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Notes on the Morphology and Age of the Tabon Cave Fossil *Homo sapiens*

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Facing the South China Sea, along the western coast of the long, northeast-to-southwest-oriented island of Palawan, the Philippines, lies an important complex of caves and rock shelters collectively called the Tabon caves (fig. 1, *a*). The name is that of a *Megapodius* species (locally called the tabon) that lays its eggs in the caves, which contain huge deposits of bat guano. The complex was intensively studied under Robert Fox's direction by the National Museum of the Philippines, which conducted more than 30 excavations there between 1962 and 1966 (Fox 1970). The most famous cave, called Tabon Cave, was the first site to establish the presence of humans in the Philippines during the Pleistocene (Shutler 1965).

Heretofore, the most complete publication concerning Tabon Cave remained Fox's (1970) excavation report. It includes a corpus of ^{14}C dates obtained during the 1960s at the University of California, Los Angeles, which documents a virtually continuous occupation of the cave between at least ca. 30,000 and ca. 9,000 B.P. Fox's excavation results have been widely cited (see, e.g., Bellwood 1997, Bulbeck 1981, Galipaud and Sémah 1993) because Tabon Cave is one of the very few sites in Southeast Asia to have yielded Pleistocene fossil *Homo sapiens*.

Archaeological activity in Tabon Cave was discontinued shortly after Fox's first publication for various reasons, among them the shift of interest to the open sites in the Cagayan Valley on Luzon Island in search of possibly earlier human remains (Fox 1978). Therefore, little analytical work was carried out on the Tabon data. Several scholars are said to have taken samples of the archaeological deposits and of the human fossils themselves, but no report was published on these materials.

Recently, the Archaeology Division of the National Museum of the Philippines has undertaken new studies of the cave. As a preliminary step, seeking to validate the data gathered by Fox, it was decided to undertake radioisotopic dating and simultaneous anthropological study of the still almost undescribed human remains, whose stratigraphic position is under discussion. This study is intended to provide new chronological data on the question of Pleistocene *H. sapiens* settlement on the margins of Sundaland.

PREHISTORIC OCCUPATION OF TABON CAVE

Tabon Cave is a karstic cavity about 40 m long, 15 m wide, and 8 m high, northwest-to-southeast-oriented and ca. 35 m above the present sea level (fig. 1, *b*). According to Fox (1970), below the surface jar burial dating to 200–500 B.C., the Palaeolithic horizons excavated may be divided into six levels, expanding on about 2.5 m of excavated stratigraphy (fig. 1, *c*) and named from the youngest to the oldest flake assemblages IA, IB, II, III, IV, and V. This classification seems based more upon the stratigraphic distribution of the artefacts (see fig. 1, *c*) than on their typo-technological characteristics. Assemblages IV and V yielded very few artefacts but seem unquestionable. Associated charcoals gave definite ages for assemblages IB, III, and IV, respectively 9,250 ± 250 B.P. (UCLA-284), 23,200 ± 1,000 B.P. (UCLA-699), and 30,100 ± 1,100 B.P. (UCLA-958). No other horizons could be dated definitively, and no suitable charcoals were reported from assemblage V.

Although Fox does not document any conspicuous difference between the assemblages, his good description of flake assemblage III reflects some interesting behavioural features of the prehistoric groups that occupied the cave. The cave obviously sheltered a lithic workshop oriented towards the production of flakes of irregular shapes and sizes, less than 20% of which had been used or retouched as tools. These tools are mainly regular and denticulated scrapers (fig. 1, *d*), for which Fox proposes the name Tabonian (see also Forestier and Patole 2000). All the operating stages are present in the cave, from raw chert lumps to flake tools via cores, hammerstones, waste flaking, unretouched flakes, and used flakes. The raw material used, chert, is noted as common in the riverbeds near the cave complex, but assemblage III also yielded several trimmed basalt choppers, together with basaltic and quartz pebbles likely to have been used as hammerstones. Fragmented faunal remains were recov-

