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 uncovered near 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 Sjarasso-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 Gigantohippus 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 Gigantehippus (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 Ktotsang 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 Ktotsang cave in July 1959 by the staff of the Institute of Vertebrate Paleontology and Palaeoanthropology (IVPP), Peiping. In general, this specimen resembles the Sinanthropus mandibles described by Weidenreich (5).

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

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Fig. 1. China, showing old paleolithic and paleoanthropological 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, Youfangtou; 12, Wupao; 13, Ch'ing-yang; 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-tsu'en; 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 resewed deposits in the Sjaras-osoo-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 Sjaras奥斯oo-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 Orod 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 variously 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, par-

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 Orod 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).
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-loa 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, Mammmontes, 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 abscesses 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-shu-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)]
ologists 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, Liu-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 *Alitheropoda*, *Hystric*, *Rhinozeros*, *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, *Alitheropoda*. 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 *Alithero-

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<td>Pithecanthropus (I, 2)</td>
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*Fig. 4. Midsagittal 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 (Chü-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, Aliuro-poda, 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 at about 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 mid-sagittal 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 Paleanthropic 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 penepalins; 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,

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Fig. 5. Three mandibles of Gigantopithecus blacki (⅜ inch equals 1 centimeter). [After Pei and Li, Vertebrata Palasiatica 4, No. 4, plate III (1958)]

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

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, Eguus, Bos, Paracamelus, 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, Spiorcerus, Rhinoceros merckii, 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 "elctonian" 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 Khotseutang 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
been reported from these sites, and the stone implements are essentially Chou-
kontienian (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 re-

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 Pleisto-
cene, is a gravel bed (the Basal Gravel)
forming the Chingshui Erosion stage which marks the end of the
of the Reddish Clay. From this
layer, scattered findings of stone imple-
ments, mostly in derived condition,
were made before the war in the Ordos
and eastern Kansu. During the last
decade, a series of industrial assem-
blages have been brought to light from
this stratum in Chiao-ch’eng, Ting-
t’s’un, and other localities in Shansi,
and, as mentioned above, from the
Locality 100 at Ting-t’s’un three human
teeth have been recovered (35, 36).
The Choukoutienian industrial traditio-
ns are repeated here in the Ting-
t’s’un assemblage, which, however, bear
a number of significant innovations
serving to place the Ting-t’s’un com-
plex 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 im-

plements, and an overall improvement
of flaking techniques. Other novel traits
also appeared at Ting-t’s’un, such as
the picklike heavy pointed implements,
stone balls, and polygonal disks. It can
be demonstrated that the mature Mous-
terian flaking technique and the manu-
facture of blades of the Ordosian be-
gan to emerge in the Ting-t’s’un com-
plex (11). Woo’s study of the Ting-
t’s’un teeth serves to suggest that Ting-
t’s’un Man was physically more ad-
vanced than Sinanthropus.

The dating of the Ting-t’s’un com-
plex, 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-t’s’un finds in the lacustrine-riber-
ne facies of the Loess stage, contem-
porary with the fossilerous beds at
Sjara-osso-gol (36). This revision ap-
ppears very curious indeed. It is con-
sidered 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 pre-
vailing wind from the northwest. Some
of the regional facies, such as Sjara-
osso-gol and Chao-t’s’un in Hopei (39),
feature a humid environment, to be
sure, but none of them are characterized
by having a warm climate. As in-
dicated by the remains of warm cli-
mate species of Lamprotula, such
southern species of fish as Mylopharyn-
godon piceus, and Elephas namadicus,
the fossilerous beds at Ting-t’s’un were

apparently deposited under a relatively
warm as well as humid climate. Fur-
thermore, several mammals typical of
the Villafranchian and Reddish Clay
stages are represented in the Ting-t’s’un
fauna, such as Palaeoloxodon toku-
nagai, Rhinoceros mercki, Rhinoceros
ichorhinus, and Pseudaxis grayi, which
were rare or absent in the loess stage.
The Ting-t’s’un industry is, as just men-
tioned, definitely less advanced than
the flake and blade industry of the
Ordosian. Unless and until the Loess
stage can be shown to contain a con-
siderable early interstadial into which
the Ting-t’s’un assemblages might more
conceivably be placed, one finds the
Chingshui Erosion stage dating the
most plausible.

Cultural assemblages that can defi-

nitely be dated to the Loess stage
have been widely uncovered from Shanshi and the Ordos during the last
decade (9, 40). These are generally characterized by points and scrapers on “Mous-
terian” 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 Pan-
chiao Erosion stage which brought about
a climatic amelioration, a forested and
swampy environment, a mesolithic in-
dustry, and Homo sapiens in North
China.

