PERTEMUAN ILMIAH ARKEOLOGI VI

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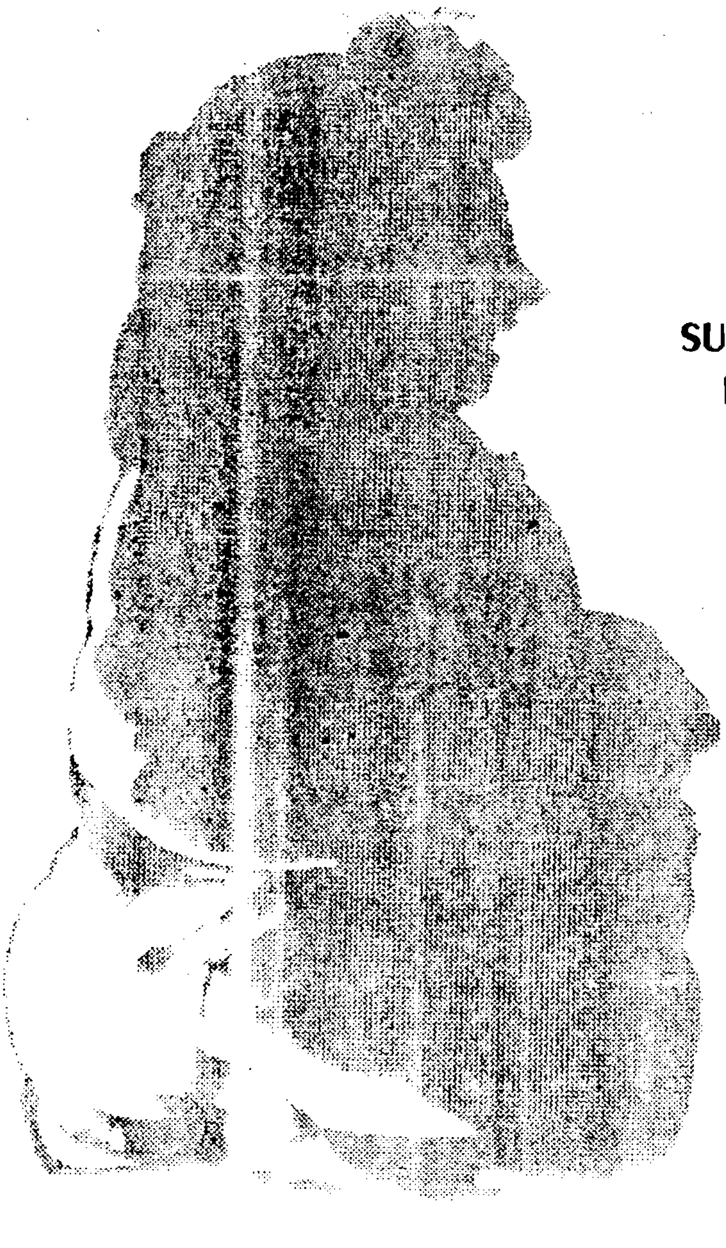
BUKU PANDUAN



SUMBANGAN ARKEOLOGI UNTUK
PERKEMBANGAN MASYARAKAT
DAN KEBUDAYAAN INDONESIA

CHRONOLOGY AND PALAEOENVIRONMENT OF PLIO-PLEISTOCENE DEPOSITS IN THE SOLO DEPRESSION (CENTRAL JAVA): THE KALIUTER AREA AND ITS RELATIONS WITH THE ANCIENT JAVANESE SETTLEMENTS.

by Tony DJUBIANTONO, François SÉMAH, Anne-Marie SÉMAH

Kronologi dan Paleoekologi endapan Plio-Plistosen di Depresi Solo (Jawa Tengah): Daerah Kaliuter dan hubungannya dengan kolonisasi pertama Pulau Jawa.

RINGKASAN

A. Pendahuluan tentang seri stratigrafi Kaliuter

Depresi Solo, yang terletak di bagian tengah Pulau Jawa, diapit oleh Perbukitan Kendeng dan Pegunungan Selatan. Daerah tersebut, termasuk lereng Selatan Pegunungan Kendeng, yang mengandung banyak situs paleontologi dan prasejarah terkenal, seperti Kubah Sangiran.

Secara umum, stratigrafi yang dapat kita tinjau di depresi Solo menunjukkan seri regresi lautan antara zaman Pliosen atas dan Plistosen tengah.

Lapisan pengandung fosil selalu dimulai dengan lapisan pertama yang berfasies daratan.

Namun, fosil vertebrata dan manusia purba yang kita dapat di daerah Sangiran telah diangkut jauh dari tempat hidupnya, kemudian diendapkan kedalam cekungan depresi Solo. Apabila kita ingin meneliti tentang kolonisasi pertama Pulau Jawa oleh fauna mammalia dan manusia purba, perlu kita mencari situs yang lebih dekat dari pegunungan yang telah berada pada zaman itu, misalnya Perbukitan Kendeng.

Dari segi itu kita memilih daerah Kaliuter sebagai daerah penelitian. Disini kita bisa meninjau suatu seri stratigrafi lautan dangkal yang sangat tebal, dimana perlipatannya memberikan banyak informasi langsung tentang evolusi tektonik Perbukitan Kendeng. Disamping itu juga, di daerah tersebut kita telah menemukan beberapa situs paleontologi baru, seperti situs Kedung Cumpleng (dengan beberapa artefak batu) dan situs Pancuran (di mana ditemukan dua gigi manusia purba).

B.Penelitian Paleomagnetisma

Analisis paleomagnetisma ternyata sangat sesuai apabila kita mau mempelajari secara kronologis lintasan-lintasan daerah Kaliuter. Kenyataannya, lapisan pengandung hasil kegiatan gunungapi sulit dianalisis dengan metoda pertanggalan mutlak seperti Potassium Argon, dikarenakan mineral-mineral telah mengalami proses pelapukan yang sangat panjang.

Beberapa zona polariti geomagnetik purba dapat dilihat pada setiap lintasan yang diteliti.

Secara keseluruhan, ternyata ada suatu kontradiksi antara hasil yang dicapai di daerah Barong (paling Utara) dan di lintasan lainnya. Hal ini dapat membuktikan bahwa endapan lempung biru telah mulai lebih dahulu di Soko, di Selatan daerah Kaliuter.

Hipotesa paleomagnetisma menunjukkan bahwa transisi Brunhes/Matuyama (0.7 juta tahun) terletak di bagian atas seri lautan, pada lapisan batugamping Balanus.

Konglomerat Kedung Cumpleng dapat dipertanggalkan pada episode Jaramillo (0.87-0.97 juta tahun), sedangkan zone positip yang terdapat pada fasies gampingan di Soko dan di Barong berumur 1.67-2.1 juta tahun yang lalu (episode Olduvai dan Reunion). Bagian bawah dari lintasan Barong diendapkan pada awal periode Matuyama, antara 2.48 dan 2.2 juta tahun yang lalu.

C.Penelitian Palynologi

Analisis pollen telah dilakukan pada lintasan Soko, mulai dari lempung biru sampai lempung pasiran diatas lapisan konglomerat Kedung Cumpleng.

Pengaruh dari hutan payau ternyata sangat stabil di sepanjang lintasan tersebut. Hal ini sesuai dengan hasil analisis sedimentologi atas endapan laguna.

Lintasan Soko dimulai dengan suatu periode dimana perbukitan di sekitarnya dihuni oleh suatu hutan hujan tropis.

Kemudian kita mendapatkan suatu periode dengan penggantian antara hutan hujan tropis dan pemandangan terbuka (rumput).

Pada bagian dasar konglomerat Kedung Cumpleng, vegetasi sekitarnya berubah kembali menjadi hutan terbuka (iklim dengan musim kemarau panjang)

Sedangkan diatas konglomerat terdapat penggantian antara hutan hujan dan pemandangan terbuka.

Pada lapisan lempungan di bagian atas lintasan, rumput dan pakis menjadi dominan, dan vegetasi mencirikan suatu periode dengan kegiatan gunungapi.

D.Daerah Kaliuter dari segi Paleogeografi

Daerah Kaliuter sendiri memberikan banyak informasi tentang evolusi geologi depresi Solo.

-Fasies dangkal ditemukan pada lapisan yang cukup tua, yaitu di lintasan Barong lebih dari 2 juta tahun yang lalu.

-Pengaruh gunungapi adalah dominan pada lapisan teratas di Kaliuter, tetapi juga dapat dilihat pada lapisan lautan yang terakhir. Ternyata bahwa pengaruh kegiatan gunungapi terjadi lebih dulu, dan secara lebih intensif pada lintasan Soko, yang terletak paling Selatan

-Di daerah Kaliuter kita mendapatkan dua bukti tentang evolusi tektonik Perbukitan Kendeng:

1.Perlipatan terakhir, yang terjadi di sekitar 0.7 juta tahun yang lalu.

2.Konglomerat Kedung Cumpleng, yang membuktikan bahwa, pada satu juta tahun yang lalu, Perbukitan Kendeng sudah muncul diatas muka air laut; perbukitan tersebut sudah dihuni pada waktu itu oleh fauna mammalia serta manusia purba.

Dengan skala yang lebih luas, kita sekarang sudah bisa mengusulkan suatu evolusi paleogeografi yang meliputi daerah Sangiran-Kaliuter.

A. AN INTRODUCTION TO THE KALIUTER SERIES

by Tony DJUBIANTONO, François SÉMAH, Anne-Marie SÉMAH

I.The Solo depression

The Solo depression, in the centre of Java Island, is filled by large volcanoes and by quaternary alluvia. It is limited by the Kendeng hill range northwards, and by the Southern Mountains of Java.

Many important fossil-bearing sites are located within the depression or along the southern flank of the Kendeng hills, like: Bumiayu, Sangiran, Trinil, Kedungbrubus and Mojokerto (Fig.1)

As a bulk, the stratigraphical series we find in the Solo depression give the picture of the recession of the sea during the Upper Pliocene and the Pleistocene.

II.The Sangiran-Gemolong series

We shall recall briefly here the classical stratigraphical section of the Sangiran - Gemolong area, near Solo town (Fig. 2).

The section begins with open sea pliocene deposits, the so-called Lower Kalibeng *Globigerina* marls. The recessive facies appear during the Upper Pliocene, as blue clays deposited in a lagoon (Upper Kalibeng beds). Pollen analysis (A.-M. Sémah, 1986) show that the lagoon was bordered by a large mangrove forest formation. These recessive facies appear at about 2.4 m.yrs ago in Gemolong, and persisted until the Plio-Pleistocene boundary (F. Sémah, 1986).

Then we find volcanic breccia dated at about 1.6/1.8 m.yrs, which yielded the oldest vertebrate remains found in Sangiran (L.J.C. van Es, 1931), followed by the deposition of the thick fossil- bearing Pucangan clays -which already contain fossil mammals and hominids.

The top of the Pucangan unit consists of a conglomeratic fossiliferous layer, named Grenzbank (G.H.R. von Koenigswald, 1940). This layer is dated between 0.7 and 0.9 m.yrs ago (see F. Sémah, 1986; N. Watanabe and D. Kadar, 1985).

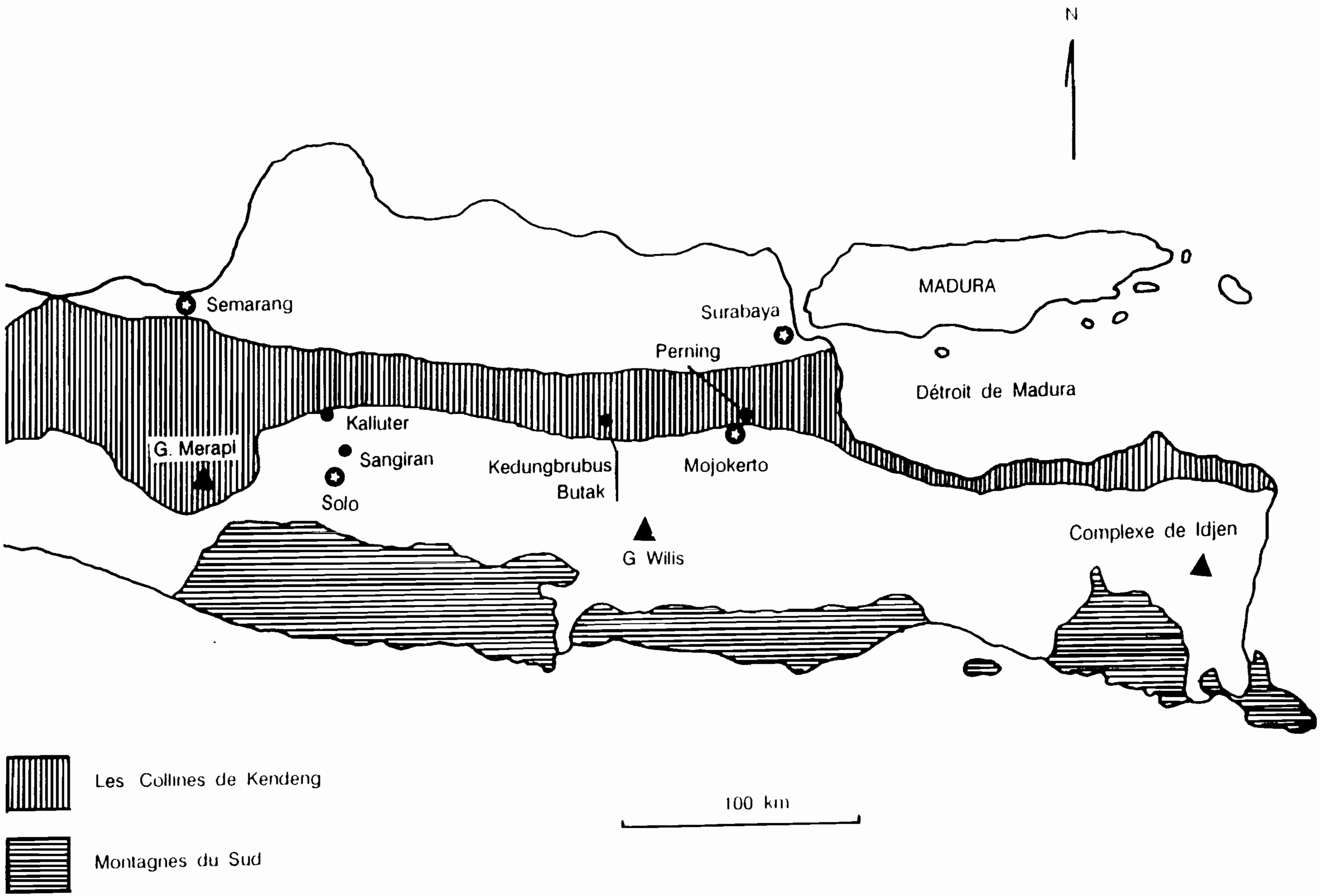


FIG 1 THE SOLO DEPRESSION

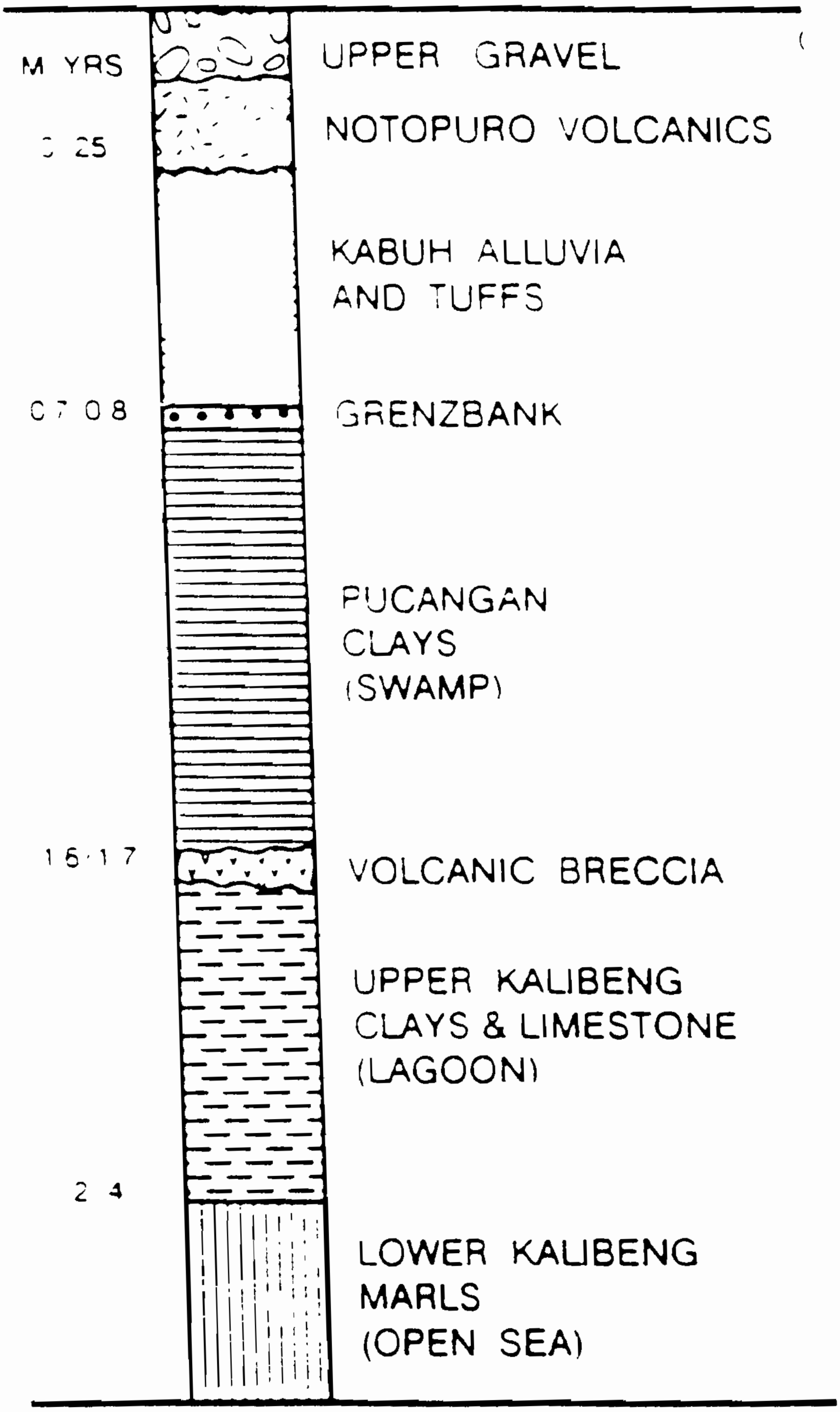


FIG. 2 SYNTHETIC SECTION OF SANGIRAN/GEMOLONG AREA

But the greatest number of mammals and hominids are found in the Kabuh volcano-sedimentary series, dating back to the Middle Pleistocene. One of the sites we presently excavate, at Ngebung, in the Sangiran dome, yielded several stone artifacts (F Sémah *et al* , 1992).

