Article XIII.—CURRENT PALÆONTOLOGICAL RESEARCH IN CHINA

By J. G. Andersson

The arrival in China of the Third Asiatic Expedition of the American Museum under the leadership of Mr. Roy Chapman Andrews, a gigantic enterprise with one of its main objects the study of fossil mammals and especially the ancestry of Man, has certainly created in American scientific circles an increased interest in the palæontological possibilities of eastern Asia.

The members of the American Museum Expedition have most cordially coöperated with the staff of the Geological Survey of China by dividing up the vast field of research and establishing a system of mutual support in an endeavor to avoid duplication of work. Moreover, Mr. Granger, the chief palæontologist of the American Museum Expedition, has put his superior technique generously at our disposal, while we on our side have offered our knowledge of local conditions for the orientation of our American colleagues.

Under these circumstances it is to be expected that the interest taken in the palæontological work of the American Museum's expedition will be extended also to the palæontological research carried on by the Geological Survey of China. In this hope I have prepared, after consultation with Mr. Granger and with my colleagues in the Survey, the following brief summary of our current research in palæontology and archæology.[1]

Much of the collecting work recorded below has been carried out by aid of funds provided from my native country, Sweden, through the good offices of a research committee headed by His Royal Highness, The Crown Prince of Sweden. According to the agreement made between Chinese and Swedish scientific authorities, the collections will be divided between the Geological Survey of China and Swedish museums.

The Swedish scientists, principally Professor Th. G. Halle of the State Museum in Stockholm and Professor C. Wiman of the University of Upsala, who have taken in hand the preparation and description of these collections, have agreed to have all the palæontological monographs prepared by them and their associates published in the Palæontologia

[1]I am much indebted to Dr. Grabau for important contributions to the section on invertebrate fossil research.

Sinica, a series of publications organized by the Director of the Geological Survey of China, Dr. V. K. Ting, and intended to include as far as possible descriptions and figures of all the fossils of China.

All invertebrate fossils from Palæozoic and Mesozoic formations are in totality handed to the Geological Survey to be described by the palæontologist of the Survey, Dr. A. W. Grabau.

In like manner all the human skeletal remains unearthed in our archæological excavations will remain in China, and the material already brought together has been taken over by Dr. Davidson Black, of the Peking Union Medical College, for description and publication in the Palæontologia Sinica.

Fossil Invertebrates

From a practical point of view, especially in stratigraphic investigations, the marine invertebrate fossils stand foremost in importance. It has been the good fortune of the Survey to secure the coöperation of one of the most eminent workers in the field of Palæozoic invertebrates, Dr. A. W. Grabau, formerly Professor of Palæontology at Columbia University, and since 1920 Palæontologist to the Geological Survey of China and Professor of Palæontology in Peking National University.

Dr. Grabau's long experience in Palæozoic invertebrate palæontology, coupled with his phenomenal capacity for work, has already resulted in the production of a number of monographs on different groups of Palæozoic fossils which will appear in the near future in the Palæontologia Sinica. It is to be expected that Dr. Grabau himself will put before American scientists a much more authoritative summary of his work. The following notes may be sufficient for the present purpose.

The first considerable collections of invertebrate fossils brought together by the Geological Survey were collected by the Director, Dr. V. K. Ting, during his travels in Yunnan in 1914–15. They comprise Cambrian, Silurian, Devonian, Carboniferous and early Mesozoic forms. The Cambrian fossils have been studied and determined by Dr. C. D. Walcott, and on some of the others Dr. Grabau has begun work.

On the progress of invertebrate palæontological research Dr. Grabau has kindly contributed the following statement:

> Before the arrival of Dr. Grabau there was no palæontologist at the Geological Survey, therefore the invertebrate fossils collected by the members of the Geological Survey in various parts of the country were sent to Illinois to be studied by a member of the Geological Survey of China under the guidance of Professor Savage. Un-

fortunately, this member became interested in economic geology and the collections were only very imperfectly studied. Recently this material is being sent back to China to be worked out by Dr. Grabau.

