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Contribution to the knowledge of the fossil mammalian fauna of Java

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CONTRIBUTION TO THE KNOWLEDGE OF THE FOSSIL MAMMALIAN FAUNA OF JAVA.

F. H. VAN DER MAAREL.

BIBLIOTHEEK DER
RIJKSUNIVERSITEIT
UTRECHT.

CONTRIBUTION TO THE KNOWLEDGE OF THE FOSSIL MAMMALIAN FAUNA OF JAVA

PROEFSCHRIFT

TER VERKRIJGING VAN DEN GRAAD VAN DOCTOR IN DE WIS- EN NATUURKUNDE AAN DE RIJKS-UNIVERSITEIT TE UTRECHT, OP GEZAG VAN DEN RECTOR MAGNIFICUS DR. L. S. ORNSTEIN, HOOGLEERAAR IN DE FACULTEIT DER WIS- EN NATUURKUNDE, VOLGENS BESLUIT VAN DEN SENAAT DER UNIVERSITEIT TEGEN DE BEDENKINGEN VAN DE FACULTEIT DER WIS- EN NATUURKUNDE TE VERDEDIGEN OP VRIJDAG 8 JULI 1932, DES NAMIDDAGS TE 4 UUR

DOOR

FRANCISCUS HENDRICUS VAN DER MAAREL

GEBOREN TE AMSTERDAM

BIBLIOTHEEK DER
RIJKSUNIVERSITEIT
UTRECHT.

Aan mijn vrouw.

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CONTRIBUTION TO THE KNOWLEDGE OF THE FOSSIL MAMMALIAN FAUNA OF JAVA.

BY

F. H. VAN DER MAAREL.

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INTRODUCTION.

The material, the description and determination of which forms the subject of the present paper, was part of an extensive collection, brought together by the exertions of the Geological Survey („Opsporingsdienst") of the Dutch East Indies, and entrusted to the author for examination. The specimens of this collection had been procured, partly from a new finding spot in the vicinity of Bumiaju (Central Java), partly from Javan localities already known for a long time. A renewed reconnoitring of the latter took place namely, in order to prepare a scheme, which had in view cooperation between the Survey mentioned and the American Museum of Natural History. On that occasion a rather great number of mammalian remains was collected, among which were some very fine specimens. The plan above mentioned was not carried into effect, so that the latter material was also sent to the writer.

The reader may form himself an idea of the extensiveness of the whole collection, if is mentioned that this consisted of four sendings, containing in total 31 cases, partly of considerable size [1]). The first, third and fourth sending consisted exclusively of specimens, obtained from the vicinity of Bumiaju. The second sending (18 cases) contained the material, collected in the other localities.

The packing was so excellent that most of the specimens either had experienced no harm whatever, or had hardly suffered any injury on the long journey. Only one specimen viz., a cranium of *Bibos sondaicus fossilis*, arrived in a very damaged condition. This was, however, not owing to the packing, but a result of the small degree of fossilization of that specimen.

Though in Bandung already much time was spent on the preparation, it appeared that by prolonged preparation a good deal of the specimens described could be brought into a considerable better condition. This work, which required both patience and skill, has aptly been done by Mr J. VAN DIJK, amanuensis of the Geological-Mineralogical Institute of the University of Utrecht.

The collection sent to Utrecht consisted for the greater part of mammalian remains. The cranial and dental remains of *Buffelus*, *Bibos*, *Rhinoceros*, *Hippopotamus*, "*Elephas*", *Stegodon*, "*Mastodon*",

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[1]) Beside these 31 cases one more case was received, comprising molluscs from, and samples of rocks of the vertebrate bearing strata, near Bumiaju. The writer intends to examine the rocks, possibly the molluscs too.

and also the proboscidean limb bones have been selected for examination.

In accepting the examination the writer had undertaken to care that the greatest possible number of specimens should be returned before the beginning of the fourth Pacific Science Congress (Bandung 1929). Consequently, the specimens, after having been carefully examined, described, measured and pictured, immediately set out on the return journey, provided or not with a provisional name. It will hardly be necessary to point out that this working method involved difficulties. On the other hand, it yielded an advantage, which is not to be underestimated. The very fact that the fossils were sent back before their determination was definitely ended, gave rise to an absolutely objective description of each specimen, and as a matter of necessity the description had to remain objective, as later on its contents could not be changed any more.

In what follows the reader will find an enumeration of all the specimens described, and of the localities [1]) from whence they have been obtained [2]).

Residency: **Pekalongan.**

Regency: **Brebes.**

District: **Bumiaju.**

Locality: Bumiaju.

a. Excavation 1—4.

Tetralophodon bumiajuensis nov. spec.:
Fr. upper jaw with inj. l. and r. M^3.
Fragment of cranium with l. and r. M^3.
Incisive tusk.
? Fr. pelvis.

Mastodon sp.:
Inj. molar.

? *Mastodon* sp.:
Posterior portion of cranium.

Hippopotamus sp.:
R. horizontal mandibular ramus.
Lower jaw.

---

[1]) See also maps n°s. 1 and 2.

[2]) In this list "fr." means fragmentary and "inj." injured. A sign of interrogation in front of the circumscription of a specimen indicates its *possible* belonging to the form under which it is mentioned.

b. Excavation 6.

Stegodon airâwana MARTIN:
Inj. cranium.

Stegodon sp.:
Nine fragments of grinding teeth.

c. Excavation 8.

Tetralophodon bumiajuensis nov. spec.:
Fr. r. mandibular ramus with M_3.
? Two femora (nos. 2 and 6).
? Three ulnae (nos. 1—3).
? Two radii (nos. 1 and 2).
? Tibia (no. 2).

Hippopotamus sp.:
Fr. upper jaw with l. and r. M^1—M^3.
Four detached lower C.

d. Excavation 9.

Hippopotamus sp.:
One detached lower C.

e. Excavation 11.

Stegodon sp.:
Three fragments of grinding teeth.

f. Excavation 13(?).

Hippopotamus sp.:
Fr. lower jaw.

g. Tji Saät.

Genus and species undetermined:
Proboscidean femur (no. 4).

h. Kali Biuk.

? *Archidiskodon planifrons* (FALC. et CAUTL.):
Fr. l. horizontal mandibular ramus with m_3(?).

i. Tji Pangglosoran.

Stegodon airâwana MARTIN:
Fragment of cranium with l. M^3.
Archidiskodon planifrons (FALC. et CAUTL.):
Detached l. M^1.

k. Tji Djedjawai.

Genus and species undetermined:
Proboscidean femur (no. 3).

l. Exact locality unknown.

Stegodon airâwana MARTIN:
Detached fr. l. M^3 and ditto r. M^3.
Detached M_1.

Residency: **Bodjonegoro.**

Regency: **Bodjonegoro.**

District: **Tambakredjo.**

Locality:

a. Mendut near Tinggang.

Bibos sondaicus (SCHL. et MÜLL.) *fossilis*:
Detached horn-core.

Stegodon trigonocephalus MARTIN:
Inj. cranium with r. M^3.

b. Lepen Alit near Tinggang.

Stegodon airâwana MARTIN:
Fr. lower jaw with l. and r. M_3.

Genus and species undetermined:
Proboscidean tibia (nº. 1).

c. Tegaron.

Buffelus bubalus (L.) ?var. *sondaicus* (SCHL. et MÜLL.) *fossilis*:
Fr. cranium and two detached horn-cores.

Residency: **Rembang.**

Regency: **Blora.**

District: **Randublatung.**

Locality:

a. Sentang Kedung Klampo near Kuwung.

Buffelus bubalus (L.) ?var. *sondaicus* (SCHL. et MÜLL.) *fossilis*:
Fr. cranium.

Elephas ?maximus L. *fossilis*:
Fr. lower jaw with l. and r. M_3.

b. Bondol near Kuwung.

Buffelus bubalus (L.) ?var. *sondaicus* (SCHL. et MÜLL.) *fossilis*:
Three fr. crania.

Rhinoceros sondaicus DESM. *fossilis*:
Cranium.

Rhinoceros ?sondaicus DESM. *fossilis*:
Fr. cranium.
Stegodon bondolensis nov. spec.:
Fr. lower jaw with l. and r. M_3.
Genus and species undetermined:
Proboscidean femur (n°. 1).

c. Tegal Sambiduwur near Kuwung.
Buffelus bubalus (L.) ?var. *sondaicus* (SCHL. et MÜLL.) *fossilis*:
Two fr. crania.

d. Wedilembut [1]).
Genus and species undetermined:
Proboscidean femur (n°. 5).

Residency: **Madiun.**

Regency: **Ngawi.**

District: **Ngawi.**

Locality:
a. Watualang.
Bibos sondaicus (SCHL. et MÜLL.) *fossilis*:
Cranium with both horn-cores preserved. Crushed cranium.
Buffelus bubalus (L.) ?var. *sondaicus* (SCHL. et MÜLL.) *fossilis*:
Two fr. crania.
Hippopotamus sp.:
Hinder portion of cranium.
Genus and species undetermined:
Proboscidean humerus (n°. 2).

b. Pitu.
Buffelus bubalus (L.) ?var. *sondaicus* (SCHL. et MÜLL.) *fossilis*:
Fr. cranium.

District: **Dero.**

Locality:
Redjuno.
Genus and species undetermined:
Proboscidean humerus (n°. 1).

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[1]) On the leaf of the staff-map (1 : 25.000), relating to the matter in question, we only found "Alas Wedilembut". Alas means forest.

Government: **Surakarta.**

Regency: **Sragen.**

District: **Sragen.**

Locality:

Kedung Kendang [1]).

Bibos sondaicus SCHL. et MÜLL. *fossilis*:
Cranium with one horn-core preserved.

Buffelus bubalus (L.) ?var. *sondaicus* (SCHL. et MÜLL.) *fossilis*:
Fr. cranium.

Genus and species undetermined:
Proboscidean femur (n°. 7) and humerus (n°. 3).

First we will occupy ourselves with the new localities NNW. of Bumiaju.

According to ZWIERZYCKI [2]) the first finds were made by Mr. N. DE ZWAAN at Limbangan, who discovered in 1922—'23 some loose specimens in the Kali Glagah and Tji Saät [3]). It lasted till March 1923 before Mr. BUNING of Cheribon announced these finds in the papers. The result was that VAN DER VLERK, at that time palaeontologist of the Geological Survey, by order of that Survey made inquiries on the spot. A brief communication of his experiences will be found in the "Mijningenieur" of 1923 [4]).

The specimens found by VAN DER VLERK, together with the collection presented by DE ZWAAN to the Geological Survey, were sent for examination to STEHLIN in Bale. The results of this investigation were embodied in a paper entitled: "Fossile Säugetiere aus der Gegend von Limbangan (Java)" [5]).

All of STEHLIN's specimens had been obtained from the Kali Biuk and Tji Saät [6]). They were considerably rounded, distinctly indicating river transport. Only a few specimens allowed of determining the species. Noteworthy is that STEHLIN recognized

---

[1]) According to the list of localities, which accompanied the second sending, and also to the labels, Kedung Kendang is situated in the residency Madiun. From the staff-map it appeared, however, that a campong of that name does not occur in the residency mentioned. As it does occur in the government Surakarta, and as it is this campong, which VAN ES (1931) mentions as a locality of vertebrate remains, we may be sure that both list and labels contained an erroneous statement.

[2]) De Mijningenieur, Jrg. 7, 1926, p. 229.

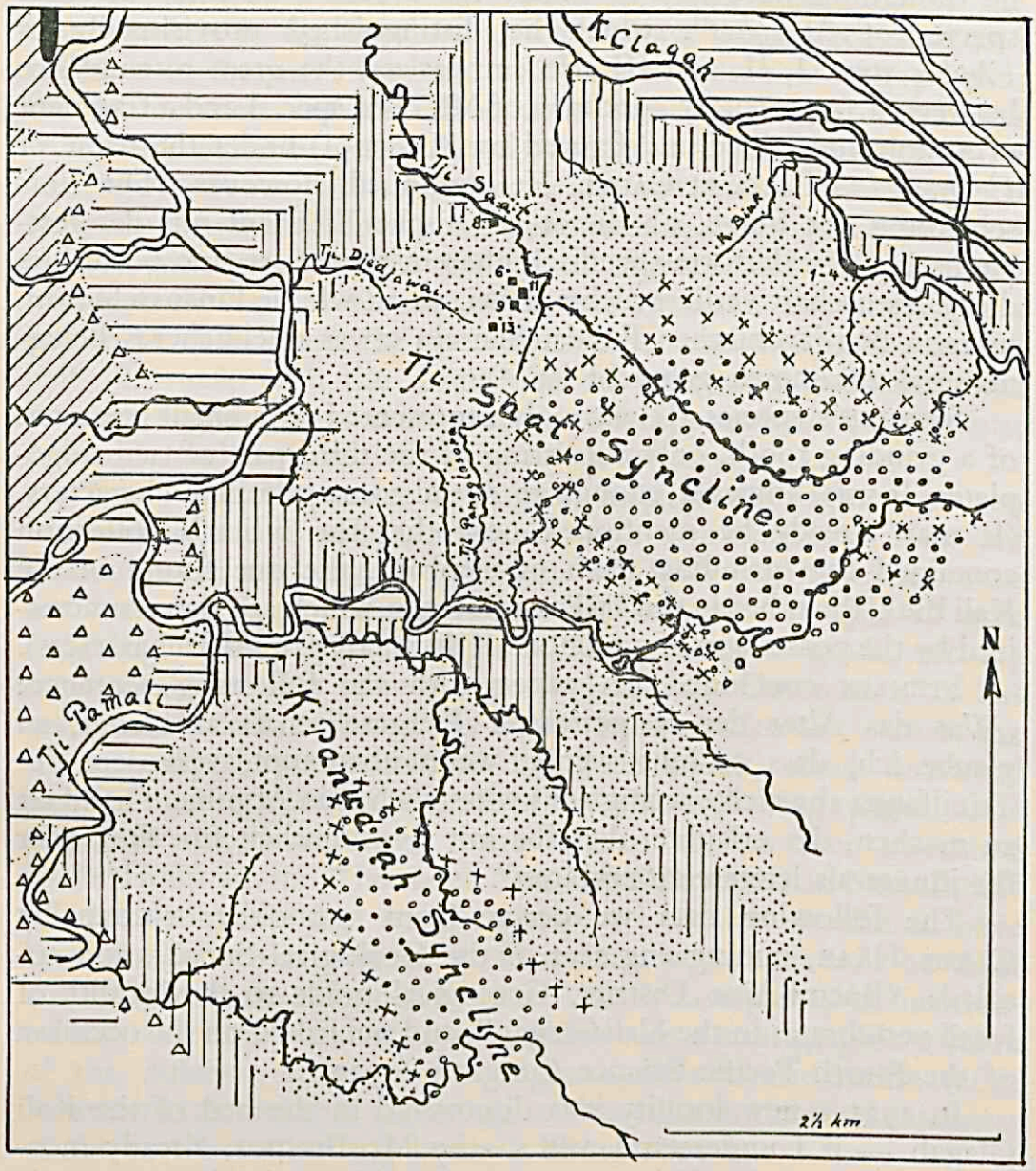
[3]) See for the topographic names map n°. 1.

[4]) Jrg. 4, p. 967.

[5]) Wetensch. Mededeelingen, Dienst v. d. Mijnbouw in Ned.-Indië, n°. 3, 1925.

[6]) I cannot see, therefore, how TER HAAR (1929) came to the assertion that all of STEHLIN's specimens ".....had been collected from the higher strata".

Map n°. 1.



Quaternary.

Upper conglomerate group with tuff beds. } Vertebrate zone.

Lower sandstone-conglomerate group. }

Turritella zone.

Breccia zone.

Limestone-marl zone.

Andesite (pipes and sills).

Excavation.

among the stegodont remains *Stegodon airâwana* MARTIN, and that he thought it necessary to accept the presence of three different species of "*Elephas*", which he distinguished provisionally as *Elephas* spec. I, II, and III. He emphasized the great resemblance between a fragmentary specimen of M^3(?) of spec. I and a fragment of a molar described and figured by MARTIN [1]) under the name of *E. hysudricus* FALC. et CAUTL. He continued, however, "Die Entscheidung der Frage, ob dieser javanische Elephant mit der festländischen Siwalikform specifisch übereinstimmt, ist cura posterior; die Wissenschaft verliert nichts dabei, wenn wir sie hinausschieben, bis von den javanischen Fundstellen ein etwas reichlicheres Belegmaterial zusammen gebracht ist" [2]).

STEHLIN's species III was only represented by a small fragment of a grinding tooth, only consisting of the third part of two ridge-plates. It was, however, enough to reveal some primitive characters. (It may already be mentioned now that the writer's collection contained two grinding teeth of elephant, the one found in the Kali Biuk, the other in the Tji Pangglosoran, which are also characterized by the possession of a number of distinctly primitive characters).

STEHLIN concluded his paper with the following sentence: „Was das Alter der festgestellten Tiergesellschaft anbelangt, so glaube ich, dass es sehr wenig, wenn überhaupt, von dem der Trinilfauna abweicht; wenigstens wüsste ich kein Argument namhaft zu machen, das erlaubte, dieselbe mit Bestimmtheit für älter oder für jünger als letztere zu erklären".

The following data we derive from a booklet, written by C. TER HAAR, mining engineer of the Geological Survey, and entitled: "Boemi-Ajoe District. Geological guide to the locality of fossil vertebrates in the Kali Glagah", and published on the occasion of the fourth Pacific Science Congress (1929).

In 1925 a new locality was discovered in the bed of the Kali Glagah — if I understand well — by Mr. BUNING, already mentioned. As a result of his report a renewed investigation was made by OPPENOORTH, at that time superintendant of the Java party of the Geological Survey. In June 1925 VAN ES [3]), mining engineer of the Geological Survey, had visited the spot, on which occasion he had got the impression that more and better preserved material might be obtainable in excavating the bones. Accordingly OPPENOORTH's investigation had for its object to ascertain whether it

[1]) Samml. Geol. Reichs-Mus. Leiden, IV, (1887), p. 57, pl. VI, figs. 2—2*a*.

[2]) This quotation has been given, because of the fact that sometimes (ZWIERZYCKI, 1926, p. 229, and 'T HOEN, 1930, p. 29) erroneously is maintained that STEHLIN determined one of his specimens as *E. hysudricus*.

[3]) See L. J. C. VAN ES. The Age of *Pithecanthropus*. The Hague 1931. Dissertation Delft 1931, p. 16.

would be possible to find the bones in situ, and if so, whether excavations would take effect. This appeared indeed to be the case. And it is the specimens, which have been excavated and collected in the years 1925 and 1926, which were sent to the writer for examination. At the same time some geological researches were made in the neighbourhood by the mining engineer TER HAAR and ZWIERZYCKI. All the excavation operations were put to a temporary standstill during the negotiations about the cooperation already mentioned of the Geological Survey and the American Museum of Natural History. When it appeared that these plans had to be abandoned, the operations were continued in the second half of 1928, with the result that an interesting collection was brought together, containing remains of hippopotamus, ruminants, crocodile and tortoise.

The writer received a geological map of the region between Limbangan and Bumiaju, together with two sections. Map and sections were made by ZWIERZYCKI. We were told that they were not intended for publication. Nevertheless, we are able to give a geological map of that region. The geological guide, already mentioned, contains namely a geological map. Our map n°. 1 has been made after a part of the latter. For the sake of clearness the site of only those excavations has been added, which furnished part of the specimens described in the following pages. One of the two sections, which were sent to us, has been published by 'T HOEN in the "Jaarboek van het Mijnwezen in Ned.-Indië" (Verhandelingen), Jrg. 1929, 1930, p. 30, so that we should have been entitled to reproduce it. From reasons which will be dealt with presently, we refrained from it. Already now it may be mentioned that 'T HOEN's publication contains also a stratigraphic column of the different strata of the region under consideration (after ZWIERZYCKI), and that according to this column the total thickness of the vertebrate bearing layers is about 1200 m.

It is easily to see that the section, published by 'T HOEN, is more or less perpendicular to the strike. No mention was made, however, of the exact situation of the section. It will be desirable, therefore, to mention that, according to the unpublished map, received by us, the section is situated in the south-easterly part of both synclines, more particularly going via that place between both synclines, where the lower sandstone-conglomerate group crops out between two strips of the Turritella zone. A superficial comparison between map (TER HAAR) and section (ZWIERZYCKI) will reveal that in the latter respect no perfect accordance exists between the two, the section showing a more simple structure. On the other hand the section shows the presence of a vertical fault

in the southwestern syncline, whereas on the map no fault will be found. VAN ES [1]) remarked that the tectonic structure is not so simple as would appear from the section published. Be that as it may, from the map it will be seen that the following statement holds good.

NNW. of Bumiaju a double syncline occurs with approximately NW.-SE. strike. TER HAAR calls the northeastern syncline: K. Saät Syncline, the southwestern one: K. Panudjah Syncline. At the time of TER HAAR's publication (1929) the exact length of the former (and probably also of the latter) was not known yet. Both synclines are separated by an anticline, in the core of which the clay-marls of the Turritella zone make their appearance. The region is intersected by the Tji Pamali and its tributaries. According to VAN ES (l.c.) the "..... region shows signs of recent upheaval; erosion still has great effect and in the valleys landslips frequently occur".

As to the exact stratigraphy an extensive enumeration has been given in a report of the Geological Survey [2]). In consequence of new determinations by VAN ES and VON KOENIGSWALD, the former was able to make some additions. The list, which follows below, has mainly been composed in combining that of the Geological Survey and that of VAN ES. The mention of *Mastodon perimensis* (one of the provisional determinations of the present writer) has been replaced by *Tetralophodon bumiajuensis*.

Zone		Sediments	Fossils	Appr. thickness in meters
Pliocene.	Vertebrate zone.	1. conglomeratic series with sandstone layers.	Scattered remains of vertebrates	250
		2. tuff horizon of grayish white sandstones.		150
		3. sandstone-conglomerate series with argillaceous sandstones, clay and marl, locally with beds of lignite, and mostly bearing lime.	*Tetralophodon bumiajuensis* nov. spec. *Stegodon airâwana* MARTIN. *Hippopotamus* sp. Several species of *Melania* and *Corbicula*, 69 % of which recent species. Some marine molluscs and foraminifera.	200

[1]) L. c. p. 48.

[2]) Jaarb. v. h. Mijnwezen in Ned.-Indië. Algemeen ged., 1930, p. 49.

Zone		Sediments	Fossils	Appr. thickness in meters
Pliocene.	Turritella zone.	blueish-gray and greenish argillaceous marls, subordinate sandy marls. mollusc bed.	Molluscs, 56 % of which recent species.	175
	Conglomerate zone.	andesitic sandstones and conglomerates.	In the upper part locally coral reefs.	200–250
Miocene.	Breccia zone.	hard, usually coarse basic andesitic breccia. Intercalations of tuff beds, and –at 300 m. from the base– a horizon of pumice-stone breccia of a thickness of 200 m; locally lava.		1000
	Tuff-sandstone zone.	fine and coarse greenish andesitic sandstones and lime bearing sandstones with intercalations of marl beds. more towards the top the sandstones become more conglomeratic and "breccia-like". a characteristic horizon is formed by a series of light coloured tuff-sandstones and grit with pieces of pumice stone.		?
	Argillaceous marl-limestone zone.	greenish, concretionary Globigerina marls, in the upper part bedded by thin layers of sandstones; more towards the base grayish-green marls with limestones, containing many foraminifera; finally unstratified concretionary argillaceous marls.	*Trybliolepidina rutteni* with several varieties. *Cycloclypeus neglectus*. *Cristellaria* sp. *Operculina* sp. *Operculinella* sp. *Amphistegina* sp. *Gypsina globulus*. *Rotalidae*, *Algae*, and pricks of echinids.	?

Both the author of the report as well as VAN ES agree as to the pliocene age of the series composed by the Vertebrate zone, Turritella zone and Conglomerate zone. I do not know, however, on what grounds the lowest boundary of the Pliocene has been drawn between the Conglomerate zone and the Breccia zone, which are both unfossiliferous. Furthermore, it may be pointed out that in all probability in TER HAAR's map (and therefore also in our map n°. 1) both Conglomerate zone and Turritella zone have been indicated by the same vertical signature. I do not know, however, with which zone the Tuff-sandstone zone has been united.

It will be remembered that in the foregoing part has been stated that according to the original opinion of ZWIERZYCKI the total thickness of the vertebrate bearing layers is about 1200 m. The above list shows that according to more recent opinions, the thickness is but 600 m. As ZWIERZYCKI calculated the thickness from the sections, it is highly probable that the section published by 'T HOEN — and already mentioned in the foregoing pages — does not hold good any more. That is, therefore, the reason why I have refrained from reproducing it.

From the report of the Survey we borrowed what follows.

The Vertebrate zone lies at the K. Glagah conformably on the Turritella zone [1]); an interjacent zone of some tens of meters consists of alternating Turritella layers and vertebrate layers, and begins with conglomeratic, andesitic sandstones, containing lumps of lignite. The latter horizon is better developed (ca. 150 m.) in the Bentarsari basin, and shows there a series of layers of impure lignite, containing 50 % of water, which high percentage should indicate a pliocene age. The lowest vertebrate bearing layers are argillaceous marls and tuffoid sandy marls of andesitic material. In the Turritella zone, thus called on account of the frequence of *Turritella djadjariensis*, 46 species of molluscs (gasteropods and lamellibranchiates) were found, 22 of which, i. e. 48 % are recent. This percentage was, however, not used as an argument for a pliocene age. According to TER HAAR [2]) this fauna has been examined by GERTH, who established the age of the Turritella zone as older Pliocene. In the report stress has been laid upon the fact that the fauna shows resemblance to that of Tjidjurai (Cheribon), examined by MARTIN, and held to be Pliocene by this investigator.

As an argument for the pliocene age of the vertebrate bearing sandstone-conglomerate series the occurrence of *Mastodon peri-*

[1]) According to TER HAAR (1929) this is invariably the case.

[2]) L. c. p. 11.

mensis, *Stegodon airâwana* and *Hippopotamus* sp. [1]) is mentioned. Though in a final chapter we shall return to the age of these beds on the basis of the determination of the mammalian remains, already now it may be pointed out that the cogency of the argument mentioned, cannot be called sufficient. It must not be forgotten that *St. airâwana* is an upper pliocene species according to DUBOIS [2]), a lower pleistocene species according to MARTIN [3]), a middle pleistocene species according to OSBORN [4]), and an upper to youngest pleistocene species according to DIETRICH [5]). As to *Hippopotamus*, it must be borne in mind that according to PILGRIM the youngest horizon in which this genus occurs, is the Boulder Conglomerate zone (uppermost Upper Siwaliks). PILGRIM [6]) regards the Upper Siwaliks as of pliocene age. MATTHEW's [7]) recent investigations on the Siwalik fauna led him, however, to the conclusion that there are no valid reasons for referring the Upper Siwaliks fauna to the Pliocene. Accordingly he reckons the Upper Siwaliks to the lower Pleistocene. Finally it may be mentioned that according to OSBORN [8]) *Mastodon (Anancus) perimensis* is an upper miocene species. I must admit, however, I do not know on what grounds.

VAN ES (l. c.) determined in cooperation with VON KOENIGSWALD, one of the palaeontologists of the Survey, part of a collection of gastropods and lamellibranchiates from the Turritella beds, collected by him and C. A. DE JONGH. The following values were found. Of 34 species determined, 19 or 56 % were still living. In VAN ES's opinion this percentage points decidedly to a pliocene age, which would be confirmed by the fact that 24 species are known to occur in the Miocene, against 33 in the Pliocene. If one compares this percentage of 56 % with the value found by VAN ES and VON KOENIGSWALD for the fauna (76 species) of the Turritella beds of Sangiran (45 %), and with those established by MARTIN [9]) for the rich marine fauna (150 species) of Sonde (53 %), and for the marine fauna (64 species) of Tjidjurai (51 %), one would be

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[1]) The mention of these forms was based on provisional determinations of the writer. It may be repeated that in the writer's present opinion the mastodont of Bumiaju is not identical with *Mastodon (Anancus) perimensis*, but represents a new species *(Tetralophodon bumiajuensis)*.

[2]) Tijdschr. Kon. Ned. Aardr. Gen., ser. 2, XXV, 1908, p. 1257. DUBOIS reckons *St. airâwana* to *St. ganesa, var. javanicus* DUB.

[3]) Unsere palaeozoologische Kenntnis von Java. Leiden 1919, p. 144.

[4]) Proc. Amer. Philos. Soc., LXX, 1931, n°. 2, p. 189.

[5]) Sitz.ber. Ges. Naturf. Fr. Berlin, Jhrg. 1924, 1926, p. 139.

[6]) Rec. Geol. Surv. India, XLIII, 1913, part 4, p. 324.

[7]) Bull. Amer. Mus. Nat. Hist., LVI, 1930, p. 445.

[8]) Proc. Amer. Philos. Soc., LXIV, 1925, p. 27.

[9]) See VAN ES's correlation table.

inclined to believe that the Turritella beds of Bumiaju show the greatest affinity to the Sonde beds. It must not be forgotten, however, that resp. 22 and 21 Bumiaju species were found to occur in Sangiran and Tjidjurai, against but 10 in Sonde. VAN ES, therefore, concluded: "A comparison with Sonde shows a great disparity to exist, but the resemblance to Sangiran and Tjidjurai is very obvious. As Sangiran (.....Lower Pliocene) and Tjidjurai (Middle Pliocene) are different in age, the almost equal affinity to both faunas makes it rather difficult to decide from this point of view to what horizon the Turritella bed of Bumiaju belongs. However, considering the rather high percentage of living species there is more reason to accept a Middle Pliocene age"[1]). In connection with the latter quotation, and with the percentages mentioned above, I should like to point out that the difference between the percentages of Sangiran (45 %) and of Tjidjurai (51 %) is 6 %, and between those of the latter and Bumiaju (56 %) is 5 %. Whilst VAN ES regards the fauna of Sangiran to belong to the Lower Pliocene, he considers the fauna of Bumiaju to be of the same age (Middle Pliocene) as that of Tjidjurai, in spite of a difference of 5 % between Bumiaju and Tjidjurai. Herewith I do not intend to maintain that an equal age of both is to be excluded. It must not be forgotten that the percentage of 56 %, found for the fauna of Bumiaju, is based on but 34 species, whereas in Tjidjurai almost twice as many species have been found.

VAN ES gave also the results of the determination by GERTH of a collection of fresh-water molluscs (*Corbicula*, *Unio*, *Melania*, *Paludina)* from the vertebrate bearing layers of Bumiaju. Of 13 species determined, 9 or 69 % appeared to be still living. From this VAN ES drew the conclusion: "This percentage points to an Upper Pliocene age of the fresh-water beds"[2]). 13 species, however, form too small a number to justify so resolute a conclusion. VAN ES's statement is the more remarkable, because on p. 26 he himself points rightly out that it is ".....necessary to exercise great caution in determining the age of the beds from the ratio of living species when too few Molluscs are present". He even set some examples, one of which is very noteworthy. In Sangiran MARTIN found a percentage of 33 % living species on 21 species; VAN ES was able to determine a ratio of 45 % out of 76 species.

GERTH[3]) advanced another objection against VAN ES's determinations of the age. He remarked namely that VAN ES, in placing

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[1]) L. c. p. 50.

[2]) L. c. p. 52.

[3]) Tijdschr. Kon. Ned. Aardr. Gen., ser. 2, XLIX, n°. 2, 1932, p. 345.

the young tertiary fauna of molluscs with 50—60 % living species [1]) in the Middle Pliocene, started from a supposition, which lacks sufficient ground, as long as we do not know that this percentage is indeed a characteristic of the middle pliocene strata of Java. We may add that MARTIN — without doubt the best connoisseur of the Tertiary of Java — has hitherto refrained from subdividing the Javan Pliocene [2]).

Later on we shall have the opportunity to return to VAN ES's very important paper. For the present we will pay attention for a moment to another argument, mentioned by VAN ES to prove the tertiary age of the vertebrate bearing strata of Bumiaju, viz., their strong folding. The report, already mentioned, of the Geological Survey even speaks of very intense folding. And as — VAN ES remarks — quaternary beds with a steep dip are unknown till now, a tertiary age is most likely. That also this argument has no absolute cogency, may be proved by a quotation, which we borrow from VAN ES himself: "Arguments derived from the dip of the beds are but of relative and local value and are insufficient to serve as a proof for the age of the beds....." [3]).

