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by

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ABSTRACT

Most of the fossil sites of Tertiary land mammals are in the Asian U. S. S. R.; the author briefly discusses their correlation with other Asian sites beyond the Soviet border. West European localities are not considered because they are better known and because they are not as closely related to those in the Soviet Union as are the Asian localities. In the Paleogene, the southern part of the Russian platform was occupied by a branch of the North European sea. Few mammal remains are known from this age in the U. S. S. R. During the Neogene the North European sea ceased to exist, and the land of the Russian platform was connected with Asia. Almost all the land mammal localities of the U. S. S. R. date from this time. An almost continuous land area existed in the Mediterranean region in late Tertiary time. The most extensive continental Tertiary deposits in the U. S. S. R. are in its Asiatic part. These are of two types: thin deposits of sands, sandstone, and claystone in the West Siberian Plain, the Turgai Plain, and Turkmenia; and thick alluvial, deltaic, and lacustrine in the Caucasus and the mountain provinces of Central Asia and Kazakhstan. After a discussion based largely on the work of Matthew and Granger, the authors conclude that the Oligocene fauna of Asia is more closely related to North America than to Europe. The next younger assemblage is the Betpak-Dala fauna of southern Kazakhstan, which Borisiak places at the Oligocene-Miocene boundary. It includes a chalicothere, *Phyllotillon betpakdalensis* (Plerow); a small rhinoceros similar to *Rhinoceros tagicus* Rom. of western Europe; *Hemioneryx* and other anthracotheres; small Artiodactyla; *Amphicyon*, sabre-toothed cats and other Carnivora; turtles, and plant remains. Borisiak feels that the oldest faunas of the Siwalik Hills have common features with the Betpak-Dala. The lower Miocene fauna has more of a European aspect than the earlier faunas; giant rhinoceros and associated small mammals have disappeared, and are supplanted by large Proboscidea, represented by true mastodons. There remains a long-legged rhinoceros (from the *Aceratherium lemanense* Pomel group), along with short-legged *Teleoceras*. Only two major middle Miocene localities are reported. One, in the northern part of the Turgai steppe, contains many more or less intact skeletons: *Aceratherium depereti* Boris., *Brachypotherium aurelianense* var. *gailiti* Boris., *Trilophodon* (*Serridentinus*?) *inopinatus* Boris. et Bel., and *Mastodon atavus* Boris. Most forms are related to the fauna of the European Miocene but are of primitive aspect. The other locality in the North Caucasus apparently contains two horizons, represented respectively by *Anchitherium aurelianense* Cuvier and a more advanced form, *Paranchitherium karpinskii* Boris. The rest of Borisiak's faunal survey deals with the *Hipparion* fauna, which is represented by many rich localities in both European and Asian U. S. S. R. One of the largest localities in the world is the Pavlodar site on the Irtysh River in Kazakhstan. Borisiak believes that *Hipparion* is older in Eurasia than in North America. Tertiary stratigraphic studies in Europe are compared with those in America. Borisiak concludes that American workers determine faunal ages as younger than do the Europeans, and cites as an example the work of the Gobi expeditions. --F. C. Whitmore, Jr.

\* \* \*

The author's purpose is to present a brief summary of information on fossil sites of Tertiary land mammals in the U. S. S. R. Inasmuch

as most of these sites, with some of the most interesting among them, are located in the Asian U. S. S. R., our own sites are correlated with other Asian sites, beyond the Soviet border. The west-European sites are not considered because they are better known than the Asian (it is hardly necessary to encumber this exposition with well-known data); moreover, they are not as closely related to ours as are the Asian sites.

<sup>1</sup>Translated from *Obzor mestonakhozheniy Tretichnykh nazemnykh mlekopitayushchykh SSSR: in Mestonakhozheniya Tretichnykh nazemnykh mlekopitayushchykh na Territorii SSSR, Trudy Paleontologicheskogo Instituta*, v. 15, no. 8, 1948, p. 5-37.

<sup>2</sup>Originally published in 1943 as 25th Soviet Paleontology Edition, *Acad. Sci., U. S. S. R.* Republished, with corrections, as part 1 of the above cited 2-part monograph. Part 2 is a catalog of 148 tertiary fossil mammal sites in the U. S. S. R. compiled by E. I. Beliaeva. A review of the complete monograph by Frank C. Whitmore, Jr., appeared in *International Geology Review*, v. 4, no. 7, July 1962.

kind of material to constitute a basis for a history of faunas. This survey, presenting material extant, may serve only as a stimulus to the next stage of study - that of the history of individual groups and the history of successive faunas.

This survey has been written on the basis of a complete list of Soviet sites of Tertiary land mammals and of the forms described from them, by Ye. I. Belyayeva. A complete list of references is appended to the Ye. I. Belyayeva catalogue of sites. Literature on Asian sites outside the U. S. S. R., mentioned in text, is given in footnotes.

Tertiary deposits are widely developed throughout the U. S. S. R. but are far from being well-known, everywhere. The stratigraphy of Tertiary marine deposits in the south of the Russian Platform, and often their facial composition and paleogeography, are known in considerable detail. This is not true for Tertiary marine deposits of the Asian U. S. S. R. The age and geologic history of continental Tertiary deposits are known only in isolated instances where they yielded organic remains, the most important among which belong to mammals.

Fossil sites of mammals are associated largely with continental deposits, although a number of them have been discovered in marine deposits, as well; these latter sites are of interest because they provide means of checking the correlation by marine and continental faunas. However, there are instances when a coincidence of marine and land fossil animals is not conducive to an unequivocal solution of stratigraphic problems (as witness the correlation of Soviet and West European deposits) because of the peculiarity of local Tertiary faunas.

Where there are no organic remains - especially those of vertebrates - it is often impossible to determine whether a given section is Tertiary, at all. This is why Tertiary marine basins can be delineated with a fair degree of certainty while there are no maps showing the distribution of the entire continental-marine Tertiary complex.

With these reservations, we can proceed with a summary of our knowledge and outline briefly the Tertiary history of the Soviet Union, as follows.

In the first half of the Tertiary (Paleogene), the south of the Russian Platform was occupied by a basin representing a branch of the North European sea (of the same age) which formed a number of more or less isolated basins: the Anglo-Paris, North German, and other smaller ones. This sea invaded our land subsequent to an Upper Cretaceous sea, although not immediately but after some interval; it engulfed the basins of the lower Dnepr, Don, middle and

lower Volga, and extended farther east, to the Turanian plain, where it joined a basin on the east slope of the Uralian plain which appears to have persisted there since the Cretaceous. Deposits of this Lower Tertiary sea are represented largely by unconsolidated arenaceous and argillaceous rocks. Only in their lower part do the sands alternate with hard sandstones; they are followed by claystones, softer marls, and more sands. These deposits carry a meager marine fauna, locally with plant remains; no land vertebrates have been found, as yet.

A narrow strip of dry land separated the south Russian Lower Tertiary sea from the Mediterranean basin to the south, with its rich southern fauna. This Lower Tertiary Mediterranean basin embraced the south of Europe, the Crimea, the Caucasus, and extended east as far as the Aral Sea and Ferghana. Its sediments have not yielded any remains of land mammals, either.

The dry land which separated the two basins - like the land to the north of them, within the Russian plain and in north Asia, on either side of the Uralian Lower Tertiary sea - naturally did not remain uninhabited; nor is there any reason to believe that it remained free of sediments. Just the same, we know of hardly any mammal remains of that period; moreover, we often cannot ascertain the presence of any contemporaneous sediments.

The North European sea ceased to exist in the Upper Tertiary, in the south of the Russian Platform and east of the Urals; the land of the Russian Platform was connected at that time with an Asian land. In the south, this land continued to be washed by the Mediterranean basin whose complex Upper Tertiary history is best known from the U. S. S. R. This history is interesting both faunally and paleogeographically. Its latter aspect is especially important in the history of faunas of the adjacent lands.

Almost all of our known land mammal sites are Upper Tertiary. Some of them are associated with the above-named basin: marine (or brackish water) deposits not only present the best burial sites but the most enduring ones, as well, while continental deposits are largely less consolidated, and more readily eroded (or destroyed by glaciers, in the north).

In the second half of the Tertiary, the Mediterranean basin gradually shrank and was broken up into isolated basins of various sizes, mostly abnormally saline: from brackish to super-saline. This is especially well exposed in the east of the Mediterranean, i. e. within our boundaries, where the Mediterranean deposits are relatively undisturbed. Without going into the details, we only note that changes in the configurations of individual basins, the variations in their salinity, etc., determined

the evolution of their respective faunas, different in different basins, as if proceeding in spurts, with temporary returns to a more abundant normal marine fauna. Such changes are typical for the so-called Euxinian faunas (semi-marine) which replaced in the Sarmatian and Meorian (second half of the Miocene) typical Mediterranean faunas (first half of the Miocene). In the Pliocene, the Euxinian faunas gave place to a Caspian type fauna, characteristic of the fresher water basins. In Western Europe, this latter fauna existed as early as the Upper Miocene; it migrated to the South Russian basin only in the Pliocene. At the close of that period, the basin was broken up into three: the Dacian, which rapidly became fresh-water; the Euxinian, which gave birth to the present day Black Sea; and the Caspian (Caspian Sea).

The history and configurations of these basins, following each other, first reconstructed by Andrusov, are now known in more detail, from new material<sup>3</sup> collected from the present land area. However, the basic Andrusov outline, cited above, remains valid. To be sure, the boundaries of these consecutive basins within the present Black and Caspian seas are drawn tentatively and not always with consideration given to data supplied by land faunas (vertebrate). A comparison of the maps of these basins leads to the following conclusions: first, their maximum spread was in a Middle Sarmatian time; after a brief shrinking, the basin expanded in the Pontian, only to shrink again to its present areas (locally, to less than that); second, they were almost continuously, with a few exceptions (such as in the Upper Sarmatian), connected with West European basins - a momentous circumstance in interpreting the spreading of land faunas.

Data on continental deposits are as scarce as they are for the Paleogene. Wherever there is a reason to assume a Tertiary age for deposits, they are represented by areno-argillaceous marsh to lacustrine-marsh formations. The corresponding deposits have an enormous development in the West Siberian plain, the Turkmenia, where they are partly Upper Oligo-

cene but largely Miocene and Pliocene. . . are thin and consist of sands, sandstones, and claystones.<sup>4</sup>

"Rocks of this type are quite different in the Caucasus and in the mountain provinces of Central Asia and Kazakhstan. Accumulated here along the periphery of newly-formed mountain ranges and intermontane troughs are thick proluvial, deltaic, and lacustrine deposits consisting, along with areno-argillaceous rocks, of prominent conglomerates; deposits of assorted salts often occur among these rocks."<sup>5</sup>

Such is, in most general features, the development of Tertiary deposits in the Soviet Union. With this background in mind, we now turn to fossil sites of land mammals, related to it.

The oldest known mammal sites are Upper (possibly Middle) Oligocene.<sup>6</sup> The probability of finding older faunas, especially in the Asian U. S. S. R., is fairly good, considering that continental deposits in neighboring Mongolia have yielded, besides the Eocene (Arshanto, etc.) and Paleocene (Gashato) faunas, also older Upper Cretaceous mammals. This probability is enhanced by the fact that, beginning with the Oligocene, faunas of both countries have much in common, up to being identical, as well as by the findings of continental floras (Jurassic, Cretaceous, Paleocene) in Kazakhstan and the east slope of the Urals. Finally, a number of considerations suggest that the development centers for the oldest Tertiary and pre-Tertiary mammals were indeed located in northern Eurasian regions. On the other hand, the fact that large areas of Soviet Asia were occupied by a Paleogene sea militates against the finding of older faunas in its southern provinces. Another unfavorable circumstance is the poor exposure of the Kazakh steppe in West Siberia. This most ancient of our mammal faunas is associated with the Turgai steppe continental section.