Extensive collections of invertebrate fossils have recently been made by Mr. E. Norin and Mr. C. C. Wang in connection with their study of the later Palæozoic formations of Shansi province; others have been brought in from these series by Dr. Andersson's private collectors. These fossils were obtained from a series of intercalated marine limestones in the continental coal-bearing formations and, as the position of these beds has been accurately ascertained in the measured sections, we will soon be able to develop a standard or type section for the later Palæozoic formations of North China.

Until recently very little had been known of the fauna of the thick Ordovician limestone of northern China. Frech had described the *Actinoceras* collected by von Richthofen, and Lorenz had specifically identified three species from Shantung. The material collected by Blackwelder was so imperfect that Weller could only make generic determinations. Recent collections in this formation have materially increased our knowledge of this fauna and, in the monograph on the 'Ordovician Fossils of North China' (Pal. Sinica, Sec. B, I, fascicle 1, 1922) just published, it is described at length by Dr. Grabau. There are now known from this formation 31 genera and 45 species, all except five of these being new.

A large collection of well-preserved fossils from the Ordovician of the Yangtze region has been sent to the survey by H. B. M. Consul, J. Langford Smith of Ichang. This contains a number of new species and the fauna will be described during the coming year.

It has been found desirable to make a comprehensive study of the Palæozoic corals of China with a revision of families and genera of Palæozoic corals in general, so far as accumulated material permits. Considerable progress has been made in this work, and the first fascicle of the monograph with one plate and 74 text figures is now in press (Pal. Sinica, Sec. B, II, fascicle 1). A second fascicle is far advanced.

Dr. Grabau is now at work on the description of the Devonian fossils of Yunnan collected by Dr. V. K. Ting and this will appear as fascicle 2 of Vol. I, Series B of the Palæontologia Sinica.

Of considerable interest is the discovery of a fairly complete though small specimen of *Eurypterus* in the coal measures of the Kaiping basin. This occurrence is in black shales, associated with plant remains, above a thin argillite with marine fossils of Lower Permian age. This is the

first *Eurypterus* found in China. A carapace of a new species of *Pterygotus(?)* has also been obtained from the coal series of Honan by Prof. J. S. Li.

Fossil Plants

Nearly every province of China is rich in coal deposits ranging in age from Palæozoic to early Tertiary. Several small collections from these formations were described by Schenk in Richthofen's monumental work 'China,' but thus far our knowledge of the fossil floras of China has remained exceedingly imperfect.

Just as Dr. Ting's collections of invertebrate fossils from Yunnan mark the beginning of research in that field by the National Geological Survey, so the plant fossils brought by him from the same region constitute the first collection of that kind made by the Survey. They represent several widely different geological horizons, and among them several specimens of Devonian plants are of especial interest.[1]

In 1916–17, Dr. Th. G. Halle, at that time assistant to Professor A. G. Nathorst but later the successor of this eminent phyto-palæontologist as keeper of the Department of Fossil Plants in the Swedish State Museum, traveled extensively in China for the purpose of collecting material from the fossil floras.

After Dr. Halle's return to Sweden we have continued to collect material for him and his associates who are now working on a number of monographs to be published in the Palæontologia Sinica.

By far the most interesting among the plant-bearing beds of China is the Permo-Carboniferous coal series. A facies of this series, well known through Schenk's researches, is the Kaiping flora of northeast Chihli, a flora of normal Palæozoic type.

Richthofen found another singular Palæozoic association of plants in Honan, the *Gigantopteris* flora, which has later been made known from Yunnan, Fukien, Manchuria and Korea by the work of French geologists, by Dr. Ting's collections, and by an important paper on this flora by Yabe.[2]

A most interesting development in our knowledge of this remarkable flora began in 1919 when one of my private Chinese collectors found in central Shansi a deposit containing numerous unusually well-preserved species belonging to the *Gigantopteris* flora.