At the upper part of the section we find the Notopuro breccias and lahars (*ca*. 0.25 m yrs. M. Suzuki *et al*., 1985), and younger alluvial formations.

III.The interest of the Kaliuter area

Whatever the site we choose in the area, the oldest continental mammals appear within the first continental layers. If our interest focuses on the older Javanese settlements, it is therefore very important to study the last marine deposits, which precisely pre-date the colonization of Java.

Volcanism, tectonics, and especially the emergence of the Kendeng hills were at the origin of the recession of the sea in the Solo depression.

At Sangiran, we observe that mammals and hominid fossils are heavily rolled, and have suffered a substantial transport far from their habitat. Logically, this habitat has to be searched for nearer to the older reliefs which were already emerged at those times.

Sites which are located near the Kendeng hills are therefore likely to provide us with important information about the older settlement, and about the plio-pleistocene tectonics in the area.

This was the basis of our interest to study the Kaliuter area, on the Southern flank of the Kendeng hills, 30 km North of the Solo town (Fig. 3).

This area presents several advantages:

-we find there thick shallow marine deposits, in the form of continuous stratigraphical sections.

-from the tectonical point of view, the Kaliuter area is directly linked to the Kendeng hills, it is therefore definitely different from other sites like Sangiran, whose folding was linked with other phenomena (for instance diapirism).

-we discovered several new fossil-bearing sites near Kaliuter.

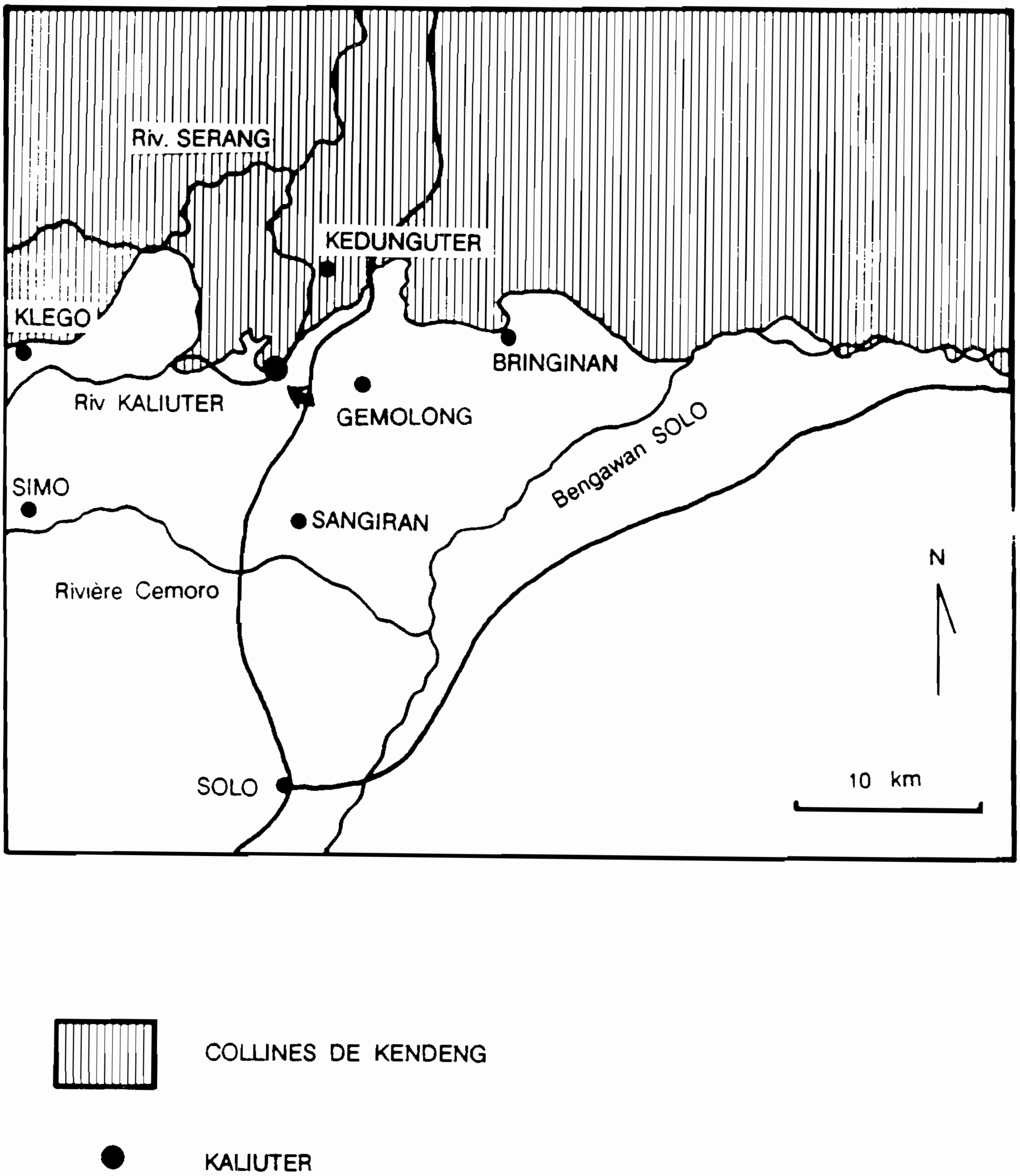


FIG. 3 LOCATION OF KALIUTER AREA

IV.The Kaliuter series

Louis Jean Chrétien van Es, a Dutch geologist, described in 1931 the stratigraphical series of Kaliuter and carried out complete geological mapping. But he did not mention the occurence of fossil mammal-bearing layers. The map given on Figure 4 is drawn from van Es' one, and completed by our own survey concerning several important stratigraphical boundaries.

We shared the stratigraphy between three parts:

-The folded series, mainly of marine character, which show a Southeast dipping linked to the Kendeng tectonics.

-The transitional series, contemporaneous of the folding event.

-The horizontal series, which postdate the last folding event.

Our stratigraphical work focused on several sections, the most important concerning the so-called folded series: Barong, Soko and Kedung Krujuk.

IV.1. The folded series

At Barong (Fig.5), at the basis of the section, we find the classical *Globigerina* marls, deposited in an open sea environment. These layers are covered by shallower deposits, like sandy clays which contain charcoals, leaves and seeds, fish and mollusca remains, and sometimes amber fragments. Higher we find banked limy layers with littoral mollusca and sea urchins. A cineritic layer is found in this part of the section, which ends by a clear contact with a fine-grained blue clay unit.

Along the Soko section (Fig. 6), we find first a yellow limestone with coral reef fragments, then the banked limy layers with mollusca, sea urchins and wood fragments. Then we have a more sandy layer, which contains a large amount of volcanic minerals. It forms the boundary with the blue clay unit.

The blue clays are very uniform. In their upper part, they show several oxydized sandy banks and thin cineritic layers. They end with a conspicuous deltaic conglomerate at Kedung Cumpleng, deposited in a coastal environment.

This conglomerate contains limestone pebbles, mollusca, corals and Balanus. Some rolled mammal bones are likely to be found here.

Then we find sandy clayey layers with fossilized trunks, a cineritic bed and again the blue clay facies.

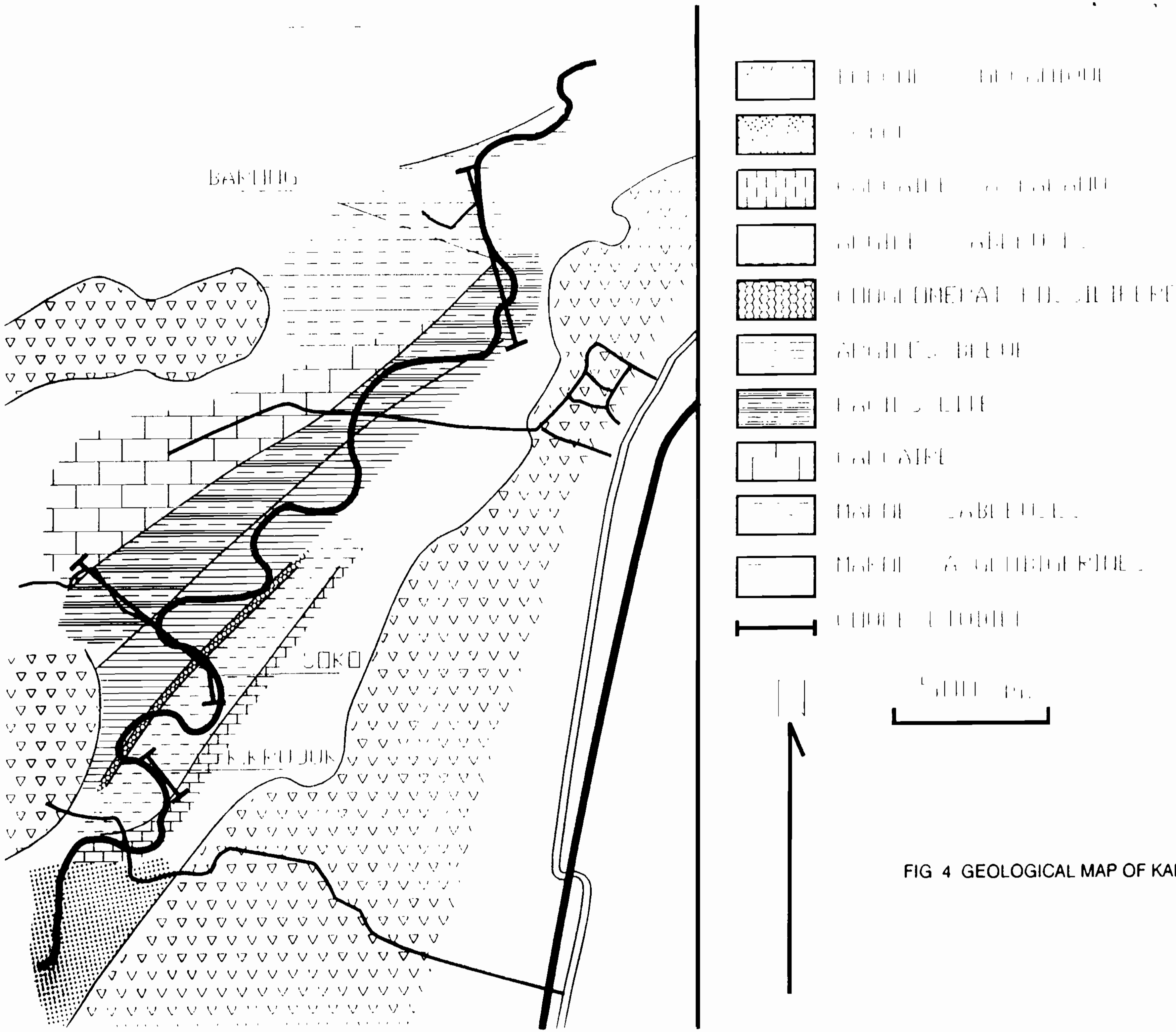


FIG 4 GEOLOGICAL MAP OF KALIUTER

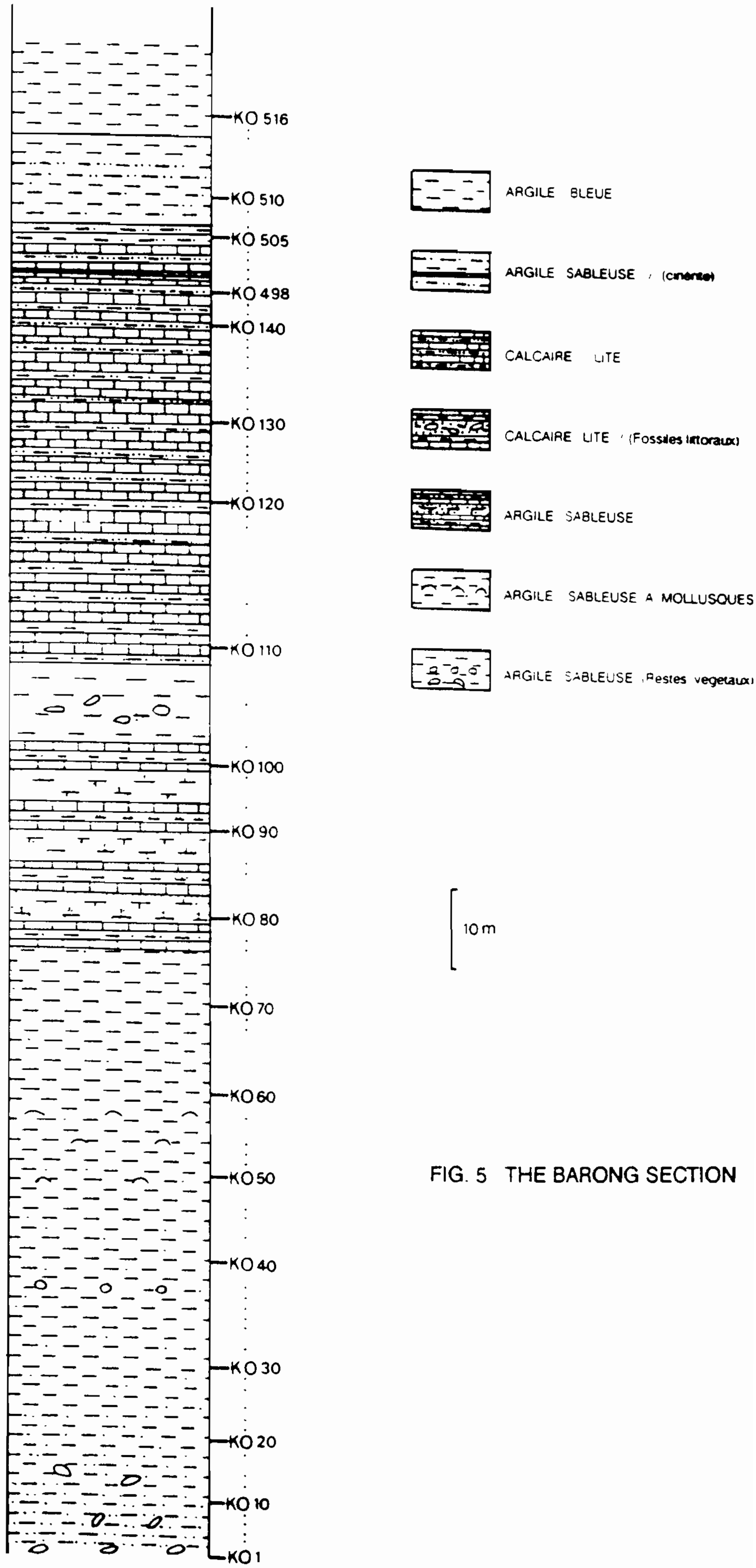


FIG. 5 THE BARONG SECTION

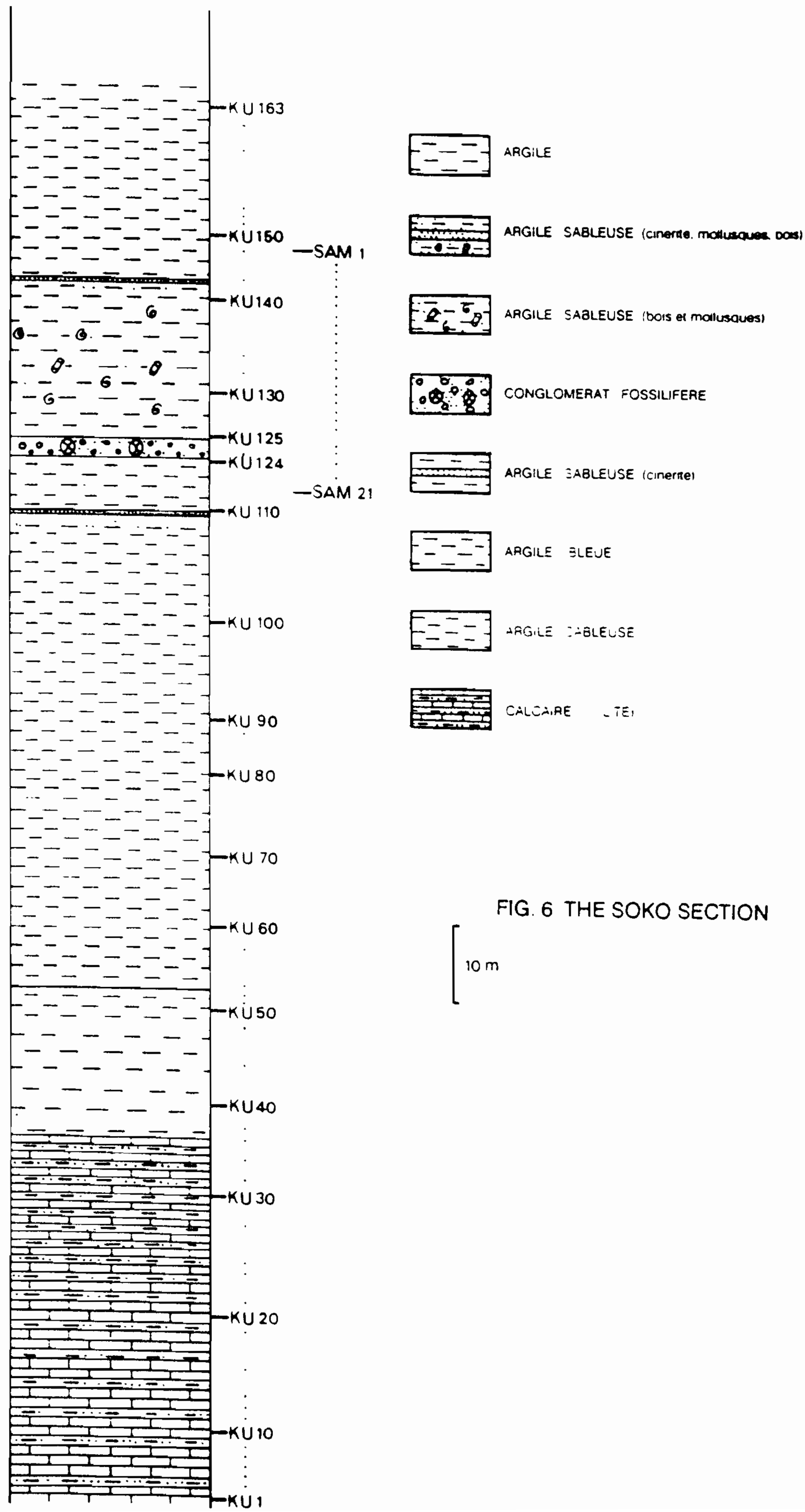


FIG. 6 THE SOKO SECTION

At Kedung Krujuk (Fig. 7), above the blue clays, we have cineritic banks, coastal limy sands and a very sandy conglomeratic layer which contains fossil mammals. The section ends with a thick *Balanus* limestone, the last marine layer which has a large extension in the area.

