Geology. — *"On Manganese Nodules in Mesozoic Deep-sea deposits of Dutch Timor"*. By Prof. G. A. F. MOLENGRAAFF, with a preliminary communication on *"Fossils of Cretaceous Age in those Deposits"*. By Dr. L. F. DE BEAUFORT.

(Communicated at the meeting of November 27, 1920).

Deep-sea deposits, which resemble in nearly every respect the recent deep-sea oozes have in the latter three decades been observed [1]) in many islands of the East-Indian Archipelago [2]), notably in the islands Borneo, Rotti, and Timor. In Borneo they are of mesozoic, probably of pre-cretaceous age, in Rotti partly of jurassic, and in Timor, as had been accepted until now of triassic and of jurassic age. Red clay-shale here and there containing radiolaria, being the equivalent of the recent red clay, as well as chert and hornstone with radiolaria, so-called radiolarites, being the equivalent of the recent radiolaria-ooze, have been found and take up a foremost place among the rocks composing the soil of these islands. Manganese nodules are not wanting in the mesozoic deep-sea deposits and I have succeeded in proving [3]) that they enclose numerous radiolaria, and thus have been formed by the precipitation of manganese in an ooze containing radiolaria. The nodules of manganese, which had been found prior to those described in this paper, differ from those of the recent deep-sea deposits in two respects. They do not present, at least not distinctly, a concentric structure, and they do not include other fossils besides radiolaria. Recent manganese nodules from the deep-sea, on the contrary, have as a rule a concentric arrangement and not seldom the nuclei around which they are grown, consist of fossil remains, as e. g. teeth of sharks. Shark's teeth devoid of any coating of manganese were frequently brought up in great quantities by the Challenger-expedition from great depths in the red clay, showing that in such cases these teeth were lying loose on the bottom of the sea.

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[1]) They are deposited in the deepest parts of the mesozoic Tethys-geosyncline and considering their character of deep-sea deposits, comparatively close to the land.

[2]) See References 1, 2, 7, 8, 9, 10, 11, 12.

[3]) G. A. F. MOLENGRAAFF, Ref. 9, pp. 426 and 427.

The late Prof. Dr. H. G. JONKER [1]), who, in the year 1916, made palaeontological explorations in the island of Timor, was fortunate enough to make a discovery, which decidedly increases the knowledge of fossil deep-sea deposits.

In the bed of a little brook, discharging itself into the Noil Tobee, also called Noil Toninu, on its right bank he found near its mouth a good exposure of beds of red deep-sea clay, containing, besides numerous nodules of manganese also teeth of *Elasmabranchii*, especially of sharks. The Noil Tobee is a small river rising about $4^1/_2$ km. E. N. E. of Niki-Niki in the district of Amanuban in Central Timor and joins the Noil Bunu at 3 km. to the North of its source, a little below the Fatu Toninu. The Noil Bunu flows into the Noil Noni [2]), and this again into the Noil Benain, which river discharges into the Timor sea, not far from Besikama. The spot in the bed of the brooklet, where JONKER has found this red clay, is situated about 480 m. above the sealevel.

JONKER had a clear vertical section dug out and entirely freed from debris which had been transported by the brooklet. A sketch taken from his diary is reproduced here without any alteration.

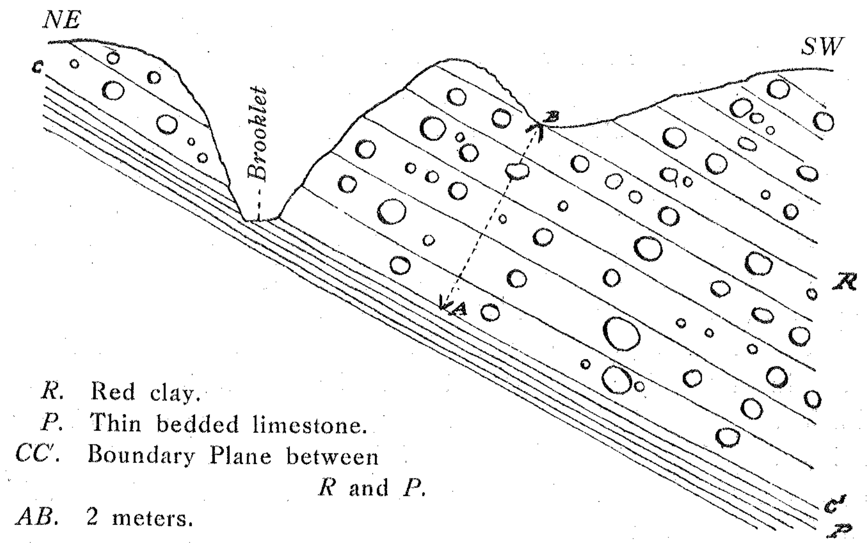

Fig. 1. Section in the Noil Tobee.

[1]) Prof. JONKER by his sudden death on 19 Jan. 1917, was prevented from preparing any of the results of his explorations for publication. His collections are stored now in the geological and palaeontological museum of the Technical High School at Delft. I have been able to make use of his diary in preparing this article.