In Central Asia, marine deposits<sup>7</sup> culminate in a giant formation of green to raspberry-col-

<sup>3</sup>A.D. Arkhangel'skiy, et al. A Brief Outline of Geologic Structure and History of the U.S.S.R. With an Atlas, Paleogeographic Maps. AN SSSR, Moscow, 1937; V.P. Kolesnikov, B.P. Zhizhchenko, and A.G. Eberzin, Neogene. Stratigraphy of the U.S.S.R., vol. XII, Moscow, 1940.

<sup>4</sup>In recent years, stratigraphy of continental deposits in the Central Asian part of the Soviet Union has become better known because of the works of Petrushevskiy, Mordvilka, Zaitsev, and others. A.B.

<sup>5</sup>Arkhangel'skiy, loc. cit., pp.275-276. Vol. XII, Stratigraphy of the U.S.S.R., mentioned in footnote 3, does not deal with continental deposits.

<sup>6</sup>Vertebrate remains found in Eastern Kazakhstan (Lake Zaysan) - vertebra of a representative of family Titanotheriidae - along river Dzheman Gor in the Manrak range, and remains of mammals and turtles in the Saur and Manrak foothills (station Dzha'il'ma) - appear to belong to a fauna older than the *Indricotherium*.

<sup>7</sup>See O. Vyalov, DAN, 1935, II, no. 3-5; T. Mordvilko, Pr. S.G., 1936, No.12, p.1057; N. Zaytsev, Izv. AN SSSR. ser. geol., 1939, No.3, p.63 ff.

ored claystones with a Lower Oligocene marine fauna. They are followed by a thick red arenogillaceous sequence, locally with lignite intercalations and gypsiferous. It is widely distributed, presenting different facies in different regions, which suggests different sedimentary conditions (fresh-water?) of the basin, or - more precisely - basins. This sequence, named the Balattam (also known as the Massaget stage), is still Paleogene; the Sazanbay continental deposits overlying it carry a Lower Miocene mammal fauna.

Our oldest known sites of mammal faunas are associated with the lower part of the Balattam section (Indricotherium beds).

The bone bed exposures have been reported from only a few localities, as yet: along river Kara-Turgai (station Alua), where they are associated with greenish-gray clays also carrying carbonized tree trunks and *Unio* shells and overlain by white sands with ferruginous sandstones; also on river Sary-su where its section has not been described; and finally in the north shore of Lake Chelkar-Teniz. The latter locality has been excavated for many years, so that the site and the section are among the best known.<sup>8</sup> Finally, meager remains of the Indricotherium fauna were found at the Askazan-Sor Lake, in the Golodnaya Steppe, in beds underlying a gravel bed with Chalicotheria (see p. 17, Russian edition).

The steep bank of the Nura at Chelkar-Terviz Lake has marine Paleogene claystones at its base, overlain by the arenogillaceous Balattam sequence. The latter is usually washed out at the Nura slopes and its good exposures are to be looked for in younger ravines crossing the Nura. Large landslides may push the continental formation far forward; thus the earliest excavations were done in one such landslide, pushed a full kilometer away from the Nura slope and into the Biskenta springs area.

Freshly exposed sections of the Balattam sequence present the following picture: barren sands on top, with intercalations of platy ferruginous sandstones, up to 10 m thick. They are separated by a sharp break (hiatus) from the underlying greenish-gray clays, up to 3 m thick; associated with it are layers with shells of *Bythinia*, *Cyclas*, *Planorbis*, and *Unio* (extremely poorly preserved), and bone beds. Present in the clays are pockets of gypsum, layers of spherulitic nodules; ferruginous sandstone, locally cross-bedded; and plant remains. At times there is more than one bond bed, with different faunas: some with remains of turtles and fishes, other with remains of land mammals.

The clays change downward to light-colored sands, cross-bedded, barren of fossils, of variable thickness (locally up to 15 m), resting on eroded dark-gray clays with a rich marine fauna (Lower Oligocene). The site itself presents a strongly elongated lens, traceable in the banks of the two adjacent ravines, with the maximum bone accumulation along its axis, with the skeletons of various animals occurring together; however, the bones of each individual are more or less confined to one spot. This site cannot be regarded as rich, and the number of bones rapidly declines toward its edges.

The fauna collected here is fairly diversified, with rhinoceros predominant: large bones of *Indricotherium asiaticum* Boris. and less conspicuous remains of smaller primitive rhinoceri *Allacerops (Epiaceratherium) turgaicum* Boris.; also the lower jaw of a small rhinoceros, possibly *Diceratherium*. Of particular interest are several smaller forms, among them *Colodon orientalis* Boris., an American form; a very early representative of chalicotheria, *Schizotherium turgaicum* Boris.; also present are *Anthracootherium* teeth (*Nemimerx turgaicus* Boris.) and rodent remains (*Cricetops affinis* Arg., *Tsagonomys* sp., etc.). This site is far from being exhausted; its Indricotherium fauna is probably much richer than given above.

Sites along rivers Kara-Turgai, Sary-Su, and east of Lake Chelkar-Teniz, in Atam-Bas-Chinka and Donguz-Tau, as well as at the northeastern terminal of the Kara-Tau range and the Turgai Mountain, have not been searched; their yield of the Indricotherium fauna is too small to pause for.

A site somewhat younger than the above-mentioned Turgai, but still Oligocene, and with a very similar fauna, is located at the Aral Sea shore, near station Saksaul'sk, at a fishing village of Agyspe (Perovsk Bay).

Here, the coastal cliffs are capped by thick (up to 5 m) white limestones with *Corbula helmersoni* Mikh., dense, stratified, with intercalations of platy marl and greenish claystone (up to 0.2 m). The limestones are underlain by greenish to brown claystone, up to 1 m thick, with small marly concretions. Associated with this claystone are the main stores of bones which also occur in the lower part of the overlying limestones. Below that, there is gray-green lumpy claystone, up to 2 m thick, with numerous disjointed remains of small mammals and birds. This claystone is underlain by light gray barren marl (2 m), followed downward by arenaceous rocks<sup>9</sup> in which no organic remains have been found.

<sup>9</sup> Probably the "Turgai stage" of N.S. Zaytsev's section (loc. cit., pp. 78-79); the overlying green claystones with *Corbula helmersoni* Mikh. present a more complex interval than given by Zaytsev.

Processed from the Aral fauna have been remains of a new representative of Indricotheriidae, more specialized than the earlier described, and designated as a new genus, *Aralotherium*. The *Corbula helmersoni* Mikh. limestones have been assigned to the uppermost Oligocene beds, so that clays with the *Aralotherium* remains can be regarded as Upper Oligocene.

The *Aralotherium* burial conditions are reminiscent of those for Indricotherium beds: the intact skeletons are lacking, although their component bones occur sufficiently close together to make it possible to reassemble more or less complete skeletons.

The *Aralotherium* fauna occurs in marine beds, so that we know nothing of the physico-geographic conditions of the land washed by the Upper Oligocene sea. Only the *Aralotherium* specialization trend, different from that for Indricotherium (limb structure) suggests a softer and perhaps marshy soil of its habitat.

Occurring in the above-mentioned underlying green-gray lumpy clay, conspicuous for its quite peculiar facies of small vertebrates, are small shells of fresh-water mollusks (*Planorbis*, *Limnaeus*), denizens of marshes and lakes. Identified among the vertebrates are rhinoceri

*Aralotherium prohorovi* Boris., *Aceratherium aralense* Boris.; rodents: *Paleocastor* sp., *Steneofiber* sp., *Schaubeumys aralensis* Arg., *Sch. woodi* Arg., *Aralomys gigas* Arg., *Eumysodon spurius* Atg., *E. orlovi* Arg., *Agispelagus simplex* Arg., *Protalactaga borissiakii* Arg., etc.; small ruminants: *Prodremotherium*, *Lophiomeryx*, *Miomeryx*; insectivore, *Palaeoscapto acridens* Matth.; and carnivores from family *Felidae*.

The significance of these sites is best appreciated through a knowledge of contemporaneous faunas from adjacent regions. Faunas of an approximately same age were discovered in Mongolia by the well-known 1922-1930 American expedition. They were encountered in several sites now assigned by the Americans to the Lower and Middle Oligocene,<sup>10</sup> largely from morphological features of their animals and partly from the relationship of their enclosing beds.

Assigned to the Lower Oligocene is the Ardyn-Obo site fauna represented by pockets of bones apparently accumulated at the bottom of an ancient stream and now occurring in gray to yellow sands in the middle of the section, between arenaceous claystones above and cross-bedded sands and gravels below.<sup>11</sup> The roster of this fauna is fairly long,<sup>12</sup> including two

<sup>10</sup> These faunas first believed to be Miocene; in like manner, in a number of other instances, the American paleontologists sought to assign a younger age to faunas discovered, than their true age; more on this on p. 62, Russian edition.

<sup>11</sup> Nat. Hist. of Central Asia, vol. II, Geology of Mongolia, 1927, p. 177-363.

<sup>12</sup> Present here, according to the American paleontologists (W.D. Matthew and W. Granger, New Creodont and Rodents from the Ardyn Obo formation of Mongolia. Am. M.N., No. 193, 1925; and New Ungulates from the Ardyn Obo formation Mongolia, loc. cit., No. 195, 1925), is a representative of *Hyaenodontidae*, among *Creodontia*: *Hyaenodon eminus* Mat. et Grang., similar to *Hyaenodon minor* Gerv. described by Deperet from Euzetles-Bains (from a group of this genus, unknown in North America). A representative of family *Oxyaenidae*, *Ardynictis furunculus* Matth. et Grang., a transition from typical Eocene *Oxyaenidae* to *Didymoconus*; its chewing apparatus is adapted to a diet of thin-shelled mollusks and large insects. Possibly present is a representative of genus *Cynodontis*, from *Canidae*.

Rodents are represented by three forms: two species of a new genus *Ardynomys* (from *Ischyromyidae*), *A. olseni* Matth. et Grang., and *A. chini* Matth. et Grang., constituting an advanced group of Upper Oligocene *Palaeocastor*, and a species of a *Desmatolagus robustus* Matth. et Grang., from *Ochotonidae*.

Of the *Ungulata*, a fragment of skull with the horn suggests the presence of *Amblypoda*.

Most conspicuous among the *Perissodactyla* is the presence of large *Titanotheria*, (*H.F. Osborn*, Upper Eocene and Lower Oligocene *Titanotheres* of Mongolia. Am. M.N., No. 202, 1925); a brachycephalic *Brontops gobiensis* Osb. (representing the same stage as *Br. brachycephalus* Osb. from the Lower Oligocene of Dakota) and a dolichocephalic *Menodus mongoliensis* Osb. (the *Menodus giganteus* stage, from the same locality). Also present are (Am. M. N. No. 195, 1925; see also "Cadurotherium ardynense, Oligocene, Mongolia." Am. M.N., No. 147, 1924) a large water rhinoceros (*Amyndontidae*), *Cadurotherium ardynense* Osb., with a strongly foreshortened cranium, and large upper and lower tusks; and a small rhinoceros *Ardynia precox* Matth. et Grang., with *Hyracodon* characteristics (close to *Prohyracodon* Koch).

Also present are forms quite close to, if not identical with, those described from the Indricotherium beds, namely *Schizotherium avitum* Matth. et Grang., with only the lower molar M<sub>3</sub> and a fragment of the lower jaw preserved; they cannot be directly compared with remains of *Sch. turgaicum* Boris. because the latter lack the M<sub>3</sub>; in any event, they are "very closely related" (see W. Matthew and W. Granger, The Fauna of the Ardyn Obo Formation. 1923. Am. M.N., No. 98, p. 4).

Present along with *Sch. avitum* is another, and smaller form - *Sch. sp.* Two representatives of *Colodon*: *C. inceptus* Matth. et Grang., somewhat more primitive than *C. occidentalis* Leidy from *Oreodon* beds of North America, and *Paracolodon curtus* Matth. et Grang.

