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CURRENT PROBLEMS IN RESEARCH

New Evidence on Fossil Man in China

The paleontological history of man in China is beginning to be documented by fossil evidence.

Kwang-chih Chang

The scientific investigation of fossil man in China was launched at the turn of the present century when scientists began to realize that the Chinese drug "dragon bones" (*lung ku*) were in reality paleontological remains and started to track down some of their reported places of origin. In 1921 the famed sites in the limestone hills near Choukoutien, about 48 kilometers southwest of Peiping, were brought to their attention. There, at Locality 1, fossil remains of over 40 individuals of an early hominid form, *Sinanthropus* (*Pithecanthropus*) *pekinensis*, were uncovered over a period of more than a decade, and these furnished the scientific world with the richest paleoanthropological site of Middle Pleistocene age. The encouragement and stimuli produced by the findings at Choukoutien were in no small measure responsible for widespread subsequent discoveries of paleolithic assemblages from the soil of China; yet prior to World War II remains of fossil man in China consisted of but a handful of specimens aside from the Peiping relics. These included an incisor tooth from the loess-lacustrine beds at Sjara-osso-gol in Shensi, found by Emile Licent and Pierre Teilhard de Chardin in 1922; skulls and skeletons of *Homo sapiens* of latest Pleistocene or earliest post-Pleistocene from the deposits of the Upper Cave in Choukoutien, found by the Geological Survey in 1933; an early hominid tooth, salvaged by G. H. R. von Koenigswald from a Hong Kong drugstore, which he has termed *Sinanthropus officinalis*; and three giant-sized anthropoid teeth found by von Koenigswald, again in drugstores at Hong Kong, and named *Gigantopithecus blacki*.

Deliberate explorations of the Chinese soil in search of the remains of fossil man were also to a large extent fostered by the strong conviction of paleontologists during the first decades of the century that Central Asia was the "cradle of mankind," and in such light had these bits of evidence from China been interpreted, notably by Franz Weidenreich. He attempted to show that *Gigantopithecus* (or, as he preferred to call it, *Gigantanthropus*), descending ultimately from higher primates of the Miocene in northern India, was ancestral to both *Sinanthropus* of Peiping and *Pithecanthropus* of Java, who in turn evolved into the modern Mongoloid and Australoid races respectively. This hypothesis has been rendered largely obsolete today, circuitously by our growing knowledge of the australopithecines in Africa and directly by new anthropoid and hominid fossils found from China itself during the last decade.

New Paleoanthropological Discoveries: 1949–1959

Since political circumstances permit no first-hand examinations of the fossils themselves, a brief summary of the published data on the new discoveries in China for each of the new localities, listed from north to south (Fig. 1), follows (*1*).

Choukoutien, Hopei. The story of the last days of the Peking Man fossils, which were lost during the last war, is now well known. The loss is irreparable, but fortunately the fossiliferous deposits of Choukoutien Locality 1 were not exhausted of human remains. Excavations at this famous cave site resumed after 1949 have so far brought to light five more teeth of *Sinanthropus*, one mandible, and two long bones—a humerus and a tibia—in 1949, 1951, and 1959 (*2*). These eight fossils all came from the *Sinanthropus* strata of the Kotsetang cave and chronologically do not exceed the upper and lower limits of the geological time covered by the old and now lost specimens. The morphological details of the teeth and long bones have not been made available, but the humerus is said to be almost completely "modern" and the tibia (not represented among pre-war specimens) slightly more "primitive" (*3*). The long bones thus serve to fill a few of the gaps in the scientific knowledge concerning the extremities of Peking Man (*4*). Two fragments of a *Sinanthropus* mandible, probably that of an old female, were recovered *in situ* near the west entrance of Kotsetang cave in July 1959 by the staff of the Institute of Vertebrate Paleontology and Paleoanthropology (IVPP), Peiping. In general, this specimen resembles the *Sinanthropus* mandibles described by Weidenrich (*5*).

Sjara-osso-gol. The loess beds and their associated riverine-lacustrine deposits of Upper Pleistocene in the Ordos

The author is instructor in anthropology at Yale University and assistant curator in anthropology in the Peabody Museum of Natural History, Yale. He has specialized in the prehistory and ancient history of the Far East.

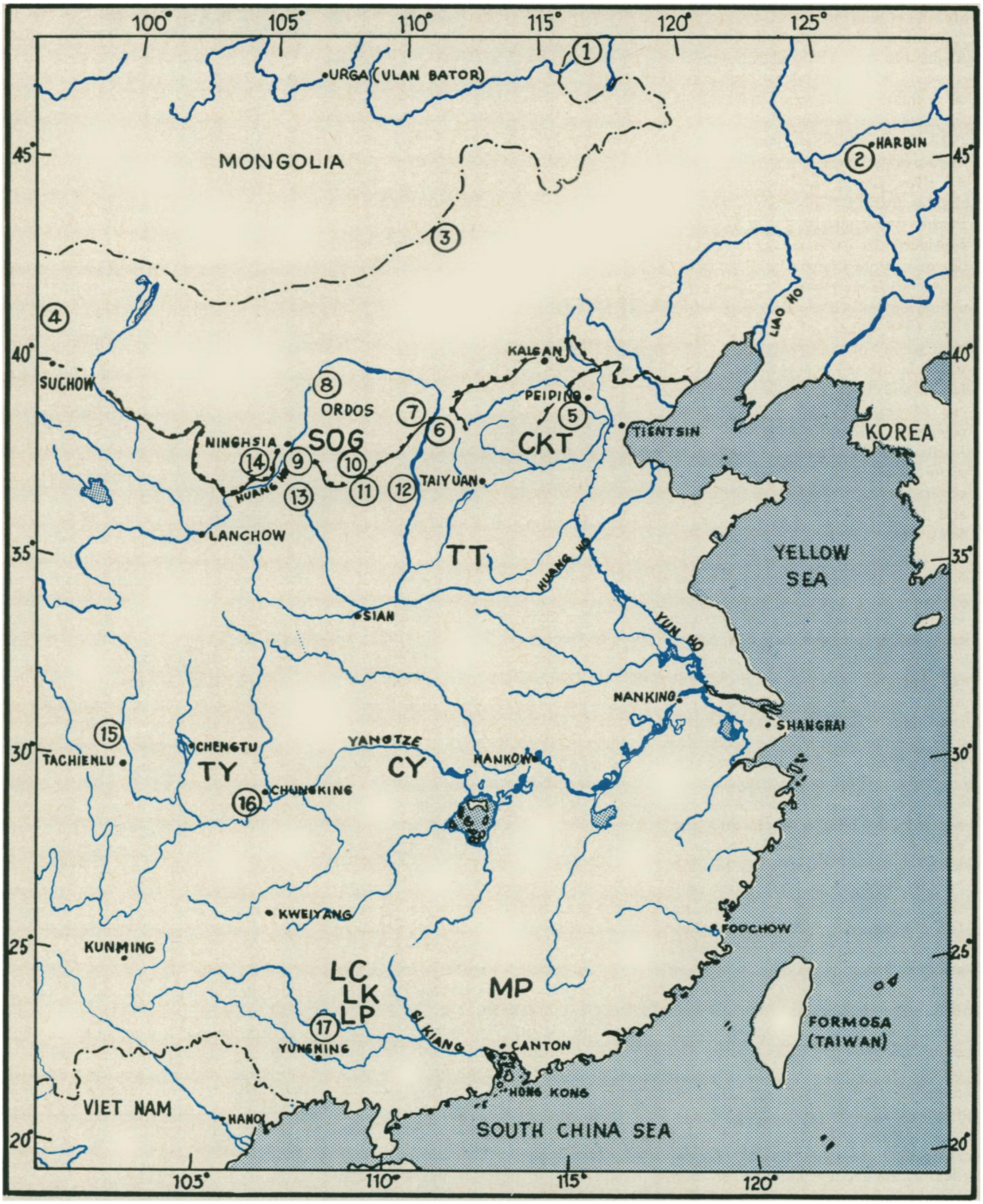

Fig. 1. China, showing old paleolithic and paleoànthropological localities (indicated by numbers) and new fossil man stations (indicated by letters). 1, Djalai-nor; 2, Harbin; 3, Tung-gur; 4, Peishan; 5, Choukoutien; 6, Paote area; 7, Chungar; 8, Northwestern Ordos; 9, Shuitungkou; 10, Sjara-osso-gol; 11, Youfangt'ou; 12, Wupao; 13, Ch'ingyang; 14, Chungwei; 15, Szechwan-Tibetan border; 16, Upper Yangtze terraces; 17, Wuming. CKT, Choukoutien (same as 5); SOG, Sjara-osso-gol (near 10); TT, Ting-ts'un; CY, Ch'ang-yang; TY, Tzu-yang; LC, Liu-ch'eng; LK, Liu-chiang (Liu-kiang); LP, Lai-pin; MP, Ma-pa. [After Teilhard de Chardin (7, map 5, with letters superimposed)]

area have long proved to be prolific in paleolithic implements and mammalian fossils; but the only known human fossil was a left upper lateral incisor tooth of a child, 7 or 8 years old, collected by Licent and Teilhard de Chardin in 1922 from rewashed deposits in the Sjara-osso-gol area (*6*). In the bed of the river, Licent also picked up a few slightly fossilized limb bones (one humerus, two femora). These are rightly considered by Teilhard as "most probably of a quite modern age" (*7*, p. 77), a conclusion subsequently confirmed by a fluorine test (*8*).

