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The Indonesian *Homo erectus* Brain Endocasts Revisited

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ABSTRACT New brain endocast reconstructions of *Homo erectus* discoveries from Indonesia since 1963 (*H. erectus* VI, 1963; VII, 1965; VIII, 1969) have been made and their volumes determined. In addition, older discoveries (*H. erectus* I, 1891; II, 1937; IV, 1937–38) have been reendocast and reconstructed, and have yielded volumes considerably different from those previously published. This is particularly so in the case of Dubois's original discovery, which yields a volume of 940 ml rather than the widely quoted volume of 750 ml. In addition, a number of morphological observations regarding hemispheric asymmetries (petalias) are provided, which suggest a condition similar to modern *Homo sapiens.*

Since 1971, this author has had the opportunity to endocast and provide reconstructions of the Indonesian *Homo erectus* cranial fragments discovered since 1963 (Jacob, 1966, 1973; Sartono, 1968, 1971). While some preliminary volumetric determinations have been published elsewhere (Holloway, 1975a, b), it appears timely for a more complete report on these efforts. Additionally, older specimens such as *H. erectus* II (von Koenigswald, 1940), H. erectus IV (discovered in 1938, Koenigswald and Weidenreich, 1939), have been reendocast and reconstructed, yielding volumes somewhat at variance with earlier published figures (Holloway, 1975; Tobias and von Koenigswald, 1964). Of interest to these discrepancies, a number of McGregor's (n.d., 1925) earlier reconstructions of Dubois's (1894) original *H. erectus* I discovery have been found at Columbia University, which bring into question the volumetric capacity of 750 ml so widely published in the paleoanthropological literature and textbooks.

Yet another reason for this report is the growing interest in hemispheric asymmetries (Galaburda et al., 1978; LeMay, 1976, 1977) and the evidence these Indonesian brain endocasts provide for such petalial asymmetries. Finally, the newer discoveries of *H. erectus* materials in East and South Africa, as well as in Europe, make such a reassessment useful for comparative purposes.

This paper will be concerned mainly with delineating the methods used in making the endocasts, their reconstructions and volume determinations, and certain observations of their morphologies with respect to asymmetries. More detailed analyses of their metric quantities, meningeal patterns, and convolutional patterns are in progress and will not be reported here.[1] In describing these endocasts, both the terminologies of Jacob (1973) and the original *H. erectus* designations by Roman numerals will be used.

Finally, some comments regarding Sartono's (1971) reconstruction of *Homo erectus* VII, discovered in 1969, will be provided, as a new reconstruction of that specimen was necessary before it could be endocast.

MATERIALS AND METHODS

Endocasting and reconstructions

With the exception of Dubois's (1894) original *Homo erectus* (I) calotte, liquid latex molds of the actual interiors of H.E. (II, IV, VI, VII, and VIII) were made using Admold 3280, a process more extensively described elsewhere (Holloway, 1978).

Briefly, the process consists of building up several layers of air-dried latex; curing the whole at 50°C for 4 hours; stabilizing the dimensions and shape of the endocast with

[1]This paper also contains photographs of some of the newer Indonesian finds described by Jacob (1973), and in part illustrated by him. Aside from Jacob's (ibid.) article, there are no good photographs of these hominids published in all standard views. The author is aware that an occlusal view of Sangiran 17 (1969) has little if any relevance to brain endocasts. This view, nevertheless, is included in this article for the record.

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plaster of paris; reconstructing the missing portions with plasticene; measuring the volume of displaced water to obtain the volume. This description is only the basic, general plan. In fact each endocast required some modification in technique.

Trinil 2 (PITH. I–1891). Several years ago, the author came across three endocast reconstructions done by McGregor in the 1920s. Each shows some modifications in the modeling of the base, which, in addition to providing a complete endocast for volumetric measurement, provides some insights into the variability of volumes with minor shape changes in reconstruction. One is McGregor's 1925 (copyright) reconstruction; a second is labeled "revised" (N.D.); the third is without a label (see Fig. 1).

Sangiran 2 (PITH. II – 1937). Sangrian 2 was endocast through the courtesy of Professor von Koenigswald at the Senckenberg Museum in 1972. The latex mold, after curing, was first removed from the calotte, and immediately replaced to ensure proper separation. To maintain stability, plaster inserts were molded in a pattern to avoid undercuts, adhered together, and the latex mold was fitted over them. The dimensions of the endocast were not found to differ from those of the original calotte. Reconstruction of the basal portion was attempted after the Sangiran 17 (PITH VIII–1969) cranium was endocast, since this latter specimen is the only one preserving the original shape of the temporal lobes, except for the poles.

Sangiran 4 (PITH IV–1938). Sangiran 4 was similarly endocast as described for Sangiran 2 above. In this case, a frontal lobe was reconstructed on the basis of the shapes of Trinal 2 and Sangiran 2. In addition, it was clearly evident that both parietal areas were collapsed, requiring some additional plasticene to match the remaining less-distorted dorsal surfaces.

Sangiran 10 (PITH VI–1963) and Sangiran 12 (PITH VII–1965). These were endocast in essentially the same manner as Sangiran 2, and both required total reconstruction of the frontal portions of the endocast. In the case of Sangiran 10, a small triangular fragment of the left frontal bone was available to help provide a guide on both the curvature (from posterior to anterior) and approximate width of the frontal to a point just anterior of the third inferior frontal convolution, or "Broca's cap" region.

Sangiran 12 required extensive reconstruction of the frontal and temporal lobes, and the foramen magnum region (see Figs. 2, 3, 5, and 6).

Sangiran 17 (PITH VIII–1969). The author first had contact with this cranium in 1971-72,

Fig. 1. Basal view of three reconstructed endocasts of Dubois's original (Trinal 2, PITH I) *Homo erectus* find. The middle view shows McGregor's (1925) copyrighted reconstruction, which most probably succeeded the earlier versions shown on right and left sides. The remodeling of the basal features is very minor, and the range of volumes is between 930 and 940 ml.

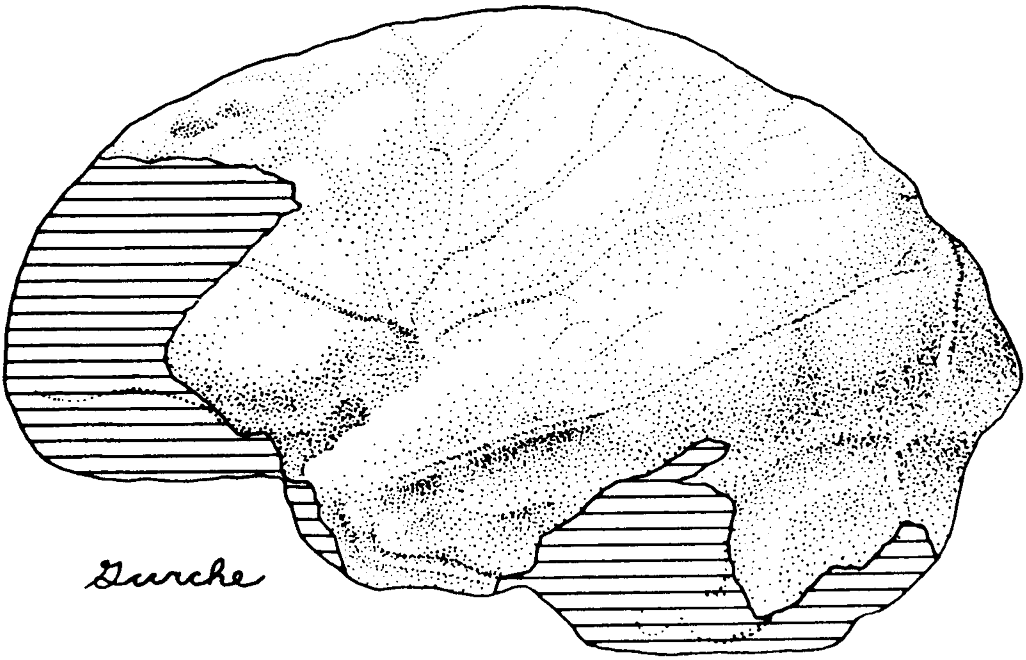

Fig. 2. Line drawing of Sangiran 10 (PITH VI – 1963) reconstructed endocast of left lateral view. Solid line portions are plasticene reconstruction. (See Fig. 5 for actual cranial remains.)