[2]) This portion of the Noil Noni is sometimes considered to form a part of the Noil Benain.

A clay ranging in colour from yellow to red and brown, and containing nodules of manganese overlies, apparently, quite conformably a thin bedded limestone, which contains badly preserved shales of Aviculidae (Halobia). The bedded limestone is well stratified, the clay, on the contrary, is not distinctly stratified except in a portion of the section, where brown and yellowish-red clay are found to alternate. In the section the beds of the clay are apparently undisturbed, but the polished slickensides, which traverse the clay, testify to its having been exposed to considerable mountain-pressure. In consequence of the large number of slickensides the clay is crumbly and it is impossible to obtain a good-sized specimen without joints. The largest entire specimen brought by JONKER, measures 8 × 6 × 2 cm. It is represented on Pl. I fig. 2. The position of the limestone and the clay is the same; both have a strike N. 35° W. and a dip 42° towards S.W. The yellow clay which prevails in the lower portion of the section is about 40 cm. thick and is followed by red, and chocolate-brown clay rather more than 3 metres thick; with it the section terminates against the surface soil.

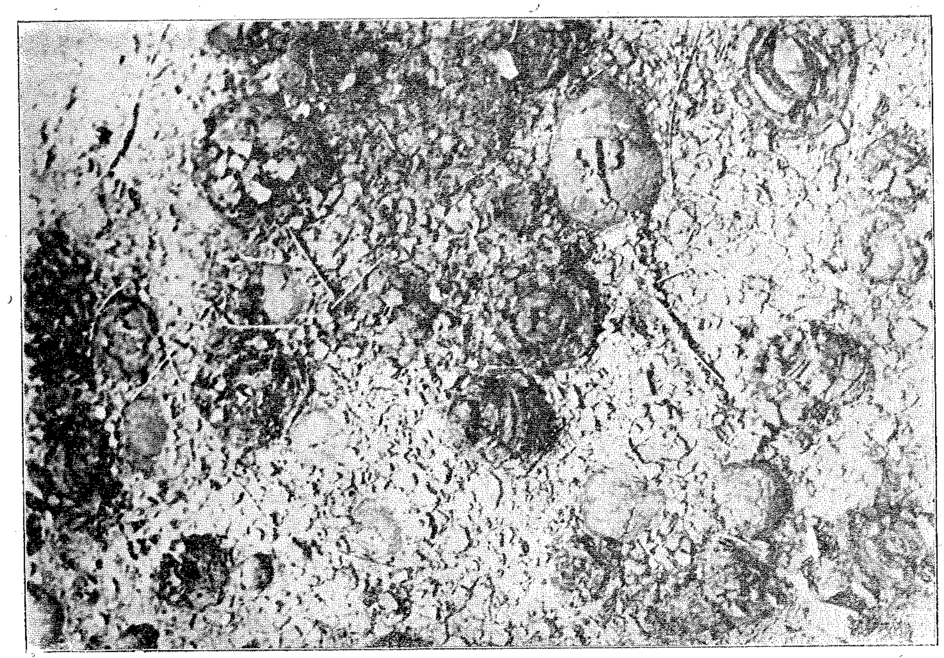

Fig. 2. Manganese nodules in red deep-sea clay, Noil Tobee Central-Timor.

Foto H. G. JONKER.

In the upper portion of the section the brown clay alternates with bands of yellowish-red clay, which brings out the stratification to greater advantage.

The manganese nodules are numerous and scattered over the entire section, as can be seen in Fig. 2. In the red clay, however, they are more numerous than in the yellow. The relation between these nodules and the clay has been represented in figure 1 only schematically. Compared with the given scale the nodules appear much too large in the drawing. The largest have on an average a longer axis of at most 10 cm., all the others have varying smaller dimensions. Small ones e.g. of a diameter of 1 or 2 cm. are as numerous as larger ones.

Further upstream JONKER discovered another exposure of red deep-sea clay with manganese nodules on the left bank of Noil Tobee, but it is inferior to the one sketched above.

Teeth of *Elasmobranchii* especially of sharks are disseminated in the red clay. JONKER has collected most of them as loose specimens weathered out from the clay. In his collection there are two pieces only in which a shark's tooth constitutes the nucleus of a manganese nodule. JONKER's diary does not give more particulars about the distribution of the shark's teeth in the clay.

a. The red deep-sea clay.

The red deep-sea clay of Noil Tobee has apparently been altered very little by diagenetic processes. It has a greasy feel resembling that of soapstone and can be scratched with the nail; in a dry state it is somewhat plastic, and distinctly so after moistening. Considering it as a rock it could hardly claim the name of clayshale, the term solid clay being more appropriate to its character. In this respect it differs from all other deep-sea shales, hitherto discovered in Timor and in other islands of the East-Indian Archipelago. In Timor mesozoic red clayshale is an important constituent in the structure of the soil, and is found in many places.

In all localities known to me the red deep-sea clay occurs as a non-plastic, fairly hard clayshale, not unfrequently slightly schistose through mountain-pressure, and always altered rather considerably by diagenesis, maybe through silicification, maybe by calcification.