We shall now proceed with the consideration of the other localities. We may begin to ask ourselves whether detailed stratigraphic and tectonic data of these localities are available. In 1927 the state of affairs was still such that RUTTEN [4]) — after the discussion of the vertebrate bearing layers of Java — had to make the bitter remark, that not only the tectonic structure and the stratigraphy of the Trinil beds was very insufficiently known, but also the startling fact occurred that our knowledge of the geology of the surroundings of Trinil, famous by DUBOIS's discoveries of *Pithecanthropus erectus* and of a very rich fauna of vertebrates, was but very small. And had VAN ES not published the results of his extensive investigations, we should have been compelled to make exactly the same remarks. Just because we had to criticize VAN ES's paper in the foregoing pages, we are the more eager to avail ourselves of the opportunity afforded of throwing light upon the great merits of this work. It is entirely due to VAN ES that at present we dispose of a lot of stratigraphic and tectonic particulars of numerous localities, all embodied in detailed geological maps and sections. Moreover, VAN ES made extensive collections of molluscs from the

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[1]) See the very instructive table given by VAN ES (l. c.).

[2]) See his recent paper: "Wann löste sich das Gebiet des Indischen Archipels von der Tethys?" Leidsche Geol. Meded., IV, 1, 1931.

[3]) L. c. p. 7.

[4]) Voordrachten over de geologie van Ned. Oost-Indië. Groningen 1927.

marine layers, which occur almost everywhere below the vertebrate bearing series. And though GERTH's remark may be true, namely, that only the relative age has been established by the determinations of these fauna by VAN ES (and VON KOENIGSWALD), it must not be forgotten that VAN ES, in publishing so many new data, considerably enriched our knowledge of these marine sediments.

I should like to draw attention to some more merits. On the occasion of the 70th birthday of Professor K. MARTIN a jubilee book was published[1]), which is a sort of reasoned fossil catalogue of the entire East and West Dutch Indies. This work has been brought about by cooparation of a number of Dutch and some foreign investigators. The *Mammalia* have been dealt with by the present writer. The various localities, which I found mentioned in the papers relating to the subject, were united in a small sketch map[2]). If that map be compared with a similar map, occurring in VAN ES's paper, it will be seen that also in this respect VAN ES collected many new data.

Noteworthy furthermore is the way in which VAN ES discussed the problem of the age of the Trinil beds. As will be known, the number of publications, dealing with this problem, is considerable, and the number of opinions is hardly less large. Consequently difficulties are met, if one tries to form a definite opinion from the chaos of assertions and opinions. VAN ES, however, had the original idea to class the arguments, advanced by the various authors, with eleven different headings viz., 1. Orogenic movements, 2. Vulcanism, 3. River terraces, 4. Culture remains, 5. The anatomical features of *Pithecanthropus erectus*, 6. The process of fossilization, 7. Marine molluscs, 8. Fresh-water molluscs, 9. Plant remains, 10. Vertebrates, 11. Climate. In this way an excellent synopsis originated.

After this expatiation, which appeared to us as wholly justified, we return to our starting-point. We shall begin with the localities Watualang, Pitu and Kedung Kendang, all situated near the Solo river[3]). It will be known that the famous localities Trinil and Sonde are also situated on that river.

VAN ES's publication contains a geological map of the Solo river region between Gesi (N. of Sragen) and Ngawi. According

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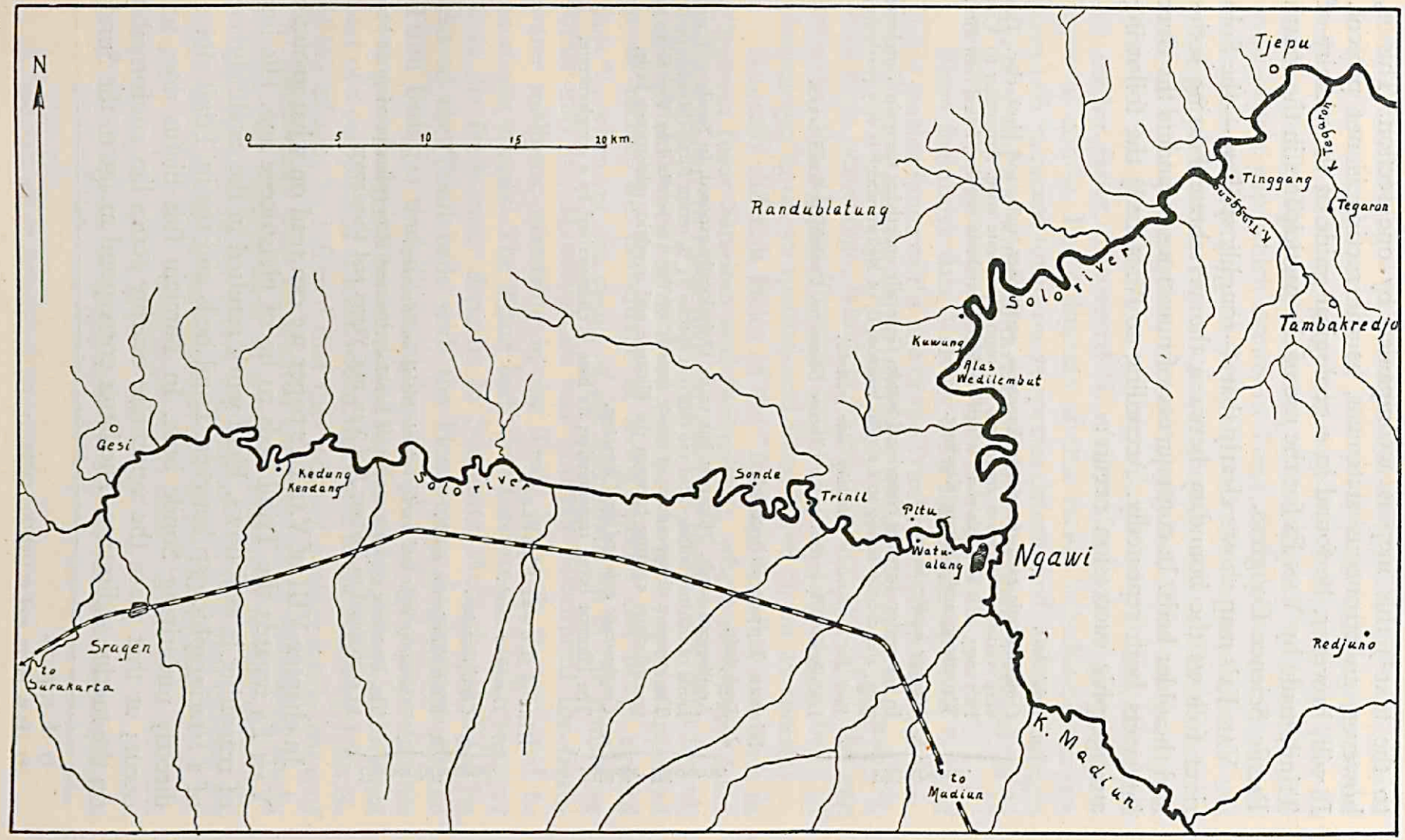
[1]) Leidsche Geol. Meded., V, 1931.

[2]) L. c. p. 471.

[3]) See map n°. 2.

Map n°. 2.


N
0 5 10 15 20 km.
Tjepu
K. Tegaron
Tinggang
Tegaron
K. Tinggang
Randublatung
Solo river
Tambakredjo
Kuwung
Alas Wedilembut
Gesi
Kedung Kendang
Solo river
Sonde
Trinil
Pitu
Watu-alang
Ngawi
Redjuno
Sragen
to Surakarta
K. Madiun
to Madiun

to the text [1]) this map is accompanied by one section. This is, however, an erroneous statement, as the section is not present. It will, however, be found in a geological guide of the vicinity of Trinil, made by VAN ES for the use of the participants in the fourth Pacific Science Congress.

VAN ES's map shows clearly that — roughly spoken — the Solo river follows the boundary between the vertebrate bearing series and the older beds. In consequence of numerous meanders the river intersects both repeatedly. According to VAN ES [2]) the following stratigraphic succession occurs:

Pleistocene.

a. Trinil beds.
Conglomeratic sandstones, conglomerates, sandstones, tuffs, and black clay. This very variable succession represents the main Vertebrate zone. According to VAN ES's map, it is also this zone, which yields the vertebrate remains, found near Pitu, Watualang, and Kedung Kendang.

b. Volcanic boulder breccia.
In the region between Ngawi and Sonde. Generally underlying the main Vertebrate zone, and corresponding to a similar horizon, E. of Ngawi, which is very persistent.

c. Sand and conglomerate containing older material.
Locally directly covering the pliocene limestone. Containing fossil bones.

Hiatus (Upper Pliocene).

Middle Pliocene.

d. Sonde beds.
Argillaceous sands. Thickness but 50 m. Only locally exposed. In Sonde with rich fauna of marine molluscs. On 150 different species 53 % recent forms (MARTIN 1919). The apparent disappearance of Sonde beds E. of Trinil is ascribed by VAN ES to an unconformity existing between the Pliocene and overlying pleistocene beds.

e. Conglomeratic beds and coral limestone.
The Pliocene being transgressive, its base is characterized by a conglomerate.

Hiatus (Lower Pliocene).

Upper Miocene.

f. Transition marls.

g. Coral limestone.

h. White Globigerina marls.

i. Alternating tuffs and marls, volcanic breccia and limestone.
The limestone contains species of Lepidocyclina and Miogypsina proving the beds to correspond to Tertiary *f* of VAN DER VLERK and UMBGROVE.

In chapter VIII of VAN ES's paper we can read on what grounds VAN ES regards the Trinil beds to be of pleistocene age. His line of reasoning is as follows. Field work resulted in the establishment of a stratigraphic gap between Trinil beds and the in Trinil almost directly underlying Sonde beds. In Bumiaju this hiatus does not occur; at that place the vertebrate bearing series lies conformably on the marine sediments. The latter correspond in age to the Sonde

[1]) L. c. p. 75.

[2]) L. c. p. 75 and correlation table.

beds, each showing a percentage of recent species between 50 and 60 %. (As already mentioned this percentage surely proves the beds to be of pliocene age; their supposed belonging by VAN ES to the Middle Pliocene, however, remaining to be solved). The stratigraphic gap which occurs in Trinil, corresponds to the vertebrate beds of Bumiaju. In Java, therefore, an upper pliocene and a lower pleistocene fauna of vertebrates occur. The vertebrate beds of Bumiaju represent, however, only one facies of the Upper Pliocene. No less than four different facies were found, of which the marine facies, discovered N. of Djombang, is of great importance of course. For sediments of that facies VON KOENIGSWALD found 66 % recent forms on 71 species determined [1]) (Sumberringin layers 2 and 3), while MARTIN established a percentage of 70 % on 50 species determined [2]) (fauna of Kedungwaru).

From the above data VAN ES drew the conclusion that "……if ever a marine fauna of the age of the Trinil beds is discovered in Java, it will show to contain more than 70 % living species of Molluscs" [3]). This high percentage, which is to be expected, would fill the gap between the Upper Pliocene and the post pleistocene beds of Grissee (90 % on 30 species) and Batavia (86 % on 22 species).

A totally different facies of the "Bumiaju beds" is met with in Surakarta (near Sangiran and Baringinan), where freshwater lake-deposits occur. In these beds 16 different forms have been found, 9 of which have been determined hitherto. As only 3 species appeared to be recent, the percentage of living species can never exceed 62½ %, whatever the result of the determination of the remaining forms may be. MARTIN-ICKE and MARTIN determined the fresh-water molluscs, occurring in the Trinil beds: 83 % appeared to be recent species. The Trinil beds therefore are decidedly younger than the fresh-water deposits in Surakarta. Accordingly VAN ES classed the Trinil beds with the Pleistocene. As furthermore the Trinil beds (1) underlie a mighty complex of volcanic sediments (Notopuro beds) in the vicinity of Pandan and (2) occur in the basal part of a complex of at least 500 m. thickness in the Kendeng Hills N. of Djombang, he inferred that they occupy a rather low horizon of the Pleistocene. VAN ES regards the presence of *Mastodon?* sp. [4]), *Stegodon* and *Hippopotamus* as another indication in that direction.

For the present the above will suffice. In our final chapter we shall return to the problem of the age of the Trinil beds.

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[1]) See VAN ES (1931), p. 115.

[2]) See VAN ES (l.c.), p. 117. VAN ES borrows these particulars from a report by MARTIN not yet published. It may be emphasized that MARTIN concludes to a pliocene age.

[3]) L. c. p. 134.

[4]) This form will be dealt with in the sequel.

Before passing on to the consideration of the other localities, it will be desirable to bring forward the following particulars concerning the Trinil beds between Gesi and Ngawi.

According to VAN ES the bones seldom occur as abundantly as in Trinil. The bone beds of a. o. Watualang and Kedung Kendang are mentioned as deposits, that might compete with those of Trinil. VAN ES protests against the opinion of some, that the origin of the bone beds should be a result of the destruction of the existing fauna by volcanic eruptions. He points out that in many cases the bones were found in cross-stratified sandstones, containing rounded pebbles indicating true river deposits. In his opinion the animals died through natural causes; they were swept by flooded rivers to some wirl-pool bend where they sank, or to sandy banks where they finally decomposed. In several cases the bones were already broken and weathered, before they were burried in the sand. Crocodiles often caused accumulation of the bones.

"In other cases the bone-bearing bed consists of black clay, containing fresh-water Molluscs and remains of fishes, crocodiles and turtles [1]). This black clay has been formed in stagnant pools and marshes or even in big lakes. Sometimes nearly complete skeletons of larger Vertebrates occur, owing to the fact that marshes often form the dwelling place of big animals." [2])

That river accumulation, not volcanic activity, was predominant is — according to VAN ES — proved by the fact that the bone beds contain detritus of miocene strata. It is these detrital products which VAN ES holds responsible for the solidification of sandstones and conglomerates.

Then VAN ES discusses the opinion, that the bones should have been washed off from the older beds. Admitting the preponderant influence of erosion, this possibility may not be immediately excluded. Many bones, however, do not show traces of wear. Furthermore, he rightly points out that *Stegodon* tusks and crania with the horn-cores attached, are too brittle in a fossil state to allow of any transport. Moreover, bigger bones and skulls often occur in medium-grained sand, containing only small pebbles, whilst big boulders are absent. Transport of the bones in a fossil state is in such cases highly improbable, as the specific weight increases by the process of fossilization.

As to the tectonic structure of the Trinil beds he mentions that the general dip is 6—10° S., showing the influence of tilting or folding movements. Several transverse faults show, moreover, that the beds did not remain undisturbed.

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[1]) Meant is tortoises.

[2]) L. c. p. 79.

We think it entirely superfluous to occupy ourselves with the geology of the surroundings of Redjuno. From that locality, namely, we are able to mention only one specimen viz., a proboscidean humerus, which did not even allow of determining the genus with sufficient reliability. Those who are interested in the stratigraphy and tectonic structure of the region, I may refer to VAN Es's publication.

As to the localities, which are situated in the districts Randublatung and Tambakredjo, we are forced to be brief, because VAN Es did not make detailed investigations in these regions. On p. 19 VAN Es mentions that he discovered in 1927 an occurrence S. of Randublatung, which appeared to be very rich in vertebrates. As Kuwung is situated SE. of Randublatung, it is highly possible that our specimens from Randublatung have been obtained from that locality. "The beds mainly consist of sandstone and gravel of volcanic origin and overlie the Miocene hills. There is a very pronounced unconformity between the slightly N.-dipping vertebrate beds and the steeply folded Miocene marls."

Still on p. 19 he cursorily deals with the localities in the neighbourhood of Tinggang. In 1926—1927 he collected there a large number of vertebrate remains from gravel beds, mostly containing pebbles of volcanic origin. "Owing to the bad exposures no data were obtainable concerning the relations to the underlying Tertiary beds. In the vertebrate beds in several spots a slight dip to the N. not exceeding 5° was established."

It may be mentioned that it is highly probable that the remains of our collection derived from these localities have been collected by VAN Es, the label of numerous specimens of the second sending bearing the mention: "Collection VAN Es".

We shall now drop the subject of the consideration of the localities, and pass on to a discussion of the few "*Mastodon*" remains which were hitherto found in the Dutch East Indies.

MARTIN [1]) described and figured under the name of *Mastodon* sp. the posterior portion of a grinding tooth, and the distal portion of an incisive tusk. DUBOIS [2]) did not agree with the generic determination. According to this investigator both specimens might rather belong to *Stegodon*. The fragment of the incisor shows a distinct flattening as a result of wear. DUBOIS rightly pointed out that this feature is not an exclusive character of the tusk of mastodonts.

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1) Samml. Geol. Reichs-Mus. Leiden, IV, 1888, p. 90, pl. XI, figs. 1—2*a*.

2) Nat. Tijdschr. v. Ned.-Ind., LI, 1892, p. 95.

LYDEKKER [1]) recorded from British Borneo a l. M^3 of *Mastodon latidens* CLIFT. [2]) The determination is certainly correct. At present this form is reckoned to the new genus *Stegolophodon* SCHLESINGER (*Prostegodon* MATSUMOTO), which OSBORN reckons to the subfamily of the *Stegodontinae*. But as far as I can see, this is merely a matter of taste.

VAN ES [3]) gave under the name of *Mastodon*? sp. two fine figures of a fragmentary grinding tooth, obtained from Sangiran, and from beds, which he regards to be of lower pleistocene age. In a note on p. 54 he mentions, furthermore, that DUBOIS showed him part of a similar molar, collected from the Kendeng Hills. In the latter's opinion these specimens might represent an atavistical deviation of a *Stegodon* molar. The writer should not like to endorse this statement. Be that as it may, VAN ES's specimen does not in the least resemble the specimens obtained from Bumiaju. As to the latter, these were originally determined as belonging to *Mastodon longirostris* by STEHLIN [4]). As already mentioned, originally the writer identified the form of Bumiaju provisionally with *Mastodon perimensis*.

Some forms of our collection appeared to be specifically identical with still living species (kerabau, banting, Javan rhinoceros and Indian elephant). In this connection I should like to make some remarks.

It is clear that everyone, who has to occupy himself with the examination of a relatively young fauna, will make comparisons with the recent fauna. In doing so, it is of the first importance that not one or some specimens of the recent species be used, but the greatest number possible. STREMME — in determining the greater part of the mammalian remains of the Trinil collection of Mrs. SELENKA — neglected this requirement, and it played tricks on him. As a matter of fact the German museums of Natural History will not contain so great a number of Dutch East Indian specimens as the Dutch museums do. I have not got the impression, however, that STREMME troubled himself sufficiently. Moreover, he apparently did not feel fully the seriousness of the requirement mentioned. Otherwise he would not have ventured to draw such resolute inferences by the help of so small a material for comparison.

As mentioned, the writer was in a far better position. And he has made an eager use of the opportunity afforded. Not because measuring skulls and composing tables of measurements is a plea-

[1]) Proc. Zool. Soc. London, 1885, p. 777, pl. XLVIII, figs. 1—2.

[2]) VON KOENIGSWALD (De Mijningenieur, n°. 11, 1931) pointed out that this specimen has possibly been imported from China!

[3]) L. c. p. 66.

[4]) See De Mijningenieur Jrg. 7, 1926, p. 230. As far as my knowledge goes STEHLIN only received photographs.

sant occupation! On the contrary. This declares in my opinion why in this respect a lot of work remains to be done. The necessity to have the disposition of tables, which show in numbers the individual variation of the cranium of recent species, may appear from the fact that FRANZ TOULA's [1]) tables of cranial measurements of *Dicerorhinus sumatrensis* are repeatedly consulted, in spite of the fact that they contain several miscalculations.

Incidently it may be pointed out that in studying the measurements of the crania of recent forms of *Hippopotamus* we arrived at an unexpected result. *Hippopotamus constrictus* MILLER, namely, appeared to have no right to specific distinction, being identical with *H. amphibius*. One more proof of the correctness of the assertion above mentioned.

As to the measuring of the skulls and the making of the tables of measurements the greatest possible accuracy has been practised. Repeatedly it has occurred that measurements, which distinguished themselves either by a very high or low value, have again been taken. The percent numbers in general have been obtained by the help of an electric calculating machine. All the percent numbers have twice been checked. Nevertheless I do not imagine my tables to be without errors. This is practically an impossibility with a material of several thousands of numbers. Also I fully realise that the material measured, does not suffice to serve as a base for far-reaching conclusions. It will be known that some anthropologists are not wholly satisfied before they dispose of the measurements of some 2000 crania.

Finally some detached remarks.

Of course it has been tried to obtain from Prof. DUBOIS the permission of comparing our specimens with those of his famous collection. Prof. DUBOIS wrote us, however, that he regretted much that he was forced to refuse our request, because his collection was not in a state for demonstration in consequence of its repeated removals.

Most specimens described are strongly fossilized. This especially concerns the specimens from Bumiaju. As to the degree of fossilization of the remaining, some require special mention. The three crania of *Bibos sondaicus fossilis*, and some specimens of *Buffelus bubalus* ?var. *sondaicus fossilis* are but little fossilized. Accordingly it was necessary to harden them. Contrary to the remaining specimens, the specific weight of the specimens mentioned is low. Also they do not show the gray colour of the specimens from Bumiaju, but have a brown appearance. One specimen of our collection is extremely little fossilized. It is the posterior portion of a cranium of *Hippopotamus* sp., and shows a remarkable recent appearance.

[1]) Abh. K.—K. Geol. Reichsanst. Wien, XIX, H. 1, 1902.

It appeared that the photographs of the proboscidean grinding teeth in general considerably gained in clearness, if the dentine material of the teeth was blackened previously. It will be seen that most specimens have been treated in that way.

Last not least the following remark. The present paper is the work of a beginner. The writer has sufficiently realized that palaeontological science will profit more by very accurate descriptions than by phylogenetical speculations of beginners. Consequently very much attention is given to the former. Especially in describing the proboscidean grinding teeth, the writer started from the supposition that it is better to give too much than too little.

I cannot conclude without expressing my sincere thanks to:

Mr. A. C. DE JONG, mining engineer, Intendant of the Geological Survey (Opsporingsdienst) of the Dutch East Indies, to whose intermediary I owe that this fine collection was sent to me for examination.

Prof. Dr. L. M. R. RUTTEN, who had the supervision of this work, and who, though not being a vertebrate palaeontologist, saved me by his clear criticism from faulty reasoning.

Prof. Dr. H. F. NIERSTRASZ, Director of the Zoological Institute of Utrecht, to whose warm recommendation I owe for a good deal that the Geological Survey entrusted me with the determination, for his unremitting attention in my work and for permitting me to measure some fine crania, contained in his Institute.

Prof. Dr. MAX WEBER for several important informations, and for his kindly lending me many separates of his collection.

Prof. Dr. EUG. DUBOIS, for his valuable informations.

Prof. Dr. E. D. VAN OORT, director of the National Museum of Natural History in Leiden for access to his museum, and the permission to measure and photograph specimens under his charge.

Dr. A. L. J. SUNIER, Director of Natura Artis Magistra at Amsterdam, for the opportunity of measuring and photographing the specimens contained in the various museums under his charge.

Prof. Dr. L. A. DE BEAUFORT, Director of the Zoological Institute of the University of Amsterdam and

Dr. H. ENGEL of the same Institute for their willingness to help, showed to me.

Mr. P. TH. N. MOESVELD for revision of the text.

Finally I am greatly indebted to my wife for her real and moral support.

Fam. BOVIDAE.

Subfam. BOVINAE.

Buffelus bubalus (L.) **?var. sondaicus** (SCHL. et MÜLL.) **fossilis.**

Pl. I, figs. 1—4.

Text fig. 1.

Localities: Sentang Kedung Klampo, Bondol near Kuwung, Tegal Sambiduwur, Tegaron, Pitu, Watualang, Kedung Kendang.

Buffalo remains are represented in our collection by eleven fragmentary crania, and two detached horn-cores. They have been obtained from seven different localities.

Number	Locality	District	Regency	Residency
1	Sentang Kedung Klampo	Randublatung	Blora	Rembang
2, 5, 8	Bondol			
3, 6	Tegal Sambiduwur			
11, 12, 13	Tegaron	Tambakredjo	Bodjonegoro	Bodjonegoro.
9	Pitu	Ngawi	Ngawi	Madiun
4, 10	Watualang			
7	Kedung Kendang	Sragen	Sragen	Surakarta

The numbers of the specimens refer to those of table B of cranial measurements.

Unfortunately all the specimens of crania (nos. 1—11) are very incomplete; some only consist of the fronto-parietal region with a short portion of one or both horn-cores. Most are broken off, either in front of the orbit or immediately behind it. In this respect two specimens are somewhat better preserved, the one (no. 2) showing the hinder half of the nasals, the other (no. 3) still having the posterior portion of the left maxillary with some molar teeth. One specimen (no. 2) possesses a zygomatic arch. In only one specimen (no. 3) the orbit is tolerably well preserved. Two crania (nos. 10 and 11) are in too bad a condition to allow of measuring.

All the specimens show a smaller or greater portion of one or both horn-cores. Two crania, one of which is figured in figs. 3 and 4 of pl. I, are in this respect the best preserved, one having

the nearly complete right horn-core, the other being in the possession of both horn-cores. But even of these a smaller or greater portion of the tip is wanting. Nevertheless, the specimens represented fortunately enable us to state the curvature and course of the horn-core of this fossil buffalo, to determine the relation of the complete core to the fronto-occipital region of the cranium, and to realize the enormous span of the horn-cores.

As far as can be gathered from these fragmentary crania they all seem to have belonged to adult individuals of the same species. I think, therefore, it will be best to give a summarized description of all the specimens.

Before commencing with the descriptive part it will be desirable to lay stress upon the fact that — in describing the crania in question — these were supposed to be placed on the anterior premolar teeth and the paroccipital processes.

The occipital surface is in a splendid state of preservation in specimen n°. 1, two views of which are given in figs. 1 and 2 of pl. I. The occipital surface is divided by the occipital crest into two semi-distinct portions, a smooth supra-cristal portion, and a rough infra-cristal portion (i. e. the true occiput) for muscular attachments. The occipital crest is a wide arch, the summit of which is mostly flattened. This crest is sometimes so prominent that it makes the impression as if the upper half of the true occipital surface has sunk into the strong frame of the crest. Above this crest the temporal fossae, which terminate in blunt, round extremities, cut into the occipital surface. The degree of constriction of the occiput will be dealt with below. In specimens 1 and 7 the course of the posterior part of the temporal fossa is the same as in the cranium of the kerabau. In specimens 2, 3, 5, 6 and 8, however, a peculiarity occurs. In these specimens, namely, the posterior parts of the temporal fossae first converge normally backwards; near the occiput, however, they change their direction, strongly diverging backwardly. To this peculiarity we shall have to return later on. The true occipital surface is much more broad than high, the interval between the upper margin of the for. magnum and occipital crest being more than three times contained in the greatest breadth of the occiput. The supra-cristal portion joins the frontals by a gentle curve. There is not the slightest trace of an intercornual ridge, with the only exception of one specimen in which the transition of forehead into occiput is not wholly gradual, but more or less angular. The absence of an intercornual ridge made it impossible to measure with tolerable reliability the height of the occipital surface (see also note 2 on p. 38). Though, therefore, the exact height of the supra-cristal portion cannot be given in mm., never-

theless it is not difficult to state that the interval between occipital crest and for. magnum is nearly equal to the interval between occipital crest and the middle of the curve formed by the gradual transition of forehead to supra-cristal portion of occiput. From the middle of the occipital crest straight downwards runs the vertical crest, affording attachment to the ligamentum nuchae between the occipital muscles. In some specimens this crest is ill-defined, in others very distinctly marked. The occipital condyles are obliquely placed; the for. magnum is subcircular. Its upper border, complete but in few specimens, is either convex or has the form of a flat reversed V. The paroccipital processes are thick, short, with blunt extremities. They are curved backwards and inwards.

The basi-occipital has a relatively great width and its posterior tuberosities are very well developed. The position of the post. nares and of the various foramina on the inferior aspect of the cranium does not differ from those of the living kerabau.

If we now continue to view the upper aspect of the cranium we notice that the frontals are nearly flat or slightly convex across, and also slightly convex from front backwards. Immediately in front of the base of the horn-cores the forehead is contracted, but not much, which is mainly caused by the fact that a strong ridge runs from the middle of the posterior border of the orbit to the antero-inferior angle of the horn-core. The upper border of the orbit is — at least in the few specimens in which the orbit is preserved — considerably oblique to the longitudinal axis of the cranium. The orbit seems to be subcircular; in the only specimen, however, in which the orbit is rather completely preserved, it is to a great extent restored with plaster, so that its proper form cannot be clearly seen. The orbits are closely approximated to the cores.

The supraorbital foramina are in general ill-preserved and often covered and filled with matrix, which could not be removed. There is, however, one specimen (nº. 4), in which the left supraorbital sulcus and foramen are finely preserved. As, moreover, the specimen in question is in the possession of the posterior extremity of the nasals, and of a part of the upper border of the orbit, we are able to give from this specimen the following particulars.

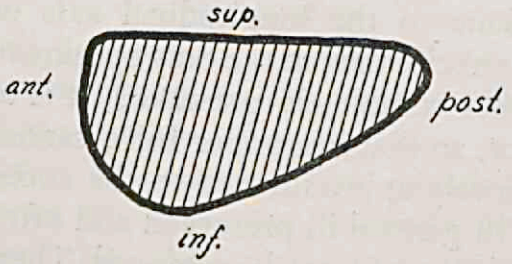
The supraorbital foramen is large and situated at the height of the posterior border of the orbit. The foramen itself is directed obliquely backwards and slightly downwards, the posterior border overhanging it. The supraorbital sulcus leads immediately into the foramen. Its posterior portion is deep and distinctly marked. More frontwards, however, the sulcus gradually dies out, so that its total length cannot be given. In the specimen under consider-

ation the sulcus is separated from the orbit by a broad, but salient ridge. In the remaining specimens this ridge is either absent or much less clearly marked.

From the imperfection of the anterior portion of the face it is impossible to determine the relations of praemaxillaries and the anterior half of nasals and maxillaries mutually, and to the posterior portion of the face. Only can be stated that the nasals are clearly convex across between the supraorbital sulci, and nearly straight longitudinally. In profile view of the cranium the nasals are situated in the elongation of the anterior half of the frontals. In front of the orbits the contraction of the face is considerable.

Now we have still to consider the horn-cores. These are triangular in cross-section. As the upper surface is continuous with the plane of the frontals, and — as has been noticed above — the latter are continued in the supracristal portion of the occipital surface by a gentle curve, it will be clear that the posterior angle of the horn-core is somewhat in advance of the true occipital surface, and still more in advance of the prominent higher part of the occipital crest. The boundary to which the base of the horn extended is clearly marked on the inferior and anterior aspect of the core by a rather sudden decreasing of height and width.

If further on will be spoken of the "horn-core" this will always mean that part of the core that formerly was covered by the horn-sheath. As has been already mentioned the horn-core is triangular in cross-section. The cross-section of the base of the core has a form represented in text fig. 1. The superior surface is flat; in some instances even slightly concave. The angle between superior and anterior surface is remarkably sharp; that between superior and inferior surface much more rounded, and blunted. Anterior and inferior border merge very gradually into one another by a gentle curve.



Text fig. 1. *Buffelus bubalus?* var. *sondaicus fossilis*. Cross-section of left horn-core near base.

The antero-posterior diameter always exceeds the infero-superior diameter throughout the whole length of the core.

From base to tips it becomes gradually more difficult to distinguish anterior- and inferior border. Some two or three dm. from the tip the core shows in cross-section — roughly spoken — the form of an ellips, the upper border of which, however, is far less convex than the lower border, and the posterior angle much more accuminated than the anterior angle.

The cores, which are of very large size and thickness, are set obliquely to the longitudinal axis of the cranium, and are considerably curved backwards in one regular curve.

In the posterior aspect of the cranium they slope slightly downwards from base to tip.

* * *

Both from the description and the figures it will have appeared that the fossil form under consideration must belong to the genus *Buffelus* in its narrowest sense. Now there are only known the following Asiatic forms of *Buffelus* s. str. [1])

Buffelus platyceros (LYD.) [syn. *Buffelus sivalensis* (RÜTIM.)].

Buffelus bubalus (L.) var. *palaeindicus* (FALCONER).

Buffelus palaeokerabau (DUBOIS).

Buffelus bubalus (L.) (Living arni and kerabau).

Buffelus platyceros (LYD.).

Bubalus platyceros, R. Lydekker, Rec. Geol. Survey India, X, 1877, p. 31; Mem. Geol. Survey India, ser. X, I, 1878, p. 127, pl. XVIII; 1880, p. 173; L. Rütimeyer, Abh. schweiz. pal. Ges., V, 1878, Nachträge, p. 186.
Bubalus sivalensis, L. Rütimeyer, Abh. schweiz. pal. Ges., V, 1878, p. 138.
Bos platyceros, R. Lydekker, Wild oxen, sheep and goats, 1898, p. 116.

