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COMMENTS AND REPLY ON

THE FAUNA FROM TRINIL, TYPE LOCALITY OF HOMO ERECTUS: A REINTERPRETATION

COMMENT I: The vertebrate-bearing deposits of Kedungbrubus and Trinil, Java, Indonesia

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INTRODUCTION

In a previous issue of Geologie en Mijnbouw it is proposed by DE VOS ET AL. (1982) that the classic Pleistocene vertebrate stratigraphy of the island of Java (Jetis, Trinil, Ngandong), as established by VON KOENIGSWALD (1939; 1940; 1956b), is incorrect, and that the so-called Jetis fauna is in fact younger than the Trinil fauna. The evidence for this view is based on the collection of fossil vertebrates that was made by DUBOIS (1890; 1891a,b,c; 1892a,b; 1894) at the end of the last century at Kedungbrubus and Trini on Java.

However, on stratigraphic grounds the view held by DE VOS ET AL. (1982) is untenable. VON KOENIGSWALD's (o.c.) vertebrate stratigraphy is essentially correct. The fossil collection gathered bij DUBOIS (o.c.) at Kedungsbrubus is indisputably older than the fossil collection from Trinil.

KEDUNGBRUBUS

Kedungbrubus is a small village on the southern slope of the Kendeng ridge in Central Java (see Fig. 1). As a locality of fossil vertebrates it was renowned already in the last century. The bones that were found by farmers in their fields, after the heavy rains of the wet monsoon, were in their eyes the remains of giants that had fallen in the great battle of the Mahabharata. From further away other people too, took an interest in this mythical battlefield, and actually dug in search of the bones, such as the erudite Javanese painter Raden Saleh. But the fame of Kedungbrubus was established for good when on November 24th, 1890, E. DUBOIS found a fragment of a lower jaw that he later attributed to his *Pithecanthropus erectus* (nowadays designated as: *Homo erectus erectus)*.

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Around Kedungbrubus one finds the greatest extent of the fossil vertebrate-bearing tuff deposits of Central Java. The term tuff in this connection must be understood as a collective term, for the fossils occur not only in deposits of volcanic tephra but also in redeposited tuffaceous claystones, sandstones and conglomerates. All these (terrestrial) deposits lie in an extensive series of sediments tens of metres thick, on top of the limestones and marls that form the (marine) core of the Kendeng ridge. Around Kedungbrubus one also finds the highest tuff deposits, namely near the Gunung Butak, a hill situated four kilometres to the north of the village, of which the summit is 400 m above sea level (see Fig. 2).

When in 1890 DUBOIS and his helpers arrived in Kedungbrubus, at first they did nothing else except pick up fossils from the surface in the fields around the village. Collecting ('verzamelen') and searching ('afzoeken') are recorded by

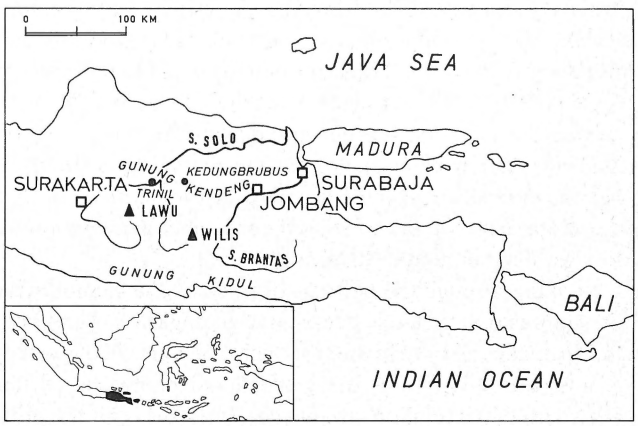

Fig. 1
Map of Central and East Java showing the locations of Kedungbrubus and Trinil (black dots); the Solo and Brantas rivers, S. Solo and S. Brantas respectively; the Lawu and Wilis volcanoes (black triangles). 'Gunung Kidul' means 'southern mountains'; 'Gunung Kendeng' refers to the Kendeng hills.

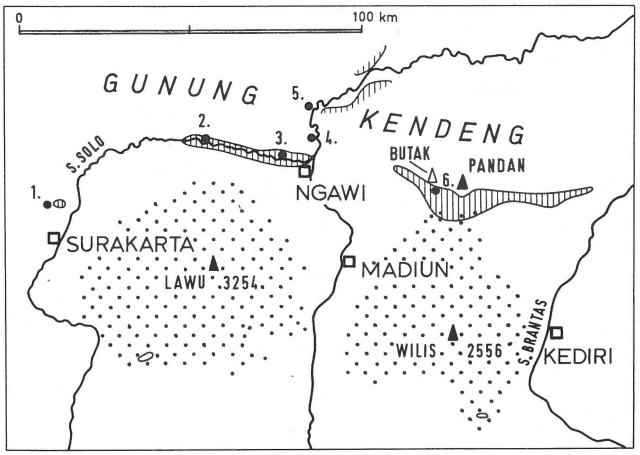

Fig. 2.
Map showing the distribution of fossiliferous tuffaceous sands and gravels along the northern and southern fringe of the Kendeng ridge in Java (vertical hatching; partly after Dubois, 1908). The black dots indicate: 1= Sangiran; 2= Sambungmacan; 3= Trinil; 4= Ngandong; 5= Cepu; 6= Kedungbrubus. The stippled areas indicate the extent of the volcanic structures of the Lawu and the Wilis; the black triangles indicate their summits. A black triangle also indicates the extinct Pandan volcano; an open triangle signifies the Gunung Butak. Between the towns of Ngawi and Cepu the Solo river transverses the Kendeng ridge; this is the Solo transverse valley ('Solodurchbruchstal').

DUBOIS in his first reports (1891a: p.13; 1891c: p.12; 1892a: p.15). Furthermore his reconnaissance expeditions were not restricted to just the immediate surroundings of Kedungbrubus, but also extended in the direction of the above-mentioned Gunung Butak. DUBOIS noted that the fossils can actually only be gathered with some success in those places where the 'bedrock' (the frequently cemented terrestrial clastics) has been exposed by weathering (1890: p.19). So it was that at these outcrops he began excavations in 1893.

All the fossil remains that were picked up and excavated by DUBOIS, those from the immediate surroundings of Kedungbrubus as well as those from the direction of the Gunung Butak, are ascribed by him to the same fauna, the so-called Kendeng fauna. This fauna he initially regarded as Pleistocene (1891b: p.16), later as Pliocene (1908: p.1270). But despite the fact that he thus equates all the fossils, DUBOIS indicates that from a geological viewpoint the vertebrate-bearing deposits near the Gunung Butak must be older than the strata that crop out close to the village of Kedungbrubus, four km further south (1894: p.11).

Looking through the writings of DUBOIS, one cannot avoid the impression that the occasional geological observations that he makes all have in them a touch of genius: all of them go against the opinions of the professional geologists of that time, and they are all invariably correct. This is all the more remarkable when one realizes that in the fields of geology DUBOIS was in fact a layman. But it was he who, for example, first fully realized the fluviatile nature of the vertebrate-bearing deposits along the Kendeng. It was also DUBOIS who called the highest tuff deposits still fluviatile, for example those around the Gunung Butak, thus suggesting folding of that region after the deposition of the tuffs – and that at a time when nobody believed in folding or tilting of Quaternary strata on Java. DUBOIS' observation that the tuff outcrops at Gunung Butak have older layers than the surface outcrops at Kedungbrubus is also correct. This was first confirmed by the fieldwork of the mining engineer VAN ES, at the end of the nineteen twenties.

VAN ES, a member of the Geological Survey of the former Dutch East Indies, wanted to find *Pithecanthropus*. Unfortunately he did not succeed, but his search did result in a thorough study of the Neogene and Pleistocene strata on Java (VAN ES 1931). As a consequence of DUBOIS' finds of hominid remains at Trinil and Kedungbrubus, almost forty years earlier, VAN ES had a special interest in the southern fringe of the Kendeng, and he drew numerous geological cross-sections of that region. One of these sections runs from the small village of Notopuro past Kedungbrubus, to the Gunung Butak (Fig. 3). Here we see DUBOIS' observations confirmed: a massive, southward dipping complex of terrestrial clastics on the top of the marine core of the Kendeng; with two principal sites of fossil vertebrate remains, one near the Gunung Butak and one near Kedungbrubus, the strata at the former site being the oldest.

The crucial question is: how much older are the outcrops at the Gunung Butak compared to those of Kedungbrubus? From the fact that DUBOIS ascribed the vertebrate fossils from both localities to one and the same (Kendeng) fauna, one can deduce that he did not attach any great importance to a difference in age. But according to VAN ES the vertebrate-bearing strata of the Gunung Butak are Pliocene, and those of Kedungbrubus Pleistocene; thus he certainly sees a conspicuous difference. VAN ES established these ages on the basis of the character of the various lithological units in the region, combined with the application of the so-called molluscan percentage method.

