill N.W. of Korobaoe.*

The sample shows a bluish grey, vitreous rock with tiny feldspar phenocrysts, much chalcedony and locally a pyritic mineral. Microscopically examined there are a number of small feldspar phenocrysts in the turbid, glassy to cryptocrystalline groundmass and besides many very small feldspar laths. The quartz, which partly may still be present in the groundmass, was moreover transported through the rock by hydatogenous effects and deposited in various modifications in the cavities.

The feldspars, of which especially the phenocrysts show well defined idiomorphic boundaries, are very clear. Their refraction is considerably higher than that of the Canada balsam. With crossed nicols they show Carlsbad twins as well as polysynthetic twins. The composition could be identified as that of labradorite. A zonal structure may often be observed, in which case the composition varies from about 63 % an. in the nucleus (labradorite) to about 50 % an. (andesine-labradorite) in the borderzone. The feldspars frequently contain irregularly formed inclusions of the groundmass, which sometimes penetrates the feldspar individuals along cracks and then supplants a large part of the nucleus, in consequence of which only a narrow rim of feldspar remains along the crystal boundaries. In the dense and cryptocrystalline groundmass black grains of ore occur. The many irregular shaped cavities are for the greater part filled with radial fibrous aggregates of chalcedony, but also with quartz, frequently surrounded by a zone of fibrous chalcedony. Tridymite, which may be recognized by its very low refraction, weak birefringence and by the imbricate arrangement of its aggregates, is also present, as well as opal, which has a still lower refraction.

S 131. *Quartz-andesite to dacite*. E. of the M. Baoekonoe, *in the vicinity of Haoediak*.

In a brownish, microcrystalline groundmass phenocrysts of feldspar occur, sometimes by themselves, but frequently also interlocked in small groups. They usually show well defined idiomorphic crystal boundaries; Carlsbad as well as polysynthetic twins occur.

A combination of these two in one section enabled us to identify the amount of an. at about 55 %, hence acid labradorite. The fine, zonal structure of these plagioclases depends only upon a small difference in the composition of the concentric zones; they are slightly more basic in the nucleus and a little more acid towards the crystal boundary. Occasionally irregularly shaped inclusions of the groundmass occur, in which carbonate and a chloritic substance are also present.

The groundmass consists of a very finely crystalline mixture of light and dark minerals. Among the dark minerals the ore, which for a great part is surrounded by a brown limonitic substance, is especially conspicuous. Some microlites may still be recognized as biotite; others may belong to the pyroxenes or amphiboles. Locally an emerald-green, finely fibrous, chloritic substance is conspicuous. Here and there finely distributed, secondary carbonate is present. The principal part of the groundmass consists of an allotriomorphic mixture of feldspar and quartz, in which feldspar predominates.

S 30. *Quartz-andesite to dacite. From a hillock about N.N.E. of Wehor.*

This rock shows a great similarity with the preceding one, at any rate as far as the original character is concerned. However it is influenced very strongly by hydatogenous effects, owing to which secondary silica is deposited, frequently in the shape of chalcedony or opal and a limonitic substance has penetrated everywhere. Beside these a zeolite mineral was also formed, probably natrolite.

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6. BASIC ANDESITES.

The samples described here, were collected from the complex of partly glass-encrusted pillow lavas which is found from the F. Kadoea in the neighbourhood of Atapoepoe, along a great part of the north coast of Timor as far as Pante Makasar in the Portuguese enclave of Oeikoesi, where it builds up the mountain Seli, and still farther to the S.W. (p. 44).

The samples, collected in the vicinity of the F. Kadoea during the MOLENGRAAFF-expedition, showed rather much olivine, hence they were described collectively with the basalts by BROUWER (2). However he also mentioned transitions to basic augite-andesites, which were described before from the same locality by WICHMANN (59).

The samples from this lava-complex, collected in 1937 between Batoepoeti and F. Kabélak, in the neighbourhood of Wini, which is situated on the coast to the N. of Kefamenanoe, and from F. Soeba near Pante Makasar, all belong to the group of basic andesites.

S 139. *Basic augite-andesite. From the hill complex of Haoe Roenat,* between Batoepoetih and F. Kabélak.

The sample present an ashcoloured, dense rock with some feldspar and augite phenocrysts of modest dimensions in a glassy to microcrystalline groundmass. It contains numerous small, spherical cavities, usually empty, but along the walls they sometimes contain a fine layer of a whitish substance.

The rock has a porphyritic texture. In a brownish, dense microcrystalline to cryptocrystalline and glassy groundmass, not very numerous phenocrysts occur of plagioclase and very light green augite.

The groundmass consists of a dense fabric of fine plagioclase laths, augite rods and grains of the same dimensions and grains of ore, between which there is a light brown mass of glass, which is somewhat darker locally, probably caused by a larger amount of non-crystallised ore.

Locally this groundmass shows distinct traces of hydatogenous effects owing to which in the mass of glass an usually plain, sometimes less conspicuous, zonal structure of light and dark brown parts arose, while moreover a very fine crystalline, pretty highly birefringent, secondary carbonate substance was deposited.

As far as the feldspar and the augite phenocrysts are concerned, in this rock they accumulated either separately or mixed, forming aggregates in the shape of rosettes, in the same way as WICHMANN (59) and BROUWER (2) found in the specimens from the neighbourhood of the Fatoe Kadoea. Moreover they are sometimes intergrown.

The diopsidic augite is very light green. The optical character is biaxial positive; the elongation is positive as well. The maximum extinction angle ($n\gamma/c$) was found to be 38°. Occasionally some inclusions of glass are present, as well as a few fine grains, possibly apatite.

Twins according to (100) are present.

The feldspar phenocrysts do not show well defined twin lamellae according to the albite law, but according to the Carlsbad law the twins are well developed. Sometimes they have a vague zonal structure, the nucleus of which is very basic, while a narrow zone enclosing it, is slightly more acid and the outmost narrow zone is again more basic. The composition is about that of bytownite. These phenocrysts often enclose a large number of glass-fragments, originating from the groundmass, which often also penetrates along cracks.

The feldspar laths of the groundmass seem to be of a slightly more acid composition, approximately that of basic labradorite. They sometimes show penetration twins.

S 442. *Augite-andesite rich in glass. From the neighbourhood of Wini.*

This rock is somewhat darker than the preceding one.

In parts it has a thin (about 5 mm) black, hyaline crust. The cavities mostly show an irregular, elongated shape.

Microscopically examined the rock is much more rich in glass than the former. The isotropic mass of glass is locally dark brown and in other places nearly opaque in consequence of an accumulation of tiny, brown, very finely fibrous aggregates. Where these finely fibrous aggregates are absent, the glass is light brown and translucent. Between these two zones there is a band, in which finely fibrous aggregates may be detected as brown spots against the lighter glass. Cracks, in which a limonitic substance has been deposited, occur in the outmost, light coloured zone. Farther away from the hyaline crust the rock shows the beginning of devitrification: microlitic rods of augite and tiny laths of feldspar may be recognized. Here and there traces may be observed of hydatogenous after-effects, which caused a light greenish, weakly birefringent serpentine-like substance to be formed, possibly by the conversion of a mineral, which was originally present, but what mineral could not be established.

The phenocrysts of feldspar and augite, as well as a number of smaller feldspar laths, which sometimes occur distributed through the rock, sometimes are accumulated or form part of the rosette-shaped aggregates of the augite crystals are clearly outlined against the glassy groundmass, described above.

The diopsidic augite is very light green; some well defined idiomorphic basal sections occur. Most individuals have an irregular extinction owing to an hourglass structure. Twins according to (100) are present. An occasional section nearly perpendicular to the acute bisectrix gives a biaxial, positive interference figure with an optical axial angle of about 60°. The maximum extinction angle ($n\gamma/c$) is 40°. Here again glassy inclusions occur as well as corrosive effects; besides it is intergrown with feldspar.

The feldspar phenocrysts do not obtain the size of those in the preceding rock. They are mostly hypidiomorphic laths, which sometimes show a fine zonal structure. The larger ones again contain glassy inclusions from the groundmass. Their composition is approximately like that of the plagioclase in the preceding rock.

S 189. *Basic augite-andesite,* situated under the white, soft rocks *behind the fortress F. Soeba near Pante Makasar (Oeikoesi).*

In the sample this rock shows a strong similarity with the preceding one. A hyaline crust is not present however and the feldspar phenocrysts are considerably larger.

Moreover microscopically examined, the groundmass proves to be much more crystalline. The augite rods and the laths of plagioclase once more form a dense fabric as in the rock, which was described first, though here the groundmass still contains much glass. Besides numerous tiny grains of ore are present.

The augite phenocrysts do not show the well defined idiomorphic boundaries, which they had in the other rocks. For the greater part they are irregularly enclosed by the groundmass. They again show an hourglass structure and sometimes a more or less zonal structure. Twins according to (100) are present. The composition corresponds to the augite of the former rocks. The feldspar phenocrysts are considerably larger than in the preceding rock. They mostly show idiomorphic boundaries. Twins occur according to the albite and the Carlsbad law; in the groundmass penetration twins also occur. The composition could be established as basic bytownite.

The description following here, concerns a rock which does not belong to the lava complex, just mentioned. It was found at the N. foot of the F. Monoe-bot in Lidak, but whether it occurs as a lavaflow or as a dike, could not be established. In any case it must belong to another period of volcanic activity than the trachyte, composing this hill, possibly it is much younger.

S 201. *Basalt to andesite. N. foot of the Fatoe Monoe-bot (Lidak).* In the dark greyish black rock phenocrysts of light feldspar occur in a finely crystalline, dense groundmass with somewhat elongated cavities, which are partly or entirely filled with a secondary substance.

Microscopically examined the groundmass consists of countless, fine black spots of ore and fine feldspar laths, which are occasionally orientated by fluxion round the feldspar phenocrysts. Between these, a green, chloritic substance is also present. The feldspar phenocrysts show twins according to the albite law; Carlsbad twins also occur. The composition is about that of basic labradorite.

A zonal structure occurs, which corresponds to the original idiomorphic crystal boundaries, which still frequently occur, but are often strongly attacked by the groundmass and destroyed locally. Occasionally they contain inclusions of ore; generally they are affected to a high degree and partly replaced by a green chloritic mass of a finely radial-fibrous structure, which is also present in the groundmass. Especially in the internal parts this supplanting asserts itself, leaving a thin zone of feldspar intact along the crystal boundary. Carbonate too encroaches upon the feldspar and pseudomorphs of carbonate after feldspar occur.

The groundmass — as has been mentioned above — chiefly consists of many grains of ore and laths of feldspar, occasionally orientated by fluxion. Among these the green chlorite-substance is also present; it often fills the tiny cavities, as a finely fibrous, fan-shaped aggregate.

Besides, in the groundmass there are numerous tiny grains and columns of augite. Apatite also occurs; however this mineral cannot be identified with certainty owing to the very small dimensions.

Carbonate too is present in the groundmass, and moreover it fills the larger cavities, sometimes by itself, sometimes together with chlorite or another xenomorphic, unevenly extinguishing mineral with a refraction, sometimes higher, sometimes lower than that of the carbonate and formed by hydatogenous effects in the same way as the carbonate and the chlorite.

In part this mineral is quartz, in part it may be chalcedony. Occasionally mineral fragments were noticed, which showed parallel extinction, the pleochroism and the interference colours of biotite. The laths of feldspar, belonging to the groundmass also show polysynthetic twins. Their composition is probably rather basic, in view of their refraction, which is considerably higher than that of the Canada balsam. In the xenomorphic, weakly birefringent parts of the groundmass feldspar of another composition may be present, as well as some quartz or chalcedony.

7. DIABASES.

The specimen S 159 was found in a low ridge in the zone of *Monotis*-limestones of the Sonnebait-series, to the S. of the F. Toekoenenoe. It was not possible to establish whether this rock occurs as a dike, a sill or a flow.

The sample S 159* was collected from the W. top of the F. Noireeoe, which is entirely built up of this rock, which is strongly weathered and crumbles down in angular fragments when struck with the hammer. Whether it belongs to the Sonnebait-series or to the Fatoe-complex cannot be decided.

S 159*. *Diabase. Western top of the F. Noireeoe.*

This ashcoloured, evenly finely crystalline rock consists chiefly of feldspar, pyroxene and ore. It has a more or less ophitic texture. Numerous olive-green, extremely fine radial-fibrous aggregates of a chloritic mineral which fill the cavities or are distributed unevenly through the rock, point to intensive alterations to which this rock has been subjected.

The feldspar, which is somewhat hypidiomorphic has a strongly turbid appearance in consequence of alteration. Yet, sometimes Carlsbad twins can be observed and occasionally polysynthetic twins. Intergrowths occur of plagioclase and augite in which case the augite often encloses the plagioclase. Owing to the strong alteration this plagioclase could not be determined exactly. The turbid appearance of the feldspar is chiefly caused by a finely distributed, sometimes fibrous, sometimes scaly, green chlorite-substance with a low birefringence.

The augite is xenomorphic and encloses plagioclase laths or is irregularly intergrown with them. Penetrations of augite and plagioclase were observed.

The mineral is colourless and conspicuous owing to its high relief. Sometimes the extinction is wavy in consequence of an hourglass structure. Twins according to (100) occur.

The maximum extinction ($n\gamma/c$) was found to be 43°.

Curiously enough the augite was not affected as strongly by far as the plagioclase by the chloritization process. Only here and there some chlorite-substance may be noticed in fine cracks as a beginning of alteration.

The ore, which is distributed indiscriminately through the rock, may be magnetite.

S 159. *Diabase. Ridge in the Monotis-limestone zone of the Sonnebait-series S. of the F. Toekoenenoe.*

The sample shows a greyish green rock with white spots of weathered feldspar; tiny, fresh columns of pyroxene are noticeable, besides many grains of ore and a green, secondary substance.

The rock is rather strongly altered and originally it consisted chiefly of feldspar, partly as phenocrysts, pyroxenes and ore. In consequence of hydatogenous effects a green, chloritic substance is present in great quantities.

The feldspar is very turbid owing to alteration. Yet polysynthetic twins may still be observed. Their composition could be established as andesine-labradorite. The feldspar of the groundmass was probably slightly more acid.

The alteration mainly led to the formation of sometimes very finely distributed sericite aggregates with often vivid interference colours.

The pyroxene shows hypidiomorphic crystal boundaries and is intergrown with the feldspar of the groundmass. However some idiomorphic, basal sections also occur. Twins according to (100) are present. The optical character is biaxial positive. The maximum extinction ($n\gamma/c$) was found to be 45°.

The augite occasionally encloses ilmenite and titanite, which minerals occur rather frequently in this rock. The titanite seems to be partly formed at the expense of the titanic iron ore, with which it is often intergrown.

For the greater part the augite is not attacked by weathering processes, but locally along cracks a beginning of alteration may be noticed.

The mass of chlorite is mostly finely fibrous; it often forms aggregates with a radial-fibrous structure, indiscriminately arranged, but scaly aggregates occur as well. This mineral shows a pleochroism from light yellow to yellowish green. The interference colours are sometimes rather high, probably in consequence of a higher amount of iron. Locally small rests of red-brown biotite can still be observed in the mass of chlorite, which to a great extent was formed at the expense of the biotite.

Apatite is also present.

8. SERPENTINE ROCKS.

The geological occurrence of these rocks has been described in the chapter on the Geological Formations (p. 41).

The samples are divided as follows:

a. Coarsely brecciated and rolled serpentine rocks.
b. Mylonitic serpentine rocks.
c. More or less stratified serpentine rocks.
d. Serpentine rocks, less subjected to brecciation, partly with rests of pyroxenes.

During the last few years various authors (12, 18, 29, 48) have maintained the uselessness of distinguishing between varieties such as metaxite, picrolite, schweizerite, hence in the following pages only the names chrysotile, antigorite and the general term serpentine will be used.

a. Coarsely brecciated and rolled serpentine rocks.

S 78*. *Top of the hill N.E. of the passangrahan at Atapoepoe.*

The sample shows a "conglomeratic" rock with projecting fragments of olive-green, glassy serpentine with a fine reticulation of ore-veinlets, cemented by crushed serpentine material. The brecciation seems to have begun as a system of cracks, along which movements occurred and infiltration took place. Distinctly can be seen how zones of crushed material were gradually formed, in consequence of which the rock came to consist of mostly angular fragments of the original serpentine rock of various sizes, surrounded and cemented by crushed and pulverised material of the same rock.

One of the larger fragments of the original rock microscopically observed, shows a light brownish yellow mass of serpentine flakes and fibrous aggregates, in which countless, irregular ore-veinlets and some larger fragments of the same material produce a kind of mesh-structure. This mass is intersected by some narrow cracks filled with colourless serpentine, which also remain conspicuous with crossed nicols owing to another orientation of the serpentine fibres along the entire length of the crack. The ore-veinlets on either side are more or less bent and their position was slightly shifted with respect to each other, while locally grains of ore are arranged longitudinally in the crack. These colourless serpentine veins probably represent zones of movement.

S 81*. *Along the motorroad Atapoepoe-Atamboea; about 150 m before km pole 295.*

This rock too is distinctly brecciated. It shows beautiful gliding-planes and striations. In the blurred green serpentine-mass there are a.o., fragments of a reddish serpentine rock. With crossed nicols the brecciated character of this rock becomes very pronounced, because fragments with a special pattern are surrounded by serpentine material with an irregular orientation. In the light greenish, yellow mass of serpentine a large quantity of disseminated ore occurs and some brown translucent picotite grains.

S 95*. *S. of Wekiar.*

The sample shows a greenish to black, pressed mass of serpentine with many veins of chrysotile.

Under the microscope the light greenish yellow, locally brownish serpentine-mass makes a rather brecciated impression, which is accentuated by the irregularly accumulated ore.

With crossed nicols it is proved that the rock contains many, partly interrupted, veins of very fine to compact serpentine aggregates. Beside these mostly fibrous serpentine masses, some larger antigorite folia occur, which show a beautiful biaxial negative interference figure with a small optic axial angle, while the elongation is positive.