This species was founded by LYDEKKER in 1877 on the evidence of one fragmentary cranium from the Siwaliks; in 1878 he published an elaborate description of the type specimen, illustrated by drawings of frontal and occipital aspect, and of a cross-section of the horn-core [2]). Mention was, furthermore, made of a detached horn-core, and of a cast of a cranium of the species, also from the Siwaliks, the original of which LYDEKKER presumed to be in the British Museum. This indeed was true, being the fragmentary specimen on which RÜTIMEYER (1878) founded his *Buffelus sivalensis*. The second part of RÜTIMEYER's memoir "Die Rinder der Tertiär Epoche, etc.", 1878, in which part the cranium of *Buffelus sivalensis* RÜTIM. was described [3]), was published after LYDEKKER's memoir

[1]) We may neglect the two fossil Chinese buffalo species which KOKEN (Palaeont. Abh. III, H. 2, 1885, p. 67, Taf. II, figs. 14 and 20; p. 68, Taf. II, figs. 15 and 21) recognized among the detached teeth of bovines in his collection, but which he left specifically undetermined. MATSUMOTO (Sci. Rep. Tôhoku Imp. Univ., Sendai, Japan, 2nd ser., [Geology], III, 1915-'18) referred the detached teeth and lower jaws of bovines of his collection from Sze-chuan (China) also to two different species. The one, *Buffelus* sp. a, (p. 19, pl. IX, figs. 4 and 5) was considered as possibly identical with *Buffelus palaeindicus* (FALCONER); the other *Buffelus* sp. b, (p. 20, pl. VIII, figs. 1-5) as perhaps identical with that species of KOKEN, which the latter described on p. 67. Also of these forms the above mentioned may suffice.

[2]) A partly restored view of the type specimen was given by LYDEKKER in 1898.

[3]) See figure in the first part (1877).

on the bovinian remains, contained in the collection of the Indian Museum, Calcutta. RÜTIMEYER could, therefore, append to his study a review of LYDEKKER's results in which he stated among others that *Buffelus platyceros* (LYD.) and *Buffelus sivalensis* were without any doubt identical. Since LYDEKKER's figure and full description were previous to those of RÜTIMEYER, the name *Buffelus platyceros* had the right of priority.

Though there are certainly affinities between *Buffelus platyceros* and our fossil form, the former is readily distinguished by the distinctly oblique position of the horn-cores on the forehead; by the rapid tapering of the horn-cores; by the form of the cores, being "perfectly triangular in section" [1]), with the posterior angle "remarkably sharp" [2]), and by the direction of the cores, being upwards, outwards, and then somewhat inwards.

Buffelus bubalus (L.) var. palaeindicus (FALC.).

Bos palaeindicus, H. Falconer, Catal. of Fossil Vertebr. of Asiatic Soc. of Bengal, 1859, p. 230; Pal. Mem. I, 1868, p. 284, pl. XXII, figs. 1—3.
Bubalus palaeindicus, L. Rütimeyer, Versuch einer natürl. Gesch. des Rindes, Zweiter Teil, 1868, p. 31; Abh. schweiz. pal. Ges. V, 1878, p. 141; R. Lydekker, Mem. Geol. Surv. India, ser. X, I, 1878, p. 132.
Bos bubalis palaeindicus, R. Lydekker, Wild oxen, sheep and goats, 1898, p. 127.
Bubalus buffelus Blum. var. palaeindicus, R. Lydekker, Cat. Foss. Mamm. in the Br. Mus. II, 1885, p. 28.

Under the name of *Bos palaeindicus* this form was founded by FALCONER (1859) on some crania. A complete description, however, was not given, but only short notices. A frontal view [3]) of an extraordinarily well-preserved cranium together with a side view of an imperfect specimen will be found in pl. XXII of the first part of the "Palaeontological Memoirs", which figure has been copied from one of the unpublished plates of the "F. A. S.", where — as LYDEKKER (1878) states — other imperfect crania have also been figured. In 1868 RÜTIMEYER gave a description of a cast of a cranium of the present form, which he had seen in various museums. A figure could not be given. RÜTIMEYER considered the form as closely allied to the living arni, only distinguished by ". . . . mächtigere, weniger nach abwärts und rückwärts gerichtete Hörner und breitere und flachere Stirn . . . ." [4]).

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[1]) LYDEKKER 1898, p. 117.

[2]) LYDEKKER 1878, p. 129. See also RÜTIMEYER 1878, p. 140.

[3]) Concerning this figure RÜTIMEYER (1878, note on p. 142) observed: „Die schöne Abbildung....., combinirt aus mehreren derselben Species — keineswegs, wie MURCHISON angibt — demselben Individuum angehörigen Fragmenten, ist, obschon nach einem Entwurf von FALCONER's Hand, doch dem Arni zu ähnlich gehalten. Der Schädel von *Bubalus palaeindicus* ist in beiden Geschlechtern nach hinten breiter."

[4]) p. 32.

In 1878 our knowledge of this form was considerably enriched by publications both of LYDEKKER and RÜTIMEYER. LYDEKKER fully described and figured a cranium (frontal and occipital aspect) from the Narbada valley, while mention was made and dimensions were given of some other specimens, two of which had been found in the topmost clay beds of the Siwaliks near Bubhor (Punjab). Besides this locality LYDEKKER mentioned the following localities, from which remains of this fossil buffalo were obtained: greater portion of the central Narbada Valley, Jamna Valley, Godavari and Perim-Ganga Valleys, and Madras (?) [1]).

RÜTIMEYER (1878) discussed four crania in the British Museum, all obtained from the Narbada Valley. Again he laid stress upon the very close relationship between the fossil form and the living arni, and doubted whether the fossil form had a sufficient right to specific distinction. He maintained, however, FALCONER's name " . . . . um einmal der palaeontologischen Sitte zu folgen, und zweitens eine weitere Verständigung über die fossile Form des Arni nicht durch Auslöschen eines Namens zu erschweren" [2]). In his review of LYDEKKER's work he is wholly convinced of the specific identity of LYDEKKER's specimens with those in the British Museum.

Contrary to RÜTIMEYER, LYDEKKER (1878) considered the differences between the fossil Indian form and the living arni important enough to distinguish between the two, so that FALCONER's name was maintained unchanged. In 1885 LYDEKKER had partly revised his opinion stating that the fossil Indian form cannot be but regarded as more than a large variety of the living buffalo (*Buffelus bubalus* L.). In his book "Wild oxen, sheep and goats of all lands", 1898, he stuck to his opinion, while the Punjab specimen was regarded as probably belonging to the same race. In that work we can also find the following summary of the characters: "Very close to the typical race, but of larger dimensions, with a more convex forehead, and the horns apparently always directed to a great extent outwardly. In the horn-cores themselves the transverse section is also somewhat different, tending to become quadrangular, instead of being strictly triangular." [3])

We shall return to this species further on. Already now, however, I may call attention to the fact that the specimen which RÜTIMEYER mentioned in 1868 was said to be distinguished from the arni a. o. by a "breitere und flachere Stirn", whereas LYDEKKER (1898)

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[1]) In 1898 LYDEKKER mentioned as localities, outside the Siwalik Hills: Narbada-, Godavari- and Pem Ganga Valley.

[2]) p. 141.

[3]) p. 127.

mentions as one of the distinguishing characters the "more convex forehead" of the present variety. This proves — in my opinion — that both forms of forehead may occur in the fossil race, which in no wise surprises me as I could state exactly the same in about thirty crania of the recent Javanese kerabau.

Buffelus palaeokerabau (Dubois).

Bubalus buffelus, E. Dubois, Nat. Tijdschr. Ned. Indië, LI, 1892, p. 94.
Bubalus palaeokerabau, E. Dubois, Tijdschr. Kon. Nederl. Aardr. Gen., ser. 2, XXV, 1908, p. 1263.
non: Buffelus palaeokerabau, H. Stremme, Pithecanthropus-Schichten, 1911, p. 124, pl. XVIII, figs. 5—6; pl. XIX, fig. 8; pl. XX, figs. 7—9, 12—14.

This fossil Javanese form was originally considered by Dubois (1892) as identical with *Buffelus palaeindicus*, which form he regarded as the ancestor of the kerabau and specifically identical with the latter. In 1908 he had changed his opinion as may appear from the following quotation: "Den Buffel des Kendeng hielt ich früher für *Bubalus palaeindicus*. Der fossilen javanischen Art kommt aber weder die längliche Form des Schädels der Narbadá-Art, noch die fast gerade Streckung und quere Richtung und der nahezu vierkantige Querschnitt von deren Hornzapfen zu. Die Schädelform ist kurz wie diejenige der lebenden javanischen Art, und an den Hornzapfen ist die frontale Fläche eben, mit scharfen Unten- und scharfen Obenrand, während ihre orbitale und ihre temporale Fläche abgerundet sind; und indem sie auch durch eine sehr stumpfe Kante sich von einander abgrenzen, kann der Durchschnitt des Hornzapfes von dreieckig fast halbkreisförmig werden. In der Form des Hornzapfes nähert der Kendengbuffel sich etwas dem siwalischen *B. platyceros* und unterscheidet sich von der lebenden Kerabauart, übrigens sind die Schädel der beiden javanischen Arten einander sehr ähnlich; die lebende stammt wahrscheinlich von der fossilen Art ab, wie der Name *Bubalus palaeokerabau* n. sp. andeuten soll." [1])

In what precedes all has been quoted that Dubois hitherto has written about this new species. Figures have not been given.

The collection of the Trinil-expedition of Mrs. Selenka contained buffalo remains, which have been described by Stremme. Three crania have been found, one of which but relatively little damaged. Especially of this cranium Stremme gave a detailed description, together with measurements and figures. Stremme too arrived at the conclusion that the relationship between the fossil Javanese form of the German Trinil collection and the recent kerabau is a very close one. He noticed, however, some differences

[1]) p. 1263.

by which the fossil form seemed to be distinguished viz., ". . . durch einen längeren Gesichtsteil im Verhältnis zum Hirnteil, durch eine stärker ansteigende Stirn; durch deren Crista und Furchen, ... durch schmalere Prämaxillen . . . ." [1]). Besides, he did not see hitherto a specimen of kerabau of the same size. He did, however, not exclude the possibility that more ample materials of the recent kerabau, than he had at his disposal, should reveal that these differences in reality did not exist.

STREMME united in a table the cranial measurements of his fossil form, of the kerabau, arni, "*Buffelus palaeindicus*" and *Buffelus platyceros*; he calculated, moreover, a number of relations, and drew some more inferences from them. At last he arrived at the conclusion that his fossil form belonged without doubt to DUBOIS's *B. palaeokerabau*.

As a matter of fact, in determining the fossil form of our collection, we shall still have to pay constant attention to STREMME's work. I should like, however, to observe already now that it will have appeared from what precedes that DUBOIS mentioned only one difference between *Buffelus palaeokerabau* and the living kerabau viz., a different form of the horn-core in cross-section. STREMME enumerated also a number of differences between the fossil form and the kerabau. He did not notice, however, any difference in form of the horn-core in cross-section. And nevertheless he considered his form as belonging *without doubt* to *Buffelus palaeokerabau*. In my opinion the possibility that DUBOIS's and STREMME's form of buffalo are identical is great, both authors emphasizing the very close relationship to the kerabau. On the other hand, however, STREMME's argumentation cannot be regarded as sufficient to make the identity probable enough. To *prove it*, will be, of course, an impossibility in consequence of the absence of any figure of DUBOIS's specimens.

Buffelus bubalus (L.)

Bos bubalis, Linnaeus, Syst. Nat., ed. 12, I, 1766, p. 99.
Bubalus sondaicus, L. Rütimeyer, Vers. einer natürl. Gesch. des Rindes, Zweiter Teil, 1868, p. 38, text fig. 4.
Bubalus indicus var. sondaica, L. Rütimeyer, Vers. einer natürl. Gesch. des Rindes, Zweiter Teil, 1868, p. 173.
Bos bubalus var. sondaica, Schlegel and S. Müller, Verh. over de nat. gesch. der Nederl. Overzeesche Bezittingen etc., Zoologie, 1839—1844, p. 205—208, pl. XL and XLI.
For more extensive synonymy see: R. Lydekker, Wild oxen, sheep and goats, 1898, p. 118.

Of this wide spread recent species there are two races, which deserve our interest viz., the wild buffalo of India, the arni, and the buffalo of the Malayan Islands, the kerabau. Of the form first

[1]) p. 125.

mentioned an extraordinary fine cranium of an adult individual is contained in the National Museum of Natural History at Leyden. Its measurements will be found in table B of cranial measurements, together with those of two more crania of the arni, borrowed from LYDEKKER (1878) and STREMME (1911). The Leyden Museum is, furthermore, in the possession of a buffalo cranium, labelled "*Bos bubalus, Arni*", while in the collection of "Natura Artis Magistra" at Amsterdam two skulls are preserved, which also are regarded as specimens of the arni. These three crania, however, are deviating in many points from the skull of the arni, so that I strongly doubt the correctness of the determination. That is also the reason why the measurements of these specimens have not been given. Above we observed that both DUBOIS and STREMME arrived at the conclusion that in Java a fossil form of buffalo occurred, closely related to the kerabau. As this race, therefore, is of the uttermost importance, it will be dealt with extensively in the sequel.

Often the kerabau will be found named as "*Buffelus* (*Bubalus*) *sondaicus* RÜTIMEYER". And indeed, RÜTIMEYER (1868, p. 38) figured [1]) an occipital aspect of the cranium of a male kerabau with the subscription "*Bubalus sondaicus*". On p. 173, however, we can read in the explanation of plates and text figures that fig. 4 in the text represents "*Bubalus indicus*, var. *sondaica*". And it was SCHLEGEL and MÜLLER (1839—1844, p. 205), who for the first time distinguished the present form as a variety (var. *sondaica*) of *Buffelus bubalus* (syn. *Bos bubalus, Bubalus indicus*). From RÜTIMEYER's text it appears that he wholly agreed with MÜLLER and SCHLEGEL. Those who are sufficiently acquainted with the studies of RÜTIMEYER on the *Bovidae*, will have noticed that this author, who knew this family as nobody else did, drew the limits of the "species" very widely. In my opinion, therefore, the subscription of text fig. 4 must be considered as an error, and the kerabau must be called *Buffelus bubalus* (L.) var. *sondaicus* (SCHLEGEL et MÜLLER).

It will be known that the kerabau occurs in abundance as a domesticated animal in the Malayan Islands. It is, furthermore, a fact that here and there, e. g. in the uttermost SE. and SW. of Java [2]), the kerabau is met with in a wild state. Whether, however, they reverted to this state from domesticity or whether they are indigenous inhabitants of the island is a moot point. The first supposition is generally accepted, but it has certainly not been proved. STREMME (1911) stated as his opinion that the occurrence of the fossil *B. palaeokerabau* in Java made it probable that the

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[1]) Text fig. 4.

[2]) See: J. MERKENS, Bijdrage tot de kennis van den karbouw en de karbouwenteelt in Nederlandsch Oost-Indië. Dissert. Utrecht, 1927.

kerabau — as CUVIER already believed — belonged to the original fauna of the island. MERKENS (1927) too, doubted — on historical grounds — the original domesticity of *all* wild specimens of kerabau.

STREMME, in determining his fossil form as *B. palaeokerabau*, had for direct comparison at his disposal but one cranium of kerabau. In this respect the present writer was in a far better position, the musea of "Natura Artis Magistra" containing not less than twenty six crania, and the National Museum of Nat. Hist. six specimens.

The being in use of M^3 was taken as a criterium of adultness. That I was right in doing so, is proved by what follows. MERKENS (1927), on p. 106 mentions that the fourth pair of permanent teeth, that is to say the lower canini, protrude, when the animal is 5½ to 6 years old. My friend Mr. P. VAN RIJN, veterinary surgeon, was so kind as to make an investigation of the relationship between the protruding of the C and the entering in use of the permanent upper molars. In one of the musea of "Natura Artis Magistra" he found a cranium with the undoubtedly corresponding lower jaw. In this specimen the C was already in use, whereas the M^3 was still untouched by wear. This single example would, of course, not afford great evidence, were it not that the length of the horn cores proved in a convincing manner the adultness of all the specimens, of which measurements are given in table B. From this table appears, first, that the shortest horn-core, which was measured, has a length of 273 mm. and secondly that in those specimens in which the horns were still present, and in which they could be removed, the difference in length between horn and horn-core is very considerable. From MERKENS (1927) we derive, furthermore, the following data. At the age of one year the length of the horn is about 50 mm., in the second year 100 mm., in the third 150 mm. As will be seen from table B, the length of the horn of the specimen with the shortest horn-core is 460 mm. Even if the rapidity of the growth of the horns should increase after the third year of the animal — which appears to me as not very probable — we may be sure that a length of the horn of 460 mm. will not be reached before the seventh year. And — as we have seen above — the kerabau reaches the adult state in his sixth year.

Of the thirty-two crania two specimens had to be excluded as being not fully grown. Two specimens, furthermore, showed such strong deviations from the normal type, that I esteemed it advisable to exclude these specimens too. There remained, therefore, the measurements of twenty-eight specimens, to which have been added the measurements of three more crania viz., those of one specimen, given by STREMME, and those of two frontlets of enormous

size, contained in the Buitenzorg Museum [1]). Of course it would have been better, if we had been able to compare our fossil form with crania of the *wild* kerabau. But even in the Dutch East Indies it will be very difficult to obtain a sufficient number of crania of the wild kerabau. We may be sure, therefore, that most, if not all the crania, which have been measured by the writer, belonged to domesticated animals.

Fortunately for us, however, the kerabau does not interbreed with the Indian or European cattle [2]), which excludes the possibility of crania of hybrids being among the specimens measured. Castration of the males, however, occurs on a rather large scale [3]), so that we may be sure, that among the twenty-eight specimens — besides males and females — a number of oxen will be represented. Three specimens from Leyden are, according to the label, males. But in the first place it is in general desirable to accept such data of museum specimens with some degree of reserve, and in the second place these specimens may represent bulls as well as oxen.

Originally it was thought that our table should considerably gain in value, if we should be able to exclude the oxen, and if we could distinguish between the crania of cows and bulls. MERKENS (1927) tried to detect cranial differences between cows, bulls and oxen. For that purpose he took twenty-one measurements of four adult specimens of each; expressed each measurement in % of the total length of the cranium, and calculated the average of each measurement for cows, bulls and oxen. After comparison of these averages he arrived at the conclusion that in some respects differences exist between the crania of cows, bulls and oxen. Though everyone will be inclined to distrust conclusions based on such few materials, it cannot be denied — after examination of all the numbers given by MERKENS — that in general his conclusions seem to be not devoid of foundation. One conclusion, however, must be rejected as being totally wrong. The average length in mm. of the cranium of cows, bulls and oxen appeared to be respectively 480, 479 and 489. MERKENS considered a difference of 1 mm. too small to be of any value regarding the small number of specimens measured [4]). He did, however, attach value to a difference of 10 mm. Now it

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[1]) My sincere thanks are due to Dr. K. W. DAMMERMANN who was so kind as to send me — at my request — the measurements of these specimens. The one (Buit. Mus. n°. 760) has been obtained from Sumba, the other (Buit. Mus. n°. 761) from Sumbawa. The measurements of the former have been published by DAMMERMANN in "Treubia", vol. X, 1928.

[2]) See: MERKENS (1927), p. 8.

[3]) Loc. cit. p. 154.

[4]) Even if MERKENS had measured 400 specimens of cows, bulls and oxen each, instead of 4, a difference of 1 mm. would be in my opinion of not the slightest importance.

appears that the total length of two of the four of MERKENS's crania of oxen differ not less than 60 mm., which totally invalidates his conclusion.

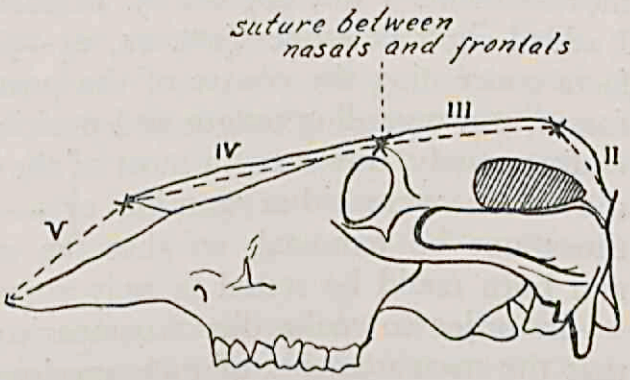
The present writer took partly entirely different measurements than MERKENS, so that not all of MERKENS's conclusions could be tested by the help of our more ample materials. Those conclusions we were able to test, are:

a. Bulls have in relation to cows a longer forehead, and a shorter nasal part. Oxen are intermediate in this respect.

b. The breadth of the praemaxillaries is greatest in cows, smallest in bulls. Also in this respect oxen are intermediate.

c. The breadth of the base of the horn is greatest in oxen, smallest in cows.

In order to be able to express the difference in length of the forehead and the nasal part into % of the total length, MERKENS took (IV+V)−(II+III). (See for the meaning of the Roman numerals text fig. 2). As none of these four measurements had been taken by me, I used (1–7)−7, which expresses an almost identical difference. The meaning of the Arabian numerals will be found in my own table B. As, furthermore, by far in most of the crania of the kerabau measured, the horns were wanting, I used instead of the breadth of the horn, that of the horn-core, against which no objections can be raised.



Text fig. 2.

In table A will be found all necessary measurements (in % of the total length). In the 4th, 5th and 6th horizontal row the smallest and greatest number have been heavy printed.

I have tried to indicate, on the base of the characteristics, given by MERKENS, which of the crania are males, and which are females. Table A shows clearly, that the number of contradictions at which we arrive then, is so great, that we are certainly justified to draw the following conclusions:

1. The differences, which MERKENS believed to exist between the crania of oxen, cows and bulls, appear in reality not to exist, if tested on more extensive materials.

2. Consequently, it is impossible to distinguish in our own table between oxen, bulls and cows.

3. This negative result proves that the (almost certain) presence of measurements of oxen in our table, need not trouble us; the differences — if indeed present — being still smaller than the small differences which MERKENS believed to exist.

Besides the cranial measurements of 31 crania of the kerabau and of 3 crania of the arni, all already mentioned above, table B contains the measurements of 9 specimens of our own fossil form, of 2 specimens of "*Buffelus palaeokerabau*", borrowed from STREMME, of 3 specimens of *Buffelus bubalus*, var. *palaeindicus* derived from LYDEKKER, and — for the sake of completeness — of one specimen of *Buffelus platyceros*, also borrowed from LYDEKKER.

As far as the condition of the specimens measured by the writer allowed, thirty measurements have been taken. As to the choice of the measurements I had to join STREMME[1]), who in his turn for the greater part followed LYDEKKER. Two of STREMME's measurements I did not use [2]). Besides STREMME's measurements I added eight new ones (nos. 14, 24—30), in order to invest some facts concerning the course of the posterior part of the temporal fossae, and regarding length and position of horns and horn-cores. Unfortunately, however, in most of the recent specimens measured the horns were either wanting or — if present — could sometimes not be removed, so that the relation between horn-core and horn could be stated in only some cases.

In order to make direct comparison possible, it is necessary that the measurements of each specimen be expressed in % of a certain measurement as unit. Usually as unit is taken the total length of the cranium. We do not dispose, however, of this measurement in our fossil crania, being all very fragmentary. For that reason the smallest breadth of the forehead has been chosen as unit in table C. In order to facilitate a review of the numerous percent numbers of table C, the maximum and minimum values of each measurement for the various forms have been united in table D. Table E contains a series of relations between certain measurements. In this respect my choice was wholly fixed, as I had to join STREMME. Only the relations 1 : 20 and 19 : 7 have

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[1]) In STREMME's table of measurements on p. 126 a lapsus calami occurs in the circumscription of measurement IV and XII viz., "Orbitalkamm" instead of "Occipitalkamm".

[2]) II. "Entfernung zwischen dem Hinterhauptskamm und dem Scheitel". From the description of our own fossil form it will appear that the transition of the frontals into the supracristal portion of the occiput is often very gradual, so that the "Scheitel" is not sharply defined. The same occurs in the cranium of the kerabau.
XXIII. "Entfernung vom Occipitalkamm zum Vorderrande der Orbita". As the crista occipitalis is a wide arch, I could not know which point of this crest STREMME meant.

been added. For the sake of an easy review the various minima and maxima of table E have been collected in table F.

As is seen from table C, in all the specimens of the kerabau the interval between the extremities of the temporal fossae (measurement 13) is not only exceeded by the "greatest" width between the temporal fossae (measurement 14), but also by the interval between the extremities of the occipital condyles (measurement 11). That m. 13 is exceeded by m. 14 is caused by the fact that the convex posterior portion of the temporal fossa of either side converge backwards. That, furthermore, m. 11 exceeds m. 13 proves that the temporal fossae cut deeply into the supra-cristal portion of the occipital surface, a fact which already RÜTIMEYER (1868, p. 33) strongly emphasized. The percent numbers in table C show also in a convincing manner that the individual variation is in this respect extraordinarily great. In my own notices, made of the recent specimens of kerabau which I saw in Amsterdam and Leyden, I read: "The manner in which the temporal fossa terminates is very variable. In some cases the temporal fossa and the plane of the occiput are — roughly spoken — perpendicular to one another; in others the posterior end of the fossa curves very gradually, and the boundary can hardly be seen. Between these extremes are a great number of transitions". This explains also why in table F the relation 4 : 13 varies from 1.82—3.87, and the relation 10 : 13 from 1.87—3.14.

As to the specimens of the arni, *B. bubalus* var. *palaeindicus* and of "*B. palaeokerabau*" m. 14 is only known from the arni cranium of which measurements have been given by the author. In this specimen m. 14 exceeds also m. 13, but only with 4 %. For the rest the arni crania show — as in the kerabau — a considerable variation in the difference between m. 13 and 11, being in spec. a 1, in spec. b 0 and in spec. c 24. Of spec. A and B of the Siwalik variety *palaeindicus* m. 11 and 13 are known. Apparently the temporal fossae do not cut so deeply into the occipital surface, m. 11 being — in contradiction to the kerabau crania — *smaller* than m. 13. The relation 4 : 13 is for spec. A of the variety in question but 1.66 which is distinctly smaller than the smallest value which was found for the kerabau. Also in the relation 10 : 13 the fossil Siwalik variety shows a tendency to smaller values. The only cranium of "*B. palaeokerabau*" of which m. 11 and 13 are known, shows in this respect no difference from the kerabau cranium.

Coming now to our own fossil specimens we notice that in the five specimens, in which m. 11 and 13 can be compared, m. 11 is *smaller* than m. 13, in two specimens even considerably smaller. In this respect, therefore, they are distinguished from the kerabau,

and in accordance with var. *B. palaeindicus*. This is also demonstrated by the relation 4 : 13 of table F, varying in our fossil specimens from 1.33—1.53 and being 1.66 in the only specimen of *B. palaeindicus*, for which the relation 4 : 13 could be calculated. One would perhaps be inclined to infer from the numbers quoted that the degree of constriction of the occiput by the temporal fossae is in our fossil form still smaller than in *B. palaeindicus*. It must not be forgotten, however, that of only one skull of the fossil variety the relation 4 : 13 is known. Moreover, the relation 10 : 13 differs but slightly in both forms.

The percent numbers of m. 13 and 14 of table C show, furthermore, clearly the remarkable feature, already mentioned in the description of our fossil specimens. In spec. 1 and 7 namely m. 14 exceeds m. 13, the course of the posterior portion of the temporal fossae being the same as in the kerabau crania. In spec. 2, 3, 5, 6 and 8, however, m. 13 is larger than m. 14, which is caused by the fact that near the occiput the temporal fossae change their direction, diverging backwardly. Probably I should have been strongly inclined to attach value to this difference, were it not that in one of two fossil crania of *Bibos* in our collection — without a shade of a doubt belonging to the living species — exactly the same deviation occurred. I must admit, however, that I cannot declare this phenomenon. Of course it cannot be connected with a stronger development of the occipital muscles, as these are attached to the true occipital surface, and not to the supra-cristal portion of the occiput.

Before trying to answer the question whether or not our fossil form is identical with the form described by STREMME under the name of *Buffelus palaeokerabau* DUBOIS, it will be desirable to consider closely the differences which STREMME thought to perceive between his form and the kerabau. As has been already mentioned, STREMME calculated [1]) a number of relations between certain measurements. From these he concluded that his fossil form presented "erhebliche Abweichungen" from the kerabau, a. o. *B. palaeokerabau* should have narrower praemaxillaries and its forehead should be longer in proportion to the interval between orbit and distal end of the praemaxillaries. As to the latter difference STREMME took the relation $\frac{\text{XXIV}}{\text{XXIII}}$. STREMME's XXIV corresponds with our m. 19.

[1]) If STREMME's table of measurements is compared with ours, it will be seen that the former contains not unfrequently errors and miscalculations which do not increase the usefulness of the tables.

We did not use, however, m. XXIII for reasons already pointed out in note 2 on p. 38. Instead of the relation $\frac{\text{XXIV}}{\text{XXIII}}$ we used 19 : 7. From table F appears that both differences in reality do not exist. Nevertheless there remain other differences. But in the first place they are small, and secondly it is almost certain that they would disappear if still more extensive materials of the kerabau had been available. STREMME hinted already at this possibility. On p. 125 STREMME mentions some more differences viz., a more strongly ascending forehead, the presence of crests and grooves on the forehead and (perhaps) a greater size. As to the difference first mentioned I may add that in the kerabau the forehead appeared to be very variable, in some cases being almost flat, in others very distinctly convex antero-posteriorly. Concerning the second difference I may mention that supraorbital sulci appeared to be either present or absent in the crania of the kerabau. As to the difference in size I may refer to spec. 30 of my table B, which shows a tip to tip interval of the horns of about 3 m. !

Summarizing we can state that the fossil Javanese form, described by STREMME *under the name of Buffelus palaeokerabau* DUBOIS, *appears to be indistinguishable from the recent kerabau. It has, therefore, no right to specific distinctness, and must be called: Buffelus bubalus* (L.) *var. sondaicus fossilis.* [1])

Finally our own fossil form. As far as can be gathered from our fragmentary specimens the resemblances to the cranium of the kerabau is so close that I should not hesitate in classing it with that variety, if not the degree of constriction of the occiput were far too small. In this respect the fossil form of our collection is distinctly separated from the kerabau, and shows resemblance with *B. bubalus* (L.) var. *palaeindicus* (FALCONER). In my opinion, however, this single difference does not suffice to establish a new variety so that I class it provisionally with *Buffelus bubalus* (L.), var. *sondaicus* (SCHLEGEL et MÜLLER) *fossilis*.

[1]) With this I do not intend to maintain that *Buffelus palaeokerabau* does not exist, though — as has been pointed out already above — identity between STREMME's fossil form and that of DUBOIS is not improbable.

Bibos sondaicus (SCHL. et MÜLL.) **fossilis.**

Pl. II, figs. 1—5; pl. III, figs. 1—4.

Localities: Watualang, Kedung Kendang, Mendut near Tinggang.

Of the genus *Bibos* I received three crania and one detached, entirely complete horn-core, obtained from the following localities.

	Locality	District	Regency	Residency
Cranium with two horn-cores and crushed cranium	Watualang	Ngawi	Ngawi	Madiun
Cranium with one horn-core	Kedung-Kendang	Sragen	Sragen	Surakarta
Detached horn-core	Mendut near Tinggang	Tambak-redjo	Bodjone-goro	Bodjone-goro

Though two crania had to be freed from considerable quantities of adherent matrix and restored with glue and plaster, they are in a rather fine state of preservation. The third cranium, however, when unpacked, showed itself to be for the greater part fallen into tiny pieces, so that it was absolutely impossible to restore it. What remained was the left maxilla together with a portion of the orbit, the greater portion of the right horn-core and a smaller piece of the left core. The maxilla contained five grinding teeth (P^3—M^3), all finely preserved.

The two crania of which views are given in figs. 1—2, 4—5 of pl. II and figs. 1—3 of pl. III agree so much in nearly every feature that their belonging to the same species cannot be doubted. The remains of the crushed cranium and also the detached horn-core show no characters by which they are distinguished from the better preserved specimens.

As will be seen from the figures, one cranium only possesses one horn-core, the other both. The specimen with one horn-core is in general better preserved. In the specimen with two horn-cores the nasals are for the greater part wanting, the occipital surface is injured; the pterygoid-sphenoid region very much damaged, and what remained of it covered with plaster in order to give the very desired support to this cranium which was broken into two behind the orbits.

As RÜTIMEYER already gave such an excellent account of the skull of the living banting, *Bibos sondaicus*, and of the great differences

which are connected to sex and age, it will be unnecessary to explain why the two figured crania and the figured, detached horn-core all belonged to male individuals. The two fragmentary cores belonging to the crushed cranium also indicate the skull of a male. There are, however, differences in age. From the curvature of the cores we may be sure that the cranium with two horn-cores is that of a mature male individual, while the cranium with one core, and the detached core belonged to old males. The molars prove this assertion to be true. In both crania all the molars are in use, but the degree of wear is greater in the cranium with one horn-core. Though of the cores of the crushed cranium a considerable part of the distal end is wanting, the curvature of the remaining part proves the cranium to belong to a younger individual. And the degree of wear of the molars supports this statement, for, though the M^3 is already in use, the remaining premolars are but little worn.