The geologist K. MARTIN, who taught in Leiden from 1877 until 1922, introduced this molluscan percentage method on Java, by means of which the relative age of Cenozoïc marine strata is deduced from the percentage of recent species of molluscs. For this percentage increases with decreasing age of the strata. DUBOIS already made use of MARTIN's results in his views concerning the age of the Kendeng vertebrate fauna (1908: p.1245-1250); VAN ES did so too. Age determination on the basis of foraminiferal evidence was then very much in the course of development (the letter classification of the Tertiary); and attemps at dating by means of molluscan key fossils were made only later.

On the slopes of the Gunung Butak one finds outcrops of marine, mollusc-bearing, argillaceous sands (see Fig. 3). According to VAN ES, the molluscan percentage method gives these sands a Middle Pliocene age (53% to 55% still living forms; 1931: p.96). On top of these sands, that have been deposited in a muddy, shallow sea, there lies a very conspicuous, terrestrial, volcanic (boulder) breccia, of which the

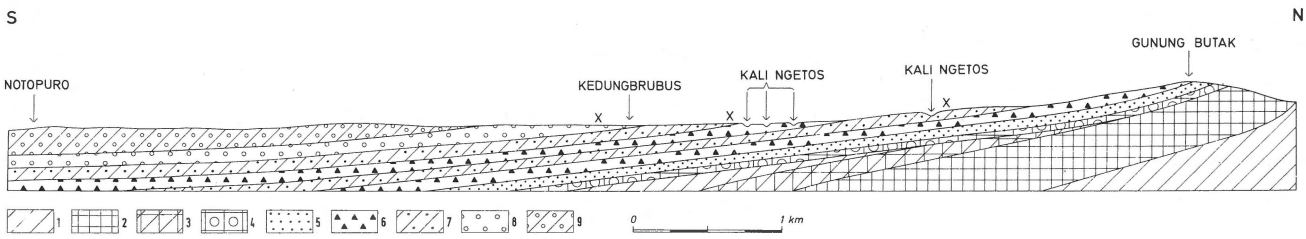

Fig. 3.
Cross-section through the southern fringe of the Kendeng ridge in Java, from the village of Notopuro to Kedungbrubus and the Gunung Butak (partly after Van Es, 1931; compare Fig. 2). From north to south (from old to young) the stratigraphic colum reads: 1= globigerine-marls (Miocene); 2= coral-limestone (Miocene); 3= transition-marls (Miocene); 4=balanus-limestone (Pliocene); 5= mollusc-bearing argillaceous sands (Pliocene); 6= volcanic breccias (Plio/Pleistocene); 7= tuffs, sandstones, conglomerates (Pleistocene); 9= conglomerates ('Notopuro Beds'; Pleistocene). The three small crosses indicate find-spots of fossil remains of vertebrates (two given by Van Es; the third by Duijfjes).

lowest part is intercalated in (in fact is intertongued with) the marine sands (1931: p.99-101). According to VAN ES this indicates that this lowest part of the breccia is also Pliocene. But the top part cannot be much younger, as from a geological point of view the sedimentation of such a breccia is very rapid. For this breccia is a lahar, a volcanic mudstream ('Murgang'), that in a short time can form a deposit several metres thick in the valleys around an active volcano. VAN ES assumed that this lahar of the Gunung Butak originated from the (now extinct) Wilis volcano (see Figs. 1 and 2)

Exposures in the landscape between the Gunung Butak and the village of Kedungbrubus show that the lahar is overlain by a series of deposits that are suggestive of more tranquil sedimentation, namely tuffaceous conglomerates, sandstones, and clays, all of a terrestrial facies, for which VAN ES reserved the name Butak Beds (1931; p.99). In view of the supposedly rapid sedimentation of the underlying lahar VAN ES assumed that the lower part of these Butak Beds is also Pliocene – and in this lower part he found vertebrate fossils (see Fig. 3; 1931: p.100-101). The upper part of the Butak Beds (that crop out just to the north of the village of Kedungbrubus, and that are separated from the lower part by a second lahar deposit) could then be Pleistocene. Definitely Pleistocene, however, is another, also vertebrate-bearing formation, that is visible immediately around Kedungbrubus, and that is composed of rather conspicuous cross-bedded river deposits. The Pleistocene age of this latter formation would be attested by the presence of more than 80% of still extant species of *Unio* and *Melania* (VAN ES, 1931: p.10,101-102).

In July, 1934, Kedungbrubus was visited by the geologist ZWIERZYCKI, who was then leader of the geological survey of Java ('Java-kaartering'), accompanied by the mining engineers TER HAAR and DUYFJES. The latter had the opportunity to discuss the geology of Kedungbrubus and its surroundings with 'ZWIER'; and TER HAAR, who were both well aware of the complexity of the Quaternary stratigraphy: ZWIERZYCKI as a result of his experiences in Sumatra, TER HAAR as a consequence of his reconnaissance along the Solo terraces in Central Java. The results of these discussions, plus the data that he had previously managed to collect during a working visit to the region in 1932, were used by DUIJFJES in a synthesis of the geology and stratigraphy of the Kendeng region (DUIJFJES, 1936). In this study he showed that the stratigraphic interpretations of VAN ES are essentially correct, and are in need of revision on only a few (minor) points.

The Butak Beds of VAN ES are regarded by DUYFJES as part of the so-called Pucungan Beds (1936: p.142-143)[2]. On the basis of his observations elsewhere in the Kendeng (Pucangan being the name of a hill north of Jombang; see Fig. 1), DUIJFJES prefered to ascribe the conspicuous, volcanic (boulder) breccias south of the Gunung Butak to one and the same formation as the conformably overlying tuffaceous conglomerates and sandstones. The entire sequence of layers is reminiscent of the activity of the Wilis volcano; the remains of vertebrates that perished during these eruptions are to be found in exposures of this Pucangan Formation everywhere between Kedungbrubus and the Gunung Butak, especially in the finer deposits.

However, like VAN ES, DUIJFJES stated that another, completely different formation, also containing vertebrates, is visible at Kedungbrubus, composed of typical fluviatile sandstones and conglomerates. For this formation DUIJFJES reserved the name Kabuh Beds (named after the village of Kabuh, also to the north of Jombang). Although this is not very clearly expressed because of the abundance of paleontological details in his text, DUIJFJES based the distinction between the Pucangan and Kabuh Formations on purely lithological evidence. The Kabuh Formation shows distinct cross-bedding, while the components are also much more abraded than those of the Pucangan Formation (DUIJFJES 1936: p.143). It is therefore incorrect to state, like DE VOS ET AL. (1982: p.208), that there is 'no appreciable difference' between the Kabuh and the Pucangan Formation on the contrary this difference is very pronounced. The Kabuh and Pucangan Formations clearly represent different genetic units, the former being fluviatile and synorogenic, consisting of erosion products of a rising Gunung Kendeng and Gunung Kidul (Fig. 1), the latter being composed of eruption products

[2] The names given by DUIJFJES to the different lithological units in the stratigraphic column are now generally accepted, and are deeply entrenched in the recent geological literature concerning Java.

of the oldest Wilis volcano[3]. Both formations are considered by DUIJFJES as rock-units. Therefore it is unjustified to accuse DUIJFJES, as do DE VOS ET AL., of attaching a chronostratigraphic value to his lithostratigraphy (1982: p.208). This chronostratigraphic value in DUIJFJES' views is secondary: it becomes only discernible when in the field the superposition of fluviatile Kabuh sediments on top of volcanic Pucangan deposits is abundantly clear.

DUIJFJES ascribed the Kabuh Formation to the Middle Pleistocene and the Pucangan Formation to the Lower Pleistocene (1936: p.136). In these age determinations he hardly differs from VAN ES; this is all the more noteworthy when one realizes that DUIJFJES too is willing to accept that the basal Pucangan Beds are still Pliocene (1936: p.148). In any case, in DUIJFJES' arguments the results of the molluscan percentage method played a most important role (1936: p.139), and he definitely did not let himself be influenced in his original delineation of the various stratigraphic units by the vertebrate fossils that have been found (1936: p.147); this again in contrast to what DE VOS ET AL. imply (1982: p.208).

Thus, it appears that the age difference, pointed out by DUBOIS, between the vertebrate-bearing deposits at Kedungbrubus and those at the Gunung Butak, is explained both by VAN ES and by DUIJFJES as a very considerable difference in age (Pliocene/Lower Pleistocene vs. Middle Pleistocene) between two totally different formations (Pucangan vs. Kabuh). Furthermore, it must be pointed out that the older Pucangan Formation crops out hardly one kilometre away from the centre of Kedungbrubus (e.g. in the banks of the River Ngetos; see Fig. 3; DUIJFJES, 1936: p.141). It is precisely for this reason that the collection of fossil vertebrates of DUBOIS is totally unsuitable for biostratigraphic studies of the kind performed by DE VOS ET AL. For bones that were collected one kilometre away from the centre of Kedungbrubus were still registered by DUBOIS (or his helpers) as 'Ked. Broeboes' or 'omgev. Ked. Br'. (surroundings of Kedungbrubus). Did they then originate from the Pucangan or from the Kabuh Formation? DUBOIS undoubtedly would also have bought fossils from the local population and the locations of such findspots would be unreliable. The 'tani' (farmer) would never indicate an exact spot, for fear that foreigners themselves go and search there, and he would thus forfeit payment. The tani might vaguely gesture towards the north (or the south), and the fossil concerned would be registered as having been found in the 'omgev. Ked. Br'.