IV.2. The transitional series

The transitional facies, showing very irregular dippings, cover the Balanus limestones. These layers have undergone a tectonic influence. They consist of blue clays, cinerite, black clays and lignitic deposits with leaves and wood. We find also limy sands with molluscs, *Balanus* and sea urchins. The sands are often cemented, showing fossil dunes and beach surfaces, with a lot of fossil trees.

IV.3. The horizontal series

Any marine indication lacks from the horizontal series, which are characterized by fluviatile cross-bedded sands, tuffs and at the top by volcanic breccia of regional extension The sands contain a lot of mammal fossils, including a complete *Stegodon* jaw found near Kedung Kancil.

The Kaliuter stratigraphy ends with deposits which postdate the erosion of the hills by the river: alluvial terraces and travertines.

V.Archaeological excavations in Kaliuter

Since 1989, the whole of the area is covered by the Kedung Ombo dam lake. In 1987 and 1988, we organized excavations in order to collect data about the main sites which have disappeared now.

The Kedung Cumpleng excavation has been carried out in the deltaic conglomerate. It yielded mammal fossils like *Stegodon, Rhinoceros,* bovids, cervids et suids. We find also crocodile teeth, bones of tortoise, shark teeth and other fishes. Several bones have completely disappeared, and are replaced by their concretionated limy mold.

Many limestone pebbles are broken, and some pieces have been worked out by man. Among these items are several very flat flakes, and bifacial tools (Fig. 8, 9 and 10).

The Pancuran site belongs to the horizontal series which postdate the folding phase. It shows coarse fluviatile sands below the volcanic breccia. These sands contain a lot of fossil mammals like *Elephas, Rhinoceros,* cervids, bovids, suids, and also a cercopithecinae tooth.

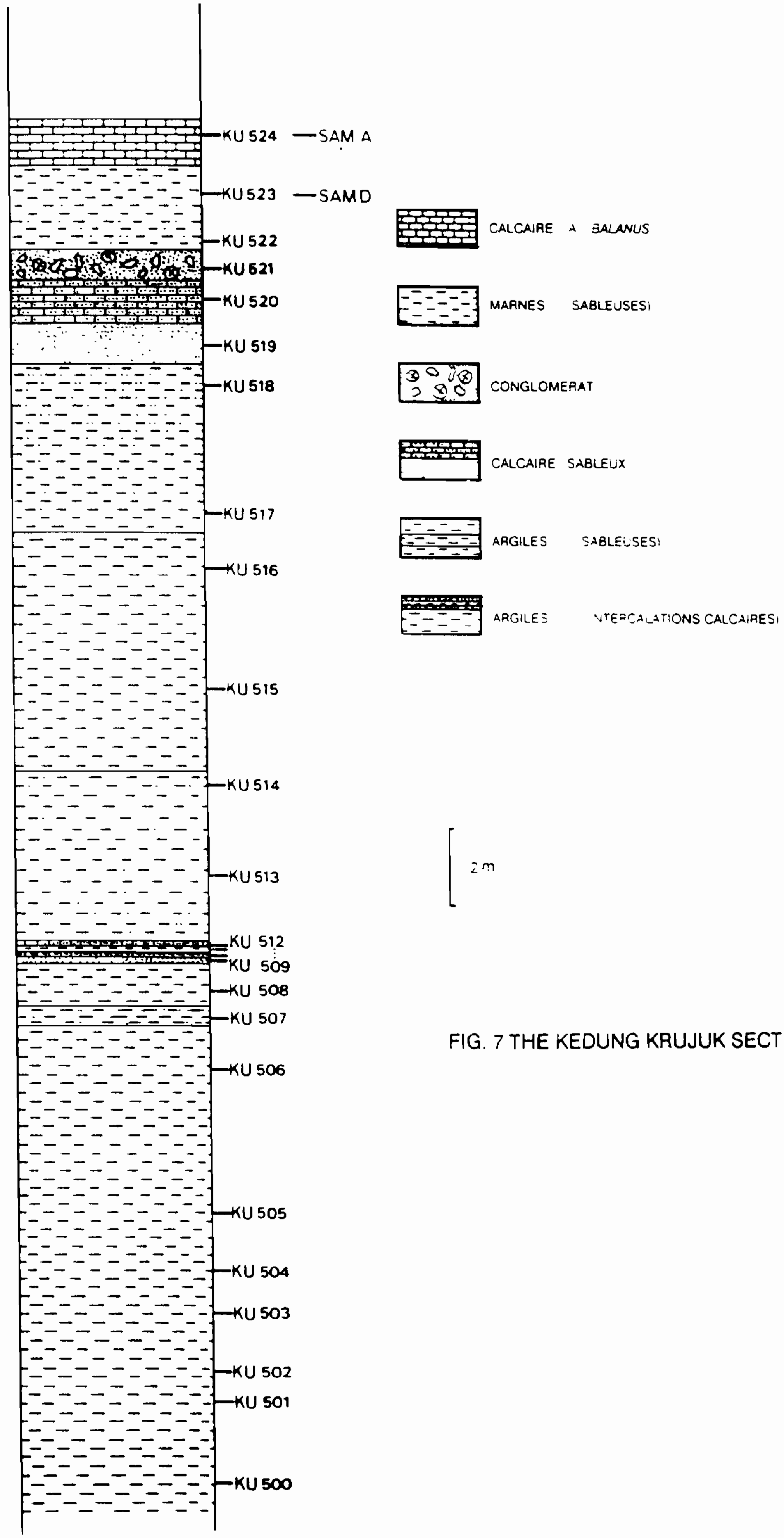


FIG. 7 THE KEDUNG KRUJUK SECTION

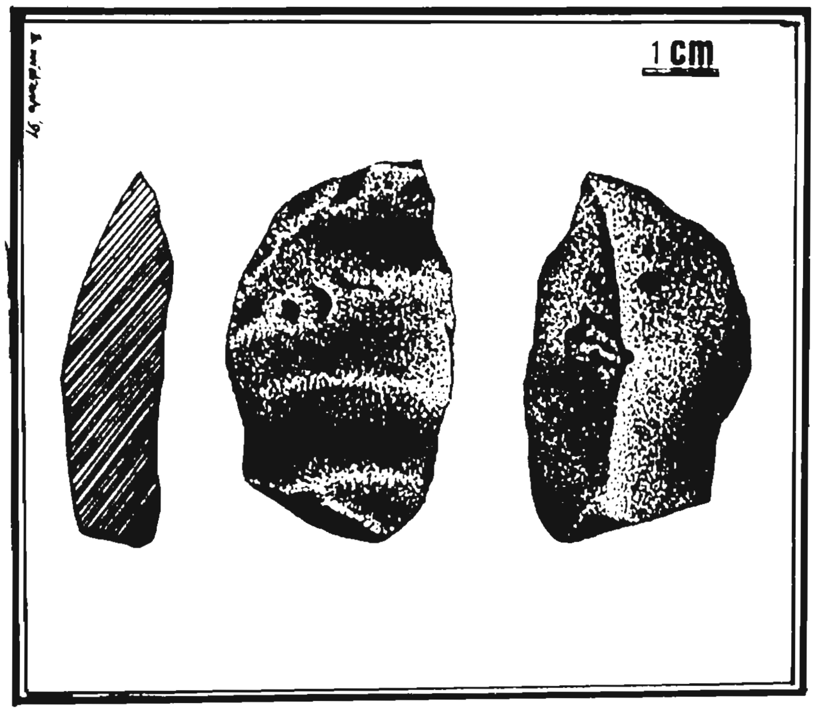


FIG. 8 KEDUNG CUMPLENG FLAKE (drawing H Widianto)

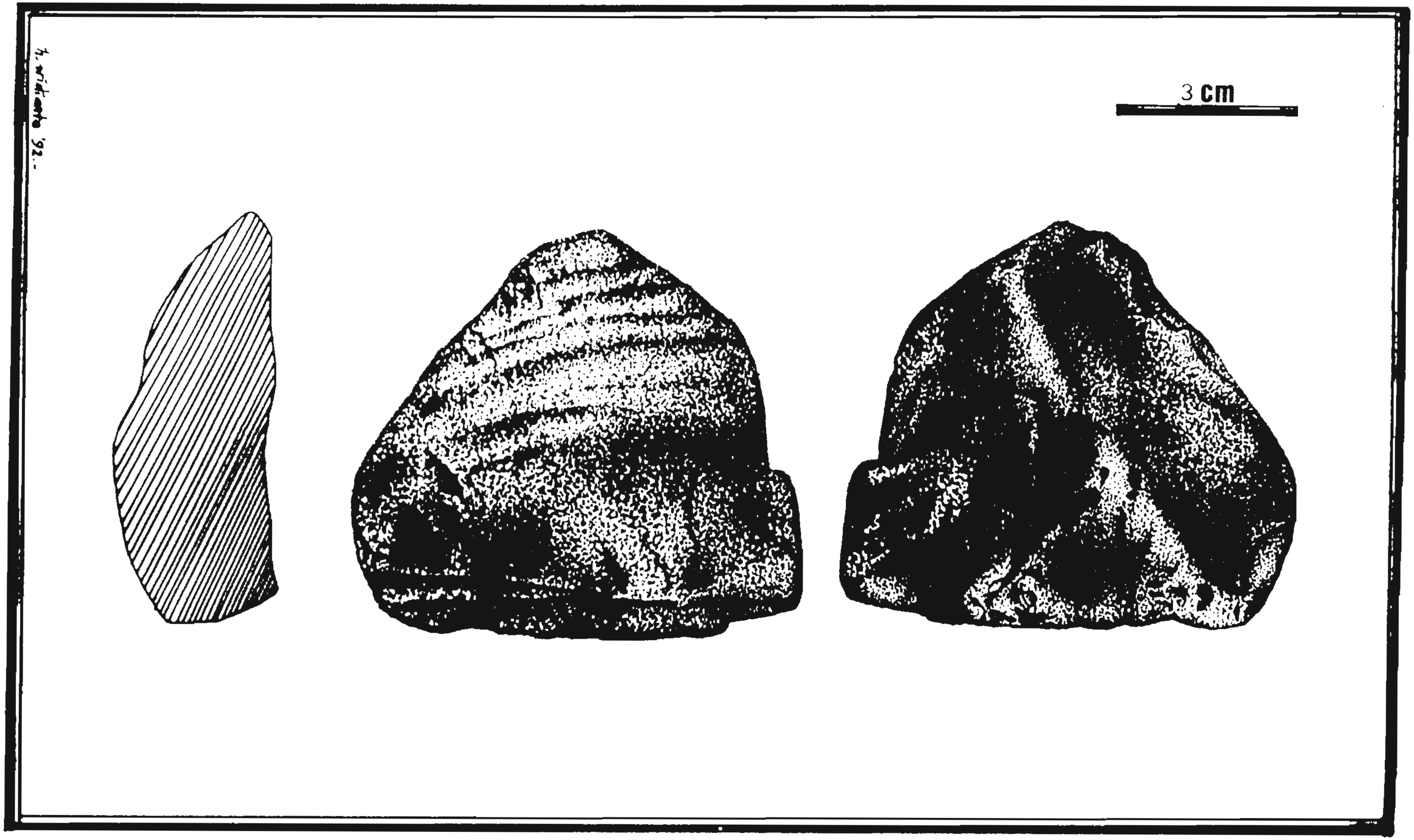


FIG. 9 KEDUNG CUMPLENG FLAKE (drawing H. Widianto)

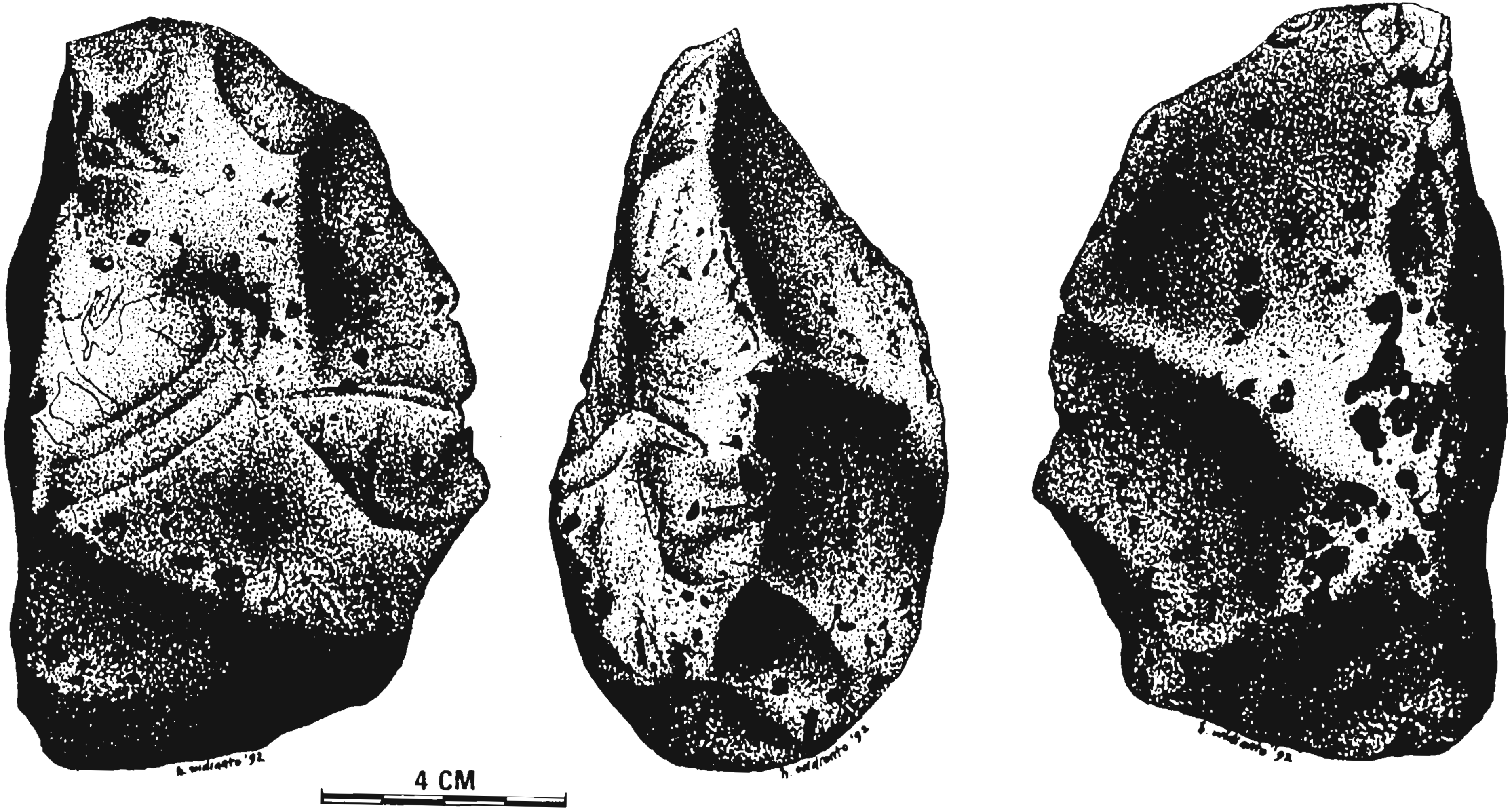


FIG. 10 KEDUNG CUMPLENG STONE TOOL (drawing H. Widianto)

Many of the bones are still in anatomic connection. The animals were killed just after a volcanic eruption, as the sinus of a young elephant skull are covered with cemented volcanic ashes.

The Pancuran site yielded also the first human fossils discovered in the Kaliuter area, *i.e* a molar and an incisor.

B.PALEOMAGNETIC STUDY OF THE KALIUTER SERIES

by Tony DJUBIANTONO

I.Paleomagnetic analysis

I.1.Methodological approach

Java Island is situated within a strong volcanic environment, but it is still difficult to date by geochronological methods the volcanic effluents intercalated in the quaternary fossil-bearing deposits

Indeed, these volcanic effluents are very often weathered volcanic ashes, which cannot be easily analyzed by means of Potassium Argon method. On the contrary, paleomagnetic analysis have given very important results on several stratigraphical series in the Solo depression. The thick Kaliuter sections are very suitable for such a research.

From a methodological point of view, our palaeomagnetic analysis on the Kaliuter sediments used a thermic attack of the viscous remanent magnetization (VRM) in order to get the direction of the primary detrital magnetization (DRM). The thermal attack has to match relaxation times of *ca.* 1 m.yrs before we can consider the obtained polarity with enough certainty.

The results we present here take the shape of angular distance to the present dipole field. This distance is zero for a pure normal polarity, and 180 degrees for a pure reversed polarity.

I.2. The Barong section

The 371 specimens of the Barong section first gave very scattered directions But several zones of magnetic polarity appear during the analysis, described as follow (Fig. 11)

-At the very basis of the section, a reversed zone followed by undetermined polarities:

-Then a reversed lower zone;

-An intermediate zone where normal polarities are dominant. But this zone is cut by an undetermined one and by a reversed subzone.

-In the upper part, a somewhat thick reversed zone.

On the stratigraphical representation (Fig. 12), we notice that the normal polarities disappear at Barong in the middle of the banked limestone facies, well below the contact with the blue clays.

I.3.The lower Soko section

The first measurements of the 214 specimens of the lower Soko section share them between a lower normal zone and an upper reversed one. The contrast becomes stronger after the thermal analysis (Fig. 13). The upper reversed zone gives very grouped results It begins just above the lower boundary of the blue clays (Fig. 14)

I.4.The upper Soko section

This section, including 82 specimens, directly follows the lower Soko section. The natural magnetization diagrams are hard to interpret, but the statistic means after thermal treatment give clear results. The section is shared between three zones (Fig. 15 and 16)

-The lower part, with blue clays, is reversed.