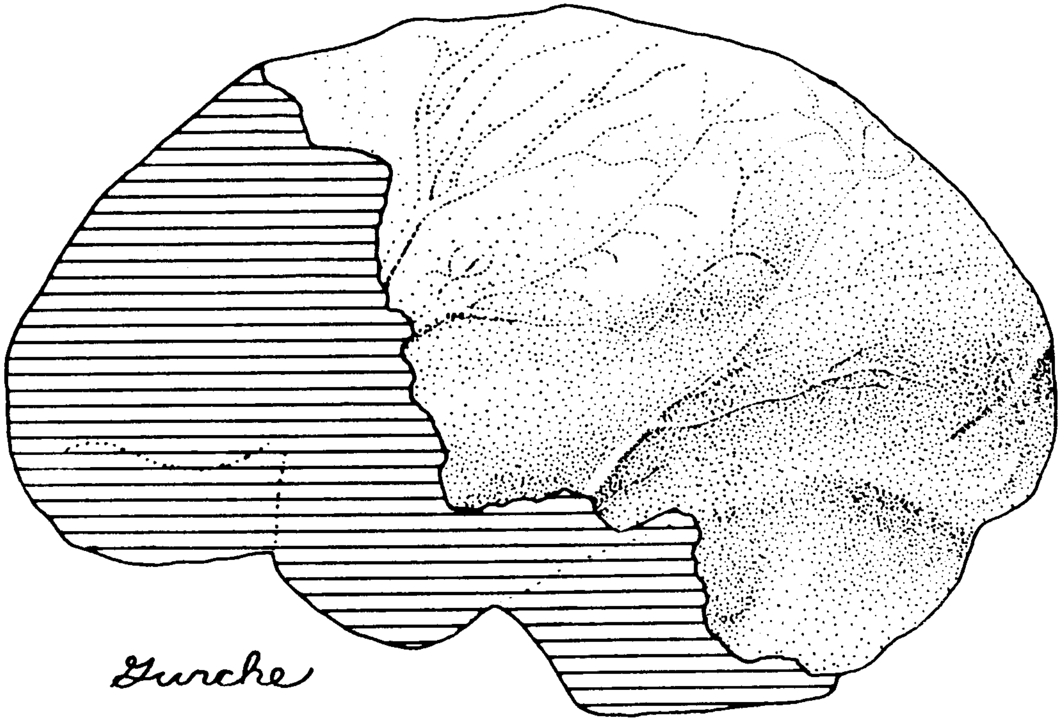

Fig. 3. Line drawing of Sangiran 12 (PITH VII – 1965) reconstructed endocast of left lateral view. Solid portions are plasticene reconstruction. (See Fig. 6 for actual cranial remains.)

and, given the poor state of the bone, it was decided that the fragments, poorly articulated, should first be disarticulated, cleaned, preserved, and refitted to each other. This was accomplished in 1973, using Butvar[2] and yielding a much improved cranium (see Figs. 4, 7a-c).

Since enough of the basal portion was missing to permit extraction of a latex shell, piece-molding with plaster inserts was not performed. Instead, the thick cured latex shell was filled with plaster under water. After hardening, the dimensions of the endocast were compared, using available landmarks on the original cranium. No significant distortion was detected. Minimal plasticene reconstruction was necessary on the rostral olfactory bec and temporal poles.

Volumetric determinations

Originally, as reported elsewhere (Holloway, 1975, 1978), volumes were determined by water displacement. These have been redone more recently by using Archimedes' principle, in which the weight in water is subtracted from the weight in air, yielding the true volume. This second method is more accurate.

Observations of asymmetry

All of the above endocasts were examined by gross visual inspection for the following characteristics: left or right occipital petalias (see Galaburda et al., 1978; LeMay, 1976, 1977, for discussion), both in terms of posterior extent and lateral width; left or right frontal petalias in terms of anterior extent and width[3]. These latter observations could only be performed on Trinil 2 (PITH I), Sangiran 2 (PITH II), and Sangiran 17 (PITH VIII). The occipital frontal petalias were thus scored simply as to which side was largest. The endocasts were *not* scored by observing them *only* in a standard dorsal orientation, but by rotating the endocasts through their midsagittal axis, and by placing the occipital poles on a flat surface to observe the tilt of the midsagittal plane. This

[2]Butvar is a trade name for butyl-acrilic in crystaline form, and is soluble in alcohol. Dr. Alan Walker kindly provided me with a sample of this material, which I used to prepare the Sangiran 17 cranium.

[3]I have not included black and white photographs of the endocast reconstructions in this article, given illustration restraints. Furthermore, the petalial configurations would not show clearly in such photographs. The petalias can be judged only by visual inspection at the present time. For the time being, the observations on petalial patterns in the text and Table 2 are the responsibility of this author alone.

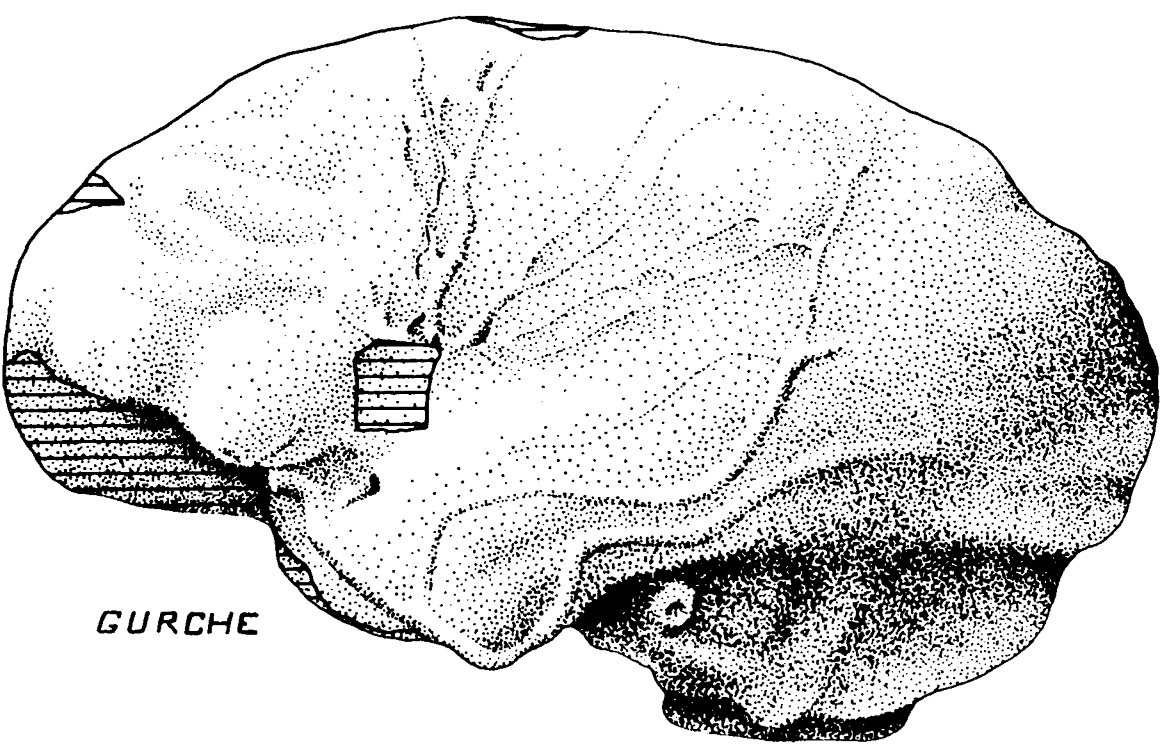

Fig. 4. Line drawing of Sangiran 17 (PITH VIII – 1969) reconstructed endocast in left lateral view. Note that only a small portion of rostral bec and temporal poles required plasticene reconstruction. (See Fig. 7 for actual cranial remains, and the maxillary portion.)