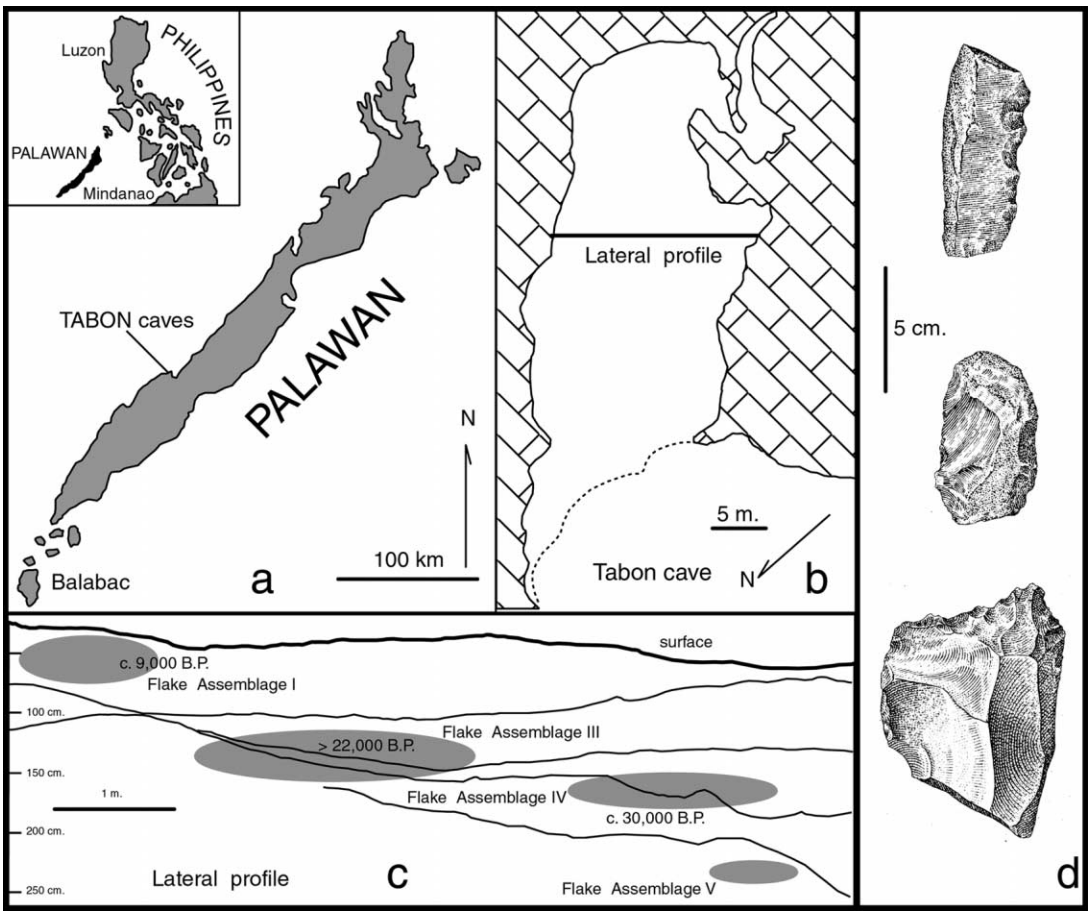

FIG. 1. *Tabon Cave and its stratigraphy.* a, *location of the site;* b, *plan of the cave;* c, *cross section of central section of lateral profile and distribution of the archaeological horizons* (*after R. Fox 1970*); d, *flake tools from assemblage III* (*after Fox 1970, courtesy National Museum of the Philippines*).

ered in the layers related to assemblages IA, II, and, to a lesser extent, III and IV. Pig and deer, the latter now extinct in Palawan, were the only large mammals which could be identified.

THE HUMAN FOSSILS

The human remains mentioned in Fox's report are two fragmentary mandibles and a fragmentary cranium with part of the frontal and nasal bones (fig. 2). Unfortunately, these were found during early 1962 fieldwork in the back of the cave, an area which was disturbed by tabon birds, but further excavations persuaded Fox (p. 40) that the human fossils originally came from layers contemporaneous with assemblage III and dated to ca. 22,000–24,000 B.P. He did not present any clear evidence to support this conviction, and Howells (1973:179; and see Bulbeck 1981) suggested that their age might be very late Pleistocene or even early Holocene. Macintosh undertook the morphological description of the Tabon frontal (as documented by his 1975 notes, still preserved in the National Museum of the Philippines, and a short article in the *University of Sydney News* [1975]) but unfortunately could not complete it.