A large number of *Artiodactyla* jaw fragments and skeleton bones belong to *Hypertragulidae*, namely *Lophiomeryx angarae* Matth. et Grang., similar to *Lophiomeryx* from phosphorites of Europe, a very primitive form; also *L. gobiae* Matth. et Grang., also similar to forms from the *Miomeryx altaicus* Matth. et Grang. phosphorites.

Finally, it appears that some poorly preserved teeth should be assigned to *Anthracootheriidae*.

<sup>8</sup> M.V. Bayarunas, Contribution to Geology of the Turgai Region. Tr. PIN, V, 1936, p. 243.

quite similar to those described from the Indricotherium beds (*Schizotherium* and *Colodon*).

Most representatives of this, the most ancient Oligocene fauna of Mongolia, have an American aspect; on the other hand, the American paleontologists emphasize the presence in it of elements affiliating it with the contemporaneous European fauna (from phosphorites).

The largest representatives of the Ulan Gochu red clay fauna are the peculiar Titanotheria which form their Asian branch, not observed in North America; according to the American paleontologists, they probably migrated into Mongolia from the north. These are Embolotheriidae (*Embolotherium grangeri* Osb. et al),<sup>13</sup> represented by rich material suggesting a number of stages passed through by this Titanotheria group; in Asia, it represents the last stage (dying out). Occurring together with Titanotheria are lophodonts, rhinoceri, artiodactyls, carnivora, rodents, etc., suggesting a Lower or Middle Oligocene age for the Ulan Gochu beds. Indeed, going downward, these red clays change to light-colored Shara Muron clays and sands (Eocene).<sup>14</sup>

The next three faunas are characterized by the presence of gigantic *Baluchitherium*. We shall consider these forms in somewhat more detail and in the order given by Osborn in the

above-cited article, based on the fact that representatives of *Baluchitherium* show in these faunas a different degree of differentiation.

The Houldjin site is a gravel bed resting on an eroded surface of older rocks (Eocene claystones?). Preserved now are but remnants of that bed, much more extensive, before. Occurring among well-rounded pebbles of hard rocks are no less well-rounded bone fragments, teeth of mammals, and armor of large turtles. Standing out from these meager remains is a well-preserved cranium of *Hypercoryphodon thomsoni* Osb. et Granger, the latest representative of amblypods.<sup>15</sup>

The Hsanda Gol fauna is richer, although it, too, is associated with pebble beds. Here, the pebble beds, conglomerates, and sandstones alternate with basalts and possibly form a large alluvial fan. Desert forms predominate in the Hsanda Gol fauna, although woody plants are present, as well.<sup>16</sup>

In the opinion of American paleontologists, most of these forms represent the Oligocene and even an early Oligocene stage of their development (Lower or Middle Oligocene).

A younger age (according to Osborn, see above) should be ascribed to the Baron Sog fauna from gray claystones and cross-bedded thin

<sup>13</sup>H.F. Osborn, *Embolotherium* gen. nov. of the Ulan Gochu Mongolia. Am. M.N., No. 353, 1929.

<sup>14</sup>C.P. Berkey, W. Granger and F. Morris. Additional new Formation in the later Sediments of Mongolia. Am. M.N., No. 385, 1929.

The Ulan Gochu fauna has not been described, as yet, with the exception of a single insectivore (*G.G. Simpson*, A new Insectivore from the Oligocene Ulan Gochu Horizon of Mongolia. Am. M.N., No. 505, 1931), belonging to a new and extinct family (*Anagalidae*) connecting *Tupaioidea* and *Lemuroidea* (origin of Primates).

<sup>15</sup>H.F. Osborn and W. Granger. Coryphodonts and Uintatheres from the Mongolian Expedition of 1930. Am. M.N., No. 522, 1932. Other forms described are (W. Matthew and W. Granger, The Fauna of the Houldjin Gravels. Am. M.N., No. 97, 1923) a well rounded lower molar of *Cadurcotherium* sp. possibly related to the Ardyn Obo form; a small rhinoceros (*Caenopus* or *Praeaceratherium*) is represented by M<sup>3</sup> similar to that of *C. occidentalis* Leidy and possibly generically close, according to the American paleontologists, to a form described as *Epiaceratherium turgaicum* Boris., from the Turgai Indricotherium beds. The third form is represented by lower molar and other teeth and small remains of the skeleton, all well rounded and tentatively assigned to *Baluchitherium*. Finally, there is a worn out M<sup>3</sup> associated first with a carnivore then to an anthracotherium, and finally designated as *Entelodon dirus* Matthew et Granger.

<sup>16</sup>Found in this site is the only known *Baluchitherium* cranium (H. Osborn, *Baluchitherium grangeri*, a Giant Hornless Rhinoceros from Mongolia. Am. M.N., No. 78, 1923). The numerous rodents (W. Matthews and W. Granger, New Bathyergidae from the Oligocene of Mongolia. Am. M.N., No. 101, 1923) are represented by crania and less commonly by other skeletal remains; described from here are 11 rodent species belonging to nine genera of groups *Simplicidentata* and *Duplicidentata*. Outstanding among them is *Tsaganomys altaicus* Mat. et Grang., the first fossil representative of family Bathyergidae (Ethiopian province). Also present are Carnivora, mostly small (W. Matthews and Granger, New Carnivora from the Tertiary of Mongolia. Am. M.N., No. 104, 1924), connecting the Hsanda Gol fauna with the phosphorite fauna of Europe and with the North American, but mostly presenting forms of its own (new genera), such as *Amphicticeps schaeckelfordi* Matth. et Grang., a highly specialized representative of *Didymoconus colgatei* M. et G., from among *Oxyaenidae*, etc.; there are several Insectivora (W. Matthew and W. Granger, New Insectivores and Ruminants from the Tertiary of Mongolia, with Remarks on the Correlation. Am. M.N., No. 105, 1924), including *Palaeosceptor acridens* M. et G. and perhaps an ancestor of *Soricidae*, as well as a primitive deer, *Eumeryx culminis* M. et G. (an intermediate form between *Leptomeryx* and *Blastomeryx*). Mention should be made of a well preserved representative of *Pelobatidae* (*G.K. Noble*, A New Spadefoot Toad from the Oligocene of Mongolia with a Summary of the evolution of *Pelobatidae*. Am. M.N., No. 132, 1924), *Macropelobates osborni* Nobl. found along with the mammals.

sands with white marly concretions, unconformably resting on the Ulan Gochu red clays; Osborn believes<sup>17</sup> that the Hsanda Gol and Houldjin faunas should be assigned to the hiatus. Present here along with *Baluchitherium*<sup>18</sup> are entelodons, lophiodons, rhinoceri, Chalicotheria, etc.<sup>19</sup>

Before turning to other contemporaneous Asian sites, mention should be made of an attempt by the American paleontologists to reconstruct the overall physico-geographical conditions of Central Asia in the Oligocene, on the basis of the fauna and the nature of sediments.<sup>20</sup>

The Lower Ardyn Obo Oligocene carries remains of turtles and a water rhinoceros, suggesting an abundance of water; the nature of sediments indicates their origin in swift currents of flood plains or alluvial fans, while the absence of sylvan forms and plant remains suggests a semi-desert climate. The Houldjin gravel and pebbles with rounded bone fragments could have been deposited under similar conditions. The Hsanda Gol deposits, on the other hand, although similar to them on the whole, carry some woody forms, petrified trunks, and streaks of coal. By and large, the three sites indicate the action of swift intermittent streams rushing down from the neighboring hills and forming extensive fans which contained, along with pebbles, fragments of mammalian skeletons; these streams descended to dry channels of intermittent rivers (with clusters of trees along their banks) which in turn flowed to shallow, also intermittent, lakes formed in hollows of broad depressions - all under the conditions of a temperate semi-desert climate.

The Ulan Gochu red clays and the Baron Sog white sands with marl intercalations were probably associated with more quiescent sedimentary conditions in those depressions. In any event, all material on hand testifies to uniform

climatic and physico-geographic conditions in Mongolia, during the entire Oligocene.

These quiescent sedimentary conditions are reflected also in the Balattam deposits of the Turgai plain with their Indricotherium fauna sites. These deposits bespeak calm waters of a large basin or a number of basins, filling up a vast depression. Although the mammal remains are mixed up, individual skeletons are not totally disjoined (*Indricotherium*, *Epiaceratherium*), with abundant plant remains in the adjacent clays. Stagnant waters with an abundant water flora (*Salvinia*, *Phragmites*) - perhaps marshy stretches - small groves of large deciduous trees of a temperate climate (*Juglans*, *Carpinus*, *Farus*, *Liquidamber*, *Taxodium*, *Sequoia*, *Populus*, *Quercus*, *Platanus*, etc.) - such was the landscape of Western Asia in the second half of the Oligocene, as against the semi-desert areas of Central Asia.

The Oligocene fauna described by the Americans from Central Mongolia was widely distributed in Central Asia. Its remains are known from the southeastern margin of Gobi (within China), the northeast of Ordos (the St. Jacques site), from its southwestern part (Choei-tong-k'eu), and in the west of the Hansu Province (Shargal-tein [Shara] Gol), on one of the south tributaries (sources) of the Tang-ho.

In the St. Jacques area, the undisturbed Oligocene clays carry cross-bedded sand streaks with remains of mammals, fishes, turtles, crocodiles, and fresh-water mollusks.<sup>21</sup> Its mammal fauna is identical with that of Hsanda Gol, not only in its content but in the state of preservation, as well.<sup>22</sup>

The same fauna, reworked in younger deposits, is known - as mentioned before - from the southeastern extremity of Ordos<sup>23</sup> and from the west of Hansu.<sup>24</sup> Present in Ordos is an ex-

<sup>17</sup>H. F. Osborn, loc. cit. Am. M.N. No. 353, 1929.

<sup>18</sup>A study of this form (W. Granger and W. Gregory, Further Notes on Gigantic Extinct Rhinoceros, *Baluchitherium* from the Oligocene of Mongolia. Bull. Am. M.N.H., vol. 72, 1936, pp. 1-73) has not corroborated the Osborn assumption of its higher differentiation stage, unless such a conclusion was the result of too broad an interpretation of that species by the authors.

<sup>19</sup>H.F. Osborn, loc. cit. Am. M.N., No. 353, 1929.

<sup>20</sup>Incidentally, this attempt hails back to when only three faunas were known: the Ardyn Obo, Houldjin, and Hsanda Gol (see Nat. Hist. of Central Asia, vol. II, Geology of Mongolia, 1927, pp. 380-381).

<sup>21</sup>P. Teilhard de Chardin. Description de Mammalifères tertiaires de Chine et de Mongolie. Ann. Pal., XV, 1926, fasc. 1.

<sup>22</sup>Present here are insectivora (*Palaeosceptor acridens* Matthew), carnivora (*Hyaenodon*, *Ictitherium*); perissodactyla, headed by *Baluchitherium* which is represented, as in the Turgai, by two races - a large and a small one; also small rhinoceri and chalicotheria (*Schizotherium avitum* Matth., larger than the Turgai form); Proboscidea, represented by a mastodon tooth fragment; and numerous remains of small artiodactyls (*Eumeryx*, a primitive deer) and rodents (*Desmatolagus*, *Tataromys*, *Tsaganomys*) - the latter abundant in more argillaceous sand streaks.

<sup>23</sup>P. Teilhard de Chardin, loc. cit., 1926.

<sup>24</sup>Birger Bohlin, Oberoligozäne Säugetiere aus dem Shargaltein-Tal (Western Kansu). Sino-Swedisch. Exped., VI; 2, P.S., Vew Ser., C, No. 3, Whole Ser., 107, Nanking, 1937.

ceptionally small fauna, typical of the more argillaceous St. Jacques beds (and the Aral?).<sup>25</sup> The Hansu fauna is the same as in Hsanda Gol and Ordos.