As the resemblance between the two figured crania on the one side, and those of the living mature male Javan banting on the other side, is very close, it will be best to commence by comparing the two together. If, however, differences occur between the two fossil crania, they will be mentioned separately.

For direct comparison I had at my disposal only one cranium, but a very fine one, namely that of an old male, contained in the Museum of the Zoological Institute of the University of Utrecht, and kindly lent to me by its director, Prof. NIERSTRASZ. The fossil specimens could, moreover, be compared with the descriptions and figures of some fine crania of the banting [1]), preserved in the National Museum of Natural History at Leyden, and with my own sketches and notices of these crania and of two more specimens contained in the museums of "Natura Artis Magistra" at Amsterdam.

Below the comparison between the fossil specimens and the crania of mature male individuals of the Javan *Bibos sondaicus* will be made in this way, that respectively upper-, hind-, side-, and lower aspect of the cranium and the horn-cores will be dealt with, each preceded by an enumeration of resemblances and differences which the present writer could state in the recent specimens. (N. B. The crania are supposed to rest upon paroccipital processes and cheek teeth.)

Upper (frontal) aspect.

This aspect shows but small individual variations. As has been already pointed out by RÜTIMEYER and clearly shown by the

1) SCHLEGEL and MÜLLER, Verh. Nat. Gesch. der Ned. Overzeesche Bezittingen (Zoölogie), 1839—1844, p. 197, pl. XXV—XXIX, and RÜTIMEYER, Denkschr. schweiz. Ges. XXII, 1868, p. 77, text figs. 10—13.

figures, given by SCHLEGEL, the whole skull becomes, from mature to old, broader in reference to its length, with the orbits very prominent, masseter crista and malar process very well developed. Nasals broad and short. I should like to add that the supraorbital sulci and foramina may show considerable variations concerning length and convergence of sulci, position and number of the supraorbital foramina. I am, therefore, convinced, that no specific value whatever may be attached to position and number of supraorbital foramina, and to length and position of the supraorbital sulcus.

Concerning the prominence of the orbit, the shortness of the nasals and their relation to the frontals, there is a very close resemblance between the fossil specimens and the recent crania. The masseter crista and the malar process are, however, less developed than in general is the case in the crania of the living species.

As will be seen from the figures the two fossil specimens show slight, mutual variations concerning the length of the supraorbital sulcus, and the number and position of the supraorbital foramina. But these variations by no means exceed the boundaries of variation found in the crania of the Javanese banting.

Hind (occipital) aspect.

The crania of mature male individuals of *Bibos sondaicus* showed that the transition of the plane of the frontals in that of the occiput is in some specimens gradual, in others rather abrupt. The latter is caused by the fact that the forehead — in profile view of the cranium — instead of being flat, and situated in the elongation of the nasals, is slightly concave and rising strongly to the vertex cranii, producing a ridge, called by RÜTIMEYER "Frontalwulst" and identical with LYDEKKER's "intercornual ridge". The feature above described appears to be connected with a rich development of bone-tubercles on the posterior half of the forehead.

From the above it will be clear that the relation between height of supra- and infracristal portion of the occiput has but little value.

As mentioned by RÜTIMEYER, the true occipital surface becomes gradually broader, so that in an old male the lower portion of the occiput ". . . . beidseits weit über den Hornansatz hinausragt . . . ."[1]). This is also the case in both fossil specimens. In the specimen with one horn-core the interval between the posterior border of the meatus auditivus externus osseus of either side exceeds with some 7 cm. the interval between the bases of the horn-cores, and in the specimen with two horn-cores the difference between both measurements is about 8 cm.

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[1]) p. 84.

There is a difference — though not essential — between the fossil specimen with one horn-core, and that with both cores regarding the degree of constriction of the supracristal portion of the occiput by the posterior extremities of the temporal fossae, being in the "two horned" specimen very considerable, and in the "one horned" cranium far less pronounced. It will be seen, however, from table H of cranial measurements that in this respect there occurs a considerable amount of individual variation in the crania of the Javan *Bibos sondaicus*. This is caused by the fact that in some specimens the curved walls of the temporal fossae gradually converge backwards, whereas in other crania the extremities of the temporal fossae change their direction near the occipital surface, so that the utmost ends of the temporal fossae *diverge* strongly backwards. It will be clear that in the latter crania m. 25 (of table G and H) will show relatively great values. But in none of the six recent crania m. 25 exceeds m. 26 (greatest interval between temporal fossae in the prae-occipital region). The "two horned" fossil cranium does not show divergence of the utmost ends of the temporal fossae, so that in this specimen the constriction of the occiput is very considerable and m. 25 distinctly smaller than m. 26. In the "one horned" specimen, however, this divergence occurs in such a strong degree, that not only the constriction of the occiput is far less pronounced, but m. 26 is even slightly exceeded by m. 25. But of course this small deviation does not afford any reason for specific distinction.

In both fossil specimens the tips of the paroccipital processes are wanting. In position, and curvature of the remaining portion, however, they show no differences from those of the crania of the recent form.

The occipital condyles also are similar in shape and position to those of the Javan banting.

In the crania of *Bibos sondaicus*, and also — according to RÜTIMEYER — in those of *Bibos frontalis* there runs, from the indentations by the temporal fossae on either side, a crista obliquely upwards meeting in the middle of the breadth of the supracristal portion of the occiput and some cm. above the middle of the occipital crest. In examining six complete crania of the living Javan banting it was revealed that also in this respect some variation may occur. In some crania these cristae originate there, where occipital crista and posterior extremities of the temporal fossae meet; in other specimens they begin about 2 cm. higher, namely at the upper angle of the indentations of the occiput by the temporal fossae. In some specimens the point where both cristae meet is situated very near to the vertex of the cranium,

in others some cm. below it. In other words at times both cristae converge rapidly, at other times they enclose a greater angle. In our fossil specimens these cristae are but poorly developed, they meet about 3 cm. above the middle of the occipital crest and about 4 cm. below the vertex cranii. Exactly as in the crania of the banting, in or immediately above the point of meeting the supracristal portion of the occiput bulges up, causing the "intercornual ridge" to show in the upper aspect of the cranium a convex outline in its middle third.

Side aspect.

Viewed from the side all the crania of mature male specimens of *Bibos sondaicus* which I examined were very much alike. The only difference which may occur, and which has already been mentioned in noticing the frontal aspect, is the sometimes abnormally strong development of the posterior portion of the forehead causing the plane of the frontals to slope stronger than that of the nasals. For the rest, however, the relation between frontals, nasals, lacrymals, maxillae, and intermaxillae, the shape and position of the orbits, the development of masseter crista and malar process is in all the specimens I saw, very much alike. Also in this respect both fossil crania are perfectly in accordance with the skulls of the Javan banting, with the only exception, already mentioned, that masseter crista and malar process are not so strongly developed as seems to be the rule in the crania of the banting.

Lower aspect.

Here also we may be short. Both fossil specimens show the same relations of the bones of the bottom of the cranium as in the banting. For dimensions, and comparisons with those of the banting, I may refer to tables G and H.

Horn-cores.

In but one specimen of cranium of the Javan banting (E) the horns could be removed from the cores. It revealed that the core by no means fills the sheath of the horn to its top, but that a distinct difference in length exists between horn and horn-core. As, especially in old male individuals, the curvature of the horn is strongest in its distal third, the core will always show a smaller degree of curvature than the horn which belongs to it. That explains why I ventured to refer the "one horned" fossil specimen to an old individual, although the curvature of the core is not so extremely pronounced. I shall not try to give an account of the various forms of the horns of the crania which I saw. Their degree of curvature

is — as was clearly pointed out by RÜTIMEYER — a function of age. I am not wholly certain, but I believe that the distance from tip of horn to tip of nasals, which, as will be seen from tables G and H, may vary considerably, is not only dependent upon age, but is also liable to common individual variation. For the sake of completeness I will try to describe the form and curvature of the horn-cores of both fossil crania, and of the detached core.

a. "One horned" specimen.

Near its base the core is directed outwards, downwards and somewhat backwards. This downward slope decreases gradually so that the core in the middle third of its course is — roughly spoken — horizontal. Then the core rises upwards in one regular curve, its tip directed slightly inwards.

If the cranium is placed on paroccipital processes and cheek teeth, and viewed in side aspect, the distal third of the horn-cores slopes distinctly backwards. The lowest point of the inferior surface of the core is at the level of the lower angle of the occipital condyles. At the base the horn-core is in cross-section approximately an ellips; its longest axis forms the antero-posterior diameter; inferiorly it is far more flattened than superiorly. The core maintains the flattened lower border throughout its proximal half; more distally it gradually disappears, and the core becomes conical. The surface of the core is deeply grooved and chanelled.

The place to which the base of the former horn extended is on lower and posterior surface of the core marked by a sudden decrease of height and breadth.

b. The detached horn-core.

This core resembles the one, described above, in nearly every feature. It is only larger and thicker, and its tip is more directed inwards. It apparently belonged to a still older male. Without difficulty it can be identified as a left core.

c. "Two horned" specimen.

The differences between the cores of this specimen and the one described first are:

1. In its proximal third it is directed somewhat more backwards and less downwards.

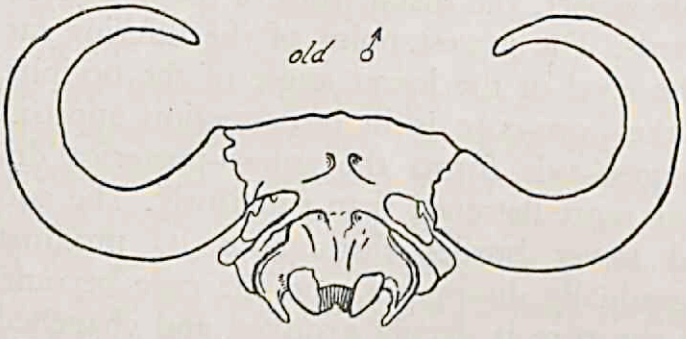
2. Its tip is directed straight upwards and not inwards (which proves its belonging to a less old individual).

3. Placed in the position above mentioned, and viewed in side aspect, the distal third of the horn-core stands nearly perpendicular.

4. The lowest point of the inferior surface is at the level of the upper border of the for. magnum.

The cores belonging to the crushed cranium are already mentioned, and are in too imperfect a condition to make a detailed description possible.

The form of the cores in cross-section of our fossil specimens is entirely similar to that of the Javan banting. Also concerning the course of the cores there is in general a close resemblance between the fossil form and *Bibos sondaicus*. In the "one horned" and "two horned" specimen, however, the maximum span of the horn-cores, in proportion to the total length of the cranium, is distinctly greater than in the five recent crania which the writer measured (See table H). That this is a point of minor importance is in my opinion proved by the fact that the detached fossil horn-core is considerably less spread out, showing almost exactly the same degree of curvature as the horns of the type specimen of the cranium of an old male (Compare fig. 4 pl. III, and text fig. 3).



Text fig. 3. Hind aspect of old male type cranium of *Bibos sondaicus* (recent). After SCHEGEL and MÜLLER. 1/11 nat. size.

As I could not state any essential, structural difference between the molars and premolars of the fossil specimens and those of the recent Javan banting, it will suffice to refer to fig. 3 of pl. II, in which an upper view of the dentition has been given. In the "two horned" specimen are preserved: left M^1-M^3, a fragment of the left P^4, and right M^2-M^3. In the one horned specimen: P^2-M^3 of either side. Of left M^2 and right M^1 the outer wall of the molar has been lost. In the crushed cranium: left P^3-M^3.

Below we shall have to compare our fossil form with the following South Asiatic and Malayan species:

Bibos frontalis (LAMB.)

Bibos gaurus (H. SM.)

Bibos palaeogaurus (FALC.)

Bibos geron MATS.

Bibos protocavifrons DUB.

Bibos palaeosondaicus DUB.

Bibos sondaicus (SCHLEG. ET MÜLL.)

The comparison between the fossil form of our collection with the Javan *Bibos sondaicus* has already been made in what precedes, but there are still some varieties of *Bibos sondaicus* which need discussion.

Bibos frontalis (LAMB.) (1) and Bibos gaurus (H. SM.) (2).

(1) Bos frontalis, Lambert, Trans. Linn. Soc. VII, 1804, p. 57 and 302.
Bos gavaeus, Colebrooke, As. Researches VIII, 1805, p. 488.
Gavaeus frontalis, Hodgson, Journ. As. Soc. Bengal XVI, 1847, p. 706.
Bos (Bibos) gavaeus, L. Rütimeyer, N. Denkschr. schweiz. Ges. XXII, 1868, p. 105.
Bos (Bibos) frontalis, R. Lydekker, Wild oxen, sheep and goats, 1898, p. 31.
(2) Bos gaurus, H. Smith, in Griffith's Animal Kingdom IV, 1827, p. 399.
Bibos cavifrons, Hodgson, Journ. As. Soc. Bengal VI, 1837, p. 745.
Bos (Bibos) gaurus, Rütimeyer, N. Denkschr. schweiz. Ges. XXII, 1868, p. 88; Lydekker, Wild oxen, sheep and goats, 1898, p. 23.
Gavaeus gaurus, Blyth. Journ. As. Soc. Bengal XXIX, 1860, p. 282.
See for more extensive synonymy of these two species: Lydekker, Wild oxen, sheep and goats, 1898, p. 23 and 31, from which the above data have mainly been derived.

We may immediately exclude *Bibos frontalis*, the gayal, and *Bibos gaurus*, the gaur from our comparison. These recent South Asiatic species are readily distinguished from the recent Javan banting — and therefore also from our fossil form whose striking resemblances to the former has been repeatedly emphasized in the foregoing part — by a number of features of which I shall mention the following ones. In both species the cranium is less elongated[1]). In the Mus. of Nat. Hist. at Leyden one cranium of gayal is preserved. It belongs, however, to an individual not fully grown for which reason I thought it better not to give the measurements. The relation between the smallest breadth of the forehead and the condylo-basal length in this specimen is 221 : 421, whereas from table G of cranial measurements may be seen that in all the specimens of the Javan banting the same relation is decidedly smaller. It must not be forgotten that the relation between the smallest breadth of forehead and condylo-basal length is smaller than may be expected in the cranium of an adult individual, as the cranium becomes broader in proportion to its length. This smaller width in reference to the total length coincides with a triangular form, far more pronounced than in the banting head.

Another difference is that the horns are but very slightly curved, with no inward bending. Of the gaur I have not seen the cranium. But this species is much better known. That its skull is less elongated in comparison to that of the banting can be clearly seen from the

[1]) LYDEKKER (1898), p. 37.

table of measurements given by RÜTIMEYER [1]), who described some crania of the species in question in an excellent way. Another difference is afforded by the high intercornual ridge on the vertex, causing the forehead to be deeply concave [2]), and the occipital surface higher than broad [3]). The horns, compared with those of the Javan banting, are shorter and more massive; towards the base becoming lower and broader [3]). For the rest, however, the course of the horns strongly reminds of the banting.

Bibos palaeogaurus (FALC.).

Bos (Bibos) palaeogaurus, L. Rütimeyer, Abh. schweiz. pal. Ges. V, 1878, p. 154.
Bos palaeogaurus, R. Lydekker, Cat. Foss. Mamm. Br. Mus. part. II, 1885, p. 23.

RÜTIMEYER mentions under the present name a fragment of a cranium from the Narbada and preserved in the British Museum. RÜTIMEYER should have named the species without any reserve *Bibos gaurus*, had he not thought it useful to give in general fossils new names. "Dennoch" — he continues — ", da ich keinen Unterschied von dem lebenden Bos Gaurus entdecken konnte, würde ich auf einen Namen verzichtet haben, wenn derselbe nicht, freilich ohne Nachweis, dass er diesem Fossil gewidmet war, in den Manuscripten FALCONER's vorgefunden hätte". LYDEKKER stated as his opinion, that the specimen is perhaps insufficient for specific determination.

Bibos geron MATS.

Bibos geron, Matsumoto, Sci. Rep. Tôhoku Imp. Univ., Sendai, Japan, 2nd ser. (Geology), III, 1915—1918, p. 21; pl. IX, figs. 1—3, pl. X, figs. 1—3.
Bibos [4]) geron, W. D. Matthew and Walter Granger, Bull. Amer. Mus. Nat. Hist. XLVIII, 1923, p. 594; text figs. 26—27.
Bibos geron, O. Zdansky, Palaeontologia Sinica, Ser. C, V, 1928, fasc. 4, p. 111.

This species has been based by MATSUMOTO upon parts of upper and lower jaw, secured from Sze-chuan, China. Fossil remains of *Bibos*, however, were already known from China long before MATSUMOTO described the present species. Both KOKEN [5]) and SCHLOSSER [6]) namely referred cheek teeth of their collections to the genus *Bibos*, but apparently thought it advisable not to establish new species on such materials. MATSUMOTO stated as his opinion that the species under consideration might possibly be not identical with KOKEN's and SCHLOSSER's species, though both are undoubtedly closely allied.

[1]) RÜTIMEYER (1868), p. 101.
[2]) See the fine figures of a male cranium given by RÜTIMEYER, loc. cit. pl. II.
[3]) Loc. cit. p. 97.
[4]) In the heading mentioned as *Bibos geron*; in the subscription of the text figures, however, as *Bibos (?) geron*.
[5]) KOKEN (1885), Pal. Abh., III, 2. p. 64, pl. II, figs. 16—17; text fig. 1.
[6]) SCHLOSSER (1903), Abh. Ak. München, M. Ph. Kl., XXII, 1. p. 159.

W. GRANGER, palaeontologist of the Third Asiatic Expedition, obtained also from Sze-chuan a fine collection in which the genus *Bibos* was represented by "a series of skulls, skeletons, upper and lower jaws, etc." [1]), which were all referred to MATSUMOTO's new species by MATTHEW and GRANGER. Of a complete skull, selected as neo-type, figures of side-, upper- and lower aspect were given. No detailed description, however. Nevertheless it is not difficult to see that *Bibos geron* is specifically distinct from our fossil form. The totally different outline of the forehead in side aspect of the cranium, the different course of the horn-cores, especially in their proximal portion, the greater breadth of the cranium in reference to its length present positive indications in this respect. Among the numerous remains from Chou-K'ou-Tien, extensively described and figured by ZDANSKY under the name of *Bibos geron*, the cranium was only represented by a damaged horn-core and a fragment of ditto.

Bibos protocavifrons DUB. (1) and Bibos palaeosondaicus DUB. (2).

(1) Bibos protocavifrons, Dubois, Tijdschr. Kon. Ned. Aardr. Gen., 2de ser. XXV, 1908, p. 1262.
(2) Bibos palaeosondaicus, Dubois, Tijdschr. Kon. Ned. Aardr. Gen., 2de ser. XXV, 1908, p. 1262.
? Bibos palaeosondaicus, Stremme in: Die Pithecanthropus-Schichten auf Java, 1911, p. 136, pl. XVIII, figs. 7—8; pl. XIX, figs. 7, 9—11; pl. XX, figs. 10—11; text fig. 10.

DUBOIS's collections of fossil mammals from the Kendeng Hills in Java contained, besides *Leptobos*, ". . . . mehrere Formen von *Bibos* . . . ., von welchen die meisten sich, mehr oder weniger nahe, dem lebenden Banteng anschliessen" [2]). These forms he united into a new species, *Bibos palaeosondaicus*. Other forms showed transitions from the latter to the Javan fossil species of *Leptobos*, whereas one form occurred which, in having a very high intercornual ridge and concave forehead, strongly resembled the gaur. Whence the name *Bibos protocavifrons* [3]).

Above has been repeated all that DUBOIS has mentioned on these new species. It is clear that our own fossil form does not belong to *Bibos protocavifrons*. Furthermore, it is not improbable that our form is identical with *Bibos palaeosondaicus*. But as little as we were able to prove the identity of the fossil *Buffelus* of our collection with *Buffelus palaeokerabau* DUBOIS, as little will it be possible to identify with sufficient certainty our form of *Bibos* with *Bibos palaeosondaicus* DUBOIS.

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[1]) MATTHEW and GRANGER (1923), p. 594.
[2]) DUBOIS (1908), p. 1262.
[3]) *B. cavifrons* syn. with *B. gaurus*.

STREMME, however, apparently esteemed the few sentences, which DUBOIS dedicated to *Bibos palaeosondaicus*, sufficient enough to consider a form of *Bibos*, obtained by the Trinil expedition of Mrs. SELENKA, as belonging *without doubt* to that species. According to STREMME, DUBOIS, in naming his form *Bibos palaeosondaicus*, followed the same custom as RÜTIMEYER did, when the latter gave the fossil specimen of *Bibos gaurus* the name of *Bibos palaeogaurus*. I do not know how STREMME came to this conception. Apparently, others have not interpreted DUBOIS in this way, the absence of any recent species among the mammalian remains of the Kendeng beds being used by some as an argument against a relatively young age of these beds.

STREMME's determination is mainly based on the hinder portion of a cranium. Therefore, he could take only the following five measurements:

1. Stirnbreite unterhalb der Hornzapfen . . . . . 222 mm.
2. Schmalste Stelle der Scheitelbeine. . . . . 95 „
3. Gröszte Hinterhauptsbreite. . . . . 205 „
4. Höhe des oberen Hinterhauptsbeines . . . . . 114 „
5. Entfernung der Stirnmitte zum oberen Rande des Foramen magnums . . . . . 205 „

He compared these measurements with the corresponding ones taken from 2 crania of the Javan banting and from 3 specimens of the Bornean banting; calculated, furthermore, six different relations from which he concluded: ". . . . alle Proportionen zeigen das schmalere und engere Hinterhaupt des fossilen *Bibos* gegenüber den rezenten. [1])".

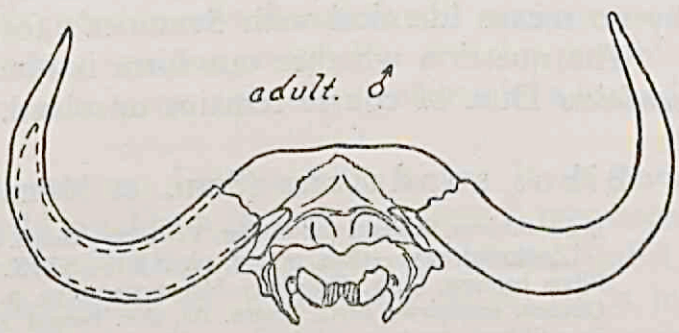
STREMME considering the fossil cranium as that of an old male will probably have compared it — though nowhere it is mentioned — with crania of adult male individuals of the Javan and Bornean banting. This taken for granted, it is extremely probable that one of the two crania, which STREMME considered as belonging to the Javan banting, in reality belongs to the Balian ox [2]). STREMME namely mentions that in the referred cranium the horn-cores are "fast gerade", while SCHLEGEL and MÜLLER, and later on RÜTIMEYER, pointed out, that in the adult male of the Javan banting the horns are bent very strongly. In a cranium of the adult male Balian ox, which I found (without horns) in the Nat. Museum of Nat. Hist. at Leyden, the horn-cores are nearly straight. This appears not to

[1]) STREMME (1911), p. 138.

[2]) Which is generally considered as the domesticated Javan banting.

be an exception as 'T HOEN [1]) gave a photograph of a living specimen of the adult male Balian ox, in which the horns are also but slightly curved.

As to the measurements taken by STREMME, the following remarks may be made. What STREMME meant by m. 1, 2 and 3 is clear; they agree with m. 3, 25 and 24 of my own table G. The meaning of m. 4 and 5, however, is not clear at all. We may even say that STREMME did *not* mean by m. 4 the height of the supraoccipitale. It will be known that in all Artiodactyla it is not the supraoccipitale which bounds the for. magnum superiorly, but the median united exoccipitalia [2]). That this is also the case in the cranium of *Bibos sondaicus* may be clearly seen in text fig. 4, which represents the hinder aspect of the type cranium of the adult Javan banting. The figure of STREMME's fossil specimen shows, however, distinctly the absence of the suture between supraoccipitale and exoccipitalia, so that STREMME certainly cannot have measured the height of the supraoccipitale. Originally, I supposed that STREMME in reality might have meant by m. 4 the interval between upper border of the for. magnum and crista occipitalis. This interval, however, appears — according to the figure, the exact scale of which can be ascertained without any difficulty — not to be 114 mm., but at most 100 mm.



Text fig. 4. Hind aspect of adult male type cranium of *Bibos sondaicus* (recent). After SCHLEGEL and MÜLLER. $^1/_{11}$ nat. size.

The circumscription of m. 5 is very indistinct. What exactly is meant by "Stirnmitte"? The highest point of the curve, formed by the more or less abrupt transition of forehead into occiput in the median line of the cranium? Probably not, for the distance between this point and the upper border of the for. magnum is — according to STREMME's figure — at most 176 mm., instead of 205 mm. We go, therefore, not too far, if we conclude that STREMME's m. 4 and 5 are entirely worthless.

In spite of all these objections it cannot be denied that STREMME's fossil specimen possesses indeed a higher and narrower occiput

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[1]) 'T HOEN, Buffel en Rund, 1921, fig. 5.

[2]) See e. g. MAX WEBER, Die Säugetiere I, 1927, p. 56.

than in the adult male cranium of the Javan *Bibos sondaicus* appears to exist. It must, however, strongly be doubted whether STREMME had a right to consider his fossil form so closely related to the recent Javan banting. For, beside the difference above mentioned, STREMME's specimen is — in my opinion — very decidedly distinguished from adult crania of the Javan banting by totally different form and course of the horn-cores. As STREMME himself observes, the horn-cores taper rather rapidly, and are but slightly curved. In all typical adult male crania of the recent Javan species, however, the horns are very strongly bent, and the horn-cores taper gradually [1]). The above will suffice to show, I believe, that our fossil form is by no means identical with STREMME's fossil specimen.

The question whether our form is identical with *Bibos palaeosondaicus* DUB. of course remains unsolved.

Bibos sondaicus (SCHL. et MÜLL.).

Bos sondaicus, Schlegel and Müller, Verh. Nat. Gesch. der Ned. Overzeesche Bezittingen (Zoölogie) 1839—1844, p. 197, pl. XXV—XXIX.
Bibos banting, Gray, Knowsley Menagerie, 1850, p. 48.
Gavaeus sondaicus, Blyth, Journ. As. Soc. Bengal XXIX, 1860, p. 296.
Bos (Bibos) sondaicus, Rütimeyer, N. Denkschr. schweiz. Ges. XXII, 1868, p. 77; Lydekker, Wild oxen, sheep and goats, 1898, p. 36.

LYDEKKER distinguished in 1898 the following races:

a. Javan race, *Bos (Bibos) sondaicus typicus.*

b. Burmese race, *Bos (Bibos) sondaicus birmanicus.*

c. Manipur race, *Bos (Bibos) sondaicus*, var.

The two latter races, being founded on differences in coloration of the skin, are of no interest here.

In LYDEKKER's publication of 1898 mention was already made, and frontlets were figured of the Bornean banting, which seemed to be distinguished in having the horns less spread out and directed more upwardly. At that time LYDEKKER did not know, however, whether this difference should prove to be constant. In 1912 [2]) he returned to the Bornean form, the British Museum having obtained new specimens both of Javan and Bornean banting. From these specimens it appeared that the difference noticed above is indeed constant and, moreover, that the Bornean banting is characterized by the flatness of the forehead and the straight intercornual ridge. In LYDEKKER's opinion these differences fully justified the right to racial distinction. This race received the name of *Bos (Bibos) sondaicus lowi.* The museums of Natura Artis Magistra contain two crania of adult male individuals of the race in question.

[1]) See text fig. 4, where the place of the horn-core is indicated with a dotted line.

[2]) LYDEKKER, Proc. Zool. Soc. of London, 1912, p. 902, text figs. 123—125.

In the National Museum of Natural History, furthermore, a cranium of the Bornean banting is preserved, which is according to the label that of a female. From the course and curvature of the horns we may be sure, however, that the latter specimen represents the cranium of an old male individual.

In a relatively recent publication 'T HOEN[1]) mentions the occurrence on the island Mojo, N. of Sumbawa, of the Balian ox, which has there reverted from domesticity. He regards the wild Bornean form as probably identical with the form of Mojo. There appears, therefore, to exist still a great amount of doubt as to the origin of the Bornean banting.

In 1909 LYDEKKER [2]) provisionally founded still another race of banting, namely *Bos (Bibos) sondaicus porteri*. But also this possible variety cannot interest us, as it seems only distinguished by a flecked skin.

The race which deserves our full attention is the Javan one. This form occurs in a wild condition in Java. 'T HOEN [3]) mentions the Southern part of Bantam, Preanger Regencies, Banjumas, Kediri, Pasuruan, and Besuki. According to 'T HOEN the Balian ox is in fact the domesticated Javan banting. Originally this tamed race only occurred in Bali, but to-day it is also found in Lombok. It has even been imported in Celebes, Sumbawa, Sumba, and New-Guinea.

The cranium of *Bibos sondaicus (typicus)* is well known. SCHLEGEL and MÜLLER published, beside descriptions, extraordinary fine drawings of the crania of male and female at different age. It was these crania, preserved in the Nat. Mus. of Nat. Hist. at Leyden, which served RÜTIMEYER [4]) as a basis for his masterly studies on the cranium of *Bibos sondaicus* and allied forms. Among the type specimens crania of an adult and an old male are represented.

In table G are united, beside the measurements of these two type specimens, and of our fossil specimens, those of the two crania of old males, contained in the museums of Natura Artis Magistra, and those of the skull of an old male in the possession of the Zoological Institute at Utrecht.

It will be known that the wild Javan banting interbreeds freely with the European and Indian cattle. Furthermore, it will be remembered that higher up mention was made of the occurrence of the domesticated banting in several islands of the Malayan Archipelago. Consequently it is highly possible that among

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[1]) Loc. cit. p. 5.

[2]) LYDEKKER, Proc. Zool. Soc. of London, 1909, p. 669, text fig. 217.

[3]) Loc. cit. p. 4.

[4]) RÜTIMEYER, Versuch einer natürlichen Geschichte des Rindes, N. Denkschr. schweiz. Ges. 1867—1868.

museum specimens, labelled as *Bibos sondaicus*, crania of the domesticated form, and of hybrids are contained. In this connection I think it desirable to lay stress upon the fact, that the five crania of male individuals, of which the measurements are given in table G, without any doubt belonged to wild specimens of the Javan banting. As to the crania D and E no explanation is needed; concerning specimens A, B and C it will suffice to mention that they show every essential feature which the type crania exhibit. Originally, the present writer intended to give in table G also the measurements of a rather large number of frontlets, which he found in the various museums, and which were regarded as belonging to the Javan banting. After all, their measurements have not been added for fear that in frontlets alone the presence of the domesticated form, and of hybrids could perhaps not always be detected. Besides the measurements of the five crania above mentioned, table G contains those of the three male crania of the Bornean banting already noticed on p. 54 and 55. They will, however, not be used in the below, the Bornean banting perhaps not being, as we saw higher up, an originally wild form. Perhaps that at some time or other, the measurements given — together with those of a much greater number of crania — will provide sufficient data to solve this problem. Though I myself did not want measurements of the crania of females, I added the measurements of the type cranium of the adult female, which may be of use to others.

As far as the materials allowed, forty-one [1]) different measurements have been taken. As to the choice of the measurements, I partly joined RÜTIMEYER who measured also the type specimens. [2]) In order to avoid confusions it will be very desirable to explain what is meant in m. 2 and 19—21 with "vertex cranii". Text fig. 5 shows some ways in which the transition of forehead into occiput in the median line of the cranium may take place; point *a*, that is to say the middle of the uppermost curve, marks the place which has been taken as vertex crania.

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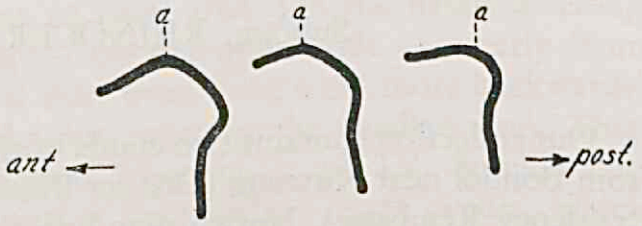
[1]) M. 20, 22 and 24 have been taken in the recent crania, after the fossil specimens were already returned to Bandung.

