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Preliminary Observation of a New Cranium of *Homo erectus* (Tjg-1993.05) from Sangiran, Central Jawa

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Abstract In May of 1993, a new well-preserved hominid skull was recovered from the Bapang (Kabuh) Formation of the Sangiran region, Central Jawa. In this paper, we provisionally describe the skull and compare it with *Homo erectus* crania from Jawa and China. The new skull possesses a series of characteristic features of Asian *H. erectus* in overall size and shape of the vault, the expression of various ectocranial structures, and other details. Among three geographical and chronological subgroups of Asian *H. erectus*, the new skull shows affinities with the Jawanese Early Pleistocene subgroup (specimens from the Sangiran and Trinil regions), as expected from its provenance.

Keywords: *Homo erectus*, human evolution, Indonesia, paleoanthropology

Introduction

In May of 1993, a new hominid skull of an adult individual was recovered from the Sangiran area, Central Jawa (Figs. 1 and 2). There is no formal specimen number for this skull. Sartono called it Skull IX, and Larick et al. (2001) provisionally labeled it as Tjg-1993.05. The discovery of the skull was first announced in academic meetings in the Netherlands (Sartono et al, 1995), Indonesia (Sartono and Tyler, 1993), and America (Tyler et al., 1994).

Recently, Tyler and Sartono (2001) published a description and a comparative analysis of this skull. The present paper includes further detailed information as well as some important corrections of their work. Tyler and Sartono (2001) compared the new skull with one Asian and one African *Homo erectus* crania (Sangiran 2 and KNM-ER 3733). In the present paper, we performed more intensive comparisons with Asian *H. erectus* materials. Because we have further cleaned the adherent matrix of the skull after the work of Tyler and Sartono, we provide here more detailed information of its surface morphology. Furthermore, some aspects of the currently

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Figure 1. Calvaria of Tjg-1993.05. Left row, the original specimen; Right row, the reconstructed cast. From top to bottom, frontal, posterior, superior, basal, and left lateral views.

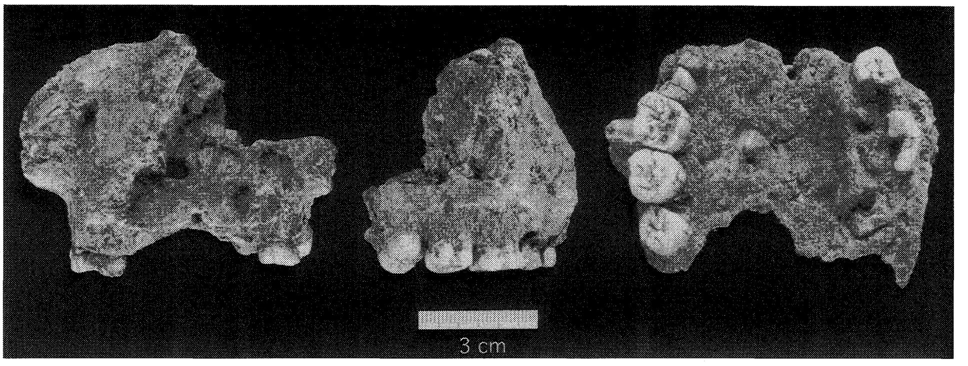

Figure 2. Maxilla of Tjg-1993.05. From left to right, frontal, right lateral, and occlusal views.

restored condition of the skull are inappropriate. Tyler and Sartono (2001) seemingly underestimated this effect, thereby having overemphasized the narrowness of Tjg-1993.05, although the skull is indeed relatively narrow compared to known Asian *H. erectus* specimens.

This work was developed from the doctoral research of J. A. (Arif et al., 2001), and focuses on comparative morphology. Here, we analyze Tjg.1993–05 in more detail about some morphological traits with possible taxonomic significance. In addition, we provide a more comprehensive review concerning the skull's provenance.