Locally a highly birefringent, talcous mineral was observed. Moreover a rather large quantity of red-brown, translucent picotite grains occur, which like the ore are often surrounded by a yellowish brown zone of limonite.

S 279*. *Western spur of the serpentine outcrop W. of Halitoekoe.*

This rock shows traces of an intensive rolling. In a dark green, greasy serpentine-mass "eyes" occur of light coloured serpentine. Under the microscope these "eyes" are not conspicuous as such, the numerous lenticles and gliding planes which intersect the ore-veinlets are however the more so. The larger fragments of ore are somewhat brownish red translucent, hence partly it must be chromite. Locally talc was found. This mineral also shows traces of movement; the talcfibres are occasionally bent and undulated.

b. Mylonitic serpentine rocks.

S 7*. *Along the road to Atamboea, S.W. of Wehor.*

This greenish rock, locally brown by iron-infiltration, entirely consists of finely crushed serpentine material, cemented together. Next to weathered ore non-oxidized pyrite occurs.

Microscopically, with crossed nicols the large masses of irregularly arranged serpentine fibres and folia are conspicuous. Among those masses various units can be distinguished, also consisting of a serpentine aggregate, but deviating in structure:

either denser and more finely fibred, or with the fibres arranged in two directions, while the fibres of the cement-mass are arranged irregularly.

Beside ores, such as magnetite, chromite, pyrite and limonite, another mineral is found here, one of the refractive indices of which is considerably higher than that of the serpentine. Its birefringence is very high, the elongation is positive, which points talc.

The largest pyrite individual shows cracks (which are filled with an oxidation product), but it does not seem to have been exposed to such violent movements as the rest of the rock. The zone of chalcedony which encloses it, is most certainly younger. Besides an occasional apatite individual occurs. The serpentine is principally chrysotile, but antigorite folia also occur.

S 80. *From the left side of the valley of the We Soemak, near the waterfall.*

The sample shows a pale green, dull, angularly crumbling mass of serpentine, consisting of agglutinated pulverised material, in which "eye" structures of harder rock-fragments are still faintly to be seen.

Under the microscope a fabric is seen of almost colourless very light greenish yellow serpentine with higher and lower birefringence, in which much iron-ore occurs, partly chromite, which is somewhat brown-red, translucent, but also magnetite and carbonate-aggregates.

The ore and the carbonate were distributed equally through the rock.

c. More or less stratified serpentine rocks.

S 141*. *Between Kg. F. Kabélak and the Oipiekan.*

This more or less weathered serpentine rock, which is coloured brown by infiltration of iron, shows a certain stratification because of the wedging out of alternate bands of lighter and darker material. Under the microscope may be seen, that the stratification is caused by the alternation of zones, which consist exclusively of yellowish to brownish serpentine, with layers in which not only serpentine, but a rather large quantity of carbonate occurs. This impression of stratification is also intensified by the alternation of zones containing serpentine with a low birefringence and serpentine zones with a higher birefringence.

The ore, which is present in rather large quantities, is partly altered into limonite, which has penetrated farther into the rock through the cracks.

d. Serpentine rocks, less subjected to brecciation; partly with rests of pyroxenes.

S 9*. *Hills of serpentine rocks to the W. of the road Wehor-Atamboea.*

The sample shows a greenish, brownish black mass of serpentine with much large, schillerizing, sometimes bent bastite. Microscopically observed, this rock proves to consist of an irregular fabric of serpentine, sometimes yellowish green with a very low birefringence — almost isotropic — sometimes light greenish yellow with a higher birefringence. Remnants of lowly birefringent, rhombic and of highly birefringent, monoclinic pyroxene occur in the mass of serpentine. Olivine cannot be recognized, though the structure of the serpentine occasionally resembles a pseudomorph after olivine. Pseudomorphs of serpentine, after pyroxene — so-called bastite — occur. Iron-ore is present as well as some brown, translucent, isotropic picotite grains. Infiltration of limonite has taken place through the cracks.

S 74. *Left bank of the M. Manoekakai, S. of the R. C. Church near Atapoepoe.*

In a light, olive-green mass of serpentine, not only schillerizing bastite but also glittering crystals and fine veinlets of ore may be observed.

Under the microscope we notice an almost colourless, light greenish yellow mass of serpentine with many irregular ore-veinlets and countless, brown, earthy, almost isotropic inclusions, which must be looked upon as alteration products of the original minerals. Grains of brown translucent, isotropic picotite also occur. With crossed nicols a kind of reticulation is recognized, because almost isotropic serpentine is intersected and enclosed by a more highly birefringent, fibrous variety. A finely fibrous and foliated aggregate of a highly birefringent mineral, which shows all the characteristics of talc also occurs. Locally bastite may also be observed.

S 79. *Left bank of the We Soemak, N.W. of the waterfall.*

A zone of pale, green serpentine material in a dense, olive-green mass of serpentine with glittering ore-crystals, contains numerous fragments, partly rounded off, partly angular, of various kinds of serpentine rocks. This "conglomeratic" zone probably represents the filling of a crack. Under the microscope the dense, olive-green serpentine mass proves to consist of a fabric of light yellowish to green, locally more brownish serpentine. With crossed nicols it becomes perceptible that serpentine with a low birefringence, locally almost isotropic, lies enclosed in fibrous serpentine with a higher birefringence, which forms a more or less reticulated pattern.

Beside iron-ore and yellow-brown translucent picotite, much carbonate occurs, sometimes in beautiful rhombohedra, but mostly as a fine, highly birefringent aggregate, deposited here and there along the cracks in the mass of serpentine.

There are some rests of pyroxenes and locally parallel extinction may be noticed in this colourless mineral. The refraction is slightly higher than n_ω of the carbonate enclosing it. The optical character is biaxial, positive; the optic axial angle is not very large. As hardly any ferruginous minerals were formed owing to the alteration, these pyroxenes must be rich in magnesia, which in connection with the above mentioned optical characteristics points to enstatite.

S 79*. *Same locality as the preceding one, but slightly more to the S.*

In the sample schillerizing bastite is conspicuous in the compact, dark green to black mass of serpentine.

Under the microscope we see how, in a mass of yellowish green serpentine, the more highly birefringent serpentine locally forms a reticulation, within which the lowly birefringent, almost isotropic, variety lies enclosed.

Beside ore and some picotite grains many rests occur in this rock of lowly birefringent rhombic pyroxenes and also some, with a higher birefringence, of monoclinic pyroxene.

S 76. *Near km pole 4 on the road Atapoepoe-Dilly.*

The sample presents a vein of dense, glassy, greenish and brownish black serpentine, which is injected in coarse light-green serpentine rock with large patches of schillerizing bastite.

Microscopically this vein shows a somewhat cloudy, brownish irregular fabric, in which clear and turbid, large and small, nearly isotropic and more highly birefringent folia and fibrous aggregates of serpentine, with much, often very finely distributed ore, are lying together irregularly. Some brown translucent grains of picotite are present, but not a trace can be detected of other original minerals. In this rock some veins are conspicuous, which consist entirely of a homogeneous, colourless completely isotropic mass of opal with a refractive index, which is considerably lower than that of the Canada balsam. In the serpentine a talcous mineral also occurs locally, which is conspicuous by its higher birefringence.

S 91. *Northmost point of the F. Loeka on the motorroad, near Atapoepoe.*

This rock consists of a pale green to whitish mass of serpentine, which seems enclosed and intersected by a compact, dark green, greasy serpentine with glittering ore-crystals and a fine network of ore-veinlets. Microscopically these differences in appearance are hardly noticeable. However we may observe, that in the light yellowish green serpentine, browner bands occur and a large quantity of ore, which forms a network of numerous veinlets. Locally the ore is more accumulated. Not a trace is to be found of original minerals. The striking difference in appearance is therefore entirely due to alteration effects, owing to which the light coloured serpentine was formed out of the dark green rock. Two generations of serpentine rock are out of the question here, though macroscopically the impression, that this is the case, is certainly made.

9. SANDSTONES OF TRIASSIC AGE.

These rocks, which were collected from the Kekneno-series as well as from the Sonnebait-series, resemble each other very much, although some are less, some more calcareous.

The one, marked S 206* even shows a coarsely crystalline aggregate of calcite, in which the grains of quartz and feldspars, and the fragments of weathered igneous rocks are embedded, but this phenomenon is probably of secondary origin. A similar rock was mentioned by MOLENGRAAFF (33) from the Island of Letti, situated N.E. of Timor.

S 246. From the Kekneno-series. *M. Baoekonoe about S. of Babkaniem.*

This greyish green, greywacke sandstone contains many flakes of colourless mica, but hardly any calcareous cement.

In a greenish and brownish mass of decomposed eruptive material, numerous grains of quartz and feldspar occur. Some of them show a normal extinction, others a very wavy one. The grains are usually distinctly angular and make a strongly cataclastic impression. The feldspar grains sometimes still show polysynthetic twinning, but generally they are rather turbid owing to alteration. They are probably rather acid plagioclases.

The rock contains a considerable quantity of ore. Moreover we observed flakes of biotite, sometimes strongly bent, chlorite in flakes, probably as an alteration product of biotite, but also in irregular, fibrous aggregates as an alteration product of the eruptive material; besides muscovite, and moreover zircon, tourmaline, garnet and apatite were found.

S 253. From the Kekneno-series, close to the contact with the Sonnebait-series; *M. Baoekonoe, about S.S.W. of Weklosoen.*

This rock too is a greenish grey, greywacke sandstone, but more compact than the preceding one, with some calcareous cement; the flakes of colourless mica are much smaller and hardly noticeable.

Here too there is a large quantity of eruptive material. However occasionally calcite may also be observed. Here again the micas are frequently bent or even broken.

S 206*. From the Sonnebait-series, *near the highest point of the path Tabéan-Woonari.*

This yellowish grey sandstone has a crystalline calcareous cement, which gives it a peculiar glitter.

Microscopically observed, this rock looks much fresher than the preceding ones, though here too much weathered, eruptive material is present. The great difference lies however in the presence of carbonate as cement, while in the rocks described above, the whole was cemented by the altered, eruptive material. In this case the calcareous cement is coarsely crystalline, and in such a way, that the grains of quartz, feldspar and eruptive material, though their combined masses are certainly as large as that of the cement, are embedded in the calcite crystals, often even without touching each other. In this rock quartz predominates. The grains are distinctly angular. The extinction usually is not wavy. Some grains are completely recrystallised. Muscovite and chlorite occur in rather large quantities; biotite and also zircon, tourmaline and garnet, as well as ore occur in much smaller quantities.

S 248*. From the Sonnebait-series, *S.W. of Weklosoen.*

Microscopically observed, this ashcoloured, calcareous sandstone strongly resembles the preceding rock, but the characteristic glitter is absent.

Yet here too the cement is calcite however it is much more finely crystalline, so that the impression of inclusions in a calcite mass is not so strong. Besides, the grains are much more irregularly distributed and sometimes there is an appreciable difference in the dimensions of the constituents. The grains are mostly angular again; occasionally the quartz shows a strong wavy extinction and some grains seem to have recrystallised.

Besides chlorite, muscovite, some biotite, titanite, zircon, apatite, tourmaline and some ore were observed.

The following table gives an enumeration of the heavy minerals, which were found in the rocks, described above.

They were separated from the lighter fraction by means of bromoform (s. g. 2.82), after the rock had been crushed and heated, first with diluted HCl and then with diluted HNO_3.

In the slide, the grains were counted in strips of ± 0.5 mm width.

		S 246	S 253	S 206*	S 248*	S 329*
Opaque (in % of the total assemblage)		67½	57	85	77	14½
Tourmaline	in % of the translucent grains	13	17½	12	13	6½
Zircon		40	42½	26	43	4½
Garnet		25	25	35	22	77
Rutile		10	3½	6	7	3
Brookite		—	—	—	—	½
Anatase		2	—	1	1	1
Titanite		—	1	1	—	1
Muscovite		4	3½	12	5	1½
Epidote		1	1	1	1	2
Hornblende (blue-green)		2	—	4	5	—
Chromite		1	2½	1	1	2
Monazite		2	3½	1	2	2

Although the samples S 246 and S 253 were collected from the Kekneno-series and the numbers S 206* and S 248* from the Sonnebait-series, a comparison between the percentages of the heavy minerals does not show great differences.

Each of these samples contains minerals, which must have been derived from crystalline schists. The sample, numbered S 329*, was collected from the Kekneno-series, in the valley of the M. Toebaten (see p. 23). The high amount of garnet points to a deposit, sedimented near a coastline, where local agents caused the enrichment in garnet.

From the Batoepoetih-region the following rocks were studied with respect to their contents of heavy minerals.

S 131*, *from the E. Point of Tg. Batoepoetih (Harnenno)*;
a soft white *Globigerina*-limestone with small, marly inclusions.

S 132, *from the isolated hill, S.W. of Batoepoetih*;
white, slightly marly limestone with Globigerinidae.

S 134*, *from the neighbourhood of Lèsebot*; collected from the hill marked with c., in fig. 6, p. 35;
white, sandy limestone, slightly stratified on account of interspersed volcanic material.

S 135, collected *between Lèsebot and Halimaneëk*;
beige, marly limestone.

S 135*, *same locality* as the preceding sample;
hard, beige, marly limestone.

S 136, *same locality* as the preceding sample;
very sandy, tuffaceous rock, with calcareous cement; more or less stratified by interspersed volcanic material.

S 137*, *from the highest hill between Lèsebot and Halimaneëk*;
compact, white limestone with Globigerinidae.

The following table gives the results of the analyses.

The principal part of the heavy fraction consists of hornblende, augite and hypersthene, all minerals, which occur frequently in the younger volcanic deposits of the islands north of Timor.

		S 131*	S 132	S 134*	S 135	S 135*	S 136	S 137*
Opaque	in $^0/_0$ of the total assemblage	33	—	46	20	32½	31	31
Zircon	in $^0/_0$ of the translucent grains	3	1	1½	1	3½	—	1
Garnet		1	—	—	2	—	—	—
Rutile		½	1	—	1	1	—	—
Titanite		—	2	—	2	1	—	1
Epidote		14	23	4	4	8	—	—
Hornblende . . .		78	55	13½	15	1	34	4
Augite (partly diopside)		2½	10	63	62	42	51	79½
Hypersthene . . .		—	6	18	13	32	15	14½
Chromite		1	2	—	—	11½	—	—

DETAILED DESCRIPTION OF SOME PARTS OF THE EXPLORED REGION.

This chapter gives an account of our observations with respect to the structure of the explored districts.

a. The country between Atapoepoe and Atamboea, on either side of the horse-trail via the F. Kadoea and Wehor.

When going from Atapoepoe to Atamboea via the F. Kadoea and Wehor, we pass first of all a zone of serpentine rocks, which are mostly brecciated and mylonitised, as has been described elaborately in the chapter on the Geological Formations (p. 41). The serpentine hills often show convex slopes (fig. 13). A little before we arrive at the spring, which supplies Atapoepoe with water, the lavas of the F. Kadoea (p. 44)

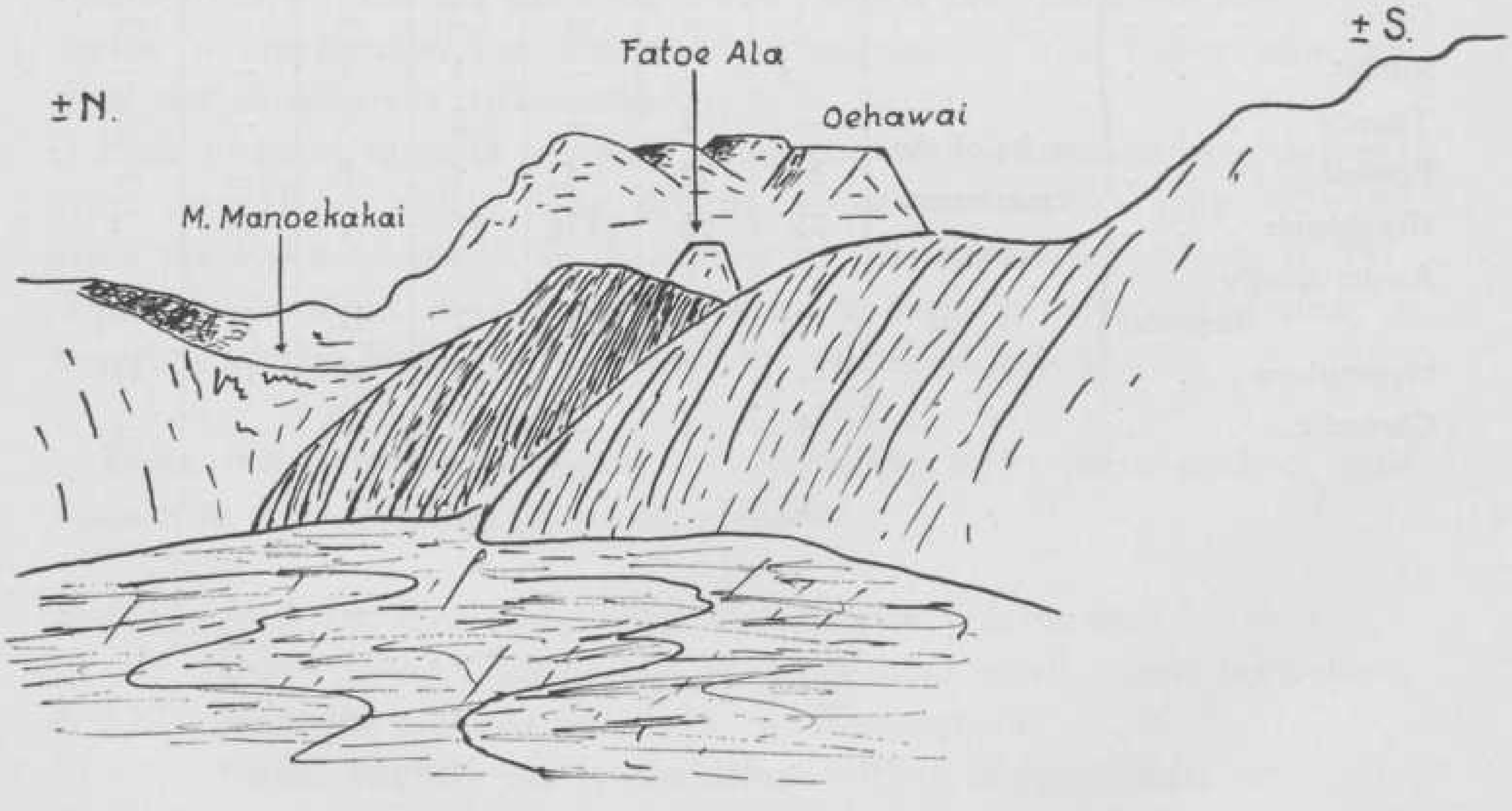

Fig. 13.