Take for example *Manis palaeojavanica,* the giant, scaly anteater of the Pleistocene of Java, that measured more than two metres in length, of which remains were collected 'nabij Kedoeng Broeboes' (near Kedungbrubus; DUBOIS, 1892: p.14). DE VOS ET AL. simply take this findspot reference as it stands, and deduce from it a Kabuh origin of the fossil remains (1982: p.208). It is much more plausible, however, that *Manis palaeojavanica* originates from the Pucangan exposures near Kedungbrubus; the notes made by the paleontologist VAN KOENIGSWALD all point in this direction.

VAN KOENINGSWALD accompanied ZWIERZYCKI, TER HAAAR, and DUIJFJES on their reconnaissance trip around Kedungbrubus in July 1934. It was in fact one of his last trips in his official capacity as vertebrate paleontologist attached to the Geological Survey of the former Dutch East Indies: later that year he was given notice as a result of sudden cuts in expenditure in connection with the critical economic situation. *(Nil novi sub sole.)* In any case, in Kedungbrubus VON KOENINGSWALD was still able to follow at close quartres the discussions between three eminent geologists, and to become acquainted with the problems of the Neogene and Pleistocene stratigraphy of the region. Only some six months before, at the end of 1933, in a report on sites of fossil vertebrates in Central Java, VON KOENIGSWALD had written that he was still nowhere near being able to form any kind of picture of the Quaternary vertebrate fauna on Java (1933: p.4). But a year later, after his visit to Kedungbrubus, his ideas have fully developed, and he presents an initial, tentative vertebrate stratigraphy (1934). VON KOENIGSWALD immediately accepted the conclusion of his companions that at Kedungbrubus there are exposures of two different vertebrate-bearing formations, and he very emphatically separated the various fossils collected into two groups. The vertebrate remains from the Pucangan Formation he classified under his 'Jetis fauna' (with *Manis palaeojavanica!),* and the remains from the Kabuh deposits under his 'Trinil fauna' (1934: p.4-5). Also in his age determination VON KOENIGSWALD relied on the results of his colleagues: the Pucangan Beds with their Jetis fauna are Upper Pliocene/Lower Pleistocene; the Kabuh Beds with their Trinil fauna are Middle Pleistocene. He did not simply accept these results, however. As previously mentioned, VAN ES and DUIJFJES relied on the molluscan percentage method; VON KOENIGSWALD had experience himself in the application of this method. For when he arrived on Java in 1931 one of his first tasks was to work through the enormous mollusc collections of VAN ES in the cellars of the 'Gedung saté' in Bandung. In later years in questions concerning dating VON KOENIGSWALD always refered to the molluscan percentage method (e.g. 1939: p.30; 1940: p.30; 1956: p.11).

From the above only one conclusion can follow: the collection of fossil remains of vertebrates that were collected and excavated at Kedungbrubus by DUBOIS and his asistants at the end of the last century cannot be used for biostratigraphic and chronological studies. This collection is a mixture of fossils from Middle Pleistocene, Lower Pleistocene and probably even from Upper Pliocene deposits.

[3] Elsewhere in Central Java the difference is even more appreciable: in Sangiran (north of Surakarta; see Fig. 1), at present the most prolific site of fossil hominid remains in Southeast Asia, The Pucangan Formation consists of black lacustrine clays (see: RADIOMATRIC AGE DETERMINATIONS).

TRINIL

It is, however, not only the DUBOIS collection from Kedungbrubus that is of questionable origin: the same applies to the DUBOIS collection from Trinil. While the Kedungbrubus fossils come from Middle and Lower Pleistocene deposits, the Trinil fossils come from Middle and Upper Pleistocene layers. For DUBOIS not only excavated in the Kabuh Formation, but also in the terraces of the Solo river.

The laborious unravelling of the stratigraphy of the fluviatile sediments near Trinil, that was carried out by geographers and geologists who successively visited the area, is an epic in itself; a synopsis is given elsewhere (BARTSTRA, 1982a). As previously mentioned, it was DUBOIS who first recognized the true fluviatile nature of the deposits in which he situated his excavation pits, and in which he found *Pithecanthropus erectus*. What DUBOIS did not see was the stratigraphic break in his profiles; below it the true Middle Pleistocene *'Pithecanthropus* beds' in which the present-day Solo river is entrenched, and above it the Upper Pleistocene terrace sediments, built up by the Solo, and unmistakably connected with its present course. It is the gradual recognition of this break in the profile that provides the clue to the history of stratigraphical research along the Solo. In this respect VAN ES and DUIJFJES – who are so unanimous in their view concerning the geology of Kedungbrubus – are the exponents of two opposing spheres of thought.

In 1929 VAN ES wrote a small excursion guide to Trinil on the occasion of the Fourth Pacific Science Congress. In this little book (that foreshadowed VAN ES' thesis of 1931) one finds the geology of Trinil described in a nutshell. Essentially there is the same succession of strata as at Kedungbrubus: southward dipping bone-bearing terrestrial deposits on top of reef-limestones and marls, that form the core of the Kendeng ridge. The River Solo, that flows from west to east alongside the Kendeng, 'winds in and out (of) the two formations' (1929: p.9). The limestones and marls, deposited in a shallow sea, do not show any sign of volcanic activity in the surroundings. This changes suddenly with the appearance of a conspicuous lahar deposit, a volcanic boulder 'conglomerate' (boulder 'breccia' in 1931), that at Trinil unconformably overlies the limestone (thus with no intercalation here as at Kedungbrubus). VAN ES correlated this lahar with the Lawu volcano. In the stratigraphic column the lahar is succeeded by black fresh-water clays and fluviatile tuffaceous sandstones with conglomerate lenses. These latter deposits contain numerous vertebrate fossils, including *Pithecanthropus erectus* (1929: p.9-12; Fig. 4). The entire complex of clastics of lahar, clays, and sandstones, that is exposed in the banks of the Solo at Trinil, is ascribed by VAN ES to one and the same (Pleistocene) formation namely the so-called Trinil Beds. The lahar of Trinil is therefore not correlated with the lahar of Kedungbrubus, for according to VAN ES the latter originated from the Wilis volcano, that was active at a much earlier date than the Lawu.

DUIJFJES, however, split the Trinil Beds of VAN ES into three separate formations. Two of these also occur at Kedungbrubus: the Pucangan and the Kabuh Formation. The third is new: river-terrace deposits. DUIJFJES showed that the lahars of Kedungbrubus and Trinil can be correlated. In fact they form an uninterrupted complex that can be traced everywhere along the southern fringe of the Kendeng. The Wilis is responsible for all these breccias; they form the (Upper Pliocene/Lower Pleistocene) basal Pucangan layers. They frequently intertongue with the underlying limestones and marls, and the hiatus that VAN ES supposed to be present at Trinil between lahar and underlying strata is thus imaginary (1936: p.146-147); see also 1938a, b and c). But DUIJFJES placed a hiatus higher in the profile, where VAN ES did not see one: namely in the river-laid sandstones with conglomerate lenses. The top part of these strata can be correlated with the drainage pattern of the present Solo river, and is thus geologically much more recent than the lower part. These top strata in the sandstone exposures near Trinil are (Upper Pleistocene) river terrace deposits; only the basal strata belong to the (Middle Pleistocene) Kabuh Beds (DUIJFJES, 1936: p.147)[4].

DUIJFJES was able to trace this break in the sequence of fluviatile layers via extensive terrace deposits that were discovered east of Trinil, in the transverse Solo valley, in 1931 (see caption Fig. 2). An important role in this discovery was played by TER HAAR, one of the companions of DUIJFJES in Kedungbrubus. In his enthusiasm about the discovery, however, TER HAAR went so far as to regard all fluviatile sediments along the Solo merely as terraces: the dipping clastics at Trinil are in his view tilted terrace fills (1934: p.53). According to DUIJFJES this is incorrect: only the Kabuh Beds show a distinct dip southward; certainly there are terrace fills, but these lie uncorformably and horizontally on top of the Kabuh layers (1936: p.147).

I have been able to ascertain repeatedly that there are river terrace sediments in the surroudings of Trinil in the course of fieldwork in the area (BARTSTRA ET AL., 1976; BARTSTRA, 1977). In the north, near the mouth of the River Papungan (see Fig. 4), such sediments are mere gravel veneers capping the small hills, that here form the foot of the Kendeng ridge. A short distance further south, however, in the meander neck near Pentuk, and on the opposite side of the river near Gajah, the terrace sediments are already much thicker (2 to 3 m) and more extensive. In addition to gravels, finer clastics also occur here. All terrace fill is easely traceable, however, because of the great contrast with the underlying marl and limestone bedrock, on which the fill has been developed. The same

[4] Here there will be no digression concerning the so-called Notopuro Beds, predominantly younger volcanic breccias on top of the Kabuh Beds. These Notopuro deposits, that are also of Upper Pleistocene age, are not present in the meander of the Solo immediately east of Trinil; to discuss them here would only add confusion to the general picture of the stratigraphy. The type locality Notopuro is mentioned in Fig. 3.