Provenance and Stratigraphy

According to a report on the Republika Minggu's (Indonesian newspaper) interview with the late Prof. Sartono, dated the 19th of July, 1993, the new skull was found in the area of the Tanjung village by Mr. Sugeng, a local farmer, when he was walking down a cliff. Later, based on the information from a local villager, Y. Zaim and Y. Rizal located the findspot in the Tanjung area and stratigraphically correlated it to the middle part of the Bapang (Kabuh) Formation (Larick et al., 2001). This conclusion is consistent with the initial announcement by Sartono and his collegues that the specimen was from the Bapang Formation (Sartono and Tyler, 1993; Sartono et al, 1995; Tyler et al., 1994). Curiously, however, Tyler and Sartono (2001) recently reported that the specimen was from the middle part of the Sangiran (Pucangan) Formation not in the Tanjung area, but in the area of another village that is about 800 m west to the Tanjung village. They also stated that the skull was found by a different person while building a new house. Because Prof. Sartono and Mr. Sugeng have passed away, the background of the find remains somewhat ambiguous, but there is little doubt that Tjg-1993.05 was derived from the Bapang Formation above the Grenzbank zone (the basal part of the Bapang Formation).

Contrary to the latest statement by Tyler and Sartono (2001), the Bapang Formation origin of Tjg-1993.05 is supported from the skull specimen itself. Aspects of the skull's preservation, bluish-gray to light brown color, fragileness, and sandy matrix attached to the skull are typical among vertebrate remains from the Bapang Formation above the Grenzbank zone. More importantly, fluorine analysis (e.g., Matsu'ura, 1982) of Tjg-1993.05 suggests that the skull did not derive from the Sangiran Formation, that a Grenzbank zone origin is also unlikely, and that a Bapang Formation origin of the skull above the Grenzbank zone is supported (Matsu'ura and Kondo, personal communication). Currently, there are two views on absolute date for the hominid bearing horizons in the Bapang Formation above the Grenzbank zone. One supports a younger chronology (about 0.7–1.0 million years ago) and the other an older chronology (about 1.0–1.5 million years ago) (Hyodo et al., 1993, in press; Larick et al., 2001; see review in Larick et al., 2000).

Methods

The skull was fragile at the time of discovery, and later broke into many pieces (Tyler, personal communication). It was reassembled after that, but this restoration is not adequate. Although the basic placement of the fragments is largely correct, sand is mixed with glue in most joints. Some fragments are juxtaposed at inappropriate angles, and this particularly affects arrangement of the left parieto-temporal and nuchal regions. In addition, some of the teeth are glued to wrong positions. Important characteristics of the skull, however, can be assessed at the present state, and we present such information in this paper. A full description of the skull must await an elaborate work of disassembly and cleaning of every fragmented piece and re-restoration.

During the course of the present study, additional cleaning of matrix was undertaken in the regions of the glenoid fossa, maxilla and teeth. In order to correct for distortion and to obtain a more accurate assessment of overall size and shape of the skull, we prepared a reconstruction using a high quality plaster cast of the Tjg-1993.05 specimen, made at the Department of Geology, Institute of Technology Bandung, Indonesia on March 1997 by Y. Yazawa. Then, two of the authors (H. B. and J. A.) cut the cast of the vault into 16 pieces and these pieces were realigned by correcting for the apparent distortion seen in the original specimen (Fig. 1). Measurements were taken from both the original specimen and this reconstruction. Those of the reconstruction are considered to be more accurate, and were used for the metric comparisons. Some pieces of the occipital may be incorrectly aligned in the original specimen. Therefore, we refrain from interpreting the details of morphology in this area except that this possible inaccurate restoration does not significantly affect the horizontal position of the opisthocranion (thus the maximum cranial length is measurable).