View from the W. side of the valley of the We Soemak, near Atapoepoe. Looking in an eastern direction. In the foreground serpentine hills, in the background young pillow lavas, constituting the Oehawai and the F. Ala.

are found in situ. Towards the E. they continue as far as the Oehawai, towards the W. as far as the end of the F. Kadoea-ridge (fig. 14).

The contact between the serpentine rocks and these lavas is nowhere exposed; it is entirely covered with detritus, which has crumbled down from the F. Kadoea-ridge. In the hills W. of the path from Atapoepoe to the F. Kadoea, the relatively undisturbed position of the white, tuffaceous rocks and the F. Kadoea-lavas with respect to the serpentine rocks, could be observed. Going from N. to S. the following rocks were found (fig. 15). "Conglomeratic" serpentine, F. Kadoea rocks (partly with hyaline crust), serpentine (locally strongly rolled and crushed), F. Kadoea rocks, white, rather soft, siliceous, tuffaceous rocks, which here form a hill, on the S. side of which could be established, that they rest immediately upon the F. Kadoea rocks. Going in a S.W. direction from the top of this hill, the white, tuffaceous rocks are followed by a narrow zone of F. Kadoea rocks, intensively rolled and crushed serpentine rocks, once more F. Kadoea rocks and then again white, tuffaceous rocks, which finally disappear under the detritus of the F. Kadoea-ridge, which rises above a girdle of waste.

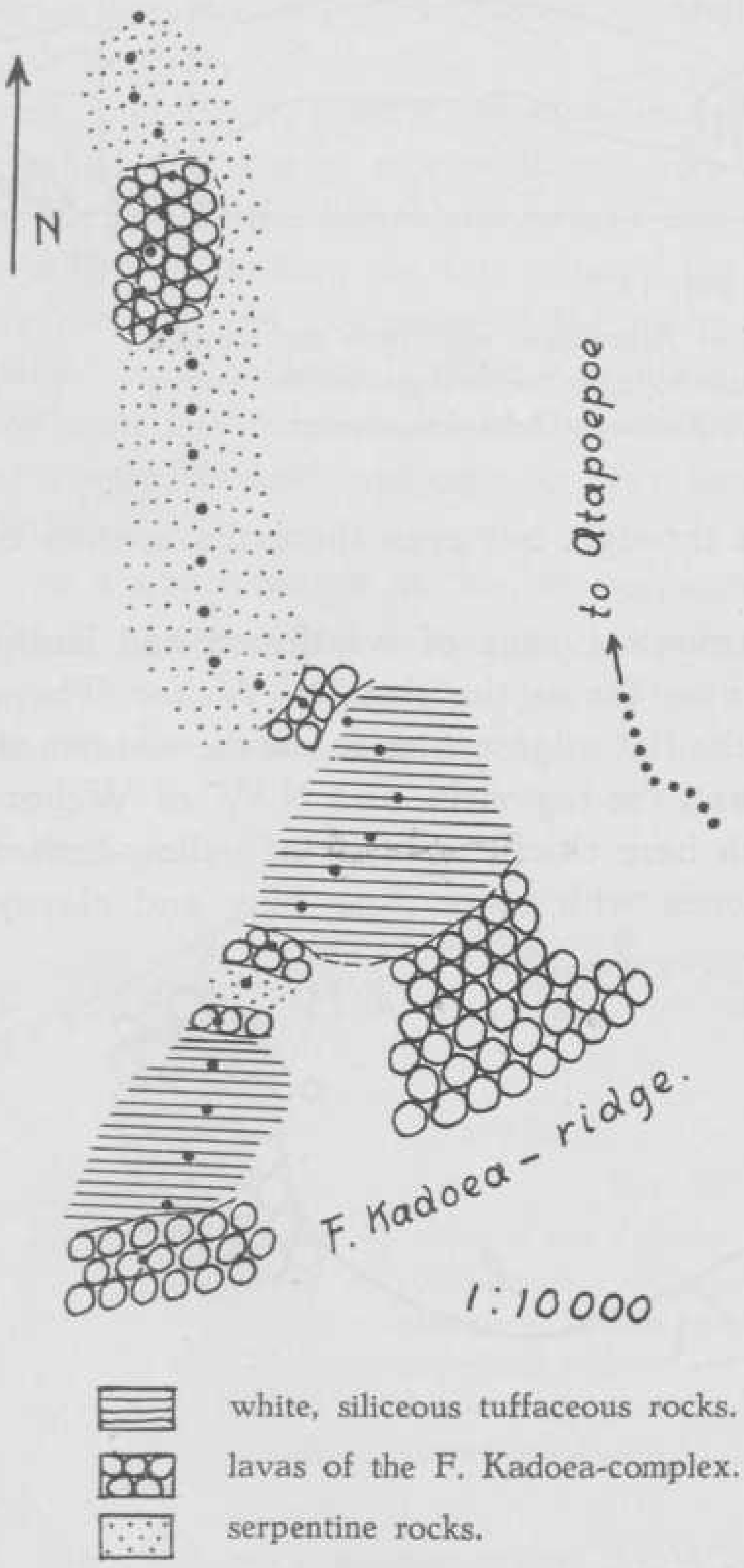

Fig. 15.

S. of the F. Kadoea-ridge lies a second, much lower ridge of a rhyolitic rock, often with well defined idiomorphic, quartz phenocrysts. The two ridges are separated by a zone of detritic material (fig. 16). S. of the

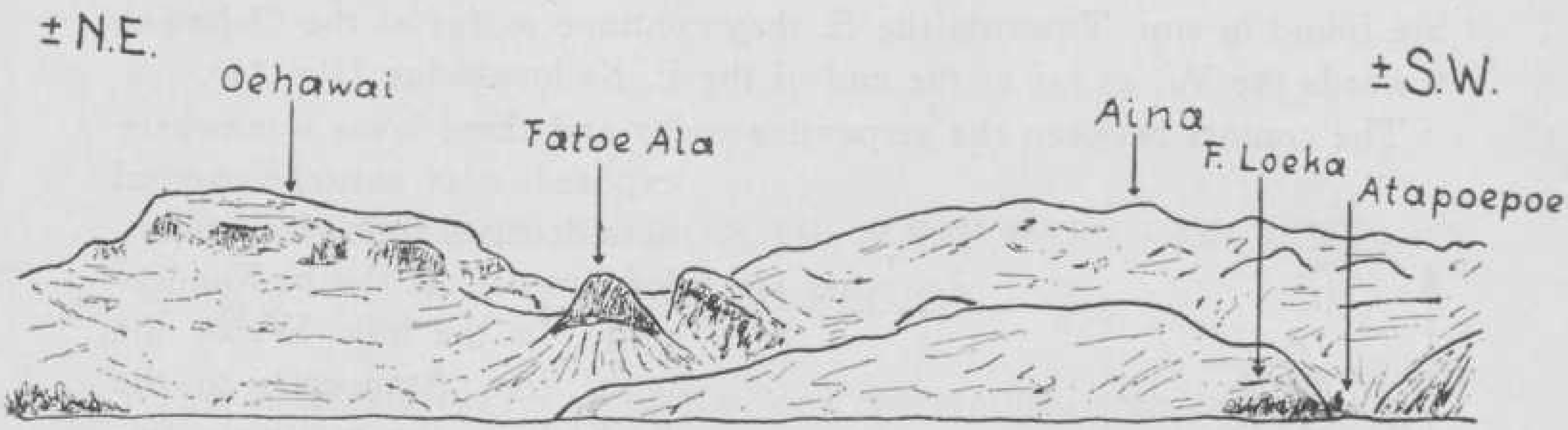

Fig. 14.

View of the coastal region near Atapoepoe, seen from the seaside.
In the foreground the serpentine hills, in the background the young pillow lavas of the F. Kadoea—Oehawai-complex.

F. Kadoea-gorge a river has cut through, but even there the contact is not exposed.

Farther on, the trail leads through a zone of weathered and badly exposed tuffs and eruptive rocks, as far as the slope to Wehor. There the Kekneno-series is exposed in the flat ridge, which forms the watershed between the basin of Atamboea and the region N. and N.W. of Wehor. The deposits of this series, which here chiefly consists of yellow-brown to grey, calcareous mica-sandstones with some more limy and clayey

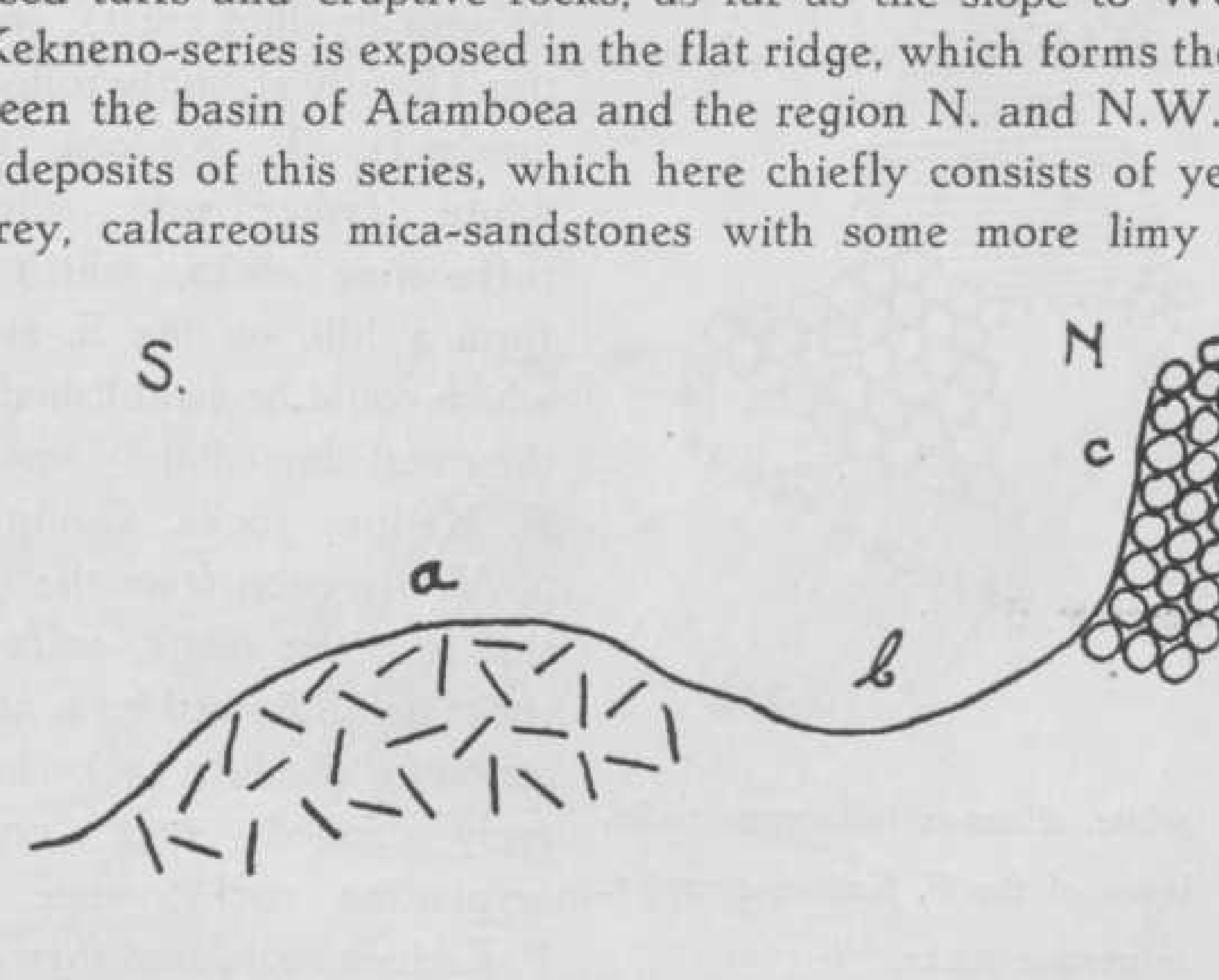

Fig. 16.

F. Kadoea- and Medamori ridges, S. of the top Aina.
a = rhyolite.
b = zone with detritic material (rhyolite + basalt).
c = basaltic pillow lava.

strata, are strongly folded. S. of the mountain Laisahé, which consists of a weathered, diabasic rock, lies a low ridge of serpentine rock, the Kekneno-sandstone dipping under it. A little more to the E., near the bivouac and the kampong of Wehor, the contact between the Kekneno-series and the serpentine rocks, situated S. of it, is completely covered with detritus.

N. and E. of Wehor some isolated patches of completely rolled out, crushed and partly recrystallised, grey-white, pink and red limestones with chert of the Sonnebait-series occur.

After descending the flat ridge of the Kekneno rocks in a S. direction we arrive at an extension of the plain of Atamboea. The difference in height is approximately 80 m. On either side the serpentine hills continue for some distance, as far as the real plain of Atamboea, which consists of young fluviatile deposits as may be observed in the channel of the Talaoe.

In a small trough in the W. serpentine hills, which is open towards the E., some small outcrops of partly very much rolled and crushed deposits of the Sonnebait-series, especially pink limestones with fragments of red chertbands, are found.

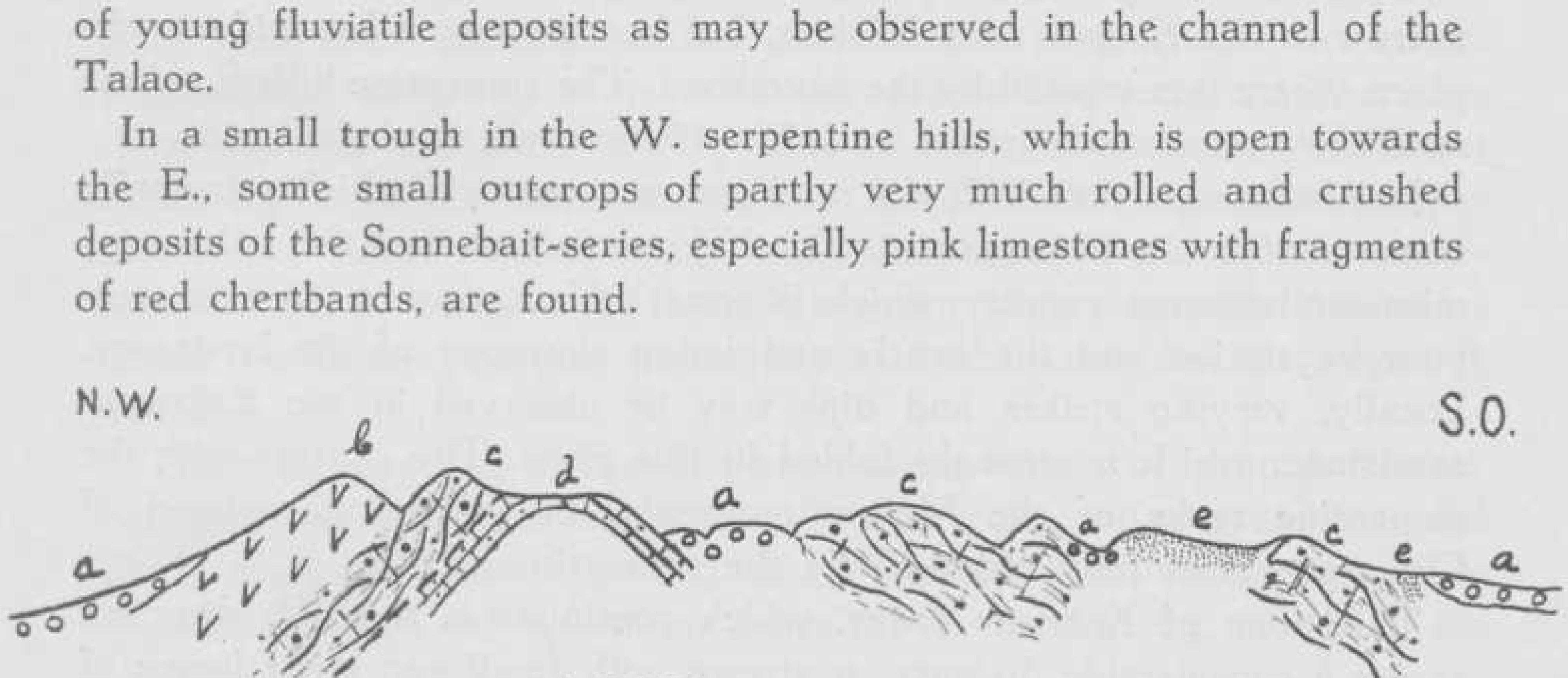

Fig. 17.

Section through the W. slope of the Laisahé, near Wehor, towards the south-east.

a = young terrace deposits and taluses.
b = weathered diabase rock.
c = serpentine rocks.
d = Kekneno-series.
e = Sonnebait-series and Fatoe limestones.

Fig. 17 shows a section across the W. slope of the Laisahé near Wehor, towards the S.E.

b. The country on either side of the motorroad Atapoepoe-Atamboea.

From Atapoepoe to Berloeli the motorroad follows the N. side of the Wehedan—Boesamata-complex, which here also consists of brecciated and sometimes strikingly "conglomeratic" serpentine rocks. Among these, apparently undisturbed serpentine rocks occur too, but when they are inspected more closely, they show distinct traces of movement.