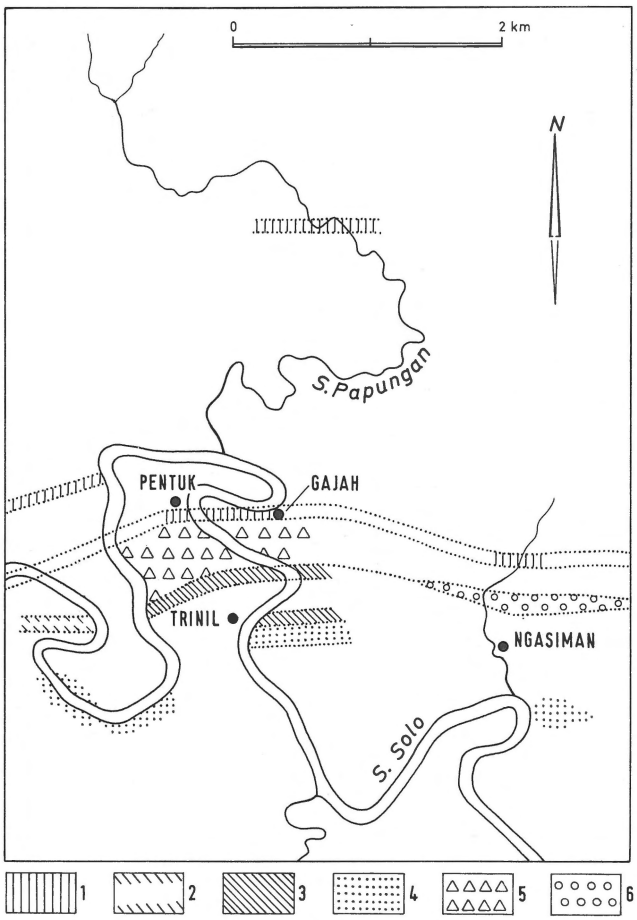

Fig. 4
Schematic geological map of the surroundings of the village of Trinil (partly after Van Es, 1929). Key: 1= coral limestone; 2= tuff; 3= black clay; 4= sandstone; 5= breccia; 6= conglomerate. Terrace gravels in the surroundings of Trinil are not indicated on this map, because Van Es did not recognize any terraces along the Solo. They are certainly present there, however (see text).

holds true for terrace sediments on top of the chaotic Pucangan breccia (lahar).

The difficulty begins in the Solo meander near the village of Trinil itself, where the terrace fills lie on top of the other river deposits, namely the Kabuh Beds. At this spot it is very diffcult to distinguish between the two units, and it will have to be attempted to find the break in the stratigraphic column on the basis of a number of considerations – considerations that are of necessity still rather vague. Certainly detailed sedimentological and petrological research along the Solo is badly needed; my own fieldwork was mainly archeological.

In the first place there are indications that the true terrace layers are less solidified than the Kabuh deposits (sands and gravels instead of sandstones and conglomerates); on the other hand it must be realized that the Kabuh deposits are by no means cemented everywhere. A difference in weathering (or in vegetation) of the river-laid sediments in the profiles along the Solo often gives an initial indication of distinct bedding, because escarpments develop. Secondly, one gets the impression that the terrace fills contain more coarse clastics than the Kabuh deposits, although there are also strata of pebbles and cobbles occasionally in the Kabuh Beds. Thirdly, the composition of these coarse clastics appears to be different in the two units; in addition to a lot of volcanic material (andesites) one finds in the true terrace sediments much chalcedony, silicified limestone and claystone (often used as raw material for prehistoric artefacts; BARTSTRA , 1982b), which are less conspicuous in the Kabuh Beds.

DUIJFJES' criterion for distinguishing between the Kabuh and terrace units (horizontally lying terrace sediments against slightly southward dipping Kabuh deposits), is unfortunately, untenable. The terrace fills near Trinil are definitely tilted, precisely as the terrace fills further east in the transverse Solo valley are also tilted; because they have all been involved in the recent epeirogenetic movements in the Kendeng ridge. This 'epeirogenetic' tilt must be distinguished from a down- and across-valley dip of the terrace sediments, that is also displayed, and that is connected with the specific genesis of the terraces along the Solo. Cross-bedding occurs both in the Kabuh Beds and in the terrace sediments (not yet recognized in BARTSTRA ET AL., 1976: p.29).

The very term terrace suggests that this phenomenon may be morphologically recognizable as a more or less step-like feature against the slopes of the river valley. However, to trace distinct scarps and flat treads along the Solo is a formidable task: in some places as a result of the dense vegetation, in other places as a result of severe denudation. Measurements of heights of presumed terrace surfaces (or far better, bases) therefore give rather meagre results. Only a low silt bank (with basal gravels) that consistently follows the Solo in its capricious course, displays the classic features of a river terrace: flat surface (tread) and scarp. This low terrace, at approximately 5 m above the Solo, is also present in the meander of Trinil. Terraces older than this low level bank one must expect to find in the form of spurs and remnants, of which the fines. (partly former overbank deposits) have largely disappeared as a result of erosion. A river terrace is an abandoned floodplain; but the older the terrace, the smaller the chance that the intricate sequence of floodplain deposits (overbank plus channel deposits) has remained unchanged (improbability of relic features). In other words: gravel pockets, veneers or banks that are high, isolated, or situated some distance away from the present river course may be high-terrace remnants.

This is the case, for example, with the previously mentioned gravels near the River Papungan. Also the extensive gravels recorded by VAN ES at the village of Ngasiman (conglomerate in Fig. 4) are in fact high terrace deposits. In other places, however, the finer clastics have not completely disappeared, for example in the Solo meander near Trinil where high-terrace sediments (not only gravels but also sands) occur on both sides of the river, at varying heights (± 8 to 20 m), and on top of the Kabuh Beds. The small monument that DUBOIS erected there, to commemorate his discoveries, stands on a

igh-terrace remnant: on close inspection morphologically nd stratigraphically discernible from the underlying Kabuh rata. On te opposite side of the river in the left bank of the olo, at the spot where the skull-cap and thigh-bones of *ithecanthropus erectus* were found, both terrace and Kabuh ediments are present; DUBOIS excavated through both units. vidence for this is provided, for instance, by a tuff analysis of everal sediment samples, collected at and near the site of UBOIS' former pits. A sample from the lowest Kabuh sands nows a heavily weathered material, of a hornblende-ntermediate plagioclase association. However, a sample om higher up in the profile (4 to 5 m above the low Solo level the dry season; in DUBOIS' view still the same formation) nows a very young and hardly weathered material, of an ugite-hypersthene-olivine-zeolite-intermediate plagioclase ssociation (DR. J.J. ANDRIESSE, Koninklijk Inst. voor de ropen, Amsterdam, pers. comm.). These deposits are no nger Kabuh Beds, but terrace fills.

The identification of high and low terrace along the Solo is ncumbered by the occurence of cut and fill terraces. vidently there were periods of entrenching in old valley fill, llowed by renewed alluviation. The result is visible in the eld, where high-terrace clastics disappear under low-terrace eposits. The occurence of cut and fill terraces along the Solo, r example in the north of the tranverse valley (in the vicinity f Cepu; see Fig. 2) has long been known (LEHMANN, 1936: .96; VAN BEMMELEN, 1949; p.585). But I observed the cut and ll phenomenon also closer to Trinil, for example near the bove-mentioned Ngasiman (Fig. 4) and several kilometres rther east, near the villages of Watualang and Pitu. In the eander of Trinil itself, presisely at the spot of DUBOIS' *ithecanthropus* pit, the top sequence of river-laid strata is so suggestive to a cut and fill stratigraphy.

It must be realized that the formation of floodplains and ver terraces is influenced by specific local conditions that ay differ from meander to meander along a river. Thus the eposition of coarse alluvium (bedload) may be related to fferences in resistance of the river bed. This is in fact ustrated in the Solo valley near Trinil, were terrace fills have eveloped on top of Miocene limestones and marls, on Lower leistocene tuffs and breccias, and on Middle Pleistocene ver-laid clastics. The terrace fills appear to be very extensive those places where hard alluvium (silicified clastics) has een transported through an area of relatively soft rock (marl nd limestone), for example near Pentuk and Gajah (see Fig.).

Apart from local conditions, there are those of regional gnificance. Thus the cut and fill terrace suggest eustatic ovements during the genesis of the Solo terraces. This had deed been assumed, for example by LEHMANN (1936), DE ERRA (1943), and SMIT SIBINGA (1949), who also relate the arious terraces along the Solo to four glacials. Others on the ther hand emphasize the influence of tectonic movements on va during the Pleistocene (e.g. VAN BEMMELEN, 1949 and ARTONO, 1976). In the neighbourhood of Trinil the folding and tilting of the Kendeng ridge were certainly of influence, as well as the activity of the Lawu volcano. Various tuff lenses and laminae in the terrace sediments are a reminder of the latter. At the time during which the Solo terraces were formed the Wilis volcano had long been extinct. But as the Solo river is partly cut in (tuffaceous) Kabuh sandstones and conglomerates, some of the volcanic constituents of the terraces must nevertheless be allochthonous.