In this study, Tjg-1993.05 is compared with other Indonesian fossil hominid skulls as well as those from the Zhoukoudian Lower Cave. Indonesian comparative materials were separated into two subgroups; specimens from the Sangiran and Trinil areas

(Sangiran 2, 4, 10, 12, 17; Trinil 2), and those from the Ngandong and Sambungmacan areas (Ngandong 1, 6, 7, 10, 11, 12; Sambungmacan 1). This is because the specimens of each subgroup are generally close to each other in terms of both morphology and chronology. The Sangiran/Trinil subgroup is inferred to belong to the Early Pleistocene, and the Ngandong specimens probably to the later Middle to early Late Pleistocene. The materials from Zhoukoudian constitute another subgroup (Skull 2, 3, 10, 11, 12). Large portions of the frontal region are not preserved in Sangiran 4, 10, and 12. Therefore, the number of measurements included in our comparisons is limited for these specimens.

Measurements of the comparative specimens were cited from the literature (Weidenreich, 1943; Santa Luca, 1980; Rightmire, 1990; Aziz et al., 1996). Original specimens were observed for Sangiran 12 and 17, while comparisons with the other specimens were facilitated by casts (Sangiran 2, Trinil 2, Sambungmacan 1, and the

Table 1. Cranial measurments of Tjg-1993.05[1]

	Measurements	Methods	Original	Reconstruction
1	Maximum cranial length	Martin, 1	(195)	(198)
2	Bregma position projected to g-op	Weidenreich, 11[3]	(91)	(91)
3	Lamda position projected to g-op	Weidenreich, 12[3]	(172)	(183)
4	Minimum frontal breadth	Martin, 9	78	77
5	Postorbital breadth	Martin, 9.1	83	88
6	Maximum frontal breadth	Martin, 10	102	108
7	Temporoparietal breadth	Martin, 8c	127	132
8	Biauricular breadth	Martin, 11	127	130
9	Maximum cranial breadth	Martin, 8	133	146
10	Biasterionic breadth	Martin, 12	114	109
11	Auriculo-bregmatic height	Martin, 20	99	104
12	Bregma height over g-op	Weidenreich, 40[2]	66	66
	Length-breadth index (8/1)		(65)	(66)
	Length-height index (11/1)		(51)	(53)
	Breadth-height index (11/8)		78	80
13	Glabella-bregma chord	Weidenreich, 57[2]	(115)	(111)
14	Glabella-bregma arc	Weidenreich, 55[2]	(117)	(115)
	Frontal curvature index (13/14)		(98)	(97)
15	Bregma-lamda chord	Martin, 30	90	98
16	Bregma-lamda arc	Martin, 27	92	102
	Parietal curvature index (15/16)		98	96
17	Frontal squama inclination: b-g ∠ g-op	Weidenreich 3[3]	(35°)	(36°)

[1] Compiled from Arif et al. (2001). Measurements of Skull IX were taken by J. A. (in mm except No. 18). Parentheses indicate estimates.

[2] Table 19 of Weidenreich (1943)

[3] Table 20 of Weidenreich (1943)