On microscopic examination I found in many cases that such a clay-shale had first been silicified, whereas later a portion of the silica has been dissolved again and leached from the rock whilst a cement of lime had been introduced into the rock.

The locality Noil Tobee, discovered by JONKER, is the only one

known until now where red deep-sea clay of mesozoic age is found unmodified as a true clay. Up to this day fossil red deep-sea clay in an equally unaltered state of preservation, has been found only in one place, viz. the island of Barbados. But here it occurs in much younger deposits, viz. in the so-called "oceanic beds" of miocene age. HARRISON [1]) describes it as "clays having a peculiarly greasy feel, ranging in colour from a dark chocolate-red through various shades of red and pink to yellow and greyish white".

There is some difference in properties between the varieties of the clay of Noil Tobee. The pale red variety displays most distinctly the properties of a true clay and is also fractured least by joints showing slickensides; it no doubt represents the purest and least modified form in which the deep-sea clay here occurs. This explains why only this pale red variety has been used by me as a material for an analysis as well as for microscopic examination. The brown varieties have undergone a more marked modification; they are harder and very much fractured by minor polished fault-planes.

An analysis of a sample of pure, pale red deep-sea clay of Noil Tobee, carried out by Prof. H. TER MEULEN at Delft, shows its chemical composition to be as follows:

SiO_2	57.6	
TiO_2	0.6	
Al_2O_3	19.2	
Fe_2O_3	7.1	
MnO_2	trace	
CaO	1.2	
MgO	1.4	
K_2O	trace	
Na_2O	2.3	
H_2O below 110°	6.2	10.2
H_2O above 110°	4.0	
	99.6	

Trace of Sulphate.

In order to compare this composition with that of recent deep-sea clay and that of the miocene deep-sea clay of Barbados, the results of the analyses have to be brought first into intercomparable form

In the analyses of the numerous samples of recent red deep-sea clay, collected by the Challenger-expedition, BRAZIER has not taken into account the salts which had been dissolved in the seawater

[1]) A. J. JUKES BROWNE and I. B. HARRISON. Lit. **3** p. 189.

adhering to the clay. Such adhering connate salts of course can no more be expected to occur in the samples of fossil deep-sea clay. The quantity of this adhering salt is not inconsiderable and amounts to 3.61 %, as shown by HARRISON and WILLIAMS [1]) in material of the Challenger. The constituents of this salt are NaCl, $MgCl_2$, $CaSO_4$, and a trace of phosphate. Moreover BRAZIER has not determined the alkalis in the samples of the Challenger, so that the figures assigned by him to SiO_2 and other substances are too high. To meet this deficiency in our knowledge of the chemical composition of the recent red deep-sea clay, HARRISON and WILLIAMS [2]) have made a new analysis of the typical red deep-sea clay collected by the Challenger determining the percentage of the alkalis and mentioning separately the quantity and the composition of the adhering sea salt. Leaving out the adhering salt the analysis of the sample of deep-sea clay, examined by HARRISON and WILLIAMS would come to this:

SiO_2	56.12	
Al_2O_3	16.30	
Fe_2O_3	10.94	
MnO_2	1.62	
CaO	1.65	
MgO	1.43	
K_2O	1.95	
Na_2O	3.34	
H_2O	6.92	whilst heating after drying at 100°
	100.31	

Now we are enabled to compare the above analysis of recent red clay with those of the fossil deep-sea clay, as soon as in both the amount of water, escaping below and above 100°, has been taken into account in the same way. Doing so it is desirable not to take into account the water which escapes on heating to 100°, because this was done neither in the analyses of the miocene deep-sea clay of Barbados, nor in the most recent analyses of recent red deep-sea clay made by G. STEIGER and discussed by CLARKE [3]).

The analysis referred to, of the cretaceous deep-sea clay of Noil Tobee, recalculated in this way runs:

[1]) I. B. HARRISON and A. J. JUKES BROWNE. Lit. **6** p. 315.
[2]) Ref. **6** p. 315 and 321.
[3]) F. M. CLARKE. Ref. **4**, p. 785.

SiO_2	61.3	
TiO_2	0.7	
Al_2O_3	20.4	
Fe_2O	7.6	
MnO	trace	
CaO	1.3	
MgO	1.5	
K_2O	trace	
Na_2O	2.5	
H_2O	4.3	Escapes on heating above 110° C.
	99.6	

In this way we have obtained the following analyses in a comparable form:

	1	2	3	4
SiO_2	56.12	54.48	60.99	61.3
TiO_2	2.01 [1])	0.98	3.63 [1])	0.7
Al_2O_3	16.30	15.94	21.03	20.4
Fe_2O_3	10.94	8.66	6.95	7.6
FeO		0.84		
MnO_2	1.62	1.21	1.24	trace
CaO	1.65	1.96	0.—	1.3
MgO	1.43	3.31	2.62	1.5
K_2O	1.95	2.85	0.50	trace
Na_2O	3.34	2.05	1.95	2.5
H_2O after drying at 100°	6.92	7.04	4.72	4.3 [2])
	100.27	99 32	100.—	98.6

[1]) In the samples 1 and 3 TiO_2 is determined from a separate quantity making the figure for Al_2O_3 too high, because TiO_2 is comprised in it.
[2]) Dried at 110°.

