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ANCIENT FAUNA OF MONGOLIA DISCOVERED BY THE THIRD ASIATIC EXPEDITION OF THE AMERICAN MUSEUM OF NATURAL HISTORY[1]

IT is a very significant fact in the history of palaeontology that the homeland, or chief center of evolution or adaptive radiation, of the mammals during the Age of Mammals and of the reptiles during the Age of Reptiles is the very last to be explored. Beginning with the first palaeontological work toward the close of the eighteenth century in Europe, continuing with the thorough exploration of Europe and southern Asia during the nineteenth century and with the wonderful discoveries in reptilian and mammalian history in North and South America from the middle of the nineteenth century onward, the homeland was still left untouched, unexplored. Discoveries in North America were so extensive and so revolutionary that many thought the homeland had been revealed in our great western fossil beds. Positive claims were advanced by Ameghino for Patagonia as the homeland of proboscidea and primates. As a residuum of these discoveries in the western hemisphere, it proves true that several orders of mammals did originate in the Americas, but the ancestral stock from which these orders radiated was still to be found. Speculation wavered between the northern hemisphere and the southern hemisphere and some zoologists advocated both hemispheres in so-called bipolar theories. Thus sprang up two new branches of science—Paleogeography and Paleometeorology—centering in more or less inductive and deductive schools of thought.

In 1889 the New York Academy of Sciences adopted a new rule, namely, that its presidency should be held not for long terms but for two-year terms, and a new condition of the presidency was the preparation of a serious presi-

[1] Address to the New York Academy of Sciences at a special meeting May 21, 1923.

dential address. In accepting this responsibility and honor the writer took the task very seriously, retired to the most secluded spot in the American Museum, namely, the sixth floor of the southeast tower, and, aided by his colleague, William K. Gregory, began to attack the problem of the homeland of the mammals. The results of two very hard years' work were delivered in the two successive winters of 1899 and 1900 and published by the academy in 1900.[2] In these addresses the succession of mammalian life in western Europe as studied by Charles Depéret was for the first time compared step by step with the succession of mammalian life as known in North America. Parallels previously drawn, especially those of Edward D. Cope, were pointed out; others were added. It was found that there was remarkably close resemblance between the life history of Europe and that of the Rocky Mountain region; there are some interludes of separation, but in the main there are longer periods of affinity. Consequently we confirmed Joel A. Allen's generalization that Sclater's division of the northern hemisphere into Palaearctica and Nearctica should be united into a single holarctic province and proved that Holarctica extended back as far as the Lower Eocene period of the Age of Mammals.

Two other generalizations followed: first, that Africa must have been an important and independent center of mammalian evolution during the whole period of the Age of Mammals; second, that in Africa there probably originated four great orders of mammals, namely, the Proboscidea, the Hyracoidea, the Sirenia and the ancient whales, Archaoceti. Of these, traces of Sirenia and the ancient whales had already been found. Two years later this generalization was confirmed by the discovery of Beadnell and Andrews in northern Egypt of the ancestors of Proboscidea and of the Hyracoidea, namely, primitive mastodons and primitive coneys.

The third generalization was of even a more sweeping character and had been adumbrated more or less clearly by many zoologists and palaeontologists from the time of Buffon; it was that the chief homeland of the mammals was not in Africa nor in southern Asia nor in Europe nor in either of the Americas, but in the unexplored regions of the roof of the world, namely, of the central plateaus north of the Himalayas. These third and fourth generalizations are expressed in the paleozoologic map. A similar theory was subsequently advocated by J. L. Wortman and was set forth with very great fullness by William D. Matthew in his well known paper published by the academy.

How far this succession of addresses and papers fired the imagination of Roy Chapman Andrews we do not know, but it may be clearly stated that the chief object of the Third Asiatic Expedition was the exploration of the unknown roof of the world. The results have far surpassed our fondest hopes. Far more than a new chapter—a new *volume*—has been opened up in the history of the earth. Central Mongolia proves to be the homeland not only of the *Mammalia* but of the *Reptilia* as well; a single year's work (1922) demonstrates this, and the present season of 1923 will confirm and extend it and will, we hope, reveal the mammals of the basal Eocene and upper Cretaceous, as yet undiscovered. Roy Chapman Andrews, leader of the expedition, was prepared for his very responsible task by several preceding years of exploration in China. The territory he explored in 1922 had been crossed by Raphael Pumpelly in 1862-65; by Richthofen in 1877, who named these Tertiaries the Khan-Khai beds; by Obrutchev in 1892-94, who applied the name "Gobi Series" to the tertiary sediments; and by Chernov in 1908.