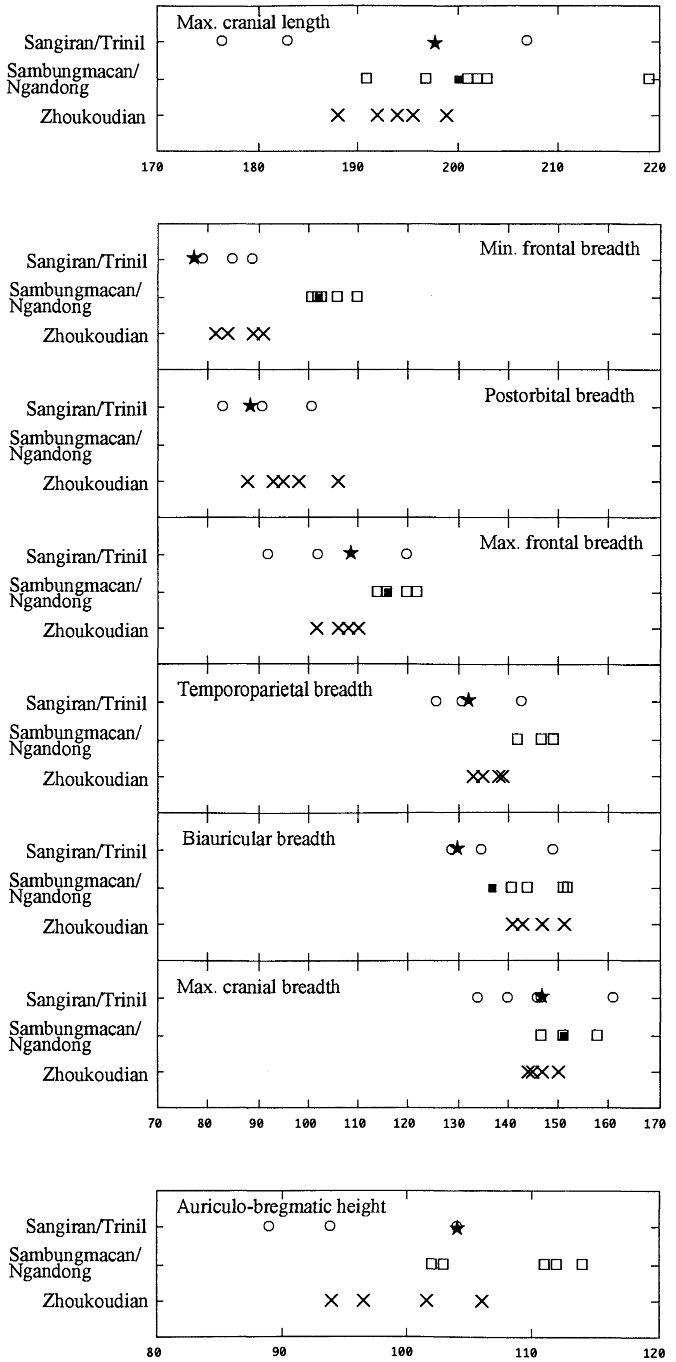

Figure 3. Comparisons of principal cranial measurements (mm). Measurements of Tjg-1993.05 are from the reconstructed cast. Solid star, Tjg-1993.05; Open squares, Ngandong specimens; Solid square, Sambungmacan 1.

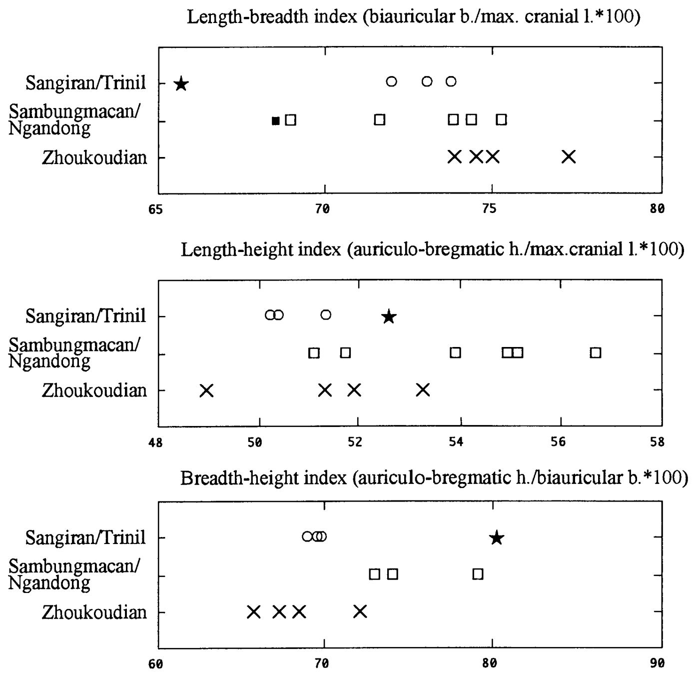

Figure 4. Comparisons of selected cranial indices. Measurements of Tjg-1993.05 are from the reconstructed cast. Symbols as in Fig. 3.