1. Recent red deep-sea clay. Pacific Ocean. Challenger station 256. 30° 22′ N. Lat and 154° 56′ W. Long. Depth 5310 m. Anal. HARRISON and WILLIAMS.
2. Average composition of 51 samples of recent deep-sea clay. Anal. G. STEIGER.
3. Miocene red deep-sea clay. Mt. Hillaby, Barbados. Anal. J. B. HARRISON.
4. Cretaceous red deep-sea clay. Noil Tobee. Central Timor. Anal. H. TER MEULEN.

On comparing the analysis 3 of the red clay of Barbados with the analysis 4 of the red clay of Noil Tobee, it strikes us that the first-named contains 1.24 % MnO_2, whereas the second contains only a trace. This may be accounted for by the fact that no manganese nodules occur in the red clay of Barbados and thus the manganese ore there is not concentrated, as is the case in the red clay of Noil Tobee. For the rest the analyses 3 and 4 resemble each other so much, that we may speak of an almost complete identity as to chemical composition between the cretaceous deep-sea clay of Noil Tobee of Central Timor and the miocene deep-sea clay of Mt Hillaby in the island of Barbados. The differences between the fossil and the recent deep-sea clay are slightly greater. This is easy to understand, as the deposit, directly it had been raised by diastrophism above the sea-level, must in some measure have been modified through diagenetic processes, in spite of its being almost impervious to water. By those processes a portion of the iron has been leached out and removed from the rock, and silica has been introduced into it. Taking this into consideration the chemical composition of the red clay, as well of Barbados as of Central Timor, appears to resemble fairly well that of the recent deep-sea clay brought up at different stations by the Challenger, as is evidenced by the above analyses. The accordance in composition with the samples of red deep-sea clay collected by the Gazelle and analyzed by VON GÜMBEL [1]) is also great.

Microscopic composition of the red clay.

The microscopic examination of four thin slides of red clay of Noil Tobee, carried out by Prof. H. A. BROUWER, yielded the following results: "The major part consists of an extremely fine clay-mass, which cannot be determined more precisely. It contains some larger fragments of minerals and rocks which were recognized as

a. a polysynthetically twinned crystal of plagioclase;

b. a small fragment of a volcanic rock with felsparlaths in the groundmass;

c. a strongly altered fragment of the groundmass probably of a volcanic rock rich in glass;

d. a fragment of a volcanic rock rich in glass, with felsparlaths, featherlets of ore and much glass;

e. some strongly altered (serpentinized) fragments, possibly of olivine originating from a volcanic rock;

f. an amorphous piece of quartz.

Ill-defined remains of radiolaria, the tests of which have mostly disappeared, occur in a small quantity in all the slides".

[1]) W. VON GÜMBEL. Ref. **5**, p. 85 and 87.

In one of the sections a nodule of manganese was found to be cut through. The concentration of the manganese ore appears to be perfect in this clay since not a trace of scattered grains of manganese has been found in any of the sections of the red clay in the slide.

Besides the fragment of quartz mentioned sub *f* visible under the microscope, I also observed with the naked eye some white points which proved to be composed of diminutive pieces of quartz. These fragments of quartz I consider to be erratic in the red clay, i. e. to be constituents of terrigenous origin, which for some accidental reason or other have been deposited in the deep sea; they may have been transported by floating treetrunks outside the littoral zone. For Timor and the East-Indian Archipelago in general such an interpretation is admissible, because also in the Mesozoicum this region cannot at any time have been far remote from land.

b. The manganese nodules.

JONKER collected a large number of manganese nodules from the deep-sea clay of Noil Tobee. The largest among them have the size of lemons, the smallest are about equal in size to nuts; in the fragments of red clay a good many occur no larger than peas. The largest specimen measures $10 \times 8\frac{1}{2} \times 6$ cm. Two types are found in the collection, the first type being represented by 90 specimens, the second by 2 specimens only.

Type 1. Nearly all nodules are spherical or ellipsoidal. A few are cylindrical in shape and evidently originated by the coalescence of two individuals.

The surface is tubercular and finely granulated, reminding one of shagreen (Pl. II, fig. 4). The colour is black to brownish black; the stripe is dark brown. The nodules are mostly dull, but display a faint metallic lustre on the projecting parts of the relief, i.e. on the granules and on the tubercles. Their hardness is less than 2. The specific weight is $\pm$ 1.7. This low value is due to the great porosity of the nodules. As to physical properties the composing material is analogous to Waad.

The manganese nodules possess a distinctly concentric structure. A radial arrangement could hardly be perceived in some, in others not at all. Several nodules in the collection were broken in two, and show very well the concentric structure. (Plate II fig. 1 and 2). Some of them are broken on purpose, but JONKER reports that just below the surface he often found the nodules broken in two pieces. The nodules have often a white or gray nucleus free from manganese in their centre, around which on all sides the manganese has been precipitated in concentric, porous layers [1]). The white nucleus is sharply contrasted with the dark envelope (Fig. 3 in the text and Pl. II fig. 3).