All terrace fills along the Solo[5] contain fossil remains of vertebrates. It has become customary to include these fossils (at least those from the higher lying fills) in one category: the so-called (Upper Pleistocene) Ngandong fauna[6]. It must be clearly realized, however, that this terrace fauna is to some extent allochthonous, and in fact consists of reworked Kabuh fossils. Fragments from the so-called main bone-bearing bed ('Hauptknochenschicht', the fossil-bearing stratum near the base of the Kabuh Beds, that yielded *Pithecanthropus)* are easily recognized as having been reworked; they are abraded and polished, heavily mineralized, and of a conspicuous dark-brown colour. In contrast the reworked fragments from higher-lying Kabuh deposits (the sandy strata between the main bone-bearing bed and the terrace fills) are much less mineralized, more fragmentary, grey in colour and cannot so easily be distinguished from the autochthonous terrace fauna.

Near Trinil the abraded, dark-brown (main bone-bearing bed) Kabuh fossils, that are re-embedded in terrace sediments, are very conspicuous. These specimens are especially abundant in low terrace strata (and in the present sand- and gravel-bars in the river: a terrace in *statu nascendi*!). They are also found to a lesser extent, however, in high-terrace fills, not yet recocgnized in BARTSTRA ET AL. (1976: p.31), and they thus give an indication of the exact time at which the Solo river began to cut into the lowest Kabuh deposits (with the main bone-bearing bed). This thus explains why for instance CARTHAUS (a geologist working with the Selenka expedition, that excavated in Trinil in 1907 and 1908) indicated in his Trinil profile a stratum with bones ('Knochenschicht') and also a stratum with severely abraded bone fragments ('mit stark abgerundeten Knochenfragmenten'). The latter are terrace deposits (CARTHAUS, 1911: Tafel VI). Nevertheless the Kabuh fossils in terrace strata do not have an abraded appearance everywhere along the Solo. During a field reconnaissance near Sambungmacan (upstream from Trinil; see Fig. 2), in the dry monsoon of 1982 I found heavily mineralized, brown-coloured bone fragments in an exposed terrace fill, that are not abraded, or rolled, or water-worn at

[5] The existence of several high-lying terraces, or of different levels within one high terrace, is a matter that will not be gone into here. For further details see SARTONO (1976); BARTSTRA (1977).

[6] Type locality: the village of Ngandong (Fig. 2), where in the 1930's this fauna was excavated from a terrace, together with the skulls of Solo Man *(Homo (Javanthropus) soloensis* (OPPENOORTH, 1932); = *Homo erectus soloensis*; = *Homo erectus ngandongensis* = *Homo sapiens soloensis).*

all. They form part of the allochthonous terrace component, nevertheless, for they have a remarkable double matrix, one of the Kabuh Beds, and one of the terrace fill.

In any case, a wealth of taphonomic problems awaits the future researcher along the River Solo, problems that have been neglected for too long. Gone are the days when all the vertebrate remains found along the river could be regarded as one fauna, from one single formation.

RADIOMETRIC AGE DETERMINATIONS

Chronometric dates for Plio/Pleistocene deposits on Java have become available in the last decade (see e.g. ORCHISTON & SIESSER, 1982; SÉMAH, 1982; HUTTERER, in press). A few comments may be necessary, as they are of relevance to the foregoing.

The oldest part of DUBOIS' collections comes from the Pucangan Beds. One K/Ar date is known for this Formation from the Kedungbrubus area, namely 1.91 Ma (andesite sample from Kebonduren; JACOB, 1975). Most of the other chronometric ages for the Pucangan Formation come from Sangiran, far to the west of Kedungbrubus (see Fig. 2), and these ages are all much younger: between ± 0.6 and ± 0.7 Ma (fission-track ages of samples of clay enriched with volcanic fragments; NISHIMURA ET AL., 1978, 1980), and even ± 0.4 to 0.5 Ma (idem; WATANABE ET AL., 1982: p.136). The Pucangan Formation in Sangiran consits of black, lacustrine clays (see note 3). This clay-unit is called Pucangan by inference: in Sangiran it is situated between marine clays, marls and limestones (that form the 'bedrock' at Kedungbrubus and Trinil), and fluviatile clastics (the Kabuh Beds). The black clay unit in Sangiran is therefore regarded as the lacustrine facies of the Pucangan Beds (c.f. BARTSTRA, 1974).

The chronometric dates now indicate a considerable difference in age between this lacustrine facies and the volcanic facies of the Pucangan Beds. There is, however, an explanation for this discrepancy. The seposition of the tuff-breccia unit near Kedungbrubus is the essential prerequisite for the sedimentation of the black lacustrine clays in Sangiran: the lahars sealed off a drainage area, in such a way that an extensive lake was able to develop (c.f. VAN BEMMELEN, 1949: p.571 ff, 591). Therefore the volcanic Pucangan facies near Kedungbrubus must be much older than the lacustrine Pucangan facies in Sangiran – also in view of the long time necessary for the sedimentation of the more than 200 m thick sequence of black clays in Sangiran. NISHIMURA's (1978, 1980) samples, for example, come from the upper part of this sequence.

This difference in age between the Pucangan deposits in Sangiran and those in Kedungbrubus also lies at the bottom of the dispute that went on for years between HOOIJER (e.g. 1957) and VON KOENIGSWALD (e.g. 1956) with regard to the age of the Jetis fauna, the vertebrate remains from the Pucangan Beds. It must be borne in mind, however, that the (Jetis) fossils from the black clays of Sangiran are much younger than the (Jetis) fossils from the volcanogenic deposits of Kedungbrubus.

If one takes for granted the date of 1.91 Ma for Kedungbrubus, then it is evident that the age determination of VAN ES, (1931) and DUIJFJES, (1936) for the Pucangan Formation near Kedungbrubus, Upper Pliocene/Lower Pleistocene, is still valid. For on Java too the Pleistocene must be regarded as beginning around 1.67 Ma coincident with the end of the Olduvai event, a minor geomagnetic marker (e.g. BUTZER, 1977; HAQ ET AL., 1977).

The Matuyama-Brunhes main geomagnetic reversal, around 0.7 Ma ago, forms the boundary between the Lower Pleistocene and the Middle Pleistocene. The above mentioned chronometric ages for the Pucangan Formation in Sangiran appear to be younger than this boundary. This could mean that the sedimentation of the black clays continued until into the Middle Pleistocene, an acceptable proposition in view of the thickness of the clay unit. However, a few upper Pucangan samples from Sangiran that have been studied for palaeomagnetic purposes (YOKOYAMA ET AL., 1980; SÉMAH ET AL., 1981/82) show still a reversed polarity (Matuyama). It thus must be taken into account that the fission-track ages provided by NISHIMURA ET AL. (1979; 1980) and WATANABE ET AL. (1982) are slightly too young. The great difference with Kedungbrubus ages remains, however.

CONCLUSION

A cursory stratigraphic and geomorphic reconnaissance is sufficient to show that DUBOIS' collection of fossil vertebrate remains from Kedungbrubus are from older deposits than his collection from Trinil. The view held by DE VOS ET AL. (1982) that Kedungbrubus is 'younger' than Trinil therefore cannot be sustained. DUBOIS' collection from Kedungbrubus is a mixture of Upper Pliocene/Lower Pleistocene and Middle Pleistocene faunas, whereas his collection from Trinil is a mixture of Middle Pleistocene and Upper Pleistocene faunas.

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COMMENT II: Remarks upon the Dubois Collection of fossil mammals from Trinil and Kedungbrubus in Java

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In two recently published papers, DE VOS & SONDAAR (1982) and DE VOS ET AL. (1982) launched ideas concerning the Dubois Collection from Trinil and Kedungbrubus. These ideas were shown by BARTSTRA (1982, 1983) to be based upon incomplete knowledge and a misunderstanding of the literature. There would be little reason for me to return to the fray at all were it not that I have been cited profusely by DE VOS ET al. (1982); this concerns palaeontological items that BARTSTRA purposefully has left to me to comment upon. This, then, will be done in the present paper.

Trinil and Kedungbrubus, both famous Pithecanthropus localities of DUBOIS, loom large in the early literature on the stratigraphy of Java reviewed by BARTSTRA (1982, 1983). In his 1934 paper on the Pleistocene stratigraphy of Java, VON KOENIGSWALD declared that he would restrict the Trinil fauna to the locality Trinil. He added: 'Ein Fundplatz mit Trinil-Fauna ist u.a. Kedoeng Broeboes in der Nähe des G. Pandan' . . . 'In Trinil selbst sind die Lagerungsverhältnisse nicht recht deutlich, da hier die 'Trinilschichten' nur wenig mächtig entwickelt sind und die tieferen Schichten keine Säuger mehr führen. Gehen wir aber weiter nach Osten zum G. Pandan, so finden wir dort unter den Sand- und Schotterablagerungen von Kedoeng Broeboes mit typischer Trinil-Fauna mehr vulkanische Absätze, die ganz andere Säugetiere enthalten. (Sowohl G. Boetak wie Kedoeng Broeboes sind Fundplätze von DUBOIS.) Dass die Schichten vom G. Boetak einem älteren Horizont angehören müssen, hat VAN ES zuerst erkannt. Wir haben hier somit unter dem Trinilhorizont noch einen älteren. Die für diesen typische Fauna ist zuerst aus der Gegend von Djetis, und Perning bei Modjokerto (Ostjava) bekannt geworden (Fundstellen, auf welche COSIJN als erster aufmerksam machte), weshalb ich dafür den Namen Djetis-Fauna gebrauche' . . . 'Aus der Djetis-Fauna sind die folgenden Arten bekannt geworden: *Manis palaeojavanica* Dubois. Von diesem Riesenschuppentier hat sich am G. Boetak eine Phalange gefunden. Nachdem DUBOIS als seinen Fundplatz dieser Art das unmittelbar benachbarte Kedoeng Broeboes nennt, diese Art aber bisher an keinen der reichen Fundstellen mit Trinil- oder Ngandong-Fauna zum Vorschein gekommen ist, scheint es mir nicht mehr zweifelhaft, dass sie aus dem Djetis-Horizont stammt' (VON KOENIGSWALD, 1934: p. 188, 190).