-Just above the Kedung Cumpleng conglomerate, normal polarities are dominant

-Reversed polarities are found again in the upper part.

I.5.The Kedung Krujuk section

The study of 48 specimens gives two zones on this section after thermal attack (Fig. 17 and 18):

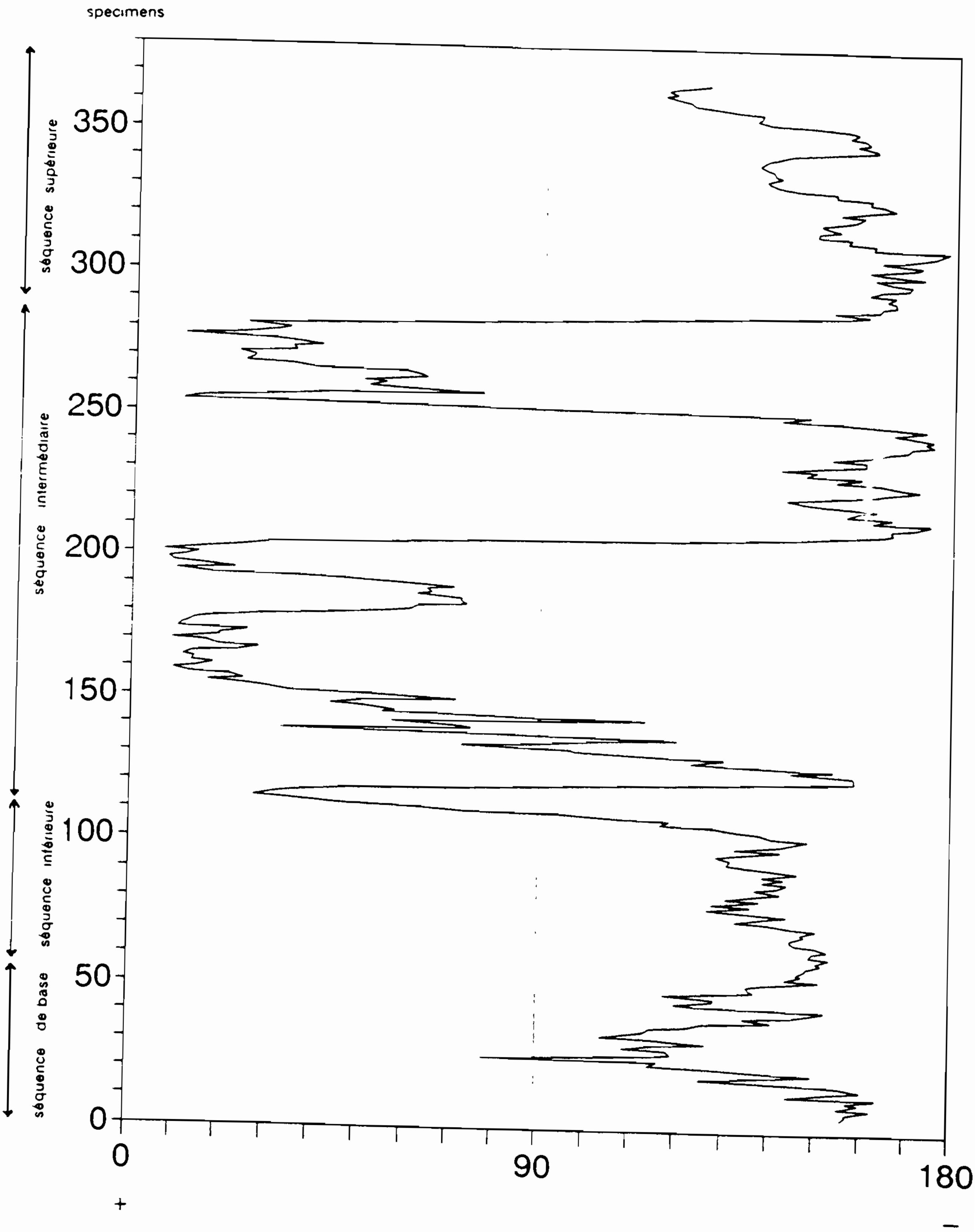


FIG. 11 BARONG, PALEOMAGNETISM

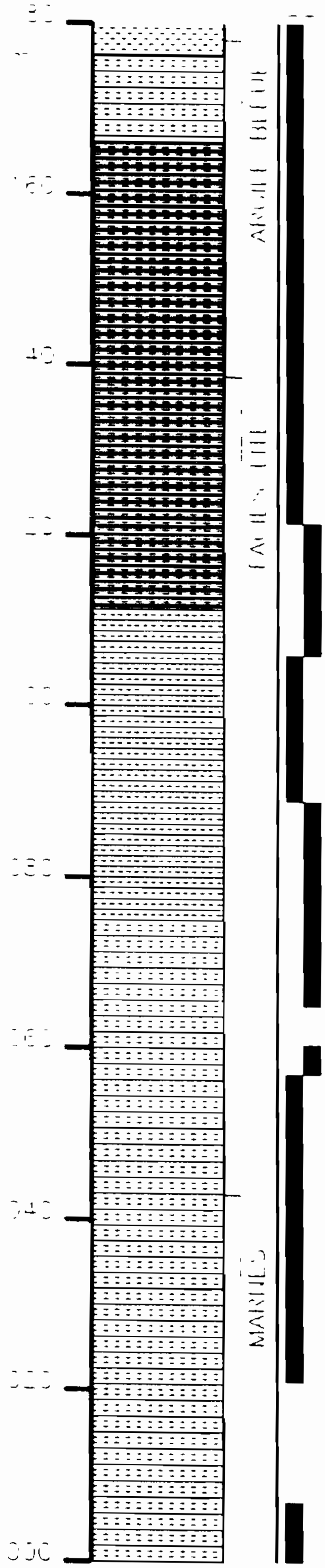


FIG. 12 BARONG , PALEOMAGNETISM vs. STRATIGRAPHY

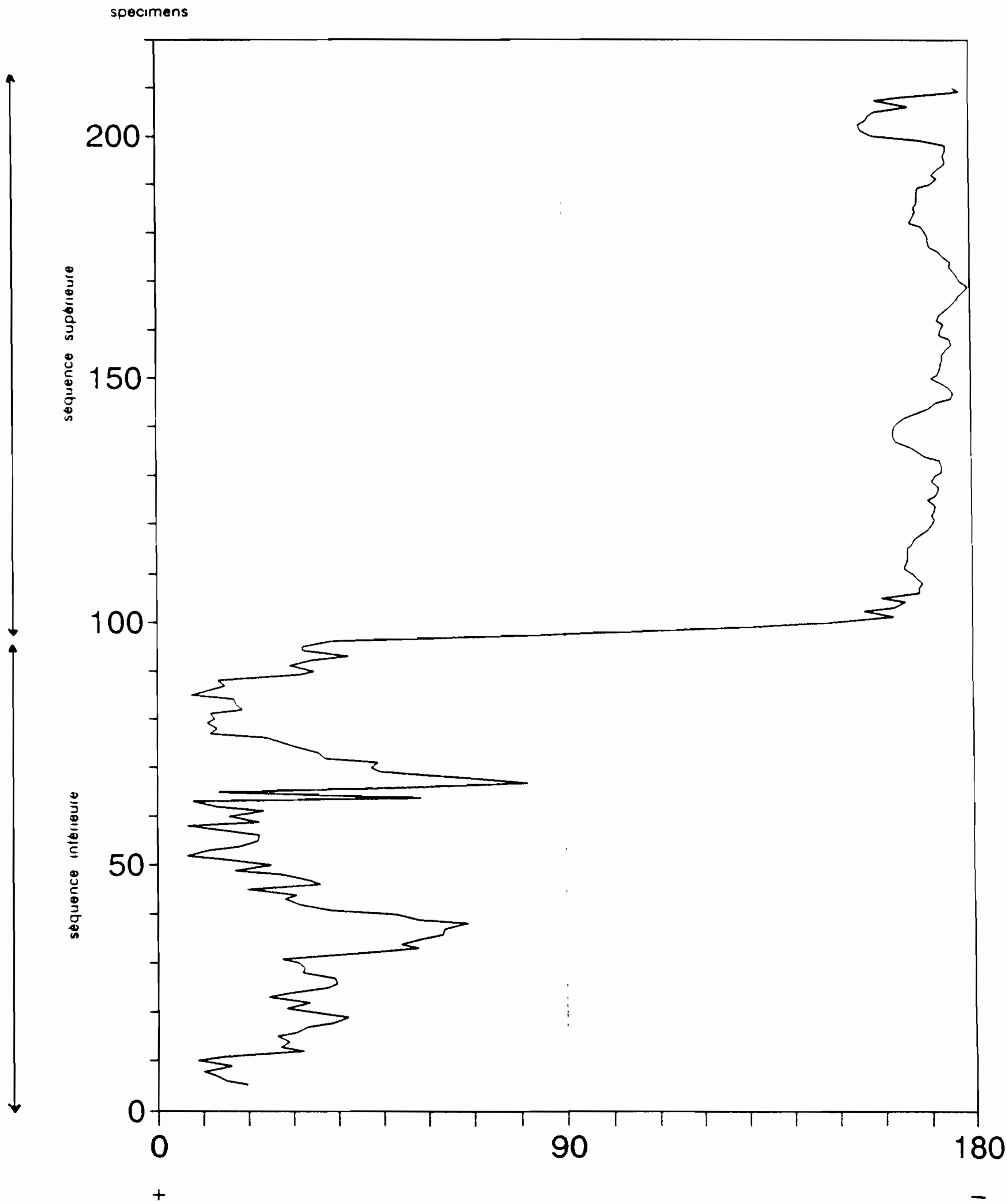


FIG. 13 LOWER SOKO, PALEOMAGNETISM

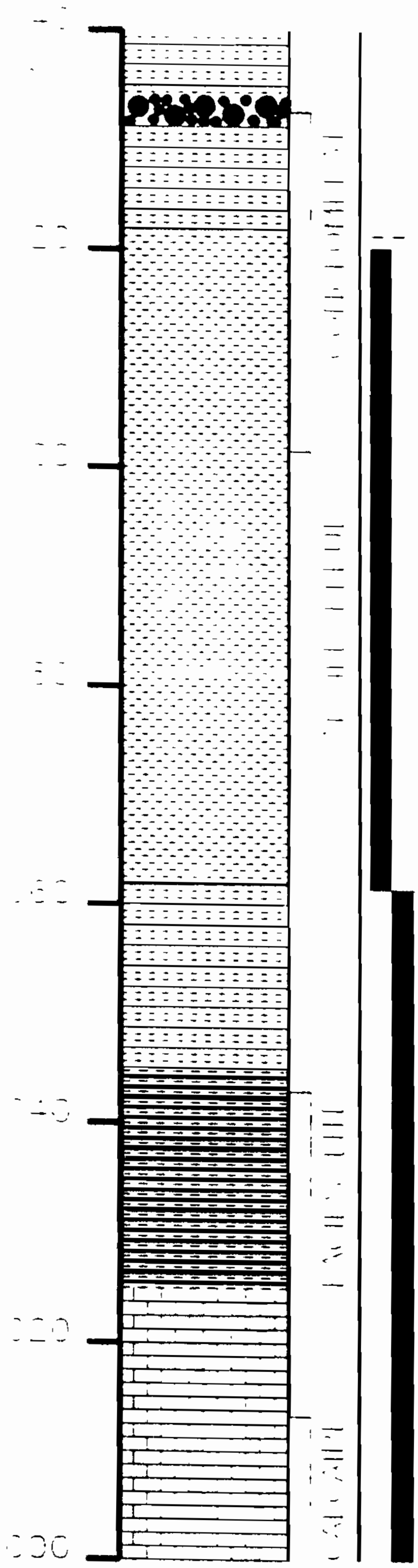


FIG. 14 LOWER SOKO, PALEOMAGNETISM vs. STRATIGRAPHY

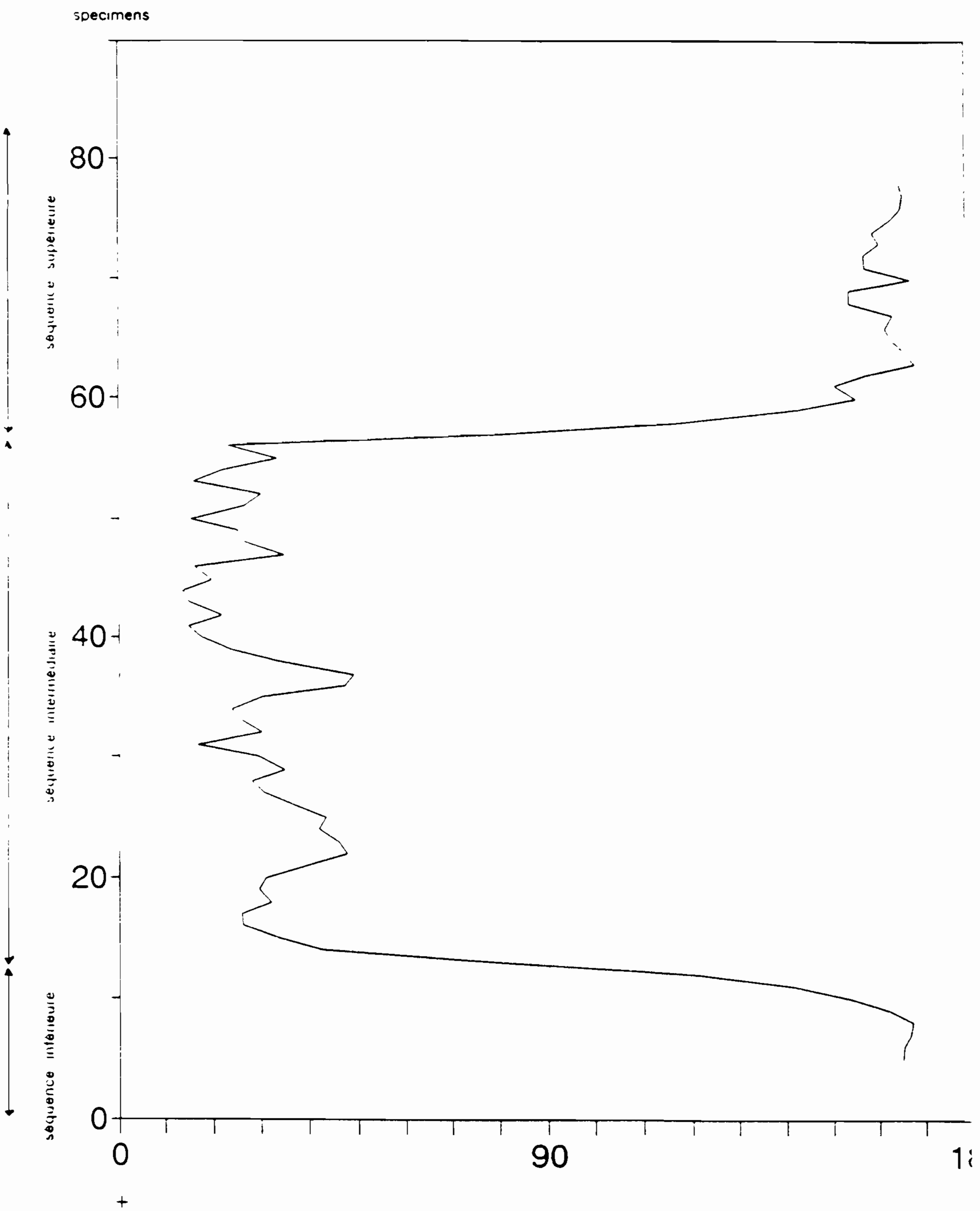


FIG. 15 UPPER SOKO, PALEOMAGNETISM

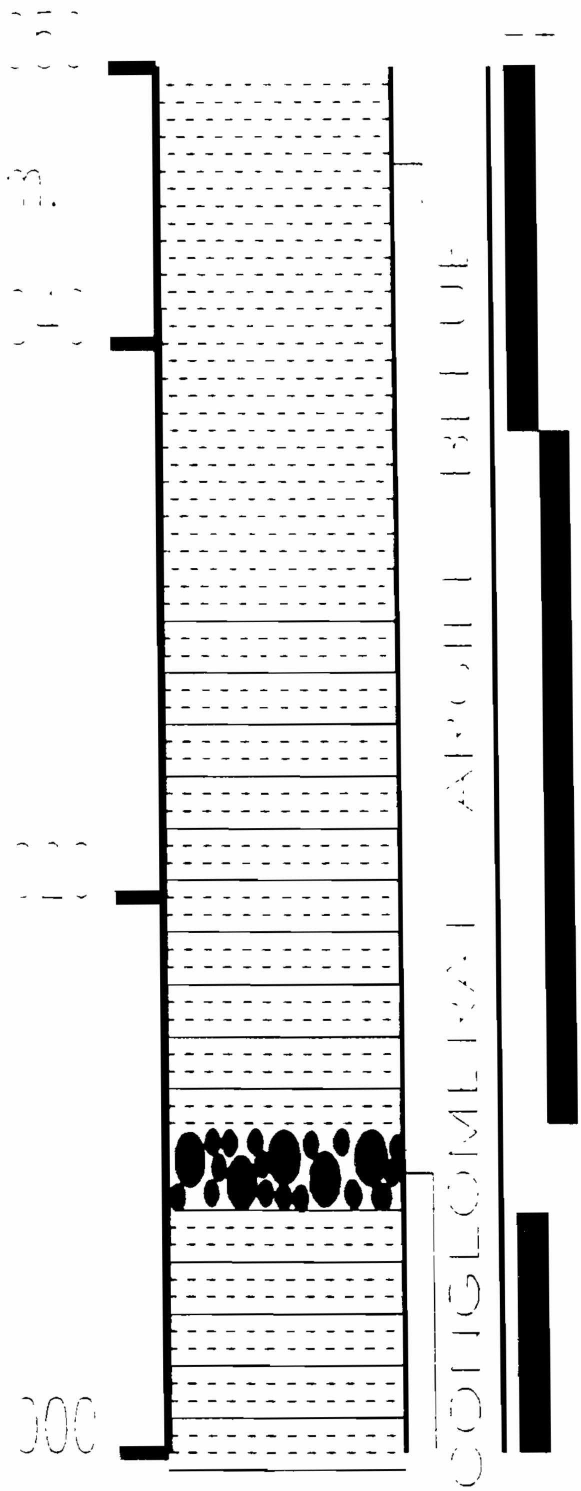


FIG. 16 UPPER SOKO, PALEOMAGNETISM vs. STRATIGRAPHY

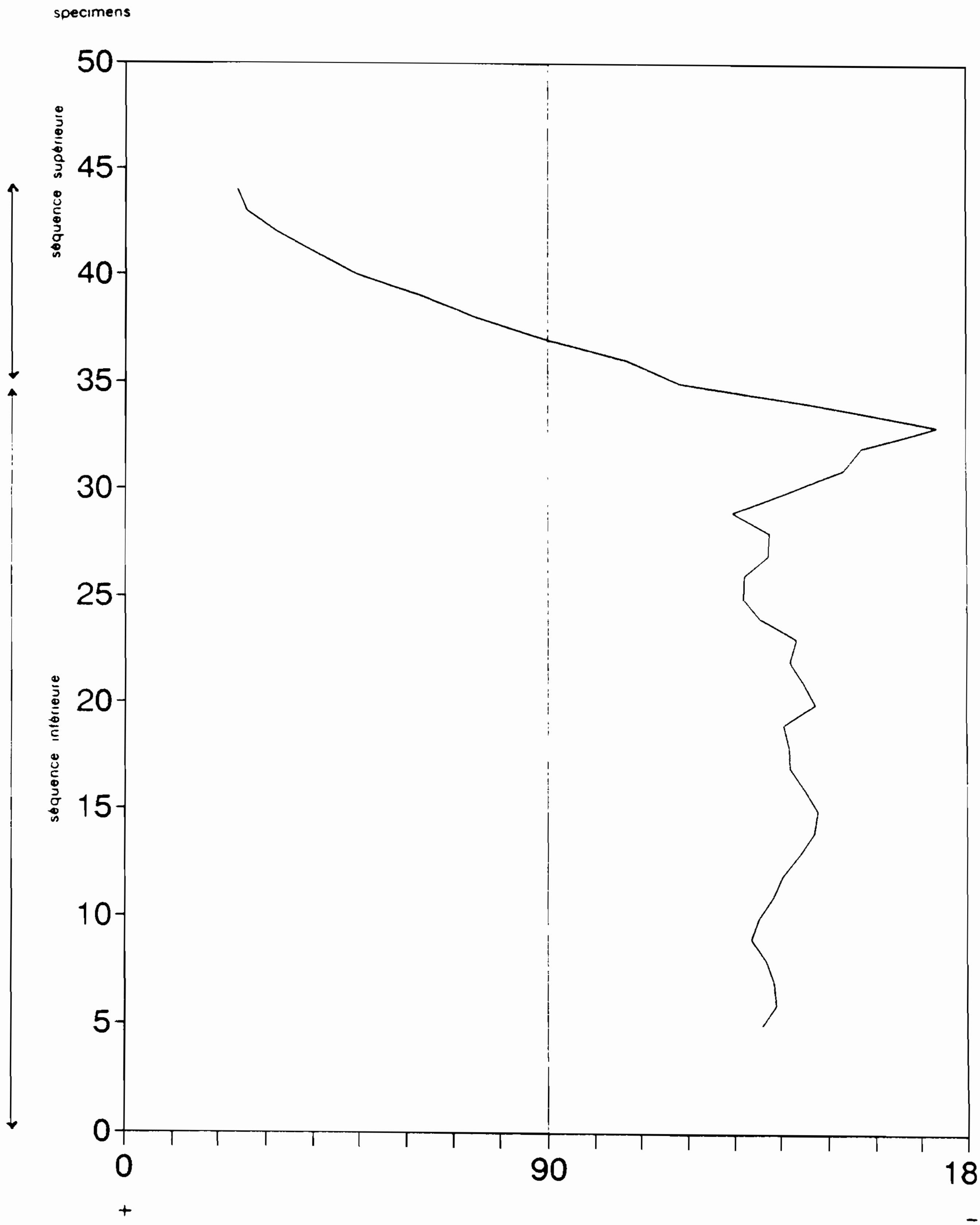


FIG. 17 KEDUNG KRUJUK, PALEOMAGNETISM

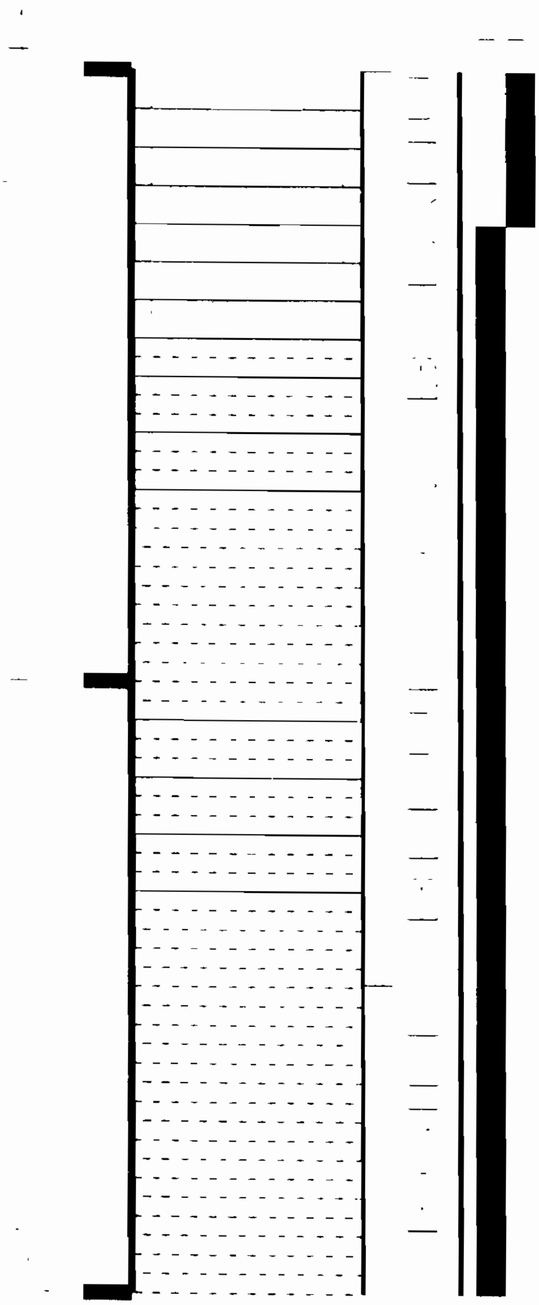


FIG. 18 KEDUNG KRUJUK, PALEOMAGNETISM vs. STRATIGRAPHY

-reversed polarities in the lower part,

-a clear and gradual change to normal polarities at the top of the section, in the Balanus limestones

II.Chronological interpretation

II.1.Lithostratigraphy vs. magnetostratigraphy

If we consider pure lithostratigraphical correlations between the studied sections, we see that the accordance between paleomagnetic results is good for Soko and Kedung Krujuk sections, which are almost situated in continuity in the field (Fig 19)

The banked limestones show a normal polarity, then we have a long reversed zone in the blue clays A smaller normal zone appears above the Kedung Cumpleng conglomerate and then we find again reversed polarities till the last transition in the Balanus limestones