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[1] A description of these collections prepared by Dr. Halle will soon appear in Dr. Ting's work on his research in Yunnan.

[2] Yabe. 'Geological and Geographical Distribution of *Gigantopteris*.' Science Reports of the Tohoku Imperial University. Second series, IV, No. 2.

A young Swedish geologist, Mr. E. Norin, invited to China by Professor E. T. Nyström of Taiyuanfu University, undertook at my suggestion a detailed survey of the whole younger Palæozoic series of Central Shansi. His research has given results beyond our expectations by revealing a succession of different floras in the lower part of the series interbedded with marine horizons abounding in fosssils, of which preliminary determinations have been made by Dr. Grabau. A paper by Mr. Norin including lists of these species will appear in an early number of the Bulletin of the Survey and will explain the sequence of these floras and their relations to marine horizons.

Similar stratigraphic researches coupled with extensive collecting of plants and marine fossils have been undertaken by C. C. Wang of The Geological Survey in northern Shansi and by Professor J. S. Li of Peking National University in northern Honan.

Large collections of the *Gigantopteris* flora as well as of marine fossils, in the provinces of Fukien and Kiangsi, have been made by Mr. J. T. Wang of the Geological Survey together with my collector, Chen.

The Mesozoic floras of different provinces have also yielded a considerable harvest, among which the extensive material of the Jurassic of northern China stands next in importance.

In northern China, Fengtien, Chihli, and Shansi, plant-bearing beds of early Tertiary age have been found, these being associated with and for the most part interbedded between basalt beds. The flora of Fushun in Fengtien is the most important of these deposits, and it has been described in the Palæontologia Sinica by Dr. Florin of the Stockholm Museum.[1] The principal species of this flora are enumerated in the table on the Cenozoic deposits which is appended to this paper.

Fossil Vertebrates

Apart from the early notes by Owen, Lydekker, and Gaudry, the fossil mammals of China have been described by Koken (Richthofen's collections) and above all by Schlosser in his work 'Die fossilen Säugethiere Chinas.'[2]

Schlosser's material was bought in Chinese medicine shops and was consequently very fragmentary, consisting mostly of isolated teeth only. Moreover, the localities were mostly unknown or in other cases were wrongly recorded. When these deficiencies, unavoidable at that time, are taken into consideration, it must be admitted that Schlosser's work

[1]Florin. 'Zur alttertiären Flora der Südlichen Mandschurei.' Palæontologia Sinica, Ser. A, I, Fasc. 1.

[2]Abhandl. des K. bayer. Akademie des Wiss., II Cl., XXII Bd., München, 1903.

is a masterly treatise on the subject. The immense progress which was made by him is shown by the fact that he recorded not less than 85 species of fossil mammals.

My own researches on the mammal deposits of China were begun in 1917 in coöperation with the Geological Survey and have been almost exclusively confined to northern China and a small area in Inner Mongolia.

As a result of this work we have not only brought together extensive collections of many mammal species, represented often by complete skulls and occasionally even by more or less complete skeletons, but we have also discovered a considerable number of vertebrate deposits representing a sequence of Cenozoic strata hitherto largely unknown in China.

The successive Tertiary and Pleistocene zones thus far recognized are shown in the accompanying table, and it will suffice to add some notes referring to the occurrence and distribution of these deposits.

Fossiliferous Eocene beds were first found by me in 1916 at Yüan Chü city, southeast Shansi, close to the Yellow River. I at first mistook these beds for deposits of early Pleistocene age, but the identification by Dr. N. Hj. Odhner, of the Stockholm Museum, of the mollusks found in them with species characteristic of the Eocene of France and western Germany proved the true age of these beds. Consequently, to Dr. Odhner is due the credit of having first recognized the occurrence of Eocene in China.[1]

The Eocene series of Yüan Chü Hsien consists of conglomerates, red and variegated clays, white sand, and thin beds of greenish-blue marly limestone, and attains a thickness of more than 1,000 meters. It forms a sunken area ("Graven") bounded by hills of Proterozoic and Palæozoic rocks.