South China. Despite well-grounded
high expectations, South China claimed,
prior to the period under review, merely
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 Quaternary 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 Quaternary 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).
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 Sjaras-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 Ordoses in the Paleanthropic 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 recognizably 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

<table>
<thead>
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<th>Possible correlation with the Himalayan glacial sequence</th>
<th>North China</th>
<th>South China</th>
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<tbody>
<tr>
<td>4th Glacial</td>
<td>Ordoses (&quot;Neanderthaloid&quot;)</td>
<td>Tzu-yang and Liu-chiang (Homo sapiens)</td>
</tr>
<tr>
<td>Upper Pleistocene</td>
<td></td>
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<tr>
<td>3rd Inter-Glacial</td>
<td>Ting-ts'un (&quot;Neanderthaloid&quot;)</td>
<td>Ch'ang-yang (?) (&quot;Neanderthaloid&quot;)</td>
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<tr>
<td>3rd Glacial</td>
<td></td>
<td></td>
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<tr>
<td>Middle Pleistocene</td>
<td>Sinanthropus pekinensis</td>
<td>&quot;Sinanthropus officinalis&quot; (?)</td>
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<tr>
<td>2nd Glacial</td>
<td></td>
<td></td>
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<tr>
<td>Lower Pleistocene</td>
<td>1st Inter-Glacial</td>
<td>Gigantopithecus blacki</td>
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<tr>
<td>1st Glacial</td>
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Fig. 10. Tentative time placement of fossil men in China.
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 the task of fossil history of man in the area of China into serious account.

References and Notes

1. Omitted from discussion are a human femur at Hsa-ts’ao-wei in Suo-hung Hsien, Anhwei province, which is like a human skull found in Yü-shu Hsien, Kirin province. Once thought to be the Pleistocene age, these have been proved to be modern; see Chiu (9). For the cultural side of the picture, see (17).


3. J. K. Woo and L. P. Chiu, in Chung-kuo genter-i hsi-shih li hsien-yü yü-echo (Sci-


7. P. Teilhard de Chardin, Early Man in China (Peiping, 1941).


10. The Osco parietal bone has a great thickness [6.5 mm near the bregma, and 6.0 mm at this region]; its anterior border 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 Osco femur is thick and its cavity small, and the popliteal index is [82]. These indicate a certain degree of primitiveness. On the other hand, the sagittal arc [253 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 facts of evidence lead to the conclusion that the Osco Man is of a late Neanderthal type.” (My translation. Data given in brackets according to the information obtained elsewhere in the same article.)


12. L. P. Chiu, C. Y. Wang, C. L. Chiu, Vertebra Palasia 4, No. 1, 28 (1960); see also (3).

13. J. K. Woo, in Shangh Hsiang-len-hsien Tsin-t’ung chiu-shih-chi shih-i li-chien Fa-chien paan-kau (Peiping, 1958), p. 18. For interested readers, some of the morphological details of the Tsin-t’ung teeth are given below. Right upper median incisor: On the lingual surface two prominent ridges extend upwards along the mesial and distal margins, forming a marked shovelled depression in between and merging with a pronounced lingual tubercle. From the latter, two finger-like projections extend downwards into the shovelled depression with the mental projection longer than the distal. The labial surface of the root is slightly larger than the lingual; the lateral surfaces are flat. It tapers upwards gradually, and no furrows are recognisable on the root. Tooth dimen-

14. L. P. Chiu, Vertebra Palasia 1, No. 3, 247-255 (1957). Some other morphological features of these fossils are as follows: Maxilla: Pronounced orthognathous; an-
terior nasal spine not prominent and facing forward; anterior wall of sinus maxillaris ext-
tends forward; both premaxilar and premaxilar; ruged palatal surface; inclusive foramen close to alveolar margin. Teeth: First premax-
olar and first molar connected with maxilla fairly narrowly, but still exhibit compounded writings, so that the first premolar much more developed buccal cusp larger and higher than lingual, and both cusp strongly inclined toward each other; paracyn of first molar is highest cusp, its crown broader than long and with rec-
tangular occlusal surface; its direction is oblique and premaxilar also has rectangular occlusal surface; its crown low and long in length and breadth; slopes of both cusp covered by a number of irregular wrinkles, more distinct in buccal slope than on lingual; it is very strong, and its lingual and distal sides show distinct vertical furrows and a median crest on mesial portion near its apex. Their dimen-
sions (in mm) are as follows: premaxilar crown length 7.4, breadth 10.6; first maxillary crown length 10.8, breadth 12.8; second premolar crown height 4.8, length 8.3, breadth 10.6; root height 20.5, breadth 7.2, height 9.8.

15. Maximum length 169.7 mm, maximum breadth 131.4 mm, with cephalic section cir-
cumference 473 mm, auricular height 111 mm, and thickness 20.3 mm.

16. W. C. Pei and J. K. Woo, Ts’u-yang Palaeo-

17. ibid. On p. 49 Woo states that the Tzu-yang Man has no skull (nor any other traces) while the Upper Cave Man has a skull. It had been deep premaxilla fossae, the sagittal crest-like elevation and the flattened mastoid process. The upper parietal area on either side of the sagittal sulcus, the relatively high and narrow nose,
Historical Structure of Scientific Discovery

To the historian of science, discovery is seldom a unit event attributable to some single mind, man, 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...