In 1956, Wang Yu-ping undertook a brief survey of the upper Sjara-osso-gol valley in the same neighborhood where Licent and Teilhard made their discovery 34 years previously. He collected paleolithic implements and mammalian fossils near Ta-kou-wan-ts'un. In the vicinity of Ti-shao-kou-ts'un, Wang uncovered a right human parietal bone and the lower half of a left human femur from a terrace formed of stratified yellow sands and sandy concretion bands. In the immediate neighborhood of the human bones (which, however, lay 60 meters apart), fossils of rhinoceros and elephant were collected, but no paleolithic implements have been reported (*9*). Woo Ju-kang, who reported on the morphology of the parietal and femur, concluded that their characters indicate that this Ordos Man is of a late neanderthaloid type (*10*).

Ting-ts'un, Shansi. Mammalian fossils and paleolithic stone implements were first brought to light in the vicinity of Ting-ts'un, Hsiang-fen county, southern Shansi, in May, 1953. Excavations by the IVPP on the left bank of the river in 1954 disclosed no less than 14 fossiliferous localities on the second and third Fen River valley terraces, and paleolithic implements were recovered from ten of these sites. At Locality 100, three human teeth were found. The chronological position of these erosional deposits is not definitely established; they have variably been interpreted as either early or late Upper Pleistocene in age (*11, 12*).

The three human teeth, all of the right side, comprise an upper medial incisor, an upper lateral incisor, and a lower second molar (Fig. 2, second row). It is assumed that they belonged to an individual about 12 or 13 years old. The general structure of the upper medial incisor is considered to be similar to that of the Neanderthals, particularly with regard to the marked shovel-shaped depression and associated finger-like projections on its lingual surface. On the other hand, the upper lateral incisor apparently shows more resemblances to *Sinanthropus* and modern Mongoloids. In the lower second molar, resemblance is greatest to *Sinanthropus* and Neanderthals. In conclusion, Woo Ju-kang states that "the morphology of all three teeth indicates that the Ting-ts'un Man is phylogenetically situated between *Sinanthropus* and modern man and is close to the Neanderthals, especially to Ordos Man. In addition, the Ting-ts'un teeth exhibit certain features indicative of closer relationship to the modern Mongoloid race than to the Caucasoid" (my translation) (*13*).

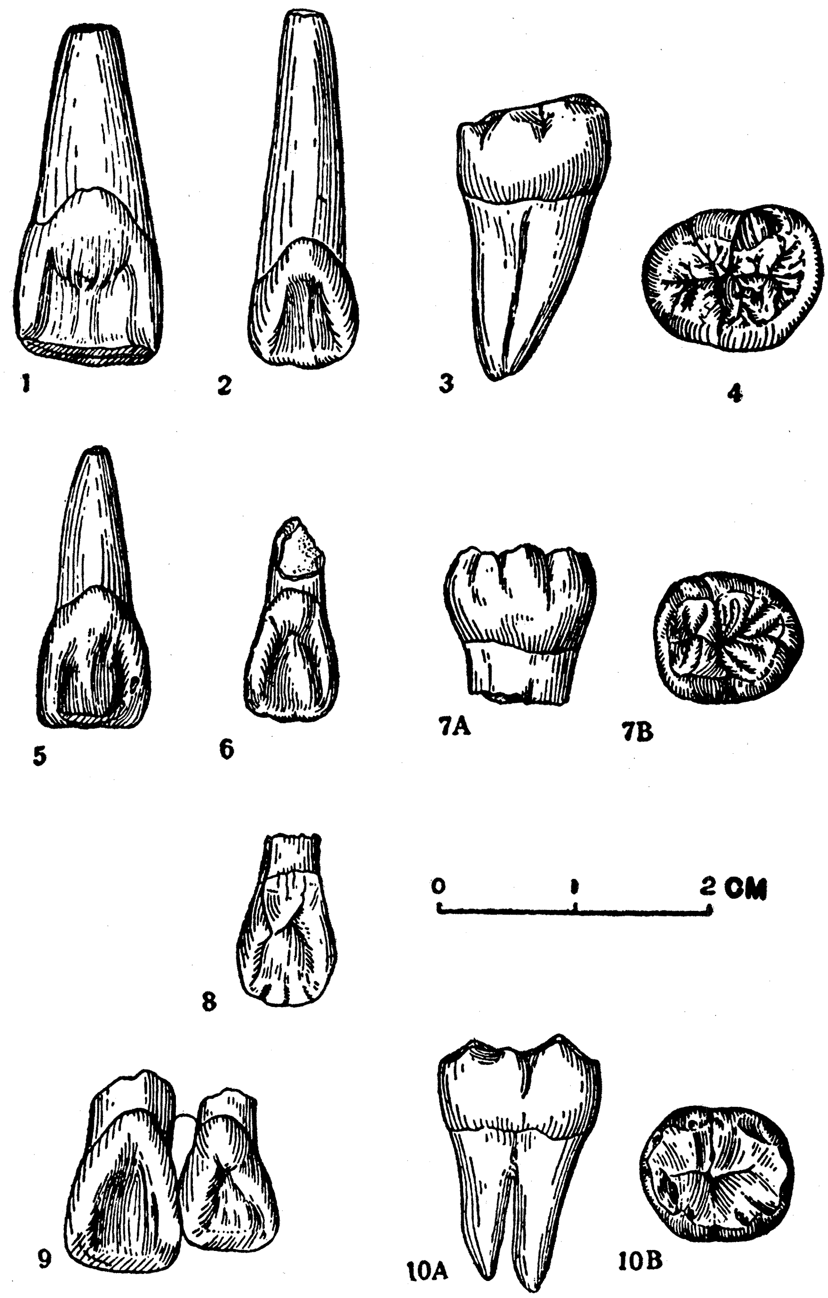

Fig. 2. Comparison of some teeth of fossil and modern men in China. 1–4, *Sinanthropus* (1, left upper medial incisor, lingual view; 2, right upper lateral incisor, lingual view; 3, right lower second molar, buccal view; 4, left lower second molar, occlusal view). 5–7, The Ting-ts'un teeth (5, right upper medial incisor, lingual view; 6, right upper lateral incisor, lingual view; 7*A*, 7*B*, right lower second molar, buccal and occlusal views). 8, The Ordos tooth (left upper lateral incisor, lingual view). 9, 10, Modern Chinese teeth (9, right upper medial and lateral incisors, respectively, lingual view; 10*A*, 10*B*, right lower second molar, buccal and occlusal views). [After Woo and Chia (*3*, Fig. 2)]

Ch'ang-yang, Hupei. From the sedimentary deposits of soft sandy clay in the Cave of Dragons (Lung-tung), on the southern slope of Kuan-lao Ridge, near the village of Hsia-chung-chia-wan, 45 kilometers southwest of the city Ch'ang-yang, Hupei province, there were recovered, in 1956, a human left maxilla and an isolated human left lower second premolar tooth. Paleontologists of the IVPP investigated the site in the spring of 1957 and uncovered a typical *Ailuropoda-Stegodon* fauna. This fauna is generally believed to be of Middle Pleistocene age, and the scientists working on the cave suggest a late Middle Pleistocene dating, for the morphology of the maxilla shows less "primitive" features than does that of *Sinanthropus.*

The maxilla, which is fragmentary, contains two teeth (first premolar and first molar). It resembles modern man in most of its features. However, it is said to be "primitive" in the relatively great width of the lower part of its nasal aperture and the relative flatness of its lateral wall, as well as in the indications that its canine teeth had well-developed roots (*14*).

Tzu-yang, Szechwan. In 1951, in the course of railroad bridge construction work on the southern bank of Huang-shan-hsi river, at a spot approximately half a kilometer west of the city of Tzu-yang, Szechwan province, workmen discovered a number of mammalian fossils, including a human skull. In the fall of the same year, excavation at this locality was undertaken by a group of geologists and paleontologists under the direction of Pei Wen-chung. More animal and plant fossils and a man-made bone awl were collected, but no additional human remains were brought to light.

Four stratigraphic layers are recognized at the site of excavation, although it must be emphasized that they are not sharply differentiated from one another and that they collectively seem to mark a single sedimentary cycle. The first layer from the top is composed of yellowish red clay, and is regarded as probably corresponding to the Northern Chinese loess both in formation and in age. Bands of sands and, further below, pebbles underlie the loess-like layer, and the human skull was found in the third layer from the surface, which also contains a large amount of mammalian fossils and petrified and/or carbonized tree trunks and leaves. Two mammalian faunas were distinguished in the deposits, one of Middle Pleistocene age characterized by *Rhinoceros, Cervus,* and *Stegodon,* and one of Upper Pleistocene age including *Equus, Muntiacus, Mammonteus,* and *Homo.*

The cranial bones of the Tzu-yang skull are relatively intact, although the right side of the skull base is lacking (Fig. 3). The facial bones are largely absent, as are the maxillae. The cranium on the whole is relatively small (*15*). The surface is rather smooth, but the occipital portion, supraorbital ridge, parietal and frontal eminences, mastoid process and supramastoid crests are all rough and massively developed. The mandibular fossa is rather wide and deep. The sutures are mostly patent externally, which led to the original identification of the skull as that of an adolescent. Closer examination, however, disclosed that almost all of the sutures are closed on the cerebral surface, that the frontal sinus is of considerable size, that the posterior section of the hard palate is almost closed, and that the maxillae exhibit evidence of chronic local bone-marrow inflammation or chronic alveolar abscess in the region of the left molar teeth, which were lost during life. These facts led the investigators to conclude that this skull probably belonged to a female over 50 years of age.