[2]) RÜTIMEYER's table of cranial measurements (1868, p. 86) does not contain the absolute values, all the measurements being expressed in % of "Länge der Schädelbasis vom vorderen Rand For. magnum bis Intermaxilla". In the text, however, some measurements are given in mm., so that it is not difficult to calculate the absolute values of the remaining measurements. If RÜTIMEYER's measurements be compared with the corresponding ones of my table G, it will be seen that they differ in general. As a rule these differences do not exceed 1—3 mm., which is easy to explain. In a few cases the difference is, however, greater. (I took the trouble to verify these measurements!) Furthermore, I may draw attention to the fact that in the circumscription of m. 13 of RÜTIMEYER's table a lapsus calami occurs. M. 13 does not represent "Höhe des Occiput vom untern Rand For. magn. bis Crista Occipit." but very probably the interval between the lower border of for. magnum to highest point of forehead.

In table H the various measurements have been expressed in % of the condylo-basal length of the cranium, while in table I the relations between certain measurements are given.

If we have a close look at table H — in which the maximum and minimum values for the crania of the Javan banting have been heavy printed — we notice that also the various percentage numbers reveal the great resemblances of our fossil cranium to those of adult specimens of the Javan banting. There remain still differences, but everyone will have expected them, being the measurements of but five recent crania available for comparison. From table H also distinctly appears the greater maximum span of the horn-cores (m. 13), and the greater values of those measurements, which bear upon m. 13. in the fossil crania. I should have been inclined perhaps to accept specific distinction on these grounds, were it not — as has already been stated — that the form of the detached horn-core of our collection is in perfect accordance with that of the type cranium of the old male of the Javan banting.



Text fig. 5.

At last, what does table I reveal? The notorious fact that nearly all the values found for the fossil form are situated between the (heavy printed) maximum and minimum values, found for but five recent crania! That the relation 19 : 25 is so small in our specimen *a* is caused by the fact that m. 25 (width of occiput between extremities of temporal fossae) is in that specimen abnormally great.

For the rest, however, the accordance is remarkably great, so that in my opinion the fossil specimen may not be regarded as a distinct form, but specifically identical with the recent Javan banting, *Bibos sondaicus* (SCHLEGEL et MÜLLER).

Fam. RHINOCEROTIDAE.

Subfam. RHINOCERINAE.

Our collection contains two crania of rhinoceroses, both obtained from Bondol near Kuwung (District Randublatung, Regency Blora, Residency Rembang). Notwithstanding the fact that one specimen is ill-preserved, we may say that these new founds enrich our knowledge of the fossil rhinoceroses of Java not inconsiderably, as will appear in the sequel.

We shall begin with the description of the finest specimen.

Rhinoceros sondaicus DESM. fossilis.

Pl. IV, figs. 1—3; pl. V, figs. 1—4.

Locality: Bondol near Kuwung.

State of preservation.

The middle portion of right zygomatic arch is wanting; the left arch is remarkably well preserved. The praemaxillaries have been totally lost; the processes of the maxillaries with which they are connected too. The absence of the praemaxillaries need not surprise us, as in museum specimens of recent rhinoceroses they are often wanting. The pterygoid processes are injured; the paroccipital processes broken off near their base. The palate is considerably damaged, both in front and in back. The petrosal of either side has been lost, their former presence being now indicated by a hole on either side of the basioccipitale. (In museum specimens I often found the petrosals detached in the brain case). The thin wall, which separates the left orbit from nasal cavity has been destroyed. The vomer is also totally absent. Of the cheek teeth only the crown of the left P^1 is wanting. The teeth are on the whole more or less injured. The degree of injury will be mentioned later on, when describing them in detail.

Description of the cranium (Pl. IV, figs. 1—3; pl. V, fig. 1).

(The cranium is supposed to rest on posterior molars and postglenoid processes.)

Brachycephalic, with strong, frontal depression and moderately high occiput, which slopes backwards [1]). Postglenoid and post-tympanic processes of the squamosal ankylosed below the meatus auditorius externus. Frontals smooth, rugosities totally absent, proving that the specimen in question was not provided with (a) frontal horn(s). Nasals rather pointed, separated by a groove extending from tips to vertex of nasal arch. On the nasals a strong rugosity occurs, extending — on the upper side — nearly from tips to vertex; on the lateral sides even some 6 cm. more backwards. Cristae fronto-parietales do not meet in the median line. They are sharper than would appear from fig. 3, pl. IV. Some 5 cm. in front of the occipital crest a low median crista occurs, which extends about 5 cm. frontwards, dying out gradually. If one compares the specimen in question with a sufficient number of equally aged crania of the living *Rhinoceros sondaicus*, it will be revealed that the eye cannot perceive any essential structural difference. In my opinion, therefore, it would be a waste of words to describe the cranium under consideration more detailed. Of course we shall have to return to it, in discussing the tables of measurements.

Description of premolar and molar dentition (Pl. V, figs. 2—4).

As to the names, given below to the various components of premolars and molars, see the appendix at p. 77.

In order to be able to give the inner aspect of the cheekteeth a photograph has been taken (fig. 4, pl. V) from the image, produced by a mirror placed obliquely between both rows of teeth.

P^1 (preantepenultimate premolar).

Left: Crown totally broken off, only the fangs are preserved.

Right: Antero-external angle damaged. Subtriangular shape. Ground down to the base of the crown, presenting a disc of dentine. Palatinally and posteriorly of the middle a very small and shallow pit occurs, surrounded by an edge of enamel. This pit represents the remainder of the medisinus.

P^2 (antepenultimate premolar).

Left: The enamel of the ectoloph has been lost. Quadriform. Deuterocone almost isolated. No crochet. Postfossette oval-shaped; in its antero-external angle a very incipient enamel fold. Though the enamel of the ectoloph has been lost, still it can be seen, that the protocone presents on the outer surface of the tooth an ill-defined rib, which dies out towards

[1]) Here and in the following pages the direction of the slope is interpreted in the manner of the geologists!

the base of the crown. In general the outer surface is clearly convex with a concavity between protocone and tritocone. A small protostyle probably was present, the indications therefore are, however, not absolutely conclusive.
The buccal extremity of the medisinus is triangular and its bottom is situated considerably below the entrance to the medisinus.
Anterior cingulum is present. Interior cingulum totally absent.

Right: Preservation and structure as in the left one, with the only exception, that the postfossette does not show an incipient enamel fold in its antero-external angle.

P^3 (penultimate premolar).

Left: Ectoloph is totally broken off. Contrary to the P^2, the deuterocone is not isolated, but has been united with the protocone, forming the protoloph. From the metaloph a thick blunt crochet projects into the medisinus.
The antero-external angle of the postfossette is occupied by an enamel fold, which — though small — can be clearly seen.
Anterior cingulum is present. Also internal cingulum, which extends from the middle of the deuterocone to the middle of the tetartocone, and consists of a single row of very small tubercles. This row is strongly curved, concave upwards. The entrance to the medisinus is on the same level with the middle of the internal cingulum. Both are situated some 12 mm. above the base of the internal side of the crown. In the succeeding teeth this distance decreases gradually, so that in the M^2 the entrance to the medisinus is almost at the base of the crown.

Right: The state of preservation is better than that of the left one, only the anterior half of the ectoloph being damaged. The crochet is still more blunt; an enamel fold in the antero-external angle of the postfossette is absent.

P^4 (ultimate premolar).

Left: Ectoloph considerably injured. Structure of the present tooth strongly resembles that of P^3. The enamel fold in the postfossette, however, is now very distinct, while lingually of the crochet (which is not so blunt as in the P^3) another faint secondary enamel fold occurs. Interior cingulum as in P^3.

Right: The only tooth which is not damaged. The ectoloph is perfectly preserved, fortunately allowing us to study the outer surface of the tooth. The ectoloph shows a very strong protostyle, separated by the parastyle fold from the protocone, which manifests itself on the outer surface by a distinct rib (protocone style). The latter style, which dies out towards the base of the crown, is well-defined in front, but posteriorly it passes gradually into the outer surface of the ectoloph. Outer surface and posterior surface of the tooth are almost perpendicular to one another, forming a sharp edge, which therefore may be called the tritostyle. The crochet is double. The buccal one is lobe-shaped, the palatinal one sharp triangular. The secondary enamel fold in the postfossette is as distinctly developed as in the left P^4. Internal cingulum as in the left P^4.

M^1 (antepenultimate molar).

Left: Ectoloph for the greater part broken off. The protoloph shows a distinct swelling in its protocone portion. The single crochet is strong, broad and blunt, and approaches the protocone very closely, being separated by a space of about 1 mm. breadth. The metaloph is very oblique with regard to the ectoloph. Already in the P^2 the metaloph is oblique, but the degree of obliqueness increases in the succeeding teeth, culminating in the M^2. The postfossette, without a secondary enamel fold, is clearly ovalshaped, its longest axis almost parallel to the oblique metaloph. The ectoloph, though strongly injured, shows still a rather strong metastyle. Internal cingulum is wanting. Only a very small tubercle is situated near the entrance to the medisinus.

Right: Ectoloph totally broken off. The structure is exceedingly like that of the M^1.

M^2 (penultimate molar).

Left: Ectoloph considerably injured. The worn protoloph is in its top everywhere of equal breadth. More towards the base of the crown the protoloph shows the same swelling of its protocone portion as in the foregoing M^1. The crochet is sharper than in the M^1 and does not approach so close the protoloph. The medisinus is in general wider. The postfossette is triangular, posteriorly bounded by a finely crenulated, posterior cingulum. Internal cingulum is totally absent.

Right: The structure resembles that of the left one down to the smallest detail. The state of preservation is better in so far as only the antero-external portion of the ectoloph has been broken off. A distinct metastyle is developed. The outer side of the metacone is clearly concave, especially in its upper portion, which is, moreover, strongly inclined outwards.

M^3 (ultimate molar).

Left: Strongly damaged. The enamel of the outer surface of inner- and front side of the protoloph has been lost, while the crochet also is considerably injured. It will therefore be better to study the structure of the M^3 in the right molar.

Right: The top of the united ectoloph and metaloph, and of the crochet is somewhat damaged. The base of the crown is subtriangular. Parastyle is present, but moderately developed. Behind the parastyle another rather ill-defined rib occurs, namely the manifestation of the paracone on the outer surface. The crochet is sharp and elongated. Internal cingulum is absent. The postero-external angle of the outer surface of the tooth ends in a sharp tubercle, closely attached to the outer surface, and representing a vestige of the posterior cingulum.

Summary of the structure of premolars and molars.

Brachyodont. P^4 and P^3 are completely molarized. The metamorphosis of the P^2 into the molar pattern is not so progressed in so far as the deuterocone is still distinctly isolated. The P^1 is far too much worn to show its former structure.

Though the ectoloph of most teeth is to a smaller or greater extent damaged, we may be sure, from the evidence of the undamaged right P^3, that the outer surface of the teeth is marked by two vertical ribs viz., a strong parastyle (protostyle of premolars) and a distinct paracone style (protocone style of premolars), in front separated by the parastyle (protostyle) fold. Backwards the paracone (protocone) style passes more or less gradually into the outer surface of the tooth. The edge where outer- and posterior surface meet is sharp and may perhaps be called a metastyle (in premolars tritostyle). The M^2 is certainly provided with a metastyle. Protoloph and metaloph are oblique in regard to the direction of the tooth row. The metaloph is always more oblique than the protoloph, while the degree of obliqueness of the metaloph increases gradually in the teeth more backwards.

Crista and antecrochet are totally absent. A crochet is distinctly developed from the P^3 up to and including the M^3. In the right P^4 the crochet is distinctly double.

In the antero-external angle of the postfossette of the left P^2 and P^3, and of the left and right P^4 a secondary enamel fold occurs. In both P^4 this fold is most distinct. It is totally wanting in the postfossette of M^1 and M^2.

An outer cingulum never occurs. Inner cingulum is present in P^3 and P^4 of either side, and consists of a curved row of small tubercles. In the molars the inner cingulum is sometimes present in the form of a single incipient tubercle in the entrance to the medisinus. An anterior cingulum is always present (except perhaps in P^1). It runs from the antero-internal angle of the protoloph (at a level equal to the inner cingulum, if this is present) in the direction of the outer surface of the tooth, thereby bending strongly upwards, and forming a valley, which probably may be called praesinus [1]). A posterior cingulum is distinctly visible in both M^2, whereas it is represented in the M^3 in the form of a tubercle.

The posterior side of the protocone (deuterocone in premolars) and the anterior side of the hypocone (tetartocone in premolars) are both either straight, slightly concave or slightly convex in profile view of the molar. Both converge strongly downwards, so that the palatinal portion of the medisinus becomes gradually narrower towards the base of the crown. The buccal extremity of the medisinus is wide or narrow depending upon the development of the crochet and the degree of wear of the tooth.

From the slightly worn M^3, we may infer that the specimen described above, belonged to an adult, though not old individual. The second specimen, however, the description of which will follow now, certainly belonged to a very old individual, as will be seen below.

Rhinoceros ?sondaicus Desm. fossilis.

Text fig. 6.

Locality: Bondol near Kuwung.

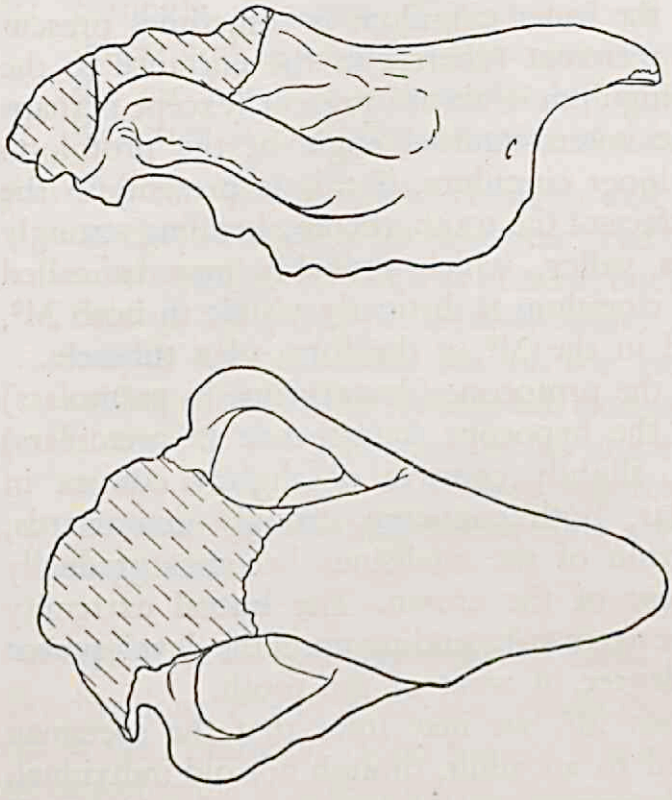
The second specimen is very much injured. Some deformation is not impossible.

State of preservation of the cranium.

The whole of the occipital and parietal region of the cranium is very much damaged. The brain case is totally uncovered, and has

[1]) See appendix.

been filled for a good deal with plaster. As both petrosals, and a portion of the basioccipitale have been lost, the bottom of the brain case presents a shapeless hole. The upper surface of the nasals is so much injured, that it cannot be seen whether or not a rugosity for a nasal horn occurred. Both zygomatic arches are remarkably well preserved; locally, however, restored with plaster. Praemaxillaries and the processes of the maxillaries, with which they are attached, have been lost. Both postglenoid processes have been broken off for the greater part. This is also the case with the right paroccipital process, whereas of the left corresponding process only the base can be seen. The tips of both pterygoid processes are absent. The palate is injured both in front and in back. The nasal cavity is for the greater part filled with matrix, which could not be removed, without running the risk to demolish the whole of the cranium. Of the right occipital condyle the greater part of the surface of the lower side is preserved, so that the total length of the cranium could be estimated with a tolerable degree of certainty.



Text fig. 6. Upper and side aspect of damaged cranium of *Rhinoceros ?sondaicus fossilis*. $^1/_9$ nat. size.

Description of the cranium.

Brachycephalic. Strong depression of frontal region. Union of posttympanic and postglenoid process below the meatus auditorius externus. No rugosities can be detected on the frontals, indicating the absence of frontal horn(s). Due to the injury of the nasals we cannot detect whether a nasal horn was present.

State of preservation of premolar and molar dentition.

Of the right tooth row remains of P^3—M^3 are present; of the left tooth row still less has been preserved viz., only remains of

M^1—M^3. These remains show that the degree of wear is very great; M^3 is ground down to a level only about 8 mm. above the bottom of the palatinal extremity of the medisinus. We may, therefore, be sure, that the cranium under consideration belonged to a very old individual.

The state of preservation of these premolars and molars being, in general, very bad, it will be of no interest to describe them detailed.

The little, which these poor remains still exhibit of the structure of the cheekteeth, seems to show that by no single character the cheekteeth in question differ from those of the foregoing specimen.

Before commencing to explain how we came to the conclusion that the well preserved rhinoceros cranium of our collection was indistinguishable from that of the living *Rhinoceros sondaicus*, we will make a comparison between the two specimens described.

As far as the bad state of preservation of the one allows of comparison, there appears to be an absolute accordance regarding essential characters. Both show:

1. a strong frontal depression;
2. union of postglenoid and posttympanic processes below the meatus auditorius externus;
3. no frontal horn(s);
4. brachycephaly.

Above it was seen, furthermore, that the remains of the cheekteeth of the ill-preserved specimen did not show any character by which the teeth could be distinguished from those of the well preserved cranium.

As, furthermore, both specimens have been found in the same locality, it is very probable that both belong to the same species. On the other hand, however, it cannot be denied that four of the ten measurements, which could be taken [1]) from the fragmentary specimen, show — if expressed in % of a certain measurement as unit — rather great differences with the corresponding maximum or minimum values found for 16 adult crania of *Rhinoceros sondaicus*. Though I certainly do not neglect the fact that more ample materials of the recent species would reveal a still greater individual variation, I thought it better to consider the identity between both fossil specimens as not totally proved. This may account for the addition of a sign of interrogation to the name under which the fragmentary cranium has been described.

[1]) See table L of cranial measurements.

As has already been emphasized on page 59, the resemblance between the well preserved cranium and that of the recent *Rhinoceros sondaicus* is extremely close. Hereafter will, furthermore, be pointed out that also concerning the various measurements a nearly complete accordance appears to exist. Moreover it will be shown that also the permanent cheekteeth dentition resembles that of the recent species down to the smallest detail. We shall, therefore, be wholly justified if the fossil specimen in question be compared only with the recent and fossil Malayan forms of the genus *Rhinoceros* s. s., and with the only Asiatic form which shows distinct affinities to *Rh. sondaicus* namely, *Rh. sivalensis* FALC. et CAUTL. In this manner the following species remain:

Rhinoceros kendengindicus DUBOIS.

Rhinoceros sivasondaicus DUBOIS.

Rhinoceros sivalensis FALC. et CAUTL.

Rhinoceros sondaicus DESM. *fossilis*.

Rhinoceros sondaicus DESM.

Rhinoceros kendengindicus DUBOIS.

Rhinoceros kendengindicus, Eug. Dubois, Tijdschr. Kon. Ned. Aardr. Gen., 2nd ser., XXV, 1908, p. 1259.

Our knowledge of this fossil Javan form must be called absolutely insufficient. DUBOIS only mentioning — after shortly dealing with *Rh. sivasondaicus* —: "Die zweite Form von Rhinoceros schliesst sich dem nur auf dem Kontinente lebenden R. *indicus* an, ist von diesem aber in untergeordneten Punkten verschieden. Das hintere Joch der oberen Molaren ist relativ breiter, die Nasenknochen sind schmaler und scharfrändiger. Ich unterscheide diese zweite Art als *Rhinoceros kendengindicus* n. sp." [1]). Though this is very little, yet it suffices in the present case to exclude *Rh. kendengindicus* from the comparison. There are certainly a number of resemblances between the crania of *Rh. unicornis* L. (*Rh. indicus* CUV.) and of *Rh. sondaicus*, and therefore also between those of *Rh. kendengindicus* and our own fossil form. The cheekteeth of the latter, however, are readily distinguished from those of *Rh. unicornis* (and therefore also from *Rh. kendengindicus*) by the absence of crista and medifossette, the latter formed by the union of crochet and crista [2]).

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[1]) p. 1259.

[2]) See e. g. W. H. FLOWER, On some cranial and dental characters of the existing species of rhinoceroses. Proc. Zool. Soc. of London, 1876.

Rhinoceros sivasondaicus Dubois.

Rhinoceros javanicus, Eug. Dubois, Nat. Tijdschr. v. N.-I., LI, 1892, p. 94.
Rhinoceros sivasondaicus, Eug. Dubois, Tijdschr. Kon. Ned. Aardr. Gen., 2nd ser., XXV, 1908, p. 1258.
non Rhinoceros sivasondaicus, H. Stremme in: Die Pithecanthropus-Schichten auf Java, 1911, p. 89, pl. XVII, fig. 8; pl. XVIII, figs. 1—2.

Originally Dubois (1892) mentioned the occurrence of *Rh. javanicus* Cuv. (*Rh. sondaicus* Desm.) in the fossil state in Java. In 1908 he apparently redetermined this form as *Rh. sivasondaicus* n. sp. As this species is of extreme importance to us, we shall quote all that Dubois mentioned about it. *Rhinoceros sivasondaicus* ".... ist ein sehr naher Verwandter des R. *sondaicus*, der jetzt lebend in Java, aber auch auf dem Festlande vorkommt. Diese lebende Art is sicher von R. *sivalensis* wenig verschieden, und Lydekker betrachtete deshalb letztere als ihre Stammform. Es ist nun sehr merkwürdig, dass die Kendeng-Form den geringen Abstand, welche noch jene beiden trennt, überbrückt. Gerade die wenigen Unterschiede die Lydekker angibt sind in der Kendeng-Form noch geringer geworden. Namentlich vermittelt die fossile Art von Java in dem Verhältnisse zwischen Länge und Breite der oberen Molaren den Uebergang jener beiden. Ich nenne sie deshalb *Rhinoceros sivasondaicus* n. sp. Jedenfalls war diese eine mit der heutigen doch nicht identische Art. Von R. *sivalensis* unterscheidet sie sich auch durch den Besitz eines zwar sehr kleinen medialen Unterkieferincisiven, von R. *karnuliensis* durch das Fehlen des Cingulum an der Innenfläche der Vorderjoche und des Höckerchens in dem Quertal der oberen Molaren" (l. c. p. 1258).

In dealing with *Rh. sivalensis* we shall return to the dental difference above mentioned.

The Trinil collection of Mrs. Selenka contained of rhinoceros remains, besides some detached upper and lower cheekteeth and limb bones, a fine, well preserved cranium. All the remains were reckoned by Stremme to *Rh. sivasondaicus* Dub., mainly from the fact, that he thought to notice some differences between the cheek-teeth of his fossil form and those of *Rh. sondaicus*. Though Stremme stated that his material did not enable him to detect a transition between *Rh. sondaicus* and *Rh. sivalensis*, yet he came to the conclusion that his form was specifically identical with *Rh. sivasondaicus* Dubois. And again we may repeat what we observed already concerning Stremme's identification of his fossil forms of *Buffelus* and *Bibos* with resp. *Buffelus palaeokerabau* Dubois and *Bibos palaeosondaicus* Dubois, namely: the probability is great that Stremme's form is identical with Dubois's form, but Stremme had certainly no right to accept this identity as if it had been wholly proved.

Hereafter we shall have the opportunity to deal with STREMME's determination more detailed.

Rhinoceros sivalensis FALC. et CAUTL.

Rhinoceros indicus fossilis, Baker and Durand, Journ. Asiatic Soc. of Bengal, IV, 1836, p. 486, pl. XV, figs. 1—3; pl. XIX, figs. 7—8.
Rhinoceros sivalensis, H. Falconer and P. T. Cautley, Fauna Antiqua Sivalensis, pl. LXXIII, figs. 2—3*a*; pl. LXXIV, fig. 5; pl. LXXV, fig. 5.
Rhinoceros sivalensis, R. Lydekker, Mem. Geol. Surv. India, ser. X, I, part 2, 1876, p. 8, pl. IV, fig. 2; pl. V, fig. 5.
Rhinoceros sivalensis, R. Lydekker, Mem. Geol. Surv. India, ser. X, II, part 1, 1881, p. 28, pl. V, figs. 1, 3—6; pl. X, fig. 4.

The literature relating to this Siwalik species is more extensive than would appear from the above, where only has been mentioned what will be needed in the below. Furthermore stress must be laid upon the fact that of each of the papers quoted only the figures of those specimens have been mentioned which appear to belong with certainty to the present species.

The name *Rh. sivalensis* appears to have been first applied to a number of specimens figured in the F.A.S. a.o. comprising a damaged, but still rather fine, adult cranium, in which both sets of cheekteeth have been preserved.

In 1836 BAKER and DURAND published a paper in which they described and figured a.o. a well preserved cranium, an occiput and several upper cheekteeth. Though all the specimens were assigned to one species (*Rh. indicus fossilis*), the authors hinted at the possibility of there being a second species. LYDEKKER twice referred to some of BAKER and DURAND's specimens viz., in 1876 and 1881. He redetermined the cranium and two M^3 as certainly belonging to the present species. A M^2, which he in 1876 also reckoned to *Rh. sivalensis*, was in 1881 considered as possibly belonging to *Rh. palaeindicus*. Another of BAKER and DURAND's specimens, namely a symphysial part of the mandible, was thought probably to belong to *Rh. platyrhinus*. Furthermore, LYDEKKER pointed out the resemblance between still another specimen, namely the occiput already mentioned and the hinder portion of the cranium described and figured by him under the name of *Rh. sivalensis*, var. *gajensis* LYD.[1])

We see, therefore, that among BAKER and DURAND's material of the fossil *Rhinoceros indicus* not only a number of different species are contained, but even two different genera.

I thought it desirable to mention these details to make what follows comprehensible. BAKER and DURAND's paper contains a

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[1]) This form was again redetermined as *Aceratherium gajense* PILG. by PILGRIM (Mem. Geol. Surv. Ind., new ser. IV, 1912). MATSUMOTO (Science Rep. Tôhoku Imp. Univ. Sendai, Japan, 2nd ser. (Geology), V, (1918—1921) rightly pointed out that according to the law of priority the name of the species must be *Acer. gajense* (LYD.).

lot of measurements among others of the cranium and occiput, both already mentioned, and of about twenty specimens of upper premolars and molars. From the above it will be clear that the measurements of the cranium may safely be used. Those of the occiput and cheekteeth [1]), however, cannot.

Apparently STREMME was not acquainted with these particulars, his tables containing, besides the measurements of BAKER and DURAND's cranium of *Rh. sivalensis*, also those of the occiput and of one tooth row [2]).

Except the cranial measurements of BAKER and DURAND's specimen and a few dental measurements which will be dealt with in the sequel, we do not dispose of more material of numbers.

A comparison between the cranium of our own fossil form with that of *Rh. sivalensis* will be made together with the discussion of the crania of the recent *Rh. sondaicus*. At this moment we shall pay attention to the differences between upper M of *Rh. sivalensis* and *Rh. sondaicus*. LYDEKKER [3]) stated: "Between the true molars of these two species, taking into consideration the small variation which I have noticed in those of the fossil, I am totally unable to discover more than one point in their plan of structure which can be taken as affording any certain indication of distinction. This point is a difference in the relative dimensions of the molars of the two species."

"Taking little worn teeth, we shall find that in R. *sivalensis* the greatest length of the anterior surface, measuring to the second "costa" [4]) of the "buttress" is exactly equal to the greatest length of the external surface; whereas in R. *javanicus* the former measurement is greater than the latter."

To illustrate this relationship, LYDEKKER gave the dimensions of:

a. M^2 of *Rh. sivalensis*, drawn in fig. 2, pl. V, 1881;

b. M^2 of *Rh. sivalensis*, drawn in fig. 5, pl. V, 1876;

c. two M^2 of *Rh. sondaicus*.

Specimen *a*, however, was later on reckoned by LYDEKKER [5]) to *Rh. sivalensis*, var. *intermedius* [6]). Though by doing so, one of

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[1]) N. B. — BAKER and DURAND's table of measurements of the cheekteeth does not indicate which of the specimens of the table have been figured.

[2]) One would perhaps be inclined to suppose that this tooth row belongs to the cranium in question. This is, however, not the case as may appear from BAKER and DURAND's text.

[3]) 1881, p. 31.

[4]) Paracone style.

[5]) Mem. Geol. Surv. Ind., ser. X, III, part 1, 1884, p. 5.

[6]) PILGRIM redetermined this tooth as belonging to *Acer. gajense*, var. *intermedium* (See Rec. Geol. Surv. Ind., XL, 1910, part 3, p. 200).

the two specimens of *Rh. sivalensis*, of which LYDEKKER gave the measurements, must be omitted, yet we may attach value to the difference mentioned, because LYDEKKER stated that in all the specimens he could procure, this relationship appeared to be constant.

In this connection I wish to observe that the structure of a rhinoceros molar is such that the length of the anterior surface decreases towards the top of the crown, while the length of the external surface increases towards the top. Consequently in a molar of *Rh. sivalensis* it will depend upon the stage of wear whether "the greatest length of the anterior surface" will be equal to or greater than "the greatest length of the external surface". It will, therefore, be clear, I believe, that the distinguishing character, which LYDEKKER discovered, will be very difficult to handle.

Now it will be remembered that the only character, which DUBOIS mentions of *Rh. sivasondaicus*, is that its molars are intermediate in this respect. I may add, that if afterwards, *Rh. sivasondaicus* should turn out to be a distinct species, we shall certainly have to admire DUBOIS for his not overlooking such a very subtle detail. As already stated, STREMME did not succeed in using this character. As to the teeth of my own fossil form they are in this respect indistinguishable from those of *Rh. sondaicus*.

Rhinoceros sondaicus DESM. fossilis.

Rhinoceros sp., G. Busk, Proc. Zool. Soc. London, 1869, p. 409, text figs. 1—4.
? Rhinoceros sondaicus Cuv. in: R. Lydekker, Cat. Foss. Mamm. in the Br. Mus. part III, 1886, p. 129.

BUSK described and figured a left and right fossilized M^2 of rhinoceros belonging to a species "not distinguishable by its dental characters from R. *sondaicus*" [1]). They were obtained from Sarawak (Borneo). Exact locality unknown. LYDEKKER provisionally referred to *Rh. sondaicus* two M^1 or M^2 of opposite sides, and three lower cheekteeth, from a depth of sixty feet in a cavern deposit at Sarawak. The upper molars were said to present all the characters of those of R. *sondaicus*.

Rhinoceros sondaicus DESM.

Rhinoceros sondaicus, Desmarest, Mammalogie, 1822, p. 399.
Rhinoceros javanicus, F. Cuvier, Hist. nat. des Mammifères, III, liv. 45, 1824, p. 2.

Of this recent species the present writer was able to examine and measure thirteen crania of adult and old individuals, being in

[1]) p. 415.

all thirteen specimens the M^3 to a smaller or greater extent abraded by wear. The National Museum of Natural History at Leyden contained five specimens; the museums of Natura Artis Magistra six, and the Zoological Institute of the University of Utrecht two. In one specimen (nº. 10 of table K) the lower jaw could not be removed without demolishing the specimen. That is the reason why length and breadth of the cheekteeth of this specimen have not been given in table N. In cranium n°. 4 only left M^2 and M^3 were present. Cranium nº. 6 wanted left P^1—M^2. Furthermore from table N will be noticed that in four specimens P^1 of either side is absent. In nearly all cases, there are, however, clear indications that this loss has taken place after the death of the animal.

Before proceeding with a discussion of the individual variation which exists both in cranium, and permanent upper cheekteeth dentition, it will be desirable to call attention to the various tables of measurements.

Table K contains, besides the measurements of the thirteen crania, already mentioned, those of:

one cranium [1]) of *Rh. sondaicus*, borrowed from FRANZ TOULA, Das Nashorn von Hundsheim, Abh. K. K. Geol. Reichsanstalt, XIX, 1902, table;

two crania of the same species, borrowed from CUVIER, Recherches sur les ossements fossiles, 1822, p. 37;

one cranium of *Rh. sivalensis*, derived from BAKER and DURAND, 1836, p. 502;

one cranium of *Rh. sivasondaicus*, derived from STREMME, 1911, p. 90 and 94;

the two fossil specimens of our own collection.

As to the measurements themselves we followed for the greater part STREMME who in his turn partly joined TOULA.

In table L all the values are expressed in % of measurement 13. The total length of the cranium could not be used as unit, because of three crania the total length was unknown. Maxima and minima have been heavy printed for *Rh. sondaicus*.

Table M contains a number of relations of certain measurements. As to the choice of the measurements we followed STREMME as

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[1]) At the time that TOULA measured this specimen, it was preserved in the Nat. Mus. of Nat. Hist. at Leyden. Apparently it has been exchanged later on.

far as possible. For *Rh. sondaicus* the greatest and smallest number of each horizontal row have been heavy printed.