But a contradiction exists with the Barong section. The lower normal zone ends in Soko at the very basis of the blue clays, and much earlier in Barong, within the banked limestone facies The difference is approximately 50 meters

In order to correlate the palaeomagnetic data, we have therefore to shift up or down the Barong section. The upward shifting is more satisfying because (Fig. 20)

-It places in the same geomagnetic zone the reversed polarities found at Barong and at Soko.

-It is in good accordance with the cartographic results which show a wedging out of the blue clays northwards. This is obvious on the virtual geological map (Fig 21) where all the area, with a constant dipping, is represented at the same altitude.

We may therefore assume that, when the blue clays already deposited at Soko, calcareous sediments still deposited at Barong.

II.2.The chronological model

Several hypothesis can be given for the chronological interpretation of our palaeomagnetic results. The uppermost reversed-normal transition could be attributed to:

-the basis of the Olduvai event (hyp. TA)

-the basis of the Jaramillo event (hyp. A)

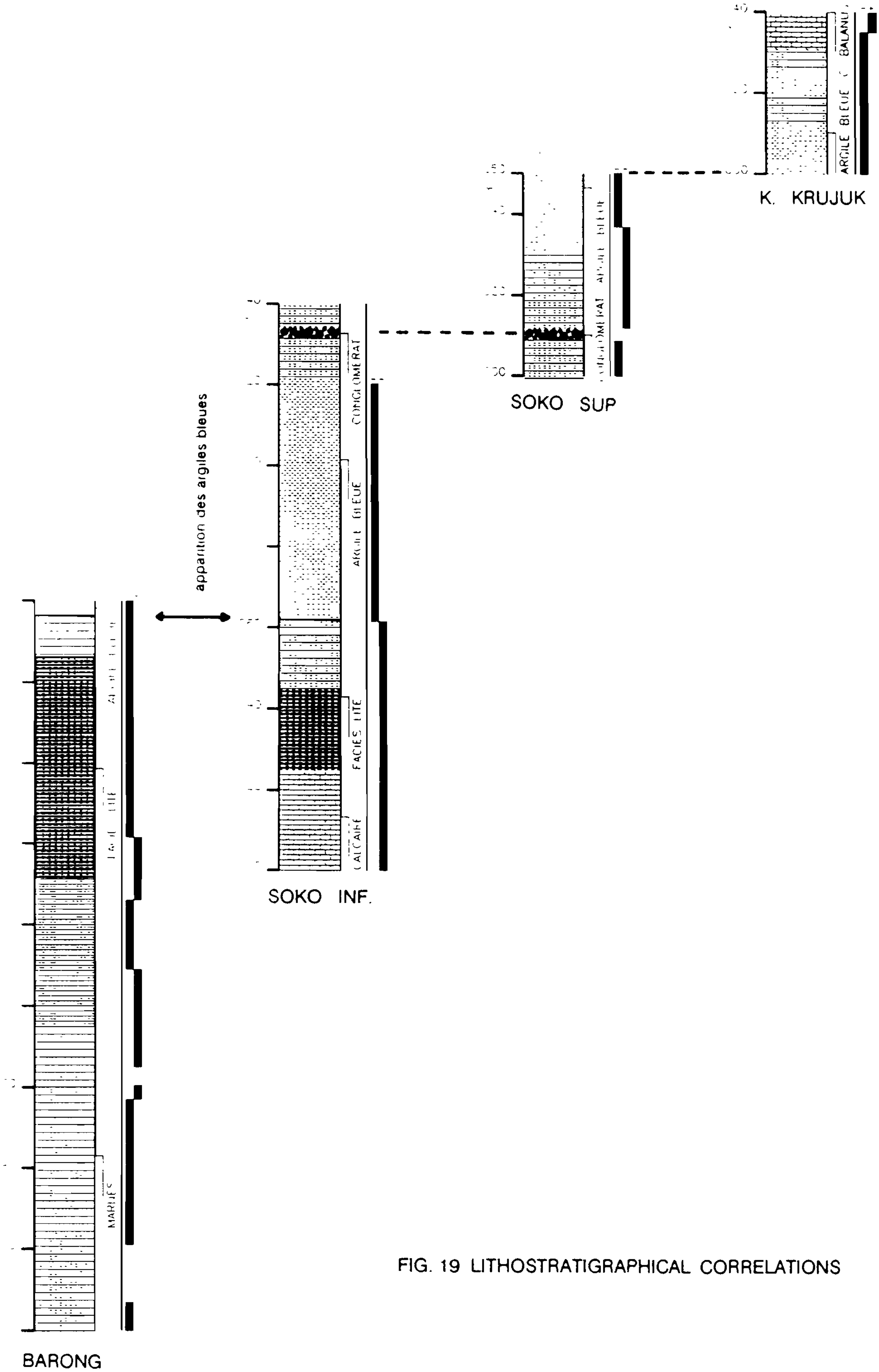


FIG. 19 LITHOSTRATIGRAPHICAL CORRELATIONS

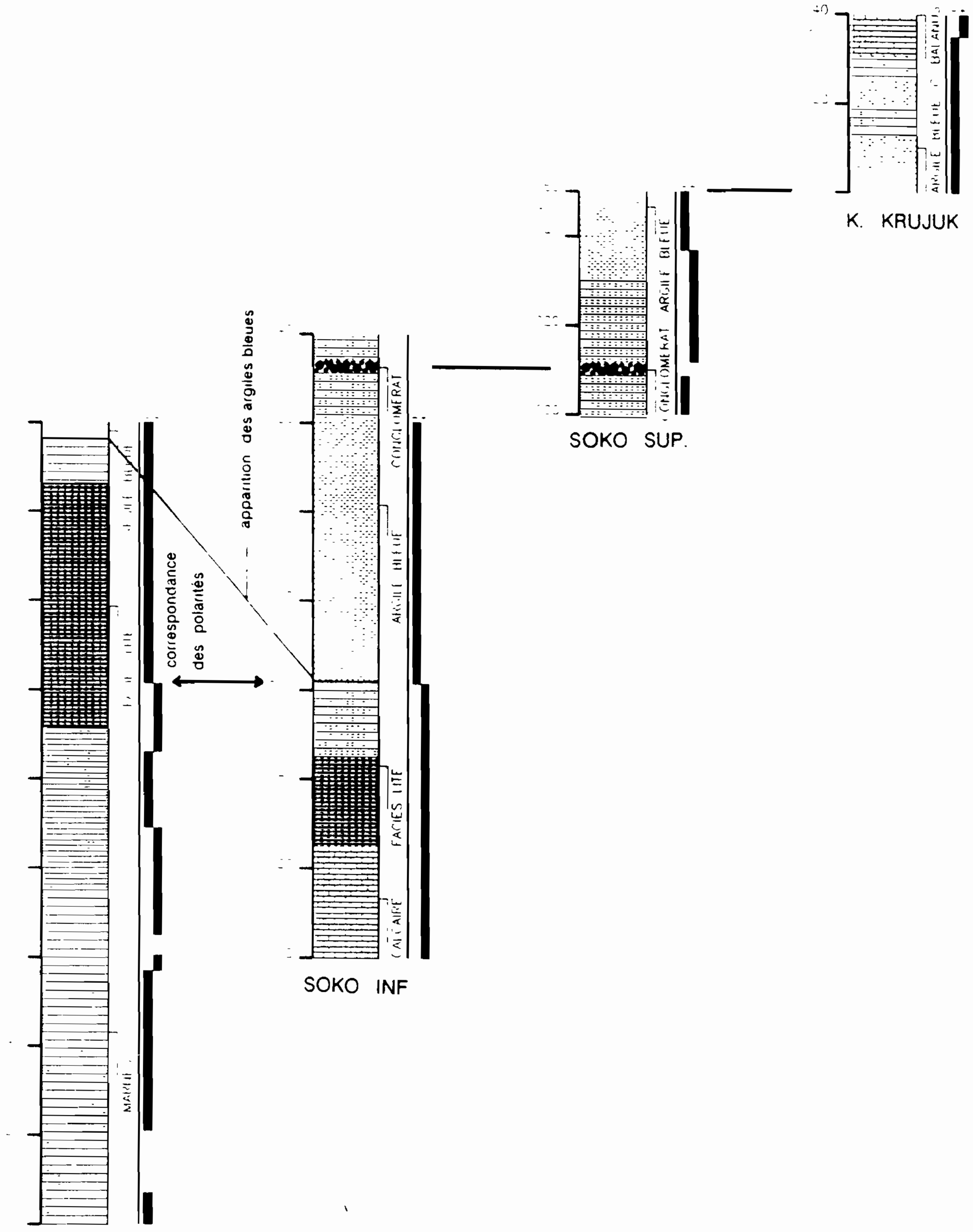


FIG. 20 PALEOMAGNETIC CORRELATIONS

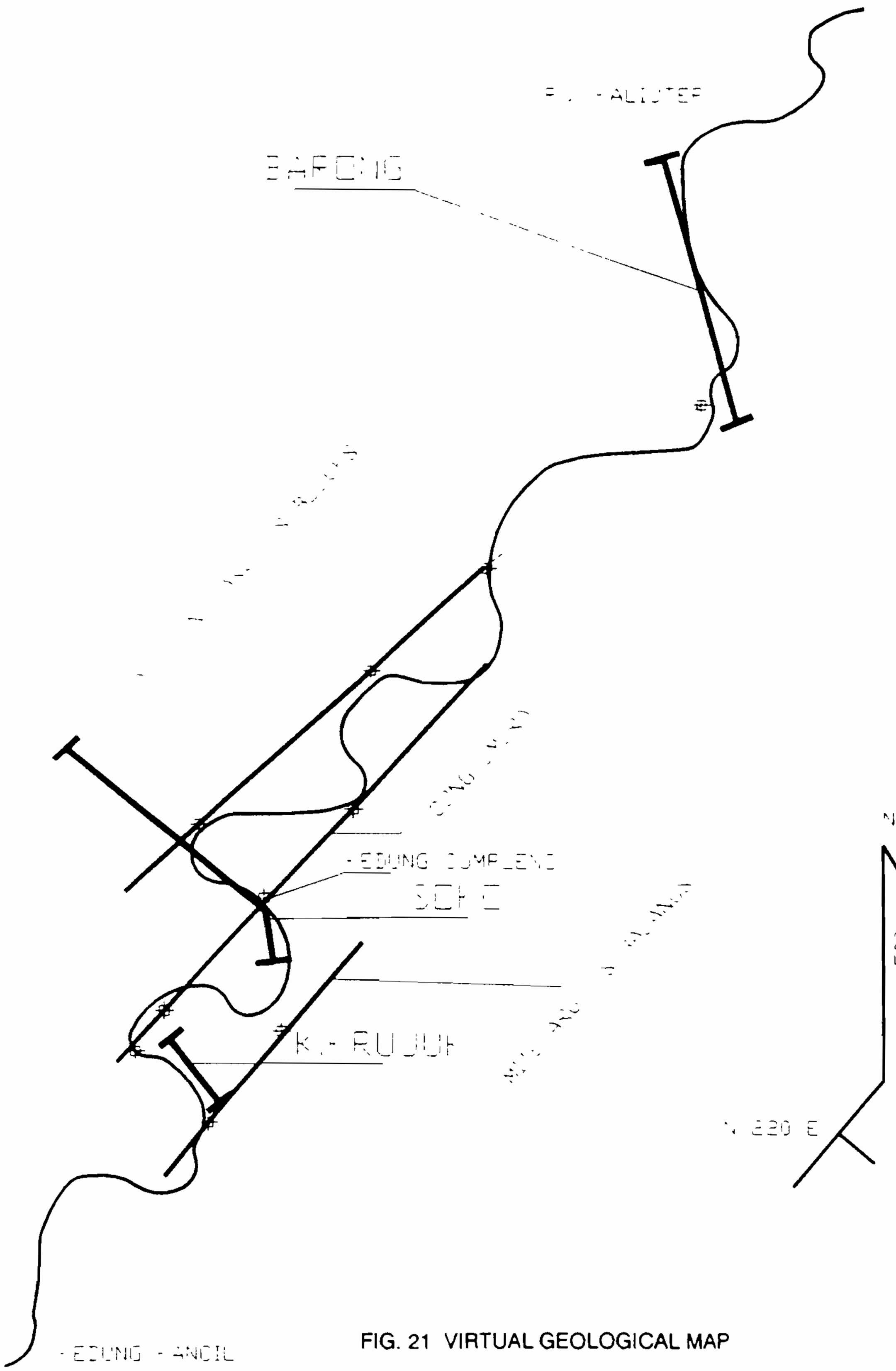


FIG. 21 VIRTUAL GEOLOGICAL MAP

-or the Brunhes/Matuyama boundary (hyp. R)

The first hypothesis can be discarded, as it would imply a Gauss age (more than 2 5 m yrs) for the Kedung Cumpleng prehistoric site. This is in contradiction with our present knowledge about older javanese settlements.