Another fossil, a "mineralized human tooth," is also mentioned on a stratigraphic profile (Fox 1970:34) among chert flakes belonging to so-called assemblage II.

Macintosh (1978) has described two other human mandibular fragments belonging to a single individual, assumed to come from Tabon, which are neither mentioned in Fox's report nor registered in the present inventory of the National Museum of the Philippines. Barker (1978) studied the teeth preserved on these mandibular fragments. It is not clear whether these fragments came from Tabon Cave or from a neighbouring site. The fossils we deal with here are, therefore, the fragmentary cranium (no inventory number), the right fragment of mandible referenced PXIIIT 436-Sg19, and a smaller left mandibular fragment (no inventory number).

THE TABON FRONTAL AND MANDIBLES

The frontal bone (fig. 2, *a–c*), although almost complete (fragments of nasal bones are also attached), is somewhat

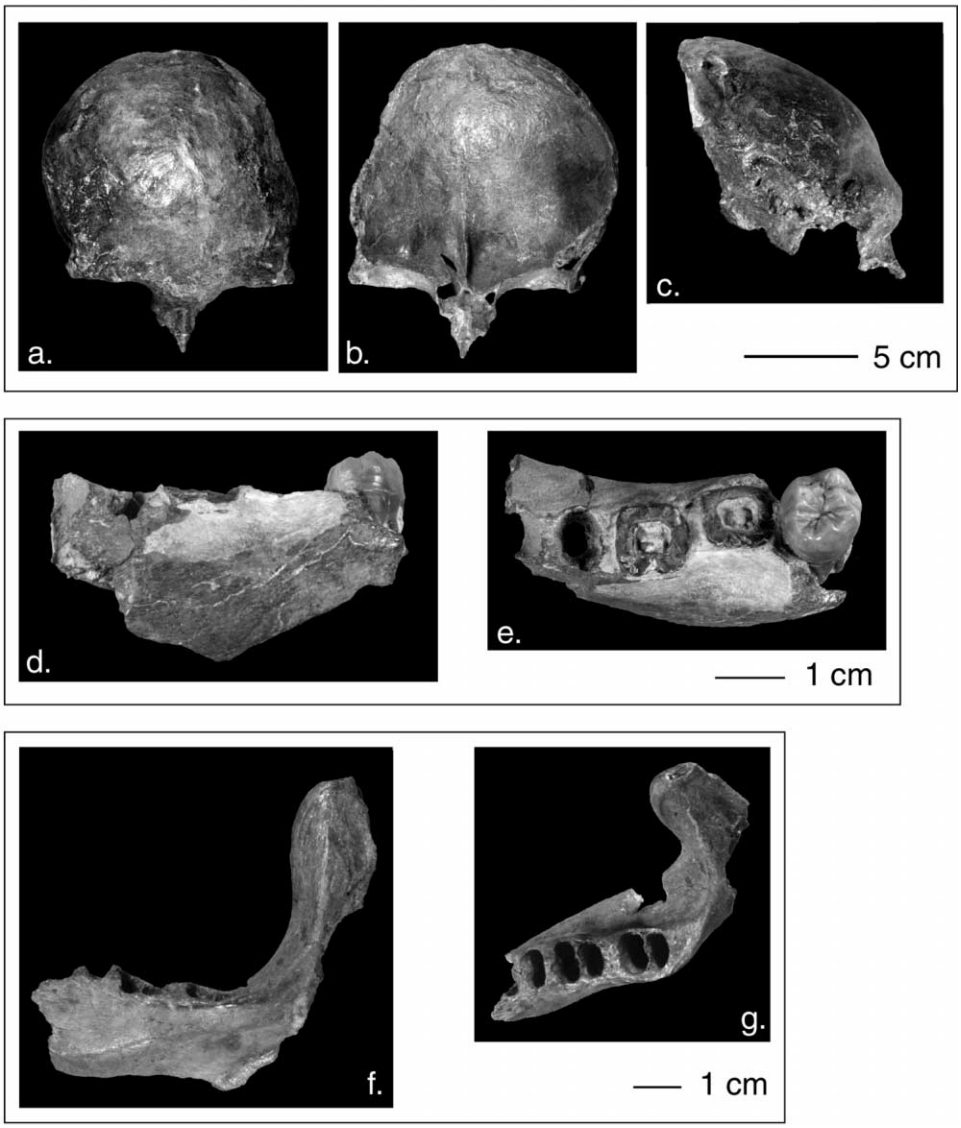

FIG. 2. *The human remains from Tabon Cave.* a–c, *frontal and nasal fragments, external, internal, and right lateral views;* d *and* e, *fragmentary left portion of mandible, external and occlusal views* (*note the wrong position of* M_3); f *and* g, *right fragment of mandible* (*PXIIIT436-Sg19*), *internal and occlusal views.*

damaged along the coronal suture and on the left side towards the pterion. Its horizontal portion is also damaged; the roofs of the orbits are preserved for a few millimetres behind the orbital rims.

The overall dimensions of the frontal are quite small (nasion-bregma 118, glabella-bregma 116, minimum breadth 97, interorbital breadth 25, nasion-bregma arch 138). The superciliary arches are well developed and projecting forward and are joined medially by a prominent glabellar region. The glabellar region, in which a persistence of the metopic suture is still visible (running for 17 mm above the nasion), is the most prominent area viewed from above. The preserved portions of the lateral trigones are weak and gracile. Behind and above the supraorbital complex, a wide sulcus is visible. This 3-cm-wide concave area crosses the whole of the frontal bone transversally. From the side, the infraglabellar notch is well depressed, although this may be because of an exaggerated inclination of the nasal bones under the nasion (deformation?). Posterior to the supraorbital sulcus, the frontal squama is rounded. Although it has undergone some surface weathering, it still shows two frontal eminences, which point to a young adult female individual. This sex determination was favoured by Fox and Macintosh but not by Howells (1973:179), although the latter does not give anatomical evidence. Scanning radiography pictures (fig. 3) show the development of the frontal sinuses, which occupy al-