Here the road leads partly through a coastal plain, which is mostly grown with cocopalms. On the seaside it is adjoined by mangrove swamps, followed by the coastal reef, which during low tide becomes nearly dry. Locally it is some hundred meters broad.

A little before Berloeli, an artificial passage has been made in the serpentine hills. W. of these there is a second coastal plain. Here the motorroad turns to the S. and follows the natural passage of the M. Berloeli between the Wehedan—Boesamata-complex and the Makon mountain. On the S. side of this complex there is another plain, closely overgrown with gewangpalms and all kinds of bushes, which is rather narrow in the E. part near Wekiar, but becomes some km wide in the place, where it is crossed by the motorroad. The serpentine hills E. of the road show an almost vertical wall, 75—100 m high, on their S. side.

Just before km pole 292, the road enters a country, which principally consists of rocks belonging to the Kekneno-series, i.e. the calcareous mica-sandstone, a country which is remarkable owing to its extremely poor vegetation and the gently undulating character of the landscape. Locally, varying strikes and dips may be observed in the Kekneno-sandstone, which is strongly folded in this place. The contact with the serpentine rocks of the Makon mountain, in the neighbourhood of Oemarese, is entirely obscured by the serpentine detritus.

This zone of Kekneno rocks, which continues in a S.W. direction across a considerable distance, is strewn with small and large lumps of various, rolled and brecciated, partly recrystallised, limestones, chiefly belonging to the Sonnebait-series, occasionally with drawn out siliceous bands and moreover mylonitised serpentine rocks, which are often completely kneaded together with the limestones. Beside these, there are blocks, often with a diameter of several meters, of reddish crystalline limestones, sometimes with rests of crinoids and also dense, beige to grey, semicrystalline, Triassic limestones of the Fatoe-complex.

Especially in the country W. of the motorroad, all this can be studied very well. The serpentine rocks occur in more or less lenticular masses, which often have a diameter of only 20 m. They are very strongly rolled and crushed, sometimes with polished lenses, consisting of harder parts, and intersected by countless slickensides.

Usually these serpentine lenses are accompanied by strongly disturbed rocks of the Sonnebait-series, e.g. near km pole 291, where rolled and crushed red limestones, with brown-red chert, pink slabby limestones with flesh-coloured-white chert (with Globotruncanae) and besides, white and light pink compact limestones with Globigerinidae were found.

Nearer to Atamboea a zone of eruptive rocks follows. First some rather weathered, amygdaloidal rocks. The connection with their surroundings could not be made out. Farther on, near km pole 290, a section occurs in volcanic agglomerates and tuffs, striking N. 32° E. and dipping 55° to the S.E., probably belonging to the Tertiary volcanic deposits. In the thick beds of coarse agglomerate, which form the lowest part, here and there non-weathered olivine may still be noticed in the matrix. A number of layers of varying thickness, now yellow or yellow-brown, now more purple, consisting of lapilli and ash follows. In various places may be observed how layers of coarse material, gradually pass into layers of finer and finer material, which phenomenon is frequently repeated. Interbedded, hardened white tuffs also occur. The connection between these deposits and the following zone of Kekneno-sandstone could not be detected. In this zone too, among the Kekneno deposits, lenticular masses of rolled and crushed serpentine rocks were found, mostly accompanied by rocks of the Sonnebait-series, while crystalline limestones of the Fatoe-complex also occur. Especially between the km poles 288 and 287.

There the deposits of the Sonnebait-series consist of strongly folded, red, grey and greenish, calcareous, siliceous rocks, full of radiolaria, and finely crystalline, thinly bedded and laminated violet limestones. They are also found W. of the motorroad in the M. Sabiak (fig. 18). E. of the

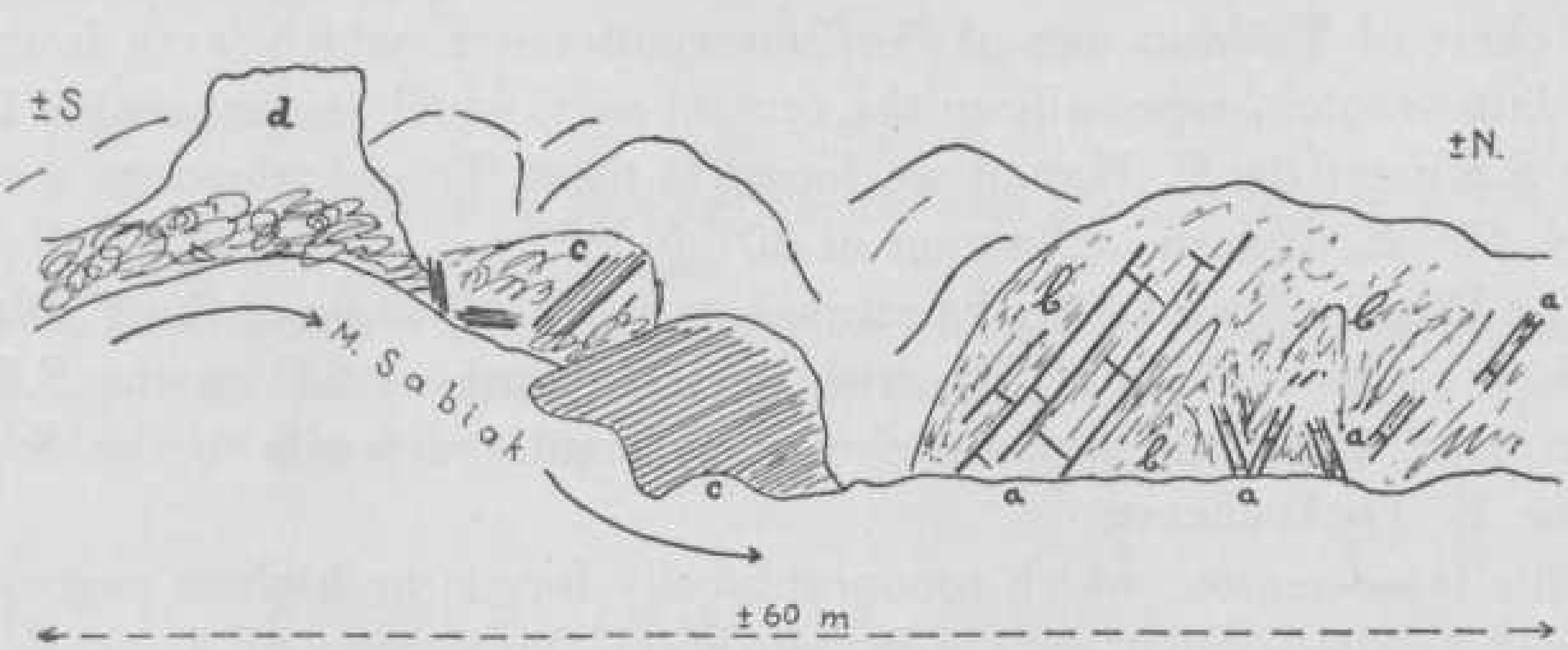

Fig. 18.

In the M. Sabiak, W. of the mountain Manoeba.

Kekneno-series { *a.* calcareous mica-sandstone.
b. crushed, clayey strata.

Sonnebait-series { *c.* thinly bedded, grey limestones.
d. crushed and laminated violet and red limestones.

road, approximately S. of the F. Wemeko and still farther E., various isolated masses of rocks of the Sonnebait-series occur, chiefly compact, pink and red limestones with drawn out and mutilated chertbands (plate II, fig. 3).

From the Manoeba mountain, S.S.W. of the kampong which bears the same name, the road, which there reaches its highest point, leads through a complex of mostly very much pressed and weathered, eruptive rocks, in which sandy tuffs and finely conglomeratic deposits with Permian bryozoa also occur.

About half-way between the km poles 284—283 the plain of Atamboea is reached. The region S. of this part of the road is covered for a great part, by displaced material of the Fatoe-complex; among it, rocks of the Sonnebait-series are found in various places.

c. The Lidak mountains and their neighbourhood.

1. *The country N. of the F. Toekoenenoe.*

This region, in which the highest tops occur, is the fatoe-region, proper of Lidak (pl. III, fig. 1). The greater part is taken up by fatoes of Permian and Triassic ages, as has been described on page 20 and 29. Beside these, eruptive rocks also occur, a.o. due N. of the F. Toekoenenoe, where they build up the F. Noireeoe and the Faffinoré. The latter resembles the rock of the Fatoes Monoe-bot and Monoe-kiiek. Its connection with the deposits of the Fatoe-complex could not be established. Nor could its connection be established with the light coloured limestones and chert of Triassic age of the Sonnebait-series, which were found in this fatoe-region, especially in the central part, which is remarkably level. Due S.S.E. of the F. Nanait we found in these Triassic deposits a strike of N. 57° E. and an inclination of 80° N.W.

The Permian, crystalline limestones in the S.W. slope of the F. Nanait show a strike of N. 65° W. with an inclination of 55° to the S.S.W. The same strike and dip are shown by similar deposits in the S. part of the F. Toekoenenoe.

This fatoe-region, which topographically forms the highest part of the district, is surrounded on nearly every side by a zone of detached and displaced material. In a broad zone, especially N. and W. of it, numerous rock-masses, belonging to the Fatoe-complex occur, which for a great part must have been carried along by the denudation movements from an originally higher locality. In some cases fluviatile erosion may have played a part as well, owing to which, strong rounding off took place. We cannot say with certainty, that all these masses of rocks, which often have considerable dimensions, were detached and displaced from the higher fatoe-region, especially in connection with the rocks of the Sonnebait-series, occurring in the same zone, which mostly show traces of strong movements. This may be established a.o. in the little river M. Bonoe, W. of the F. Soemeta near Sesekoi, where there is a small outcrop of crushed deposits of the Sonnebait-series, covered by debris of the Fatoe-complex. The general strike of the gliding planes is ± N.N.W., the inclination is varying W.S.W.

A similar observation was made near the well We Kokoea, E. of Sesekoi (fig. 19). The vertical wall of the Permian Fatoe Kokoea runs

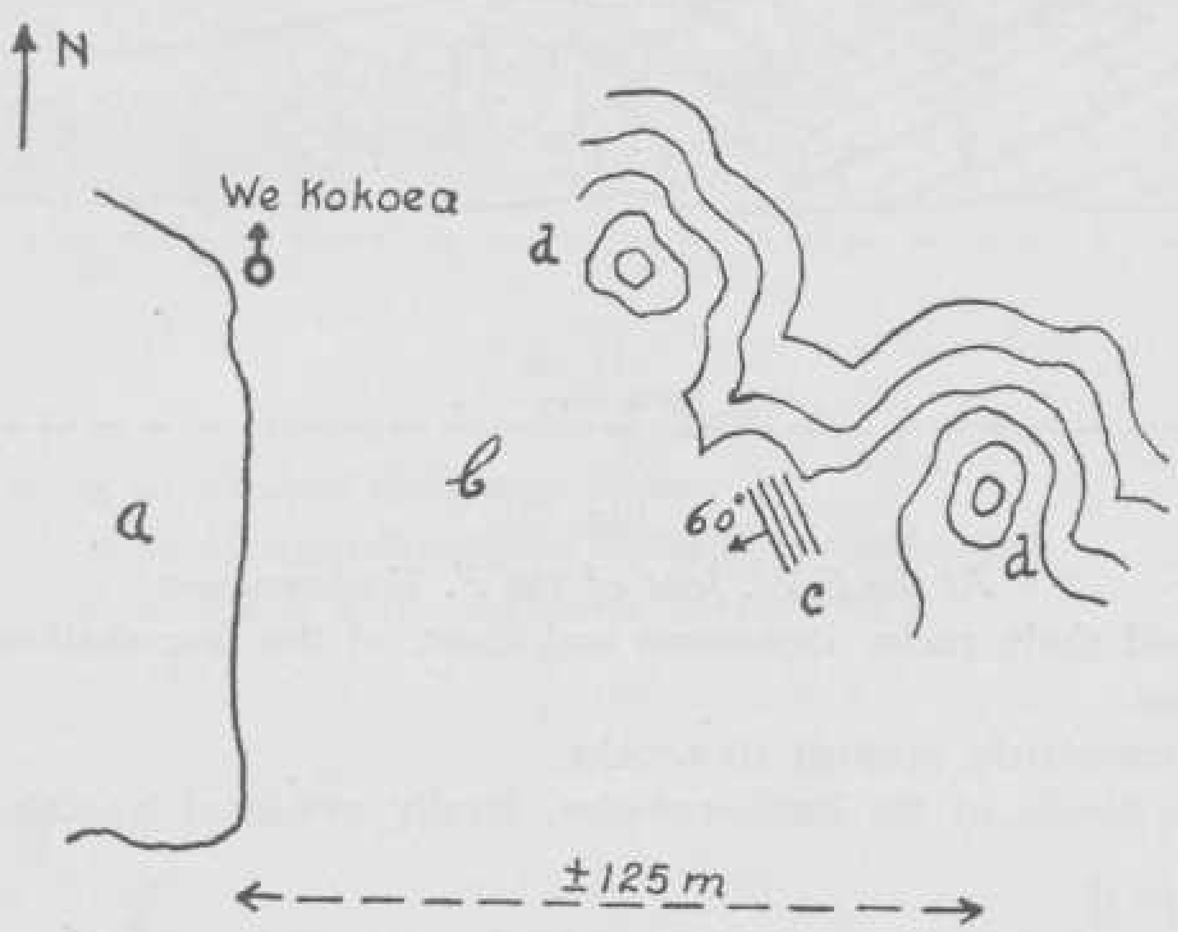

Fig. 19.

Sketch of the situation near the well We Kokoea.

a = Permian of the Fatoe-complex.
b = zone of completely crushed and rolled out rocks of the Sonnebait-series.
c = strongly laminated limestones of the Sonnebait-series.
d = crushed serpentine rocks.

nearly S. from the well. E. of it there are two hillocks of strongly pressed and crushed serpentine rocks and in the zone between, all kinds of crushed and rolled rocks of the Sonnebait-series occur, among which the limestones containing Halobiidae may still be recognized. The average strike of these rolled and crushed rocks was found to be N.N.W., with an inclination of about 60° W.S.W.

2. *The country S. of the F. Toekoenenoe.*

In the region S. of the F. Toekoenenoe, Triassic deposits, containing Halobiidae, of the Sonnebait-series, occur frequently. They are always strongly folded and locally rolled out, forming multicoloured zones of clay, e.g. S.W. of the F. Toekoenenoe in the little river, approximately W. of the spring (fig. 20). Basic eruptive rocks were found in various

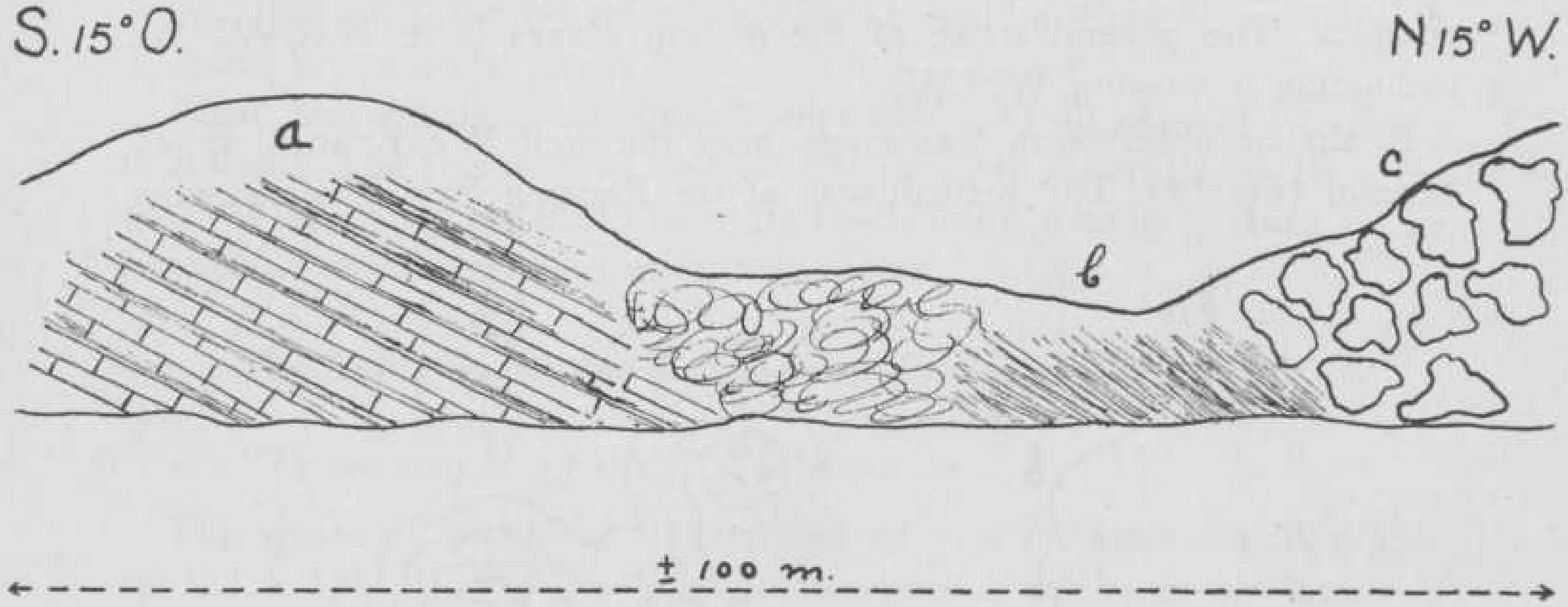

Fig. 20.

At the S.W. foot of the F. Toekoenenoe.

a = clayey and shaly rocks, limestones and chert, of the Sonnebait-series, containing Halobiidae.

b = zone of completely crushed clay-rocks.

c = limestone blocks of the Fatoe-complex, locally cemented by calc-sinter.

places among these deposits, but whether they lay conformably in this series, or are of younger ages, could not be determined.

Approximately N. of Weloerai, between this kampong and Tala, an outcrop of crushed and rolled out serpentine rock was found. The light coloured Triassic limestones with chert of the Sonnebait-series clearly rest upon these serpentine rocks (fig. 21); they have a strike of N. 62° E. and an inclination of about 30° S.S.E.