Most of the mammal remains noted in the stratigraphic table were found by me on a second visit in May 1921 and were identified by Mr. Granger. The additional highly interesting discovery of the rhinocerid *Amynodon* was made in December 1921 by my palæontological collaborator, Dr. Otto Zdansky, Associate Palæontologist of the Geological Survey, who also has identified the reptiles from the Eocene beds as well as many mammals from the younger deposits. I take this opportunity to express to Mr. Granger and to Dr. Zdansky my sincere thanks for their most welcome help.

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[1]N. Hj. Odhner. 'Lacustrine Mollusca from Eocene deposits in China.' Bulletin of the Geological Survey of China, No. 4.

In the preceding section of this paper, while speaking of the fossil plants, I have already mentioned plant-bearing beds connected with basalts which have been referred by Florin to the Oligocene. No vertebrate remains have thus far been discovered in this section of the Cenozoic sequence.

The *Hipparion* clays of northern China are the richest deposits of fossil mammals so far known in this country. Until recently the mode of occurrence of the *Hipparion* fauna has been enveloped in a veil of mystery. From the study of his "medicine-bones" Schlosser recognized a very rich association of species accompanying *Hipparion*, but the geological records, such as Richthofen's and Bailey Willis' monographic works, give no information as to the deposits containing this abundant and remarkable fauna. On the other hand, the source of the "medicine bones" could be traced only with much difficulty as they had passed through so many hands that the origin had been nearly lost sight of.

However, we succeeded in locating some typical *Hipparion* localities in Honan and Shansi, and through this it became evident that the earlier explorers, such as Richthofen and Bailey Willis, had not distinguished the Pliocene clays from the Pleistocene loess, but included nearly all kinds of Cenozoic deposits under the latter name. Loczy alone made a proper distinction between the Pliocene clays and the overlying loess.

Only a small part of the rich *Hipparion* fauna has thus far been identified and could be mentioned in the stratigraphic table. A large number, including some very remarkable types, will be described in due course in the Palæontologia Sinica.

In August 1921 a mammal deposit was discovered at Chou K'ou Tien, about 45 km. southwest of Peking, on the occasion of a joint excursion undertaken by Mr. Granger, Dr. Zdansky, and myself. This was a cave deposit in the Ordovician limestone, and was subsequently excavated by Dr. Zdansky, who has communicated the preliminary list of the fossils given in the table. An article describing this deposit, tentatively considered to be Upper Pliocene, has been prepared by Dr. Zdansky and will appear soon in the Bulletin of the Geological Survey.

In 1918 Dr. V. K. Ting, the Director of the Geological Survey, discovered near the San Men rapids in the Yellow River, on the Shansi-Honan border a series of stratified sands and gravels below the loess, which were characterized by the frequent occurrence of very large freshwater mussels which belong, according to determinations of Dr. Wm. H. Dall in Washington, to the genera *Quadrula* and *Cuneopsis*. Similar

deposits were found by myself in other localities along the Yellow River. They contain, besides the mussels, some few and fragmentary mammal bones, which have thus far not been identified.

No deposit of China is more famous, singular and apt to challenge the explanatory efforts of the geologist than the North China loess, the Huang T'u of the Chinese language. Many interpretations of this peculiar and widely distributed soil have been given by different scientists but none seems better to correspond to all its topographic, geological and physical properties than the wind-drift theory first advocated by Richthofen. Nevertheless, our recent fossil finds in the loess have brought into the discussion arguments of a very conflicting nature.