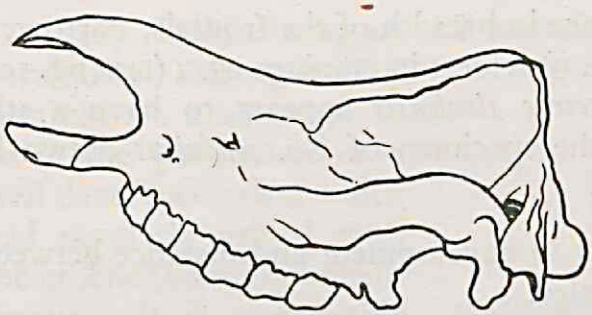
In table N the length, breadth (both measured at the base of the crown) and the relation length : breadth of each cheektooth have been united. Why this table does not contain — in contradiction to STREMME's table — measurements of premolars and molars of *Rh. sivalensis* will be clear, I believe, after what has been stated in the foregoing part. Originally we added to table N also the measurements of two cheekteeth sets which will be found mentioned on p. 39 of CUVIER's paper quoted. When it appeared, however, that in P^2—M^2 of one of these rows the relation $\frac{\text{length}}{\text{breadth}}$ not inconsiderably exceeded the highest value found in the corresponding teeth of twelve foregoing crania it was thought better to exclude them from our table.

As will be seen we have given all dental measurements in mm. STREMME, however, in tenths of mm. In my opinion this is absolutely superfluous. For, though the structure of a rhinoceros tooth certainly permits exact measuring of the breadth, it surely does not allow of measuring the exact length of the tooth. Moreover it must not be forgotten that length as well as breadth of corresponding teeth of opposite sides may differ distinctly.

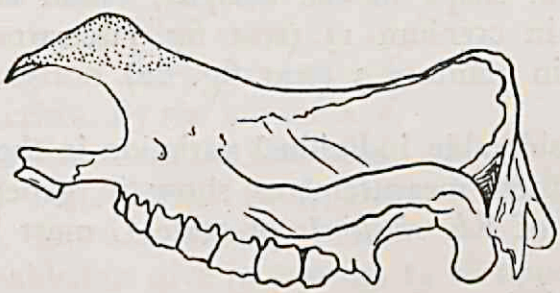
In table O, at last, the breadth and length have been expressed in % of resp. the breadth and length of the fourth premolar. Both in table N and O maxima and minima found for the teeth of *Rh. sondaicus* have been heavy printed.

We shall now return to the measurements of the sixteen crania of *Rhinoceros sondaicus*. Both from table L and M it will be seen that even such a relatively small number of specimens already may show a considerable individual variation. Especially concerning some points there appears to exist noticeable differences between the crania of the present species. In this respect we may bring forward:

a. The great differences in degree of depression of the frontal region; smallest in cranium n°. 5 (text fig. 7), greatest in cranium n°. 8 (text fig. 8). Both text figures show, moreover, clearly that a feeble frontal depression coincides with slightly curved nasals. Table L exhibits, furthermore, decidedly that whereas the difference between the greatest and smallest value, found for m. 6 in 16 crania of *Rh. sondaicus* is 18 %, the greatest value is exceeded by no less than 22 % by the only cranium of *Rh. sivalensis*.



Text fig. 7.



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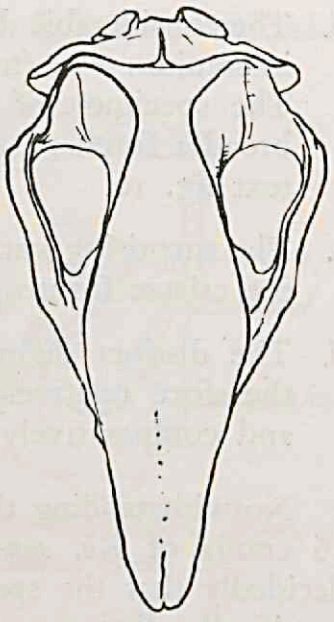

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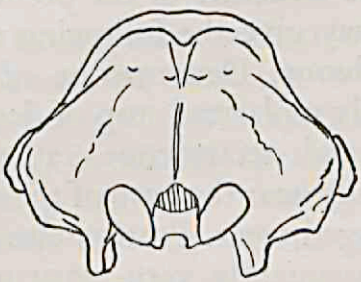
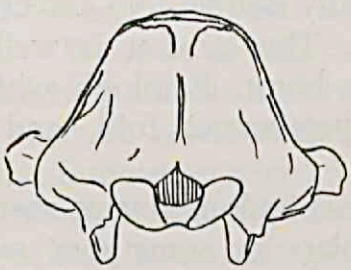
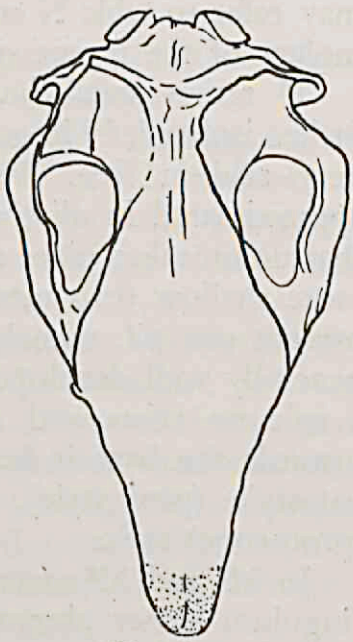


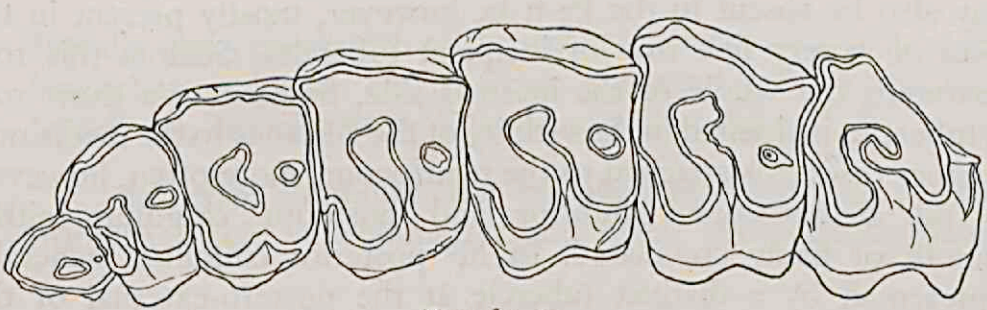
Text fig. 11.



Text fig. 12.



Text fig. 10.



Text fig. 13.

Text figs. 7—13. *Rhinoceros sondaicus* (recent). Text figs. 7—12 of approximate equal size ($^1/_9$ nat. size). Text fig. 13 ($^1/_2$ nat. size).

b. The considerable difference in breadth of the frontals, narrowest in cranium n°. 2 (text fig. 9), widest in cranium n°. 1 (text fig. 10). The specimen of *Rhinoceros sivalensis* appears to have a still broader forehead than the specimen of *Rh. sondaicus* drawn in text fig. 10.

c. The surprising variability in development and distance between the cristae fronto-parietales.

d. The distinct differences in shape of the occiput; broad and therefore relatively low in cranium 13 (text fig. 11), narrow and comparatively high in cranium 3 (text fig. 12).

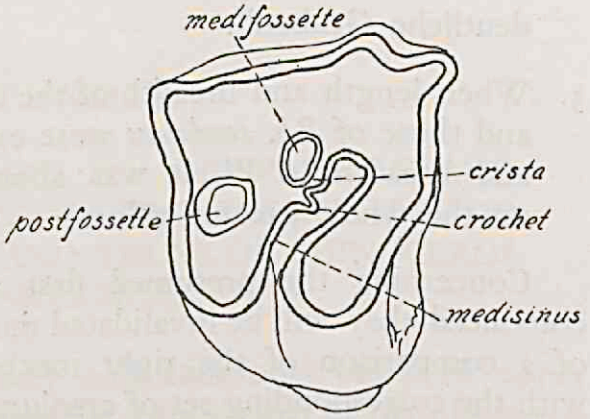
Notwithstanding the considerable, individual variation in these 16 crania of *Rh. sondaicus*, their measurements show in general decidedly that the specimen of *Rh. sivalensis* of table L must be specifically distinct.

As to the individual variation of the dental measurements I may refer to table N and O. Of the structure of the premolars and molars of the recent species we may give the following summary.

P^1 rather small, but not deciduous. Deuterocone of P^2 more or less isolated. P^3 in general entirely molarized; top of deuterocone very seldom free. Deuterocone and tetartocone rather closely approximated in all the P, especially near the base of the crown, so that union takes place after prolonged wear. Postfossette distinctly more shallow than medisinus; consequently very worn teeth only present one pit, namely the buccal part of the medisinus. Crochet generally well developed, occasionally double. No antecrochet. As a rule no crista and medifossette. The crochet is well defined, towards the base it becomes more blunt. Ectoloph with distinct parastyle (protostyle), paracone (protocone) fold, and paracone (protocone) style.

In M^2 and M^3 metastyle. Outer cingulum always absent; inner cingulum either absent in the molars or sometimes represented by a small tubercle at the entrance to the medisinus. Inner cingulum may also be absent in the P; it is, however, mostly present in the form of a very fine row of incipient tubercles. Seldom this row surrounds the whole of the internal side. Sometimes a short row of tubercles is situated in the vicinity of the entrance to the medisinus, in other cases it is attached to the tetartocone, more often, however, to the deuterocone. Anterior and posterior cingulum either smooth or finely crenulated. In M^3 posterior cingulum generally represented by a distinct tubercle at the postero-external of the crown. An incipient secondary enamel fold in the postfossette of the premolars may occasionally occur.

Lastly I will bring to the attention the following noticeable peculiarity. The right P^3 of cranium n°. 2 appeared to be in the possession of a well developed crista which had regularly united with the crochet, forming a medifossette. It is remarkable that none of the other teeth of the cranium in question show any trace of a crista. By the kindness of the director of the Nat. Mus. of Nat. Hist., Prof. Dr. E. D. VAN OORT, I am enabled to give in text fig. 14 an upper view of the specimen, made after a photograph, taken for me in Leyden.



Text fig. 14. Right P^3, abnormally developed, of *Rhinoceros sondaicus*. $^4/_5$ nat. size.

After having dealt with cranium and cheekteeth of *Rh. sondaicus* so extensively, we shall try to answer the question:

Is the form, which STREMME described under the name of *Rh. sivasondaicus*, in reality specifically distinct from *Rh. sondaicus*, or will it be possible to identify STREMME's form with the recent species with the help of the more ample materials of the latter we had at our disposal?

After a detailed comparison of the fossil cranium of his collection with that of an old ♂ and a young ♀ of *Rh. sondaicus*, STREMME concluded: "Weist so die allgemeine Schädelform nur Unterschiede von der rezenten auf, die innerhalb der individuellen Variationsbreite liegen können, so bestehen doch in der Bezahnung Abweichungen, die die Aufstellung einer neuen Art gerechtfertigt erscheinen lassen" [1]). My own tables L and M show that the correctness of STREMME's first supposition is entirely proved by the facts.

The differences in the dentition which STREMME noticed are:

1. Equally worn cheekteeth of the recent species revealed ". . . . eine länglichere, schwach eingedrückte vordere Grube [2]) und einen schärferen, bei einzelnen Zähnen geteilten Sporn". [3])

2. ". . . der erste Prämolar, der bei allen rezenten Java . . . Nashörnern . . . ein verkümmerter und schon bei nicht allzuhohem

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[1]) p. 91.
[2]) Meant is "prefossette".
[3]) p. 91.

Alter abgekauter Zahn war, ist hier bei der abgekauten Zahnreihe des fossilen Nashorns noch relativ stattlich und zeigt zwei deutliche Gruben".

3. When length and breadth of the cheekteeth of STREMME's form and those of *Rh. sondaicus* were expressed in % of resp. length and breadth of P^4, it was shown that STREMME's form gave on the whole greater values.

Concerning the presumed first and second difference, I am convinced they will be invalidated much more rapidly with the help of a comparison of the right toothrow of STREMME's specimen with the corresponding set of cranium 5 of *Rh. sondaicus* and drawn (after a photograph) in text fig. 13, than by means of a lot of words.

As to the third difference I may refer to my own table O. Though I immediately admit that still the breadth of P^1, P^3 and M^1 of "*Rh. sivasondaicus*" show the greatest values, we may be absolutely sure that also these differences would disappear, if but we had been able to collect the measurements of some more crania of the recent *Rh. sondaicus*.

As, moreover, the other rhinoceros remains, which STREMME described, do not afford any reason for specific distinction I conclude:

The fossil form described by STREMME *under the name of* Rh. *sivasondaicus* DUB. *is specifically indistinguishable from the recent* Rh. *sondaicus, and must therefore be called* Rhinoceros *sondaicus* DESM. *fossilis.*

At last our own fossil cranium (specimen *a* of the tables).

Both from the tables and from comparison of the description of the specimen in question with our enumeration of cranial and dental characters and peculiarities of *Rh. sondaicus* appears — without leaving a shade of doubt — that also our form is specifically identical with the recent *Rh. sondaicus*, and consequently also with STREMME's specimen.

APPENDIX.

ON THE TERMS APPLIED TO THE PRIMARY AND SECONDARY ELEMENTS OF UPPER PREMOLARS AND MOLARS IN GENERAL AND THOSE OF RHINOCEROS IN PARTICULAR.

The terminology of primary and additional cusps of upper premolars and molars, based upon the tritubercular theory of COPE—OSBORN, was originally as follows:

Primary cusps	Protocone	for	Antero-internal	cusp
	Hypocone	„	Postero- „	„
	Paracone	„	Antero-external	„
	Metacone	„	Postero- „	„
Additional cusps	Protoconule	„	Antero-intermediate	„
	Metaconule	„	Postero- „	„

SCOTT's [1]) investigations, however, lead him to the conclusion that the cusps of the premolars were not homologous with the corresponding ones of the molars. Accordingly he proposed a series of new names, which are for the primary cusps of upper premolars as follows:

Primary cusps	Protocone	analogous	with	paracone	of molars
	Deuterocone	„	„	protocone	„ „
	Tritocone	„	„	metacone	„ „
	Tetartocone	„	„	hypocone	„ „

As regards the upper premolars OSBORN accepted in full SCOTT's interpretation.

SCOTT was convinced that the conules of the premolars were not homologous with those of the molars. ("In position these conules correspond to the proto- and metaconules of the molars, but are obviously not homologous with them") [2]). He

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[1]) The Evolution of the Premolar Teeth in Mammals. Proc. Acad. Nat. Sci., Philadelphia, 1893, p. 405—444.

[2]) Loc. cit. p. 413.

committed, therefore, an incompleteness in not proposing new names for the conules of the premolars. OSBORN, too, failed to do so.

I should not have been at all surprised if OSBORN had not accepted SCOTT's new names for the primary cusps of the upper premolars. This assertion will be sufficiently explained by the following quotation. OSBORN [1]) in dealing with the subject of nomenclature observes: ". . . . the system of terms was originally based upon the actual homologies of the primary elements of the trigon and trigonid, but in extending it to the other parts of the crown and to the secondary cusps it was found that we must apply similar terms to some of the later elements in the upper and lower teeth, which are merely analogous to each other . . . ., *otherwise the terms soon multiply, so as to become a burden rather than a convenience*" [2]).

Perhaps the present writer should not have ventured to draw attention to these points, were it not that OSBORN had been inconsistent in another point. At the same time that OSBORN introduced the terms proto-, para-, meta- and hypocone for the primary cusps of the upper premolars and molars, he proposed namely some new names for the peripheral pillars, which occur in the upper cheek teeth of all ungulates. In view of the rhinoceros premolar and molar there are two pillars which may interest us, namely those which OSBORN gave the names of parastyle and metastyle, the prefixes (para-, meta-, etc.) being applied ". . . according to their proximity to the cones . . . ." [3]). One should expect that OSBORN after acceptance of SCOTT's terms "proto-, deutero-, trito- and tetartocone" for the primary cusps of the upper premolars, should have named the antero-external and postero-external pillar of the premolar resp. protostyle and tritostyle, instead of parastyle and metastyle. He did not, however. See e. g. figs. 116 and 192 in OSBORN's work "Evolution of Mammalian Molar Teeth".

Some subsequent investigators — I may mention ZDANSKY [4]) and COOPER [5]) — apparently met with the same inconsistency, for they use the term protostyle for the antero-external pillar of the premolars. It is, however, an enigma to me, why COOPER —

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[1]) Evolution of Mammalian Molar Teeth. Biological Studies and Addresses, vol. I, 1907, p. 69.

[2]) The italics are ours.

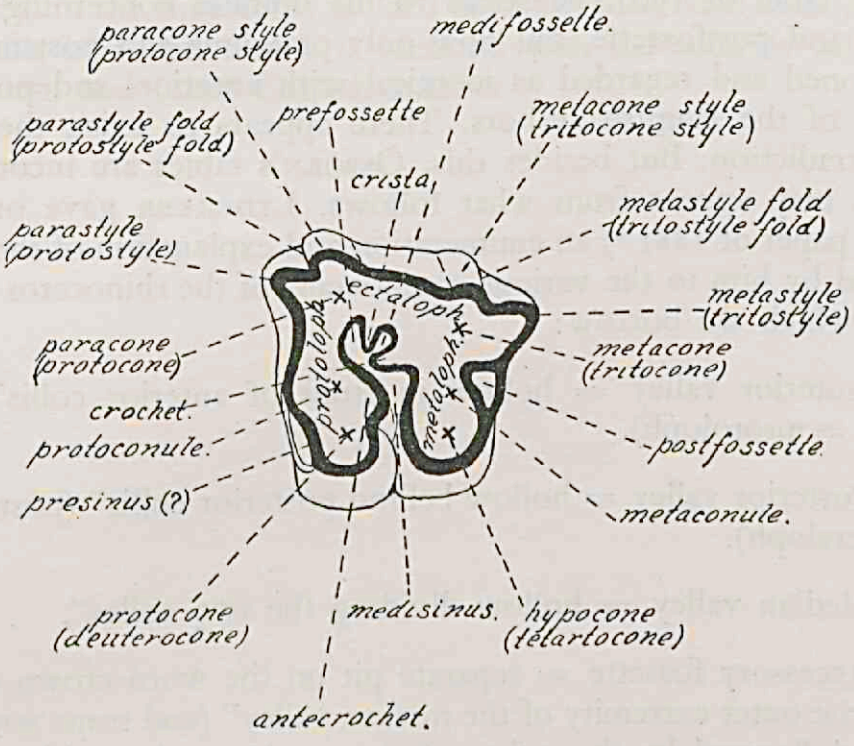
[3]) OSBORN (1907), p. 70.

[4]) OTTO ZDANSKY, Die Säugetiere der Quartärfauna von Chou-k'ou-tien. Palaeontologia Sinica, Ser. C, V, fasc. 4, 1928.

[5]) C. F. COOPER, On the skull and dentition of the Paraceratherium bugtiense. Phil. Trans. Royal Soc. of London, Ser. B, vol. 212, 1923—1924.

in whose specimens of premolars also the postero-external pillar was developed — does speak of protostyle, and not of tritostyle instead of metastyle [1]).

Turning now to the rhinoceros premolar and molar of the upper jaw, we have only some remarks to add. After what preceded



Text fig. 15. Diagram of a hypothetic left upper cheek tooth of rhinoceros showing the terms applied to the various components of upper premolars and molars. (The terms which only refer to premolars are placed in parenthesis.)

it will need no explanation why we used, in describing the premolars of *Rhinoceros sondaicus fossilis*, the terms protostyle fold and protocone style. As to the greater part of the remaining terms I may refer to text fig. 15. It will only be desirable to pay attention to OSBORN's terms praesinus, medisinus and postsinus. As far as my knowledge goes OSBORN gave twice viz., in 1898 [2]) and 1907 [3]), a table in order to show the parallelisation between his terms and those of former authors. Of course hereafter only the terms applied to the rhinoceros tooth will interest us. His table of 1898 contains the terms medisinus and postsinus, which he regarded as identical with resp. anterior and posterior valley of the English authors

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[1]) See e. g. COOPER, p. 382.

[2]) The extinct Rhinoceroses. Mem. Amer. Mus. Nat. Hist. I, pt. 3, 1898.

[3]) Loc. cit.

[Boyd Dawkins (1867), Busk (1877), Lydekker (1881) [1]), Foote (1874)]. According to the same table the authors above mentioned should not have used terms identical with Osborn's prae-, medi- and postfossette. Without any further explanation Osborn speaks, furthermore, dealing in the text [2]) with the rhinoceros molar of "the three inner valleys ... presinus, medisinus and postsinus". In his table of 1907, he sticks to his opinion concerning prae-, medi- and postfossette, but now only praesinus and postsinus are mentioned and regarded as identical with anterior- and posterior valley of the English authors. There appears to exist, therefore, a contradiction. But besides this, Osborn's tables are incomplete, which may appear from what follows. Lydekker gave on p. 8 of his paper of 1881 [3]) an enumeration and explanation of the terms applied by him to the various components of the rhinoceros molar, from which we borrow:

"Anterior valley = hollow in front of anterior collis" (ant. collis = protoloph).

"Posterior valley = hollow behind posterior collis" (post. collis = metaloph).

"Median valley = hollow dividing the two colles".

"Accessory fossette = separate pit on the worn crown cut off from the outer extremity of the median valley" (and some sentences further) "caused by the union of the crochet and combing-plate" (combing-plate = crista).

Furthermore, it may be mentioned that Lydekker did not distinguish rigorously between the term valley and fossette, which appears from this quotation: "When worn down" the "tooth .... would present two fossettes on the crown (formed by the outer part of the median valley and by the posterior valley)" [4]). With these data it is not difficult to introduce the following corrections:

medisinus = median valley,

postfossette = posterior valley,

medifossette = accessory fossette.

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[1]) Osborn mentions 1882, but apparently meant 1881 as I do not know a publication of Lydekker on rhinoceroses of 1882.

[2]) Osborn, 1898, p. 105.

[3]) Siwalik Rhinocerotidae, Mem. Geol. Surv. of India, ser. X, II, part 1, 1881.

[4]) Loc. cit. p. 16.

OSBORN [1]) meant by postsinus the vestige of the primitive valley, which may occur in the third upper molar of some species between the ectoloph and the posterior surface of the metaloph. This pit, therefore, is apparently considered as not homologous with the postfossette of the remaining premolars and molars. I cannot, however, see the reason. What OSBORN meant by the praesinus of the rhinoceros molar I have not succeeded in detecting. I believe, however, that it is identical with the anterior valley of LYDEKKER and other English authors.

[1]) See OSBORN 1898, p. 142.

FINAL CONSIDERATIONS.

Bumiaju.

The following determinations are of interest:

Tetralophodon bumiajuensis nov. spec.

The molars of this species appeared to show very great affinities to *Tetralophodon longirostris*. According to VON KOENIGSWALD [1]), however, the form of Bumiaju is easily distinguished from the European species by the absence of lower incisive tusks.

Stegodon airâwana MARTIN.

The stegodont of the Trinil beds (= Kendeng beds = Pithecanthropus beds).

Archidiskodon planifrons FALC. et CAUTL.

Hitherto this species had not been recorded from the Dutch East Indies.

Hippopotamus spec.

The remains did not allow of determining the species. We were able, however, to show that the Bumiaju form is specifically distinct from the species of DUBOIS's collection viz., *Hippopotamus sivajavanicus* DUB.

The question is: Are these determinations apt to strengthen or to weaken the opinion of an upper pliocene age of the Bumiaju beds? The prevalent opinion is that "*Mastodon*" does not occur in the Pleistocene of Eurasia, whereas it does appear in that of America. This supposition, however, remains to be proved. MATTHEW [2]), namely, in correlating European with American mammal faunas, came to the conclusion that it is either necessary to revise the American succession downward, or the European succession upward. In the latter case "*Mastodon*" should occur, therefore, also in the Pleistocene of Europe. In a quite recent publication OSBORN [3]) does not exclude this possibility either [4]).

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[1]) De Mijningenieur, 11, 1931, p. 200.

[2]) See Bull. Amer. Mus. Nat. Hist., LVI, 1930, p. 439.

[3]) "The Geologic Age of *Pithecanthropus*". Rep. Centenary Meeting Brit. Ass. for the Advancement of Science, London 1931, p. 451. London 1932.

[4]) The correctness of this affirmation may appear from the following quotation: "*Eoanthropus dawsoni* was the companion of *Archidiskodon planifrons* and *Anancus arvernensis*, hence of upper Pliocene or lower Pleistocene age" (l. c. p. 452).

It will be known that PILGRIM [1]) places the Upper Siwaliks in the Pliocene. MATTHEW (l. c.), however, stated as his opinion that he could not find any valid reason for referring the Upper Siwalik fauna to the Pliocene. If, therefore, MATTHEW's assertion should turn out to be correct, "*Mastodon*" [in the form of *Pentalophodon sivalensis* (CAUTL.) [2])] should occur in the Pleistocene of Asia. In the writer's opinion "*Mastodon*" in all probability occurs in the Javan Pleistocene. As already mentioned in the Introduction, in Sangiran a mastodont-like, fragmentary molar has been found by VAN ES in beds, which he regards contemporary with the Trinil beds. Moreover, it was mentioned that a similar grinding tooth had been obtained by DUBOIS from the Trinil beds, but that it might represent in the latter's opinion an atavistical deviation of a *Stegodon* molar. In our opinion, however, this supposition is highly improbable. In what follows it will be seen that some of our determinations give a very strong support in favour of a pleistocene age of the Trinil beds. Consequently "*Mastodon*" in all probability occurs in the Pleistocene of Java [3]).

Turning now to *Stegodon airâwana*, we may be brief. We shall return to that form later on. For the present it will suffice to call to mind that remains of *St. airâwana* are abundant in the Trinil beds, and that VAN ES's researches have shown the Trinil beds to be of younger age than the Bumiaju beds.

As to *Archidiskodon planifrons*, the following remarks may be made. According to PILGRIM (l. c.) this species occurs in the Pinjor horizon (middlemost Upper Siwaliks). In MATTHEW's opinion, therefore, it occurs in the Pleistocene of the Siwalik Hills. It may be added that it is said also to occur in the Narbada deposits, which are generally considered as Lower Pleistocene. It must be borne in mind, however, that our knowledge of the Narbada beds must be called totally insufficient.

Remains to consider *Hippopotamus* spec. According to PILGRIM [4]), *Hippopotamus sivalensis* occurs in the Boulder Conglomerate Zone (uppermost Upper Siwaliks). MATTHEW (l. c.) pointed out that the British Museum specimens of the Upper Siwaliks show two diverse types of fossilization, and that the specimens, which are well fossilized,

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[1]) Rec. Geol. Surv. of India, XLIII, 1913, pl. 26 (table).

[2]) The name of this species is erroneously left out of the faunal list of the Upper Siwaliks, given bij MATTHEW (l. c. p. 443).

[3]) As far as my knowledge goes *Pentalophodon sivalensis* is the only mastodont species which has hitherto been found in the Upper Siwaliks. I cannot see, therefore, how VON KOENIGSWALD (l. c.) came to the assertion that the Bumiaju form resembles certain progressive forms of the Upper Siwaliks so closely, that it is either identical with, or at least closely allied to one of them.

[4]) L. c. p. 324.

may belong to an older horizon, "perhaps Pliocene". As among the specimens of *H. sivalensis* both types of fossilization are represented, there is, therefore, a possibility that this species occurs both in the Pliocene and Pleistocene. *Hippopotamus iravaticus* is, however, an undoubtedly tertiary species. According to PILGRIM [1]) it occurs in the Dhok Pathan Zone (middlemost Middle Siwaliks). PILGRIM places the Middle Siwaliks in the upper Miocene [2]), MATTHEW in the Pliocene. As already pointed out, however, the Bumiaju form is certainly not identical with *H. iravaticus*.

In the Narbada beds *Hippopotamus* is represented by *Hippopotamus* ("*Tetraprotodon*") *palaeindicus*, and *Hippopotamus* ("*Hexaprotodon*") *namadicus*. It will be remembered that we arrived at the conclusion that the Bumiaju form, being hexaprotodont, is certainly distinct from *H. palaeindicus*, but that it shows affinities to *H. namadicus*. It appears, therefore, that neither the *Hippopotamus* remains afford conclusive evidence in favour of an upper pliocene age of the Bumiaju beds. We will return to the problem of their age later on.

Region between Gesi and Ngawi.

(See map n°. 2.)

In this region are situated our localities Pitu, Watualang, and Kedung Kendang. Furthermore the famous locality Trinil. Stratigraphy and tectonic structure are owing to VAN ES well known.

The following determinations are of interest.

Bibos sondaicus (SCHL. et MÜLL.) *fossilis*.

Buffelus bubalus (L.) ?var. *sondaicus* (SCHL. et MÜLL.) *fossilis*.

Hippopotamus spec. (Hinder portion of cranium).

It will be remembered that the mammalian remains of the rich collection, brought together by the Trinil Expedition of Mrs. SELENKA, have been examined by JANENSCH (*Proboscidea*) and STREMME (the rest). It was the latter who drew his conclusions from the determinations, made by either. One of the first conclusions at which STREMME arrived, was: "So sehen wir hier eine Fauna, die recht beträchtlich von der heutigen verschieden ist und *keine mit ihr gemeinsame Art enthält* [3]); von den gut bestimmbaren Arten ist nicht eine mit einer heutigen identisch" [4]). It has

[1]) L. c. p. 285.

[2]) That is to say to the Pontian. By some investigators, among who PILGRIM, the Pontian is referred to the Upper Miocene, by most however, to the Lower Pliocene.

[3]) The italics are ours.

[4]) Die Pithecanthropus-Schichten auf Java, p. 143.

been shown that this assertion is not correct. In our opinion there are no valid reasons for distinguishing the forms, reckoned by STREMME resp. to *Buffelus palaeokerabau* DUB. and to *Rhinoceros sivasondaicus* DUB., from the still living species *Buffelus bubalus* var. *sondaicus*, and *Rhinoceros sondaicus*.

Another conclusion of STREMME was that — though he could not find conclusive evidence either in favour of an upper pliocene age, or of a lower pleistocene age — it could not be denied after comparison of the Trinil fauna with upper pliocene European faunas "..... dasz eine gewisse Wahrscheinlichkeit für das oberpliocäne Alter det Kendeng-Fauna spricht." [1]) In his comparison STREMME made use of a faunal list, given by SCHLOSSER, and containing all the genera of some classic faunas, a.o. those of Val d'Arno. The latter fauna, however, formerly regarded as Pliocene, is considered at the present moment by some of the best modern Italian and French authorities as early Pleistocene [2]).

Be that as it may, we do not doubt that STREMME would have come to a pleistocene age, had he — as we — arrived at the conclusion that the Trinil fauna contains at least three still living species viz., *Bibos sondaicus fossilis*, *Buffelus bubalus* var. *sondaicus fossilis*, and *Rhinoceros sondaicus fossilis*.

Vicinity of Kuwung and Tinggang.

(See map n°. 2.)

Our knowledge of the stratigraphy of the vertebrate bearing layers is very insufficient. Regarding the mammalian remains, there seem to be few reasons to accept another age than for the Trinil beds. It may be emphasized that DUBOIS did not accept a different age.

The following determinations are of interest.

Bibos sondaicus (SCHL. et MÜLL.) *fossilis*.

Buffelus bubalus (L.) ?var. *sondaicus* (SCHL. et MÜLL.) *fossilis*.

Rhinoceros sondaicus DESM. *fossilis*.

Elephas ?maximus L. *fossilis*.

Stegodon airâwana MARTIN.

Stegodon trigonocephalus MARTIN.

Stegodon bondolensis nov. spec.

As to the first three determinations comment will be needless. As already pointed out on p 172, the lower jaw, which we deter-

[1]) L. c. p. 145.

[2]) See MATTHEW, l. c. p. 438.

mined as possibly belonging to the recent *E. maximus*, might perhaps belong to *E. hysudrindicus* DUB., a form, which is said to be intermediate between *E. indicus* (*maximus*) and the Siwalik *E. hysudricus* (Boulder Conglomerate Zone, uppermost Upper Siwaliks). Even if PILGRIM's opinion of the age of the Upper Siwaliks is adopted, we may *E. hysudrindicus* expect only to occur in pleistocene deposits [1]).

Concerning *Stegodon trigonocephalus* we may mention that in the opinion of some this form is specifically indistinct from *St. airâwana*. Though we do not agree with that opinion, we immediately admit that the grinding teeth of both Javan forms show exactly the same height of development.