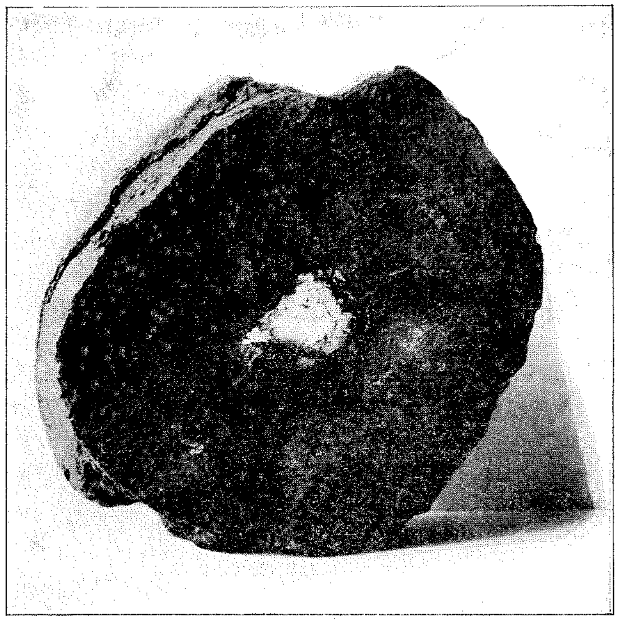

Fig. 3. Manganese nodules with a white nucleus of chert containing radiolaria for the greater part altered into amorphous silica.

In some of the specimens part of the nuclear mass is of a greenish colour and dimly transparent. These parts can easily be recognized as chert with a strong pocket lens.

The nuclei are always brittle and more or less friable. In one case I succeeded in having a thin section made through an entire nodule, nucleus and envelope, without interfering with the structure. This slide is reproduced in Pl. I fig. I.

On microscopic examination this nucleus appeared to consist of radiolarite, being converted for the greater part into white, amorphous silica. In it the radiolaria are packed close together, their casts being filled up with a crystalline mosaic of quartz. The concentric arrangement and the porous character of the manganese envelope round this nucleus are easily recognizable in this figure. In some other slides

[1]) Very rarely a white substance free from manganese, quite similar to that of the nuclei, was found outside the centre of a nodule, between two layers of the manganese envelope.

made from these nodules I could state the presence of some radiolaria also in the manganese substance itself.

The chemical composition is shown in the following analysis of one of these nodules made by Prof. H. TER MEULEN:

SiO_2			24.4	
Fe_2O_3			25.5	
Al_2O_3			9.8	
MnO			16.9	
CaO			1.5	
BaO			0.32	
MgO			0.34	
K_2O			0.15	
Na_2O			1.46	
NiO			0.28	
CoO			0.16	
CuO			0.12	
Cl	(oxyg. aeq.)		0.60	
H_2O	escaping below	110°	7.9	18.1
	,, above	110°	10.2	
			99.63	

Traces of lead, sulphate and phosphate.

This substance might be called a **Waad** rich in iron and silica. For the sake of comparison I give this analysis of a nodule of Noil Tobee in the following table, after recalculation as if the material had been dried at 110°, next to an analysis of manganese nodules from the recent deep-sea clay brought up by the Challenger at four different stations.

From this table it appears that the composition varies very much in the different nodules [1]). On account of the high percentage of iron they all might be called iron-manganese nodules. The composition of the nodule of Noil Tobee lies, except for its contents of alumina, within the extreme values, found on analyzing the nodules of manganese of the present oceans.

Type 2. Among the manganese nodules of Noil Tobee there are two of a different type, which I have named the second type. One of them is broad and flat, measuring $10 \times 9^1/_2 \times 3^1/_2$ cm.; the second is more spherical and smaller. They have a specific gravity of 4.2 and their hardness is 6. Thus they are much heavier

[1]) An analysis made by A. SCHWAGER of a manganese nodule found in red deep-sea clay by the Gazelle in the Pacific Ocean, is given by W. VON GÜMBEL Ref. **5** p. 102.

and harder than those of the first type. They have a smooth surface and bear a close resemblance to the manganese nodules occurring near Sua Lain in the island of Rotti [1]) in jurassic marls, which enclose numerous radiolaria. They are also very much like those which were collected in Timor near Mt Somohole in deep-sea clay of presumably triassic age.

Comparative table of analyses of manganese nodules in red clay.