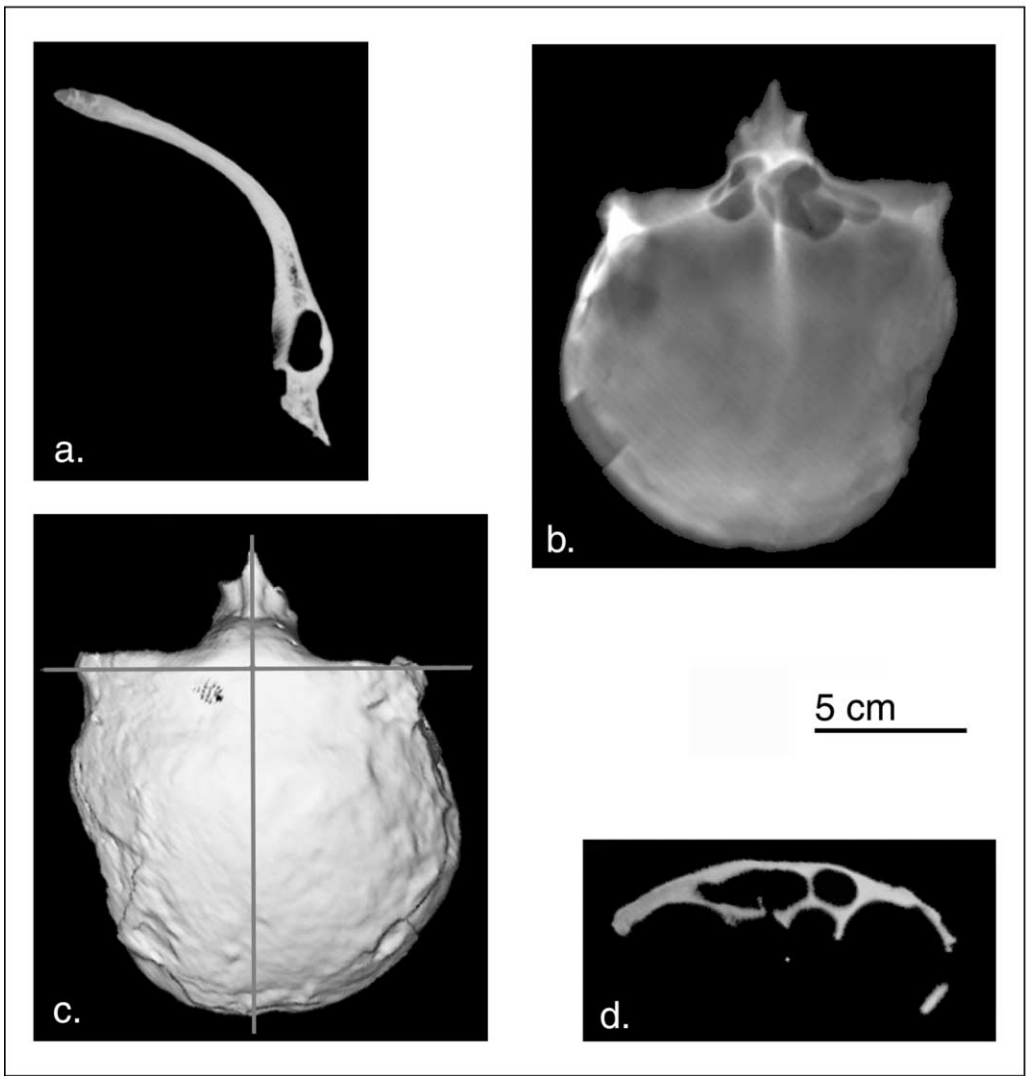

FIG. 3. *Radiographic and scanning pictures of the Tabon frontal and nasal fragments.* a, *sagittal section* (*see location on* c)*;* b, *radiography from the internal face;* c, *three-dimensional reconstruction of the external face; d, transversal section* (*see location on* c).

most all the space behind the superciliary arches and are more developed on the left side.

The fragmentary left portion of mandible (fig. 2, *d* and *e*) is heavily mineralized and represents the upper part (alveolar and alveolar basis) of the left mandibular body from the middle of the P_3 socket to the anterior part of the M_3 socket. M_1 and M_2 are broken at the bases of their crowns, and only their roots are present (fig. 4, *a*). The status of the third molar, which has been glued to the mandible, is very doubtful: its anatomical position is wrong, and its shape does not fully resemble that of the one represented in Fox's report (fig. 2, p. 41). It may have come from another part of the collection or may even be the tooth mentioned by Fox on the stratigraphic profile (1970:34) but not registered in the collection.

In cross section, the portion preserved (the uppermost part of the corpus) tends to be barrel-shaped, and the beginnings of a *planum alveolare* may be observed on the inside near the P_4 socket (fig. 2, *e*). The *linea obliqua externalis* is prominent but very smooth and runs subparallel to the occlusal plane. This *linea obliqua* delimits the lower edge of a very distinct depression running from the base of the M_2 socket to the base of the posterior part of the M_1 socket. The *foramen mentale* is not visible. The mandibular fragment was presumably broken just posterior to the most probable position of this *foramen mentale*, on the axis of the roots of P_4. The mylohyoid line is not preserved. Only the *prominentia alveolaris* is visible, except at the basis of the P_4 socket, where a small portion of the *fossa subalveolaris* (*planum alveolare*) is discernible. The empty P_4 socket tends to be cone-shaped, with a rounded rather than an ellipsoid