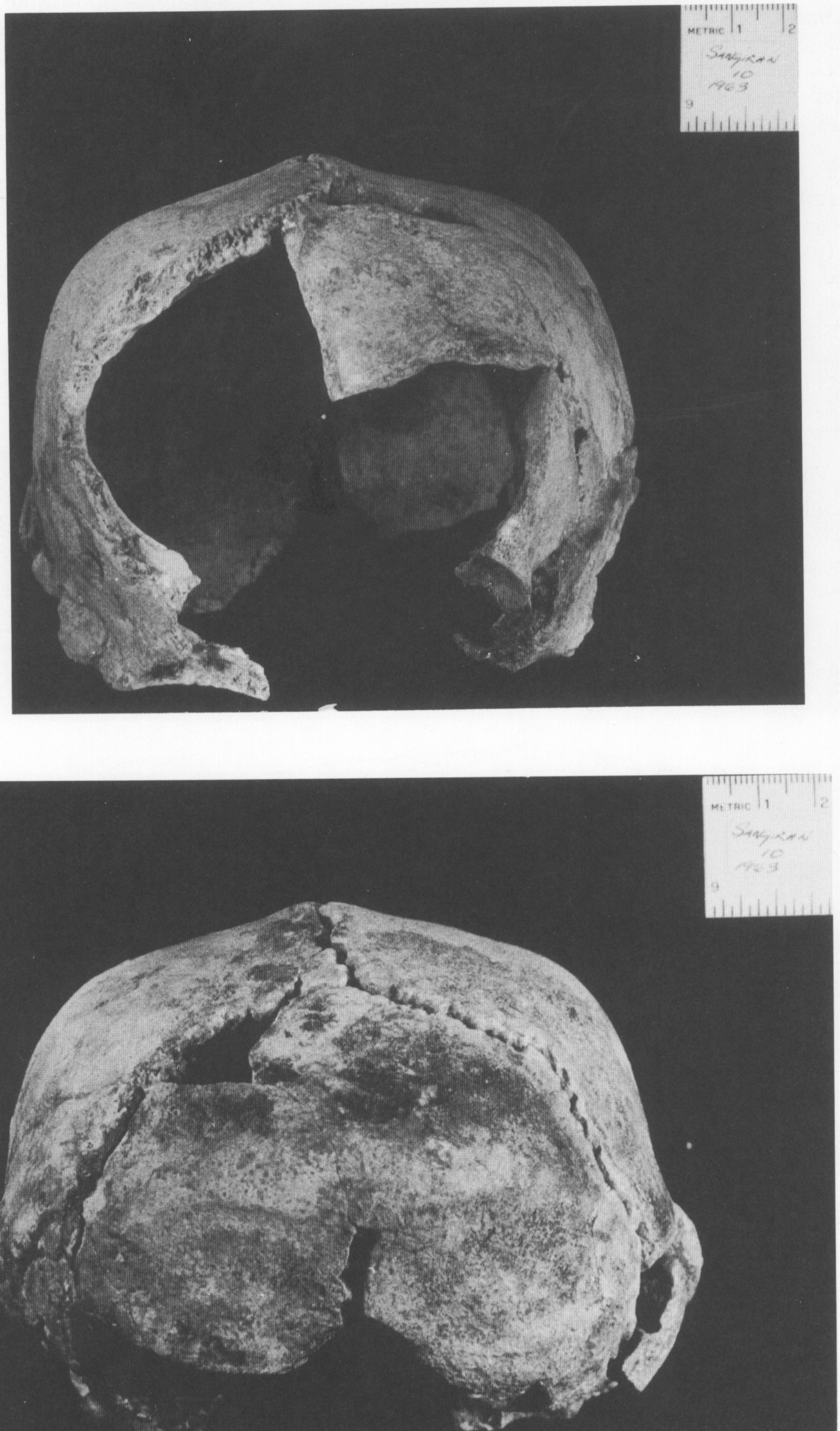

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Fig. 5. Actual cranial remains of Sangiran 10 (PITH VI - 1963) in a) frontal (top) and occipital (bottom), b) basal and dorsal, and c) right and left lateral views.

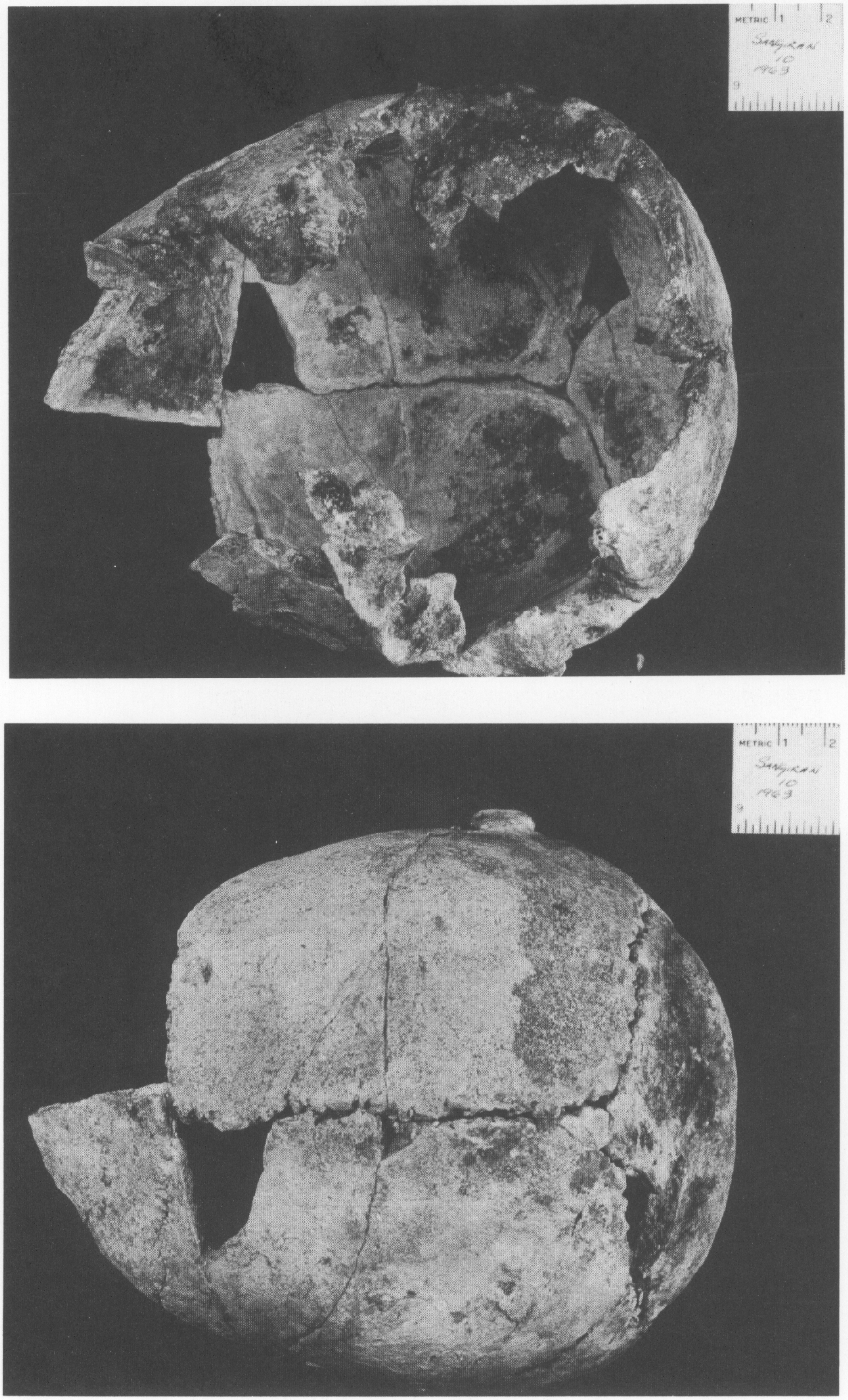

Fig. 5b. Basal (top) and dorsal (bottom) views.