Fossils are always very rare and mostly isolated in the loess. One of the most common is the egg of a big ostrich, first described by Brandt from S. Russia under the name *Struthiolithus chersonensis.* This bird might very likely have been a steppe form and thus would fit in well with the eolian theory.

Another rather common fossil of the loess is an *Elephas* which has been identified by Dr. Zdansky as probably *E. namadicus.* If this identification is confirmed when the material is definitely worked out, it will be a remarkable fact, for we would hardly expect to find in a steppe, or rather a semi-desert deposit such as was postulated by Richthofen, an elephant species which was originally described from the ancient alluvium of the Narbada valley in India.

There are other discoveries in the loess pointing to much more aquatic conditions than would be allowed by the eolian theory, as for instance the presence of a beaver and of a turtle.

It must be specially emphasized that these discoveries all refer to the genuine unstratified loess. There are also more recent beds of redeposited loess, more or less abundantly interstratified with gravel and in its present condition representing more truly a fluviatile deposit. In such redeposited loess in northernmost Chihli there has been found a very large bighorn sheep (first identified by Mr. Roy Chapman Andrews) and a deer.

In Inner Mongolia we have carried on the collecting of fossil vertebrates only in a very small area, about 130 km. north of Kalgan. The most interesting find is a deposit of sand containing a microfrauna, *Lagomys, Talpa, Lepus, Dipus, Castor,* amphibians, fishes and very numerous fresh-water mollusks together with some bigger forms such as *Cervavus,* a rhinocerid and fragments of big bird eggshells suggesting *Struthiolithus.*

The deposit is of singular interest because of the strongly aquatic character of the fauna (*Castor*, frogs, fishes and several species of fresh-water shells) all of which indicate a climate widely different from that of the present day.

Early Man

Very little systematic work has thus far been carried on in China for the study of prehistoric man and consequently our knowledge of this field is very deficient.

In Schlosser's collection there was a tooth of an anthropoid mammal, possibly an early type of man, and the Japanese palæontologist Matsumoto has described from Honan a fossil human sacrum which, according to his opinion, shows a striking similarity to the sacrum of the *Homo neanderthalensis* of Western Europe.[1]

In our research we have never come across any undisputed proof of Palæolithic Man. Northernmost Chihli has furnished a big "laurel-leaf" shaped instrument of the type which, among European archæologists, is considered to be characteristic of the Solutrean stage. But it appears that the type has survived in the Neolithic period, and such an isolated find, at the very best, can be taken only as an encouragement for further research in the same area.

Even the Neolithic has thus far yielded no undisputed traces in China. We have recently found and excavated extensive deposits of a Neolithic type. They have never yielded any metal objects but numerous artifacts of stone, bone, deer antlers, pig tusks, etc., as well as potsherds in great abundance. In most respects it is a true Neolithic furniture, but the pottery looks too rich and varied to make such a great age probable and there are many vessels which seem to have been turned upon the potter's wheel. There are also fragments of a fine polychrome ware strongly suggesting the polychrome pottery collected by Pumpelly in his oldest culture, Anau I, in Russian Turkestan. When all these facts are taken into consideration I would prefer tentatively to place this culture in the transition period to the early metal ages.

Some of the ceramic forms show striking affinity to pottery and bronzes of early Chinese history, especially the Chou Dynasty. There is consequently little doubt that we are dealing here with an early Chinese culture.

Detailed descriptions of these sites and their furniture will appear soon in the Palæontologia Sinica.

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[1]Matsumoto, 1915, 'On some fossil Mammals from Honan, China.' Reports of the Tohoku Imperial University, Geology, III, No. 1.