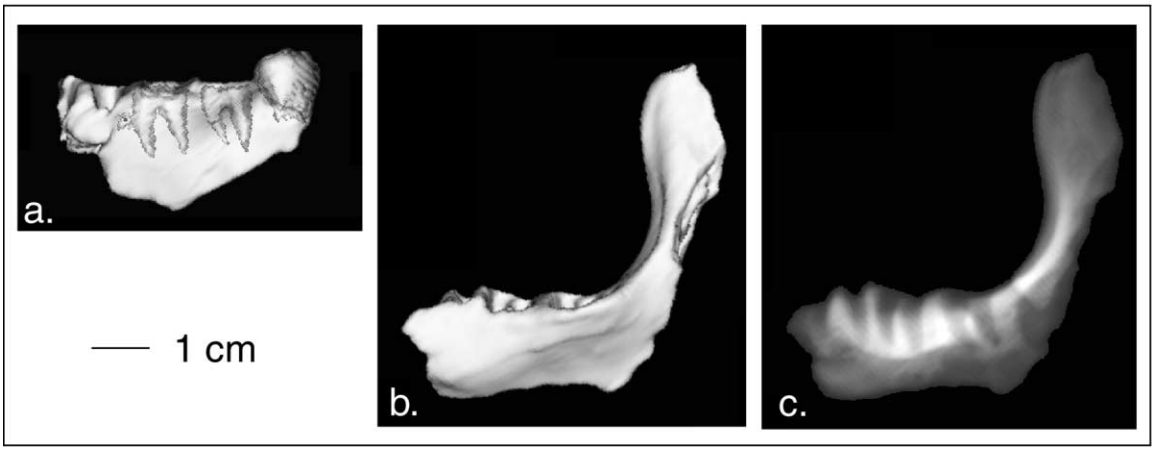

FIG. 4. *Radiographic and scanning pictures of the Tabon mandible fragments.* a, *Fragmentary left portion of mandible, external view with superimposition of tooth roots;* b *and* c, *right fragment of mandible (PXIIT436-Sg19), three-dimensional reconstruction of the internal face and radiography.*

aperture. It does not exhibit the clear bucco-lingual elongation commonly encountered in *Homo* individuals, but neither does it present the three-rooted shape characteristic of *Pongo* species.

In cross section, the Tabon mandibular corpus is wide, with convex walls, whereas the Zhoukoudian Locus G no. 1 and Locus A no. 2 and Sangiran 1b mandibular fragments are rectangular with subparallel and vertical walls. For the morphological characters discussed above, the Wajak II mandible (one of the most robust *Homo sapiens* mandibles in Southeast Asia) would most closely match the Tabon fragment. However, its *planum alveolare* is more developed, and all the measurements available are larger for the Tabon fragment (see tables 1 and 2 and fig. 5). Furthermore, the maximum of curvature of the *linea obliqua externalis* is more accentuated and in a more posterior position in Wajak II (at the M_2/M_3 level) than in the Tabon mandible (at the M_1/M_2 level). Many of the characteristics of the mandible in addition to its dimensions would tend to place it closer to *Pongo* than to *Homo*, but the P_4 socket does not support that interpretation. It would appear to correspond at least to an amazingly robust *Homo* specimen.

The glued third molar shows a crenulated occlusal surface but not of the type encountered in *Pongo*. The crenulations and the shape of this molar would better match a large *Homo* M_3 (MD = 12.8; BL = 11.1 mm).

The right mandibular fragment (PXIIIT436-Sg19: fig. 2, *f* and *g*; fig. 4, *b* and *c*) exhibits the portion corresponding to the three molars and the anterior part of the *ramus mandibulae* including the almost complete coronoid process. All the teeth are absent, apparently having been lost post-mortem (there is no alveolar resorption). The *linea obliqua externalis* is very smooth and joins the

TABLE 1
Mandibular Corpus Thickness (mm)

	n	P4/M1 Mean	S.D.	M1/M2 Mean	S.D.	M2/M3 Mean	S.D.
Tabon PXIIT436-Sg19	1	–	–	15.00	–	16.50	–
Tabon (unnumbered)	1	19.00	–	21.00	–	21.50	–
Wajak II	1	17.00	–	19.00	–	22.00	–
Extant *Homo sapiens*[a]	16	13.94	1.14	15.50	1.71	16.28	1.75
Fossil Asian *H. sapiens*[b]	5	13.50	4.95	17.25	2.47	19.50	3.54
Homo erectus[c]	4	17.13	2.14	18.63	2.69	19.50	2.89
Pongo pygmaeus[d]	8	18.44	1.64	19.19	2.42	21.69	3.08

NOTE: Mandibular corpus thickness was measured transversally at the three interalveolar locations preserved in the Tabon mandibular fragment.
[a]Sixteen male individuals from the collection of the Institut de Paléontologie Humaine, Paris.
[b]Wajak II (Indonesia), Zhoukoudian Upper Cave 101 (China), Moh Khiew Cave 91B1, Moh Khiew Cave 91B2, and Sakai Cave 92B1 (Thailand).
[c]Sangiran 1b (Indonesia), Zhoukoudian (Locality 1) A2.2 and G1.6 (China), Tighenif (Morocco).
[d]Eight female and young male individuals from the collection of the Laboratoire d'Anatomie Comparée, Muséum National d'Histoire Naturelle, Paris.