Ngandong and Zhoukoudian series).

Description

Tjg-1993.05 is one of the best-preserved crania ever found from the Lower Pleistocene of Jawa. Presently, the specimen consists of three separate parts: most of the calvaria, a small portion of the left temporal, and a large part of the maxilla with three complete crowns of the molars. Although Tyler and Sartono (2001) described the right zygomatic, this part had seemingly been lost before we started our work in 1997. The calvaria consists of a nearly complete frontal, both parietals, the occipital, majority of the right temporal except the petrous part, the left temporal squama, and a part of the greater wing of the right sphenoid. The outer surface is well-preserved and much of the surface morphology and most anatomical landmarks can be discerned without difficulty. The zygomatic process of the right maxilla remains, but the left maxilla is badly damaged. The palate and the nasal cavity are still covered by matrix. Complete crowns of the right M^1, M^2 and M^3 are preserved. Broken crowns of the other premolars and molars are also preserved, but further cleaning is needed before final identification. Some of these teeth have been glued to wrong positions. For example, the lingual half of the left M^3 has been moved to the left premolar position, and the fragment of left M^2 is also displaced.

Posterior half of the sagittal suture is open on the outer surface. The coronal suture is closed near the bregma and is completely obliterated at the midcoronal portions. Damage obscures the state of closure in the other regions of the major cranial sutures. Occlusal wear on the molars is moderate. The lingual cusps of these teeth are worn flat and a dentine island is seen on the protocone of the M^1. The buccal cusps are also worn but they still retain some cusp relief. These conditions suggest that this individual was a young or middle-aged adult at the time of death.

As is recognized from Table 1 and Fig. 1, distortion of the restored original specimen does not significantly affect overall vault length, but it does affect the breadth measurements. The measurements taken from the cast reconstruction were used for the metric comparisons below. Fig. 3 shows comparisons of selected measurements between Tjg-1993.05 and the comparative specimens. The vault of Tjg-1993.05 shows a general similarity to the comparative specimens in both size and shape. In all the measurement items but one, Tjg-1993.05 falls within the range of variation of the Sangiran/Trinil subgroup. Although the minimum frontal breadth of Tjg-1993.05 is outside this range, the difference from the Sangiran/Trinil subgroup is little. The vault of Tjg-1993.05 is long and low compared to the condition of *H. sapiens*. In posterior view, cranial breadth is greater at lower levels and the maximum breadth is measured on the supramastoid crest, as in most of the comparative specimens.

Compared to the other Jawanese and Chinese specimens, however, the vault of Tjg-1993.05 is relatively narrow and high to some extent. While vault length of Tjg-1993.05 is close to that of the largest specimen of the Sangiran/Trinil subgroup (Sangiran 17), its breadths are rather small and closer to those of the smaller specimens of the Sangiran/Trinil subgroup (Sangiran 2, 10 and Trinil 2) (Figs. 3 and 4). As Tyler and Sartono (2001) stated, the maximum length of the vault is somewhat extended by a strong anterior projection of the brow ridge in this specimen. The length-breadth index of Tjg-1993.05 is, however, still smaller than the comparative specimens even if 5 mm is subtracted from the maximum cranial length (this results in an index of 67.4) as done by Tyler and Sartono (2001: 18).