Place	Challenger Stat. 160	Challenger Stat. 252	Challenger Stat. 276	Challenger Stat. 286.	Noil Tobee	Rotti 2d type
Depth in fathoms	2600	2740	2350	2335		
SiO_2	21.80	27.62	13.66	20.01	26.5	2.9
Al_2O_3	22.30 (Al_2O_3 + Fe_2O_3)	6.60	3.10	2.81	10.6	2.3 (Al_2O_3 + Fe_2O_3)
Fe_2O_3		17.82	46.40	17.88	27.7	
MnO_2	39.32	25.48	14.82	38.15	18.3	57.7
MnO						10.5
CaO	2.21	2.91	3.53	3.58	1.63	5.6
BaO					0.35	11.7
MgO	0.89	1.27	0.74	0.33	0.37	
K_2O					0.16	
Na_2O					1.59	1.1
NiO			trace	trace	0.30	
CoO			trace	trace	0.17	0.3
CuO	trace	trace	trace	trace	0.13	
Cl (oxyg. aeq)					0.65	
CO_2						small quantity
H_2O escaping above 110°	11.—	15.20	14.40	11.35	11.1	± 15.3

When broken into halves these nodules look quite compact and homogeneous and show no trace of a concentric structure. In the last column of the above table the chemical composition of a nodule of the second type from Sua Lain [2]) in the island of Rotti is given. It differs much from that of the nodules of the first type. These nodules of the second type of Noil Tobee have not been examined any further, because JONKER's notes do not tell us whether

[1]) Ref. **12** p. 326, 393; **2** p. 61 and **9** p. 1064.

[2]) The large percentage of BaO accounts for the high specific gravity,

they originate from the red clay in situ or whether they have been transported by the brooklet from a higher level.

c. The fossils in the red clay and in the manganese nodules.

These fossils have been examined by Dr. L. F. DE BEAUFORT, who has summarized his results, thus far obtained, as follows:

"The fossils derived from the deep-sea deposits of Noil Tobee consist for the greater part of tooth-fragments of *Elasmobranchii*. With a few exceptions only the crown of the teeth has been preserved and of these also the dentine has been dissolved, so that only an enamel sheath remains.

This state of preservation, quite in keeping with what could be anticipated in a deep-sea deposit, renders the determination of the objects very difficult. In many cases it is even impossible to class the fragments as a definite species or even as a definite genus.

By far the greater number of the teeth belong to sharks of the *Lamnidae*. Thus far no older specimens of this family are known than those belonging to the chalk, unless the genus *Orthacodus* of the Upper-Jura be classified among the *Lamnidae*.

This genus, however, is not represented in the collection under consideration. We recognize in it tooth-fragments of *Carcharodon* (known from Chalk and Tertiary deposits), *Lamna* (Cretaceous to Recent), and *Scapanorhynchus* (know only from the Upper Chalk).

Furthermore I include a single fragment among the genus *Hemipristis* (Upper Chalk, Tertiary, and a single recent species) of the family of *Carchariidea*.

Considered merely palaeontologically, the fossils mentioned above might be believed to belong to the Upper Chalk. This view is substantiated in large measure by the presence in the collection of some well-preserved teeth of the easily recognizable genus *Ptychodus*, teeth of this genus, which is looked upon as a precursor of the *Myliobatidae*, being found up to the present only in the Upper Chalk of Europe and North-America.

In the Timor-collection we find teeth of 3, perhaps of 4 species of this genus. They may be assimilated to, or anyhow they are closely related to the following species: *P. decurrens* Ag., *P. dixoni* Dudley and *P. rugosus* Dixon. These three species, which according to SMITH WOODWARD (Quart. Journal Geol. Soc. London, Vol. 67., 1911, p. 276) form an ascending progression, occur according to DIDLEY (l.c. p. 263 seqq) in different layers of the Upper Chalk of England.

Over and above the teeth discussed, the collection also contains some undetermined fish-teeth and a fragment of a tooth of a reptile, furthermore some fin-spines presumably of *Selachii* and lastly some fragments of bones, indeterminable thus far.

It may be that a closer investigation of these hitherto undetermined pieces from the remarkable collection will reveal that still older types are among them. As yet I can establish only with absolute certainty that *"in the deep-sea deposits of Timor there occur types, known up to now either exclusively from the Upper Chalk or from no older strata than the Upper Chalk."*

The above examination goes to show that the fossils found in the red deep-sea clay and also in some of the manganese nodules are of upper-cretaceous age. From this we can logically infer that the deep-sea clay in which the teeth of *Elasmobranchii* are formed, is also of upper-cretaceous age. This result is divergent from what might be concluded from the stratigraphy of the complex of layers, to which the deep-sea clay belongs, as observed by JONKER. It is evident both from the description and the section (fig. 1) that the red clay directly and comformably overlies a well stratified bedded limestone, in which are found not very well preserved, but clearly recognizable, remains of *Aviculidae* (Halobia). These are only known to occur in deposits of triassic age, and JONKER, therefore, did not hesitate to consider the red deep-sea clay with manganese nodules as triassic.

Although I believe the palaeontological evidence to be conclusive, it appears necessary to look for an explanation of this controversy. Two ways in which the section (fig. 1) may be read deserve consideration in order to account for the apparent contrariety.