The second one would imply an Olduvai-Reunion age for the Kedung Cumpleng site (*ca.* 2 m.yrs ago). It is extremely old, but not completely impossible.

Nevertheless, we presently choose the third hypothesis for several reasons:

-The palaeomagnetic analysis carried out in the upper horizontal series did not show reversed polarities. These series are likely to be related to the Brunhes chron.

-The sedimentation curves drawn are closer with the one of Sangiran-Gemolong in the case of this "youngest" hypothesis (Fig. 22).

Our model (Fig 23) relates therefore the Kedung Cumpleng conglomerate to the Jaramillo event. This age represents a minimum age for this prehistoric site

The normal sequences found in the Barong section are related to the Olduvai-Reunion events (1 67-2 1 m.yrs). It is not strange to find reversed sub-zones in such a complex geomagnetic period. A more complicated geomagnetic figure was described in the Omo valley seris by R.T Shuey et al. (1974)

The reversed zone found at the bottom of the Barong section dates therefore back to the beginning of the Matuyama chron, between 2.48 and 2.2 m.yrs ago.

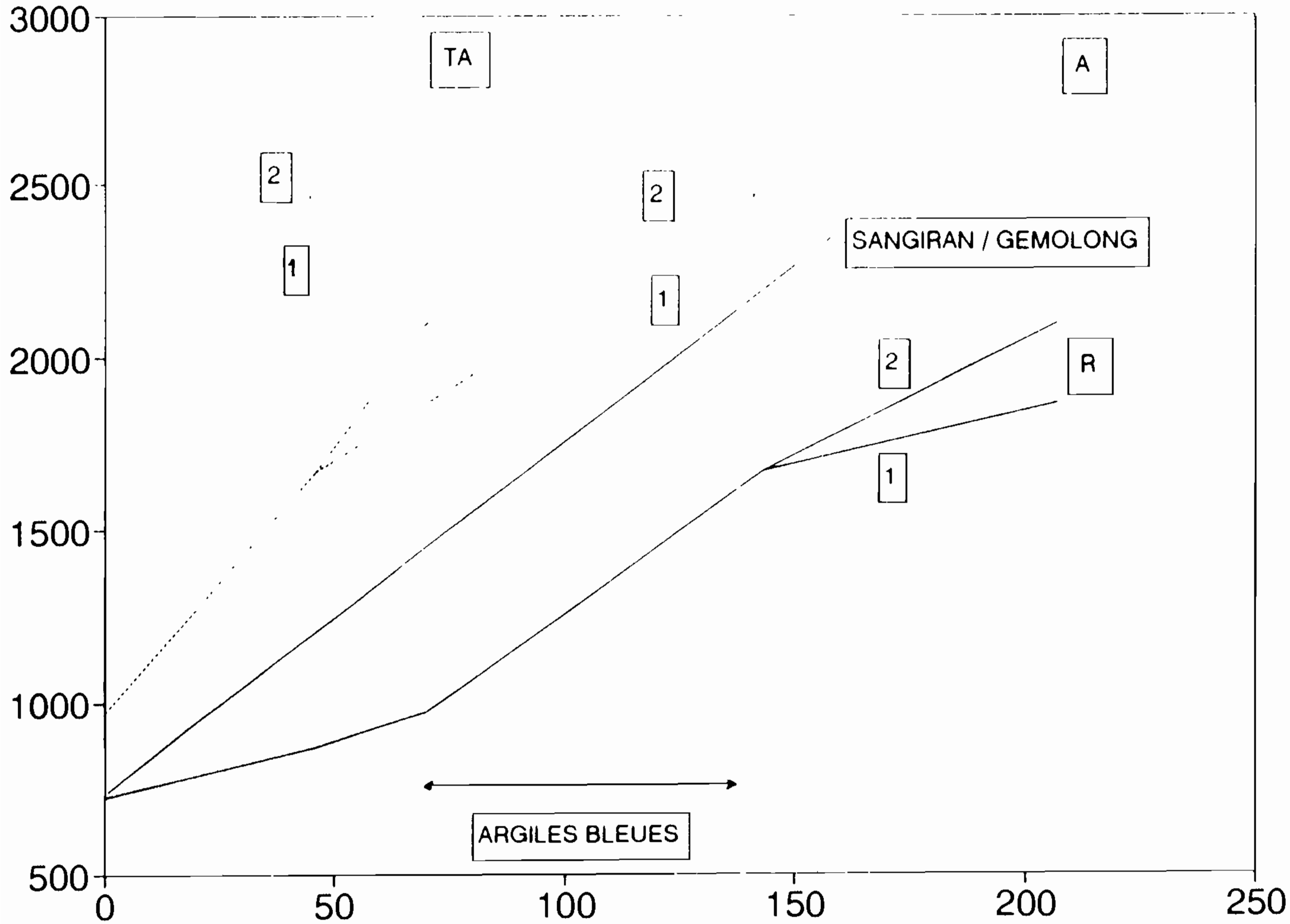


FIG 22 SEDIMENTATION CURVES (hyp R vs Sangiran-Gemolong)

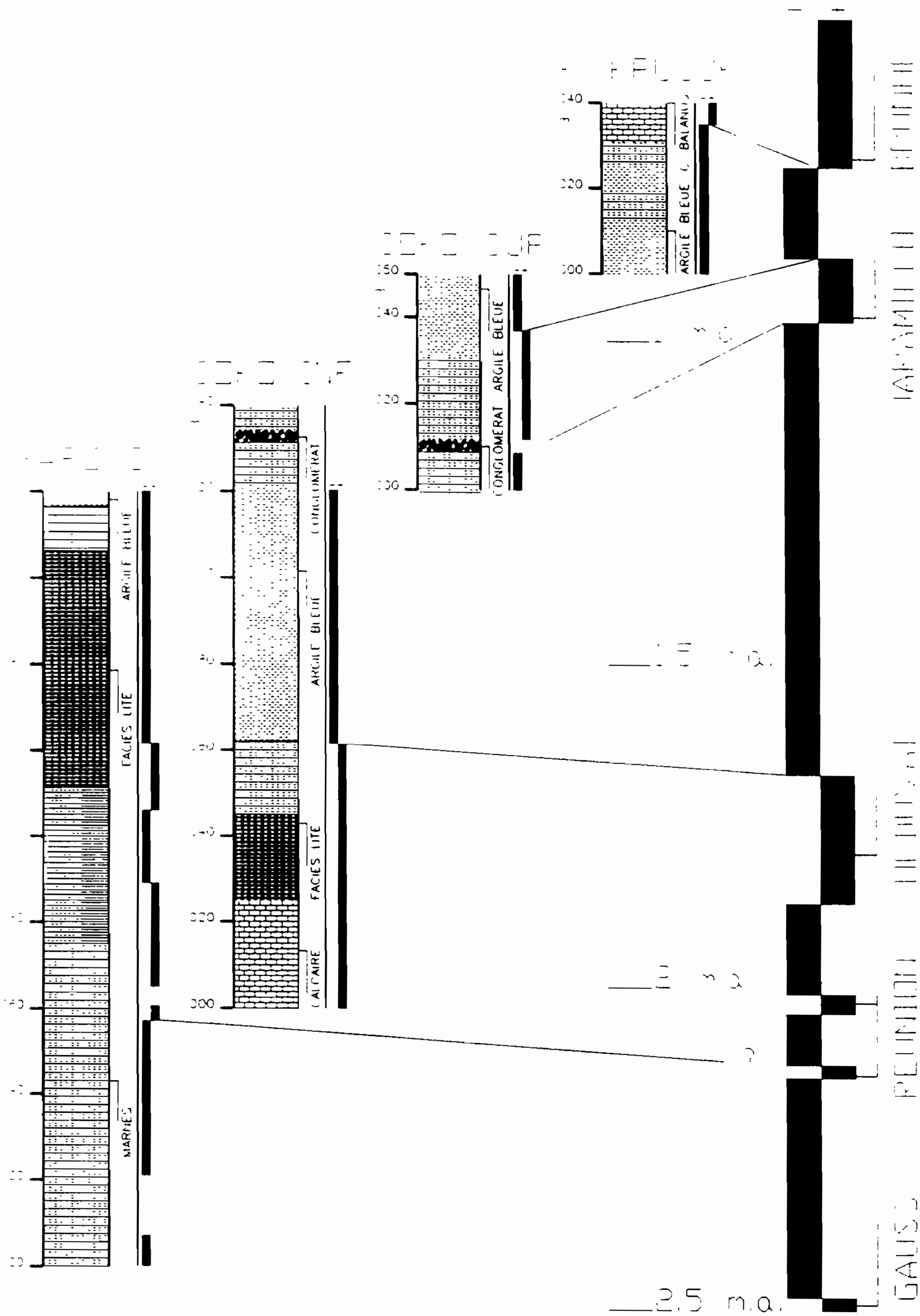


FIG. 23 CHRONOLOGICAL MODEL

C.POLLEN ANALYSIS OF THE SOKO SECTION, KALIUTER

by Anne-Marie SÉMAH

I.The Pollen diagram

The pollinic study of the Kaliuter area focused on the Soko sections, beginning with the blue clays and ending well above the Kedung Cumpleng conglomerate.

The pollinic diagram shows a lot of different arboreal elements. The tree percentage, as observed in Figures 24 and 25, is higher than the herbaceous one -except for smaller oscillations-, and similar to the fern frequency.

Many taxa are regularly present in the basic diagram. Among the trees, the Arecaceae, and especially *Nypa fruticans; Casuarina, Excoecaria,* the Fagaceae, *Calophyllum, Engelhardia,* the Meliaceae, the Myrtaceae, *Podocarpus,* the Rhizophoraceae and Sonneratiaceae, the Tiliaceae and *Avicennia*. Among the herbaceous plants, the Asteraceae, Cyperaceae and Poaceae; among the ferns, *Pteris* and *Stenochlaena palustris*.

Several of these taxa percentages vary. For instance, *Casuarina, Podocarpus* and the Rhizophoraceae are mainly represented at the bottom and at the top of the sequence; as for the Poaceae, they benefit at the top from a decrease in the number of Cyperaceae, and *Stenochlaena palustris* disappears when reaching the highest layers.

Many plants are found in a more sporadic way or are more isolated, like *Ilex, Dacrydium, Elaeocarpus, Ficus, Myrica, Pterospermum, Symplocos*, the Ulmaceae, the Mimosaceae and many grasses.

The recalculated diagram (Fig. 26), which excepts the most important mangrove elements, displays curve shapes that are somewhat different from the basic ones, especially near the Rhizophoraceae peaks of it.