Since 1914 three different investigators have paid attention to the degree of specialization of the grinding teeth of *St. airâwana*. The first was SOERGEL [2]). He pointed out that in the anterior portion of the teeth of that species the top of the ridge-crests is divided into three by two longitudinal, shallow clefts. As the same phenomenon frequently occurs in *Elephas* teeth, SOERGEL concluded: "In der Dreipfeilerbildung an Proximalende von Stegodontenzähnen haben wir ein fortgeschrittenes, zum speziellen Zahnbau der Gattung *Elephas* überleitendes Merkmal zu erblicken" [3]). SOERGEL pointed out, furthermore, that in the Siwalik stegodonts this feature seems to be absent; consequently they would be older. This difference, together with the greater number of ridge-crests and the thinner enamel, is one of the chief reasons, why SOERGEL regards the Kendeng fauna to be of undoubtedly pleistocene age. The question is, however, not so simple as would appear from the above. From our descriptions and figures of the teeth of *St. airâwana*, it will namely be seen that sometimes the ridge-crests are divided into four, because of the presence of a median, an outer, and an inner constriction. The median constriction indicates the presence of a median, longitudinal cleft. As such a condition is a characteristic of *Mastodon* teeth, its occurrence in *Stegodon* teeth (e. g. those of *St. clifti*) is regarded as a primitive feature. Taken together, we may say that the grinding teeth of *St. airâwana* show in most cases an "*Elephas* character", but in some cases beside it a "*Mastodon* character". Nevertheless it cannot be denied that *St. airâwana* is a progressive species, more specialized than *St. ganesa-insignis*, the species of the Upper Siwaliks, and which

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[1]) The more so, if is added that LYDEKKER already suggested the possibility of a lowermost pleistocene age of the topmost beds of the Siwaliks, and that PILGRIM (l. c. p. 325) refrained from "in the least disputing LYDEKKER's suggestion".

[2]) Palaeontographica, Suppl. IV, Abt. III, Lief. I, 1914.

[3]) L. c. p. 13.

is said also to occur in the Narbada deposits. If therefore — SOERGEL observes — the Narbada stegodont should turn out to be really specifically identical with the form of the Upper Siwaliks, and if indeed should appear that the Narbada deposits are of lower pleistocene age, the Kendeng fauna has to be assigned to the Middle Pleistocene.

The next investigator, who tried to ascertain the age of the Kendeng fauna by the help of the molars of *St. airâwana*, was DIETRICH [1]). His train of thought was as follows. The general progress of the phylogenetic evolution of the dentition of *Stegodon* is: reduction in the region of premolars and (or) milkmolars, addition, i. e. increase of length and of number of ridge-crests, in the region of the molars. Therefore it would be possible to fix in numbers the degree of specialization, if we but disposed of sufficient data to calculate the formula $\frac{\text{length } m^1 \times \text{length } M^3}{\text{length } m^2 \times \text{length } M^2}$ [2]). We lack, however, sufficient data, so that we have to do with the "Längen-Jochzahl-quotient" [3]). After making use of all the measurements available for $M\frac{3}{3}$ — phylogenetic the most active tooth — DIETRICH found the following values:

		M^3	M_3
Stegodon airâwana	(+ *trigonocephalus*)	20	21
„ *insignis*	(+ *ganesa*) . . .	25	27
„ *clifti*	(+ *bombifrons*) . .	29	33

From these values it appears that from *St. clifti* to *St. airâwana* the number of ridge-crests an unit of length increases. But that of course is not new. DIETRICH, however, deduces more from them. He pointed out that according to PILGRIM *St. clifti* and *St. bombifrons* occur in the Dhok Pathan horizon (middlemost Middle Siwaliks) as well as in the Tatrot horizon (lowermost Upper Siwaliks), while *St. ganesa-insignis* occurs in the Boulder Conglomerate Zone (uppermost Upper Siwaliks) and is said to occur in the Narbada deposits. If, therefore, PILGRIM's determination of the age of the various Siwalik horizons is adopted [4]), the difference between the values 33 and 27 (resp. 29 and 25) symbolises a lapse of time, comprising the whole Pliocene. And as the values, which DIETRICH calculated

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[1]) Sitz. ber. Ges. Naturf. Fr. Berlin, 1924, p. 134.

[2]) I cannot see why DIETRICH did not prefer the formula $\frac{\text{length } M^2 \times \text{length } M^3.}{\text{length } m^1 \times \text{length } m^2.}$

[3]) That is to say the relation $\frac{\text{total length.}}{\text{number of ridge-crests.}}$
In our opinion it had been better not to use the quotient, but the product.

[4]) And if the Pontian is reckoned to the Lower Pliocene.

for *St. ganesa-insignis*, are situated almost in the middle between the values found for *St. airâwana* (+ *trigonocephalus*) and *St. clifti* (+ *bombifrons*), he arrived at the conclusion: "Selbst wenn das Entwickelungstempo rascher geworden ist, kommen wir für *Airawana* zu einem sehr viel jüngeren Alter, nämlich zu Jung- bis Jüngstpleistocän" [1]).

We may raise the following objections against DIETRICH's assertions:

1. How little do we know of the movement of evolution!
2. If MATTHEW's views of the age of the various Siwalik horizons are adopted, the difference between DIETRICH's values 33 and 27 (resp. 29 and 25) symbolizes a lapse of time, which reaches at least to the base of the Middle Pleistocene. In that case *St. airâwana* would therefore be still younger than "Jung- bis Jüngstpleistocän".
3. The occurrence of a complex of layers of about 500 m. thickness above deposits, contemporary to the Trinil beds [2]), argues strongly against an upper- to uppermost pleistocene age.

The third author, who has occupied himself — be it indirectly — with the height of development of *St. airâwana*, is OSBORN [3]) (in cooperation with EDWIN H. COLBERT). OSBORN maintains that the grinding teeth of *Elephas* and *Stegodon* can be used as "priceless enamel chronometers" [4]). Therefore it is only necessary to measure very accurately the total enamel length. His method is called ganometric (ganos = enamel). Concerning *Stegodon* grinders the following — roughly estimated — values are mentioned:

Stegodon airâwana, Middle Pleistocene, M^2, 510 mm.

„ *bombifrons*, Lower Pliocene, M^2, 410 „ .

For the present these values do not mean much. It was already long known to us that the enamel of *St. bombifrons* is less plicated than of *St. airâwana*. The difference of 100 mm. has no signification, so long we do not dispose of the value found for the corresponding molar of a species as *St. ganesa-insignis*. And even if we did know, OSBORN will have to prove the correctness of his assertion that the total enamel length can be used as a chronometer.

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[1]) L. c. p. 139.

[2]) See the Introduction.

[3]) Proc. Amer. Philos. Soc., LXX, 1931, p. 187. See also OSBORN's two papers in the Rep. of the Cent. Meeting Br. Ass. London 1931.

[4]) Rep. of the Cent. Meeting Br. Ass. London 1931, 1932, p. 452.

Unfortunately enough in OSBORN's provisional publications on the present subject the technique of the ganometric method is not dealt with. Has use been made of grinders with a certain degree of wear, and has the total length of all the plications been measured at the grinding-surface? Or has in one way or another the height of the various ridge-crests been included? Apparently it has. COLBERT, namely, pointed out: "The measurements thus far assembled are all rough and preliminary; out of the thirty-six teeth studied, only two were unworn; consequently there are large estimated factors in most of the measurements" [1]).

It remains with us to consider *St. bondolensis* nov. spec. On p. 158 it will be seen that this form has been obtained from Bondol near Kuwung, a locality from which also remains of *Buffelus bubalus* ?var. *sondaicus fossilis* and *Rhinoceros sondaicus fossilis* have been procured. This is surprising, as *St. bondolensis* is a rather primitive species, the height of development of which is equal to that of *St. bombifrons*. It will be remembered that the youngest Siwalik horizon in which the latter species occurs, is the Tatrot horizon (lowermost Upper Siwaliks, Lower Pliocene according to PILGRIM, Lower Pleistocene according to MATTHEW). If MATTHEW's views should appear to be correct, the occurrence of *St. bondolensis* together with still living species, would be comprehensible. On the other hand it must not be forgotten that the stratigraphy of the locality mentioned is very badly known. There remains, therefore, a possibility that *St. bondolensis* has been obtained from older strata. Nevertheless the problem remains that the grinders of all the *Stegodon* species, hitherto found in Java, are characterized by enamel, clearly consisting of two layers. Consequently "Stufenbildung" occurs. Why the latter feature is distinctly exhibited only in the teeth of the Javan species is an enigma to me.

To return now to our starting point, we may say that there are several indications, which point in the direction of an older age of the Bumiaju fauna compared with the Trinil fauna [2]) viz.,

1. The Bumiaju fauna does not contain recent forms; the Trinil fauna does.
2. In the Bumiaju beds a very primitive species of *Elephas* (*A. planifrons*) has been found; in the Trinil beds it is absent.

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[1]) Proc. Amer. Philos. Soc., LXX, 1931, p. 191.

[2]) With Trinil fauna I mean the fauna of the Trinil beds between Gesi and Ngawi.

3. The Bumiaju specimens are always well fossilized; in the Trinil specimens the state of fossilization is in some cases far less progressed.

4. The Bumiaju beds are considerably more folded than the Trinil beds.

Stress may be laid upon the fact that each argument alone has but little value. But all together they afford in our opinion strong evidence in favour of an older age of the Bumiaju beds.

It will be noticed that we arrive at the same conclusion to which VAN ES came on geological-stratigraphical grounds [1]). The question is: Do we agree with VAN ES as to the lower pleistocene age of the Trinil beds, and the upper pliocene age of the Bumiaju beds? As already pointed out in the Introduction, VAN ES started from a supposition which lacks sufficient grounds. Nevertheless his assertion may be true. The occurrence of recent species among the Trinil fauna proves in our opinion its pleistocene age. It may therefore be Lower Pleistocene. And in that case the Bumiaju beds have to be placed into the Upper Pliocene. As far as our knowledge goes for the present, the mammalian contents of the latter do not prove it, but neither do they afford sufficient evidence against such a supposition.

We cannot conclude without drawing attention to the following possibility. In a quite recent paper MARTIN [2]) has pointed out that the descriptions of tertiary molluscs from Burma and N. W. India by VREDENBURG and DE COTTER have shown that in these regions tertiary strata occur, which contain both Javan and European species. The discovery is of course of great interest for the correlation of tertiary beds in Europe and Asia. A. o. it enabled MARTIN to emphasize the pliocene age of the marine Sonde beds. He did not let on, however, about the question to which part of the Pliocene the Sonde beds belong. Apparently there is a possibility that the Sonde beds represent (or include) the Upper Pliocene. In that case the Trinil beds — being separated by a stratigraphic gap from the underlying Sonde beds — would belong to the Middle Pleistocene, and the Bumiaju beds — which according to VAN ES are contemporary to the hiatus in Trinil — should be of lower pleistocene age. In my opinion neither the mammalian fauna of the Trinil beds, nor of the Bumiaju layers give sufficient arguments against this supposition.

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[1]) See the Introduction.

[2]) Leidsche Geol. Meded., IV, 1, 1931.

SUMMARY.

1. The Bumiaju fauna is older than the Trinil fauna.

2. The Trinil fauna is certainly of pleistocene age, more particularly either Lower of Middle Pleistocene, but not Upper Pleistocene.

3. Accordingly the Bumiaju fauna is of upper pliocene or lower pleistocene age.

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PLATE I.

Buffelus bubalus (L.) ?var. *sondaicus* (SCHL. et MÜLL.) *fossilis*.

Fig. 1. Occipital view of fragmentary cranium n°. 1*.0.27 nat. size. p. 25.

Fig. 2. Right profile view of ditto, after removal of the right (detached) horn-core. 0.30 nat.size. p. 25.

Fig. 3. Occipital view of fragmentary cranium n°. 8*. 0.10 nat. size. p. 25.

Fig. 4. Front view of ditto. 0.09 nat. size. p. 25.



* See table of measurements B.

PLATE II.

Bibos sondaicus (SCHL. et MÜLL.) *fossilis*.

Fig. 1. Palatal view of "one-horned" ♂ cranium. 0.14 nat. size. p. 42.
Fig. 2. Front view of ditto. 0.16 nat. size. p. 42.
Fig. 3. Right P^2—M^3 of ditto, viewed from the grinding surface. 0.46 nat. size. p. 42.
Fig. 4. Occipital view of ditto. 0.17 nat. size. p. 42.
Fig. 5. Right profile view of ditto. 0.17 nat. size. p. 42.



PLATE III.

Bibos sondaicus (SCHL. et MÜLL.) *fossilis*.

Fig. 1. Front view of "two-horned" ♂ cranium. 0.15 nat. size. p. 42.
Fig. 2. Right profile view of ditto. 0.16 nat. size. p. 42.
Fig. 3. Occipital view of ditto. 0.16 nat. size. p. 42.
Fig. 4. Hind view of left detached horn-core of old ♂. 0.24 nat. size. p. 42.



PLATE IV.

Rhinoceros sondaicus DESM. *fossilis.*

Fig. 1. Front view of cranium no. a. *
Fig. 2. Left profile view of ditto.
Fig. 3. Palatal view of ditto.

} 0.21 nat. size. p. 58. (Occipital view in fig. 1, pl. V).

* See table of measurements K.

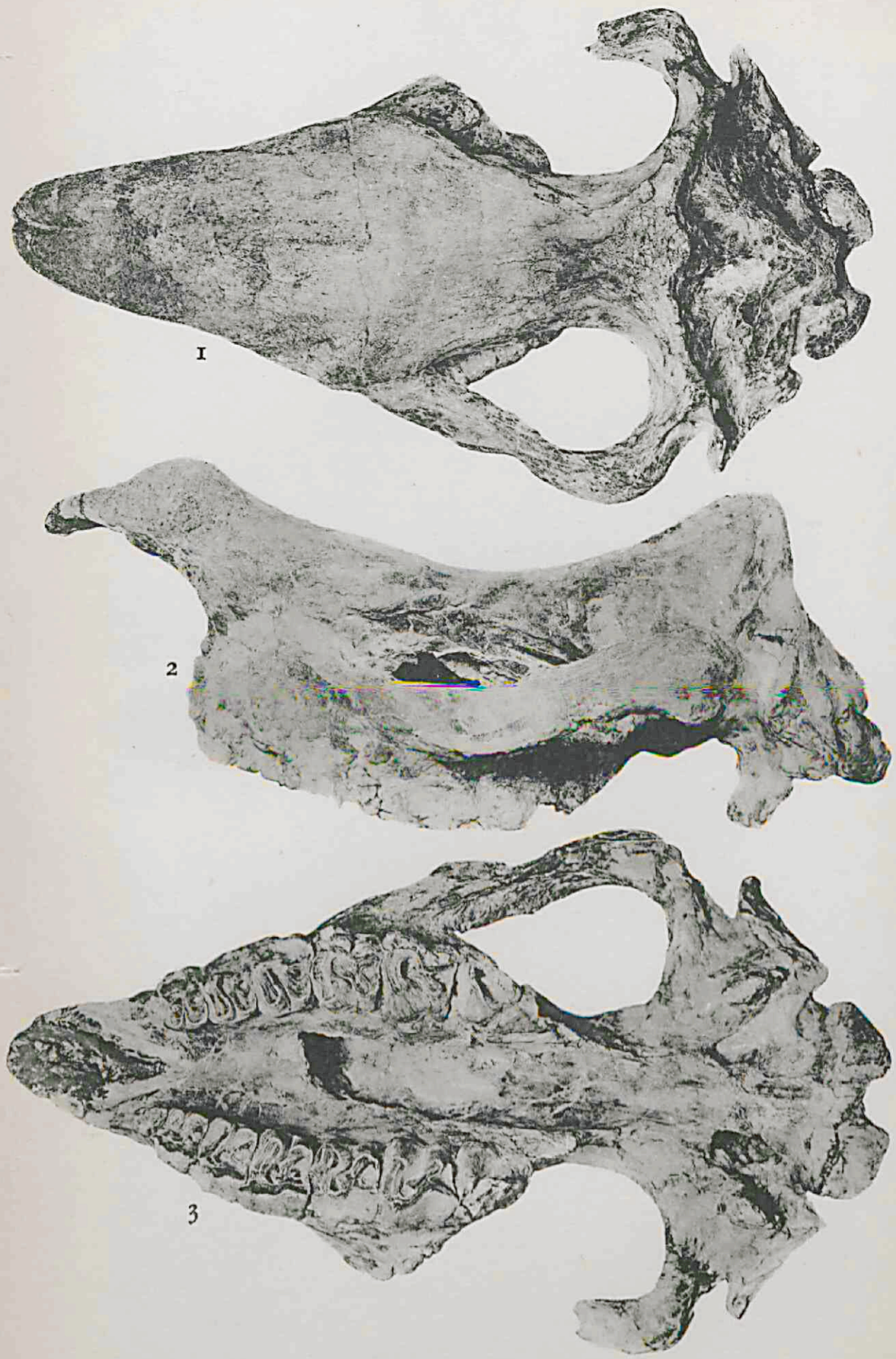

PLATE V.

Rhinoceros sondaicus DESM. *fossilis.*

Fig. 1. Occipital view of cranium no. a. * 0.23 nat. size. p. 58. (The same specimen as of figs. 1—3, pl. IV).

Fig. 2. Outer view of right P^4 of ditto. 0.95 nat. size. p. 61.

Fig. 3. Right P^1—M^3 of ditto, viewed from the grinding surface. 0.60 nat. size. p. 59.

Fig. 4. Reflected image of the inner view of the same tooth row. 0.52 nat. size. p. 59.

Hippopotamus spec.

Fig. 5. Outer view of right detached lower canine (specimen a). 0.50 nat. size. p. 88.

* See table of measurements K.

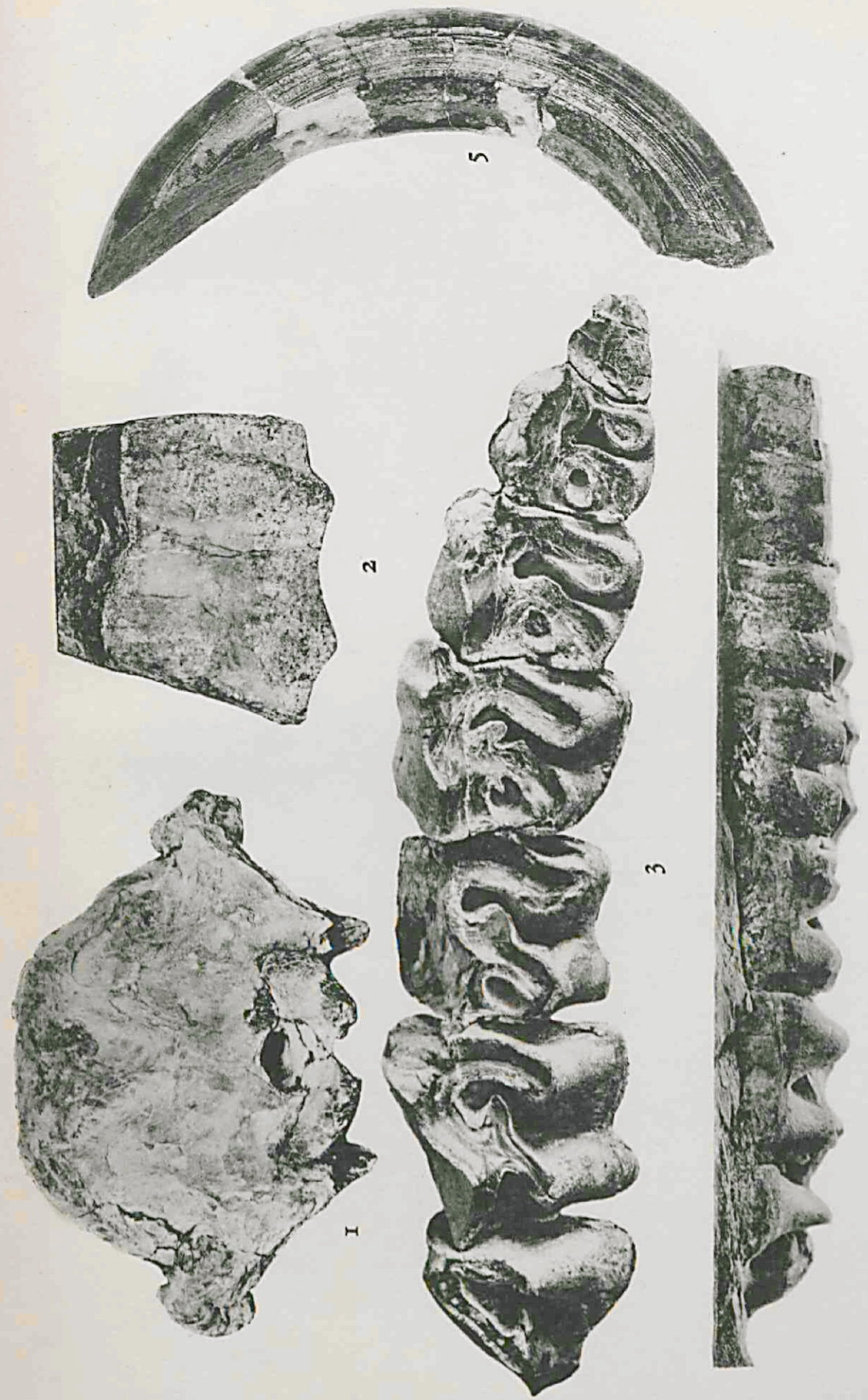

PLATE VI.

Hippopotamus spec.

Fig. 1. Upper view of right horizontal mandibular ramus. 0.51 nat. size. p. 82. (Right profile view in fig. 1, pl. XIX).

Fig. 2. Anterior view of symphysial extremity of ditto. 0.50 nat. size. p. 82.

Fig. 3. Palatal view of fragmentary right upper jaw with M^1—M^3. 0.65 nat. size. p. 87.

Fig. 4. Outer view of ditto. 0.65 nat. size. p. 87.



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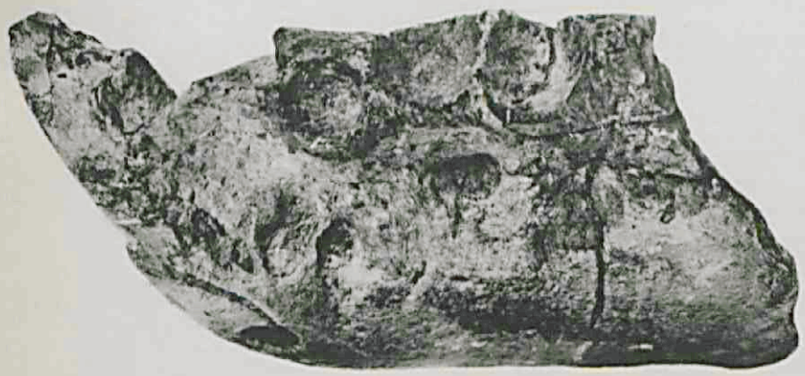

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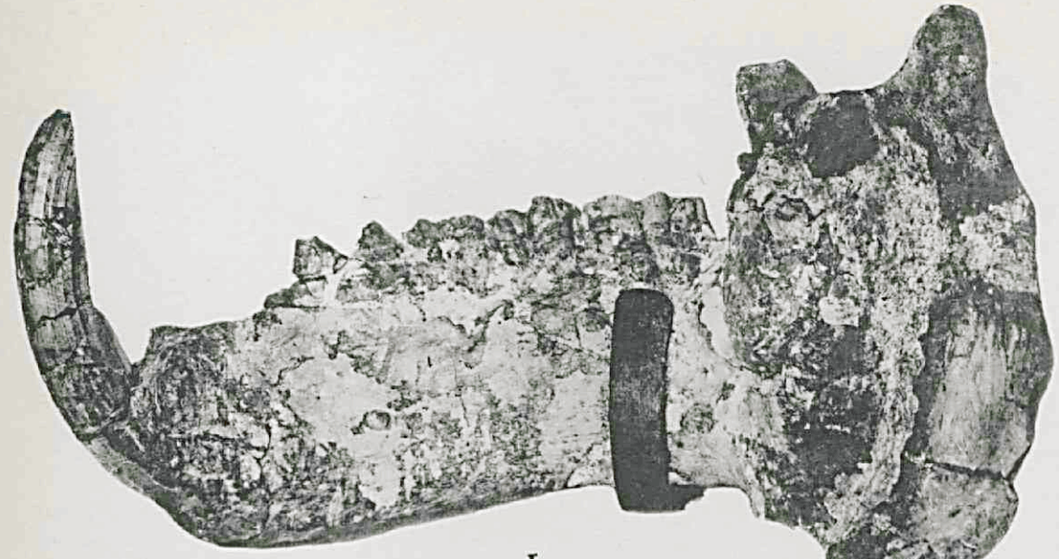
PLATE VII.

Hippopotamus spec.

Fig. 1. Left profile view of fragmentary lower jaw. 0.24 nat. size. p. 82.

Fig. 2. Upper view of ditto. 0.31 nat. size. p. 82. (Anterior view in fig. 2, pl. XIX).



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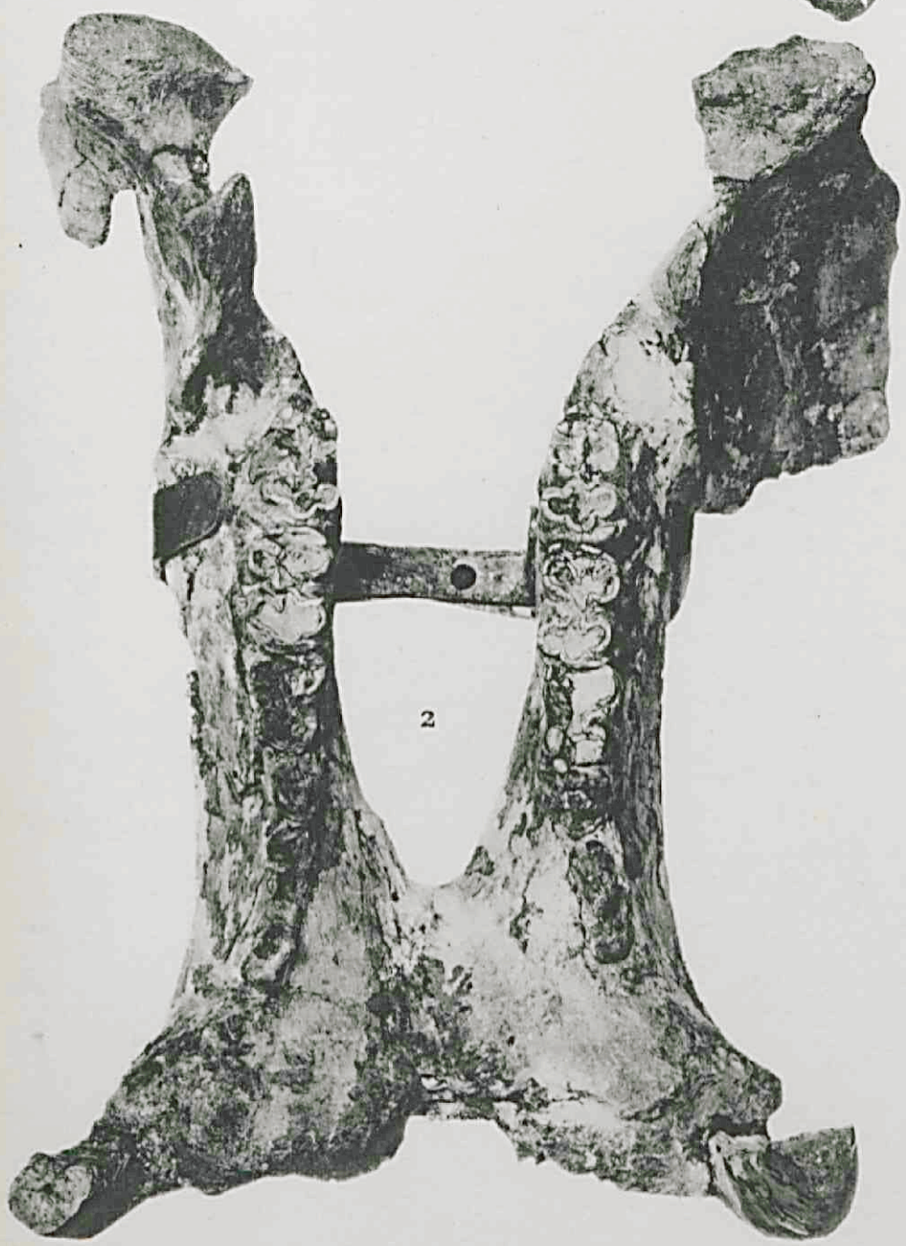

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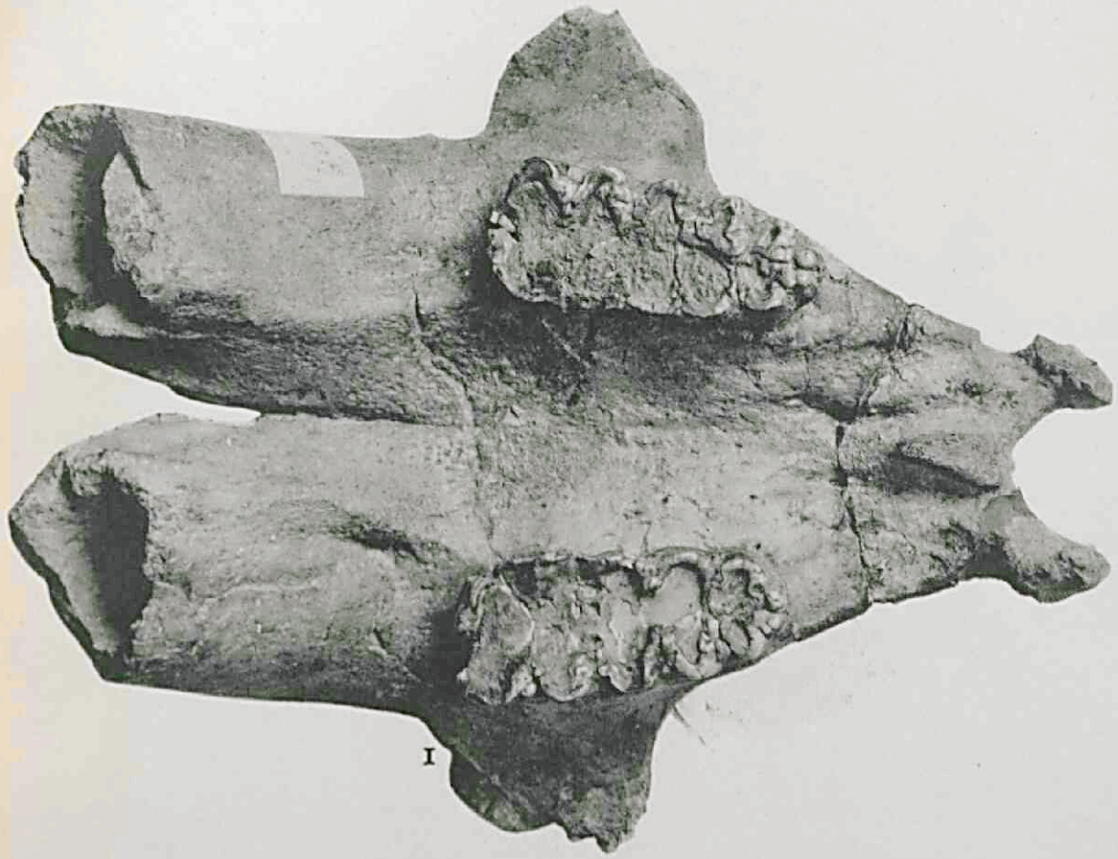
PLATE VIII.

Tetralophodon bumiajuensis nov. spec.

Fig. 1. Palatal view of fragment of cranium with l. and r. M^3 in situ. 0.22 nat. size. p. 116. (Left profile view in fig. 2, pl. X).

Fig. 2. Inner view of fragmentary right mandibular ramus with M_3. 0.29 nat. size. p. 108.