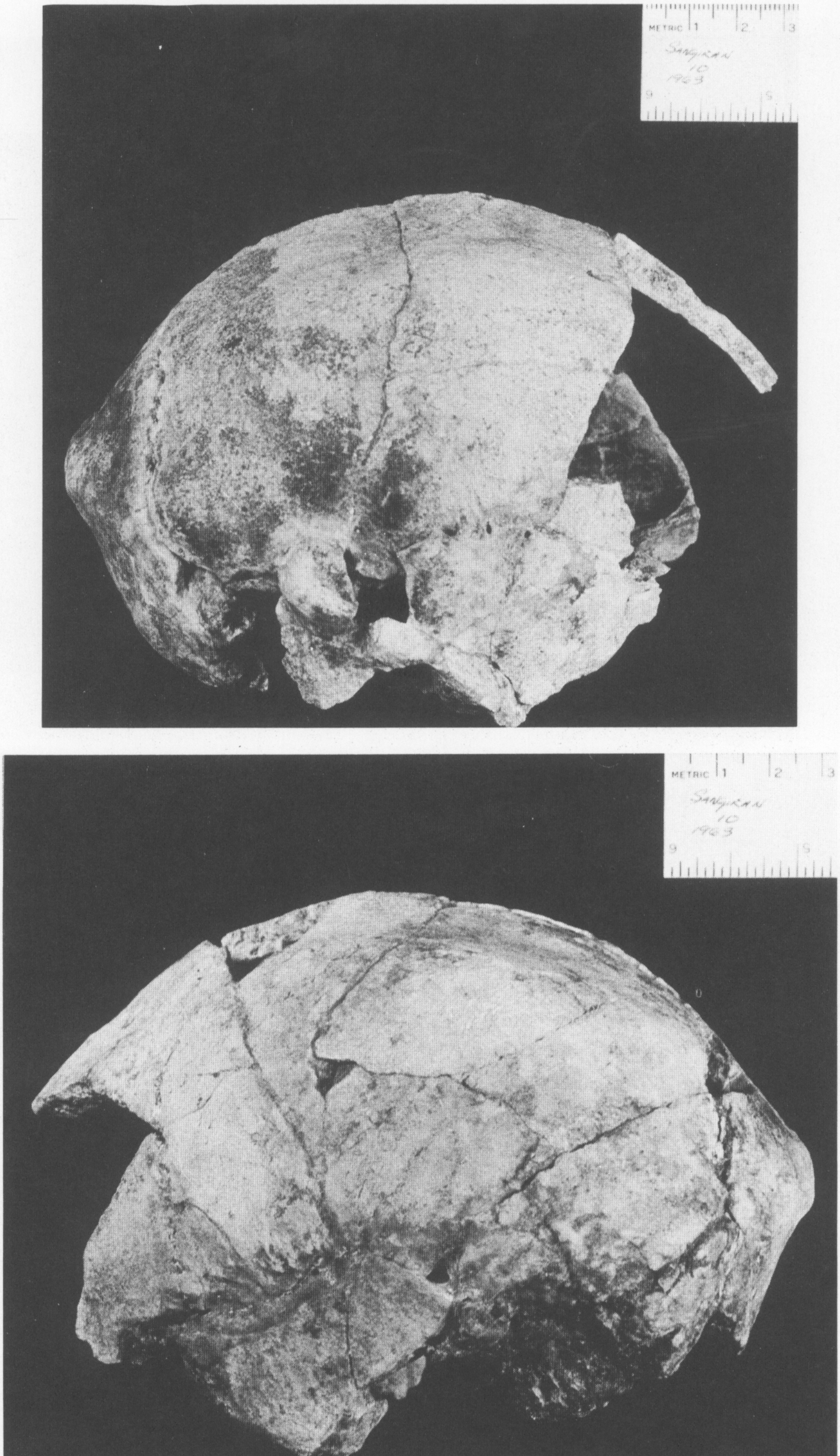

Fig. 5c. Right lateral (top) and left lateral (bottom) views.

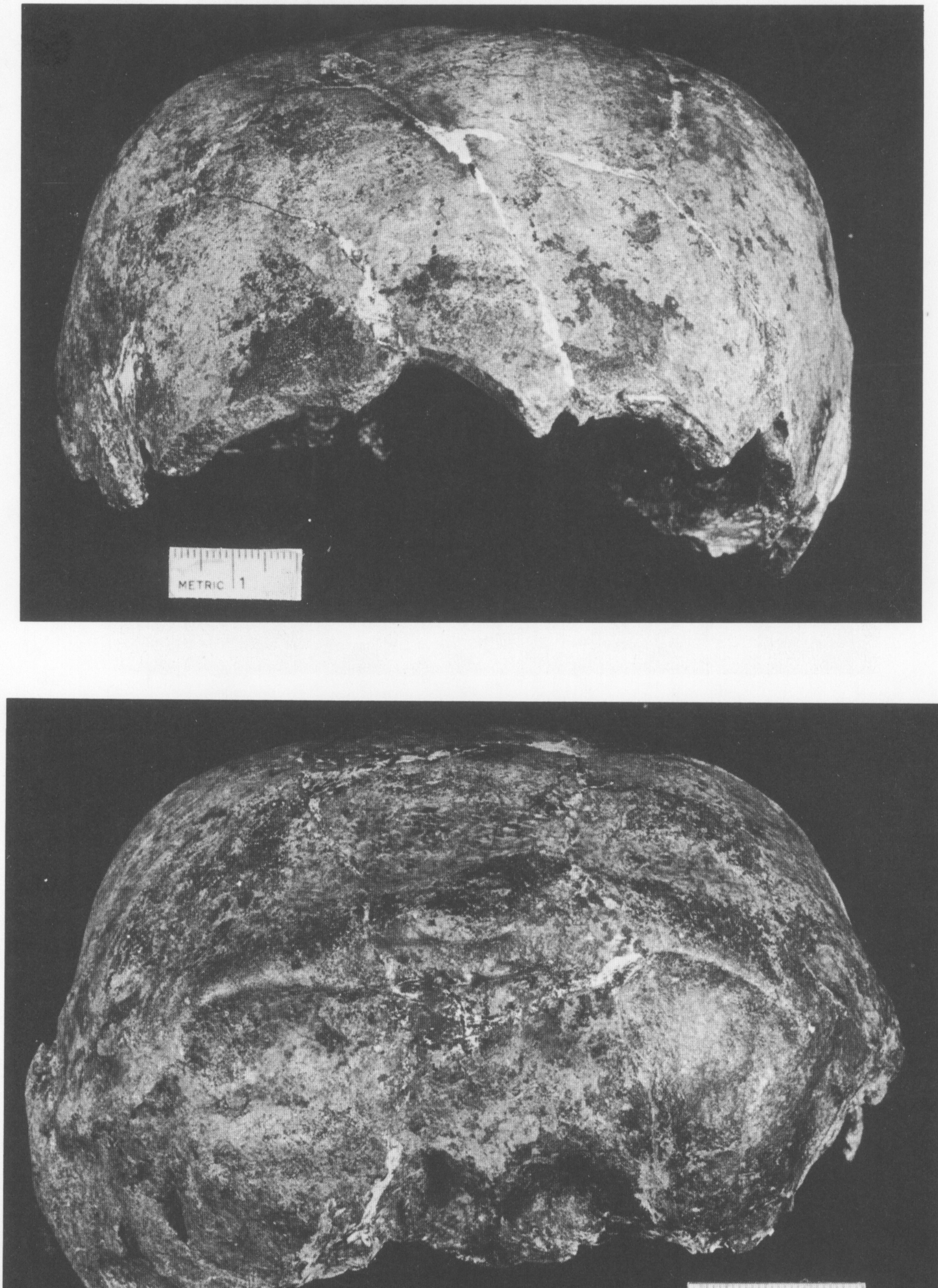

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Fig. 6. Sangiran 12 (PITH VII – 1965) remains. (Views are the same as in Fig. 5 legend.) a) frontal (top) and occipital (bottom) views.