No Oligocene deposits with a Baluchitherium fauna have been observed in South Asia, as yet.<sup>26</sup> It is absent, along with any other Tertiary mammal fauna, from North Asia, as well, although the latter has often been regarded as a possible development center for a number of groups.

In correlating these Oligocene faunas of Asia with those of Turgai, the first impression is that the presence in the latter of Indricotherium - which the American paleontologists identify with the Mongolian Baluchitherium occurring in their three faunas - renders the Turgai fauna correlative with the latter, only. On the other hand, present along with Indricotherium are forms which - as pointed out before - are quite close to forms from the older Ardyn Obo fauna, if not identical with them (which cannot be demonstrated). Such forms are the representatives of genera Colodon and Schizotherium.

With regard to Colodon, the Ardyn Obo fauna contains two representatives of Helaletidae: Colodon inceptus Matth. et Grang. and Paracolodon curtus M. et G. Both possess less specialized teeth than C. orientalis, their P<sup>4</sup> being more molarized; although M<sup>3</sup> of Colodon inceptus M. et G. is more triangular than that of the Turgai Colodon - evidence of higher primitivity. Moreover, the Eocene Deperetella<sup>27</sup> (from Chara Murun beds, older than the Ardyn Obo) represents a specialization higher than even the Turgai Colodon. Thus the higher specialization

of C. orientalis, as compared with C. inceptus, does not necessarily mean its younger age.

More definite data are provided by the Turgai representative of chalicotheria. First of all, this form, although not necessarily identical with Schizotherium avitum M. et G. from Ardyn Obo, is very closely related to it.<sup>28</sup> Second, it reveals very primitive features - more primitive than in the Quercy phosphorite forms: it is considerably more primitive than Moropus, being morphologically intermediate between that form and Eomoropus. This was stated in the description of the Turgai Chalicotherium.

Subsequently this form was an object of study for all authors dealing with Chalicotheria of Asia, and particularly so for Colbert.<sup>29</sup> As a result of his analysis, he concludes (l. c., p. 6) that Sch. turgaicum Boris. is not Macrotherium, as believed by Koenigswald,<sup>30</sup> but rather belongs to a more primitive genus, possibly more primitive than Schizotherium, because some features connect it with the Eocene Eomoropus and Grangeria. Sch. turgaicum appears to belong near the base of the Schizotherium branch, in the same way as Grangeria marks the beginning of the Chalicotheriinae branch. Colbert illustrates these conclusions in his phylogenetic table (l. c., p. 7).

Thus Sch. turgaicum tends to lower the age of the Indricotherium beds,<sup>31</sup> regardless of whether or not the Turgai form is close to the Mongolian Ardyn Obo form.

The two other Turgai fauna forms, Epiacetherium and Indricotherium, have their analogs

in higher horizons. Out of those, the Epiacetherium genus representative, in its time, was a criterion for determining the age of the Indricotherium beds. It has been established by now that this form does not belong to an European genus Epiacetherium but rather to another Asian genus, named Allacerops by H. E. Wood.<sup>32</sup> This is important in determining the relationship between European and Asiatic Oligocene mammal faunas; however, it does not alter the time criterion because a rhinoceros with that degree of specialization could not be associated with horizons younger than Oligocene. The Mongolian remains, correlative with the Turgai Allacerops, are too scarce to make any conclusions from that correlation.

There remains the last and the largest Turgai form, Indricotherium asiaticum. Baluchitherium grangeri, a form very closely related to it - even identical, according to the American students<sup>33</sup> - has been observed in three faunas: the Houldjijn, Hsanda Gol, and Baron Sog, which the Americans (including Matthew) are inclined to believe to be of an Oligocene age. Osborn<sup>34</sup> believes them to be Lower and Middle Oligocene, with the Baron Sog fauna the younger of the two because its Baluchitherium is represented by a more advanced (l. c., p. 4) form than B. grangeri, from the other two faunas. Granger and Gregory do not share this view; on the contrary, they group into a single species all giant rhinoceri - the Mongolian and the Turgai (see p.850).

A more detailed study of these remains from Mongolia, Baluchistan, Turgai, and the Aral favors the Osborn view. It appears that, despite their comparatively short history (from Middle Oligocene through Lower Miocene at the most, as now established), giant rhinoceri - like Embolotheriidae (see above) which are known only from Lower Oligocene - ran a rather complicated course of history. For that reason, they may be divided into at least four forms (whether genera or merely species, is another matter), with the Turgai form apparently the most primitive.

Thus a correlation of the Mongolian Oligocene faunas with the Indricotherium fauna of Turgai and the Aral leads to the conclusion that out of the five giant rhinoceri faunas, the Turgai has the most ancient habitat. Its age, hitherto believed to be Upper Oligocene, should be lowered.

This new lower limit is determined by the underlying marine section. The age of marine clays at the base of Nura on the north Chelkar-Teniz shore has been determined as Lower Oligocene; consequently, the Turgai Indricotherium cannot be older than Middle Oligocene.

Another point to be considered is the relationship between these Asian Oligocene faunas and the contemporaneous European ones.

The European and Asian Oligocene Indricotherium faunas were presumably connected by a representative of genus Epiacetherium; however, as we have seen, this turned out to be wrong: the Turgai form, now assigned a generic name of Allacerops, reveals the same degree of specialization as Epiacetherium and as some American Oligocene forms.

On the other hand, in describing the Mongolian Oligocene faunas, the American paleontologists pointed out the similarity of some (a few) forms with the European, while the bulk of them gravitated toward North America. Thus the representative of genus Hyaenodon from the Ardyn Obo fauna was assigned to the Brachyrhynchinae of that genus, unknown from North America. Ardynia praecox M. et G. is similar to a representative of this genus from the European phosphorites, as is Miomeryx. Palaeopriodon gracilis from the Hsanda Gol fauna is similar to the phosphorite genus, both in its teeth and limbs. However, considering the great scarcity of remains and the preliminary nature of most descriptions, such correlations are hardly more reliable than the Epiacetherium identification given above. On the basis of the main body of material, it is perhaps more correct to regard the Oligocene fauna of Asia as related exclusively to that of North America.<sup>35</sup>

The next youngest fauna appears to belong to the Oligocene-Miocene boundary. It was collected at the Askazan-sor post of the Golodnaya Steppe (Betpak Dala), in South Kazakhstan. Here, a large mesa of the Askazan remnant is made up of fine-grained, micaceous, stratified sands (thin intercalations of coarser-grained ochre-colored sands), up to 30-40 m thick, cross-bedded, locally cemented to a brown ferruginous sandstone. Also present is gravel with well-rounded bones and teeth which present abundant but extremely unrelated material. Di-

<sup>32</sup> H. E. Wood. Status of Epiacetherium. Journ. Mammal., XIII, 1932, No.2, 169-171.

<sup>33</sup> The late Osborn had no definite opinion on the identity of these forms: he cites the Turgai form under its generic and specific names. Their identity was first asserted by Granger and Gregory in the opus cited.

<sup>34</sup> Am. M.N., No.353, 1929.

<sup>35</sup> This conclusion is in opposition to Osborn (The Age of Mammals, 1910, p.182) who regarded the Oligocene fauna as common to the entire Holarctic province, as a result of a convergence of all three northern continents into a single landmass. Nonetheless, Osborn's paleogeographic map (Fig.77, p.183) correctly represents the marine basin along the Uralian east slope, which has brought about this difference in the faunas.

<sup>25</sup> This fauna consists of disjoined bones and jaw fragments of small mammals: insectivora (Palaeoscaptor?); rodents of the same forms as in the St. Jacques and Hsanda Gol sites with some new species (Sinolagomys) of a more modern aspect; artiodactyls (Eumeryx, Procapreolus), etc.; also present are remains of birds, turtles, small gastropods, and plant seeds.

<sup>26</sup> In the southeast of South Asia, in Burma, the Pegu formation of a thick Tertiary series along the Irrawaddy River and along the sea yielded some disjoined fauna remains (Cadurcotherium, Telmatadon, Dorcatherium) which may be assigned to the Oligocene and Miocene; giant rhinoceri (Baluchitherium) was missing in this fauna. The Oligocene mammal fauna is altogether missing throughout the rest of South Asia. A fauna of giant rhinoceri is known from Baluchistan where it was first discovered. Here, however, it belongs to the Lower Miocene; is represented by a different form (Paracetherium) than in Mongolia and Turgai; and is accompanied by different mammal groups (see text following).

<sup>27</sup> W. Matthew and W. Granger. New Mammals from the Chara Murun Eocene of Mongolia. Am. M.N., no.196, 1925.

<sup>28</sup> W. Matthew and Granger, loc. cit., Am. M.N., No.98, 1923.

<sup>29</sup> E. H. Colbert. Distributional and Phylogenetic Studies on Indian Fossil Mammals. III. A Classification of the Chalicotherioidea. Am. M.N., No.798, 1935. See same author: Chalicotheres from Mongolia and China in the American Museum. Bull. Am. M.N.H., v.67, 1934, art. VIII. See also W.D. Matthew. 1929. Critical observations upon Siwalik Mammals. Bull. Am. M.N.H., v.56, art.516; G.H.R. Koenigswald. Metaschizotherium Fraasi, n.g., ein Neuer Chalicotheriide aus dem Obermiocän von Steinheim a. Alabuch. Palaeontographica, Suppl. Bd. VIII, 1, 1932.

<sup>30</sup> In the final systematic table of Colbert, it still is designated as genus Macrotherium (loc. cit., p.12).

<sup>31</sup> It should be noted that Colbert is against relating the Sch. turgaicum and Sch. avitum, as he assigns them to different branches (loc. cit., 1, 12).

rectly underlying the bone gravel are beds with meager Indricotherium fauna remains (see p. 9 above, Russian edition).

Described from this fauna, as of now, is a single chalicotherium, and a new species *Phyllotillon betpakdalensis* (Plerow), similar to *Phyllotillon naricus* Pilgr. from the Baluchistan Gaj beds (see p. 18, Russ. ed.); also a few teeth of a small rhinoceros, similar to *Rhinoceros tagicus* Rom. from Western Europe but differing in their less molarized pseudo-molars. In addition, there are here remains of assorted rhinoceri, Anthracotheria (*Hemimeryx*, etc.), small Artiodactyla, small and large Carnivora (*Amphicyon*, sabre-teeth tiger, etc.), turtles, and plant remains (wood fragments).

In Central Asian provinces of Mongolia and China, faunas similar to the Betpak-Dala are unknown. Better preserved here is the Lower Tertiary organic world, with the Upper Tertiary faunas much poorer, except for the locally abundant *Hipparion* fauna. The reverse is true for South Asia where marine conditions prevailed over large areas, in the Lower Tertiary. Toward the beginning of the Upper Tertiary, the Lower Tertiary Asian Mediterranean basin underwent changes similar to its European branch. Because of the recurrent orogenic movements, it gave place to basins of another type: marine sediments were replaced by lagunal, lacustrine, and fluvial, with remains of a land flora and fauna, although still interbedded with marine beds carrying vestiges of the Mediterranean fauna. Associated with these deposits in Baluchistan, Sind, and along the south Himalaya foothills (Siwalik Hills) are sizable sites of mammal remains. The oldest of these faunas appears to have common features with the Betpak-Dala fauna.

In Baluchistan, marine deposits terminate with the Nari formation represented by Nummulitic limestones (corresponding to the Chattien stage),<sup>36</sup> in its lower part, with the upper part represented by sandstones and conglomerates with *Lepidocyclus* and overlain by the Gaj formation of yellow limestones with the same fauna. The upper part of the Nari formation and the Gaj formations are correlative with the Aquitanian stage of Europe, although it is possible that the top Gaj beds are as young as Burdigalian (Pilgrim); they terminate the marine section.