First of all the cretaceous deep-sea clay, overlying directly conformably the triassic bedded limestone, may not have been deposited there originally, but may have been brought there afterwards by orogenetic movements. The plane *cc'* (fig. 1) in this case would not be a partition-plane between two superposed formations, but would represent the tectonic contact of two formations of very different age. A large break and a marked stratigraphic gap would then separate the two conformable, successive complexes of layers. Similar stratigraphic hiatus between conformably superposed formations, are of frequent occurrence in Timor with its chaotic tectonic, and are peculiar to regions, which have been considerably disturbed by orogenetic movements with considerable horizontal displacements, as BERTRAND has set forth as early as the year 1890. Most often, however, the difference in age between the conformably superposed formations is not so great as must be assumed in the case of Noil Tobee. Frequently I encountered

G. A. F. MOLENGRAAFF: "On Manganese Nodules in Mesozoic Deep-sea deposits of Netherlands Timor".

Plate I.

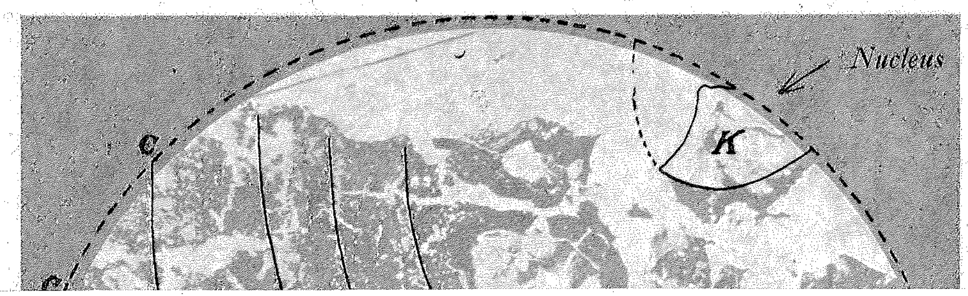

Fig. 3.

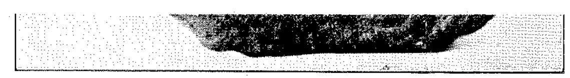

Fig. 4.

G. A. F. MOLENGRAAFF: "On Manganese Nodules in Mesozoic Deep-sea deposits of Netherlands Timor".

Plate I.

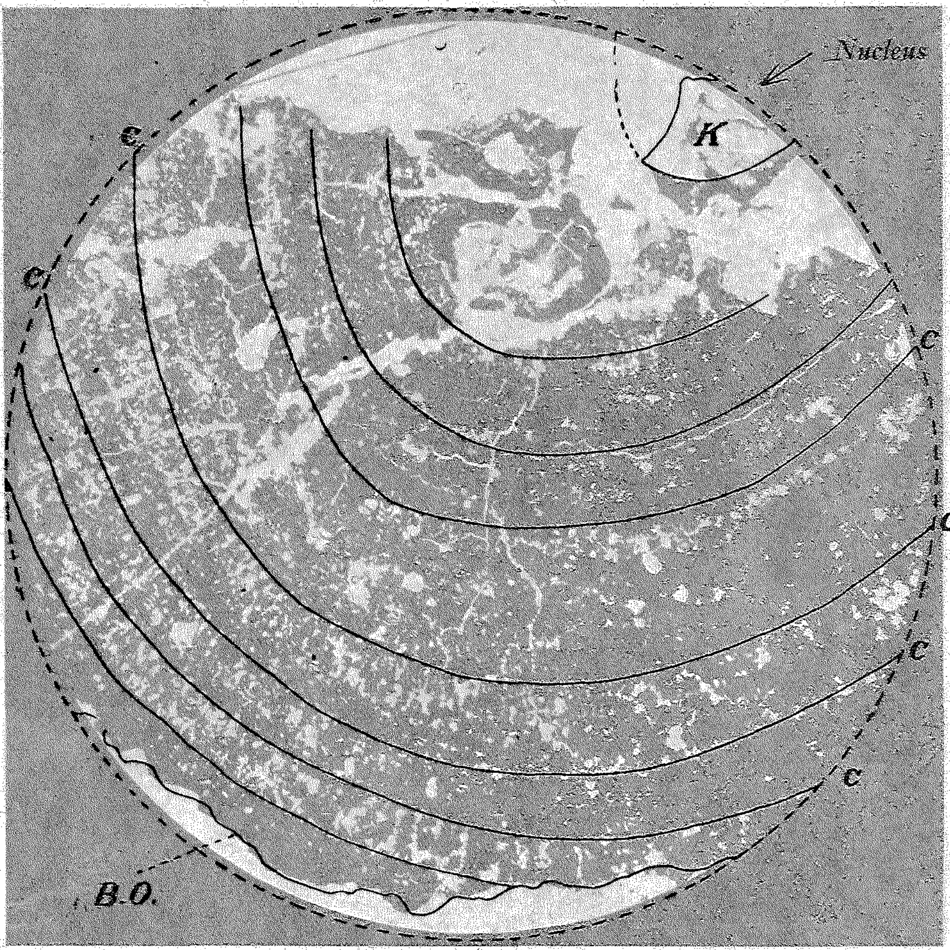

Fig. 1.