The morphology of the Tzu-yang skull has been described in great detail. Judged by its relatively great height, by its greatest interparietal breadth, and by a number of other morphological details, it is unquestionably of the *Homo sapiens* type. On the other hand, Woo Ju-kang (*16*) has pointed out that it also exhibits a number of "primitive" characters. The phylogenetic position of Tzu-yang Man is best expressed by a comparison of its midsagittal craniogram (Fig. 4) with those of some other fossil forms, as shown in Table 1. Woo (*17*) also observes that the Tzu-yang skull bears some resemblances to both the Upper Cave Man and *Sinanthropus.*

Liu-ch'eng, Kwangsi. Gigantopithecus teeth were discovered *in situ* for the first time in early 1956 in the Niu-shui-shan-hei-tung cave in Ta-hsin county, Kwangsi province, in association with the Pleistocene *Ailuropoda-Stegodon* fauna of South China. Subsequent surveys and excavations in this province have uncovered over 1000 isolated teeth from many limestone caves and three mandibles from the cave of Hsiao-yen-tung (or Chü-yüan-tung) in Liu-ch'eng county, Kwangsi (*18, 19*). The first of these mandibles was discovered by a peasant digging fertilizer from the cave; but the second and third were excavated *in situ* by paleon-

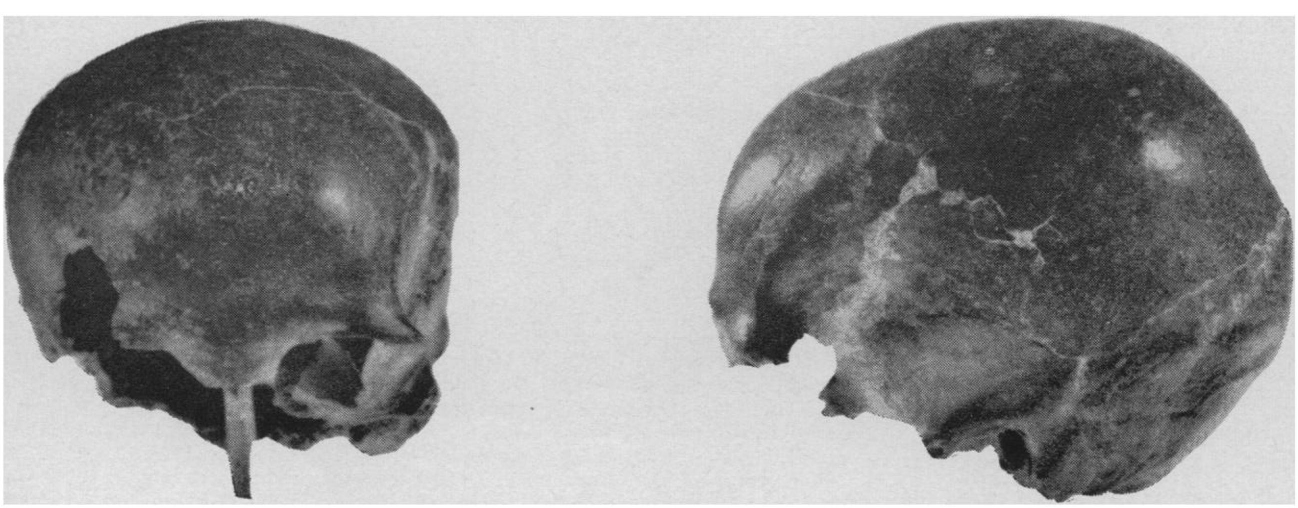

Fig. 3. The Tzu-yang skull. (Left) frontal view; (right) lateral view. [After Pei and Woo (*16*, plates I and II)]

Table 1. Comparison of midsagittal craniograms [after Woo and Peng (*24*, p. 180)].

Groups	Calvarial height index	Bregma position index	Bregma angle (deg)	Frontal angle (deg)
Living races	51 to 59			
8 Cro-Magnons	46 to 55	28 to 37	46 to 57	74 to 90
Tzu-yang	45.3	41.8	47.5	81
Liu-chiang	42.9	44.2	45	76.5
9 Neanderthals	33 to 43	33 to 40	38 to 49	50? to 74
Ma-pa	41.6	40.6	45	70
Sinanthropus (*2, 3, 10–13*)	35 to 41	37 to 42	38 to 45	56 to 63
Pithecanthropus (*1, 2*)	33 to 37	36 to 43	38 to 43	48 to 55

tologists of the IVPP in 1957–58. The cave deposits which yielded the mandibles and other mammalian fossils exhibit four layers which indicate no less than two cycles of climatic change; the deepest layer represents the first cycle, whereas the three layers above it together comprise the second. "Whether all the climatic changes took place in a single unit of geological time or in two units, is a question which cannot be solved at the present moment" (*20*). The first and second mandibles of *Gigantopithecus* were found in the upper part of the second layer from the bottom; and the third mandible was recovered from the layer immediately above this. Hence all three mandibles seem to belong to the second cycle. The associated fauna includes *Hyaena licenti*, fragments of mastodon teeth, and an archaic form of chalicotherid; these have led the investigators to place the age of *Gigantopithecus* within the Lower Pleistocene of South China.

Mandibles I, II, and III (Fig. 5) have been assigned, respectively, to an old female, a young male, and an old male. They are, proportionate to the giant teeth, of gigantic dimensions. Both the mandibles and the isolated teeth of *Gigantopithecus* exhibit unmistakably simian characteristics; but, on the other hand, it has been claimed that they also possess features in which they are "closer to man than any other anthropoid apes, living or extinct" (*20*). Considering the late age of *Gigantopithecus*, it is apparent that it could not have been on the direct line descending to *Pithecanthropus* and *Homo*, although its possible relationship to the australopithecines is an interesting and worthwhile problem.

Liu-chiang (Liu-kiang), Kwangsi. In September, 1958, workmen digging for phosphorus fertilizer in Tung-tien-yen cave, Lui-chiang county, Kwangsi, discovered a fossil human skull and portions of the postcranial skeleton. A number of other mammalian fossils were also found in the same cave; these subsequently were identified as bones and teeth of *Ailuropoda, Hystrix, Rhinoceros, Stegodon, Megatapirus, Sus, Ursus*, and others. According to the paleontologists who investigated the finds, the human fossils were found near the entrance of the cave along with the complete skeleton of a giant panda, *Ailuropoda*. Both of these skeletons were embedded in loosely consolidated limestone breccia, intercalated with grayish brown sands and clays. As these deposits differ markedly from the hard yellowish ones containing abundant vertebrate fossils of the *Ailuropoda-Stegodon* fauna which are found widely in Kwangsi caves, Woo Ju-kang, who reported the finding of Liu-chiang Man, assumes that "the fossil human skull together with that of *Ailuropoda* is later than Middle Pleistocene. As the human skull is definitely fossilized and of *Homo sapiens* type, it can be assumed that it is of late Pleistocene age" (Woo's own translation with some editorial changes) (*21*).

The human remains consist of a nearly complete skull lacking parts of both zygomatic arches and the mandible (Fig. 6), the lower four thoracic (to which are cemented four fragments of ribs) and the five lumbar vertebrae, the sacrum, a fairly well-preserved right hip bone which lacks the pubic portion, and fragments of both femora. These bones are assumed to be from the same individual, probably a middle-aged male. Like Tzu-yang Man, the Liu-chiang Man is said to be of the *Homo sapiens* type, with some "primitive" characteristics. On comparing the data given in Table 1, Woo concludes that Liu-chiang Man can be neatly placed between the Neanderthals and Tzu-yang Man. Furthermore, this skull shows a number of characteristic features of great interest in racial anthropology. The postcranial skeleton of Liu-chiang Man is characterized by a vertebral column which is short and weak relative to the size of the skull, and by a number of "primitive" features. "Based on the above analysis," Woo states, "it is concluded that the Liu-chiang Man was a primitive form of *Homo sapiens* of an early type of evolving Mongoloid. This new discovery of the Liu-chiang human fossils with such primitive Mongoloid features in Kwangsi of South China, as well as the Tzu-yang skull uncovered in 1951 in the southwest Szechwan province, seems to indicate that South China might be a part of the birthplace where the

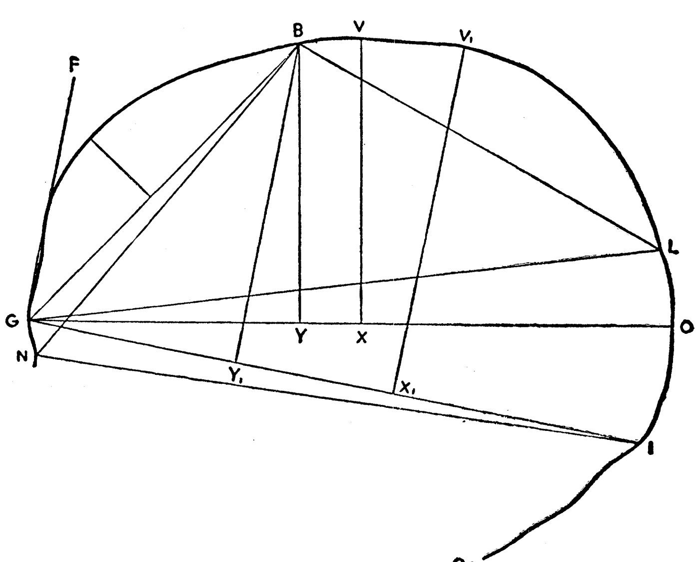

Fig. 4. Midsaggital craniogram of the Tzu-yang skull. [After Pei and Woo (*16*, Fig. 3)]

Mongoloid race originated and also to show that the Mongoloid group was in the process of formation and differentiation in the late Pleistocene" (Woo's own translation with some editorial changes) (*22*).