In connection with a fossil femur of *Manis palaeojavanica* from the Citarum valley in Western Java, in a fauna regarded by VON KOENIGSWALD (1935: p. 87-88) as very probably a Jetis fauna, I wrote: 'DUBOIS' type specimens are from Kedoeng Broeboes, a locality with both lower Pleistocene (Djetis-) fauna and middle Pleistocene (Trinil-) fauna (VON KOENIGSWALD. 1934, p. 188). VON KOENIGSWALD (l.c.: p. 190) records a phalanx of *Manis palaeojavanica* Dubois from the Djetis deposits of Goenoeng Boetak, which is very near the type locality. He states that, the species not being found in any of the rich fossil localities with Trinil or Ngandong (upper Pleistocene) fauna, it is not to be doubted at that DUBOIS' specimens originated from the Djetis deposits. If *Manis palaeojavanica* Dubois indeed is typical of the Djetis fauna, the femur in the STEHN & UMBGROVE collection supports VON KOENIGSWALD'S view that the Tji Taroem valley fauna belongs to the lower Pleistocene' (HOOIJER, 1947: p. 417).

Some years afterwards, I had already come to the conclusion that the Jetis beds, although underlying the Trinil beds and therefore geologically older, do contain many invading elements of the 'Sino-Malayan fauna' of VON KOENIGSWALD (1940: p. 72) and therefore belong to the same Middle Pleistocene, post-Villafranchian *Stegodon-Ailuropoda* faunal block as do the Trinil beds (HOOIJER, 1952: p. 439). Consequently, I was not so much interested any more in age differences between Jetis and Trinil. The Gunung Butak bone of *Manis palaeojavanica* referred to by VON KOENIGSWALD in 1934 as a phalanx in reality is a third metacarpal that is identical with its homologue in the type skeleton of *Manis palaeojavanica* from Kedungbrubus (HOOIJER, 1974a). To all intents and purposes this bone may be from the Jetis beds. Bones of the same species from Niah Caves in Sarawak could be no older than some 40,000 years (HOOIJER, 1961), pointing to a considerable species longevity of *Manis palaeojavanica*. It should be emphasized here that *Manis palaeojavanica* may well be a member of the Trinil and the Jetis fauna although it has not so far been found at Trinil proper: the Borneo finds show that the species did not become extinct until late Pleistocene times.

In the paper by DE VOS & SONDAAR (1982) it is maintained that the fossils from Trinil proper constitute a single faunal unit, are all from the same level, and therefore may be used for what they call 'palaeofaunistical studies and biostratigraphy' (l.c.:p. 59). BARTSTRA (1982), basing himself upon the observations by authors such as VOLZ, TER HAAR, and DUYFJES as well as on his own fieldwork, pointed out that two different fluviatile units exist in the Solo meander near Trinil where the excavations by DUBOIS and the Selenka Expedition took place, viz., the Middle Pleistocene Kabuh beds, and the Late Pleistocene and sub-Holocene terrace sediments, both of them fossiliferous. DE VOS & SONDAAR (1982) tried to establish a 'pure' Trinil fauna ('sensu stricto') by accepting as Trinil faunal elements only material found at the site of Trinil proper. In doing so they found that specimens catalogued as

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Trinil came from the surroundings of Trinil, such as a portion of DM^4 of *Elephas hysudrindicus* (Coll. Dub. no. 2226: HOOIJER, 1955: p. 117) that came from Ngancar, ca. 1 km SE of Trinil (DE VOS ET AL., 1982: p. 208), and a horn core of *Epileptobos groeneveldtii* (Coll. Dub. no. 2746: HOOIJER, 1958: p. 33) that came from Tawang, 2 km SW of Trinil (DE VOS ET AL., 1982: p. 209). These specimens had been entered in the catalogue as coming from Trinil although they had not been found precisely at the Trinil site. However, even if one eliminates all the material found in the vicinity of Trinil the fact remains that a specimen from the centre of Trinil is not necessarily Middle Pleistocene (BARTSTRA, 1982). In view of these facts, reiterated by BARTSTRA, it is clear that the fossil collections made at Trinil are not unified as to age: they range from Middle to Late Pleistocene and sub-Holocene. It is, therefore, futile of DE VOS & SONDAAR to attempt to sort out a 'pure' Trinil fauna on the basis of the DUBOIS Collection from Trinil, which is neither a distinct entity nor representative of a particular faunal stage. This has important consequences also for palaeoanthropology.

As pointed out by DAY & MOLLESON (1973) the femora of Pithecanthropus (*Homo erectus)* from Peking and East Africa are platymeric, whereas the Trinil femora assigned to *Homo erectus* have higher indices and fall within the range for modern man. This lead DAY & MOLLESON to question whether the Trinil femora are contemporaneous with the calotte; might not these be younger than the calotte and not belong to *Homo erectus* but to *Homo sapiens* instead? This important question should be reconsidered in the light of BARTSTRA's observation that, in the places where the calotte and the first femur of Trinil were found, DUBOIS excavated through two units, the Middle Pleistocene Kabuh sediments and the Late Pleistocene terrace sediments.

DE VOS ET AL. (1982: p. 210) stated that Pleistocene Trinil probably was situated on an island. One would like to know large the island was, if ever Trinil did exist as an island. Purely hypothetically, this must have been a very small island, Trinil in the centre, not including the *Elephas hysudrindicus* locality Ngancer, or the *Epileptobos groeneveldtii* locality Tawang, one or two km from Trinil referred to above. If these localities had been considered to belong to their island of Trinil, DE VOS & SONDAAR (1982: p. 58) would not have excluded these two species from their Trinil fauna sensu stricto. The hypothesis that the Trinil fauna (by the counts of DE VOS & SONDAAR) of at least some fifteen, mostly large, mammalian species including tiger, stegodont, rhinoceros, large bovids and Pithecanthropus could be supported on an island just a few km across is utterly improbable.

A serious omission in the faunal list of Trinil proper is *Elephas celebensis*. DE VOS & SONDAAR (1982: p. 51) mention 'HOOIJER 1974' but fail to list that paper in their references and it is in this paper that I described a DM_4 of *Elephas celebensis* from Trinil (HOOIJER, 1974b: p. 90/91, pl. I middle figures).

DE VOS ET AL. (1982) also deal with the fauna from Kedungbrubus. As related above, VON KOENIGSWALD realized that at this site there are both the Trinil and the Jetis fauna. BARTSTRA (1983, this issue) pointed out that the Dubois collection from Kedungbrubus is a mixture of Late Pliocene/Early Pleistocene and Middle Pleistocene faunas and hence is not unified as to age. This is a far cry from DE VOS ET AL. (1982) who stated that the fauna from Kedungbrubus represents a single faunal stage later than that from Trinil. This surprising conclusion is based upon a list of species from Kedungbrubus proper, which turns out to be more extensive than that from Trinil proper. Be that as it may, the collecting and searching for fossils at Kedungbrubus by DUBOIS and his helpers was not restricted just to the immediate surroundings of the site but extended in the direction of Gunung Butak as well (BARTSTRA, 1983, o.c.). Gunung Butak, it will be remembered, was the site of the metacarpal of *Manis palaeojavanica* recorded as a phalanx by VON KOENIGSWALD in 1934. Forty years earlier, DUBOIS had already indicated that the fossil-bearing strata at Gunung Butak must be older than those cropping out at Kedungbrubus (BARTSTRA, 1983, o.c.), 4 km further to the south. DE VOS ET AL. (1982) ventured the conclusion that the species of mammals present at Kedungbrubus and not at Trinil do represent new arrivals in Java since the time of deposition of the Trinil beds. Kedungbrubus has a fauna similar to the Jetis fauna and DE VOS ET AL. assumed that the Trinil fauna antedates the Kedungbrubus fauna (DE VOS ET AL., 1982: p. 210). This is upsetting the vertebrate stratigraphy of Java as established in the thirties with the Trinil fossils from the Kabuh beds and the Kedungbrubus fossils from the Jetis or Pucangan beds, the former being not earlier than the latter but later, according to the principle of superposition.

