# The age of the hominid-bearing deposits of Java: state of the art

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## Abstract

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The new standard biozonation for the Plio-Pleistocene continental deposits of Java, and its paleogeographical implications, are discussed. The four oldest faunal zones, Satir, Ci Saat, Trinil and Kedung Brubus, of this biozonation are identified in the famous vertebrate-bearing strata around Sangiran. Thanks to this biostratigraphy and to the availability of lithostratigraphically controlled absolute dates from the Sangiran area (provided by the joint Indonesian-Japanese Research Programme CTA-41) it is now possible to date the biostratigraphy:
Kedung Brubus fauna:  around 0.8 Ma
Trinil H.K. fauna:      around 1.0 Ma
Ci Saat fauna:          around 1.2 Ma
Satir fauna:            around 1.5 Ma
Semah's (1982) interpretation of the magnetostratigraphic data from the Sangiran area is not the most plausible one and an alternative is presented.

## Introduction

In the last three years the discussion on the age of the Javanese hominids has been revived by the availability of new data and by a reconsideration of old data. In general the new ideas do not fit the 'classic' bio-, litho- and chrono-stratigraphic framework for Java, which is still defended by a few authors. It is not the purpose of this paper to continue the debate on the principles of stratigraphy as applied in the past (vide Sondaar et al. 1983), but to review the newest data, to see how they fit together and to present a preliminary report of our current research.

## Faunal evolution on Java

Recently the biostratigraphic concept for the Plio-Pleistocene continental deposits on Java has changed drastically. De Vos et al. (1982) pointed out that the 'classic' biostratigraphy of the Javanese Pleistocene (Jetis fauna – Trinil fauna – Ngandong fauna, senso Von Koenigswald 1934) is no longer tenable.

They concluded that the Trinil Haupt Knochenschicht fauna (= Trinil fauna s.s., which is exclusively based on the fossils from the main bone bed naar Trinil) and not the Trinil fauna senso Von Koenigswald (which is a composite fauna list based

on several localities) is older than the composite Jetis fauna of Von Koenigswald. Consequently, according to De Vos et al. (1982), *Homo modjokertensis* is not older, but younger than the type specimen of *Homo erectus* from the main bone bed near Trinil (Trinil H.K.).

It was also pointed out that the latter fauna is relatively poor in species, which, in combination with the presence of endemic taxa (*Duboisia* and *Rattus trinilensis*), is an indication for isolated paleogeographic circumstances.

In their biostratigraphic scheme the next younger episode is characterized by the fauna from Kedung Brubus, which is a more balanced fauna with new arrivals like *Tapirus, Epileptobos, Hyaena* and *Elephas*, which point to a better landconnection with the mainland. The younger Ngandong fauna contains more advanced forms and lacks the endemic genus *Duboisia*.

Hardjasasmita (1982) demonstrated that this faunal succession can be characterized also by means of the Suidae: the Trinil H.K. fauna by *Sus brachygnathus*, the Kedung Brubus fauna by *S. brachygnathus* and *S. macrognathus* and the Ngandong fauna by *S. macrognathus*.

Von Koenigswald (1939) considered the fauna from the Punung cave in central Java as part of his Trinil faunal zone (Trinil fauna s.l.), but according to De Vos (1983) the Punung fauna is much younger and comparable with the *Pongo* faunas from cave deposits in the Padang highland, Sumatera (table 1). He considered the Punung fauna to be intermediate in age between the Ngandong and Wajak fauna's (Van den Brink 1982).

Sondaar (1984) discussed this faunal succession in more detail and added two fauna's, older than Trinil H.K., to this faunal succession (Table 1): the Satir fauna and the Ci Saat fauna, respectively from the lower and the middle part of the Kali Glagah Formation near Bumiayu on the boundary of West and Middle Java. The Kali Glagah Formation, consisting of fluviatile deposits, overlies the marine Kali Biuk Formation. The Satir fauna represents the oldest mammal assemblage known from Java and is characterized by the presence of the primitive elephant *Mastodon* and the giant tortoise *Geochelone*. Furthermore, Cervidae and a primiti-
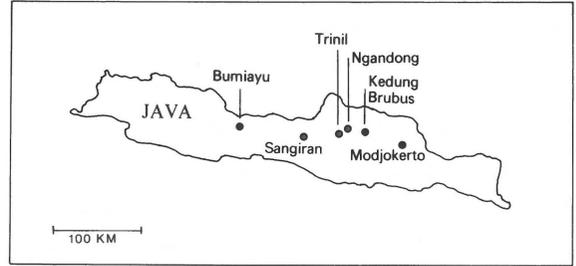


*Fig. 1.* Locality map.

ve *Hexaprotodon* are present in this fauna. The limited number of taxa present in this fauna (unbalanced) as well as the composition of the fauna demonstrate that Java was isolated from the mainland after emerging from the sea. Elephants, ruminants (especially deer) and hippo's are good swimmers and are always among the first mammals to reach islands. The fossil faunas from the islands in the Mediterranean Sea demonstrate this with ample evidence (Sondaar 1977).