A little S. of the F. Toekoenenoe, lies the F. Manoeaman (fig. 22). The highest part of it consists of dense, beige, semi-crystalline limestones, in which oolitic structures may be noticed locally, as described on p. 30. The N. part, which is lower, consists of light flesh-red to red, very compact limestones with a conchoidal fracture (p. 32) alternating with red to red-brown chertbands and a brown radiolaria-rock. They show distinct traces of movement and are completely brecciated locally. Their strike is E. to W. on an average; the dip is 50° N. in the S. part; more towards the N. it increases till the position of these strata is almost vertical in the most N. part. More towards the W. they are even overturned.

The E. continuation of the F. Manoeaman is much lower. Close to the

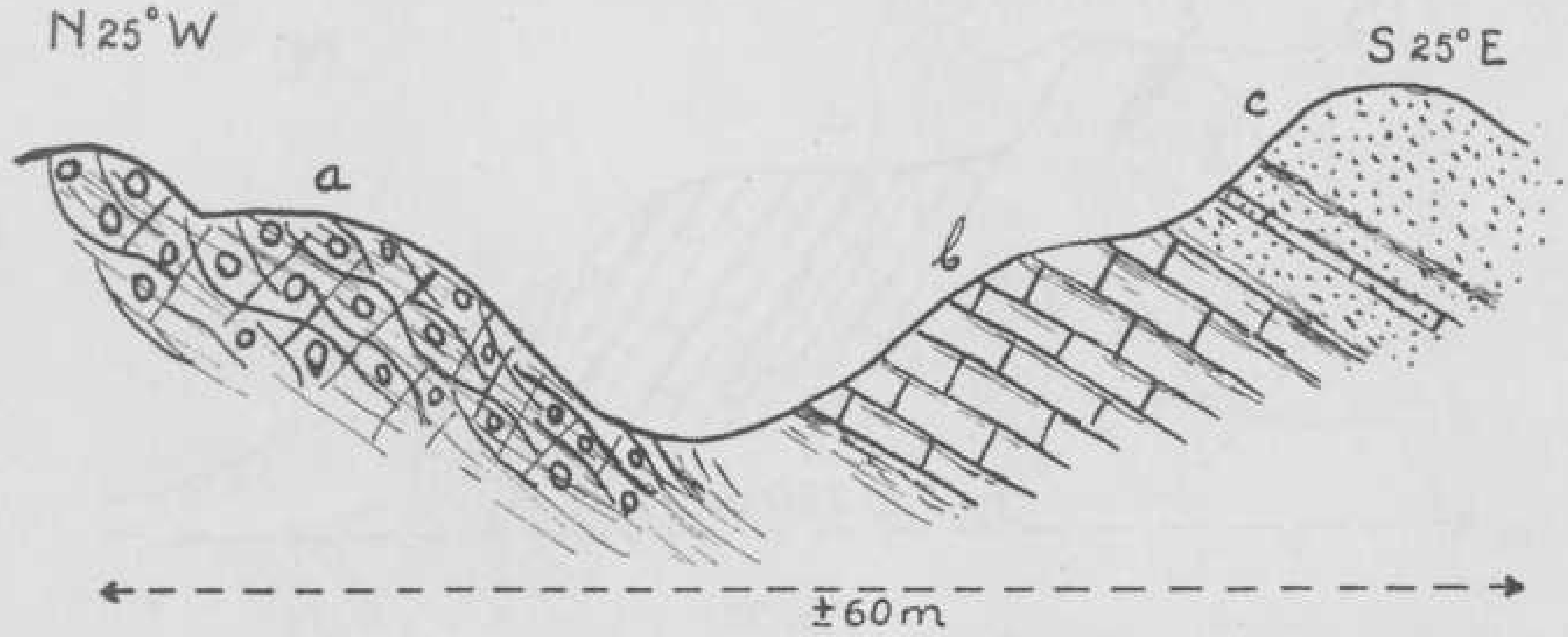

Fig. 21.

Between Weloerai and Tala.

a = crushed serpentine rocks.
b = *Monotis*-limestones of the Sonnebait-series.
c = chert, with limestones interbedded.

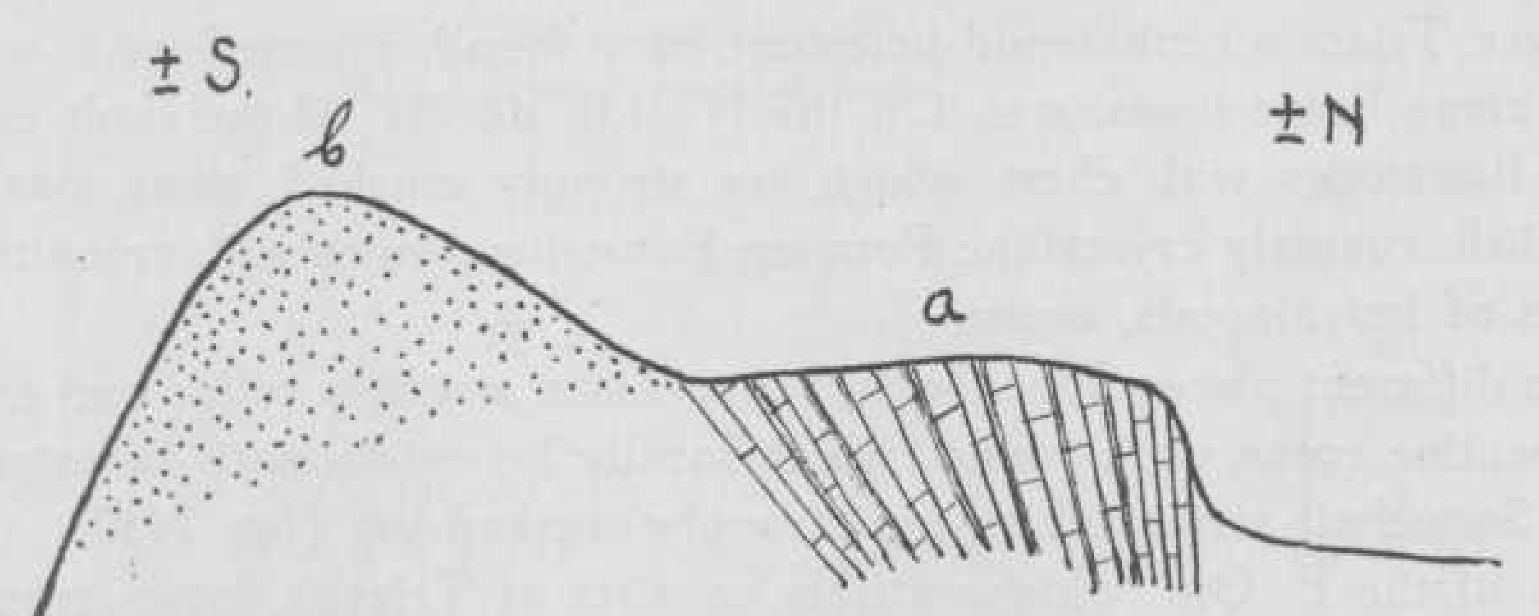

Fig. 22.

Highest part of the F. Manoeaman.

a = red to flesh-coloured, dense limestones with red chertbands and red-brown radiolaria-rocks.
b = dense, beige, oolitic limestones of the Fatoe-complex.

W. of Berkase the following details could be observed (fig. 23). Here too the ridge has a higher S. part, which is built up of the same Triassic Fatoe-limestones and a lower N. part, which again consists of flesh-red to red, compact limestones with chertbands and a brown radiolaria-rock, strongly crushed locally. On the steep S. side of the top, orange-red

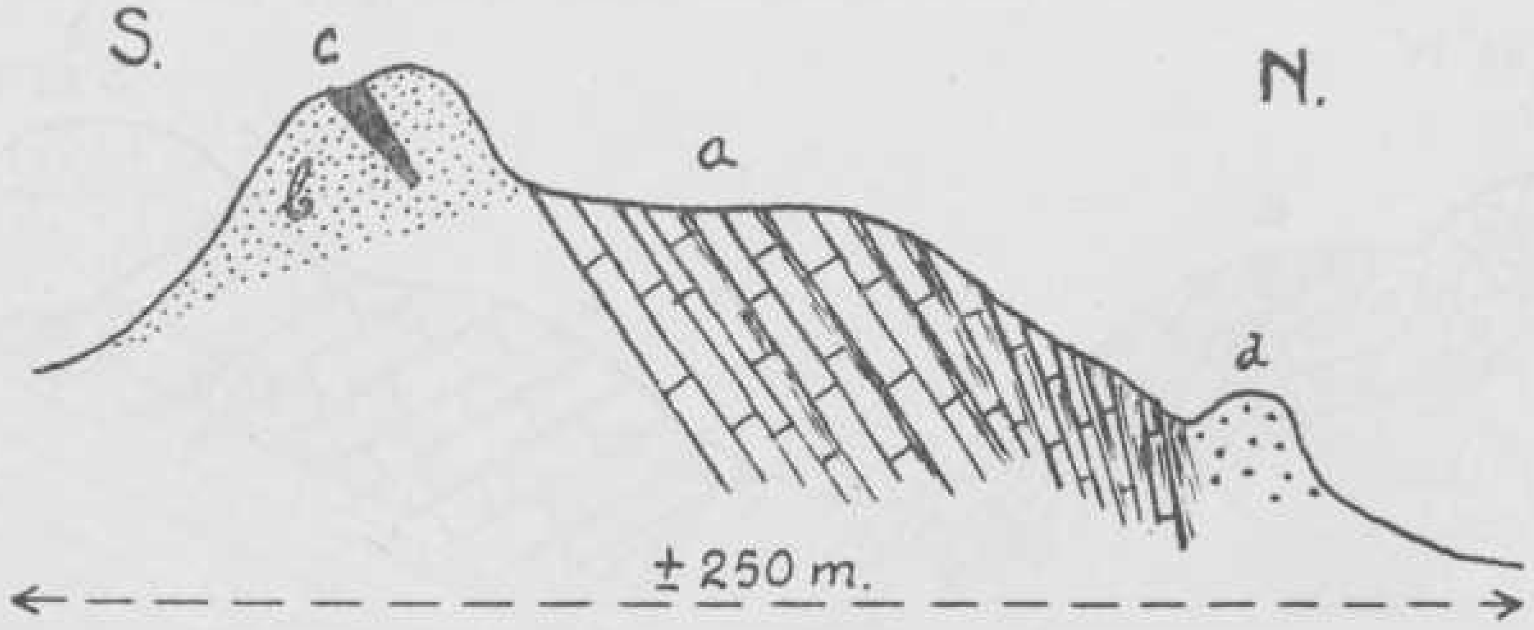

Fig. 23.

Eastern extension of the F. Manoeaman, close to Berkase.

a = compact, flesh-coloured to light brick-red limestones, alternating with red to brown chertbands and radiolaria-rocks, with calcareous and argillaceous cement.
b = dense, beige, oolitic limestones of the Fatoe-complex.
c = Lower Triassic cephalopod-limestone.
d = coarsely crystalline, Permian limestones of the Fatoe-complex.

Lower Triassic cephalopod-limestone was found, jammed as it were in the beige Fatoe-limestones. On the N. side, due N. of the flesh-red and red limestones with chert, which are strongly crushed, some masses of reddish, coarsely crystalline Permian Fatoe-limestones with trochites and rests of brachiopods, occur.

In different places S. of the F. Manoeaman strongly rolled and crushed serpentine rocks were found, which locally lie on *Monotis*-limestones of the Sonnebait-series, which are strongly crushed too (fig. 24).

S. of the F. Oni, which entirely consists of Triassic fatoe-limestones, strongly rolled and crushed serpentine rocks were also found. Between the F. Oni and this outcrop of serpentine rocks, light brick-red, marly limestones with Globotruncanae occur. S. of the serpentine rocks (fig. 25) light, beige limestones with Globotruncanae were found and still farther S., *Monotis*-limestones, Permian deposits, containing ammonites with at the base the conglomerate of weathered, eruptive rock-fragments, showing a strike of N. 79° E. and a dip of 40° N. and also amygdaloid, occur once more. Nothing could be observed here, concerning the mutual relations between Cretaceous, Triassic and Permian.

In the M. Baoekonoe, ± S.S.W. of Weklosoen, across a distance of a few hundred meters the rocks of the Kekneno-series are exposed, though interrupted by young terrace-deposits. It is chiefly the familiar

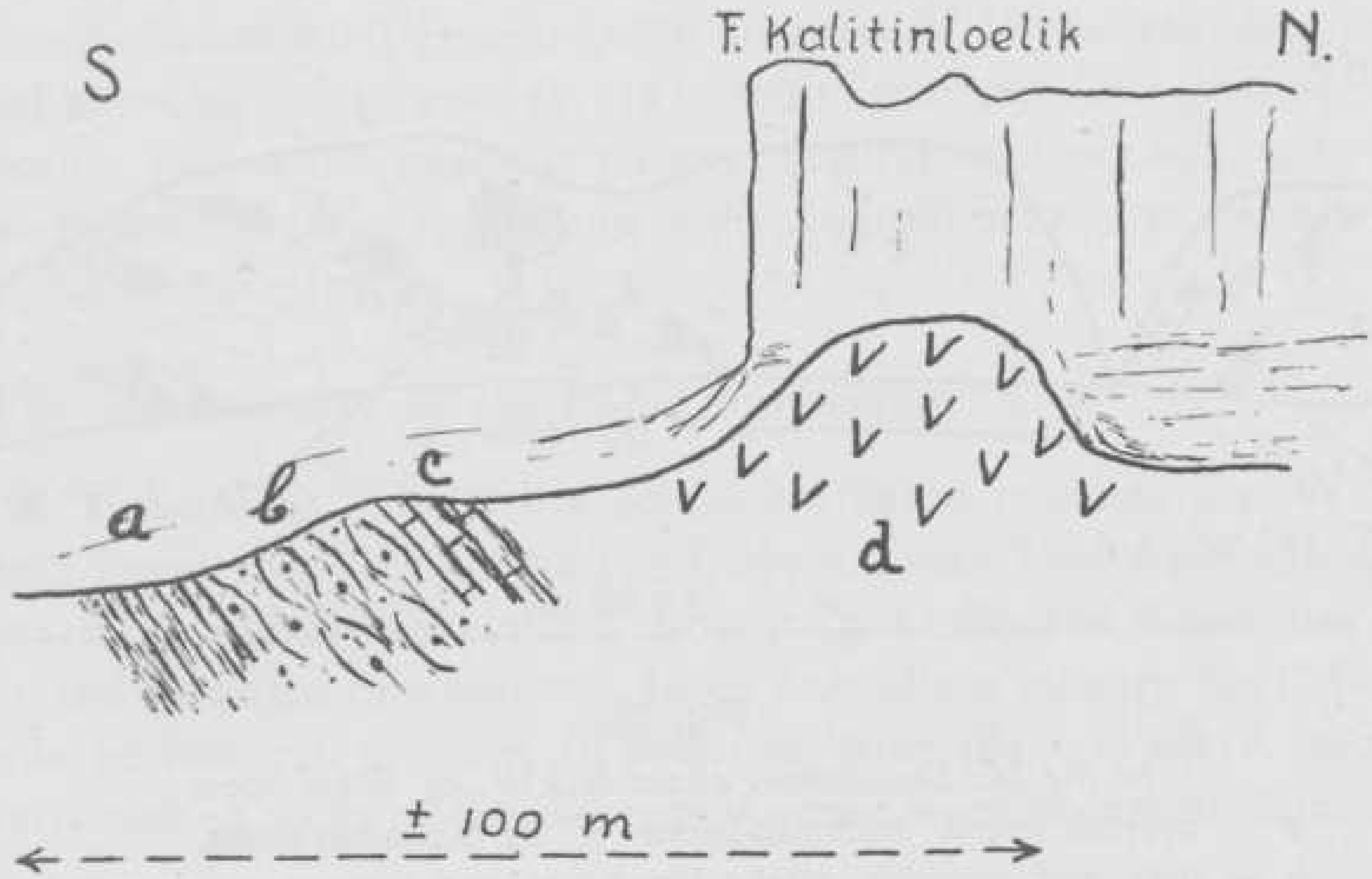

Fig. 24.

South of the F. Manoeaman.

a = crushed *Monotis*-limestones of the Sonnebait-series.
b = crushed and rolled serpentine rocks.
c = compact, red limestones with chertbands.
d = weathered basic eruptive rock.

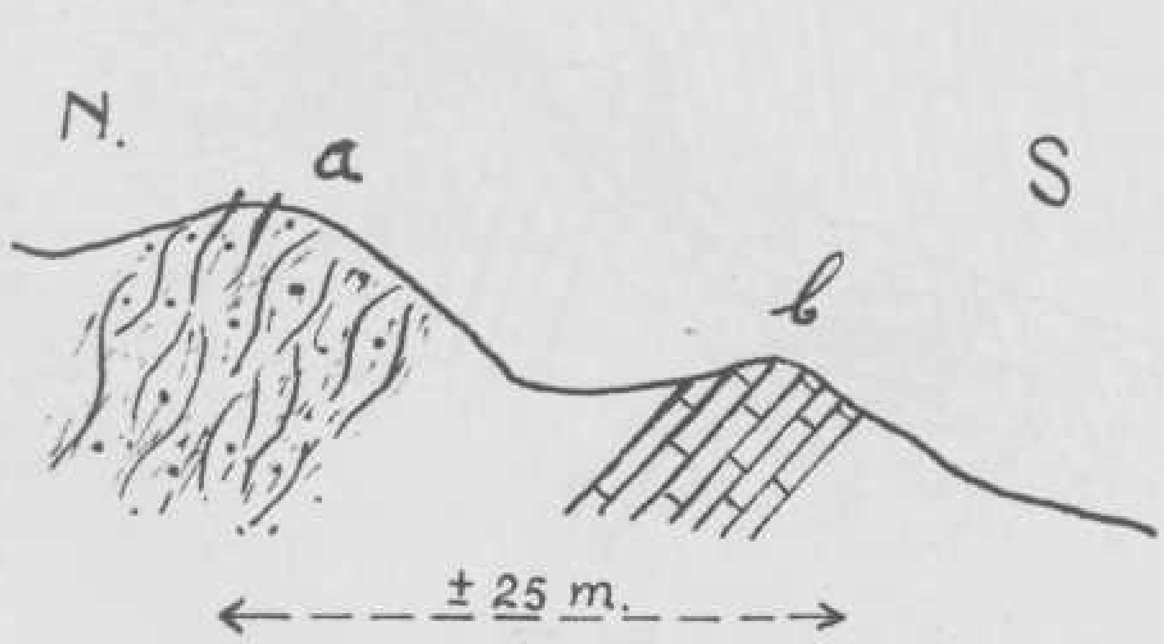

Fig. 25.