Anteriorly, the general architecture of the robust supraorbital torus is similar to

Table 2. Dental measurements of Tjg-1993.05 and Sangiran 17[1]

	Tjg-1993.05		Sangiran 17	
	MD	BL	MD	BL
Rt. M^1	11.8	12.5	11.4	12.8
Rt. M^2	11.7	12.8	11.2	12.7
Rt. M^3	9.5	12.8	9.4	13.3

[1] Meaurements taken by Y. K. from the original specimens (in mm). Measurement methods after Wood (1991).

that of Sangiran 17, although the torus of the latter is significantly larger in transverse dimension. The torus is thick but does not show lateral thickening observed in several of the Ngandong crania (Rightmire, 1998). The glabellar part is missing but the morphology of its adjacent regions indicates that it strongly protruded anteriorly relative to the lateral parts of the torus. The supraorbital notch exists as a big and deep notch (8 mm in width). Lateral to this notch, there is a bony projection called the supraorbital process (Weidenreich, 1943).

The lateral ends of the torus are flared, and the postorbital constriction is as pronounced as the other Sangiran specimens and Trinil 2. The supratoral plane is wide anteroposteriorly as in the other Sangiran and Trinil specimens. In the Ngandong/Sambungmacan series, this plane is narrower and is mostly absent in the region above the glabella. Additionally, in the frontal of Tjg-1993.05, this plane is relatively flat and there is no development of the supraorbital sulcus as described for Zhoukoudian *H. erectus* by Weidenreich (1943).

As in the comparative specimens, the right and left frontal squama meet at an angle. The metopic ridge does not exist as an independent keel, but is identified as a continued expression of this angle. The right and left squama are relatively flat and do not show the overall swelling seen in the Ngandong/Sambungmacan series (Weidenreich, 1951; Santa Luca, 1980; Rightmire, 1990), nor the bump (frontal eminence) observed in the Zhoukoudian specimens (Weidenreich, 1943: 23,193). The central part of the squama forms an eminence, which continues posteriorly to the metopic ridge. A similar eminence is also seen in Trinil 2, but this structure is more salient in the new skull. The frontal squama of Tjg-1993.05 rises rather steeply in the midline region compared to those of the other Sangiran and Trinil specimens. This character is consistent with the high vault of Tjg-1993.05, but is partly a reflection of the aforementioned eminence.

The area of the bregma is elevated, but there is no development of a keel along the intact posterior half of the sagittal suture. On either side of the posterior sagittal suture, the vault surface is flattened. The temporal line is defined as a low, faint ridge, and passes along midhight of each parietal. There is a distinct angular torus at the posterior end of this line. A part of the supramastoid crest is preserved on both sides. They are strongly developed and continuous to the root of the zygomatic process. The temporal squama is low and its superior border runs in a relatively straight course.

The glenoid fossa is well-preserved on the right side. The fossa is not as deep as typically observed in the Ngandong and Zhoukoudian series, partly because of the more gentle inclination of the anterior articular surface of Tjg-1993.05. The anterior articular surface does not show a noticeable convexity in the sagittal plane, and the articular tubercle is virtually absent as in Sangiran 2 and 17. The medial part of the glenoid fossa is broken away and presence or absence of a recess at this location cannot be determined. The postglenoid process is clearly defined as a sharp transverse ridge.

Morphology of the occipital bone cannot be assessed with much accuracy. Although both Tyler and Sartono (2001), and Arif et al. (2001) provided some morphological information of the skull's occipital region, we now think that the accuracy of their descriptions is suspect given the currently restored condition of this part. At least, the bone is sharply angulated as in the other comparative specimens, and there is an occipital torus along the border between the upper and lower scales.

Internal morphology of the vault is not observed in detail because of the patches of matrix still adherent to the bone surface, but the well-developed sylvian crest, which reaches the sphenoid angle of the parietal bone, can be discerned.

The maxilla and teeth also show similarities to those of the Sangiran 17 cranium as far as the remaining parts are concerned. The zygomatic process appears to be more massive than those of the Zhoukoudian specimens. In front view, the zygomaticoalveolar crest takes a relatively horizontal course near its junction to the maxillary body. The crest originates above M^1. The three molars are similar to those of Sangiran 17 in absolute size and degree of posterior crown size reduction (Table 2). The four principal cusps are well-developed in M^1, but the distal cusps are reduced in M^2 and M^3. This cusp arrangement is also similar to that in Sangiran 17.