Furthermore, the presence of a giant land tortoise confirms the above-mentioned reconstruction of the paleogeography during the deposition of the lower part of the Kali Glagah Formation which contains the Satir fauna (Table 1).

The next younger fauna (Ci Saat fauna), from the middle part of the Kali Glagah Formation is still poorly known, but it contains faunal elements newly arrived on Java: the *Mastodon* is replaced by the more advanced elephant *Stegodon*, while Bovidae and a large felid are also present.

On the basis of the foregoing we can reconstruct the fauna evolution on Java as follows (see also Table 1):

1) Shortly after emergence the island of Java was invaded and inhabited by a typical and unbalanced island fauna, which consisted of Cervidae, *Hexaprotodon, Mastodon* and *Geochelone* (Satir fauna).

2) Subsequent arrival of new taxa (especially bovids, a felid, a suid (?) and *Stegodon,* points to less isolated circumstances (Ci Saat fauna).

3) Further improvement of the connections with the mainland enabled *Homo erectus, Meganthropus, Rhinoceros,* and *Sus brachygnathus* (Trinil H.K. fauna) to arrive on the scene. The land connection with the mainland, however, was not

*Table 1.* Faunal succession based on mammals and Geochelone, after De Vos *et al.* (1982), De Vos (1983) and Sondaar (1984). First* and last° occurrence of Proboscidians.

| Faunal succession | | Environment | Some localities with land vertebrates |
|---|---|---|---|
| Recent | | | |
| Wajak | Wadjak Man (*Homo sapiens*) fauna has a recent character with a few extinct species | open woodland | Wajak |
| Punung | *Pongo, Hylobates, Ursus malayanus, Elephas maximus*, *Sus vittatus, Capricornis.* | humid forest | Punung |
| Ngandong | *Stegodon trigonocephalus°, Sus macrognathus, Elephas hysudrindicus°, Homo erectus ngandongensis* | open woodland | Ngandong, Sidorejo |
| Kedung Brubus | new arrivals of: *Tapirus, Hyaena, Epileptobos, Elephas hysudrindicus*, Sus macrognathus, Stegodon hypsilophus*°* | open woodland | Kedung Brubus, Jetis, in the so-called 'Kabuh' of Sangiran |
| Trinil H.K. - - - - - | endemics, like *Duboisia* and *Rattus trinilensis*. relatively | open woodland | Trinil H.K., 'Grenzbank' in Sangiran area, |
| Ci Saat | poor in species. *Meganthropus, Rhinoceros, Sus brachygnathus. Homo erectus erectus, Stegodon trigonocephalus*, bovids and large felid.* | | Ci Saat, upper part of the 'black clays' of Sangiran, Ci Julang? |
| Satir | unbalanced island fauna with: *Mastodon*°, Hexaprotodon, Cervidae* and Geochelone | partly mangrove forest | Satir (loc. 1-4), middle part of the 'black clays' of Sangiran. |

yet fully established and the Trinil H.K. fauna still shows a low diversity with endemic taxa (*Duboisia* and *Rattus trinilensis*).

4) Later, a good connection with the Asian mainland permitted the existence of a balanced fauna on Java with new fauna elements: *Tapirus, Hyaena, Elephas, Epileptobos* and *Sus macrognathus* (Kedung Brubus fauna).

5) The connection with the mainland persisted (?), but the fauna from Ngandong, which is representative for this episode, is still insufficiently described (the second author currently started this research). It differs, however, from the former fauna by the absence of *Sus brachygnathus* and *Duboisia* and the presence of *Homo erectus ngandongensis*.

6) The next episode is characterized by a quite different fauna. *Stegodon* and *Elephas hysudrindicus* are replaced by *Elephas maximus*, a new migrant. In this fauna we find for the first time the extant species of *Sus vittatus*. *Pongo* (orang-utan) is typically abundant. Further taxa in this fauna are:

*Hylobatus, Ursus malayanus* and *Capricornis sumatraensis*. On the basis of the high number of *Pongo* fossils, this fauna is interpreted as characteristic of a humid forest. Based on the fauna an interglacial period is supposed (Punung fauna).