West of Halitoekoe.

a = crushed serpentine rocks.
b = beige limestones with Globotruncana-fauna.

grey-greenish mica-sandstone, with a strike of N. 73° W., and a dip of 60° S.S.W. (fig. 26). On the crushed sandstone lies a zone, locally with beds of grey and greenish, marly limestones and calcareous clay-rocks (*b*) of which could not be said, whether they belong to the Kekneno-series or to the Sonnebait-series. They have the same strike as the sandstone, but owing to creep, a dip of only 25° S.S.W. Thereupon

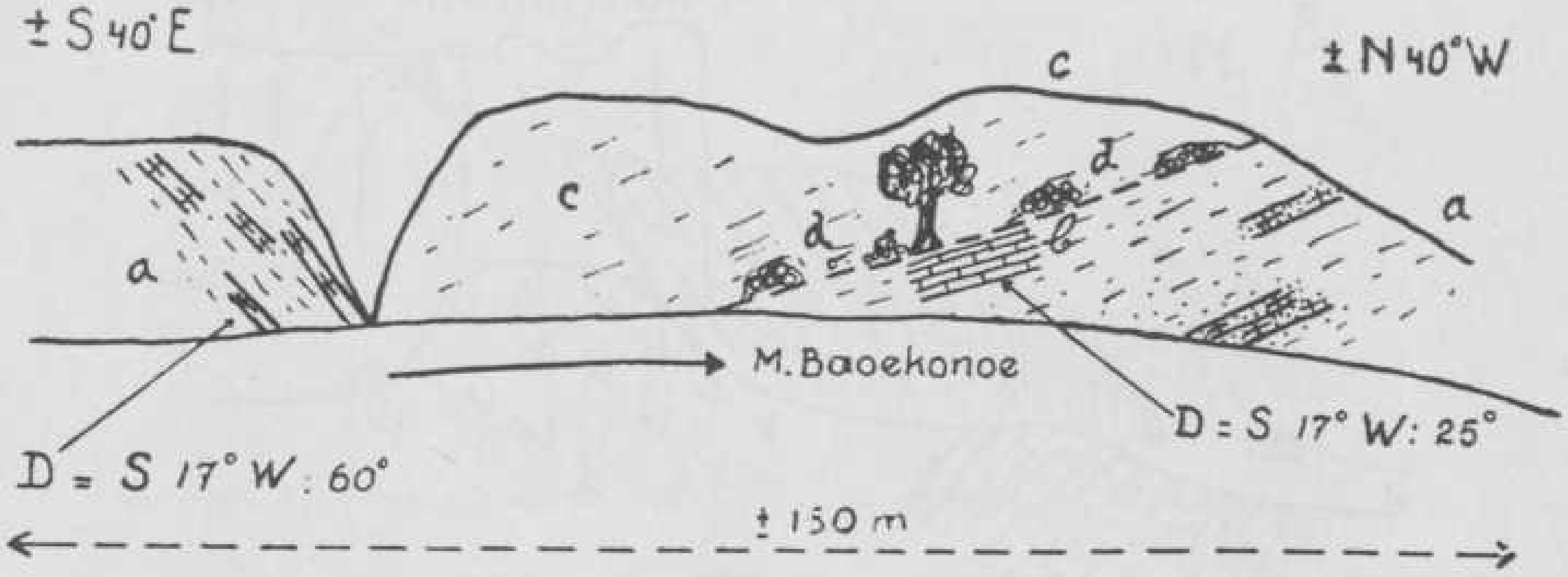

Fig. 26.

In the M. Baoekonoe, about S.S.W. of Weklosoen.

a = greyish green, mica-sandstone of the Kekneno-series.
b = grey and greenish, marly limestones and calcareous clay-rocks.
c = red-brown Permian deposits of the Sonnebait-series.
d = fragments of amygdaloidal rocks and conglomerate.

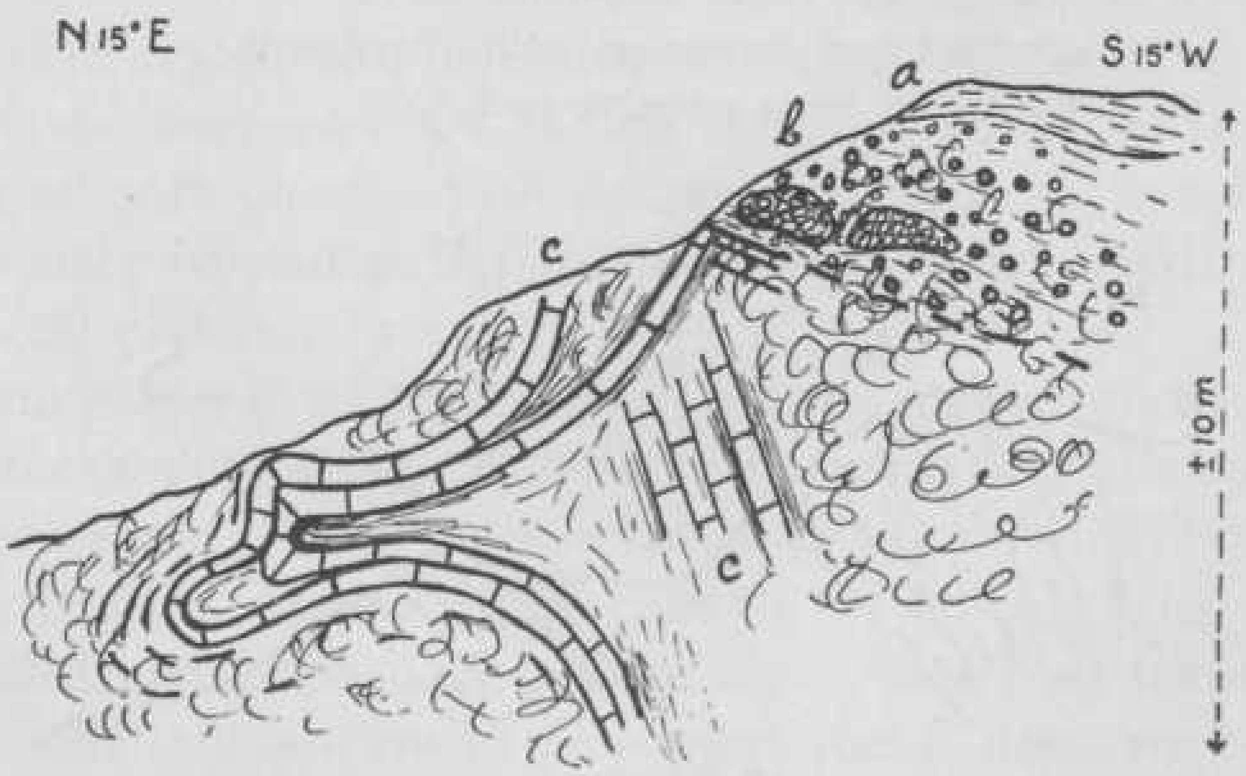

Fig. 27.

In the M. Baoekonoe, about S. of Weklosoen.

a = red-brown Permian deposits of the Sonnebait-series.
b = crushed amygdaloid and conglomerate.
c = greenish, grey and ashcoloured, marly limestones.

lie red-brown, Permian deposits of the Sonnebait-series (*c*) with ammonites; at their base there are crushed and weathered fragments of amygdaloid and the conglomerate of weathered, eruptive rock-fragments (*d*).

Something similar was observed more towards the E., about S. of Weklosoen (fig. 27). There the sandstone is not exposed, but deposits of red-brown Sonnebait-Permian (with ammonites, *Orthoceras*-fragments and stem-ossicles of crinoids) (*a*) with crushed amygdaloid and conglomerate (*b*) at the base, lie on strongly folded, greenish, grey and dark ashcoloured, marly limestones with a great many, extremely fine shells of Halobiidae (*c*).

3. *The surroundings of the Fatoe Fohomalas.*

The F. Fohomalas, which lies somewhat more towards the W. and on a much lower level, as if it had slid down, away from its companions, is composed of coarsely crystalline, mostly light coloured limestones with trochites and Permian brachiopods. In its immediate vicinity the detached and displaced material prevails. In between, from place to place, strongly rolled and crushed rocks of the Sonnebait-series were observed. Especially

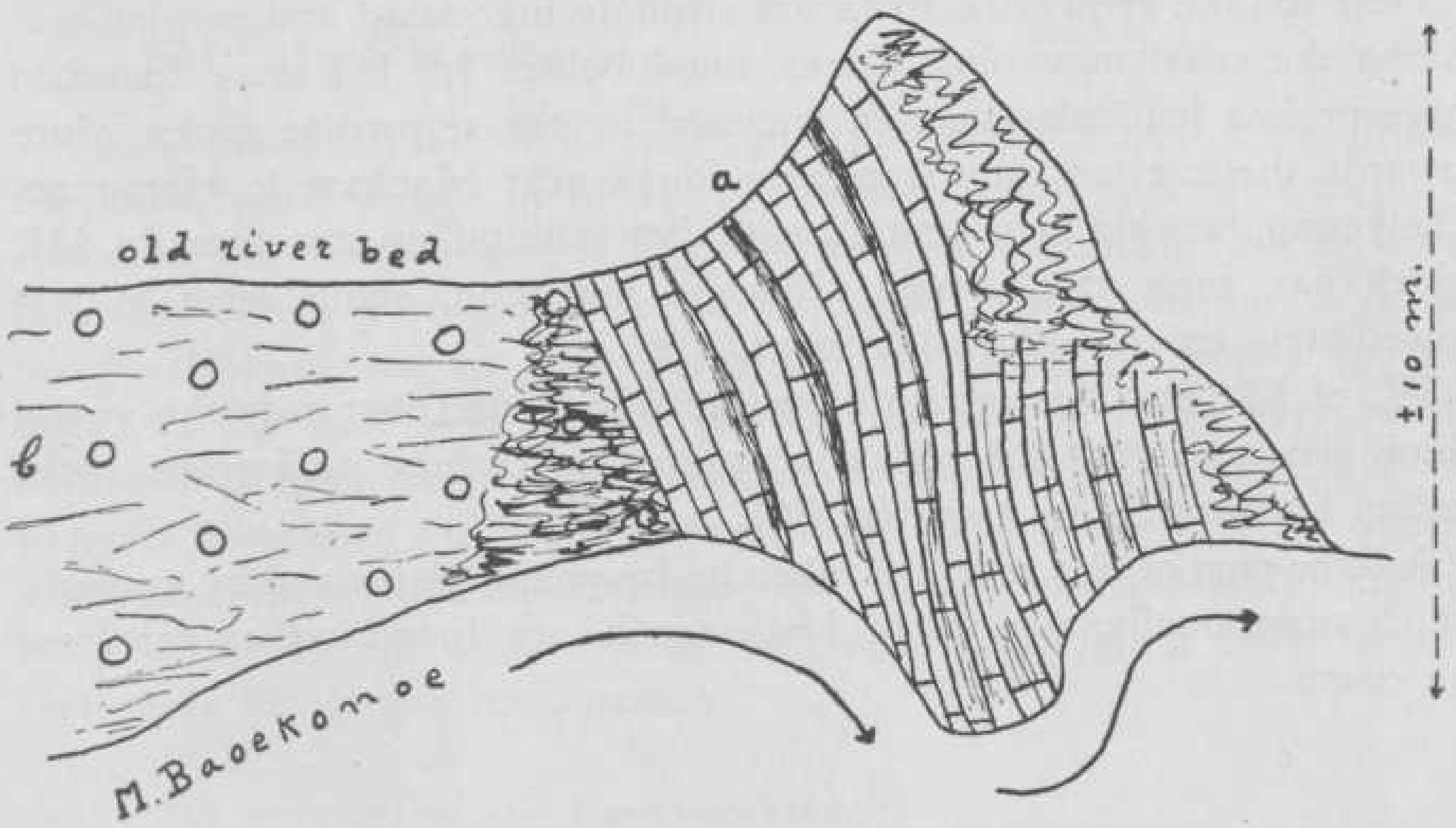

Fig. 28.

In the M. Baoekonoe, about S.S.W. of the F. Fohomalas.

a = argillaceous limestones and calcareous clay-rocks of the Sonnebait-series, containing Halobiidae.

b = old river terrace.

the crushed light brick-red, marly limestones with brown and greenish patches of clayey material, which in view of their Globotruncana-fauna, belong to the Upper Cretaceous, are easily recognized. They were often found, a.o. S.W., N.W. and also N. of the F. Fohomalas, where they occur along the path from Hoféhan to F. Kabélak, across a considerable distance. The kampong of Hoféhan is built on weathered, amygdaloidal eruptive rock. Beside these cretaceous rocks, rocks containing Halobiidae of the Sonnebait-series were found repeatedly. Near We Alas, S. of the F. Fohomalas, they are strongly rolled and crushed and lie under the red-brown, Permian limestones with chertbands of the Sonnebait-series, which in this locality show a strike of N. 42° W., with a dip of 25° N.E.

A little W. of the F. Fohomalas the Kekneno-series is once more exposed. There the strike is about N. to S.; more N. it is approximately N.E.—S.W. and farther on, towards the N.E. it runs about E. to W.

In the larger rivers, such as the M. Baoekonoe, dissected river terraces are found, which most probably point to a younger uplifting (fig. 28).

d. The coastal region W. of Berloeli.

Most observations, which could be made in this region have been mentioned above.

Here too the serpentine rocks are strongly brecciated and mylonitised. Along the coast in various places, amphibolites (p. 11) were found in more or less lenticular masses, enclosed by the serpentine rocks. More towards the interior, they were also found near Mankase in Harnenno. The young, basaltic to andesitic lavas, often with pillow-structures (p. 44), which a.o. form the pointed Oipiekan mountain, again seem to rest immediately on the serpentine rocks.

W. of Maoebesi no serpentine rocks were found, but only the young pillow lavas, with *Globigerina*-limestones, marls and tuffaceous rocks resting horizontally on them (p. 36).

A large part of this region is taken up by young plains and by swamps, which occasionally, e.g. S. of Halimaneëk, are found rather far from the coast.

MAJOR GEOLOGIC FEATURES OF THE EXPLORED REGION.

The explored region might be divided into the following tectonic units.

1. *The Kekneno-series.* This is the lowermost unit.

It was found principally W. and N. of the Lidak mountains. In various localities in this zone, masses occur of strongly tectonically influenced rocks of the Sonnebait-series, as well as lenticular masses of serpentine rocks, and also rocks of the Fatoe-complex, which however partly show distinct traces of fluviatile erosion.

In the M. Sabiak, W. of the Manoeba mountain and in the M. Baoekonoe (p. 83 and 90) could be established, that the rocks of the Kekneno-series dip under those of the Sonnebait-series. The existence of this overthrust-plane, which had already been suggested by WANNER (55), was confirmed by the investigations, made in 1937 (10).

2. *The Sonnebait-series.*

The deposits of this series were principally found in a zone around the fatoe-region proper of Lidak, but in the central part of it they are also exposed. These rocks, strongly influenced tectonically by the overthrusting of the Fatoe-complex, dip distinctly under it as e.g. S.W. of the F. Toekoenenoe (p. 86), W. of Sesekoi in the M. Bonoe (p. 85) and near the well We Kokoea (p. 85). Locally they are even partly stripped off from their original position in the Sonnebait-series, like the compact limestones with chertbands of the N. part of the F. Manoeaman. The structure of the Sonnebait-series, which was probably already complicated, owing to older phases of mountain-building (56), became even more intricate in consequence.

3. *The deposits of the Fatoe-complex.*

These lie tectonically higher than those of the Sonnebait-series, and topographically too they form the highest part of the country. They consist chiefly of Permian and Triassic limestones (p. 20 and 29) and possibly a part of the eruptive rocks also belongs to this unit.

4. *The rhyolitic to quartz-andesitic rocks and the basic andesites to basalts* with the Young Miocene and/or Pliocene *Globigerina*-limestones, marls and tuffaceous rocks resting on them, have not been subjected to the great overthrust movements, any more than the Quarternary deposits.

The serpentine rocks.

These rocks, which in the investigated area, occur in such large masses and in so many different localities, claim our special attention.

Above has been mentioned (p. 41) that these rocks, for the greater part, show traces of strong movements, which fact has been mentioned before in connection with other localities (22). Hence it is pretty certain, that they played an important part in the great overthrust movements. However, their relation to the other tectonical units could not be established, any more than the fact, whether they might belong to one of these units.

A great difficulty remains in this connection, viz. that the possibility exists, that not all outcrops of serpentine rocks originally belonged to the same mass of serpentine, or that they are of the same age.

We found serpentine rocks first of all along the coast, where they cover a large area. E. of Atapoepoe strongly dynamometamorphic limestones of unknown age occur together with serpentine rocks, and also a partly crushed granite, which must have been carried along by the masses of serpentine rocks. Farther W., in the neighbourhood of the boundary between Beloe and North-Middle-Timor, the serpentine rocks are accompanied by more or less lenticular masses of diopside-plagioclase-amphibolites (p. 49).

Near Wekiar, S. of Atapoepoe, serpentine rocks occur with deposits of the Kekneno-series and strongly rolled and crushed rocks of the Sonnebait-series. In a zone, which runs in a S.W. direction this combination was also found repeatedly, especially along the motorroad Atapoepoe—Atamboea (p. 82).