Ma-pa, Kwangtung. A fossil human skull cap and many other mammalian fossils were found in June, 1958, in a cave in Shih-tzu-shan, a limestone hill, southwest of the village of Ma-pa, near the city of Shao-kuan (Ch'ü-chiang), in northern Kwangtung. Excavations were subsequently undertaken under the auspices of the IVPP and the Provincial Commission for the Preservation of Ancient Monuments, during September and October of the same year. These diggings disclosed no more human remains, but brought to light additional mammalian fossils. The associated fauna includes *Hyaena, Ursus, Ailuropoda, Felis tigris, Tapirus, Rhinoceros, Sus, Cervus, Bos, Hystrix, Lepus, Stegodon*, and *Paleoloxodon namadicus*, apparently a typical South China Middle Pleistocene assemblage (*23*).

The fossil human skull cap consists mainly of the frontal and the two parietal bones, with fairly complete nasal bones and the right orbit (Fig.7). The condition of the sutures and the muscular crests suggest that it belonged to a middle-aged male. The skull is ovoid in *norma verticalis*. In *norma lateralis* (Fig. 7, bottom), it seems higher than the skulls of either *Sinanthropus* or Solo Man of Java. The frontal squama has a broad frontal bulge, which, as in Solo Man, descends and merges into the torus instead of being separated from the latter by a pronounced *sulcus supratoralis* as in *Sinanthropus*. Viewed from the front (Fig. 7, top), the greatest lateral projection of the skull is about at the level above the supramastoid crest. A slight midsagittal crest is present, but less marked than in *Sinanthropus*. The most conspicuous features in frontal view are the supraorbital tori which are similar to those of *Sinanthropus* in that they almost form a continuous crossbar at the base of the forehead. Separated only by a slight depression in the glabellar region, the tori are very thick and project markedly both forward and sidewise. They are thickest at their median ends as in the La Chapelle Neanderthal, instead of at their middle parts or lateral ends as in Solo Man or *Sinanthropus*. Their upper surfaces merge gradually into the frontal squama, as just mentioned, with a very slight *sulcus supratoralis*. As far as the anterior contour of the supraorbital tori is concerned, the Ma-pa skull falls between the linear contour of *Pithecanthropus-Sinanthropus* and the convex contour of the Neanderthals and in this respect is close to Solo Man. The contour of the right orbit is rounded as in the Neanderthals rather than rectangular as in Peking Man and Solo Man, and it has no *incisura frontalis medialis* as among the latter. The interorbital breadth (mf-mf) of the Ma-pa skull is 20.8 mm, considerably larger than the average for modern man. There is no circumscribed *fossa lacrimalis*. All of the sutures which separate the nasal part of the frontal bone from the nasal, maxillary, and lacrimal bones lie nearly at the same level, as in *Sinanthropus*, Solo Man, and Rhodesia Man. A midsagittal craniogram of the Ma-pa skull was reconstructed (Fig. 8), and the data derived therefrom are given in Table 1. These seem to place the Ma-pa skull within the Neanderthal range. Taking all features into consideration, Woo Ju-kang concluded that the Ma-pa skull "probably belongs to the early Paleoanthropic stage in human evolution" (*24*).

Time Placement of the Discoveries in the Chinese Pleistocene

As Pierre Teilhard de Chardin has pointed out, "human China" does not really begin before (but it positively begins with) the closing of the Miocene period, when for the first time the physiographic pattern and the faunistic assemblage in which we are still living become distinct (7, p. 1) The Pontian period of the Chinese Pliocene represents a single, well-defined, major cycle of sedimentation, acting on a thoroughly rejuvenated floor of old peneplains; and with the appearance of the Villafranchian fauna the stage of mankind in China was established. The subsequent events must be described separately for North China and South China,

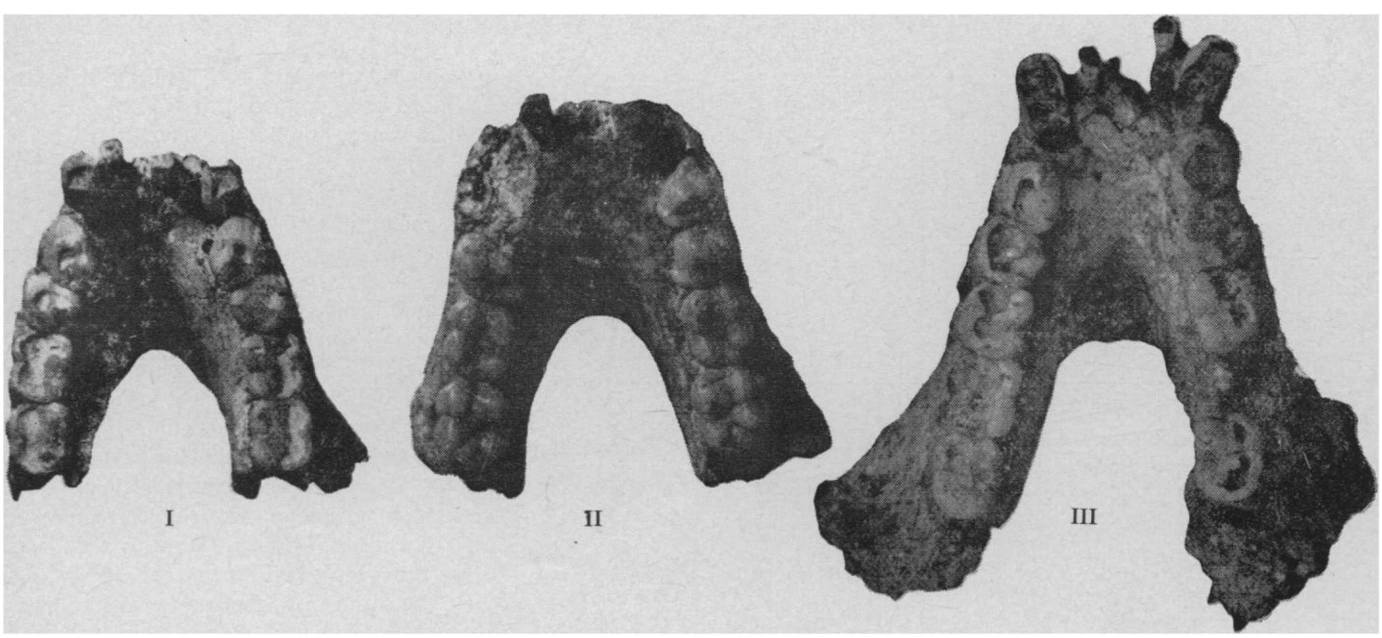

Fig. 5. Three mandibles of *Gigantopithecus blacki* (1/5 inch equals 1 centimeter). [After Pei and Li, *Vertebrata Palasiatica* 4, No. 4, plate III (1958)]

the two major divisions of this vast area sharply demarcated by the Tsinling mountains and their related, consecutive ridges which have divided China into two major climatic and paleozoological provinces ever since the Palaeozoic.

North China. The climatic and sedimentary cycles of the Pleistocene in North China as known prior to the last war have been reconstructed by Movius in 1944 (*25*). The first cycle, equated with the Lower Pleistocene elsewhere, was initiated by the Fenho Erosion interval and by the appearance of an essentially Villafranchian-type fauna, including *Elephas, Equus, Bos, Paracamelas, Cervus*, and *Ovis*. Neither human remains nor acceptable cultural relics have ever been unearthed from this period. The Villafranchian is then separated from the Middle Pleistocene by a distinctly marked phase of continental uplift known as the Huangshui Erosion stage, which brought about the establishment of the modern drainage system in the Huang Ho valley and an abrupt change in the sedimentation from dominantly lacustrine deposition to red slope-wash clays and thick red loamy fans. The Reddish Clay stratum, known as the stage of Choukoutien Sedimentation since it led to the widespread development of fissure deposits of the Choukoutien type, contains a typically Middle Pleistocene fauna, characterized by the first appearance in North China of a hominid, *Sinanthropus*, and by a variety of other mammalian forms such as *Sinomegaceros* (*Euryceros*) *pachyosteus, Hyaena sinensis, Spirocerus, Rhinoceros mercki, Elephas namadicus, Equus Sanmenensis, Canis lupus*, and *Nyctereutes*. This long sedimentation cycle of the Reddish Clay stage is best represented by three characteristic sites in the Choukoutien region: Localities 13, 1, and 15, which are generally regarded as being chronologically successive, in that order. According to Movius, these three phases, representing the whole of Middle Pleistocene and the initial phase of the Upper, were deposited under different climatic conditions; they probably correspond, respectively, to the Second Glacial, the Second Interglacial, and the Third Glacial of the Himalayas (*26*). Stretching throughout this lengthy time interval are the hominid species known as *Sinanthropus pekinensis*, and his cultural assemblage, the Choukoutienian. The latter is known to be characterized by the overwhelming prevalence of two basic technological traditions, chopper-chopping-tool, or pebble, tradition, and the "clactonian" flaking tradition.