7) In the Wajak fauna, which comes next, *Elephas* is not present. Tapirus is found, however, and probably documents its last occurrence on Java. This fauna bears an open woodland character, indicating a colder period.

The revision of the classification of certain taxonomically doubtful groups (e.g. Hippopotamidae, Bovidae, Cervidae) as well as the ongoing description of the Ngandong fauna will refine this scheme. Knowledge of the fossil rodents from the various faunas, which is still virtually nihil, will contribute significantly to this biostratigraphy. In the 1984 fieldseason, large-scale sampling for fossil rodents has been carried out near Trinil and in the Bumiayu area.

170

### The biostratigraphy of the Sangiran area

Although the Sangiran area is famous for its vertebrate fossils (especially the hominids), and a good lithostratigraphic succession is exposed, none of the faunal assemblages used for the proposed new bio-stratigraphic zonation originates from this area. This is mainly due to the fact that no locality data are available for most fossils in the existing collections from this area. Even the lithological unit from which they originate is not known. The lithostratigraphic concept of the area has been discussed recently (Sondaar et al. 1983; Watanabe & Kadar, in press) and new, locally defined formations are being introduced. For the time being we will refer to the various lithological units that are mentioned in this paper as follows (from bottom to top): marine clays (=so-called Kali Beng Formation), black clays (=so-called Pucangan Formation, estuarine clays); Grenzbank (=boundary bed) (calcified conglomerate bed); 'kabuh-beds' (=so-called Kabuh Formation, fluviatile deposits).

Fortunately, the detailed lithostratigraphic cor-

relations and systematic excavations in the Sangiran area, carried out by a joint Indonesian-Japanese team (Indonesia-Japan Research Cooperation Programme CTA-41) from 1977 till 1979 provided new stratigraphic information:

1) The fauna from the middle part of the black clays (mainly Cervidae and Hippopotamidae) reported by Aimi & Aziz (in: Watanabe & Kadar, in press), is interpreted by Sondaar (1984) as an unbalanced island fauna. In the upper part of the black clays also *Bubalus* and *Bibos* have been found, as well as *Stegodon* (Aziz, 1980, unpublished report). From the Grenzbank Aimi & Aziz collected a more diverse fauna with also Carnivora, Rhinocerotidae, Suidae and the endemic antilope *Duboisia*. The first presence of *Elephas* is reported from the 'kabuh-beds'.

2) Matsu'ura (1982) demonstrated that the fluorine content of the fossils from the various lithological units varies (Fig. 2). On that basis he concluded that all fossil hominids from the Sangiran area, originate from the Grenzbank and the 'kabuh-beds', with the possible exception of *Pithecanthropus* IV, *Pithecanthropus* B and *Pithecanthropus*
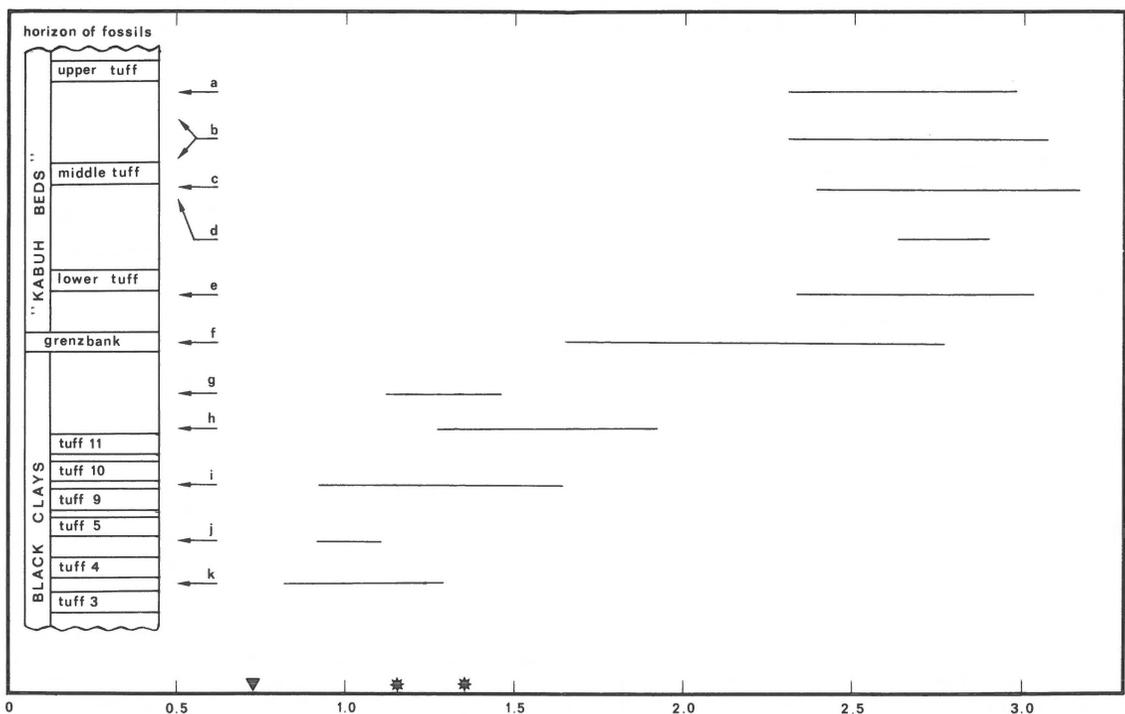