In the Bugti Hills of the Dera Bugti province, the Gaj formation - specifically its upper beds (Pilgrim)<sup>37</sup> - are partially replaced by river deposits<sup>38</sup> with fresh-water mollusks (*Unio*, *Melania*, *Paludina*), turtles, and crocodiles. Associated with the same beds (Upper Aquitanian and Lower Burdigalian, according to Pilgrim) are mammal fossil sites.

The Dera Bugti fauna (Gaj series) is fairly abundant and adequately known (Pilgrim, F. Cooper).<sup>39</sup> Strictly speaking, two horizons are present here; however, they are difficult to differentiate and their fauna is described as a unit. This fauna is quite interesting in its composition. It is here that the first Asian proboscidea appear, represented by very primitive forms. Although their identification may be open to argument, the primitive aspect of their teeth is unquestionable. Described from the same beds is *Mastodon angustidens* Cuv. (F. Cooper);<sup>40</sup> its presence along with the primitive forms can be explained by the fact that there are two stratigraphic horizons here, rather than one; furthermore, the *Mastodon angustidens* is represented by a fairly primitive form.<sup>41</sup>

Another interesting group is Anthracotheria, observed in large numbers and in quite diversified forms. The center of their development is believed to be in North Asia<sup>42</sup> from where they migrated to Europe (Upper Eocene) and to North America (Lower Oligocene). However, very primitive forms of them are known from Egypt (Lower Oligocene) and Burma (Eocene), while the Middle Asian deposits have yielded so far only a few Anthracotheria remains. Are we, then, to transfer their development center to South Asia? The comparatively young age of Bugti deposits, where they are abundantly represented, suggests a cautious approach to this problem, pending a richer harvest of data from those provinces where older deposits are developed - particularly Burma.

The third group is rhinoceri, again quite diversified: water-loving (*Cadurcotherium*, *Metamynodon*), steppe denizens (*Chilotherium*, *Teleoceras*), true rhinoceri (*Rhinoceros*), *Dicerotheria*, and hornless species. Occurring among the latter is a giant rhinoceros, *Paraceratherium*.

Without pausing for *Gelocidae* (*Prodrematherium* and *Gelocus*), we must say a few words of the fourth important group, the Chalicotheria. They are represented by two forms belonging to two different branches: with a short molar crown and a long molar crown. Belonging to the first branch is *Schizotherium pilgrimi*; with *Phyllotillon naricus* belonging to the second.

The Betpak-Dala fauna is incomparably poorer than the Bugti. First of all, according to data extant, it carries no proboscidea. Water-loving forms, such as *Cadurocotherium*, appear to be missing among the fairly diversified rhinoceri. The anthracotheria remains, fairly numerous, have not been described, as yet. Very numerous are representatives of Chalicotheridae - the long crown forms, apparently very similar in their teeth structure to *Phyllotillon naricus* Pilgr. from the Bugti beds; unfortunately, the lack of a Baluchistan form skeleton precludes any substantiated judgment of their relationship; the Betpak-Dala skeleton presents many special features seeing it apart - for instance - from the *Moropus* skeleton from the North American Miocene, despite their great similarity in the teeth structure.

The presence of anthracotheria and giant rhinoceri renders an Oligocene aspect to the Bugti - Betpak-Dala fauna, which precludes these beds from being younger than transitional from the Oligocene to Miocene.

Quite different is the next fauna from definitely Lower Miocene deposits.<sup>43</sup> While we have dealt up to now with definitely "Asian-American" type forms, the advent of the Miocene alters abruptly the aspect of the fauna to a "European" one: giant rhinoceri and the associated small fauna disappear to give place to large Proboscidea represented by true mastodons, and only the long-legged rhinoceri from the *Aceratherium lemanense* Pomel group persist along with short-legged *Teleoceras*. By that time, Europe and Asia already were one continent, with a break between it and North America which lasted till the end of the Pliocene.<sup>44</sup>

A unique Soviet site of a Middle Miocene fauna is located in the north of the Turgai steppe. Here, in a river cliff at post Dzhilimdzhar, in the middle course of the Dzhilanchik, mottled gypsiferous clays of the Balattam formation contain pockets of younger (Sazanbay) sandy and marly deposits carrying mammal remains in groups of one or two skeletons, more or less intact. The fauna collected here is rather monotonous, consisting largely of rhinoceri and proboscidea: *Aceratherium depereti* Boris., intermediate between *A. lemanense* Pomel and *A. tetradactylum* Lartet, from Western Europe; *Brachypotherium aurelianense* var. *gailiti* Boris., related to *Br. aurelianense* Nouel from the Orleans sands (Burdigalian stage) of France, and specifically to its least differentiated representatives; *Trilophodon* (*Serridentinus*?) *inopinatus* Boris. et Bel., a quite primitive form regarded by Osborn<sup>45</sup> as very closely related to *Tr. cooperi* Osb. from the Baluchistan Bugti beds; and finally *Mastodon atavus* Boris., the most primitive among the *M. angustidens* series.

Thus the Dzhilanchik fauna consists of forms closely related to the European Miocene fauna but still of a quite primitive aspect. This is especially true for the mastodons connecting the European forms with their representatives in southwestern Asia, which province constituted a secondary development center for proboscidea, at the Oligocene-Miocene boundary.

<sup>36</sup>This section is cited after Haug.

<sup>37</sup>G. E. Pilgrim. The Vertebrate Fauna of the Gaj Series in the Bugti Hills and the Punjab. Pal. Ind. N.S. v. IV, No. 2, 1912.

<sup>38</sup>F. Cooper writes that this false bedding in sand, gravel, and clay appears to have been formed in a sink hole where animal bones, partly chewed up by crocodiles, were accumulated; these ossuaries extend for many square yards.

<sup>39</sup>Present among Carnivora are *Pterodon*, *Cephalogale*, and *Amphicyon* similar to *A. major* Blin.; Proboscidea: *Hemimastodon*, *Moeritherium*, also *Mastodon angustidens* Cuv. and remains of *Dinotherium*; *Perissodactyla*: rhinoceri are represented by *Cadurcotherium*, *Metamynodon*, *Dicerotherium*, *Teleoceras*, *Chilotherium*, and *Paraceratherium* (under various names); Chalicotheria: *Schizotherium* (?) *pilgrimi* Forster Cooper, and *Phyllotillon naricus* Pilgrim; among Artiodactyla - an immense number of Anthracotheria, quite diversified (described by F. Cooper. The Anthracotheriidae of the Dera Bugti Deposits in Baluchistan. Pal. Ind. N.S. v. 8, no. 2, 1924); also *Prodremotherium*, *Gelocus*, *Prograffa*. (See also Pal. Ind. N.S., v. IV, No. 2, 1912); F. Cooper, *Baluchitherium Osborni* - syn. *Indricotherium turgaicum* Borisiak. Philos. Trans. Royal. Soc. of London, Ser. B, 212, 1924; id., The Extinct Rhinoceros of Baluchistan, Ibid., Ser. B, 223, 1934; id., New Anthracotheres and Allied from Baluchistan. Ann. M.N.H., Ser. 8, XII, 1913, p. 515; id., New Genera and Species of Mammals from the Miocene Deposits of Baluchistan. Preliminary Notice. Ann. M.N.H., Ser. 8, XVI, 1915; id., *Metamynodon bugtiensis* sp. n., from the Dera Bugti Deposits of Baluchistan. Preliminary Notice. Ann. M.N.H., Ser. 9, IX, 1922, etc.).

<sup>40</sup>Forster Cooper. Miocene Proboscidea from Baluchistan. Proceedings of the Zool. Soc. of London, 1922.

<sup>41</sup>See A. Borisiak. Tr. GIN, 1936.

<sup>42</sup>N. F. Osborn. Age of Mammals, 1910; p. 149-188.

<sup>43</sup>The sharp difference in the constitution of the Dzhilanchik and Betpak-Dala faunas might corroborate an older age for the latter, if not for the possibility of several contemporaneous but different facies existing together.

<sup>44</sup>H. F. Osborn. The Revival of Central Asiatic Life, Nat. Hist., XXIX, No. 1, 1929, pp. 2-16.

<sup>45</sup>H. F. Osborn. Proboscidea. A Monograph of the Discovery, Evolution, Migration, and Extinction of the Mastodons and Elephants of World, v. 1, 1936, 278.

In addition to these forms, the Dzhilanchik fauna comprises remains of other mastodons, rodents, turtles (*Testudo turgaica* Rjab.), etc.

No mammal fossil site has been found as yet in higher Lower and Middle Miocene beds discovered in the Turgai steppe.

Of about the same Miocene age in the U. S. S. R., besides the Dzhilanchik fauna is that at the Belomechetskaya station in the North Caucasus. This site is also unique in the Soviet Union, inasmuch as we do not know of any other Middle Miocene land mammal site, except for isolated findings of *Mastodon angustidens* in Chokrak deposits of the Kerch Peninsula. Stratigraphic relations of the Belomechet site are not clear<sup>46</sup> (there is no accurate geological description); it appears, though, that these mammal remains belong to two horizons rather than to a single one. This is because we have here a true *Anchitherium aurelianense* Cuv., on one hand, and the form with a high state of preservation and a higher differentiation stage, on the other. That form has been named *Paranchitherium karpinskii* Boris.: although not identical with the American *Parahippus*, it represents the same differentiation stage. Also present here is *Rhinoceros caucasicus* Boris. from sub-family *Dicerorhinae*, with as yet little molarized pseudo-molars and an incipient horn (small [corny] growth on nasal bones), as well as a representative of a new family of Proboscidea, *Platybelodon danovi* Boris., with wide and flat tusks in the lower jaw and with incipient ones in the upper. The Carnivora remains (*Amphicyon*) have

not been described, as yet. Rodents are represented by *Palaeocricetus* sp. and *Cricetodon caucasicus* Arg.

Equally scarce are Miocene fauna sites in Asia outside the U. S. S. R. In Mongolia, two sites have been assigned to the Miocene: the Loh, the older one; and the Tung-Gur, the younger and the richer one. The latter was first believed to be Pliocene, then Mio-Pliocene, and finally ended as Miocene.

The Loh deposit is associated with thin olive-green clays and gray sandstones resting on red banded Hsanda Gol deposits (see p. 12, Russ. ed.). In both the composition of its fauna (rhinoceri and mastodons) and in the degree of differentiation of its representatives, this site is related to the Dzhilanchik; and its age, too, is probably Lower Miocene.<sup>47</sup>

The Tung-Gur Mongolian fauna comprises remains of *Anchitherium gobiense* Colb., very closely related *A. aurelianense* Cuv., from Europe, but larger and differing in a number of minor features, which, according to the European views, relegates it to Middle rather than to the Upper<sup>48</sup> Miocene. Another interesting form of the same fauna is a representative of *Platybelodon*. As we have seen, these are the two genera which characterize a definitely Middle Miocene North Caucasion fauna.

The Tung-Gur deposit is associated with light-colored clays interbedded with gravels where the bones occur; described from here has been a large number of mammals.<sup>49</sup>

<sup>46</sup>General information on the Chokrak horizon at station Belomechetskaya is given in vol. XII of "Stratigraphy," 1940, p. 109, fig. 25.

<sup>47</sup>Described from here (H.F. Osborn. *Serridentinus* and *Baluchitherium*, Loh Formation, Mongolia. Am. M.N., No. 148, 1924) are two typical fossils: *Serridentinus mongoliensis* Osb., which has its relative (?) in *S. inopinatus* from Dzhilanchik; and a small *Baluchitherium*, as identified by Osborn - with cranium of a different shape and with more specialized (molarized) pseudo-molars than with the Oligocene *Baluchitheria* of Mongolia. However, Matthew (A Review of the Rhinoceroses with a Description of *Apelops* Material from the Pliocene of Texas. Univ. of Calif. Public., Bull. of the Dept. of Geol. Sciences, vol. 20, No. 12, 1932) believes that it belongs to a rhinoceros branch, namely to the hornless group *Coelodonta*. Also found in Loh were other rhinoceros remains (such as a hind leg with very elongated metapodials). An abundance of assorted rhinoceros remains is also typical of the Dzhilanchik site with its long-legged (*Aceratherium depereti* Boris.) and short-legged forms (*Brachypotherium aurelianense* v. *gailiti* Boris.).