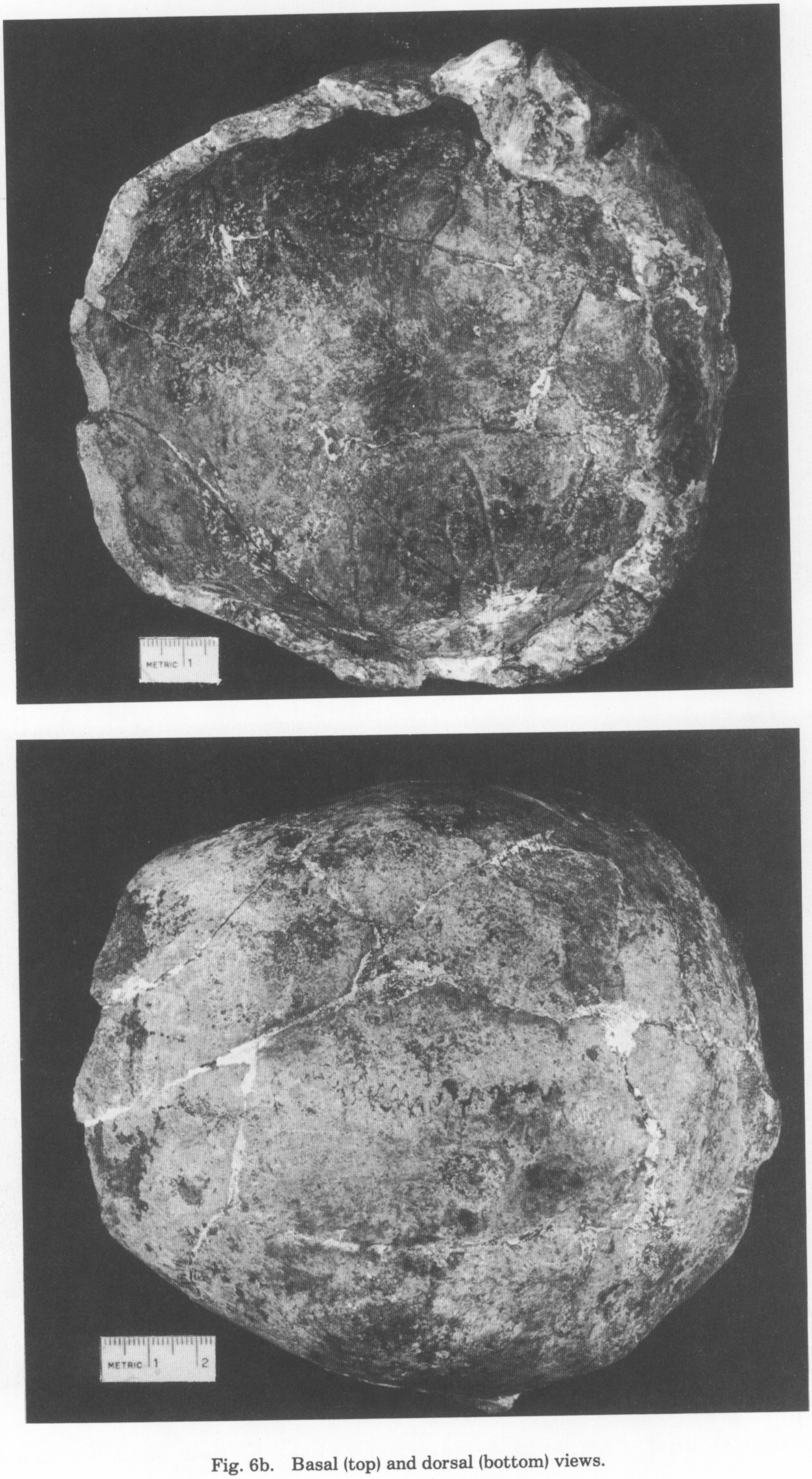
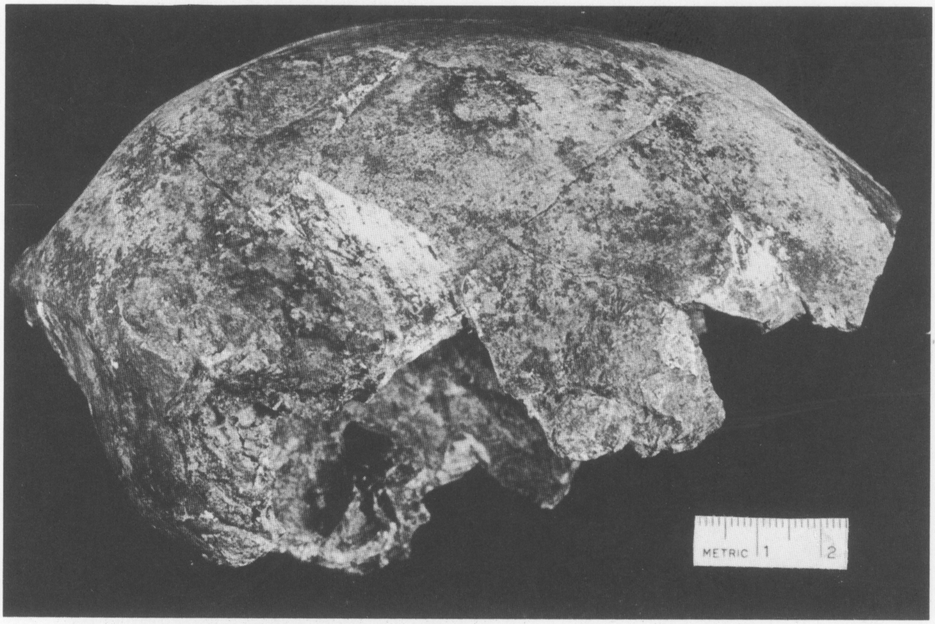


Fig. 6b. Basal (top) and dorsal (bottom) views.



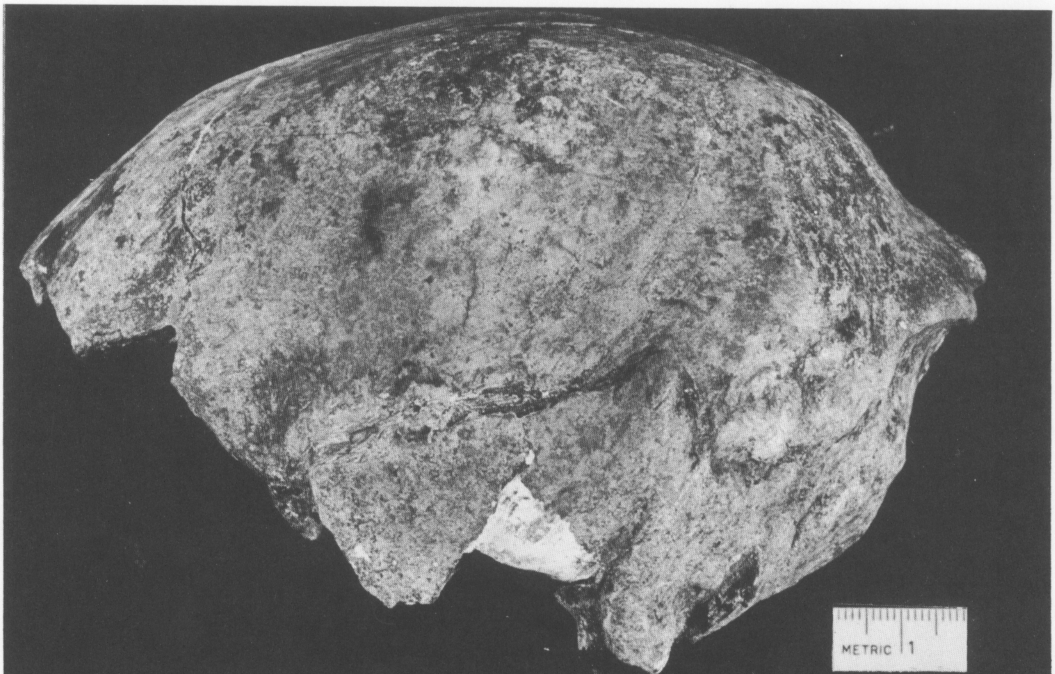


Fig. 6c. Right lateral (top) and left lateral (bottom) views.