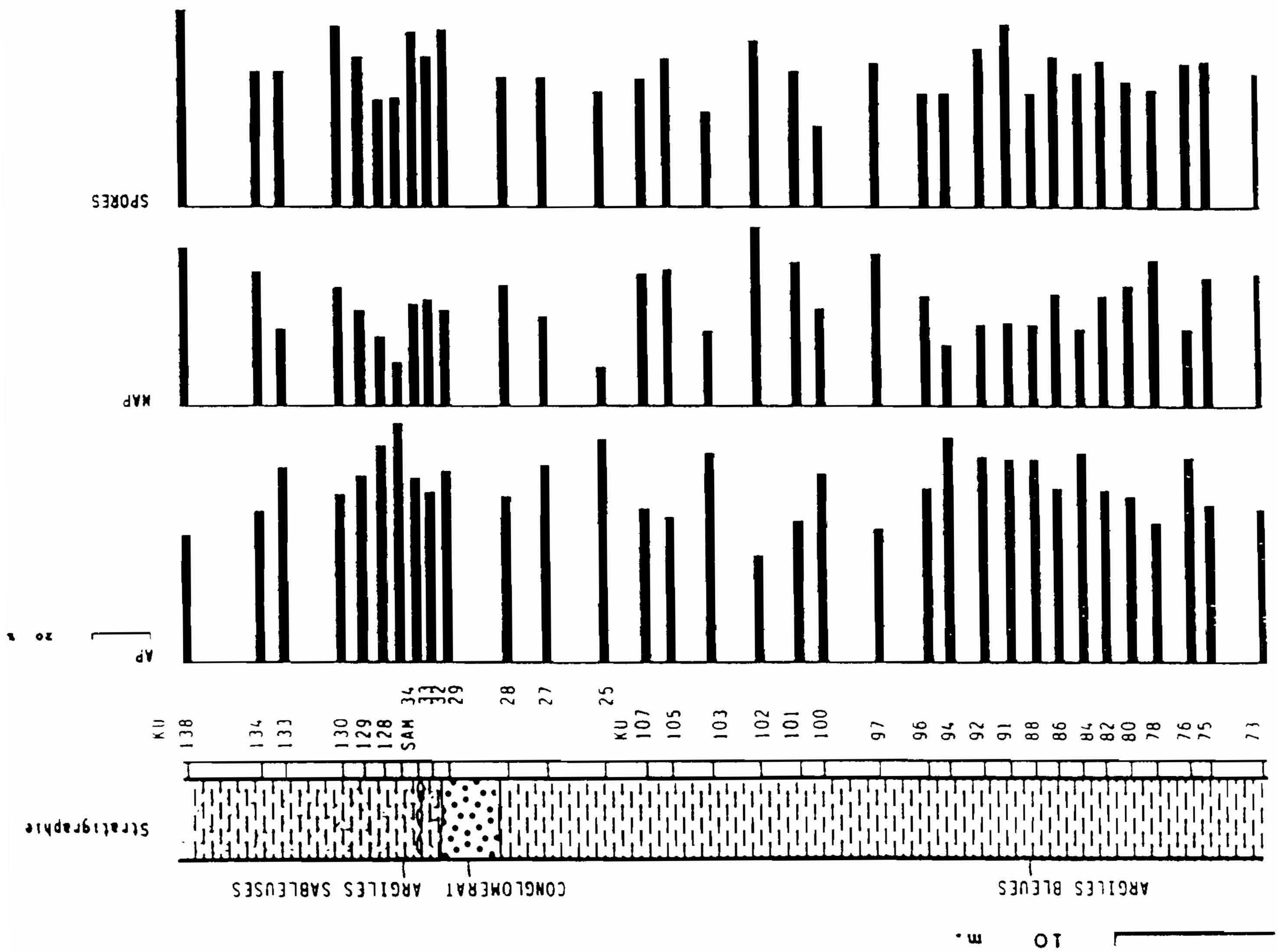


FIG. 24 SOKO, AP/NAP DIAGRAM

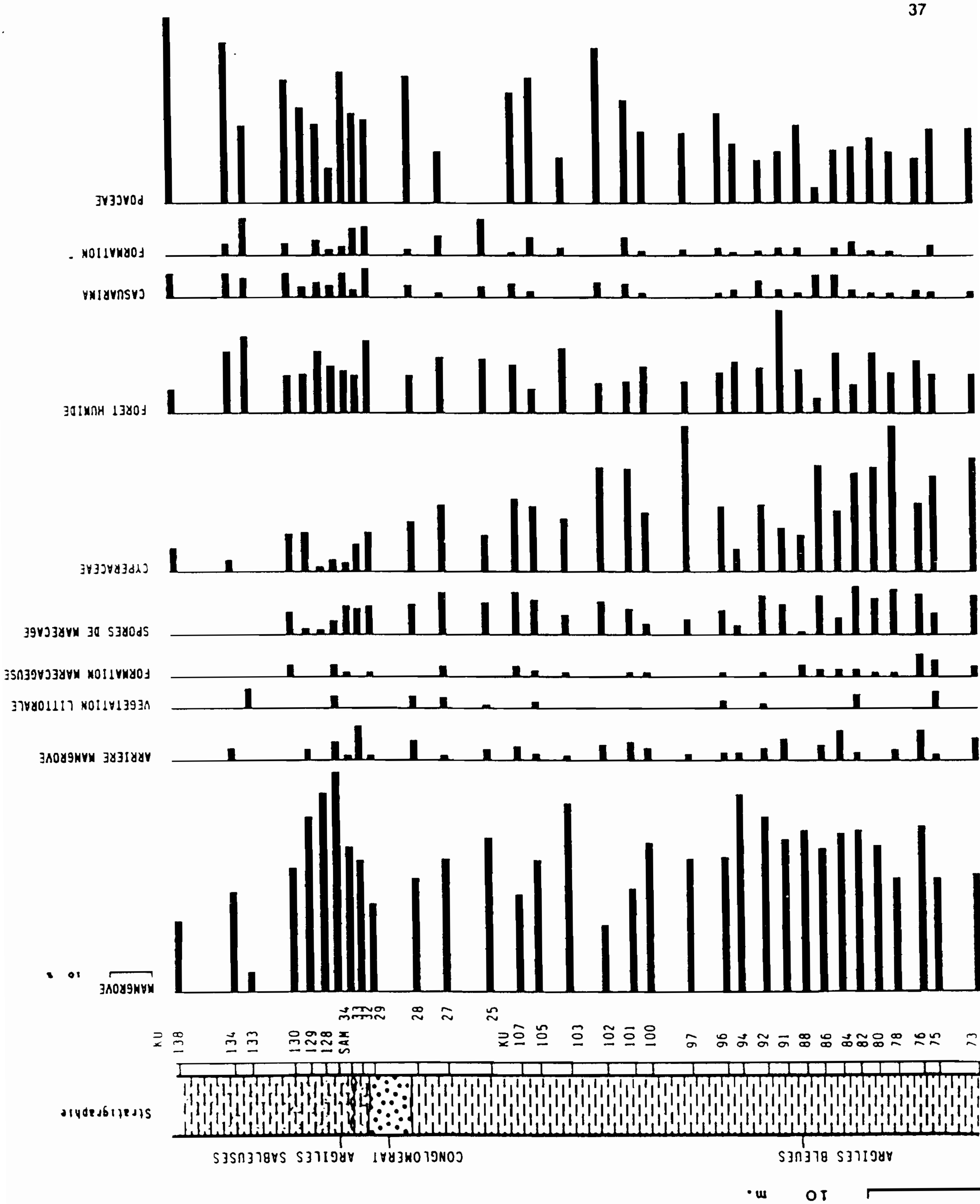


FIG. 25 SOKO, VEGETAL FORMATIONS DIAGRAM

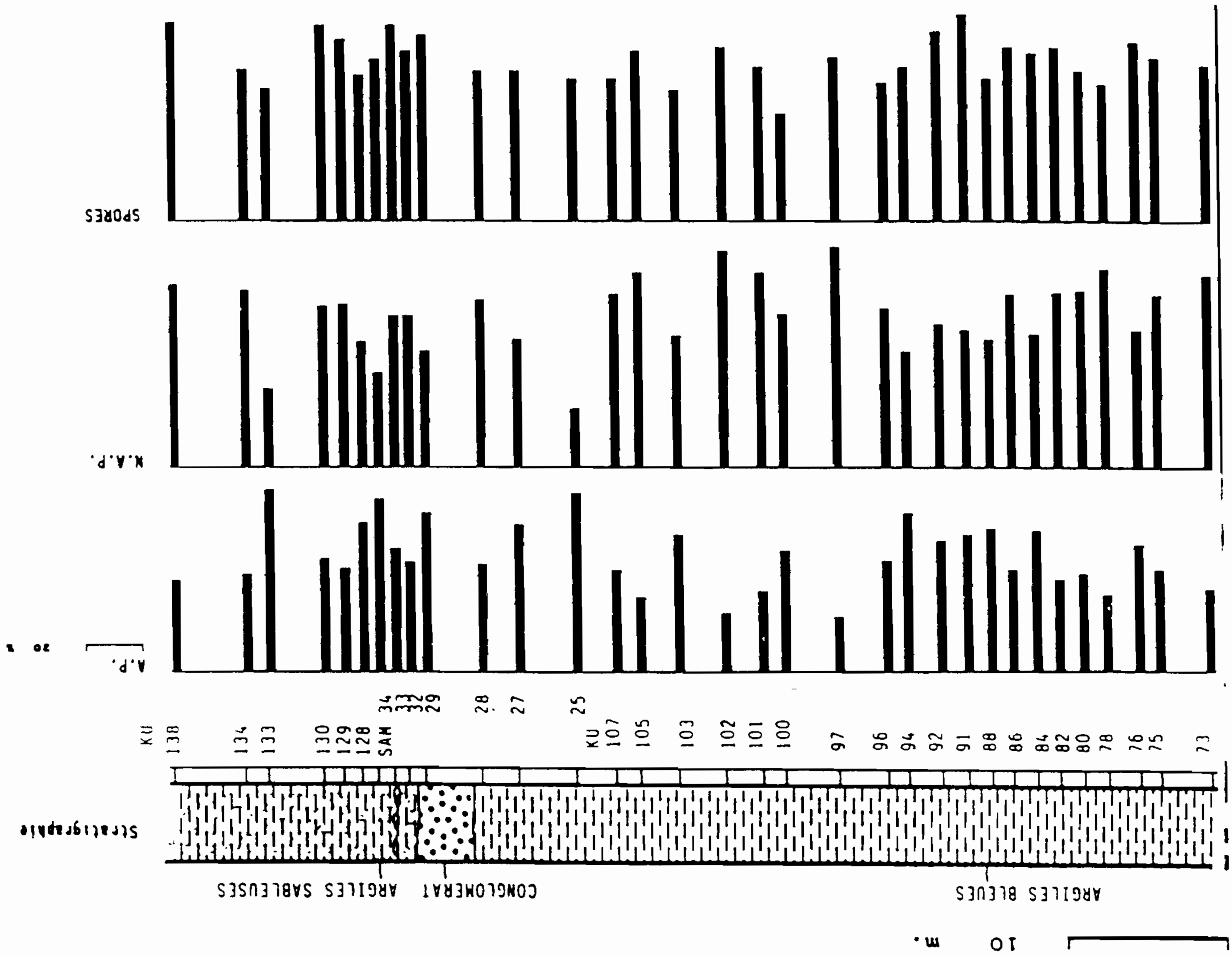


FIG. 26 SOKO, RECALCULATED AP/ NAP DIAGRAM

II.Interpretation elements

The bulk of the diagram, in which we found microplancton cysts everywhere, is dominated by the mangrove and back mangrove associations (Fig. 25). Those two vegetal formations are subject to several changes along the section, but the mangrove forest is always conspicuous. Its curve is mainly due to the Rhizophoraceae, which give three peaks in the KU 94, KU 103 and SAM 34 spectra. This vegetal association took place not so far from the sampled sites. Such a conclusion is in good accordance with the sedimentological analysis (T. Djubiantono, 1992), which give granofacies of intern mangrove deposition within the blue clays.

The comparison between Figures 24 and 26 shows that the non- mangrove tree frequency is still important. This very curve is subject to several changes.

Beyond the shoreline developed a swampy forest and a frankly continental vegetation where the rain forest elements dominate the more open forest ones (Fig. 25).

Figure 25 also shows that the Cyperaceae get lower in frequency when going from the bottom to the top of the section, and that the Poaceae follow a reversed trend.

Although Figures 24 and 26 give a rather regular picture of the frequencies, the oscillations we see on Figure 25 for each vegetal association lead us to qualify those general observations.

The first zone -spectra KU 73 to KU 96- has higher tree and fern percentages. The Cyperaceae and the rain forest elements are very important, pointing to a humid period.

Between the KU 97 and KU 107 spectra, the AP / NAP ratio decreases, owing to larger Poaceae frequencies. We observe small oscillations where the grasses (Poaceae, Cyperaceae) oppose to the rain forest plants. The latter progress in KU 100, KU 103 and KU 107.

The NAP group drops drastically in the SAM 25 layer. No Poaceae, and only a few Cyperaceae have been found here. Besides the rain forest pollen, other taxa from the more open formation get here their maximal values, while *Podocarpus imbricatus* disappears. This open vegetation indicates a drier period.

In samples SAM 27 and SAM 28, we get fewer trees and more Poaceae, with a more open character of the local vegetation.

Between the SAM 29 and KU 130 spectra, we find again alternances between a rain forest-like and a more open vegetal formation:

- in SAM 29, when compared with the SAM 28 layer, the Cyperaceae and the Poaceae decrease while the rain forest elements progress, especially with *Podocarpus*, as the open forest plants and the ferns do

- in SAM 32 and SAM 33, the Poaceae progress and the trees decrease

- in SAM 34, which is one of the spectra where the mangrove association was the most important, we find a few Poaceae and Cyperaceae; the trees belong to the rain forest.

- Between KU 128 and KU 130, we have a new Poaceae and Cyperaceae increase, correlated with a drop of the tree frequency

Figure 26 shows sharp variations in the KU 133 spectrum many trees and a few grasses From this layer to the KU 138 sample, we observe a progressive decrease of the trees and a progression of the ferns. Rain forest taxa become less important, the open forest and swampy forest elements disappear The NAP group is dominated by the Poaceae, and *Casuarina* holds steady.

Those observations show a rather open environment, disturbed by the volcanic activity The soil is covered by Poaceae and ferns

III. Paleoecological Conclusion

***The influence of the mangrove forest remains even all along the studied section at Soko.**

The first twenty meters of blue clays (Zone A on Fig. 27) show the dominance of the rain forest trees, the Cyperaceae and the ferns.

***During this stage, the continent was occupied during this stage by a rain forest like formation.**

The following twenty meters (Zone B) show an opposition between the grasses and the rain forest elements

***Zone B presents an alternance between rain forest and open formation periods.**

From the top of the blue clays to the bottom of the conglomeratic layer (Zone C), we find an increase of seasonal or open forest taxa and then a Poaceae dominance.

***This zone includes, at least at its base, a less humid period during which an open forest developed in the plain and on the hills.**

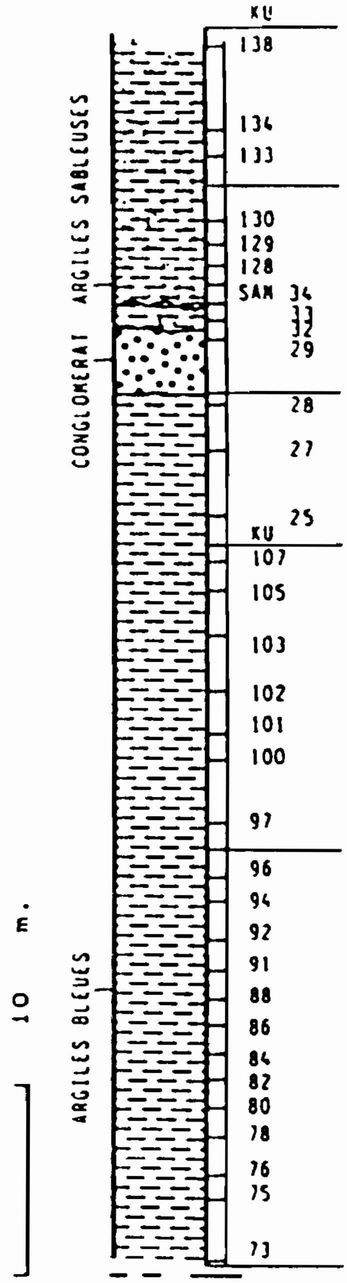


FIG. 27 SOKO, POLLINIC ZONES

Then we find the deltaic conglomerate, which yields the oldest mammals found on the site. The upper conglomerate samples, like the lower part of the overlying sandy clays (Zone D), show again alternating rain forest / more open vegetation

***The uppermost pollinic spectra (Zone E) present a locally open vegetation, probably impoverished by the volcanic activity, where Poaceae and ferns dominate.**

It is worthy to notice on Figure 25, at the top of the fossil- bearing conglomerate of Kedung Cumpleng, the relative opposition between back mangrove and swampy ferns on one side, and mangrove forest on the other side This could well correspond to a smaller oscillation of the sea level (eustatism?) one million years ago.

D.PALEOGEOGRAPHICAL SIGNIFICANCE OF THE KALIUTER SERIES

by François SÉMAH

I.The informations gathered from the Kaliuter area

Besides the discovery of new fossil-bearing sites, the study of Kaliuter area gives new important data about the geological evolution of this northern part of the Solo depression

I.1.The deposition environment

The whole of the studied sections show that the deposition environment cannot be described as open-sea: recessive conditions appear very early in the area, as observed near the basis of the Barong section, more than 2 m.yrs ago. The layers described by L. J C van Es (1931) as the Lower Kalibeng *Globigerina* marls are in fact sandy marls deposited in a shallow sea. The banked limy facies contains many littoral fossils, and the blue clays were deposited near a mangrove formation (tidal area).

All along the Barong, Soko and Kedung Krujuk sections, we observe a global recession of the the sea.

I.2.The influence of volcanoes

The influence of volcanic activity on the sedimentation is very important in the horizontal series (tuffaceous sands, breccia...). But it can be observed also in the folded marine series:

-Directly, as we noticed the presence of several cineritic banks

-Undirectly, by the measurement of magnetic susceptibility. Such measurements give an idea of the magnetic mineral content of the sediment, which is itself largely dependent on the volcanic minerals content. The analysis show that the volcanic influence has been more important in the Soko section than in the Barong one , and appeared also earlier (Fig. 28 and 29).

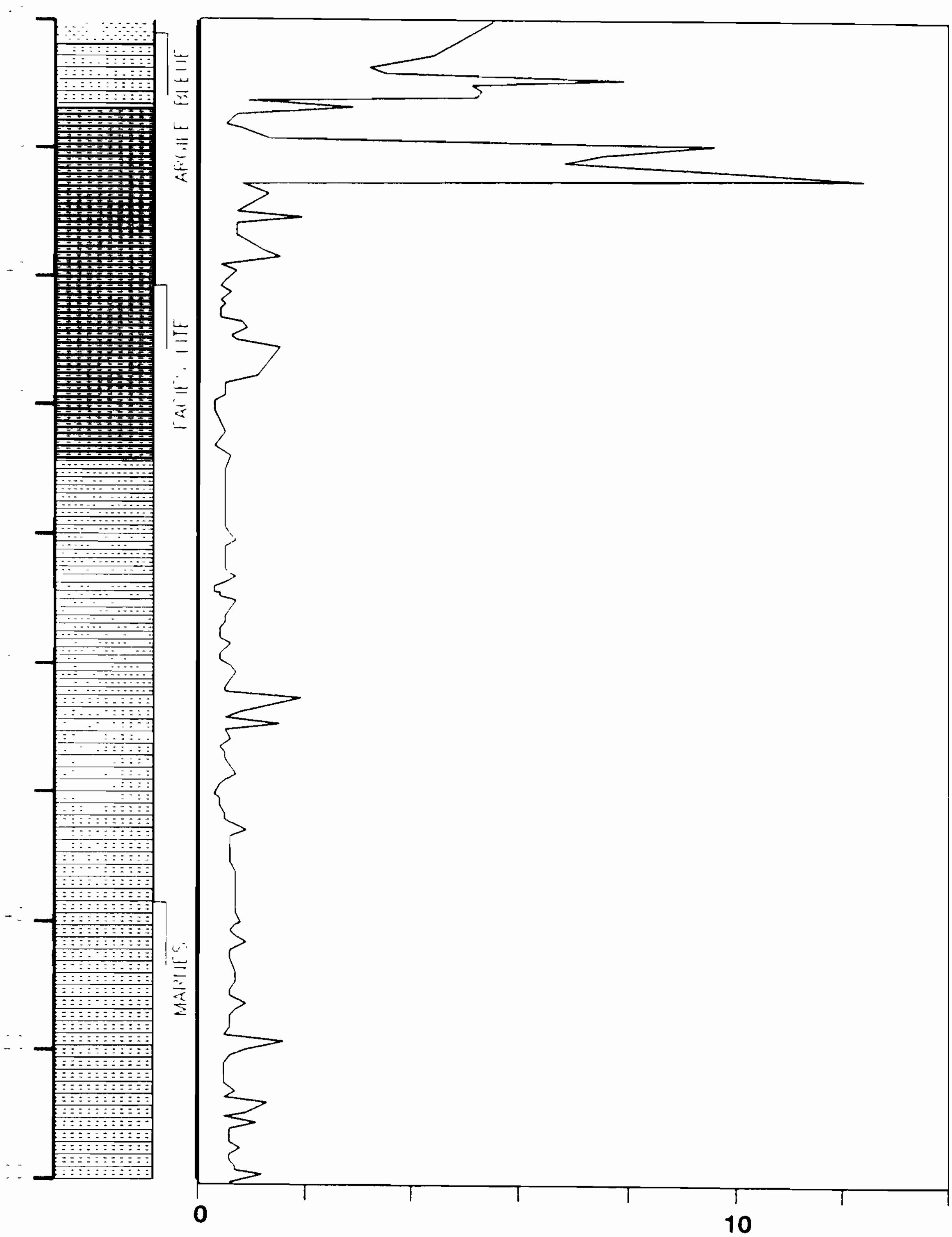


FIG. 28 BARONG, MAGNETIC SUSCEPTIBILITY

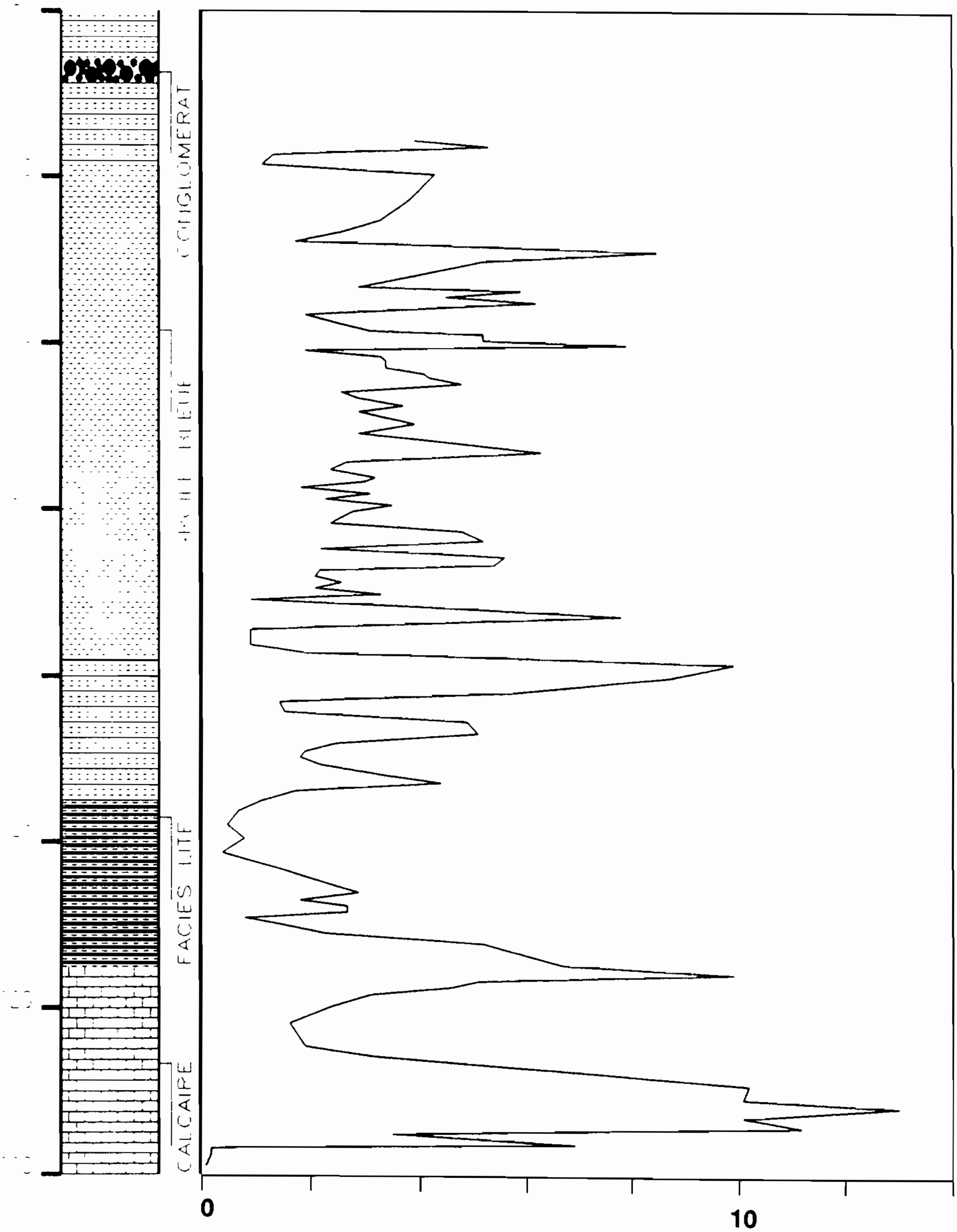


FIG. 29 SOKO, MAGNETIC SUSCEPTIBILITY

The fine-grained blue clays themselves, which contain a lot of smaller magnetite cristals, are likely to be the result of the weathering of volcanic ashes which thickly cover the flanks of the volcanoes

I.3.Tectonics

From the structural point of view, the Kaliuter area gives two important data:

The first one is the tectonic unconformity between the folded series and the horizontal ones This unconformity represents the last folding phase of the Kendeng hills, and can be dated at about 0.7 m.yrs ago (Brunhes/Matuyama boundary).