In the opinion of DE VOS ET AL. (1982: p. 209) an invasion of *Manis, Hyaena, Elephas, Tapirus, Rhinoceros kendengindicus, Rusa* and *Epileptobos* took place at the base of the Jetis beds of Kedungbrubus. This is not a very original idea. It was first proposed by VON KOENIGSWALD, and I have always maintained (see, e.g., HOOIJER, 1962) that there was an invasion of mammals of the *Stegodon-Ailuropoda* complex in the Jetis beds; this includes some of the elements listed by DE VOS ET AL. as well as others. However, to place the Trinil fauna earlier than that of Kedungbrubus, which would mean that all these invading elements were not already there in Java at the time of deposition of the Trinil beds, is patently wrong: this is topsyturvy stratigraphy. As to the age of the Kedungbrubus fauna, DE VOS & SONDAAR (1982: p. 52) wrote: 'HOOIJER probably does not want us to believe that the fauna of Kedung Brubus ranges from Upper Pliocene to Upper Pleistocene'. As a matter of fact I do hold the view that the range of the Kedungbrubus fauna is just about that. I did describe from Kedungbrubus specimens belonging to three temporal subspecies of *Hippopotamus sivalensis* one of which was recorded before from Bumiaju and Cijulang, and the other two recorded from the Jetis beds, and from Trinil and Tinggang (Solo valley), respectively (HOOIJER, 1950). This is in keeping with the time range of the Kedungbrubus deposits: Late Pliocene to Middle Pleistocene inclusive (BARTSTRA, 1983, o.c.).

REPLY Facts and fiction around the fossil mammals of Java

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INTRODUCTION

The conclusions of DE VOS & SONDAAR (1982) and DE VOS ET AL. (1982) can be summarized as follows:
(1) The collecting of fossils by DUBOIS and his assistants was reliable and accurate.
(2) The Kedung Brubus fauna is younger than the Trinil fauna.
(3) VON KOENIGSWALD's (1934) biostratigraphy, which is based on composite faunal lists, is incorrect.
(4) The fauna from the Trinil locality contains endemic elements and is relatively poor in taxa; this points to isolated circumstances.

The main criticisms of BARTSTRA *(this volume)* and HOOIJER *(this volume)* are:
(1) Because the fossils collected in Trinil, as well as those from Kedung Brubus, are from different lithostratigraphic units, they represent a mixture of Middle Pleistocene – Upper Pleistocene and Upper Pliocene/Lower Pleistocene – Middle Pleistocene faunas respectively.
(2) The faunal sequence as proposed by DE VOS ET AL. (1982) does not corroborate the lithostratigraphy of DUIJFJES (1936).

DE VOS & SONDAAR (1982) demonstrated with ample evidence that DUBOIS and his assistants collected the fossils in a very accurate way. It is curious that BARTSTRA (this volume) does not discuss or even mention this article, although he is one of the editors of the journal in which it was published.

To doubt the accuracy and care in which DUBOIS carried out his excavations is a serious accusation; it decreases the value of the famous collection and frustrates paleontological and biostratigraphical research in S.E. Asia.

TRINIL LOCALITY

(1) The faunal list given by DE VOS & SONDAAR (1982) of Trinil is exclusively based on specimens collected at the site itself from the beds close to the lowermost level of the Solo River in the dry season, and not from strata '4 or 5 m' above this level. Each specimen used is well documented.

The strata at the locality are subhorizontal (VAN ES, 1929). DUBOIS (1896) reported a dip of 5° S, which is in accordance with the strike-dip indication near Trinil on the geological map in the excursion guide of VAN ES (1929). The map in BARTSTRA (this volume, figure 4) is an enlarged and erroneous version from which the structural indications (strike-dip and fault) are left out. Since BARTSTRA did not change the outline of the outcrops of the various strata on the geologic map of VAN ES, he apparently agrees with the strike and dip of the strata as reported by the original author.

From these facts it must be concluded that the fossils from Trinil, sensu DE VOS & SONDAAR (1982) originate from one and the same stratigraphical level.
(2) BERGMAN & KARSTEN (1952) examined the fluorine content of fossils from the Trinil locality in the Dubois collection (Including the *homo erectus* fossils). They concluded: 'Very important with regard to the controversy on the contemporaneousness of the *Pithecanthropus* skull and the femur, is the fact that the fluorine content of both pieces is of the same order. This does not give conclusive evidence that both fragments belong to the same individual, nor even to individuals of a single species, but it is a conclusive argument for settling the dispute about the relative age of those bones as it is evidence for a similar degree of antiquity of both pieces. Finally the contemporaneousness of the animal and of human remains now has been established.' BERGMAN & KARSTEN, 1952, p. 151-152).
(3) DE VOS ET AL (1982) reported the presence of relatively few different taxa in the fauna from Trinil s.s. (which was one of their reasons to advocate an isolated position of Java during the deposition of the Trinil sediments). This observation does certainly not substantiate the suggestion that the Trinil collection is a mixture of two different faunas; in that case the number of different taxa present would be far greater.

Furthermore, HARDJASASMITA (1982) demonstrated that the Suidae in Trinil are represented by only one species *(Sus brachygnatus)*, which shows a remarkable homogeneity.

KEDUNG BRUBUS

(1) The fact that DUBOIS considered the faunas from the different localities in the Kedung Brubus area as part of the same faunal stage does not mean that he actually mixed specimens from different sites.
(2) The fossil remains from Butak in the collection are labelled as such and are not incorporated in the fauna list of Kedung Brubus (DE VOS ET AL., 1982).

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(3) The statement that DUBOIS did not keep fossils separate from different sites in the area around Kedung Brubus is not true. For example, in the collection a suid jaw is present which is labelled as coming from Kedung Pring which is located 500 m SE of Kedung Brubus. From other specimens the exact distance between their locality and Kedung Brubus proper is documented. As can be deducted from his fieldnotes, DUBOIS was very accurate in measuring the distances between the various localities (he used trigoniometric methods). The contact between the so-called Kabuh and Pucangan Formations is about 1 km north of Kedung Brubus and there is no reason to assume that DUBOIS would not have documented separately the fossils which came from such a distance from Kedung Brubus.
(4) According to BARTSTRA (this volume), the area north of Kedung Brubus towards Butak and perpendicular to the strike of the strata, where the lower part of the so-called Kabuh Formation and the upper part of the so-called Pucangan Formation are exposed, is the possible source area of contaminating fossils. This area, however, is not fossiliferous as is demonstrated by the maps of VAN ES, 1931 and DUIJFJES, 1936.

For the reasons mentioned we can safely conclude that the fossils which are labelled Kedung Brubus, originated from Kedung Brubus proper, from a very limited area, and from one stratigraphical level.

BARTSTRA's remark that DUBOIS would undoubtedly have bought fossils from farmers is unfair and there is no indication whatsoever that DUBOUS bought fossils. On the contrary: the chances that he did so are extremely small since in those days unauthorized possession of fossils was severely punished (BRONGERSMA, 1941). It should be remarked, on the other hand, that the biostratigraphy of VON KOENIGSWALD, which is followed by BARTSTRA (this volume), is partly based on purchased fossils (VON KOENIGSWALD, 1956, p. 96).

LITHO- AND CHRONOSTRATIGRAPHY

Formations are lithostratigraphic units that consist of consecutive series of sedimentary beds, sufficiently homogeneous to be regarded as a unit. Furthermore, the practicability of mapping is an essential characteristic of formations.

It is a contradiction in terms to define for example a volcanic and a lacustrine facies in one formation, since this distinction is based on large scale differences in lithology. Furthermore, the indication lacustrine facies is not a lithological description but the interpretation of certain lithological properties and of the fossil content of the sediment.

It is not correct to draw chronostratigraphical conclusions from a certain lithology. Even if one is certain that the lithological correlations are correct (in continental deposits this is practically possible only when one is able to trace the formation in the field), there is no guarantee, that a lithological interface represents an isochron, again, especially so in continental deposits.

These considerations are not just of theoretical value and this is demonstrated for example by stratigraphic work over the past decade in the Siwalik deposits of Pakistan (e.g. PILBEAM ET AL., 1977). It became clear that the mixing of different types of stratigraphy in the past resulted in unreliable correlations. It is noteworthy that the ages assigned by VON KOENIGSWALD (1934) and HOOIJER (1952) to the beds on Java, are based on correlations with the outdated stratigraphical framework of the Siwalik deposits of the Indian Subcontinent.

As remarked by DE VOS ET AL. (1982), it was common practice in these days of DUIJFJES to give chronostratigraphic meaning to the lithostratigraphy. Although BARTSTRA does deny this, there are numerous examples in the papers of DUIJFJES to demonstrate this (e.g. DUIJFJES (1938a) used: 'Poetjangan beds', 'Poetjangan étage', 'Poetjangan time'). Apart from that the lithostratigraphy itself as proposed by DUIJFJES is presently no longer tenable.