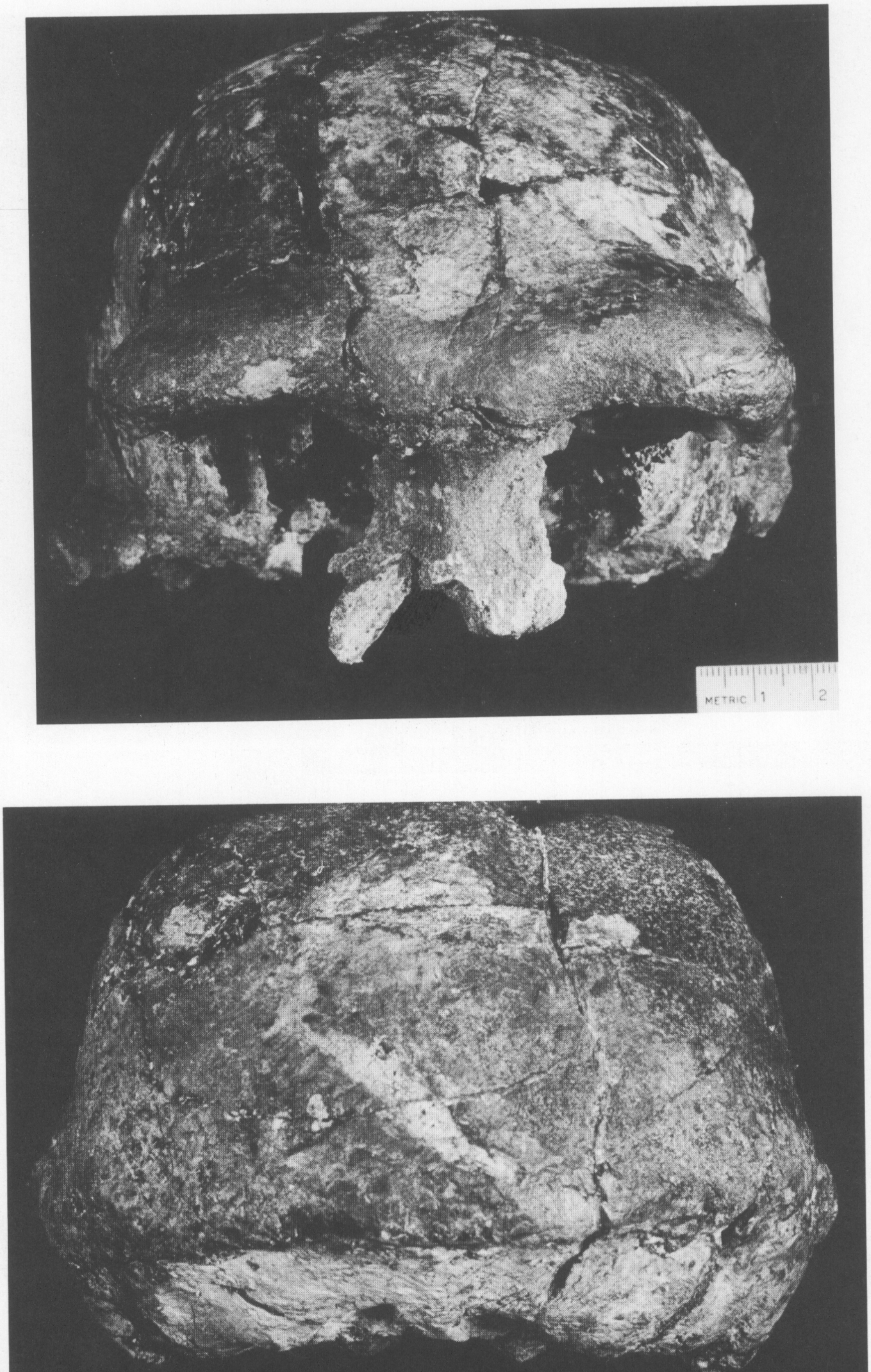


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Fig. 7. Sangiran 17 (PITH VIII - 1969) remains after disassembly of Sartono's reconstruction, cleaning, coating with Butvar, and reassembly. (Views are the same as in Figs. 5 and 6, except that (d) shows right lateral and occlusal views.) a) frontal (top) and occipital (bottom) views.

Fig. 7b. Basal (top) and dorsal (bottom) views.

Fig. 7c. Right lateral (top) and left lateral (bottom) views.

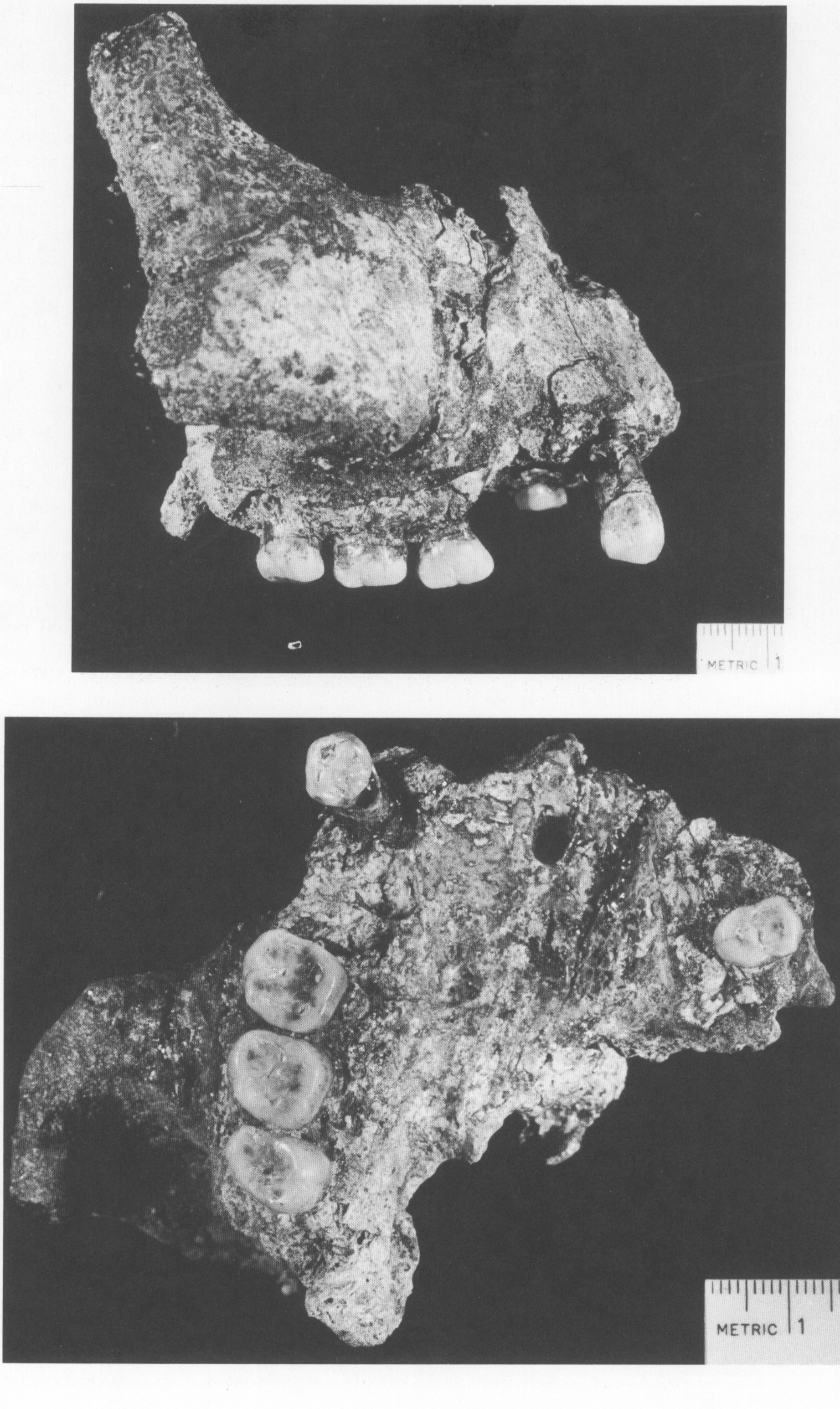

Fig. 7d. Right lateral (top) and occlusal (bottom) views.

is important, since the occipital poles can vary in posterior extent depending on whether they are viewed dorsally or basally.

Measurements and indices

While this author (Holloway, 1978; 1981) believes there to be only very limited usefulness in linear measurement approaches to endocasts, chord and arc measurements were taken for future statistical analyses and comparisons. Their main purpose is to provide some quantification of the overall shape configurations of the endocasts. Thus, chord and arc measurements for *length* (frontal pole to occipital pole; the arc being dorsal), *maximum width, depth* from vertex to the most inferior portions of the temporal poles in the midsagittal plane, *bregma-lambda, bregma-asterion,* and *biasterionic breadth* were taken to the nearest mm with spreading and sliding calipers, and a flexible metal tape.[4]

Indices or ratios of some these measurements were calculated for both this sample of Indonesian *Homo erectus* endocasts, and those of the African pongids, *Australopithecus* (Taung, STS 5, STS 60, and OMO 338y), and modern *Homo sapiens.*

RESULTS

Table 1 indicates the results of volume determinations from this study and compares them to previously published estimates. As can be seen, there are significant differences between these and previous estimates (see Discussion). Table 1 also provides the *mean, standard deviation* (s.d.), *variance,* and coefficient of variation (c.v.) for these six specimens.