The pre-war picture of the Reddish Clay Man and Culture in North China remains basically unchanged, but new findings of human industries at Choukoutien and in southern Shansi call for some degree of elaboration. At Locality 1 of Choukoutien, excavations undertaken in 1958 by the IVPP disclosed three more fossiliferous strata below the ten layers recognized by Teilhard and Young in 1929 (*27*). Since fossil remains of *Sinomegaceros flabellatus*, index fossil of the Locality 13 horizon (*28*), rather than *Sinomegaceros pachyosteus*, were found from these new layers, Chia Lan-po concludes that the bottom layers of Locality 1 were contemporary with Locality 13 (*29, 30*, pp. 273–282); this is essentially in accord with a geological analysis of the Locality 1 deposits undertaken by Huang Wan-po (*31*). Man's occupation of the Kotsetang cave started with the deposition of the lens at the very bottom, where a flake implement was unearthed during the 1958 season (Fig. 9). It was struck from a pebble of chert, with an unfaceted platform and retouched edges. Together with the chopping-tool of Locality 13 of presumably the same age, these two implements initiated the two Choukoutienian technological traditions from the beginning of Middle Pleistocene in North China. *Sinanthropus* apparently occupied this locality continually from there on, through two cold and dry climatic phases and one mild and damp interval. This conclusion is further confirmed independently by recent comparative studies of *Megaceros* (*30*, p. 279) and *Hyaena* (*32*) of North China and Europe and by the analysis of the pollen spectrum of a Locality 1 specimen (*33*).

From the Reddish Clay stage deposits in southern Shansi and northern Honan, recent investigations have brought to light a number of industrial assemblages. No human remains have

Fig. 6. The Liu-chiang skull. (Left) Frontal view; (right) lateral view. [After Woo (*21*, plate I)]

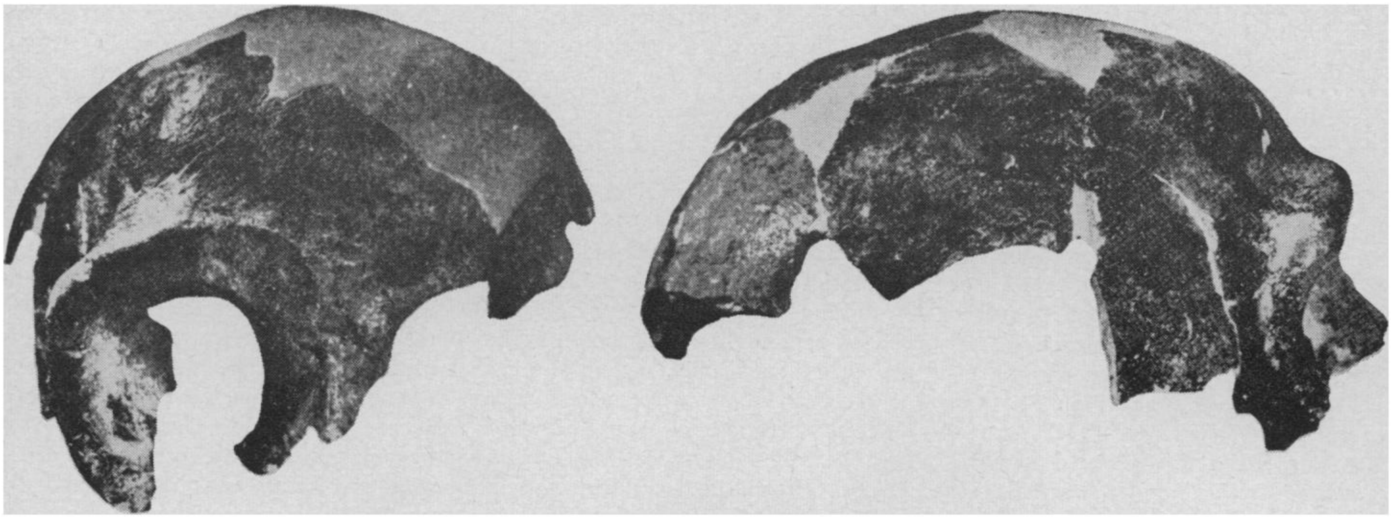

Fig. 7. The Ma-pa skull. (Left) Frontal view; (right) lateral view. [After Woo, *Vertebrata Palasiatica* **3**, No. 4, plate I (1959)]

been reported from these sites, and the stone implements are essentially Choukoutienian (*12, 34, 35*). It may be significant to note that the distribution of the known Reddish Clay stage sites of man has been shown to be confined to the eastern fringes of the western highlands of North China, from the Western Hills in the Choukoutien region in the northeast to the big bend of the Huang Ho in the southwest.

At the base of North China's loess, which was formed during the final cool and semi-arid phase of the Pleistocene, is a gravel bed (the Basal Gravel) deposited during the Chingshui Erosion stage which marks the end of the stage of the Reddish Clay. From this layer, scattered findings of stone implements, mostly in derived condition, were made before the war in the Ordos and eastern Kansu. During the last decade, a series of industrial assemblages have been brought to light from this stratum in Chiao-ch'eng, Ting-ts'un, and other localities in Shansi, and, as mentioned above, from the Locality 100 at Ting-ts'un three human teeth have been recovered (*35, 36*). The Choukoutienian industrial traditions are repeated here in the Ting-ts'un assemblage, which, however, bear a number of significant innovations serving to place the Ting-ts'un complex half-way technologically between the Choukoutienian and the Ordosian. These include the emergence of parallel-sided flakes which may be considered as the prototype of the Ordosian blades, the evidence of elaborately prepared striking platform on flakes, the relative abundance of bifacially flaked core implements, and an overall improvement of flaking techniques. Other novel traits also appeared at Ting-ts'un, such as the picklike heavy pointed implements, stone balls, and polygonal disks. It can be demonstrated that the mature Mousterian flaking technique and the manufacture of blades of the Ordosian began to emerge in the Ting-ts'un complex (*11*). Woo's study of the Ting-ts'un teeth serves to suggest that Ting-ts'un Man was physically more advanced than *Sinanthropus*.

The dating of the Ting-ts'un complex, however, is controversial. The preliminary reports of this site placed it in the late Reddish Clay stage (*37*), and Movius argues for a Chingshui Erosion stage dating (*38*). In the final report, Pei, Woo, and others revised their original dating by placing the Ting-ts'un finds in the lacustrine-riverine facies of the Loess stage, contemporary with the fossiliferous beds at Sjara-osso-gol (*36*). This revision appears very curious indeed. It is considered established that the Loess stage of North China, notwithstanding its divisibility into several regional facies, was as a whole characterized by a cool and semi-arid climate with a prevailing wind from the northwest. Some of the regional facies, such as Sjara-osso-gol and Chao-ts'un in Hopei (*39*), feature a humid environment, to be sure, but none of them are characterized by having a warm climate. As indicated by the remains of warm climate species of *Lamprotula*, such southern species of fish as *Mylopharyngodon piceus*, and *Elephas namadicus*, the fossiliferous beds at Ting-ts'un were apparently deposited under a relatively warm as well as humid climate. Furthermore, several mammals typical of the Villafranchian and Reddish Clay stages are represented in the Ting-ts'un fauna, such as *Palaeoloxodon tokunagai, Rhinoceros mercki, Rhinoceros tichorhinus*, and *Pseudaxis grayi*, which were rare or absent in the loess stage. The Ting-ts'un industry is, as just mentioned, definitely less advanced than the flake and blade industry of the Ordosian. Unless and until the Loess stage can be shown to contain a considerable early interstadial into which the Ting-ts'un assemblages might more conceivably be placed, one finds the Chingshui Erosion stage dating the most plausible.

Cultural assemblages that can definitely be dated to the Loess stage have been widely uncovered from Shansi and the Ordos during the last decade (*9, 40*). These are generally characterized by points and scrapers on "Mousterian" flakes and by burins and end-scrapers on blades, along with persistent pebble and flake implements, and at some sites also by the initial appearance of the microblade tradition. The tooth, parietal, and femur of Sjara-osso-gol can easily be placed into a late phase of this Loess stage. This stage was closed, along with the Pleistocene period, by the Panchiao Erosion stage which brought about a climatic amelioration, a forested and swampy environment, a mesolithic industry, and *Homo sapiens* in North China.