<sup>48</sup>The Americans assign the Hipparion fauna to the Pliocene, thereby raising the age limit for preceding faunas. Colbert assigns the Tung-Gur fauna to the Upper Miocene, in his description of *Anchitherium gobiense*. (A New Anchitheriine Horse from the Tung-Gur Formation of Mongolia. Am. M.N., No. 1019, 1939). In Europe, *Anchitherium tunggurensis* appears in the Burdigalian and is most common in Burdigalian to Tortonian beds.

<sup>49</sup>Rodents: *Amblycastor tunggurensis* Stirton; *Protalactaga tunggurensis* Wood; *Prosilphneus lupinus* Wood - corresponding in the degree of their differentiation to this age (Upper Miocene); Proboscidea: *Serridentinus gobiensis* Osb. and *Platybelodon grangeri* Osb.; Perissodactyls: *Rhinoceros* (not described), *Anchitherium gobiense* Colb., and two representatives of *Macrotherium* - *M. brevirostre* Colb. and *M. sp.*; Suidae; *Listriodon mongoliensis* Colb. terminates the line of *Iophodonta* *Listriodon*; deer - *Stephanocemas thomsoni* Colb., *St. triacuminatus* Colb., *Dicrocerus grangeri* Colb. and *D. sp.*; giraffes - *Palaeotragus tunggurensis* (the closest related to Sebastopol *Achtiaria expectans* Boris.); antelopes - *Olioceros* (?) *grangeri* Pilgrim, *O. (?) noverca* Pilgrim; Carnivora - *Hemicyon*, *Hyaena*, *Ictitherium*, *Metailrus* (see H.F. Osborn and W. Granger). The Shovel - Tuskers, *Amebelodontinae*, of Central Asia. Am. M.N., No. 470, 1931; *ibid.*, *Platybelodon grangeri*, three Growth Stages, and a new *Serridentine* from Mongolia. Am. M.N., No. 537, 1932; E.H. Colbert, *Palaeotragus* in the Tung-Gur Formation of Mongolia. Am. M.N., No. 874, 1936, etc.).

A vast majority of forms described from Tung-Gur are new species, some of them representing new genera; present in addition to mammals here are remains of birds (*Eogrus* sp.), turtles, and fishes.

It appears that the light-colored Tung-Gur clays have been deposited in a calm sea, with sands and gravels periodically brought in by rivers, along with remains of mammal skeletons.

The next fauna known to us (not counting the isolated findings of *Rh. tetradactylis* (*incisivus*), etc., in Lower Sarmatian of the Ukraine, is the Hipparion fauna which appeared in the European U. S. S. R. in the Middle Sarmatian. The only occurrence of this most ancient stage of the Hipparion fauna is in the Middle Sarmatian marine section at Sebastopol, where a lens (?) of soft white limestone carries bone breccia. The Hipparion fauna is also known from Upper Sarmatian of the Odessa region (settlement Grossulivo), North Caucasus (Kutsay Mountain near Petrovskoye), and Trans-Caucasus where it has been observed at Udabno (Georgia), Dzha-paridze (Kakhetia), and the Eldorado valley. In the latter locality, abundant remains of the Hipparion fauna, along with marine forms (*Cetotherium*), are imbedded directly in marine calcareous sandstones interbedded with limestones. In addition, there are numerous findings of this fauna from Sarmatian deposits of the southern U. S. S. R., not definitely dated. There are a few findings of the Hipparion fauna in Meotian beds of the Kherson and Odessa regions and the Moldavian A. S. S. R.

This rich material from domestic sites is far from being exhaustive; neither has it been processed in the same detail. This is particularly true for the Hipparion itself.

With these reservations, the roster of the Hipparion fauna may be drawn as follows:

In the Sarmatian:<sup>50</sup> Equidae - *Hipparion*, everywhere designated as *H. gracile* Kaup (S - var. *sebastopolitanum* Boris.), *Protohippus* (?); Chalicotheriidae (E); Rhinocerotidae - *Aceratherium* (*incisivum* Kaup); S - *zernovi* Boris., E - *transcaucasicum* Bogat.), *Rhinoceros* (*pachygnathus* Wagn.), *Dicerorhinus* (E - *orientalis* Schl.); Camelidae - *Camelus* (*chersonensis* Pavl.); Cervidae - *Cervus* (*furcatus* Fraas); Giraffidae - *Achtiaria* (S - *expectans* Boris., E - *borisski* Alex.), *Giraffa*; Bovidae - *Tragocerus* (S, E - *leskevitschi* Boris., *valenciennesi* Gaud.), *Gazella* (*brevicornis* Wagn.), *Tragor-eas* (S); Suidae - *Sus* (E - *erymanthus* Roth -

Wagn.), *Listriodon*; Proboscidea - *Mastodon* (E - *longirostris* Kaup, E - *pentelici* Gaud., *angustidens* Cuv.), *Dinotherium* (E - *giganteum* Kaup); Hyaenidae - *Ictitherium* (*robustum* Gerv., *hipparionum* Gerv., S - *tauricum* Boris., *sarmatium* Pavl.), *Hyaena* (*erocuta*), E - *eldarica* Bogat., E - *eximia* Roth-Wagn.; Felidae - *Pseudaelurus* (*intrepidens* Leidy), *Machairodus*; also remains of Primates (E? and Udabno), cetaceans, birds, reptiles, and fishes.

In the Meotian: Equidae - *Hipparion* (*gracile* Kaup, locally *H. minor*, *H. mediterraneum*, and *Hipparion* sp.); Rhinocerotidae - *Aceratherium* (*incisivum* Kaup, *schlosseri* Web., *kovalevskii* Pavl., *simplex* Krokos), *Rhinoceros* (*pachygnathus* Wagn., *schleiermacheri* Kaup); Cervidae - *Cervavitus* (*taraliensis* Chom.), *Cervocerus* (*novorossiae* Chom.), *Procervus* (*variabilis* Alex.); Giraffidae - *Palaeotragus* (*roueni* Gaud.), *Helladotherium* (*duvernoyi* Gaud.), *Samotherium* (*boissieri* F. Major), *Giraffa* (*parva* Weith.); Bovidae - *Tragocerus* (*frolovi* Pavl., *amalthus* Gaud., *parvidens* Schl., *rugosifrons* Schl., *validus* Chom.), *Protragelaphus* (*skouzesi* Weith.), *Paleoryx* (*majori* Schl., *stutzeli* Schl., *palassii* Gaud.), *Criotherium* (*argaloides* F. Maj.), *Gazella* (*brevicornis* Warn., *capricornis* Roth et Wagn., *deperdita* Gerv.); Suidae - *Sus* (*erymanthus* Roth et Wagn., *major* Gaud.); Proboscidea - *Dinotherium* (*giganteum* Kaup), *Mastodon* (*longirostris* Kaup, *pentelici* Gaud., *turicensis* Schinz.); Hyaenidae - *Hyaena* (*eximia* Roth et Wagn.), *Lycyaena* (*parva* Chom., *choeretic* Gaudry), *Ictitherium* (*robustum* Gerv., *hipparionum* Gerv.); Mustelidae - *Mustela* (*leporinum* Cho., *palaeattica* Weith.), *Promephitis* (*maeotica* Alex.); Felidae - *Machairodus* (*cultridens* Cuv., *aphanistus* Kaup, *parvulus* Chom., *schlosseri* Weith.), *Felis* (*attica* Wagn.); Canidae - *Simocyon* (*primigenius* Wagn.); Hysteriidae - *Hystrix* (*bessarabiae* Riab.); Leporidae - *Lepus* (*laskarevi* Chom.); Ochotonidae - *Ochotona* (*eximia* Chom.); Orycteropidae - *Orycteropus* (*gaudryi* F. Major); also ostriches, reptiles, and fishes.

A comparison of these fauna rosters from the Sarmatian and Meotian shows without a doubt that this is one and the same fauna, although its individual elements underwent certain evolution, during that time. It is much richer in the Meotian, due probably to the accident of preservation. Some groups are represented by more diversified forms; there are a number of new groups (deer, carnivores, edentata), which may indicate different facial conditions. The latter is that much more probable since the Sarmatian sites are associated with marine deposits, while the Meotian occur in continental deposits, in-

<sup>50</sup>Symbols: S-Sebastopol (Mid. Sarmatian); E - Eldar (Up. Sarmatian); without these letters - other Sarmatian sites.

cluding river loads, gravel fans (the Tiraspol gravel), etc.

Present in the Asian U. S. S. R., in addition to a number of small findings of isolated representatives of the Hipparion fauna in various localities of Kazakhstan, is one of the largest sites in the world - the Pavlodar site at the Irtysh. As is the case of all Asian sites of this fauna, the exact age of the Pavlodar site is unknown. It is represented by a huge bone yard, with the total thickness of the bone beds reaching 10-12 m (the bone breccia proper is up to 3 m thick), extending for several kilometers along the Irtysh. Its section is as follows:

Underlying drab-yellow Quaternary sands is pink marly clay with blue patches (2 m thick); light-gray dense marly clay (1.5 m); loamy micaceous sand (1.5 m); cross-bedded micaceous sands (with local mica layers), 8-10 m.

All this interval, with the exception of pink clay, carries bones, with the bulk of them associated with the upper part of cross-bedded sands, the overlying loams, and the lower part of gray clays.

Most of the bones are accumulated at the Goose Crossing (a stretch of the Irtysh bank), and down the stream, as a secondary occurrence in Quaternary beds. It appears that we deal here with the channel of a Tertiary river which carried along the carcasses of huge herds of herbivorous animals and of carnivores accompanying them.

This fauna has not been fully processed; its composition can be presented as follows: Equidae - Hipparion, a dominant form (excavations in only a small part of the site yielded over 200 individuals); Rhinocerotidae - largely *Chilotherium*, also small remains of a very large form (*Sinotherium*?); Proboscidea - a few disjoined remains; Bovidae - *Tragocerus* (*amalthus* Gaud.), *Gazella* (*deperdita* Gerv.); Cervidae - *Procervus*; Giraffidae - *Samotherium*, *Palaeotragus*; Felidae - *Machairodus* (*irtyshensis* Orł.) (very large) and its smaller species; Hyaenidae - *Crocota* (*eximia* Roth et Wagn.), *Ictitherium* (*hipparionum* Gerv.); Mustelidae - *Parataxidea* (*crassa* Zd.); *Plesiogulo* (*brachygnathus* Schlosser), *Mustela* (*palaeosinensis* Zd.); Semantoridae - *Semantor* (*macrurus* Orł.), reptiles (turtles), birds (*Struthio*, *Sushkinia*).

Described from Pontian limestones of the south of the European U. S. S. R. and the Caucasus are individual elements of a typical Hipparion fauna; mentioned along with *Hipparion gracile* Kaup are *Mastodon* (*borsoni* Hays, *longirostris* Kaup), *Dinotherium* (*giganteum* Kaup), *Acera-therium* (*incisivum* Kaup), *Antelope* (*palassi* Gaud.), and *Capreolus* (*matheroni* Gerv.). A rich site with this fauna is located in the vicinity of Stavropol-Caucasia; occurring there, along with the above-named forms, are *Mastodon arvernensis* Croizet et Jobet, *Rhinoceros schleiermachi* Kaup, *Tapirus*, *Giraffidae*, *Pliocervinae*, *Suidae*, *Carnivora* (*Amphicyon*, *Felis*), *Amblycastor* (*caucasicus* Arg.), etc. Some of the Kazakhstan Hipparion findings (see above) are probably also Pontian, although some of the others are definitely younger.