Table 2 provides an indication of petalial asymmetry patterns of each of the six brain endocasts. As is apparent, the tendency toward a left-occipital, right-frontal combination is suggested, but in fact the frontal portions can only be scored for three of the six.

Table 3 contains the linear arc and chord measurements on the brain endocasts for the Indonesian *Homo erectus* sample, and their statistical characteristics. Table 4 provides the shape indices, the main purpose of which is to emphasize both their considerable quantitative homogeneity and platycephalic condition. Significance tests are not regarded as relevant here, and are omitted.

DISCUSSION

Volumes

As is evident from Table 1, the brain endocast volumes determined in this study are quite different from those previously published. Tobias's (1971) book, pages 81–91, gives the best description of his methods and those of some of his predecessors, particularly those of Eugene Dubois. The three brain endocasts which McGregor reconstructed are full, in the sense that the missing basal portions have been added. The partial endocast methods described by Tobias (1971:82–87) rely on a percentage correction, based on an extremely small sample of pongids, modern

[4]It should be pointed out that these measurements do include reconstructed areas of the endocasts, particularly for length on the 1938, 1963, and 1967 finds, and depth on all but the 1969 find. This means, of course, that variation has been reduced through the techniques used to render the reconstructions, and all indices should be regarded as approximations only.

TABLE 1. Brain endocast volumes of the Indonesian Homo erectus *specimens (all measurements in ml)*

Specimen	Volume (ml) this study	Previous estimates and source (ml)	Year discovered
Trinil 2 (*H. erectus* I)	940	850 Tobias and von Koenigswald (1964, 1971) Weidenruch (1943), Jacob (1966)	1891 1891
Sangiran 2 (*H. erectus* II)	813	775 Tobias (1971); 815 Boule and Vallois (1957)	1937
Sangiran 4 (*H. erectus* IV)	908	750 von Koenigswald (1962) Jacob (1966)	
Sangiran10 (*H. erectus* VI)	855	975 von Koenigswald (1962)	1963
Sangiran12 (*H. erectus* VII)	1,059	915 Tobias (1971)	1965
Sangiran17(*H. erectus* VIII)	1,004	1,029 Tobias (1971); Sartono (1971)	1969
mean	929.83	882.33	
S.D.	91.667	110.67	
Var.	7,002.4	10,207.2	
C.V.	9.86%	12.54	

A comparison of volume estimates between this and previous studies, with accompanying statistics. *H. erectus III* values are not included as there is only a single parietal.

TABLE 2. Petalial asymmetry patterns for the Indonesian Homo erectus *specimens*

Specimen	Occipital petalia	Frontal petalia	Both
Trinil 2 (*H. erectus* I – 1891)	Slight left, A-P Definite left, lateral	Right, A-P, lateral	Yes
Sangiran 2 (*H. erectus* II – 1937)	Definite left, A-P Definite left, lateral	Right, lateral	Yes
Sangiran 4 (*H. erectus* IV – 1938)	Slight left, A-P Slight left, lateral	Missing	–
Sangiran 10 (*H. erectus* VI – 1963)	Definite left, A-P Slight right, lateral	Missing	–
Sangiran 12 (*H. erectus* VII – 1965)	Slight left, A-P Slight left, lateral	Missing	–
Sangiran 17 (*H. erectus* VIII – 1969)	Uncertain (see Discussion)	Uncertain (see Discussion)	Uncertain (see Discussion)

A summary of petalial findings. A-P is anterior-posterior axis from frontal to occipital poles. The lateral designations under "occipital petalia" refer to width in the posterior parietal region when the endocast is viewed dorsally. The lateral designations under "frontal petalia" refer to width of frontal lobe.

TABLE 3. Endocast measurement

Measurement (mm)	H. e. I (1891)	*H. e.* II (1937)	*H. e.* IV (1938)	*H. e.* VI (1963)	*H. e.* VII (1965)	*H. e.* VIII (1969)	*H. e.* average N = 6
1. Frontal-pole to occipital pole							
a. chord	156	148	156E	158E	161E	161	156.67
b. arc	208	202	205E	210E	230E	202	209.50
2. Maximum breadth							
a. chord	125	120	125	117	130	129	124.50
b. arc	205	192	195	185	208	212	199.50
3. Depth, vertex to temporal pole	98	93	95	94	99	100	96.50
4. Bregma-lambda							
a. chord	83	70	N.A.	82	92	90	83.40
b. arc	87	72	N.A.	87	97	93	87.20
5. Bregma-asterion							
a. chord	110	106	112E	113	104	113	109.67
b. arc	132	125	135E	133	130	136	131.83
6. Biasterionic-breadth	92E	92	73E	85E	96E	95	88.83

Endocast measurements, both in arc and chord dimensions. E means "estimated," since reconstruction of the frontal portions was necessary, or where the region was otherwise missing. N.A. means "not available," meaning that lambda and bregma are not evident on *H. erectus* IV.

Homo sapiens, and Sangiran 2, which is *not* complete in its basal portion. The Sangiran 2 cranial capacity is 813 ml, very close to Boule and Vallois (1957) stated value of 815 ml, although their methods were not published to my knowledge. The endocast reconstruction I undertook of Sangiran 2 was based on an actual latex rubber cast with no distortion, and which matched the original bony measurements of the calvarium. The plasticene additions were relatively minor. Tobias's (1971) corrections for Trinil 2 were based on using the 775 ml (Weidenreich, 1943; Jacob, 1966; von Koenigswald, 1962) value for Sangiran 2. I seriously doubt that one can consistently fill one of these fragmented specimens to precisely the same level each time; furthermore, much larger sample sizes are necessary. Assuming normal variation in any partial: whole ratio, the average could well be incorrect for any actual single specimen. My point here is that full reconstructions, where the reconstructed portions follow the actual curvatures and morphology of the particular specimen, are probably somewhat more secure in giving more accurate volumes. In fact, on Trinil 2, Tobias's (1971:84) values ranged from 556 to 581 ml, a variation of 25 ml, or about 5%. Giving a 10% error factor, Tobias's figure of 850 ml ± 85 ml brings the upper estimate to 935 ml, which happens to be very close to Dubois's (1898) value of 900 ml, Weinert's (1928) value of 935 ml, or Ariens-Kappers and Bouman's (1939) estimates of 900–950 ml. I have not been able to find references regarding McGregor's reconstructions, but I find no

TABLE 4. Endocast indices

	(1891)	(1937)	(1938)	(1963)	(1965)	(1969)	*H. erectus* average N = 6	Gorilla N = 39	Pant N = 33	Panp N = 40	Aust N = 4	Homo N = 4
Breadth: length	0.80	0.82	0.80	0.74	0.80	0.80	0.79 (0.77)	0.77	0.83	0.83	0.78	0.78
Breadth: height	1.27	1.29	1.31	1.24	1.31	1.29	*1.28* (1.25)	1.17	1.21	1.20	1.13	1.08
Length: height	1.59	1.59	1.64	1.68	1.63	1.61	*1.62* (1.61)	1.52	1.46	1.44	1.44	1.40
Bregma-lambda arc:chord	1.05	1.03	*N.A.*	1.06	1.05	1.03	1.04	1.04	1.05	1.06	1.08	1.09
Bregma-asterion arc:chord	1.20	1.18	1.20E	1.18	1.25	1.20	1.20	1.15	1.17	1.20	1.18	1.23
H.³:Volume	1.00	0.99	0.94	0.97	0.92	1.00	*0.97* (0.98)	1.05	1.11	1.12	1.24	1.25
Breadth arc:chord	1.64	1.59	1.56	1.58	1.60	1.64	1.60	1.60	1.53	1.56	1.55	1.72

Resulting indices from the measurements in Table 3. Italicized values are those which appear different from either Australopithecines or *Homo sapiens*. Panp = *Pan paniscus*, Pant = *Pan troglodytes*. Parenthesized values are the averages for the *Solo* endocasts as described in Holloway (1980). H³/volume is the height³ divided by its volume.

way in which they appear incorrect, although the basal portions might be somewhat fuller than in life. I believe a volume of 940 ml is probably the best estimate we have to date for Trinil 2.