Discussion and Conclusions

Because of the present poor state of the restoration, final conclusions concerning the detailed morphology of Tjg-1993.05 must await a re-restoration of the original specimen. In spite of this limitation, several important conclusions and suggestions for future studies can be drawn from the present study.

Tjg-1993.05 shows a series of characteristic features of Asian *H. erectus* in size and overall shape of the vault as well as in the expression of various ectocranial structures. Among the Asian *H. erectus* materials compared, Tjg-1993.05 shows resemblance to the crania of the Sangiran and Trinil series, as expected from its geographic and stratigraphic derivation. Tjg-1993.05 exhibited similarities to these specimens in morphological details of the supraorbital torus and the supratoral plane, pronounced postorbital constriction, relatively flat vault surface in the region between the temporal line and the midline of the vault, and possibly the details of the glenoid fossa. In addition, the maxilla and the maxillary molars of Tjg-1993.05 resemble those of the Sangiran 17 specimen. Therefore, the new skull is reasonably assigned to the Jawanese Early Pleistocene subgroup of *H. erectus.*

On the other hand, the vault of this specimen is relatively narrow and high, and in these traits, Tjg-1993.05 expands the range of variation of the Sangiran/Trinil hominid skulls. The relatively high cranial vault and associated steep inclination of the frontal squama of this specimen are of some interest. Two factors may relate to these features. If the pattern of cranial sex difference was similar between modern human and *H. erectus*, then the steeper frontal inclination of Tjg-1993.05 may well be related to sexual dimorphism. In this case, this specimen is assigned female and the Sangiran 17 cranium, whose frontal squama recedes strongly posteriorly, is considered a male. Such inference is supported from difference in overall size between the two crania (Sangiran 17 is larger).

Another possible factor, which is compatible with the previous one, supposes that some evolutionary changes had occurred in the hominid skull during the Early Pleistocene of Jawa. Such a scenario had been proposed by Jacob (1973, 1975, 1976) based on his studies of crania, and was later followed by Sartono (1975). They pointed out an overall similarity between Sangiran 17 and the crania from the Ngandong and Sambungmacan sites. In this context, the higher cranial vault of Tjg-1993.05 is to be interpreted as an advanced character. This possibility is, however, difficult to test at present. Among the Sangiran/Trinil subgroup, the porion-bregma height measurement is available from three crania (Sangiran 2 and 17, and Trinil 2), but the stratigraphic origin has been confirmed for only one of these specimens (Sangiran 17 to just below the Middle Tuff of the Bapang Formation: Matsu'ura, 1982, Itihara et al., 1985). The Trinil 2 cranium is correlated to the basal Bapang Formation (Grenzbank zone, more than 20m below the Middle Tuff) mainly by analyses of mammalian fauna (De Vos et al., 1994). Also, the stratigraphic level of Sangiran 2 is presently not clear. Although its alleged findspot was correlated to just below the Middle Tuff of the Bapang Formation (Itihara et al., 1985), its fluorine content suggested derivation from the Grenzbank zone (Matsu'ura, 1982). If Sangiran 2 is derived from the Grenzbank zone, the possibility of morphological change through time is worth further examination.

Another characteristic of Tjg-1993.05 is worth mentioning. Rightmire (1998) suggested that a less broad face across the orbits may be one of a few distinct facial features of African *H. erectus* compared to Asian *H. erectus* (the metric analysis was based on KNM-ER 3733 and 3883, KNM-WT 15000, Sangiran 17, Zhoukoudian 11, and Gongwangling). However, the present study indicates that there was a great degree of variation in this trait within the Sangiran/Trinil hominid series. Although the exact measurement of biorbital breadth is not available for Tjg-1993.05 because of damage, its estimate (90–100 mm) is less than those of the African specimens examined by Rightmire (1998, Table 3).

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