TABLE 2
Interalveolar Lengths (mm)

	n	M2/M3-M1/M2 Mean	S.D.	M2/M3-P4/M1 Mean	S.D.	M2/M3-P3/P4 Mean	S.D.
Tabon PXIIIT436-Sg19	1	11.00	–	20.00	–	–	–
Tabon (unnumbered)	1	13.00	–	24.00	–	32.00	–
Wajak II	1	10.00	–	(21.00)	–	(31.00)	–
Extant *Homo sapeins*[a]	16	10.66	1.12	21.19	1.66	27.81	2.26
Fossil Asian *H. sapiens*[b]	2	10.00	–	20.00	–	28.50	–
H. erectus[c]	4	12.25	0.96	24.00	2.16	31.38	2.98
Pongo pygmaeus[d]	8	13.50	1.28	26.00	1.98	36.00	2.94

NOTE: Interalveolar lengths were measured on the inside parallel to the alveolar plane from the rear of the M2 socket to the three interalveolar loctions preserved in the Tabon mandibular fragment.
[a]Sixteen male individuals from the collection of the Institut de Paléontologie Humaine, Paris.
[b]Wajak II (Indonesia), Zhoukoudian Upper Cave 101 (China).
[c]Sangiran 1b (Indonesia), Zhoukoudian (Locality 1) A2.2 and G1.6 (China), Tighenif (Morocco).
[d]Eight female and young male individuals from the collection of the Laboratoire d'Anatomie Comparée, Muséum National d'Histoire Naturelle, Paris.

anterior border of the ramus at an angle of about 95°. The *foramen mentale* is not preserved. The anterior border of the coronoid process is flattened, and a small sharp ridge delimits the insertions of the temporal muscles on both medial and lateral surfaces of the process. The mylohyoid line is smooth but underlined by a narrow groove running from the rear of the M_3 socket to the anterior fracture of the corpus, at the level of the M_1 socket. Under the mylohyoid line, the submandibular fossa is observable up to the basal fracture but is not very deep. In frontal view, the ramus is oblique to the lateral face rather than subvertical, resulting in an angle between the occlusal plane and the ramus axis of about 120°. From above, the extramolar sulcus is particularly developed at the lateral alveolar margin of the M_3 socket (ca. 8 mm wide). The general morphology and the measurements of this fossil match those of a modern *H. sapiens* (fig. 5).