Sangiran 4 is a difficult matter. For one thing, the parietals have clearly collapsed somewhat, and the endocast must be augmented with plasticene in this region. The frontal portion of my reconstruction was molded along lines provided by both Trinil 2 and Sangiran 2 frontal portions. Unfortunately, the present reconstruction has lost its elastic properties, and the Sangiran 4 specimen should be reendocast in the future. The original cranial portion, for all its cracks, is still a large, robust, and thick-boned calvarium, and I am convinced that the value of 750 ml given by Tobias and von Koenigswald (1964) and von Koenigswald (1962) is incorrect, once the distortion is taken into account. The value of 908 ml was determined prior to the dissolution of the reconstruction.

The 975 ml value for Sangiran 10 given by Jacob (1966) is a rough estimate only. Anyone who has examined the originals must be acquainted with its generally smaller size and relative gracility. I believe my reconstruction of 855 is accurate, but possibly on the low side given the narrowness of the frontal lobe reconstruction. I can find no basis for a 975 ml estimate, however.

Sangiran 12 is a large cranial portion, very broad across the occipitals and parietal portions, and relatively high. Sartono's (1968) estimate of 900 ml is not justified methodologically, nor is von Koenigswald's value of 930 ml stated in a letter to Tobias (1962:88 "empirically demonstrated"). Tobias's own average value of 915 ml (for the two undemonstrated estimates) should be dropped in favor of the 1,059 value based on the actual reconstruction.

The Sangiran 17 endocranial volume of 1,029 ml (letter to Tobias from Professor Sartono dated March 30, 1971; Tobias, 1971:89) is relatively close to my reconstruction of 1,004 ml. The difference is small, but the basis for it is large. When I examined that cranium in 1971–72, I was amazed at how poorly it was articulated, and found it necessary to disassemble the pieces, clean them, preserve them with Butvar, and rearticulate them. I believe the fitting was better, and that my volume determination of 1,004 ml is the more accurate.

Tobias (1971:87) mentions a volume of 890 ml for the "*Homo erectus* III" specimen, which consists of a single parietal. With all due respect to the talents of Weidenreich (1943) and Tobias's averaging, a *single* parietal *does* *not* form a particularly secure basis for an estimate.

Consequently, the statistics provided in Table 1 are based on only six and not seven specimens. The standard deviation of 91.7 ml, and coefficient of variation of almost 10% are within normal expectations of populational variability.

All of these statistics raise the average size of the Indonesian cranial capacities to a value more closely approximating both the African and other Asian endocast samples.

Asymmetries

In a large sample study, currently in progress by Christine de L'Coste and me, we are finding a very distinct difference in asymmetry patterns between pongids and hominids. Over 140 pongid endocasts, composed of *Pan paniscus, Pan troglodytes, Gorilla gorilla,* and *Pongo pygmaeus,* and a total of 40 hominid endocasts from *Australopithecus* to Neandertals, have been studied for petalial patterns. While asymmetries in pongids are not unusual, particularly in the anterior-posterior dimension, the combination of left-occipital, right-frontal, in *both* A-P *and* lateral dimensions is particularly (and significantly so) strong in both fossil hominids and modern *Homo sapiens* (see Galaburda et al., 1978; LeMay, 1976, 1977).

The Indonesian endocasts described in this paper are not complete, but as Table 2 suggests, the pattern is most suggestive of the same pattern found in right-handed people with left cerebral dominance. In the Galaburda et al. (1978) paper, there is a reference to a right occipital petalia for Trinil II, the original Dubois find. This assessment is very dependent on the orientation of the endocast, for in fact, when it is rotated, the left occipital pole is more projective, but in an inferiorally directed orientation. Almost all of the Indonesian endocasts show some peculiarities in their occipital lobes, which might be described as a "puckering" effect. One occipital pole is thin, and inferiorally directed, a condition very pronounced on Sangiran 12, but it does not appear to be in any constant relationship to the direction of the transverse sinus.

It would be premature to speculate unduly on the significance of these asymmetries. It is nevertheless intriguing that such patterns are correlated with archaeological contexts (mainly from Africa and Europe) indicating stone tool making, hunting of large animals, and various sites suggesting living, camping, butchering, and stone tool making activities. Unfortunately, so little information from Indonesia is available regarding the archaeological contexts that the African and European *Homo erectus* material provides the clearer picture. In that regard, left-occipital, right-frontal petalial combinations exist for these specimens: Sale, KNM ER 3733, 3883, OH 9, and the Rhodesia specimen. Thus, right-handedness is suggested on the basis of analogy with clinical and neuronanatomical information on modern *Homo sapiens* as reported in Galaburda et al. (1978), LeMay (1976, 1977), and elsewhere. If the analogy, or better homology, were to be pressed, it could *easily* be speculated that hemispheric specialization, i.e., symbol manipulation (left) and visuospatial integration (right) were an established pattern by *Homo erectus* times. While this is my own bias, it must be indicated that the evidence is only supportive, and not definitive.

The petalial pattern for the Sangiran 17 (Pith VIII – 1969) endocast requires separate discussion. Table 2 shows the scoring of patterns as "uncertain." This is due to at least two factors. First, the left frontal bone fragments do not articulate perfectly, and there is a resulting distortion that may make the left frontal pole appear more forwardly placed than the right.

The right frontosphenoidal area is damaged on the original fragments such that the third inferior frontal convolution is obscured, particularly in lateral extent, while the left Broca cap region is well rounded and protruding. Given these problems, from a dorsal view the lateral width of the *right* frontal lobe does appear nevertheless wider, a pattern to be *expected* if the left cortical hemisphere were dominant, as in right-handedness among *Homo sapiens.*[5]

Depending on the axis of visual orientation, the *right* occipital pole is variably *more* projective posteriorally, and is also inferiorally deflected. The pole region, however, is much narrower on the right side, and the longitudinal-transverse sinus is very strongly marked toward the right side. In lateral width, however, the *left* occipital pole is widest, and that greater width continues forward in the whole left parietal region, a pattern again associated with left cerebral hemispheric dominance. A left-transverse sinus is visible, but clearly smaller than the right. This combination of details should underline two important considerations.

First, fragmented crania with less than perfect articulation can be a problem in scoring petalial patterns. Second, the very strong transverse sinus could accentuate localized oc-

[5]I am grateful to the reviewer who pointed out that this is a statistical statement, and not an absolute correlation. That is, one can find left-handed persons with the right-handed petalial pattern, although it is statistically much less frequent than the cases of right-handedness associated with left-occipital, right-frontal patterns.

cipital pole projection in both posterior and inferior directions *without* violating overall cerebral asymmetry patterns in a functional sense. That is, one could find greater right-occipital pole protrusion in the posterior direction associated with right-occipital (and parietal) widths less than on the left side.

For these reasons, I have scored this endocast as "uncertain" to its petalial patterns, but do believe that Sangiran 17 (Pith VIII) *does show an overall petalial configuration congruent with left hemispheric dominance, and is thus suggestive of right-handedness.*

Measurements and indices

As mentioned previously, the measurements and indices have been provided to depict the unquestionable platycephalic condition of these brain endocasts. The relatively high homogeneity of the figures and indices in Tables 3 and 4 are reflective both of the endocasts' similarity, and to some extent the modeling methods used to reconstruct missing portions from intact specimens. The indices in Table 4 simply underline, in a comparative way, the flattened shape characteristic of the Indonesian sample, as seen particularly in the length:height, breadth:height, and height^3:volume ratios. As the functional significance of platycephaly is very dubious, statistical tests for significant differences have not been performed. The parenthesized figures in Table 4 represent the Solo brain endocasts (Holloway, 1980), and are almost identical to those for the Indonesian *Homo erectus* group. To the degree to which one may wish to argue phyletic relationship on the basis of such ratios, the indices do underline the closeness between these two groups.

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