The second one is the presence of the deltaic fossil-bearing conglomerate at Kedung Cumpleng. This conglomerate contains a lot of limestone pebbles transported by a river It proves that, one million years ago, the Kendeng hills did already exist northwards, and that they had already been colonized by continental mammals and by man.

The question of the age of these emerged reliefs is still unsolved. But we can assume that they are somewhat old. If we go downwards in the Kaliuter series, the next unconformity can be found in Miocene layers, at the contact between the Kerek and Lower Kalibeng formations. We think that the first Kendeng "ridge" formed at those times, but was not definitely emerged. The emersion was helped by eustatic drops of sea-level (since 2 4 m yrs ago) and/or by a continuous uplift

II.Palaeogeographical implications

On a larger scale, we can present a more concise vision of the geological events which took place in the Solo depression when *Pithecanthropus* arrived in Central Java. For that purpose, we shall use also the available data on several other sites like Sangiran, Bringinan, Onto-Simo and Gemolong (F Sémah, 1986; S. Sartono *et al* 1984)(see Fig. 30 and 31).

II.1.Sea level oscillations

It seems established now that a recessive evolution of the sedimentation took place in the area at the very beginning of the Matuyama period. 2.4 m.yrs ago, the older Kendeng reliefs contributed to the recession of the sea by forming a barrier northwards.

But further eustatic sea-level oscillations are hardly visible in the stratigraphic sections, except for the one pointed by pollen analysis near the Kedung Cumpleng conglomerate (see above).

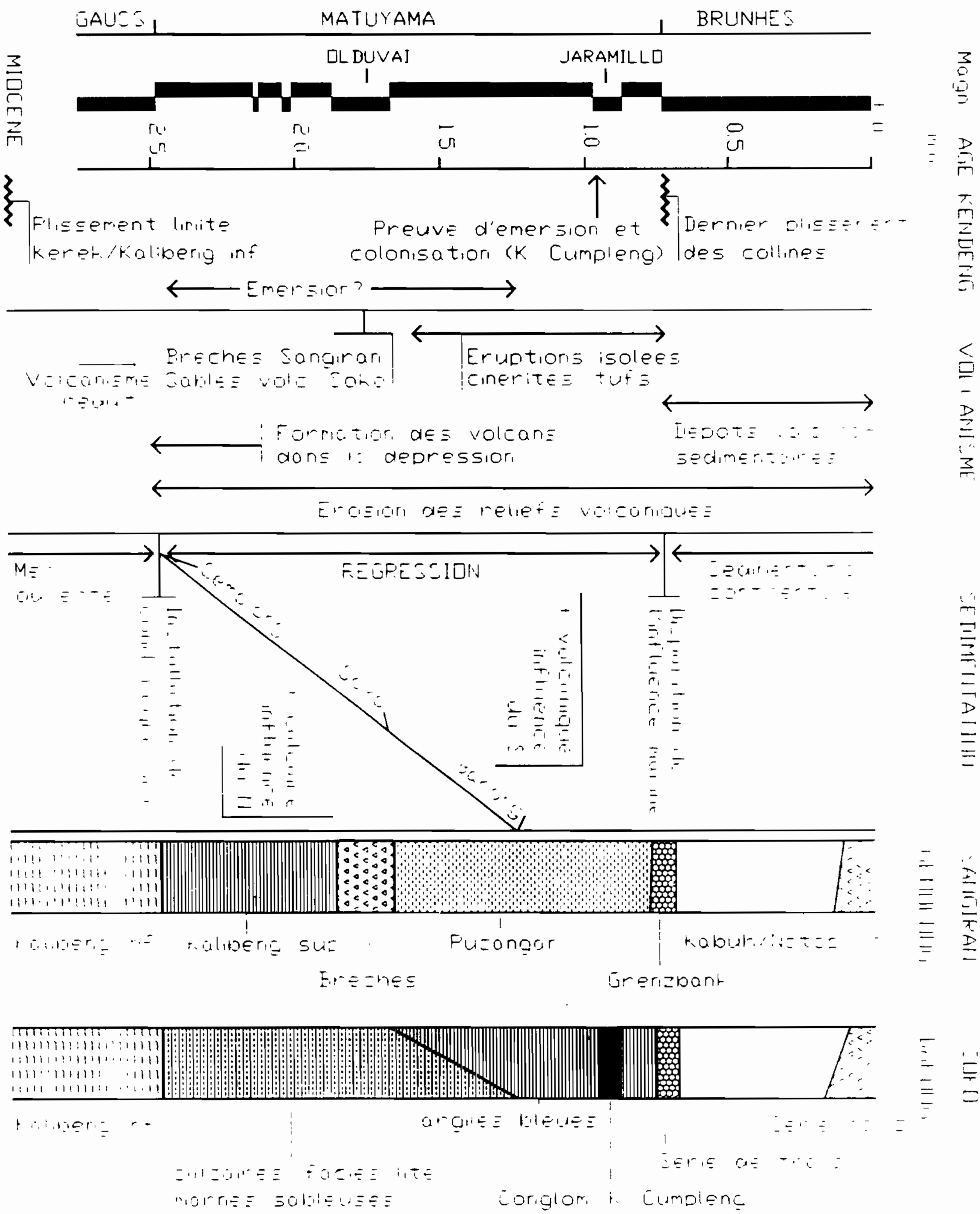
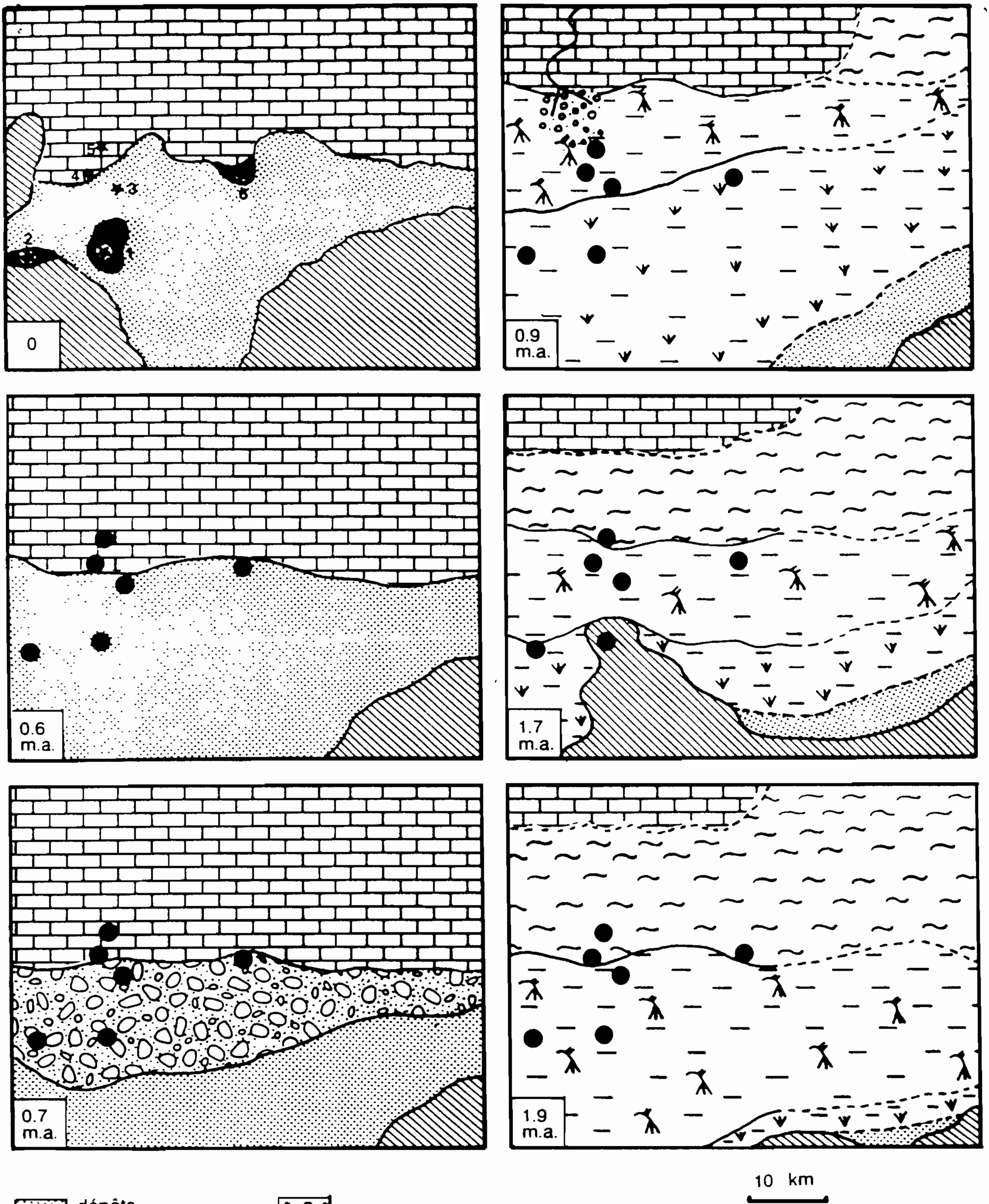


FIG 30 GEOLOGICAL EVENTS IN THE SOLO DEPRESSION



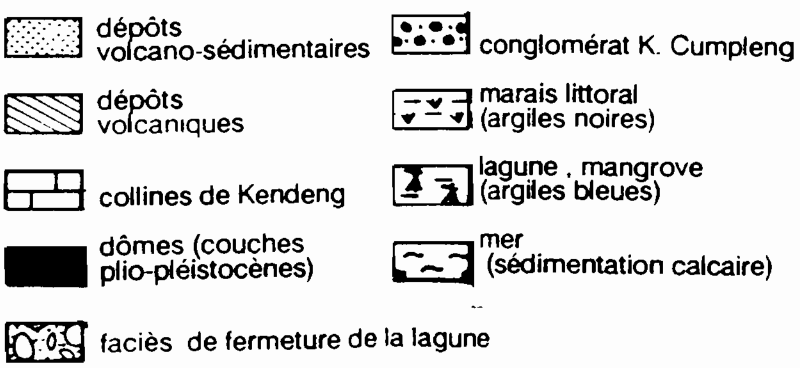


FIG. 31 PALEOGEOGRAPHICAL EVOLUTION

II.2.The larger volcanoes

We know that the larger volcanoes in the Solo depression became active at ca. 2 m yrs ago (see Y. Bandet *et al.*, 1989; R.C. Maury *et al.*, 1987). The older works by Dutch geologists (see for instance R. W. van Bemmelen, 1949) said that the Gunung Wilis alone, far to the East, was active at those times. Some of its products could have been transported westward to Sangiran.

In fact, the Sangiran lahars, dating back to the Plio-Pleistocene boundary, are sometimes very thick. They more likely originate from a closer volcanic centre, like the Lawu volcano. These lahars contributed to pond up the Solo lagoon, and gave more continental conditions in the Sangiran area (the Pucangan swampy clays).

These larger volcanoes played a large part in the recession of the sea:

-Directly, by the ponding up of the lagoon with eruption products.

-But also by the simple sedimentation of weathering products of volcanic effluents.

The thick clayey Upper Kalibeng and Pucangan units originate from the weathering of volcanic ashes and of the volcanic cones.

Along the Kaliuter sections, we observed an abrupt change above the so-called banked limestone facies. We can explain this sedimentation rupture as a change in the source of the sediment:

-In the lower part of the sections, sedimentation was linked with a limy source, that is the Kendeng hills to the North.

-In the upper part, the origin of the sediment changed and it comes from a Southern volcanic province.

This change progressed gradually northwards. At Gemolong, the blue clays appear *ca.* 2.4 m.yrs ago. At Soko, at the end of the Olduvai event, *ca.* 1.7 m.yrs ago. At Barong, several kilometers to the North, well after the end of the Olduvai event. We see that the horizontal changes of facies are very rapid and important in the Solo depression. Therefore, our stratigraphical approach has to consider geodynamically the geological events which took place at those times; it cannot be restricted to an usual lithostratigraphic definition of geological formations.

For instance, the clayey swampy deposits called "Pucangan" at Sangiran are synchronous with the blue clays deposits at Kaliuter. The facies depends on the palaeogeographical conditions: clays deposited under the form of black clay at Sangiran, and of blue clay at Kaliuter (nearer to the sea). Lithostratigraphical correlations between "Pucangan" and "Upper Kalibeng" facies between the two areas is therefore a nonsense from the chronological point of view.

II.3.The Kendeng hills

Several researchers during the Dutch period thought that a folding phase occured near the Plio-Pleistocene boundary (ie. near the Sangiran lahars now dated at 1 7 m yrs ago) Our observations do not confirm this view. The transition from the lagoonal facies to more swampy conditions at Sangiran was mainly linked to the volcanic activity.

The last folding phase of the Kendeng hills we recognized dates back to the Brunhes/Matuyama boundary. It marks the definitive disappearance of marine influence in the Solo depression. At Sangiran and Onto-Simo, we observe a clear change in the sedimentation, with the deposition of the *Grenzbank*, a conglomeratic bed which mixes marine and continental elements. At Kaliuter, we find the so-called transitional beds (with beach deposits) described above.

The *Grenzbank* and the disappearance of marine influence at Sangiran is therefore the indirect trace, in the depression, of this last folding phase of the Kendeng hills

Then we find the volcano-sedimentary Kabuh deposits all over the area Volcanic activity became more and more intense in the area (Notopuro breccia), and the Kendeng hills were eroded, giving the geological landscape its present aspect

BIBLIOGRAPHY

BANDET, Y., F. SÉMAH, S. SARTONO, et T. DJUBIANTONO, 1989.

Premier peuplement par les mammifères d'une région de Java Est, à la fin du Pliocène âge de la faune du Gunung Butak, près de Kedungbrubus (Indonésie).

C.R Acad. Sci. Paris, 308, Série II, p.867-870.

BEMMELEN, R.W. van., 1949.

The Geology of Indonesia and adjacent archipelagoes.

Martinus Nijhoff ed., Den Haag, 3 vol., 732 + 265 pp.

DJUBIANTONO, T., 1992

Les derniers dépôts marins de la dépression de Solo, Java Central, Indonésie Chronostratigraphie et Paléogéographie.

Mémoires Semenanjung, I., 206 pp

ES, L.J.C. van., 1931.

The age of Pithecanthropus.

Martinus Nijhoff ed., Den Haag, 142 pp.

KOENIGSWALD, G.H.R. von, 1940

Neue Pithecanthropus-Funde 1936-1938

Dienst v d. Mijnbouw Ned.Indië, Wetensch.Med., 28, 236 pp..

MAURY, R.C., R. SOERIA-ATMADJA, H. BELLON, J-L. JORON, Y.S. YUWONO et E. SUPARKA, 1987.

Nouvelles données géologiques et chronologiques sur les deux associations magmatiques du volcan Muria (Java, Indonésie).

C R. Acad.Sc. Paris, t. 304, Série II, 4, p.175-180.

SARTONO.,S, SÉMAH, F. ET T.DJUBIANTONO, 1984.

Paleomagnetic results from the Bringinan and Gemolong Domes (Central Jawa). Correlation with the Sangiran Section.

Buletin Geologi, Jurusan Geologi, ITB, 13, p.17-21.

SÉMAH, A.-M., 1986.

Le milieu naturel lors du premier peuplement de Java.

Résultats de l'analyse pollinique.

Thèse de Doctorat ès Sciences Naturelles, Université de Provence, 3 vol., 188+119pp.

SÉMAH, F. 1986.

Le Peuplement ancien de Java Ebauche d'un cadre Chronologique.

L'Anthropologie, 90, n° 3 ,p. 359-400.

SÉMAH. F., A-M. SÉMAH, T.DJUBIANTONO et H.T.SIMANJUNTAK, 1992.

They also made stone tools.

Journal of Human Evolution. (sous-presse).

SHUEY, R.T., F.H. BROWN et M.K. CROES ., 1974

Magnetostratigraphy of the Shungura formation, Southwestern Ethiopia: fine structure of the lower Matuyama polarity epoch

Earth and Planet. Sc. Letters, 23, p.249-260.

SUZUKI, M., WIKARNO, BUDISANTOSO, I. SAEFUDIN, et M. ITIHARA., 1985. Fission tracks ages of pumice tuffs layers and Javites of hominid fossil bearing formations in Sangiran area, Central Java.

in N. Watanabe & D Kadar (1985) "Quaternary Geology of the Hominid fossil bearing formations in Java".

Geological Research and Development Centre, Bandung, Special Publication no.4, p.309- 357.

WATANABE, N. & D. KADAR, 1985.

Quaternary Geology of the Hominid fossil bearing formations in Java",

Geological Research and Development Centre, Bandung, Special Publication no.4