More abundant remains, evidently belonging to more than one horizon (probably both Lower and Upper Pliocene), were uncovered at the right bank of river Ishim, at the Kokchetav latitude.

Present here are remains of Equidae: *Hipparion*; Rhinocerotidae; Giraffidae; Cervidae; Camelidae: *Camelus* (*praebactrianus* Orł.), *Paracamelus*; small Artiodactyla; Proboscidea: *Mastodon* (*angustidens* Cuv. of the *tapiroides* Cuv. type); Rodents: *Ochotona*, *Trogontherium* (*vuvieri* Fusch.), *Castor*, *Steneofiber*, *Lepus*, *Cricetus*, *Arvicola*; insectivores: *Talpa*; carnivores: *Machairodus* (*ischimicus* Orł., *aphanistus* Kaup); and turtle remains.

Beginning with the Middle Pliocene, the Hipparion fauna underwent considerable changes. In Western Europe, that period is marked by a Russillon fauna.<sup>51</sup> In the European U. S. S. R., it is known from two localities, for the time being: in the Apsheron Peninsula, from light-gray sandstone on the east slope of the Lok-Batan mud volcano (*Cervus elaphus* L., *Gazella subgutturosa* Guldenst., etc.) and in Bessarabia where fairly abundant remains have been collected from a number of sites. The richest of them is associated with ravines running to rivers Kagul, Sal'chi, and Prut.

Described from here are: Equidae - *Hipparion* (*crassum* Gerv.); Rhinocerotidae - *Rhinoceros* (*longirostris* Krokos, *leptorhinus* Cuv.), *Acera-therium*; Camelidae - *Camelus* (*bessarabensis* Chom.); Cervidae - *Cervus* (*ramosus* Cr.-Job., *pyrenaeus* Dep.), *Capreolus* (*australis* de Ser.); Bovidae - *Palaeoryx* (*boodon* Gerv.), *Gazella*; Hippopotamidae - *Hippopotamus*; Suidae -

*Sus* (*provinsialis* Gerv.); Proboscidea - *Mastodon* (*arvernensis* Cr.-Job.), *Dinotherium*; Rodentia - *Castor* (*praefiber* Dep.), *Hystrix*, *Prolagus*, *Lepus*, *Ochotona*, *Spalax*, *Mus*, *Sciurus*; Felidae - *Machairodus* (*cultridens* Gaudry), *Lynx* (*brevirostris* Cr.-Job.) Hyaenidae - *Hyaena* (*borissiakii* Chom.); Mustelidae - *Mustela*; and Canidae - *Vulpes* (*vulpes* L., *fossilis* L.).

This fauna underwent a further change in the Upper Pliocene. Hipparion was no longer dominant; it was now accompanied by a single-hoofed horse and a number of other forms connecting this fauna with a subsequent one, of the beginning of the Tertiary.

Representatives of this fauna are known from many points of the south margin of the European U. S. S. R., in the Caucasus, and Cheleken Island; isolated findings were made in the Urals and in Middle Asia, with the richest material collected from the Paludina beds of the Aral Sea shore.

A general roster of the fauna, mostly tentatively identified, is as follows: Equidae: *Hipparion* (*crassum* Gerv. or sp., *Equus* (*stenonis* cf. *major* Boule)); Rhinocerotidae: *Rhinoceros* (sp.), *Elasmotherium* (sp.); Cervidae: *Cervus* (*elaphus* Lin., *ramosus* Cr.-Job.); Camelidae; Suidae; rodents: *Trogontherium* (*cuvieri* Fisch.); Felidae: *Machairodus*; Ursidae; Canidae: *Canis* (*lupus* L.); Proboscidea - numerous remains, with most common *Mastodon* (*arvernensis* Cr.-Job., *borsoni* Hays.) and *Elephas* (*planifrons* Falc.) (*Akchagyl*), *meridionalis* Nesti (Apsheronian); also remains of birds and fishes.

A peculiar site is the Odessa "catacombs" filled up with red clays carrying numerous vertebrate remains. Larger forms, in addition to *Mastodon* remains, include *Camelus*, *Gazella*, assorted carnivores (*Ursus*, *Mustela*, *Vulpes*, *Canis*, *Hyaena*, *Felis*, etc.), rodents - large (*Lepus*, *Trogontherium*) and small birds (*Struthio*), fishes, etc.

These are the data provided by our sites for a reconstruction of the history of the Hipparion fauna. They embrace a long period of time, from the Middle Sarmatian to Apsheronian, and they pertain to horizons whose sequence has been established as definitely as nowhere else in Europe. However, only a few of its forms have been described in more or less detail;

most of them are still awaiting their processing, after which it will be possible to judge their historical value.

Not much better off is material on the Hipparion fauna in other countries. This fauna, which spread extremely rapidly at one time throughout Europe and Asia, is more common than any other and appears to be too well known for a further study. As a result, some elemental problems - of its origin (its relation to its predecessors), distribution, and the evolution of its individual elements during the fairly long time of its existence - remain unanswered. Now, this is one of those faunas which call for particularly nice paleontological studies - not only a study of all its collected remains, which is necessary in view of the above-mentioned status of their processing - but for new field investigations and new material.

What are the data on this fauna from other provinces of Asia? We shall pause here only for the most important findings.

The American Asian expedition obtained a few remains of the Hipparion fauna, namely those from the Hung Kureh light colored clays and sands in the Baga Bogdo foothills. Mentioned from here are hipparion, rhinoceros, large deer, *Gazella*, *Camelus* (?), and *Castor*.<sup>52</sup> Sands and clays that enclose them are deposits of a water basin. The American geologists correctly observe that this suggests the advent of a more humid climate than in the preceding epoch.<sup>53</sup> In any event, these sediments are separated from the preceding formation by a sharp break which results in an abrupt change in the fauna composition.<sup>54</sup>

Sites with a more abundant Hipparion fauna were discovered by our expeditions in Western Mongolia (hills Oshi and Chono-Horyak). Collected there, besides Hipparion, were rhinoceros remains (*Chilotherium*, *Iranotherium*, *Sino-therium*), *Giraffidae*, *Camelus*, *Mastodon*, etc.

Another large site is located in the Chilton Gol, farther east, at the eastern Gobi boundary (west of Dalay-Nor, considerably north of Ordos). The geologic section here is rather complex, with disturbed red beds at the base, overlain unconformably by horizontal white rocks (sand and marls) with basalt flows on top. The Hipparion fauna occurs in both red and white

<sup>52</sup>A mastodon found here was subsequently assigned to the Quaternary, as were remains of an ostrich (*Struthiolithus*) and small birds (G.M., 235).

<sup>53</sup>G.M., 365, 381.

<sup>54</sup>The large area of Upper Tertiary deposits with a fauna, discovered in 1928 east of the Kalgan road (Spock, Pliocene Beds of the Iren Gobi. Am. M.N., No. 394, 1929) turned out to be Miocene (Tung-Gur formation, see p.21).

<sup>51</sup>Cf. Pilgrim, "Are the Equidae reliable for the Correlation of the Siwalik with the Cenozoic Stages of No. America?" Rec. Geol. S. India, vol. 73, pt. 4, 1938, 443. Pilgrim points to the extinction in the Russillon fauna of genera still present in our Bessarabian fauna; it is possible that the River Kagul fauna is older than the Russillon and represents the Middle Pliocene link missing in Western Europe (Pilgrim, 1938, 445-446). Indeed, Andrusov believed this fauna to be of a Kuyal'nits age (Stratigraphy of the U. S. S. R., 1940, XII, 532).

beds.<sup>55</sup> A correlation of these two faunas shows that the white rocks contain more insectivores and rodents, which may be due to the difference in facies. The stratigraphic relationship would suggest greater differences.<sup>56</sup> However, the published data on hand preclude even a preliminary approach to this subject.

The Chinese Hipparion fauna was first described by Schlosser from Haberer's collection (1899-1901) of "dragon's teeth" (teeth of fossil animals, so named, are attributed curative properties in China).<sup>57</sup>

North China contains a number of Hipparion fauna sites, with Hipparion the most numerous of the fossil mammals. These sites are located in provinces Shansi, Shensi, Hansu, Honan, Szechwan, Shantung, etc.<sup>58</sup> They are everywhere associated with the so called red "hipparion clays," locally of complex constitution (interbedded with gravel, sand, marls, limestones, etc.). Going upward, the red hipparion clays (Upper Miocene - Lower Pliocene) change to reddish clays (Upper Pliocene) which gradually change to thick loesses (Quaternary). Pao-te-Hsien, the richest site, is located in Northwest-Shansi where it occupies an area up to 20 km<sup>2</sup>, with the bone bed (up to 1 m thick) distributed in isolated lenses. The fauna from these sites, collected by the 1918-1923 Swedish expedition under Anderson, was processed by Prof. Wieman. A number of monographs (Zdansky, Sefve, Bohlin, Ringstrom, etc. give the following roster of forms.<sup>59</sup>

Equidae: Hipparion presents an unusual varie-

ty of forms.<sup>60</sup> In the opinion of the author who described them, this not only indicates a center of their development but also suggests China as the province where Hipparion became the ancestor of the horse. Present besides the hipparion were anchitheria;<sup>61</sup> also described were (Schlosser, see above) teeth first assigned to Anchitherium but subsequently identified (Osborn, Romer) as those of Hypohippus.

Tapiridae: Tapirus (teihardi Zdansky), an unusual member of this fauna, inasmuch as the tapir is a denizen of marshes.

Rhinocerotidae: are a predominant element of this fauna<sup>62</sup> (small antelopes alone are more numerous), with 90% of the remains belonging to representatives of genus Chilotherium (andersoni Ring., habereri Schloss., habereri var. laeticeps Ring., wimani Ring., planifrons Ring.) which were widely distributed in Asia and in the south of the Russian plain, as far as Samos (farther on to the west, it is replaced by Aceratherium); it appears to be a steppe form, absent under other conditions (as for instance in Honan). Known in addition to Chilotherium are Dicerhinus orientalis Schlosser, Diceratherium palaeosinense Ring., and Sinootherium lagrelii Ring.

Cervidae:<sup>63</sup> Cervulinae - Eostyloceros (blainvillei Zd., triangularis Zd.), Dicrocerus Schl., (rutimeyeri Schl.), Axis (speciosus Schl.).

Bovidae:<sup>64</sup> Tragocerus (gregarius Schl., spectabilis Schl.), Protoryx (?) (planifrons Bohl., schansiensis Bohl.), Paraprotoryx (minor Bohl.), Paleoryx (sinensis Killg.), Tragorens (?)

<sup>55</sup>Briefly, the composition of these two faunas is as follows (Teilhard de Chardin. Ann. Pal., XV, f.1, 1926): present in red clays are Carnivora - Martes (andersoni Schloss.), Hyaena; Perissodactyla - Aceratherium, Hipparion (richthofeni Kok.); Artiodactyla - Moschus (primaevus Teilhard); Cervavus (?); Rodentia - Ochotona; Proboscidea: Stegodon. From white rocks: Carnivora - Hyaena (ictitherium); Perissodactyla - Rhinoceros, Hipparion (it has not been demonstrated that this is another species); Artiodactyla - Gazella, Alcicephalus; Rodentia - Chalicomys, Prosiphneus; also Proboscidea and insectivores.

<sup>56</sup>T. de Chardin assigns the red clays to the end of the Miocene (Pontian); the white beds, to the beginning of the Pliocene.

<sup>57</sup>M. Schlosser, Die fossilen Säugetieren Chinas. Abh. bayr. Ak. d. Wiss., II, cl., Bd. XXII, 1903.

<sup>58</sup>I.G. Anderson. Essays on the Cenozoic of Northern China. Mem. Geol. Surv. China, (A) No.3, 1923, 107; L.F. Yuh. The Geology of the Hsi-shan or the Western Hills of Peking. Geol. Mem., (A), No.1, 1920.