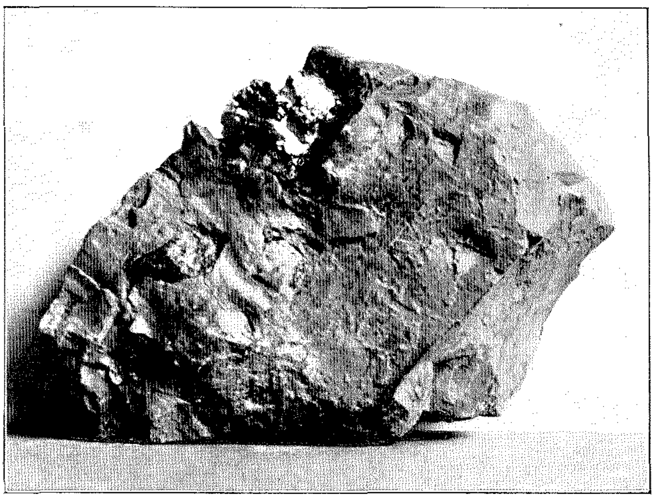

Fig. 2.

upper-triassic deposits overlying permian deposits conformably; in the case of Noil Tobee it would appear that an upper-cretaceous deposit is superposed conformably on an upper-triassic sediment. In such a case certain characteristics of the plane of contact between the two formations often reveal it to be a tectonic plane. In fact in such cases the plane is as a rule more or less polished, slickensided or plastered over with a thin layer of gouge. No mention is made of it by JONKER in his notes about the geology of the place. Probably he conceived the plane cc' between the red clay and the bedded limestone to be a normal partition between two deposits in normal succession.

Secondly it is possible, that the section after all represents a true undisturbed succession; if so, the red clay with nodules of manganese would embody the sum total of all that has been deposited here, in the deep-sea, from upper-triassic to uppercretaceous time. In such a case one might expect the fish-teeth, described above, not to occur in the lowermost part of the section. The notes on hand do not settle the question. An a priori rejection of this solution would not be warrantable either. True, the thickness of the red clay (in the section rather more than 3 m.) is small if compared with the enormous time its deposition must have taken, but then also the process of sedimentation must have been extremely slow in the deepest parts of the oceans far removed from the land, i.e. in the areas of the red clay.

EXPLANATION OF THE PLATES.

PLATE I.

Fig. 1. Section of a manganese nodule from the cretaceous deep-sea clay of Noil Tobee.

K. Nucleus, consisting of modified radiolaria-chert.

CC Concentric shales of manganese ore.

B.O. Outer surface of the nodule.

Fig. 2. Fragment of red deep-sea clay of Noil Tobee, containing a small manganese nodule with a large, white nucleus. Natural size.

PLATE II.

Fig. 1 and Fig. 2. Broken nodules manganese of Noil Tobee, clearly showing concentric arrangement.

Fig. 3. Nodule of manganese showing concentric layers and a white nucleus.

Fig. 4. Nodule of manganese seen from the outside. The surface is mammillated and is like shagreen in appearance by numerous little rugosities.

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Palaeontology. — *"The Proto-Australian Fossil Man of Wadjak, Java"*. By Prof. EUG. DUBOIS.

(Communicated at the meeting of May 29 and September 25, 1920).

Tjampur Darat or Wadjak, the capital of the district of Wadjak, is a village (dessa), south-west of the town of Tulung Agung, and about in the meridian of the Wilis-summit. There the plain of Kediri has penetrated, past Mount Kĕlut, into the Gunung Kidul — the Southern mountain range —, and has obtained a steep Eastern boundary. The origin of this abrupt breaking off of the Tertiary lime-stone mountains has been attributed, no doubt rightly, by VERBEEK and FENNEMA to a fault running along that escarpment, through Tjampur Darat or Wadjak and Gamping [1]). In this southern continuation of the plain of Kediri, separated from the Indian Ocean by a mountain tract only 3 kilometers broad, lies the Rawa Bening (Clear Lake), now for the greater part a marsh, the water of which flows off through the Kali Tjampur, which, after uniting with the Kali Bendo, coming from the West, to form the Kali-Ngrowo, falls into the Brantas on the North of Tulung Agung. Repeated eruptions of Kĕlut and other volcanoes must gradually have raised the bottom of the lake with volcanic ashes. And while in the similar deposits which were formed downstream, the river easily kept its bed deep, the lake, which was probably very large at first and extended as far as the foot of the lime-stone rocks, had to diminish in extent and depth in course of time. Possibly the upheaval of Southern Java may also have contributed to this effect.

On the slope of that part of the mountain that extends, almost rectilinearly, over a distance of 800 meters in W. S. W. direction, immediately on the south of Tjerme and at 2 kilometers distance S. S. W. of Tjampur Darat, fossil human bones were found in 1889 and 1890. The plain lies there at the foot of the mountain 90 meters above the level of the sea, the plateau more than 140 meters higher, i.e. more than 230 meters above the level of the sea. Near the top the rock rises up almost vertically, for the rest the gradient is on an average 30°, through the accumulation of fallen lime-stone blocks

[1]) Fault N°. XXXI on the map "CVII and DII" of the Geological Atlas of Java and Madura.