As developed in China, the underlying series of rocks, from the Jurassic downwards, had been described by von Richthofen and later by Bailey Willis in his researches in China of

[2] 1900.182. The Geological and Faunal Relations of Europe and America during the tertiary period and the theory of the successive invasions of an African fauna. *Science*, N.S., Vol. xi, No. 276, Apr. 13, pp. 561-574.

1900.187. Correlation between tertiary mammal horizons of Europe and America. An introduction to the more exact investigation of tertiary zoogeography. Preliminary study with third trial sheet. . . . Presidential address before N. Y. Academy Sci. delivered February 26, 1900. With a list of the author's scientific publications, 1878-1899, appended by direction of the Council of the Academy. *Ann. N. Y. Acad. Sci.*, Vol. xiii, No. 1, July 21, 1900, pp. 1-72.

1907. Our geologic party found a great unconformity separating the folded sediments of Jurassic and earlier time from all of the desert basin sediments; after the Jurassic period the marine sediments of the roof of the world ceased. Above the Jurassic and also above the Great Unconformity, sediments are entirely epicontinental—*this Cretaceous-Tertiary continent constituted the homeland of the chief orders of reptiles and mammals!*

The series underlying the Great Unconformity from the Archean to the Jurassic had been recognized by Willis in China, and that pioneer work was of great help to the geologists of the expedition. The Nan-K'ou Series of China seems to be continuous across Mongolia. A great bathylith was found by our party invading these older metamorphic rocks and extensively exposed by erosion. It is on this complex erosion floor that all of the later Cretaceous-Tertiary strata were laid down, some of which were again swept away by the Post-Jurassic interval. The Later Mesozoic and Cenozoic sediments of Mongolia lie upon the peneplaned surface of this complex of old deformed rocks with its Great Bathylithic Invasion. This is a wide contrast to conditions in the Rocky Mountain Plateau region of America, where marine sedimentation continues to the very close of the Cretaceous and the Tertiary sediments overlie either the Cretaceous or the Jurassic. Above the great Post-Jurassic unconformity ten new formations were discovered by our expedition and more or less clearly distinguished from each other by their vertebrate remains, according to the field determinations by Granger and Berkey. Four of these are in the Cretaceous, two at the confines of the Eocene and Oligocene, three in the Miocene, one in the Pliocene.

The only precedent to the magnitude and novelty of this reconnaissance in the geologic history of the arid regions of the world is to be found in the early surveys of our own western territories by Hayden as geologist-in-chief, Holmes as topographer and Leidy as vertebrate paleontologist.

SUMMARY OF FOURTEEN NEW FOSSIL-BEARING FORMATIONS DISCOVERED

Zones.

1. Pleistocene. An erosion epoch.
2. Pliocene. Cervus (Elaphus?) zone. Determined August 27, 1922.
2. Miocene. Not yet defined by determination of fossils.
2. Middle Miocene, Houldjin, Hsanda Gol, *Baluchitherium* zone, in two localities, *B. grangeri.* April 30, August 5, 1922.
1. Upper Eocene, Irdin Manha. *Protitanotherium zone. P. mongoliense,* April 27, 1922.=Uinta Beds of Utah.
1. Lower Eocene. Fossils not identified. September 14, 1922.
1. Upper Cretaceous. Iren Dabasu dinosaur beds.=?Ceratops, or Triceratops Beds of Montana. April 25, 1922.
2. Lower Cretaceous, Dja-doch-ta. Protoceratops zone. Ancestors of the Ceratopsia. September 2, 1922. No equivalent in N. America or Europe.
1. Jurassic. Plant remains.
1. Permian. Marine invertebrate remains. September 7, 1922.

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14 new life zones.

The geologic personnel of the expedition included Charles P. Berkey as chief geologist; Frederick K. Morris as geologist and topographer; Walter Granger as vertebrate palaeontologist. The entire personnel under Leader Andrews included a party of twenty-five—eight Americans, eight Chinese, nine Mongolians. By means of a train of seventy-five camels and two freight and three light automobiles, a three thousand mile reconnaissance was made between April 18 and September 20, 1922, when the party returned to Peking. The work was greatly aided by the Geological Survey of China, now under the management of Dr. V. K. Ting, honorary director, and Dr. W. H. Wong, acting director, with headquarters in Peking. On reaching the confines of Mongolia Berkey and Morris began a systematic and continuous route map and geologic cross section, which was carried throughout the whole itinerary. These studies early in the work determine the major structural and formational units and locate the major unconformities and other physical changes. The great Post-Jurassic unconformity, the Pre-Jurassic unconformity, the lesser Post-Cretaceous unconformity and the

Great Bathylithic Invasion were one after the other definitely distinguished.