South China. Despite well-grounded high expectations, South China claimed, prior to the period under review, merely

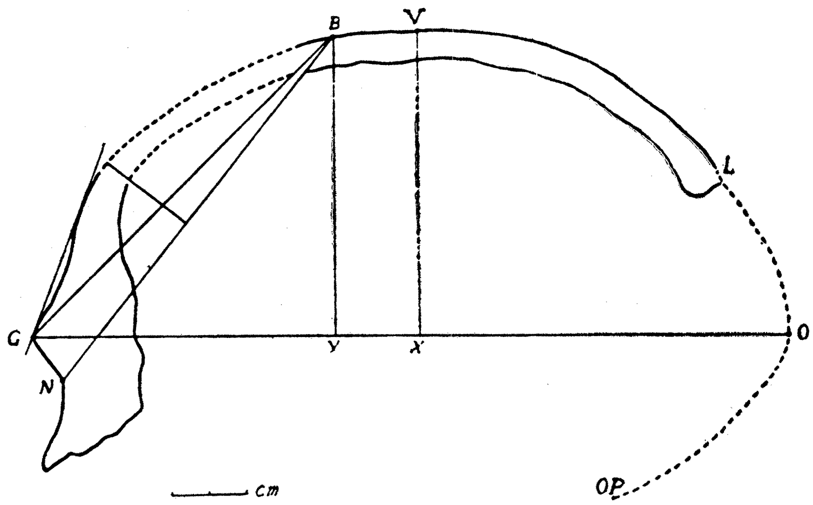

Fig. 8. Midsaggital craniogram of the Ma-pa skull. [After Woo, *Vertebrata Palasiatica* 3, No. 4 (1959)]

some stone implements from Pleistocene deposits in Wu-ming county of Kwangsi and along the Yangtze Gorges between Ichang and Chungking. The last ten years happily witnessed the discoveries of important early human fossils from Ch'ang-yang, Tze-yang, Liu-chiang, and Ma-pa. Unfortunately, the Pleistocene stratigraphy and faunal history of South China are still imperfectly understood; consequently, the dating of the new fossils is at present at a highly uncertain state.

The subdivision of the Pleistocene period in South China has been made according to the cycles of erosion and sedimentation observed in the Yangtze valley terraces (*41*). Such studies, however, have been of little use for dating purposes, for the majority of South China Pleistocene mammalian fossils, including those of man, came from cave or fissure deposits. With the exception of a small collection of possibly Villafranchian fauna in Yuan-mo, Yunnan province (*42*), all of the Pleistocene mammalian fossils unearthed in South China prior to the war were grouped into a single fauna, known as the Sino-Malayan or the *Ailuropoda-Stegodon* fauna, and dated Middle Pleistocene (*43*).

Since all of the recent discoveries of human fossils are associated with this *Ailuropoda-Stegodon* fauna, a subdivision of the latter becomes necessary if a relative dating of the fossil men is to be attempted. Fortunately, the new *Gigantopithecus* and Tzu-yang Man localities afford certain definite clues. At the Hsiao-yen-tung cave, some Villafranchian and Pontian forms are found, as enumerated above, which serve to indicate that the *Ailuropoda-Stegodon* fauna of South China may have started from the Lower Pleistocene. This fauna, furthermore, is shown to have persisted into the Upper Pleistocene according to the faunal assemblages at Tzu-yang and T'ung-nan in Szechwan, and a cave in Kwangsi (*16, 44*). A reassessment of these recent findings together with former materials has led Pei Wen-chung to conclude that:

"According to the new studies of the mammalian fossils found in association with the remains of primitive men, it seems that the so-called *Ailuropoda-Stegodon* fauna already came to exist as early as at Early Pleistocene and even as late as to Late Pleistocene. . . . As shown by the mammalian fauna, in South China, during the whole Quarternary time, it seems that it has little been changed, so far as the climate and geography are concerned. In other words, this is meant that during the entire Quarternary age, the climate and geography of South China were scarcely different from those of today in Malaya or the provinces Yunnan and Kwangsi" (Pei's own translation) (*45*).

An apparent oversimplification of the actual picture, this conclusion nevertheless provides the only framework now available for dating the fossil human remains discovered in South China. It is thus possible, on the basis of the geological and paleontological data described above, to assign *Gigantopithecus* to a relatively dry phase between two wet intervals during the Lower Pleistocene, and the Tzu-yang Man to an early phase of the last climatic stage (Fourth Glacial?) during the Upper Pleistocene. The faunal lists for Ma-pa, Ch'ang-yang, and Liu-chiang finds offer no positive evidence for any precise dating. The former two fossils can be anywhere from the Middle to the Upper Pleistocene, as far as their associated fauna is concerned, and the geological rather than faunal evidence of the Liu-chiang discovery (*21*) helps to assign them to a later date than the Middle Pleistocene. For a more precise time placement of these three human fossils, one can only rely upon, at the present time, their own morphological features in comparison with other better-dated finds elsewhere in China (Fig. 10).

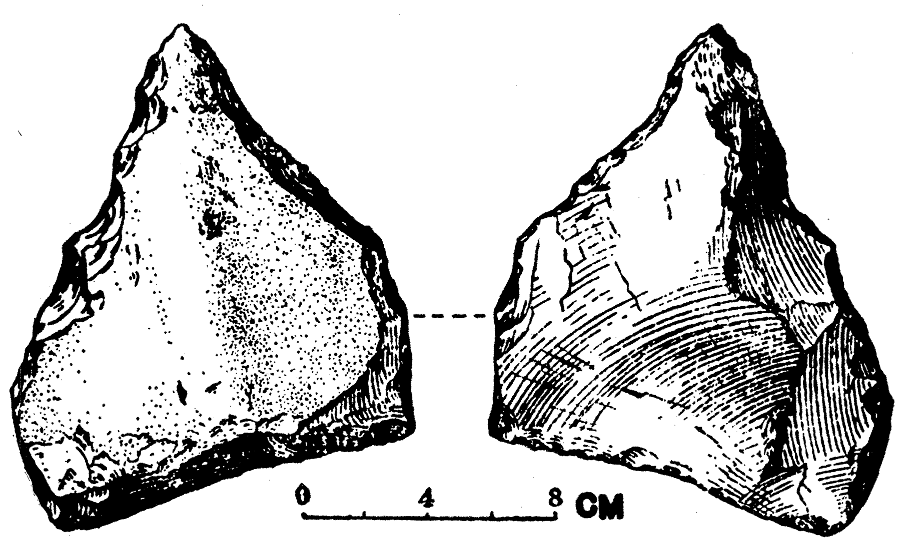

Fig. 9. A chert chopper discovered in 1958 at Choukoutien, Locality 1, Group A, Layer 13. [After Chia (*27*, Fig. 3)]

Comment

It has been shown that the newly discovered human fossils in China come from a wide area and represent a long time span. In addition, post-Pleistocene human remains have been widely reported from mesolithic and neolithic time periods and cultural contexts (*46*). Thus emerges a picture, still very incomplete, of human evolution in this part of the world.

It now appears clear that *Gigantopithecus* can be removed from the family tree that leads to modern man, for morphological as well as chronological considerations. It is a fascinating and highly significant anthropoid in its own right, and its possible relationship to the African australopithecines ought to be closely examined.

True hominids in China begin with the appearance of *Sinanthropus* in North China at the beginning of the Middle Pleistocene or probably the onset of the Second Glacial period. Prior to the period under review, *Sinanthropus* was the only known early hominid form from China, and between it and the earliest *Homo sapiens* that had been uncovered from Chinese soil—the Upper Cave remains—there was a tremendous hiatus (except for an isolated Ordos tooth) in the fossil record of man in China. Now, we are confronted with no less than six additional relatively well-documented human forms of Pleistocene age that morphologically as well as chronologically have filled the hitherto blank space. Four of these, Ma-pa, Ch'ang-yang, Ting-ts'un, and Sjara-osso-gol, possess certain neanderthaloid affinities, as mentioned above, whereas the other two, Liu-chiang and Tzu-yang, are *Homo sapiens* with features that have been described as "primitive" or "archaic." Apparently following Weidenreich's classificatory scheme, Woo Ju-kang and N. N. Cheboksarov place *Sinanthropus* and the Ma-pa skull in the Archanthropic (Protoanthropic) stage, the Ch'ang-yang and Ordos in the Paleoanthropic stage, and the Liu-chiang and Tzu-yang in the Neoanthropic stage (*47*). Thus, a typologically complete series of human fossils from *Pithecanthropus* through *Homo sapiens* types is firmly established for this area. Scientists thus face the task of comparing and cross-dating these finds with comparable fossil forms elsewhere, and must endeavor to answer such pertinent questions as the typological and genetic affinities and relative dating between Chinese "neanderthaloids" and *Homo sapiens* and their Western and Southern counterparts. Such questions certainly remain to be answered. One important gap in our present state of knowledge is a minute subdivision of the Upper Pleistocene, a period when *Homo sapiens* first appeared.

Comparative and cross-dating problems aside, it is significant to point out that a continuity of morphological characteristics from the Archanthropic stage onward through the appearance of the modern Mongoloid race in the area of China has been noted by some authors. Franz Weidenreich has singled out 12 morphological features of *Sinanthropus* which, according to him, are found among modern Mongoloids widely but among other races rarely. He concludes that:

". . . the peculiarities of the *Sinanthropus* skeleton, to sum up, are neither 'adaptive' nor have they any recognizable connection with special functions which could not be performed otherwise. Their transmission to *Homo sapiens* corroborates first the thesis that *Sinanthropus* is a direct ancestor of *Homo sapiens*, and secondly, that there is a closer relationship to Mongols—or at least to certain Mongolian groups—than to any other races, particularly to whites. This statement does not mean that modern Mongols derived exclusively from *Sinanthropus* nor that *Sinanthropus* did not give origin to other races. In any case, it is safe to say that racial groups supplied with those peculiarities have *Sinanthropus* in their ancestry. Had only one character been transmitted, the relationship might be questioned, but as there are *twelve* special features which behave in the same way the coincidence cannot be accidental" (*48*).