Pleistocene	*Upper*	REDEPOSITED LOESS and gravel in N. Chihli with *Ovis, Cervus, Bos.*	
	Middle	PRIMARY LOESS (Largely eolian) with *Struthiolithus chersonensis* and *Elephas cfr. namadicus.*	
	Lower	SAN-MEN SERIES: Fluviatile gravel, sand and clay in the Yellow River valley, with fragmentary mammal remains and freshwater bivalves: *Quadrula cfr. spurius, Qu. cfr. affinis, Cuneopsis cfr. capitatus.*	
Pliocene	*Upper*	CAVE-DEPOSIT OF CHOU-K'OU-TIEN, CHIHLI: *Ursus, Hyæna, Machairodus,* Rhinocerid, *Equus, Sus,* Cervid, Bovine and other *Artiodactyla, Talpa,* Rodents (2 sp.), Bird.	
Miocene	*Lower Pliocene or Upper Miocene*	HIPPARION CLAYS of Shansi, Honan, Shensi and Kansu; red and variegated clays with lime carbonate concretions and gravel beds: *Cynoephalus?, Machairodus, Ictitherium?, Hyæna, Mastodon, Elephas, Aceratherium, Hipparion richthofeni, Sus* (2 sp.), *Tragocerus, Cervavus, Giraffine, Struthio.*	
Oligocene	*Fushun Series*	COAL BEARING SERIES OF FU-SHUN and Shih-Men-Chai in Fengtien province: tuffaceous sandstone, conglomerate and shale (740 m.) with thick coal seams: *Osmunda lignitum. Sequoia langsdorfi, Glyptostrobus europaeus, Populus glandulifera, Alnus kefersteini, Dryophyllum dewalqui, Fugus feroniae, Zelkova ungert,* etc. SOFT SHALE OF HAN-JO-PA in southern-most Chahar with *Pinus, Comptonia anderssoni, Carpinus?, Phyllites.* SANDSTONE, SHALE, CLAY AND COAL AT SHANG-YANG-KOU, Fan-Chih-Hsien, Shansi, with undetermined plant-fossils.	The plantbearing deposits of Fengtien, Chahar and Shansi, here described, all occur in connection with basalt beds and may be approximately contemporaneous.
Eocene	*Yüan-Chu Series*	CONGLOMERATES, RED AND VARIEGATED CLAYS, WHITE SAND AND GREENISH BLUE MARLY LIMESTONES with *Chara,* Ostracoda, *Planorbis pseudammonius, Pl. sparnacensis, Pl. chertieri, Physa cfr. lamberti, Euchilus deschensianum, Ceratodes sinensis, Eupera sinensis.* Also numerous but fragmentary vertebrate remains; *Teleostei, Chelonia (Trionyx), Crocodilia* and some few Mammals (*Amynodon,* Rodent, Lemuroid or Insectivore).	

Provisional List of the Hipparion Fauna (Lower Pliocene) of North China

Prepared by Dr. O. Zdansky

ANTHROPOIDEA
- *Cynocephalus*, 2 species

PERISSODACTYLA
- *Hipparion richthofeni* Schl.
- *Teleoceras*, 4 species
- *Aceratherium*
- *Sinotherium lagrelii* Ringström[1]
- *Anchitherium*

ARTIODACTYLA
- Cervidæ of different size
- Many antelopes
- *Chilinotherium tingii* Wiman[2]
- *Sus*, 2 species

CARNIVORA
- *Hyæna*
- Viverridæ, several species
- Felidæ
- *Machairodus*
- ?*Arctocyon* or *Hyænarctos*
- Mustelidæ, 2 species

PROBOSCIDEA
- *Mastodon*
- *Stegodon*
- *Elephas*

RODENTIA
- Castorid
- Rodent of squirrel size

AVES
- Struthionid

REPTILIAN
- Emydid
- Testudinid

[1] A new type of Rhinoterotidæ. For type description, see: T. J. Ringström, '*Sinotherium lagrelii*, a new fossil rhinocerotid from Shansi, China.' Bull. Geol. Survey, No. 5.

[2] A new member of the Giraffidæ.

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New taxonomic names are printed in **heavy-faced type**, also the main reference in a series of references.

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