The itinerary of the geologic party and series of discoveries are briefly stated by Professor Berkey as follows:

Left Kalgan April 21. Went into camp at Iren Dabasu after finding rhinoceros jaw evening of April 24. First dinosaur bones found at Iren Dabasu morning of April 25 by Berkey before breakfast. Camp was divided April 25, leaving the geologic group, Morris, Granger and Berkey, at Iren Dabasu, giving special attention to the collecting of fossils. First finds of Titanotheres and other early Tertiary fossils by Granger at Irdin Manha April 27. Additional finds made at Irdin Manha by the geologic group May 2. First Baluchitherium bones found at Houldjin in the vicinity of Iren Dabasu, April 30, by Berkey. Geologic group stayed at Iren Dabasu until May 7. Basin later referred to as Tsagan Nor Basin was entered first at Mt. Uskuk June 21 by the whole party. First exploratory trip to Loh June 22 by the group, with recovery of a few fragments of bones. Discovery of dinosaur bones and fossil insects and fossil fish June 25 in the Ondai Sair locality by Berkey and Morris. Three great collections of Later Tertiary fossils judged to be of Miocene age made by Granger at Loh in the Hsanda Gol formation June 27-August 3. Discovery of Baluchitherium skull at Loh August 4 or 5 by Granger and Wong. Discovery of stag, mastodon, etc., judged to be of Pliocene age in the Hung Kureh district July 27 by Berkey. Whole group made collections later. Left the Tsagan Nor Basin August 13. Discovery of dinosaurs in the Ashile District by Granger August 20-27. Side trip to the Gurban Saikhan across a new basin by Morris and Berkey August 19-27. Discovery of Protoceratops by Shackelford at Dja-doch-ta September 2. Additional collections by the whole party. Discovery of Paleozoic strata with Permian fossils September 7 in the Sair Usu district by Berkey and Morris. Discovery of Ardyn Obo fossil-bearing beds September 10. Collections by the whole party. Discovery of Eocene forms in the sedimentary beds of Shara Murun by Granger and Andrews September 14. Discovery of fragments of bone in the sediments at the edge of the Mongolian plateau above Kalgan by Berkey September 19.

The first fossils brought back by Mr. Shackelford, photographer of the expedition, included the three great discoveries of the season, namely, (1) a superb *Baluchitherium* skull found east of the Altai Mountains, which is now being fully described by the writer; (2) a complete skull of *Protoceratops,* a pre-dentate dinosaur, ancestral to the giant Ceratopsia, just described by William K. Gregory; (3) jaw of *Protitanotherium,* which will shortly be described by the writer in *American Museum Novitates.* The main shipment of the Mongolian collection has just reached the American Museum and includes all the fossils collected on this very rapid reconnaissance. During the present season the same beds are being visited by a strong collecting party and already reports of additional discoveries of importance are reaching the museum.

HENRY FAIRFIELD OSBORN

SOME EXPERIMENTAL STUDIES ON THE CENTRAL NERVOUS SYSTEM[1]

ONE of the great contributions of the last century to the field of biological science was the application of experimental methods to the study of development, and the factors underlying the production of individual structure. Though many of the fundamental facts of embryology were known, the complexity of the factors which operate during the process of development was so great that further progress could be accomplished only by segregating or isolating certain structural units and by changing intrinsic and extrinsic relations to so modify the conditions of development that some tentative answers could be made to the question of causation in development.

One of the interesting problems in nervous embryology has been: What makes neuroblasts differentiate into neurones? and as a corollary to that, Why do neurones, whose cell bodies lie in a certain region, grow over a definite pathway and establish connections with another group of neurones so that they may become part of a complex chain of nervous units?

By experimental methods, Dr. Harrison has shown clearly that neuroblasts will develop into neurones when isolated from many of the normal environmental factors. Primitive nervous tissue from the central nervous system of the

[1] A paper read before the Tri-State Medical Society in New Haven, April 19, 1923.