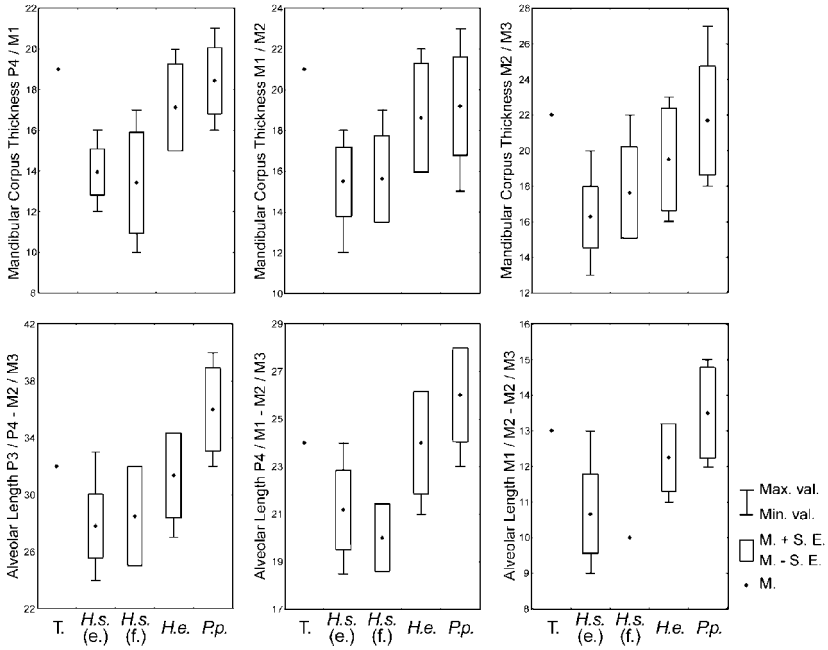

FIG. 5. *Comparative measurements for the Tabon Cave mandibular fragment.* T., *Tabon;* H.s. (e.), *extant* Homo sapiens; H.s. (f.), *fossil Asian* Homo sapiens; H.e., Homo erectus; P.p., Pongo pygmaeus; M., *mean;* M. + S.D., *mean plus standard deviation;* M.−S.E., *mean minus standard deviation;* Max. val., *maximal value;* Min. val., *minimal value.*

URANIUM-SERIES DATING OF THE HUMAN REMAINS

In order to get a qualitative estimate of the uranium content of the fossils, the Tabon frontal and the left mandibular fragment were measured by means of non-destructive gamma-ray spectrometry. The mass of the fossils and the relatively low uranium content (about 2 ppm) prevented any attempt at direct dating. However, the detection of a small amount of uranium allowed the use of alpha-ray spectrometry and the calculation of the $^{230}Th/^{234}$ U ratio by chemical separation of uranium and thorium isotopes. Such treatment classically includes (Bischoff et al. 1988) dissolution by HNO_3 and H_2O_2, separation of uranium and thorium using anionic exchange resin, and extraction and deposition before spectrometric counting. A 0.47-g sample of nasal bone was used for this purpose and counted for a week. The sample proved to have a 0.142 ± 0.016 $^{230}Th/^{234}U$ ratio. Its 2.88-ppm uranium content is quite consistent with the gamma-ray rough estimate, suggesting a homogeneous distribution of that element in the fossil. The $^{230}Th/^{232}$ Th ratio (> 100) shows that no detrital thorium entered the bone after its burial. Following the early-uranium-uptake hypothesis (Bischoff and Rosenbauer 1981), this ratio would imply an age of 16,500 ± 2,000 B.P. for the fossil.

CONCLUSION

Although the precise geochemical history of the fossil is not fully known, the isotopic $^{230}Th/^{234}$ U ratio directly measured on the Tabon fragmentary cranium strongly suggests a late Pleistocene age. It therefore confirms to some extent Fox's (1970) suggestion of the antiquity of that fossil without being any more precise about its stratigraphic position within the published scheme. It does provide more precision about Palawan Island human settlement well before the Holocene by *H. sapiens*, most probably via the very narrow, several-kilometre-long strait which still separated the island from Borneo during the Upper Pleistocene eustatic declines of sea level. The late Pleistocene declines of sea level (especially during oxygen-isotope stage 2) left the cave far inland, and according to Fox this would account for the conspicuous lack of marine shells in the anthropic Pleistocene layers of Tabon Cave.

The surprising morphology and problematic taxonomic attribution of the fragmentary left mandibular fragment raise the question of a possible colonization of Palawan by Pongidae during the Upper Pleistocene, but doubts concerning the origin of the M_3 and the morphology of the P_4 socket make any conclusion impossible at this stage.

It is hoped that the present fieldwork undertaken by the Archaeology Division of the National Museum of the Philippines will provide us with more archaeological data through a new excavation grid and a better stratigraphic control of Fox's published observations and open the way for new isotopic datings on speleothems and fossil bones and teeth.

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The Importance of Early Maize Agriculture in Coastal Ecuador: New Data from La Emerenciana[1]

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Maize has often been described as "the grain that civilized the New World." This characterization, however, relies too much on the ethnohistorical evidence indicating that maize was the preeminent crop at the time

1. [Supplementary material appears in the electronic edition of this issue on the journal's website (http://www.journals.uchicago.edu/CA/home.html).]