*Fig. 2.* Ranges of the fluorine content of vertebrate fossils from the various lithological units in the Sangiran area after Matsu'ura (1982). Fluorine content of fossils of unknown locality measured in Utrecht: * *Mastodon*; ▼ *Geochelone*.

*dubius*, which fossils may also originate from the upper part of the black clays. The source bed of *Pithecanthropus* II, which closely resembles the holotype from Trinil, is most probably the Grenz-bank.

It is now possible, by measuring the fluorine content, to trace back the source beds of biostratigraphically important fossils from old collections which lack locality data. For example, Von Koenigswald (1940) mentioned a tooth fragment of *Mastodon bumiajensis* from an unknown locality in the Sangiran area. On the basis of the fossilisation he concluded that it originated from the 'Kali Beng Formation', which underlies the 'black clays'. The presence of *Mastodon* is of great significance since this primitive elephant was among the first invaders of Java and is characteristic for the Satir faunal zone from the lower part of the Kali Glagah Formation near Bumiayu. Last year, two *Mastodon* teeth fragments from Sangiran were found in the old collections of the Geological Museum in Bandung (no. K310 and K311), of which the fluorine content was measured in Utrecht. The fluorine content of respectively 1.14% and 1.34% does not corroborate an origin from the 'Kali Beng Formation' as advocated by Von Koenigswald (1940), but indicates that K310 must be from the middle part of the 'black clays'. The content of K311 is less exclusive since it fits both the values from the middle and from the upper part of the 'black clays' (fig. 2). Another, biostratigraphically important, specimen from the Sangiran area without proper locality data was reported by Sondaar (1981): an epiplastron from the giant tortoise *Geochelone*. Giant land tortoises are typically part of isolated faunas and Sondaar therefore suspected that the specimen originated from the 'black clays', which unit produced an unbalanced island fauna. The fluorine content of 0.72% confirms this idea and locates it in the middle part of the 'black clays' (Fig. 2). Since *Geochelone* is also present in the lower part of the Kali Glagah Formation and since it is characteristic for the Satir faunal zone, it can be concluded that the fauna from the middle part of the 'black clays' near Sangiran should be correlated with the Satir faunal zone.

Also, the faunas excavated by the Indonesian-Japanese team from the other aforementioned lithostratigraphical horizons, can be linked to the new standard biozonation. The fauna from the upper part of the 'black clays' (with the first bovids and *Stegodon* replacing *Mastodon*), resembles the Ci Saat fauna from the middle part of the Kali Glagah fauna. The fauna from the 'Grenzbank', with *Homo* (=*Pithecanthropus*) *erectus erectus*, *Meganthropus*, *Sus brachygnathus*, *Duboisia* and *Rhinoceros*, is correlated with the Trinil H.K. fauna. The presence of *Elephas* among the fossils from the 'kabuh-beds', links this fauna to the kedung Brubus faunal zone (Fig. 1).

## Chronostratigraphy

Absolute ages have been reported from various lithological units and different places on Java. Many of these ages, however, are contradictory and confusing when they are applied to date the various geological and paleontological events. For instance, the age of the so-called Pucangan Formation in different places varies between 0.5 and 1.9 Ma as reported by Bartstra (1978). This is not surprising since absolute ages are only useful for correlation between lithostratigraphic and chronostratigraphic columns, when the lithostratigraphic correlations are reliable, which they are not in the case of the Javanese Plio-Pleistocene (Sondaar et al. 1983). If then, as a next step in an attempt to date the various faunas, this litho-chronostratigraphic scheme is correlated with the 'classic' biostratigraphic sequence, which is not tenable in itself (De Vos et al. 1982; Sondaar 1984), the confusion is complete.