Weidenreich's thesis has been found implausible by many scholars, including Woo and Cheboksarov, who have cited the occurrence of the shovel-shaped upper incisors and the mandibular torus among groups of fossil men that cannot be reasonably considered as ancestral to modern Mongoloids. Weidenreich's presumption as to the nonadaptiveness of the peculiar characteristics in question remains to be demonstrated, to say the least. It is noteworthy, however, that some of these traits, such as the shovel-shaped upper incisors and the sagittal crest, recur consistently among all of the recent finds whenever these bony parts are recovered. Considering the fossil men found in China alone, the persistent recurrence of several

Possible correlation with the Himalayan glacial sequence		North China	South China
Upper Pleistocene	4th Glacial	Upper Cave (*Homo sapiens*) Ordos (*"Neanderthaloid"*)	Tzu-yang and Liu-chiang (*Homo sapiens*)
	3rd Inter-Glacial	Ting-ts'un (*"Neanderthaloid"*)	Ch'ang-yang (?) (*"Neanderthaloid"*)
	3rd Glacial		Ma-pa (?) (*"Neanderthaloid" or Sinanthropoid*)
Middle Pleistocene	2nd Inter-Glacial	*Sinanthropus pekinensis*	*"Sinanthropus officinalis"* (?)
	2nd Glacial		
Lower Pleistocene	1st Inter-Glacial		*Gigantopithecus blacki*
	1st Glacial		

Fig. 10. Tentative time placement of fossil men in China.

morphological features—either indicative of genetic transmission or marking functional adaptations—through the entire time span of human evolution in this part of the world is certainly a remarkable fact, though by no means a conclusive phenomenon.

The typological sequence and morphological continuity of the fossil men in China thus may be indicative of a population continuity and an evolutionary autonomy in this area, as Woo and Cheboksarov have noted, even though a total isolation must be ruled out. This must not be taken to mean that human development in China was a completely closed and self-sufficient process. It simply means that there probably was a central nucleus of interrelated genes that was transmitted from the early hominids in this area to its present inhabitants. Moreover, it does not mean that the origin of the Mongoloid race has been pinpointed, either in time or in space. It is to be realized that modern races are significant only at the contemporary time level as categories of population and that "races" of man in a past period must be categorized in their own right. Instead of looking for origins of the modern Mongoloid race, one might more feasibly try to explain the modern distribution of races in the light of the racial differentiation of the fossil man population.

Recent studies of the Upper Cave population and the newly discovered evidence for a less than well-differentiated Mongoloid-Negroid group in Southwest China (Liu-chiang and Tzu-yang) seem to indicate that the modern Mongoloid race, as such, is the result of a relatively recent development. The human strain that led subsequently to modern Mongoloids and, possibly, also to some of the modern Oceanic Negroids, seems to be intimately related to a group of men in South China who had the distinction of being the earliest *Homo sapiens* in East Asia. Unless the north-south cross-dating mentioned above has gone completely astray, it now seems that when the Liu-chiang and Tzu-yang Men had achieved a full *sapiens* status during the last phase of the Upper Pleistocene, the Ordos Man in the north during the same period, or maybe slightly later, was still, according to Woo, neanderthaloid.

These brief and broad observations concerning the phylogenetic implications of the new human fossils in China must be regarded as being highly tentative and grossly superficial. One thing emerges clearly from the above analysis, however, namely, to consider either human evolution in general or racial differentiation in particular, the physical anthropologists have already had to take the fossil history of man in the area of China into serious account.

References and Notes

1. Omitted from discussion are a human femur at Hsia-ts'ao-wan in Ssu-hung Hsien, Anhwei province, and fragments of a human skull found in Yü-shu Hsien, Kirin province. Once thought to be of the Pleistocene age, these have proved to be modern; see Chiu (*8*). For the cultural side of the picture, see (*11*).
2. H. L. Movius, Jr., *Am. Anthropol.* **57**, 334–335 (1955); L. P. Chia, *Vertebrata Palasiatica* **3**, No. 1, 41–45 (1959); T. K. Chao, *ibid.* **4**, No. 1, 30–32 (1960).
3. J. K. Woo and L. P. Chia, in *Chung-kuo jen-lei hua-shih ti fa-hsien yü yen-chiu* (Science Press, Peiping, 1955), pp. 43–46.
4. J. K. Woo, *Vertebrata Palasiatica* **4**, No. **1**, 18–19 (1960).
5. See J. K. Woo and T. K. Chao, *ibid.* **3**, No. 4, 169–172 (1959).
6. E. Licent, P. Teilhard de Chardin, D. Black, *Bull. Geol. Soc. China* **5**, 285–290 (1926).
7. P. Teilhard de Chardin, *Early Man in China* (Peiping, 1941).
8. C. L. Chiu, *Acta Palaeontologica Sinica* **3**, 323–326 (1955).
9. Y. P. Wang, *Wen-wu ts'an-k'ao tzu-liao* **1957**, No. 4, 22–25 (1957).
10. J. K. Woo, *Vertebrata Palasiatica* **2**, No. 4, 210 (1958): "The Ordos parietal bone has a great thickness [6.5 mm near the bregma, and 6.0 at the tuberosity], its anterior branch of the grooves for the middle meningeal vessels is smaller than the posterior branch, and its sutures are relatively simple. The bony substance of the shaft of the Ordos femur is thick and its cavity small, and the popliteal index is [63.8] relatively small. These indicate a certain degree of primitiveness. On the other hand, the sagittal arc [125 mm] and the chord/arc index [88.0] are close to modern man, so are the comparatively fine body of the femur and its low degree of forward bending. These bones are both highly fossilized, and the deposits from which they were recovered may belong to Upper Pleistocene. These bits of evidence lead to the conclusion that the Ordos Man is of a late neanderthaloid type." (My translation. Data given in brackets are inserted according to the information obtained elsewhere in the same article.)
11. K. C. Chang, *Asian Perspectives* **2**, No. 2, 41–62 (1958).
12. L. P. Chia, C. Y. Wang, C. L. Chiu, *Vertebrata Palasiatica* **4**, No. 1, 28 (1960); (see also 36–38).
13. J. K. Woo, in *Shan-hsi Hsiang-fen-hsien Ting-ts'un chiu-shih-ch'i shih-tai i-chih fa-chüen pao-kao* (Peiping, 1958), p. 18. For interested readers, some of the morphological details of the Ting-ts'un teeth are given below. *Right upper medial incisor*: On the lingual surface two prominent ridges extend upwards along the mesial and distal margins, forming a marked shovel-shaped depression in between and merging with a pronounced lingual tubercle. From the latter, two finger-like projections extend downward into the shovel-shaped depression, with the mesial projection longer than the distal. The labial surface of the root is slightly larger than the lingual, and the lateral surfaces are flat. It tapers upwards gradually, and no furrows are recognizable on any surface. Tooth dimensions: Crown height 11.6 mm, length 8.3 mm, breadth 6.4 mm; root height 11.0 mm, length 5.6 mm, breadth 5.5 mm. *Right upper lateral incisor*: Again the lingual surface is characterized by the shovel-shaped depression and undivided basal tubercle. A very shallow groove on the distal edge of the latter recalls the Ordos tooth. Dimensions: Crown height 10.6 mm, length 7.0 mm, breadth 6.0 mm; root length 4.4 mm, breadth 5.5 mm. *Right lower second molar*: The crown is 8.0 mm high, 11.2 mm long, and 10.1 mm wide, with a prominent median part of the buccal surface. It has five well-defined cusps, forming an oval-shaped occlusal surface. The protoconid is slightly longer than the metaconid; thus in its wrinkles it is farther removed from the *Dryopithecus* pattern than is *Sinanthropus*. The hypoconulid is relatively large, with a pronounced accessory (sixth) cusp on its buccal side. A small triangular fossa is present along the mesial edge of the occlusal surface between protoconid and metaconid, confined distally by a small ridge extending from metaconid to protoconid but cut off in the middle by the main mesio-distal groove. Protoconid and hypoconid are separated by an unpronounced groove.
14. L. P. Chia, *Vertebrata Palasiatica* **1**, No. 3, 247–252 (1957). Some other morphological features of these fossils are as follows: *Maxilla*: Pronouncedly orthognathous; anterior nasal spine not prominent and facing forward; anterior wall of *sinus maxillaris* extends forward beyond first premolar; rugged palatal surface; incisive foramen lies very close to alveolar margin. *Teeth*: First premolar and first molar connected with maxilla fairly worn, but still exhibit complicated wrinkles; crown of first premolar much more developed bucco-lingually than mesio-distally; buccal cusp larger and higher than lingual, and both cusps strongly incline toward each other; paracone of first molar is highest cusp, its crown broader than long and with rectangular occlusal surface; isolated lower second premolar also has rectangular occlusal surface; crown low relative to its length and breadth; slopes of both cusps covered by a number of irregular wrinkles, more distinct in buccal slope and distal part; its root very strong, and its lingual and distal sides show distinct vertical furrows and a short cleft on mesial portion near its apex. Their dimensions (in mm): First premolar crown length 7.4, breadth 10.6; first molar crown length 10.8, breadth 12.8; second premolar crown height 4.8, length 8.3, breadth 10.6, root height 20.5, length 7.2, breadth 9.8.
15. Maximum length 169.3 mm, maximum breadth 131.1 mm, with cephalic index of 77.4, circumference 473 mm, auricular height 110 mm, with height-breadth index of 84.0.
16. W. C. Pei and J. K. Woo, *Tzu-yang Palaeolithic Man* (Science Press, Peiping, 1957). On pp. 48–49 they state: "The supra-orbital ridges are very prominent. The position of the bregma lies posterior to 1/3 of the whole median sagittal arc of the skull. The frontal and parietal bones are flatter. The squamous, tympanic and mastoid parts of the temporal are thicker, the temporal squama is smaller, the basal part of the zygomatic process of the temporal is more slanting in upward and posterior direction than those of modern man. The mastoid portion is well-developed, the mastoid process and the supra-mastoid crest are massive. The middle part and asterion region of the lambdoid suture is simpler. There exists a fairly well-developed median sagittal crest. The mandibular fossa is deeper and the articular tubercle is also more developed than those of modern man. The junction of the temporal surface and the infratemporal surface of the great wing of sphenoid is marked only by a linear infratemporal crest. The occipital plane of the occipital squama is thick and rough. The length of its median sagittal arc is shorter than that of the nuchal plane, while in modern man, on the contrary, the former is longer than the latter. In the inner surface of the occipital bone, the occipital cerebral fossae in Tzu-yang man, contrary to those of modern man, are larger and deeper than the cerebellar fossae. The frontal crest on the inner surface of the frontal bone starts at the same level as the nasion, that is, lower than that of modern man. The lacrimal fossa is shallower and wider than that of modern man. The prenasal fossae are very large and deep. There is no marked canine fossa. The upper dental arch is U-shaped. Both incisive and palatine foremina are large" (Woo's own translation which accompanies the Chinese text).
17. ———, *ibid.* On p. 49 Woo states that the Tzu-yang skull "bears some resemblances to the Upper Cave Man such as the large and deep prenasal fossae, the sagittal crest-like elevation and the flattening of the upper parietal area on either side of the sagittal suture, the relatively high and narrow nose,