S. of the mountain Makon, serpentine rocks and Kekneno-sandstone adjoin each other, but their mutual situation could not be established. Near Wehor could be observed however, that the Kekneno-sandstone dips under the serpentine rocks.

Near Oebaha, N.N.W. of the fatoe-region of Lidak, serpentine rocks were found on the border between the Kekneno-series and the Sonnebait-series. About N. of Weloerai, between this kampong and Tala, we could establish, that Triassic rocks of the Sonnebait-series rest immediately upon rolled and crushed serpentine rocks (p. 87).

Therefore all these details might point to the conclusion, that serpentine rocks played a part in the overthrusting of the Sonnebait-series over the Kekneno-series. The observations, made S. of the F. Manoeaman, where, W. of Halitoekoe, beige rocks with Globotruncanae of Upper Cretaceous age, lie under strongly rolled and crushed serpentine rocks (p. 89) might then be ascribed, either to the influence of the overthrusting of the Fatoe-complex, or to the fact, that we are here concerned with two masses of serpentine rocks, with originally entirely different tectonical positions.

However it is striking, that S. of a line, running E.—W. through Halitoekoe, no serpentine rocks were found.

Taking everything into consideration, we do not yet possess sufficient data to establish fully the tectonical position of the serpentine rocks.

Little can be derived from our observations concerning the age of the overthrust movements. The rocks, found between Obenani and Sesekoi (p. 33), which a.o. contain numerous rounded fragments of dense, oolitic Fatoe-limestones, while in the cement Globotruncanae occur, point to the fact, that in the Upper Cretaceous, the deposits of dense, oolitic limestones were already moving.

Whether these rocks, which are sometimes finely and sometimes more coarsely conglomeratic, constitute a separate unit, could not be established.

PALAEONTOLOGICAL APPENDIX.

DESCRIPTION OF SOME PERMIAN AMMONOIDS

from F. Koekatoe, Lidak, by W. P. de Roever [1]).

Waagenoceras lidacense nov. spec. (pl. V — fig. 2).

Description. The shell is extremely globose and involute, slightly flattened on the flanks, but well rounded on the venter. The whorls grow slowly and are deeply embracing, giving a semilunar shape to the cross-section of the whorl, which is much broader than high. The umbilicus is narrow and deep, with a rather sharp umbilical shoulder; the umbilical wall is broad and nearly perpendicular. The involution is rather large. The whorls show three deep constrictions, which pass over the ventral part of the whorl in a practically straight line; on their way from the ventral part to the umbilicus they show however a gentle curve forwards, followed by a curve backwards ending in the umbilicus.

The surface of the shell is not known, but does not seem to have possessed any very strong ornamentation. The body chamber is unknown.

The following measurements give an idea of the shell proportions (the measurements are not very reliable owing to the rather bad preservation of the shells):

	I.	II.
Diameter (D)	42 mm	26 mm
Height of last whorl (H)	21 mm	13 mm
Height of penultimate whorl	14 mm	8 mm
Height of last whorl above venter	8 mm	6 mm
Involution (I)	13 mm	7 mm
Thickness of last whorl (T)	38 mm	26 mm
Thickness of penultimate whorl	29 mm	20 mm
Width of umbilicus (U)	5 mm	4 mm

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[1]) In concluding this description the author wishes to express his gratitude to Prof. Dr. H. GERTH for his advice and valuable suggestions conducive to the determination of the ammonoids.

Shell ratios:

$$\text{I.}\quad \frac{U}{D}=0{,}12 \quad \frac{I}{H}=0{,}6 \quad \frac{T}{H}=1{,}8 \quad \frac{T}{D}=0{,}9$$

$$\text{II.}\quad \frac{U}{D}=0{,}15 \quad \frac{I}{H}=0{,}5 \quad \frac{T}{H}=2{,}0 \quad \frac{T}{D}=1{,}0.$$

The septa are rather close together and in some places almost touch each other. The suture follows a circularly forwards curved line between the sipho and the umbilicus. The external suture is composed of a divided ventral lobe, seven lateral lobes on the flanks, and an eighth lobe is visible on the umbilical wall. There are seven saddles between the ventral lobe and the umbilical shoulder, on which a smaller eighth saddle is situated.

The ventral lobe is divided into two branches by a moderately high and narrow median saddle. Each of the branches is strongly curved, with the convexity towards the umbilical side; they are coarsely dentated and end in one point, which is longer than the others. One smaller point is situated on the ventral side of this branch, and there are three points on the umbilical side. Each of these branches thus bears five points. The lateral lobes are long and rather narrow with nearly parallel sides. The first lateral lobe is not as deep as the ventral one, and shows six secondary points. Two of its points have the same length and on both sides of these two secondary points, there are two others, those near the umbilicus being the longest. The second lateral lobe, which shows five points, ends in one longer point, with two points on each of its sides. The third and fourth lateral lobes are very similar to the second, but less deep. The fifth lateral lobe bears four points, one point being the longest, with two points on its ventral and one on its umbilical side. The sixth lateral lobe bears two longer points, which have nearly the same length, with one more point on each side of them: the whole lobe thus is fourpointed. The seventh lateral lobe, which is much smaller than the others, is still clearly situated on the flanks and bears one longer point on the umbilical, and a smaller one on the ventral side. An eighth lobe is visible on the

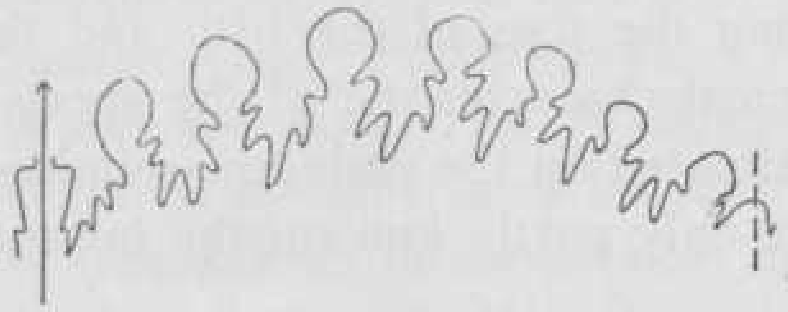

Fig. 29.
External suture of *Waagenoceras lidacense* nov. spec. (Fatoe Koekatoe-Lidak) at a diameter of ± 30 mm (2 × enlarged).

umbilical wall, but the suture of the umbilical wall is not very well preserved in our specimens. From the second lateral lobe to the umbilicus the lobes decrease in depth, whilst the seventh lobe and the eighth lobe on the umbilical wall are very small.

The median saddle of the ventral lobe is about half as long as the lobe; it is narrower at the base than at the top, with a slight indentation on each side. The top of this saddle ends in two parallel points, which give a bottle shape to its upper part; the suture thus is not closed at the ventral side. The first lateral saddle is about twice as high as the median saddle; it is distinctly curved, with the convexity towards the umbilical side. The lateral saddles all end in a long phylloid top with some lateral branches.

Only the first lateral saddle is strongly asymmetrical. The dimensions of the others gradually decrease, but for the seventh saddle, which is somewhat broader than the sixth.

The line, connecting the tops of the first six lateral saddles, forms a circular curve, which dissects the seventh saddle somewhat below its top. This is caused by the fact, that the sixth lateral saddle is clearly somewhat lower than the line connecting the tops of the fifth and the seventh saddle, which fact forms a typical characteristic of the species. The eighth saddle is much lower, and situated on the umbilical shoulder.

The sutures of the umbilical wall are only partly known; the internal sutures are unknown.

Relation to other species. The Sicilian *Waagenoceras*, which are younger than those of the Word-formation, show much stronger dissected lobes and saddles, than *Waagenoceras lidacense* nov. spec. The species from Texas are much more related to our species, especially the globose forms as described by BÖSE (p. 171) [1]) and PLUMMER & SCOTT (p. 157—164) [2]).

However there are smaller differences by which our species are distinguished from these Texas forms too.

Since MILLER (p. 413) [3]) suggested the name *Hanieloceras* for the complex *Waagenoceras* from Timor, no *Waagenoceras* s. str. were

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[1]) E. BÖSE, The Permo-Carboniferous Ammonoids of the Glass Mountains, West Texas, and their stratigraphical significance. Univ. Texas Bull. 1762, p. 1—180, 1917.

[2]) F. B. PLUMMER and G. SCOTT, Upper Paleozoic Ammonites in Texas. Univ. Texas Bull. 3701, p. 1—516, 1937.

[3]) A. K. MILLER, Age of the Permian limestones of Sicily. Amer. Journ. Science, Ser. V, Vol. XXVI, p. 409—427, 1933.

known from Timor, until DE MAREZ OYENS (p. 1123) [1]) recorded the presence of *Waagenoceras* spec. nov. det. (non *Hanieloceras*) from Tae Wei. This species from Tae Wei, having a bigger diameter than our species, shows sutures which are much like those of *Waagenoceras lidacense*, except for the very low sixth lateral saddle. This sixth lateral saddle of the *Waagenoceras* spec. nov. det. from Tae Wei is half as high as the fifth lateral saddle, whilst the seventh lateral saddle is nearly as high again as the fifth. Thus the sixth lateral saddle of the Tae Wei species is better regarded as a secondary saddle, but this nomenclature is used only because the sixth lateral saddle of *Waagenoceras lidacense* is somewhat lower than his neighbours too. Owing to this fact the species from Tae Wei is perhaps to be regarded as an ancestral form of the Lidak species.

Age. The deposits of the Sosio valley (with *Neostacheoceras*, *Tauroceras* (*Gemmellaroceras*), *Hyattoceras* and complex forms of *Waagenoceras*) are clearly younger than those of Tae Wei (with *Stacheoceras*, *Popanoceras*, *(Pro)Hyattoceras* and rather primitive *Waagenoceras*). The *Waagenoceras* zones of the Word-formation in West Texas must also be regarded as older than the Sicilian deposits. *Waagenoceras lidacense* nov. spec. then is to be regarded as of about the same age as the *Waagenoceras dieneri*-zone from the Word-formation in Texas and as Tae Wei (with the possibility, that it is somewhat younger than Tae Wei, with very slight difference in ages).

Number of specimens examined: two.

Locality: F. Koekatoe, Lidak together with *Adrianites* ex. aff. *cancellatus* f. *globosa* (HANIEL).

Adrianites ex. aff. *cancellatus* f. *globosa* (HANIEL).

Description. The form of the shell, sutures and sculpture of our species is very near to that of *Adrianites cancellatus* f. *globosa* (HANIEL).

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[1]) F. A. H. W. DE MAREZ OYENS, Preliminary note on the occurrence of a new ammonoid fauna of Permian age on the island of Timor. Proc. Kon. Ned. Ak. v. Wet. Amsterdam, Vol. XLI, Nr. 10, p. 1122—1126, 1938.

Only the sixth lateral saddle which lies on the umbilical wall with the forms described by HANIEL, in the case of the Lidak species lies on the umbilical shoulder. Further there are perhaps smaller differences in the sculpture of the shell, which however bears the same typical strong radial and spiral ornamentation as the forms of HANIEL.

WANNER (p. 549) [1]) mentioned the possibility that the *Adrianites cancellatus* of Bitaoeni and Basleo might possess some slightly different characteristics. Before a revision has been made of all known *Adrianites cancellatus*, no exact statement can be made about the relation of the Lidak species to other *Adrianites cancellatus* from Timor, and about the question whether the Lidak species is to be considered as a variety or a new species.

Number of specimens examined: eight.

Locality: F. Koekatoe, Lidak, together with *Waagenoceras lidacense* nov. spec.

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[1]) J. WANNER, Das Alter der permischen Besleo-Schichten von Timor. Centr. Blatt für Mineral. Geol. und Pal. 1931 B., p. 539—549.

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PLATE I.

Fig. 1.

View of the coastal region near Atapoepoe, taken from the Aina.

Fig. 2.

View of Atapoepoe, the coastal reef and the serpentine hills, looking in a W. direction.

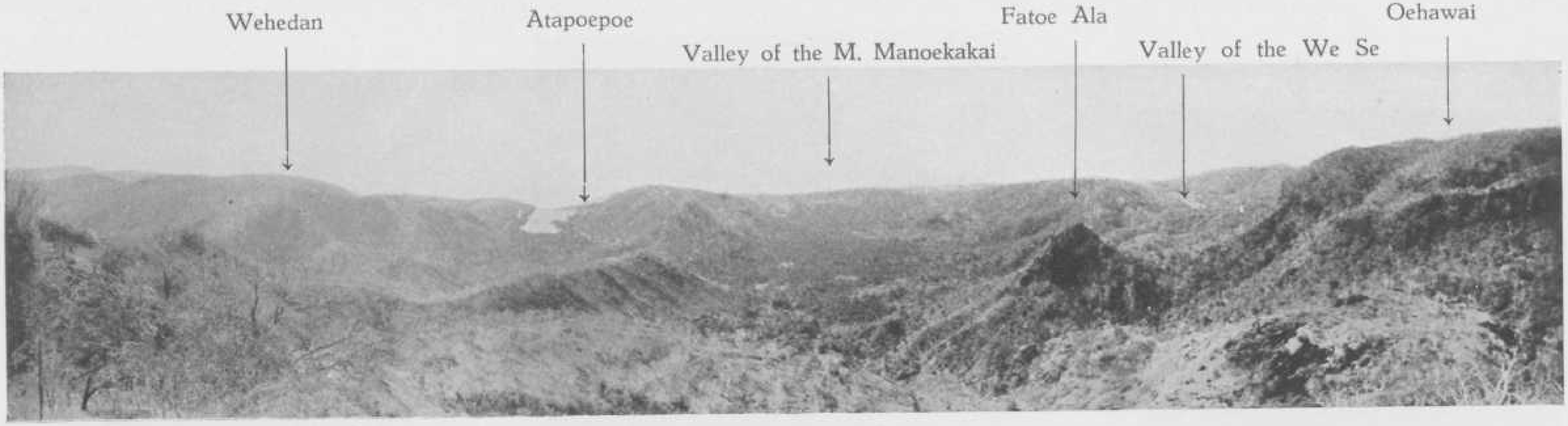

Wehedan
Atapoepoe
Valley of the M. Manoekakai
Fatoe Ala
Valley of the We Se
Oehawai

Fig. 1.

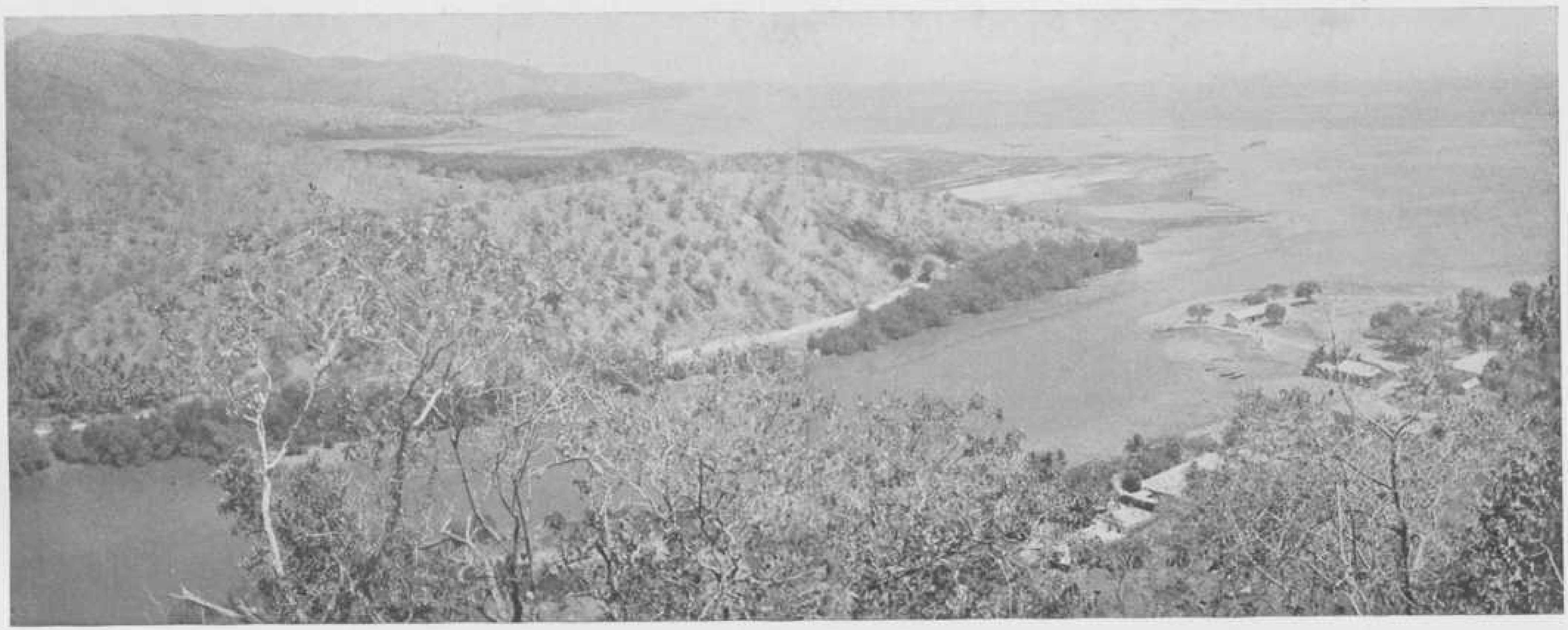


Fig. 2.