In this paper we consider only the absolute dates as reported from the Sangiran area by the Indonesian-Japanese Research Program CTA-41, which resulted from systematic investigations in a lithostratigraphically controlled area. As discussed earlier, it is possible to recognize the new biostratigraphic standard zonation in the Sangiran area. It will therefore be possible to date the various faunal events on Java by means of the absolute dates from this area. Three sources of absolute dates are here considered:

A) Fission track dates from zircons in tuff beds as reported by Suzuki & Wikarno (vide Matsu'ura 1982; Watanabe & Kadar, in press):

| kabuh-beds | middle tuff | 0.78 ± 0.15 Ma |
|---|---|---|
| black clays (upper part) | tuff 10 | 1.16 ± 0.24 Ma |
| black clays (middle part) | tuff 6 | 1.49 ± 0.32 Ma |
| black clays (middle part) | tuff 5 | 1.51 ± 0.25 Ma |

B) The age of the tektites from Sangiran has been investigated by two different methods (Ninkovitch & Burckle, 1978), directly by fission track dating and indirectly by correlation with the tektite layer that was identified in deepsea-cores at the Brunhes-Matuyama boundary. Both methods establish the age of the tektites at about 0.7 Ma.

However, the source bed of the tektites in the Sangiran area was not exactly known (all tektites were surface finds) and therefore the correlation of this chronostratigraphic date with the lithostratigraphic column was doubtful. Ninkovitch & Burckle (1978) supposed that the tektites originated from the 'erosional surface that separates the Kabuh beds and Notopuro breccia'. During CTA-41 fieldwork the source bed was identified in the Pucung digging site, located between the upper and middle tuff (middle part of the upper half of the 'kabuh-beds') (fig. 2). This lithostratigraphic position of the 0.7 Ma date (and the Brunhes-Matuyama boundary), which is slightly lower in the section than suspected by Ninkovitch & Burckle, corroborates the zircon date of Suzuki & Wikarno (In: Matsu'ura, 1982) for the middle tuff (0.78 ± 0.15 Ma).

C) The magnetostratigraphy of the Sangiran area is discussed by Semah (1982). He reported (from top to bottom) a normal polarity for the 'Notopuro Formation', the 'kabuh-beds' and the Grenzbank. The first reversed polarity from the top of the 'black clays', a few metres below the Grenzbank, was identified as the Brunhes-Matuyama boundary (0.73 Ma). The next normal polarity was reported from the top of the marine 'Kali Beng Formation', just below the 'black clays' and identified as the top of the Olduvai event (1.67 Ma), which is com-patible with a K/Ar date (2.0 Ma ± 0.6) from the basis of the 'black clays' (Nishimura et al., 1981). However, this interpretation of the paleomagnetic data faces two major problems: a) The Brunhes-Matuyama boundary (around 0.7 Ma) is far too low in the section (just below the Grenzbank). As mentioned before, this boundary was situated (as established by three different methods) in the upper half of the 'Kabuh-beds'. b) The Jaramillo normal event (from 0.97 to 0.87 Ma) is absent. According to the interpreation of Semah this normal event should be present in the samples from the 'black clays'. Semah explained its absence by incomplete sampling due to landslides. However, another interpretation of the magnetostratigraphic data is more plausible: the change in polarity from normal to reversed in the top of the 'black clays' does not represent the Brunhes-Matuyama boundary, but corresponds with the base of the Jaramillo event (0.97 Ma), which corroborates the zircon date (1.16 ± 0.24 Ma) from tuff 10 in the upper part of the 'black clays'. Also in this interpretation a paleomagnetic event (the reversed period between the Brunhes normal period and the Jaramillo normal event) would be missing in SÈMAH's data. It should, however, also be noted that in this model, the missing normal polarity is situated in the middle part of the 'kabuh-beds', i.e. in coarse clastic sediments with internal erosional contacts; a hazardous lithology for magnetostratigraphic research.

## Conclusions

Combining the chronostratigraphic data with the biostratigraphic model results in the following ages for the various faunas:

| | |
|---|---|
| Kedung Brubus fauna: | around 0.8 Ma |
| Trinil H.K. fauna: | around 1.0 Ma |
| Ci Saat fauna: | around 1.2 Ma |
| Satir fauna: | around 1.5 Ma |

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