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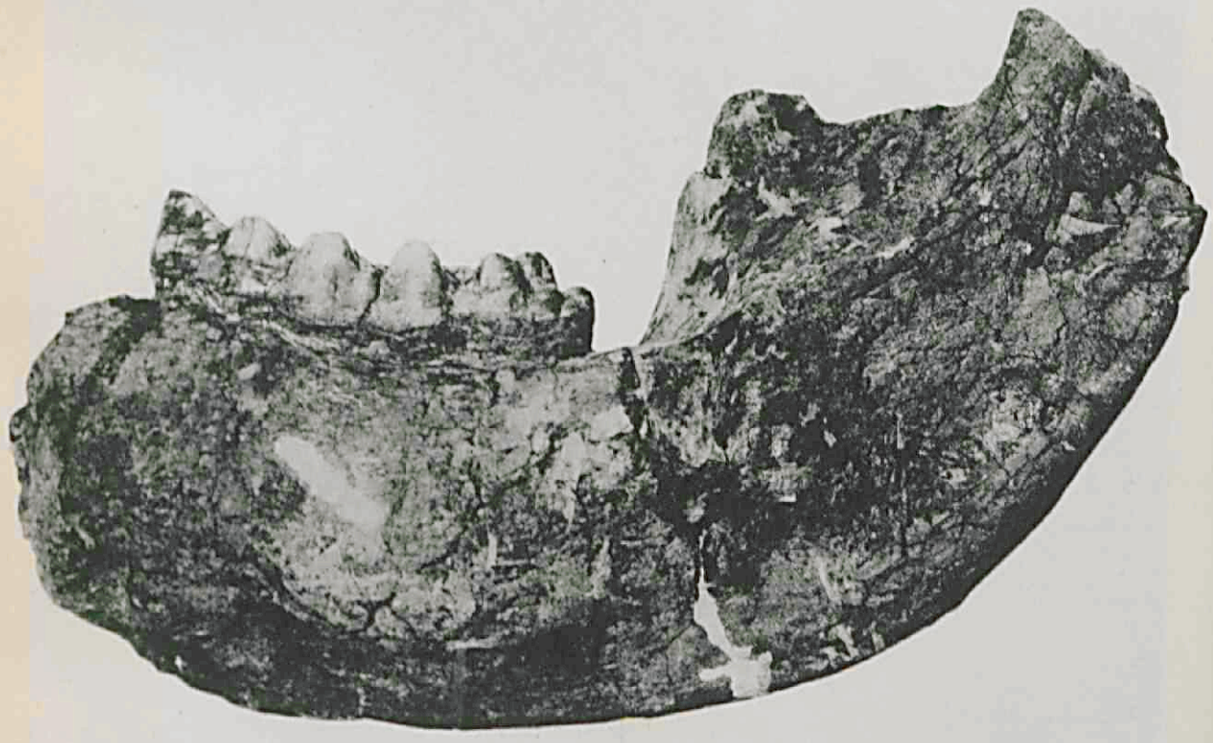

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PLATE IX.

Tetralophodon bumiajuensis nov. spec.

Fig. 1. Fragmentary r. M^3, viewed from the grinding surface. 0.81. nat. size. p. 113.

Fig. 2. Outer view of ditto. 0.88 nat. size. p. 113.

Fig. 3. Right M_3 (of ramus portrayed in fig. 2 of pl. VIII), viewed from the grinding surface. 0.53 nat. size. p. 108.



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2



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PLATE X.

Tetralophodon bumiajuensis nov. spec.

Fig. 1. Detached upper incisive tusk. 0.17 nat. size. p. 120. In all probability belonging to the specimen portrayed in fig. 1, pl. VIII and fig. 2, pl. X.

Fig. 2. Left profile view of fragment of cranium. 0.30 nat. size. p. 116 (palatal view in fig. 1, pl. VIII).

Fig. 3. Left M^3 (of cranium portrayed in fig. 1, pl. VIII and fig. 2, pl. X), viewed from the grinding surface. 0.78 nat. size. p. 117.



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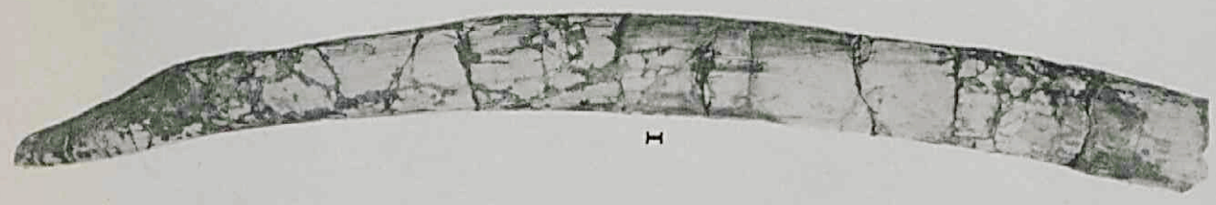

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PLATE XI.

Stegodon trigonocephalus MARTIN.

Fig. 1. Damaged mature cranium with r. M^3 in situ, viewed from the upper and partly from the outer side. 0.14 nat. size. p. 151.

Fig. 2. Right profile view of ditto. 0.14 nat. size. p. 151.



2



1

PLATE XII.

Stegodon airâwana MARTIN.

Fig. 1. Left M_3 and posterior extremity of M_2 (of lower jaw portrayed in figs. 2—3, pl. XIV), viewed from the grinding surface. 0.55 nat. size. p. 141.

Stegodon trigonocephalus MARTIN.

Fig. 2. Right M^3 (of cranium portrayed in figs. 1—2, pl. XI), viewed from the grinding surface. 0.63 nat. size. p. 151.

Fig. 3. Outer view of ditto. 0.46 nat. size. p. 151.

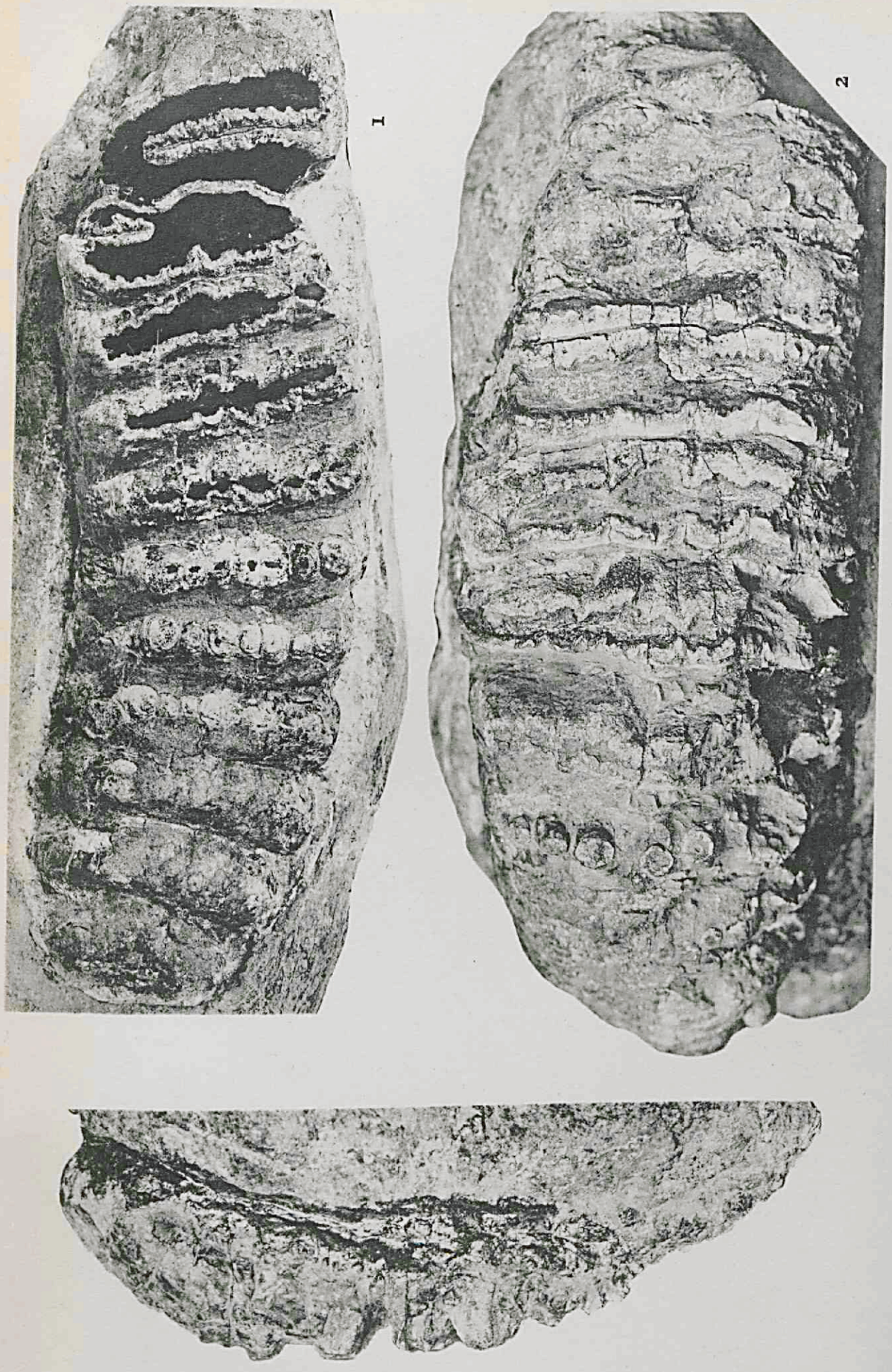


PLATE XIII.

Stegodon airâvana MARTIN.

Fig. 1. Left M^3, viewed from the grinding surface. 0.64 nat. size. p. 142.

Fig. 2. Inner view of ditto. 0.51 nat. size. p. 136.

Stegodon spec.

Figs. 3 and 5. Fragments of (probably) upper grinding teeth, vertically and longitudinally bisected. 0.56 nat. size. p. 164.

Fig. 4. Fragment of grinding tooth, horizontally bisected. 0.56 nat. size. p. 164.

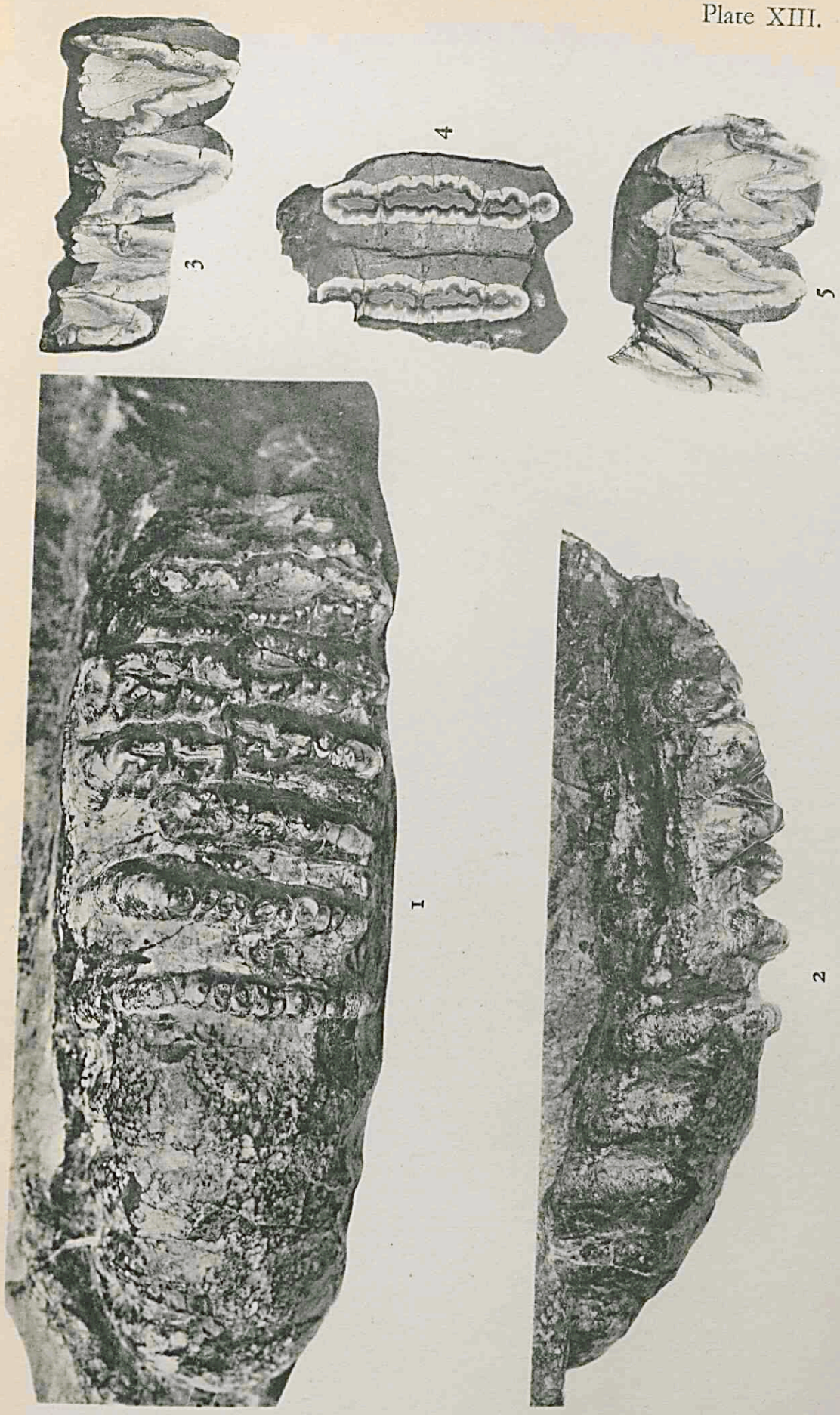


PLATE XIV.

Stegodon bondolensis nov. spec.

Fig. 1. Left M_3 (of lower jaw portrayed in figs. 4—5, pl. XIV), viewed from the grinding surface. 0.63 nat. size. p. 159.

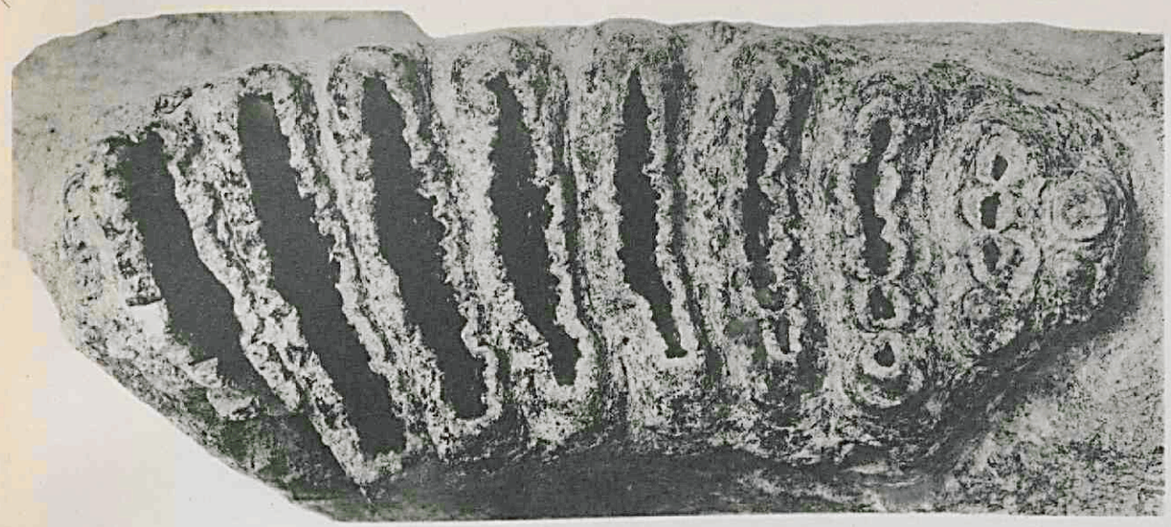
Fig. 4. Upper view of fragmentary lower jaw with l. and r. M_3 in situ. 0.15 nat. size. p. 158.

Fig. 5. Right profile view of ditto. 0.15 nat. size. p. 164.

Stegodon airâwana MARTIN.

Fig. 2. Upper view of fragmentary lower jaw with l. and r. M_3 in situ. 0.10 nat. size. p. 141.

Fig. 3. Left profile view of ditto. 0.10 nat. size. p. 141.



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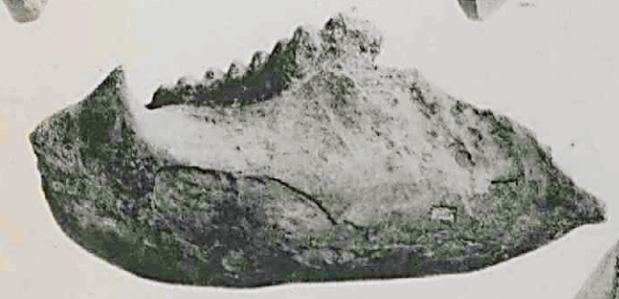

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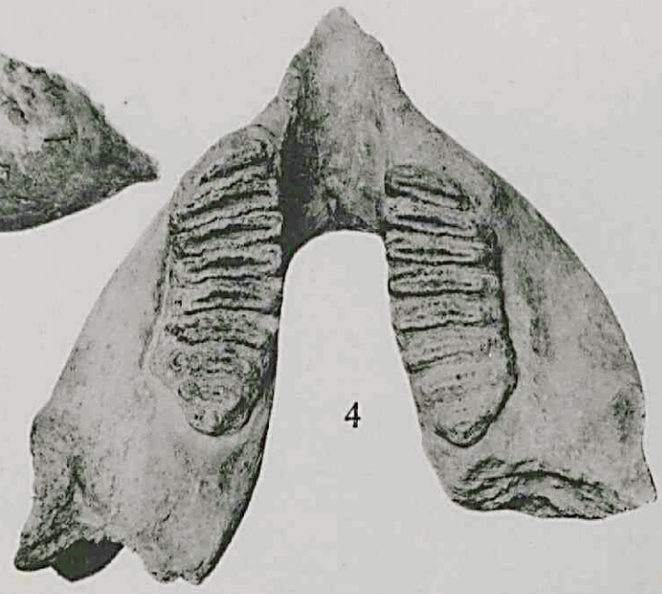

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PLATE XV.

Stegodon airâwana MARTIN.

Fig. 1. Left detached M^3, viewed from the grinding surface. 0.50 nat. size. p. 132.

Fig. 2. Inner view of ditto. 0.52 nat. size. p. 132.

Fig. 3. Outer view of right detached M_1. 0.68 nat. size. p. 138.

Fig. 4. The same specimen, viewed from the grinding surface. 0.70 nat. size. p. 138.

? *Archidiskodon planifrons* FALC. et CAUTL.

Fig. 5. Left lower grinding tooth, probably m_3, viewed from the grinding surface. 0.51 nat. size. p. 176.

Fig. 6. Inner view of ditto in fragment of left horizontal mandibular ramus. 0.47 nat. size. p. 176.

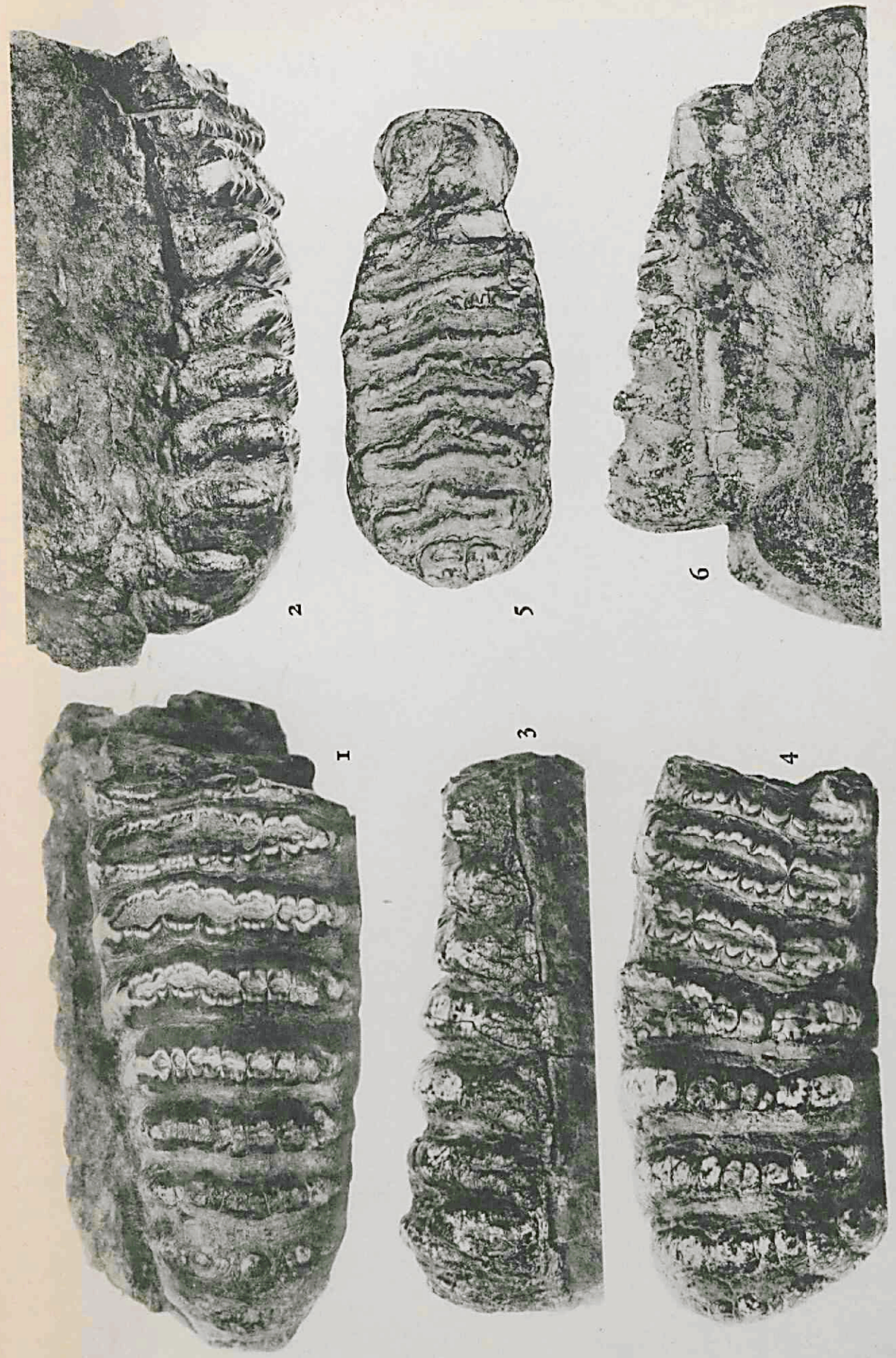


PLATE XVI.

Elephas ? maximus L. *fossilis.*

Fig. 1. Left M_3 (of lower jaw portrayed in figs. 2—3, pl. XVI), viewed from the grinding surface. 0.48 nat. size. p. 169.

Fig. 2. Upper view of fragmentary lower jaw with l. and r. M_3 in situ. 0.15 nat. size. p. 168.

Fig. 3. Left profile view of ditto. 0.12 nat. size. p. 168.

? Tetralophodon bumiajuensis nov. spec.

Fig. 4. Proximal surface of articulation of ulna no. 1 * and radius no. 2 *. 0.14 nat. size. p. 188.

Fig. 5. Distal surface of articulation of the same specimens. 0.13 nat. size. p. 188.

Fig. 6. The same specimens viewed from the inner side. 0.10 nat. size. p. 188.

Fig. 7. The same specimens viewed from the front side. 0.10 nat. size. p. 188.

* See tables of measurements Y and Z.



PLATE XVII.

Elephas planifrons FALC. et CAUTL.

Fig. 1. Detached left M^1, viewed from the grinding surface. 0.77 nat. size. p. 173.

Fig. 2. Outer view of ditto. 0.65 nat. size. p. 173.

? *Tetralophodon humiajuensis* nov. spec.

Fig. 3. Fragmentary pelvis. 0.13 nat. size. p. 189.

Fig. 4. Left femur (no. 2 *), hind view. 0.11 nat. size. p. 186.

?? *Mastodon* spec.

Fig. 5. Right femur (no. 4*), inner view. 0.12 nat. size. p. 187.

Fig. 6. Front view of ditto. 0.12 nat. size. p. 187.

Fig. 7. Hind view of ditto. 0.11 nat. size. p. 187.

* See table of measurements W.

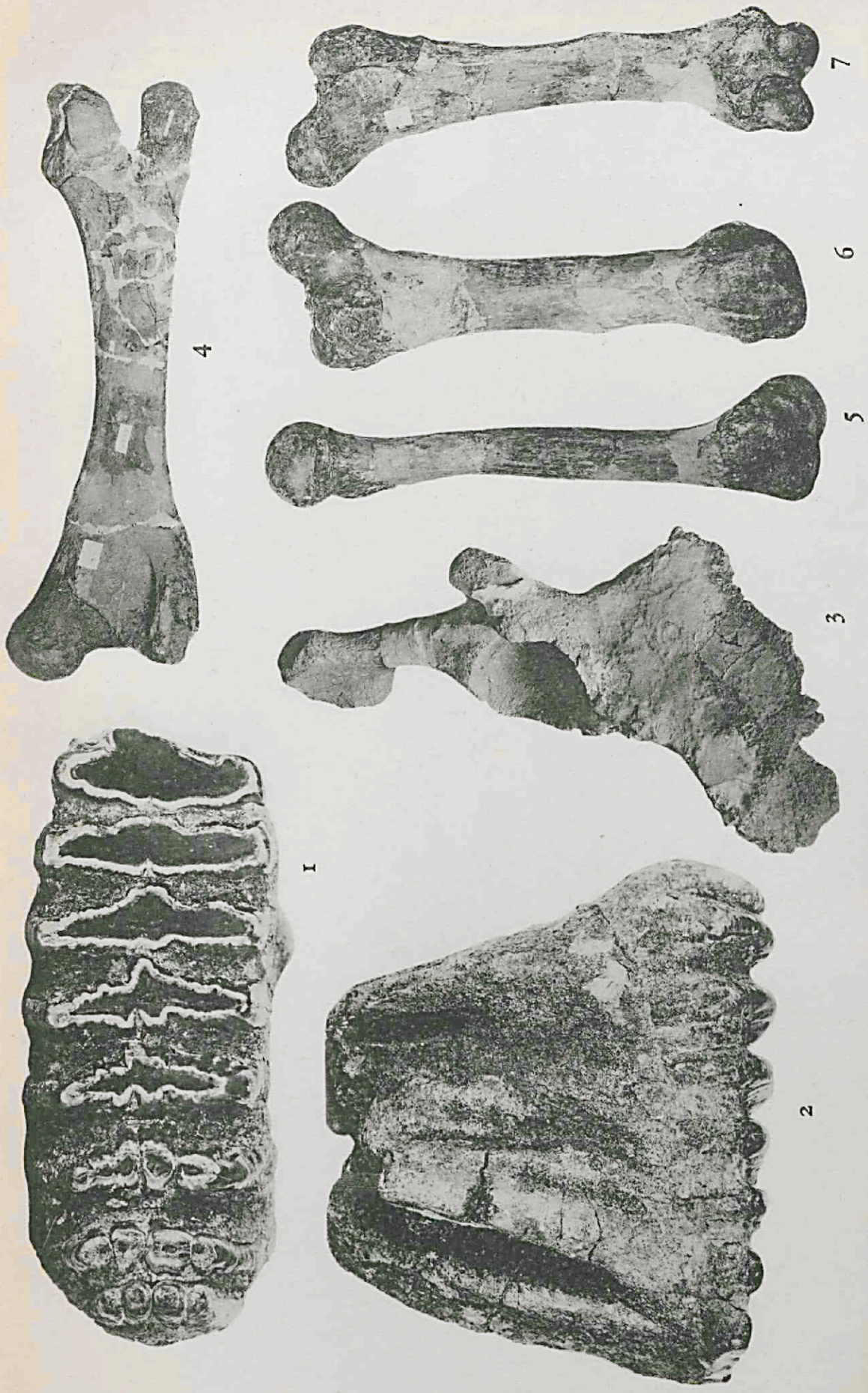


PLATE XVIII.

Hippopotamus spec.

Fig. 1. Right profile view of posterior portion of cranium. 0.48 nat. size. p. 89.

Fig. 2. Upper view of ditto. 0.45 nat. size. p. 89. (Hind view in fig. 3, pl. XIX).

Fig. 3. Detached lower incisor, probably belonging to the mandible, portrayed in figs. 1—2, pl. VII. 0.69 nat. size. p. 85.



PLATE XIX.

Hippopotamus spec.

Fig. 1. Right profile view of fragmentary lower mandibular ramus. 0.41 nat. size. p. 82. Same specimen as of figs. 1—2, pl. VI.

Fig. 2. Anterior view of right half of symphysial extremity of the specimen, portrayed in figs. 1—2, pl. VII. 0.50 nat. size. p. 84.

Fig. 3. Hind view of posterior portion of cranium. 0.47 nat. size. p. 89. Same specimen as of figs. 1—2, pl. XVIII.



PLATE XX.

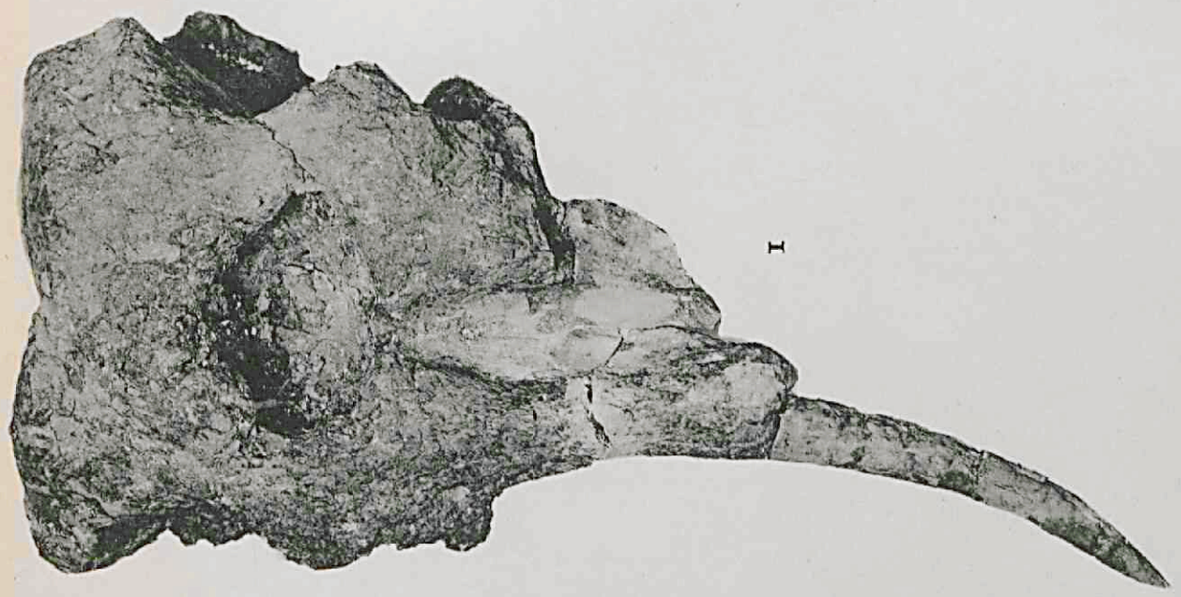
Stegodon airâwana MARTIN.

Fig. 1. Front view of damaged immature cranium. 0.13 nat. size. p. 146.

Hippopotamus spec.

Fig. 2. Upper view of fragmentary lower jaw. 0.42 nat. size. p. 86.





STELLINGEN.

I.

Hippopotamus constrictus MILLER 1910 is stellig identiek met *Hippopotamus amphibius* L. Afgezien van *Choeropsis liberiensis* MORT. zijn er dus niet drie recente nijlpaardensoorten bekend — zooals algemeen wordt aangenomen — maar hoogstens twee.

II.

De terminologie der componenten van molaren en premolaren, opgesteld door OSBORN en SCOTT op grond van de trituberculair theorie, bevat onvolledigheden en inconsequenties.

III.

De karbouwen, welke thans in het wild in het uiterste ZW. en ZO. van Java worden aangetroffen, behoeven niet uitsluitend af te stammen van verwilderde exemplaren.

IV.

Bij de beoordeeling van de vraag of een fossiele vorm al of niet identiek is met een recente, rust op elk onderzoeker de verplichting zich moeite te geven zijn fossiele exemplaren te vergelijken met een zoo groot mogelijk aantal recente van ongeveer gelijke ouderdom.

V.

Het pisiforme is homodynaam met het calcaneum.

VI.

Aan de hand van Stegocephalen en Amphibiën ontbreekt niet — zooals ABEL meent — de eerste vinger, maar de vijfde.

VII.

JAEKEL is er niet in geslaagd een aannemelijke verklaring te geven voor het achterwaarts gerichte pubis van het vogelbekken.

VIII.

SOERGEL's reconstructie van *Chirotherium* is het resultaat van groote scherpzinnigheid en streng logische redeneering.

IX.

Wat betreft de beteekenis der begrippen „diabaas" en „doleriet" bestaat er groote verwarring.

X.

Het albitisatie-proces doet ons een verklaring aan de hand voor de genese van sommige alkali-gesteenten.

XI.

Ook in woestijngebieden moet aan chemische verweering een rol van beteekenis worden toegekend.

XII.

Door VON KOENIGSWALD's mededeelingen in „De Mijningenieur" van November 1931 komt de vraag over het al of niet voorkomen van Devoon op Celebes in een nieuw licht te staan.

XIII.

WEGENER's hypothese der continent-verschuivingen ondervindt een belangrijke steun door het feit, dat een ter zake kundig geoloog (DU TOIT) met klem gewezen heeft op de groote geologische overeenstemming, welke bestaat tusschen de O.kust van Z.-Amerika en de W.kust van Afrika.

XIV.

VOLZ' argumentatie van de pleistocene ouderdom der Trinillagen is ten eenen male onvoldoende.