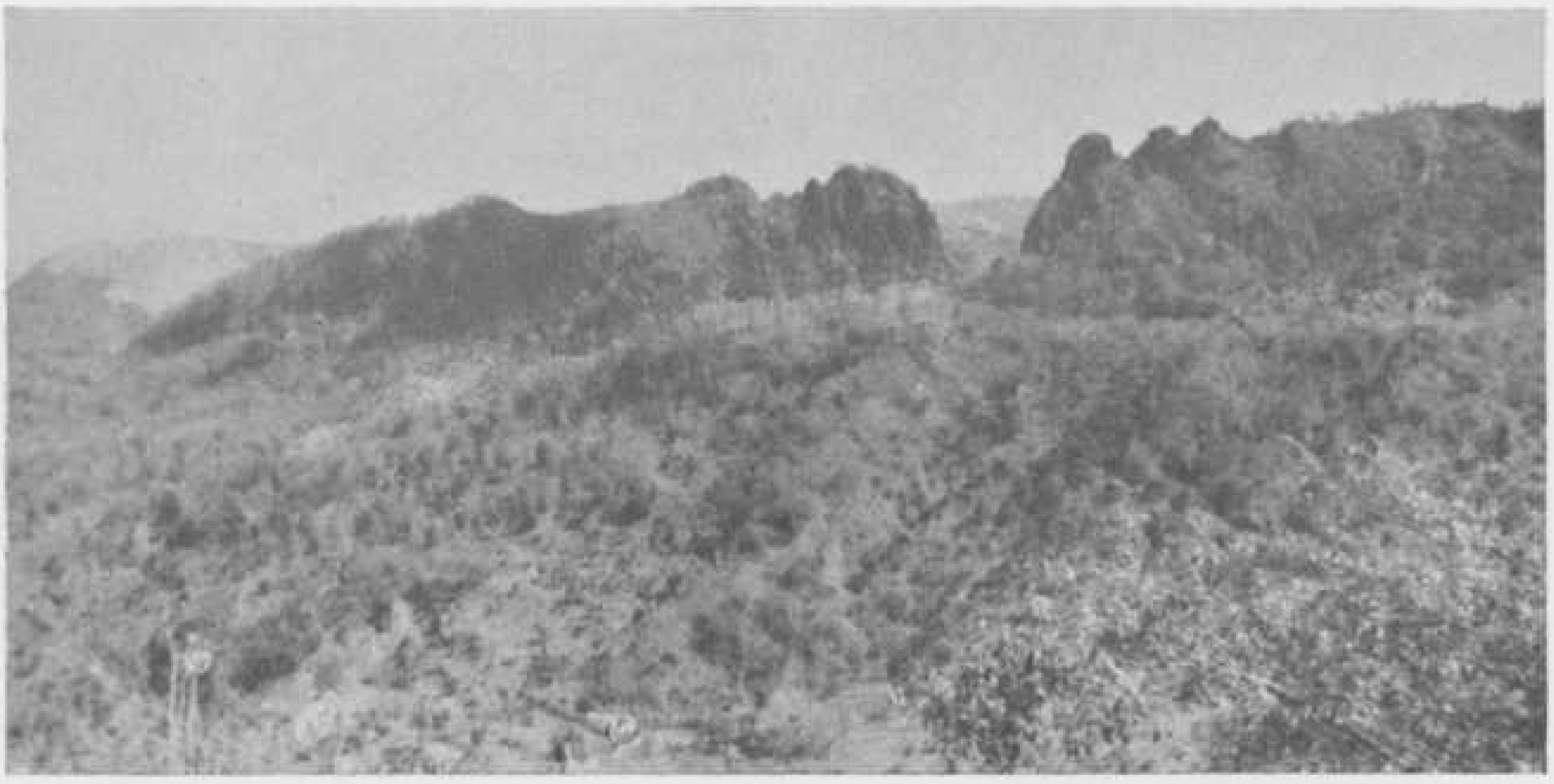


Fig. 1.

Fig. 2.

Fig. 3.

PLATE II.

Fig. 1.
The F. Kadoea, seen from the serpentine hills S. of Wehor.

Fig. 2.
Convex discontinuity in the serpentine hills S. of Wehor, E. of the road to Atamboea.

Fig. 3.
Red and pink limestones with chertbands, drawn out and crushed, some hundred meters E. of the F. Wemeko.

PLATE III.

Fig. 1.
View of a part of the Fatoe-complex of Lidak. Taken from the E. extension of the F. Manoeaman, from about north to east.

Fig. 2.
View near We Kokoea (Lidak). From left to right the F. Sakoe, the F. Kakai and the F. Rakfaoe (background); to the right a part of the F. Kokoea.

PLATE III.

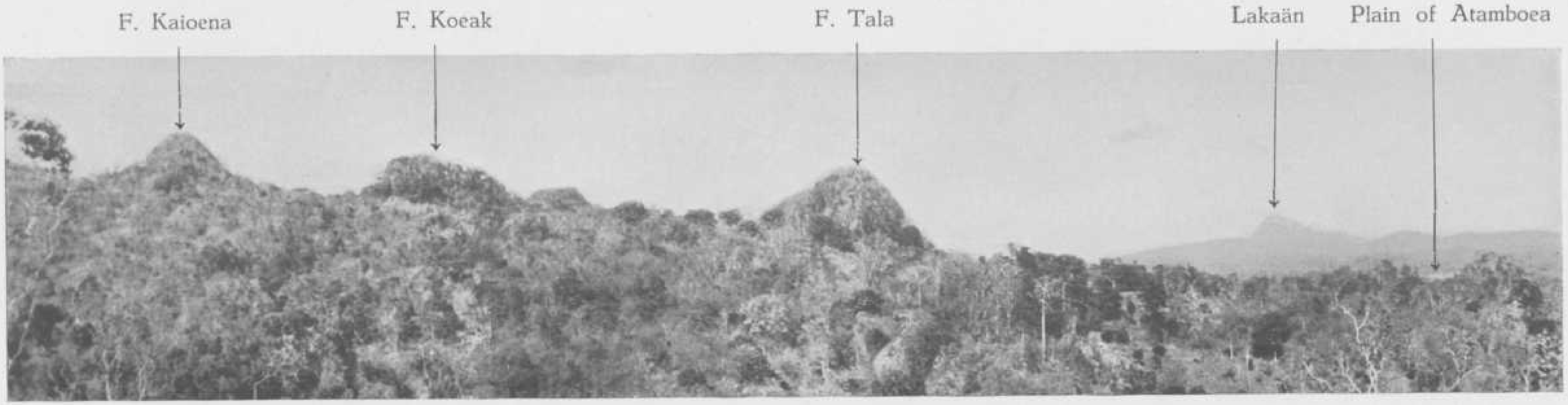


Fig. 1.

Fig. 2.

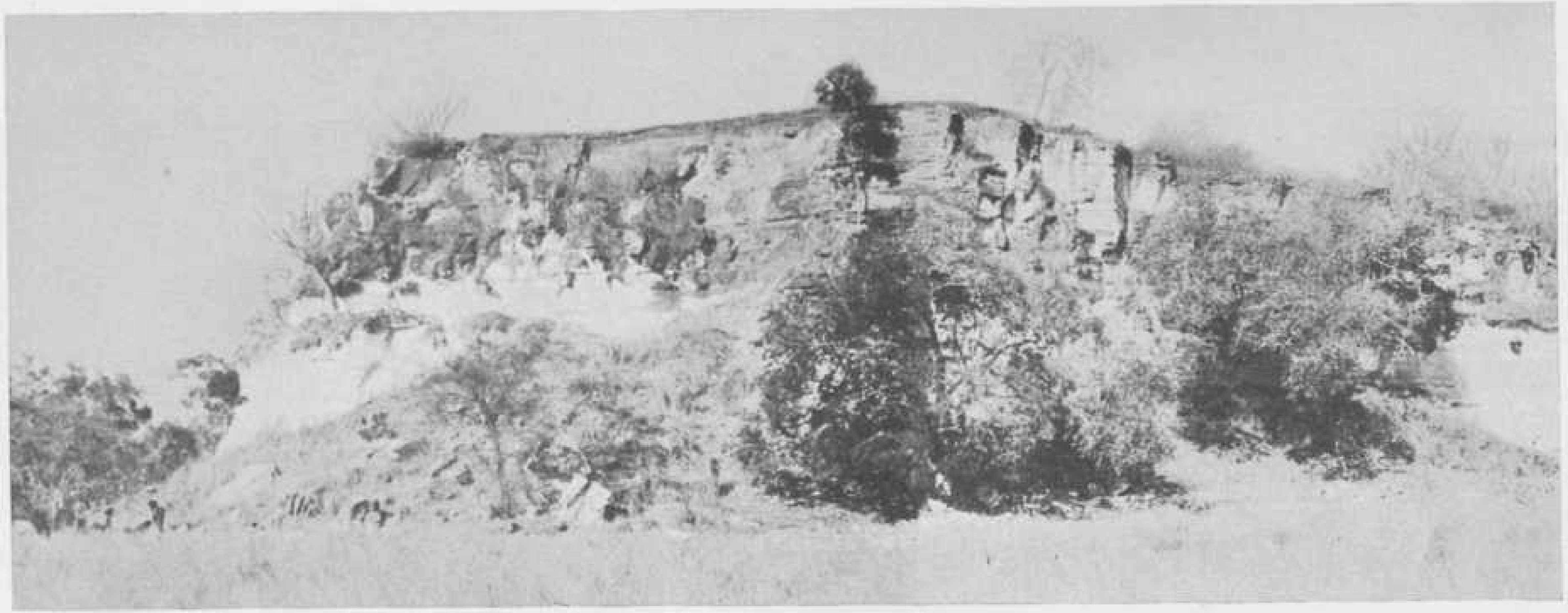


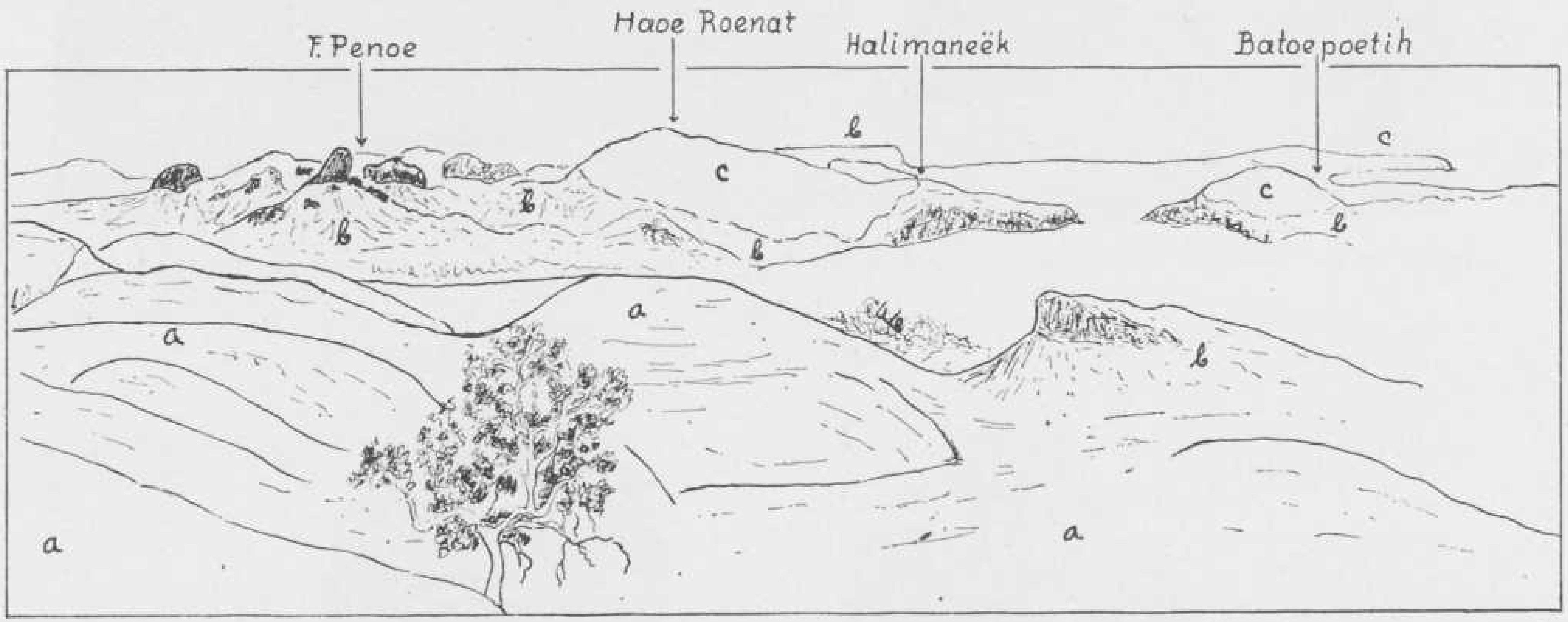
Fig. 1.

Fig. 2.

PLATE IV.

Fig. 1.
Cape Batoepoetih, seen from the seaside.

Fig. 2.



View of the surroundings of Batoepoetih and the Haoe Roenat hill-complex, taken from the W. foot of the Oipiekan, looking to the west.

a. = serpentine rocks.
b. = andesitic to basaltic lavas, often with pillow structures.
c. = *Globigerina*-limestones, marls and tuffaceous rocks.

PLATE V.

Fig. 1.

Fatoe Soeba, near Pante Makasar (Oeikoesi). *Globigerina*-Limestones, marls and tuffaceous rocks (right), dipping away from Tertiary andesitic to basaltic lavas.

Fig. 2.

Waagenoceras lidacense nov. spec. Fatoe Koekatoe-Lidak (about natural size).

Fig. 1.

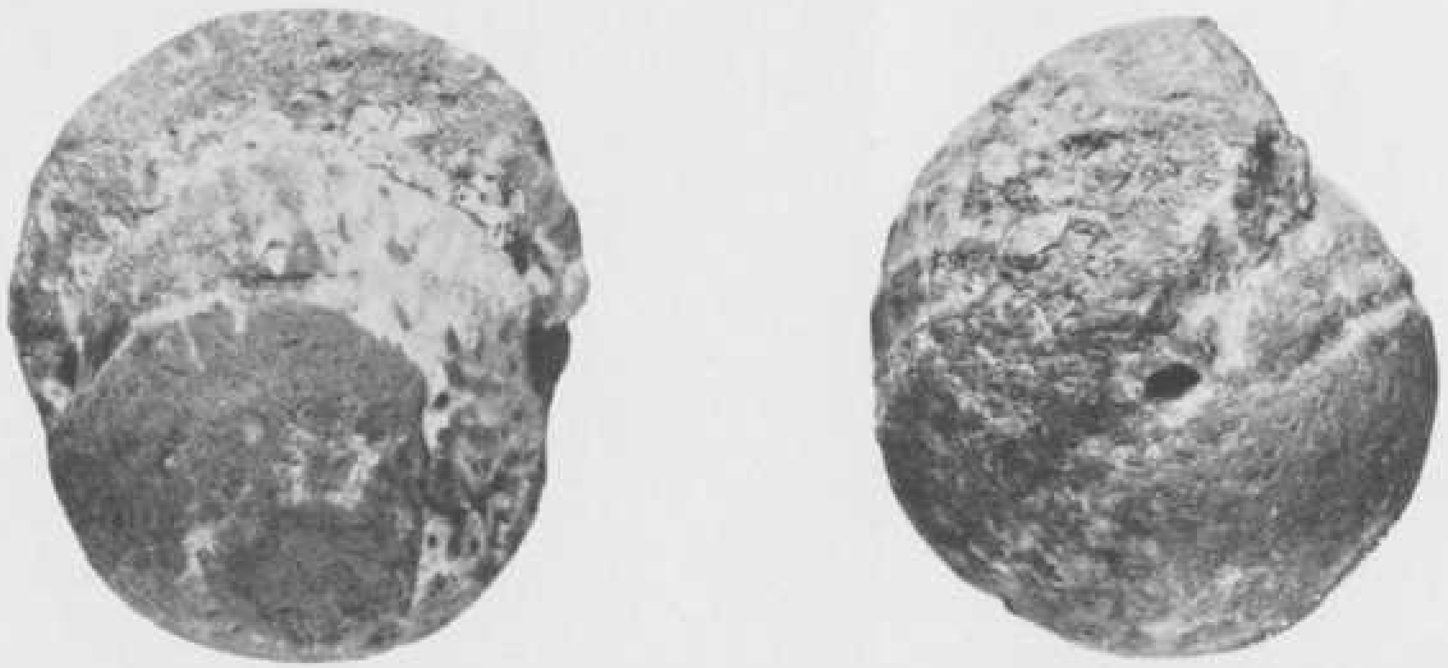


Fig. 2.


SAWOE-SEA
N
Geological Map of a part
of N. E. Netherlands Timor
Scale 1 : 50000
Surveyed by A. L. SIMONS (1937)
SEDIMENTARY ROCKS.
Quarternary and alluvial deposits;
a. in the basin of Atamboea.
Globigerina-limestones, marls and tuffaceous rocks. (Pliocene.)
Massive limestones of Permian and Older Mesozoic age (Fatoe-complex).
Sonnebait-series. a. Mesozoic deposits, mainly in bathyal facies. b. Permian deposits.
Kekneno-series; mainly flysch-facies of Triassic, possibly also Permian age.
Crystalline limestones of the coastal region.
Sonnebait-series, covered by partly displaced material of the Fatoe-complex.
C = Cretaceous
J = Jurassic.
T = Triassic.
P = Permian.
Dip and strike.
IGNEOUS AND METAMORPHIC ROCKS.
Tertiary Volcanic rocks (probably all pre-Pliocene).
a. Basic Andesites to Basalts.
b. Diabases.
c. Rhyolites and Dacites to Quartz-andesites.
Serpentine rocks.
Amphibolites.
Basic eruptive rocks. a. Permian and Mesozoic. b. Permian.
Granites.
Spring or well.
Swamps.
Isohypses (interval 25 m).
F = Fatoe.
M = Motta = river.
Tg = Tandjoeng = cape.
Military bivouac.
Kampong = Native village.
Motorroad with km pole.
Horsetrail.
Foottrack.
ATAPOEPOE
ABAT
FATOE LOEKA
BERLOELI
DEMARESE
AT TOEAN
Tg. Batoepoetih
BATOEPOETIH
Hoeë Roenat
Dipiekan
OBENAI
TENOE
ATAMBOEA
WEKATIMOEN
SEBENO
TOENTOEN
HOFEHAN
WOONARI
TABEAN
WELOERAN
TALA
HALILAS
TOEBATEN
BOEBOERLOELIK
HALITOEOE
WEHOR
M. Baoenokoe
M. Talaoe