etc., on the one hand, and with the *Sinanthropus* such as the sagittal crest, the torus angularis, the flat orbital roof, the well-developed articular tubercle, the absence of post-glenoid process, etc., on the other" (Woo's own translation which accompanies the Chinese text).
18. W. C. Pei, *Acta Paleontologica Sinica* **4**, No. 4, 477–489 (1956); *Vertebrata Palasiatica* **1**, No. 2, 65–70 (1957).
19. ———, and Y. H. Li, *Vertebrata Palasiatica* **2**, No. 4, 193–197 (1958).
20. ———, *ibid.*, p. 199. (The material I quote is the translation by Pei and Li.)
21. J. K. Woo, *ibid.* **3**, No. 3, 109–110 (1959).
22. ———, *ibid.* pp. 115–116. The following are some of the morphological details of Liu-chiang Man. *Cranium*: 189.3 mm long, 142.2 mm wide, with cephalic index of 75.1, and basion-bregma height of 134.8 mm. Angle between the lines joining nasion and right and left fronto-malare orbitale points is 143.5°, a figure intermediate between the modern Mongoloid (145 to 149°) and the Australo-Negroid (140 to 142°) ranges according to Roginsky and Levin as quoted by Woo. The Simotic index is 28.3, falling within the range for modern Australo-Negroid races (20 to 45). But, as among modern Mongoloids, the nasal bones are flat at the root and broad, with a low ridge and a predominantly concave nasal profile and lacking any depression at nasion. The prenasal fossae are shallow and the malar bones fairly large and protruding. The upper lateral incisors exhibit clear shovel-shaped characters. *Femur*: The right femur has a platymeric index of 73.7 (average for Neanderthals, 75.6; that for modern Northern Chinese, 80.2, as quoted by Woo), and the left femur has an index of robusticity of 36.4 in transverse diameters and one of 38.2 in sagittal diameters (being between the same indices for *Sinanthropus* —32.9 and 37.6—and the Upper Cave average —46.9 and 47.0).
23. Kwangtung Provincial Museum, *Paleovertebrata et Paleoanthropol.* **1**, No. 2, 94 (1959).
24. J. K. Woo and J. T. Peng, *Vertebrata Palasiatica* **3**, No. 4, 175–182 (1959). A few important measurements of the Ma-pa skull are: Thickness of the parietal at bregma is 7 mm; it has a frontal chord/arc index of 86.3, a parietal chord/arc index of 93.9, and an occipital chord/arc index of 79.9. On the cerebral surface of the parietal, imprints of the meningeal vessels show that the posterior branch is, as in the Ordos parietal, more developed than the anterior.
25. H. L. Movius, Jr., *Papers of the Peabody Museum*, Harvard University, 19 (1944).
26. ———, *Trans. Am. Phil. Soc.* **38**, 345–348 (1948).
27. See L. P. Chia, *Vertebrata Palasiatica* **3**, No. 1, 41 (1959).
28. Also found at Nan-kou-ling in Ch'ih-ch'eng, northern Hopei, in association with *Siphneus epitingi*, *Rhinoceros mercki*, and *Equus sanmeniensis*. L. P. Chia and J. C. Chai, *ibid.* **1**, No. 1, 47–51 (1957).
29. L. P. Chia, *ibid.* **3**, No. 1, 41 (1959).
30. H. D. Kahlke and C. K. Hu, *ibid.* **1**, No. 4 (1957).
31. W. P. Huang, *ibid.* **4**, No. 1, 45–46 (1960).
32. B. Kurtén, *Am. Museum Novitates* **No. 1764** (1956); *Quarternaria* **4**, 69–81 (1957); *J. Paleontol.* **31**, 215–227 (1957).
33. ———, *Vertebrata Palasiatica* **3**, No. 4, 173–175 (1959).
34. T. Y. Wang, C. L. Chiu, C. C. Pi, *Paleovertebrata et Paleoanthropologia* **1**, No. 2, 88–91 (1959); L. P. Chia, *K'ao-ku* **1959**, No. 1, 18–20 (1959); C. L. Chiu, *Vertebrata Palasiatica* **2**, No. 4, 281–287 (1958).
35. L. P. Chia and T. Y. Wang, *K'ao-ku-t'ung-hsün* **1957**, No. 5, 12–18 (1957).
36. W. C. Pei *et al.*, *Shan-hsi Hsiang-fen-hsien Ting-ts'un chiu-shih-ch'i shih-tai i-chih fa-chüeh pao-kao* (Peiping, 1958).
37. L. P. Chia, in *Chung-kuo jen-lei hua-shih ti fa-hsien yü yen-chiu* (Peiping 1955).
38. H. L. Movius, Jr., *Quarternaria* **3**, 13 (1956).
39. W. C. Pei *et al.*, *Vertebrata Palasiatica* **2**, No. 4, 213–225 (1958).
40. S. S. Chang, *ibid.* **3**, 47–56 (1959).
41. P. Teilhard de Chardin and C. C. Young, *Bull. Geol. Soc. China* **14**, 161–178 (1935).
42. M. N. Bien, *ibid.* **20**, 179–204 (1940). A Lower Pleistocene dating of this assemblage has been confirmed by new materials collected recently [W. C. Pei, *Vertebrata Palasiatica* **1961**, No. 1, 16–30 (1961)].
43. G. H. R. von Koenigswald, *Anthropol. Papers, Am. Museum Nat. Hist.* **43**, 301–309 (1952). The diagnostic forms of this fauna are: *Pongo* cf. *satyrus*, *Ailuropoda*, *Megatapirus*, *Rhinoceros sinensis*, *Stegodon orientalis*, *Arctonyx*, *Hystrix*, *Rhizomys*, *Paguma*, *Rusa*. Von Koenigswald also includes *Gigantopithecus* and the so-called *Sinanthropus officinalis*.
44. M. C. Chow, *Vertebrata Palasiatica* **1**, No. 1, 57 (1957); W. C. Pei, *ibid.*, p. 16 (1957).
45. W. C. Pei, *ibid.* **4**, No. 1, 41 (1960). A more detailed analysis of this problem is in H. D. Kahlke, *ibid.* **1961**, No. 2, 83–108 (1961).
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Historical Structure of Scientific Discovery

To the historian discovery is seldom a unit event attributable to some particular man, time, and place.

Thomas S. Kuhn

My object in this article is to isolate and illuminate one small part of what I take to be a continuing historiographic revolution in the study of science (*1*). The structure of scientific discovery is my particular topic, and I can best approach it by pointing out that the subject itself may well seem extraordinarily odd. Both scientists and, until quite recently, historians have ordinarily viewed discovery as the sort of event which, though it may have preconditions and surely has consequences, is itself without internal structure. Rather than being seen as a complex development extended both in space and time, discovering something has usually seemed to be a unitary event, one which, like seeing something, happens to an individual at a specifiable time and place.

This view of the nature of discovery has, I suspect, deep roots in the nature of the scientific community. One of the few historical elements recurrent in the textbooks from which the prospective scientist learns his field is the attribution of particular natural phenomena to the historical personages who first discovered them. As a result of this and other aspects of their training, discovery becomes for many scientists an important goal. To make a discovery is to achieve one of the closest approximations to a property right that the scientific career affords. Professional prestige is often closely associated with these acquisitions (*2*). Small wonder, then, that acrimonious disputes about priority and independence in discovery have often marred the normally placid tenor of scientific communication. Even less wonder that many historians of science have seen the individual discovery as an appropriate unit with which to measure scientific progress and have devoted much time and skill

The author is professor of the history of science, University of California, Berkeley. This article is based on a paper presented at a joint session of the American Historical Association and the History of Science Society, held 29 December 1961, in Washington, D.C.