DUIJFJES (1938a) distinguished three units in the type area: the clay facies of the Pucangan beds (about 350 m); conformably overlain by the volcanic facies of the Pucangan beds (about 480 m); on top of which the Kabuh beds (about 300 m) are deposited also, in a volcanic facies. From figure 1 in DUIJFJES (1938a) and the description of the lithology it is clear that the only lithological break which warrants the distinction of two formations is between the so-called clay and volcanic facies of the Pucangan beds, whereas there is no appreciable difference in lithology at the proposed boundary between the Pucangan and Kabuh Formations. DUIJFJES (1938a, p. 43) justified the incorporation of the lower part of the volcanic sequence in the Pucangan (= Poetjangan) Formation by the occurence of guide fossils of the so-called Djetis fauna in a gravel bed in this volcanic sequence. Because the Pucangan beds were considered to be of Lower Pleistocene age and the Djetis fauna to be indicative for the Lower Pleistocene, DUIJFJES drew the boundary between the Kabuh and Pucangan Formations just above the mammal-bearing gravel bed.

It is surprising that BARTSTRA (this volume) considers this classic example of the mixing of litho-, chrono-, and biostratigraphy as still valid. He remarks that the difference in lithology between the Pucangan and Kabuh Formations is more appreciable in Sangiran than in the type area (!) because at this site in central Java (about 150 km W of the type area) the Pucangan Formation is developed as 'black lacustrine clays'.

We note:
(1) The Pucangan and Kabuh Formations have no lithological identity in the type area and are not defined as mappable units.
(2) The lithology in Sangiran, as well as in Trinil (about 100 km W of the type area), is different from that in the type area.
(3) Accurate correlation on the basis of the lithology in continental deposits over distances of 100 to 150 km, is

virtually impossible as there are no continuous exposures.
(4) To identify the 'lacustrine black clays' of Sangiran as the Pucangan Formation 'by inference' on their position in between marine clays, marls, limestones and fluviatile clastics (which BARTSTRA calls the Kabuh Formation on insufficient criteria) is incorrect and not valid.
(5) There is no lithostratigraphical evidence, which part of the strata near Sangiran, Trinil, and Kedung Brubus is the exact lateral equivalent of the Pucangan and Kabuh beds of DUIJFJES in the type area.

As pointed out before, even when the lithostratigraphic correlations are established beyond doubt, which certainly is not the case on Java, it is not correct to use the lithostratigraphy for chronostratigraphical correlations.

The age of the various mammalian faunas as reported by BARTSTRA (this volume), is not based on biostratigraphical arguments, but on the supposed age of the sediments from which the fossils originate. BARTSTRA mixes litho- and chronostratigraphy and his chronostratigraphical conclusions are based on an unreliable, lithostratigraphic framework.

The discrepancy of at least 1.1 Ma between the absolute dates of the so-called Puncangan Formation near Trinil (0.5±0.3 Ma) and the so-called Pucangan Formation near Kebonduren (1.9 Ma) as reported by BARTSTRA (1978), substantiates this statement.

BIOSTRATIGRAPHY

Accurate knowledge of presence or absence of taxa in fossil-bearing deposits is essential for paleontological and biostratigraphical studies. Also the exact locality is a necessity for such studies. An example which demonstrates this is the presence or absence of *Epileptobos groeneveldtii (=Leptobos cosijni)*. VON KOENIGSWALD (1934) considered this bovid a guidefossil for the Djetis fauna and reported its absence in Trinil. He concluded from this that the Trinil fauna is younger than the so-called Djetis. However, HOOIJER (1956, p. 5-6) argued that this bovid is present in Trinil: 'Since in DUBOIS's time no distinction had been made yet between the Trinil and the Djetis beds we do not know exactly from which of the two levels the Dubois collection specimens have been derived, with one exception, viz., the collection from Trinil proper. At Trinil, the type locality of the Trinil fauna, the Djetis beds, if present, are unfossilliferous. One of the Dubois collection specimens of *Epileptobos groeneveldtii* (Dubois) (no. 2746) originates from Trinil; it has been found 1,5 m above the lowest level of the Solo river at that locality, and proves the occurence of the species in the Trinil fauna sensu stricto.'

The presence of *Epileptobos* at Trinil is again mentioned by HOOYER in 1975. The remark 'found 1,5 m above the lowest level of the Solo river' suggests that HOOIJER (1956) took careful note of the locality data, which were marked on the label attached to the specimen as well those registered in the catalogue; however, his reproduction of these data is not correct: the locality from which the specimen originates is labeled and registered Tawang and not Trinil. This mistake of HOOIJER (1956) is serious because the supposed presence of *Epileptobos* in Trinil he used as evidence to reject the conclusions of VON KOENIGSWALD (1934).

The conclusion of BARTSTRA (this volume) that the Trinil fauna is mixed and ranges from Middle to Late Pleistocene and Sub Holocene is now accepted by HOOIJER (this volume), since he states: 'It is therefore futile to attempt to sort out a pure Trinil fauna'. This is only futile, however, if one follows the working method of HOOIJER. He considers it 'a serious omission' that DE VOS ET AL. do not include his so-called *'Elephas celebensis'* in the fauna list of Trinil s.s. This specimen was not included because it was bought at Trinil in November 1972 (HOOIJER, 1974, p. 90). We agree with BARTSTRA (this volume), that the locality indications of purchased fossils are not reliable. DE VOS et al. (1982) and DE VOS & SONDAAR (1982) stated clearly that they only used specimens of which the exact provenance is known. Purchased fossils do not belong in this category and are omitted in order to get a realistic fauna list of a locality.

HOOIJER (this volume) mentions *Manis palaeojavanica,* which was still present in the fauna of the Niah caves (40,000 years old) 'but (has) not so far been found at Trinil proper'. This substantiates the ideas of DE VOS ET AL. (1982) and DE VOS & SONDAAR (1982) and contradicts the statement of BARTSTRA (this volume) that the specimen of this genus originated from the so-called Pucangan Formation near Kedung Brubus.

Manis, Hyena, Elephas, Tapirus, Epileptobos, are not present in the Trinil locality, which has been demonstrated by two independent and very extensive excavations, by DUBOIS, from 1891-1900 and by the Selenka expedition from 1906-1908. From the absence of these taxa it can therefore be concluded that these animals were not living in the area during the deposition of the bonebed (Hauptknochenschicht). HOOIJER (this volume), however, rejects this conclusion, without arguments, as being 'patently wrong'. We take the absence of these animals as a hard paleofaunistical fact, which is of use for biostratigraphical purposes.

The remark of HOOIJER (this volume) that he considers Kedung Brubus to range from Upper Pliocene to Upper Pleistocene without further comment, comes as a surprise because in his latest publication on this subject (HOOIJER, 1975) he held the opinion that this locality is of Middle Pleistocene age. The supposed presence of three subspecies of *Hippopotamus sivalensis* in this fauna is based on little and fragmentary material and is therefore doubtful.

NINKOVICH ET AL. (1982) reconstructed the paleogeography of the area considered. The concluded: 'During the Early Late Pliocene sea level dropped an estimated 40 metres, still not sufficient to link Java with the Asian mainland. It was not until the more extreme climatic shifts during the Latest Pliocene that sea level dropped far enough to expose a substantial part of the Sunda shelf and permit faunal exchange between Asia and Java. This exchange continued sporadically during glacial stages of the late Pliocene and Early Pleistocene. It was probably not until the advent of extreme glacial

events beginning during the Middle Pleistocene that the entire Sunda Shelf was exposed for any length of time'.

These conclusions corroborate our reconstruction of the paleogeography as deduced from the faunal sequences. The older part of the Kali Glagah fauna from West Java and Sangiran might be interpreted as an insular fauna and is probably of Late Pliocene age (SONDAAR, 1981). The composition of the younger Trinil fauna suggests a very limited faunal exchange with the Asian mainland. The Trinil fauna is poor in species and endemic taxa are present: *Duboisia* and *Rattus trinilensis,* (MUSSER, 1982). It therefore represents a type 2 fauna in the scheme of DERMITZAKIS & SONDAAR (1979), which means a peninsular or disconnected part of the continent.

The younger Kedung Brubus fauna is more balanced and points to a better faunal exchange with the mainland, which may be related with the extreme glacial events during the Middle Pleistocene as reconstructed by NINKOVICH ET AL. (1982).

CONCLUSIONS

BARTSTRA (this volume) and HOOIJER (this volume) fail to demonstrate that the conclusions of DE VOS ET AL. (1982) and DE VOS & SONDAAR (1982), as summarized in the introduction of this paper, are not correct.

In their attempt to demonstrate the incorrectness of these conclusions they depend largely on lithostratgraphic and chronostratigraphic arguments, whereas the findings of DE VOS ET AL. and DE VOS & SONDAAR (1982) are strictly limited to biostratigraphy. It is shown in this paper that BARTSTRA's and HOOIJER's concept of litho-, chrono-, and biostratigraphy is outdated and fundamentally incorrect.

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EDITORS' COMMENT

We consider the foregoing debate as unduly long for a written discussion. The commentators, however, insisted that only a thorough and detailed analysis could guarantee that the topic under discussion is dealt with adequately. We decided to publish the discussion virtually as submitted, because otherwise it would not have been published in these pages at all.

We think that the discussion is important; it bears on the famous excavations in Java, where the bones were unearthed on which stand the age and evolution of Early Man in Asia. There, since the latter part of the 19th century, eminent Dutch professional and amateur (?) scientists took part in the search for the 'Descent of Man'.

Whatever the outcome of the debate, it certainly emphasizes the need for every scientific collector to discipline him/herself to carefully locate, collect, describe and document samples, preferably according internationally established and approved methods.