<sup>59</sup>Also see T. de Chardin and Young, Fossil Mammals from the Late Cenozoic of China. P.S., (C) IX, 1, 1931.

<sup>60</sup>Sefve [Die Hipparionen Nord Chinas. P.S., (C), IV, 2, 1927] counts 11 Hipparion species and a new genus Proboscidipparion. T. de Chardin and Young [P.S., (C) IX, 1, 1931], confirming the diversity of the Hipparion forms, add a twelfth species (H. houfenense).

<sup>61</sup>Zdansky [Equus und andere Perissodactyla. P.S., (C), VI, 5, 1935] has it, "Anchitheriine, gen. et sp. indet."

<sup>62</sup>T. Ringström. Nashörner der Hipparion-Fauna Nord.Chinas. P.S., (C), 1, 4, 1924.

<sup>63</sup>O. Zdansky. Fossile Hirsche Chinas. P.S., (C), II, 3, 1925; Weitere Bemerkungen über fossile Cerviden aus China. P.S., (c), I, 1927.

<sup>64</sup>B.Bohlin. Cavicornier der Hipparion - Fauna Nord-Chinas. P.S., (C), IX, 4, 1935; P. Teilhard and C.C. Young. Fossil Mammals from the late Cenozoic of Northern China. P.S., (C), IX, 1, 1931.

(lagrelii Bohl., palaeosinensis Schl.), Antilopira (licenti Teilh. et Young), Gazella (gaudrii Schl., dorcadoides Schl., altidens Schl., pao-tehensis Teilh et Young, blacki Teilh et Young), Urmatherium (intermedium Schl.), Plesiaddax (depereti Schl., minor Bohl.).

Gazelles are especially numerous; the antelope fauna is peculiar (with its local genera and species) and points to the presence of different "facies" within China, as is true for rhinoceri. The Honan site differs from the others in its antelope fauna, in the same way as the Samos Hipparion fauna differs from that of Pikermi (Greece).

Giraffidae,<sup>65</sup> too, are peculiar in the Chinese Hipparion fauna: dolichocephalic forms (typical of Pikermi, India) are missing here, as are Sivatheriinae. Palaeotraginae - Palaeotragus (microdon Kok., cf. coelophrys Rodl.-Weith., decipiens Bohl.), Samotherium [cf. neumayeri Rodl.-Weith., sinense (Schl.), tafei (Kill.)] - representative of this sub-family have the same distribution as Chilotherium and apparently do not spread farther than Pikermi; Giraffinae - Honanotherium (schlosseri Pilgr.).

Suidae:<sup>66</sup> Chleuastochoerus (stehlini Schl.), Microstonyx (arymanthus R.-W.), Propotamochoerus (hyotherioides Schl.), Listriodon gigas Pears.

Proboscidea:<sup>67</sup> were not processed by the Swedes; according to other authors, they include Mastodon americanus Kerr and Tetralophodon exoletus Hopw., also Serridentinus (wimani [Hopwood], lydekkeri [Schlosser]), Trilophodon spectabilis Hopw., Tetralophon sinensis Koken, Pentalophodon (sinensis Hopw., cuneatus Teilh. et Trassaert), Mastodon (borsoni Hays., intermedium Teilh. et Trass.), Stegodon (licenti Teilh. et Trass., zdanskyi Hopwood).

Glires:<sup>68</sup> Chalicomys (broili T. et Young), Prosiphneus (eriksoni Schl., sinensis T. et

Young), Pararhizomys (hipparionum T. et Y.), Paralactage (sunii T. et Y.).

Carnivora:<sup>69</sup> Canidae - Amphicyoninae - Amphicyonine (?); Simocyon (primigenius Roth et Wagn.); Caninae - Canis (antonii Zdansky, chinesis Zdansky), ? Vulpes (sinensis Schl.); Ursidae - Indarctos (lagerlii Zdansky, sinensis Zd.), Hyaenarctos, Ursus (böekhi Schl.); Mustelidae - Sinictis (dolichognathus Zd.), Proputorius (minimus Zd.), Mustela (palaeosinensis Zd.), Plesiogulo (brachygnathus Schl.); Lutrinae - Lutra (aonychoides Zd.); Melinae - Parataxidea (sinensis Zd., crassa Zd.), Melodon (majori Zd., incertum Zd.); Mellivorinae - Eomellivora (wimani Zd.); Hyaenidae - Ictitherium (gaudrii Zd., sinense Zd., wongi Zd., hyaenoides Zd.); ? Lycyaena (dubia Zd., Hyaena (variabilis Zd., honanensis Zd.); Felidae: Machairodontinae - Machairodus (polanderi Zd., tingi Zd., maximiliani Zd.); Felinae - Metailurus (major Zd., minor Zd.); Dinofelis (abeli Zd.); Felis (palaeosinensis Zd.).

Primates:<sup>70</sup> Macacus (andersoni Schl.) and Procynocephalus (wimani Schl.).

We have discussed the Chinese Hipparion fauna in some detail because it is now one of the best known local faunas. Its study has shown that it is distinctive, first of all by lacking some of the South Asian and Western European forms and second by carrying several forms peculiar to itself. Of note is the presence of tapir - this denizen of marshes - and the remains of horses: ancient forms (Anchitherium) and sylvan Hypohippus, as well as a variety of the Hipparion representatives. It is of interest that some Asian forms (rhinoceri, antelopes) are not present west of the Odessa-Samos meridian.<sup>71</sup> Finally, different "facies" are suggested within the Chinese fauna: the steppe and probably a sylvan one.

Turning to South Asia, we find two areas of continental deposits with the Hipparion fauna sites of widely differing values, namely in India and Burma.

<sup>65</sup>B.Bohlin. Die Familie Giraffidae mit besonderer Berücksichtigung der fossilen Formen aus China. P.S., (C), IV, 1, 1926.

<sup>66</sup>H. Pearson. Chinese fossile Suidae. P.S., (C), V, 5, 1928.

<sup>67</sup>A.T. Hopwood. Fossil Proboscidea from China. P.S. (C), IX, 3, 1935. P. Teilhard and M.Trassaert. The Proboscidiens of Southeastern Shansi. P.S., (C), XIII, 1, 1937.

<sup>68</sup>P. Teilhard de Chardin and C.C. Young. Fossil Mammals from the late Cenozoic of Northern China. P.S., (C), IX, 1, 1931.

<sup>69</sup>O. Zdansky. Jungtertiäre Carnivoren Chinas. P.S., (C), I, 2, 1924; Weitere Bemerkungen über fossile Carnivoren aus Chinas. P.S., (C), IV, 4, 1927.

<sup>70</sup>M.Schlosser. Tertiary Primates from China. P.S., (C), I, 2, 1924.

<sup>71</sup>Osborn (The Age of Mammals, 1910, 322) pointed out earlier that the Asian Hipparion fauna extends as far as Maraga where it is transitional from the Asian to the Pikermi and Samos assemblages.

As we have seen (p. 18), the contraction of the south Asian branch of the Mediterranean basin which separated Hindustan from the continent of Asia was accompanied, in the Upper Tertiary, by laying down of brackish water deposits followed by fresh-water ones (lacustrine) and finally by river deposits. We have already become acquainted with their oldest fauna, from the Bugti beds. Higher horizons, getting coarser upward (with a progressive rise of mountain ranges), and attaining a total thickness up to 500 m, now form the Siwalik Hills of India, along the south fringe of the Himalayas; the same horizons for the Salt Range foothills, and are known from Sind (the Manchar beds), and farther on as far as the Indian Ocean (Perim Island). The second area of Tertiary deposits is represented by the basin of the Irrawaddy river, in Burma.

Preserved in the Siwalik beds, whose deposition continued in the Quaternary, are remains of a rich fauna. Its nature was determined by an abundance of moisture (lakes, rivers flowing from the mountains), vast forests, and the presence of lofty mountains gradually rising in the Tertiary and isolating this province from the rest of Asia.

The study of the Siwalik fauna was initiated over a hundred years ago; but it is only in the last ten years - thanks to new findings and their processing by outstanding experts on Tertiary mammal fauna of the Old and New Worlds (Pilgrim, Matthew, Colbert) - that its composition, nature, and relationship to contemporaneous faunas of the Old World have become clearer. At the same time, the stratigraphy of the Siwalik beds has been refined. However, their precise correlation with European, Asian, and American deposits remains unknown.

As of now, the Siwalik series is divided into three formations: the lower, middle, and upper, each being subdivided into two or three stages. Reading upward, we have members Kamli and Chinji, of the Lower Siwalik formation; members Nagri and Dhok-Pathan, in the Middle; and the Tatrot, Pinjor, and Boulder Conglomerate in the Upper. Hipparion appears at the base of the Chinji and is best developed in the Dhok-Pathan; in the Pinjor, it is replaced by *Equus*. There is no unity of opinion on the latter being as young as Quaternary: Pilgrim assigns the Pinjor to Upper Pliocene. Even more controversial is the correlation of lower beds.

We shall not give here the rosters of consec-

utive Siwalik faunas; they are given in full, along with stratigraphic data, in works of Colbert<sup>72</sup> and Matthew.<sup>73</sup> We confine ourselves to a brief description of individual faunal groups, using data of these two authors, largely of Colbert, to whom we are indebted also for the interpretation of phylogenetic relationships.

Primates are represented by very fragmentary material, although demonstrative of a great variety of highly specialized forms (a development center).

Rodentia are rare in the collections; new findings, apparently more representative (Lewis, Yale University), have not been processed, as yet.

Carnivora. Remains of Creodonta persist in Lower Siwalik beds (*Dissopsalis* among Hyaenodontidae). Carnivora present a great variety of forms. Of note is genus *Indarctos* which appeared in India, in the Upper Tertiary, and migrated from there to China and North America (California) - an instance of migration from the Old World to the New. This migration path is ascribed to *Hipparion*, as well, by some authors (Pilgrim, see below).

Tubulidentata. The easternmost occurrence of *Orycteropus*.

Proboscidea are numerous and diversified, beginning with the lowest horizons. Middle Siwalik beds carry assorted representatives of *Trilophodon*, *Serridentinus*, etc., with an interesting short-jawed *Synconolophus*; true elephants (*Stegodon*) appear beginning with Middle Siwalik beds, and become numerous in upper beds (*Archidiscodon planifrons* Falc., etc.).

Perissodactyla are a group particularly conspicuous, whose representatives were used in the correlation. Known from Lower and Middle beds is the only Hipparion genus, represented by two species: *H. antelopinum* (Falconer et Cautley) and *H. theobaldi* (Lydekker) (three additional species were described, all synonyms of *antelopinum*), out of which *H. theobaldi* is the largest (like a middle size horse), with massive limbs, and more common (in the Chinji as well as in Middle Siwalik beds) than *H. antelopinum* which is smaller and with thinner limbs.

Chalicotherioidea. *Macrotherium salinum* F. Cooper (Lower Siwalik) and *Circotherium* (*Nestoritherium*) *sindiense* Lydekker (Manchar beds of Sind).

Rhinocerotidae include representatives of several phylogenetic branches; a new genus *Gaindatherium* (a probable ancestor of *Rhinoceros*) may be singled out in Lower Siwalik beds - a branch which developed in situ; Middle Siwalik beds contain *Chilotherium* and *Acerotherium* which subsequently migrated to India (*Ac. perimense* Falconer et Cautley - a very large form).

Suidae are extremely numerous and diversified, which suggests India as their development center; their numerous genera and species belong to six branches which in turn are broken up. Of note is *Palaeochoerus* from Lower Siwalik beds, which constitutes the main branch of pigs; also primitive peccari (*Peccarichoerus*), etc.

Anthracotheriidae belong to both branches - the conservative bunodonta and progressive senodonta; they are represented by several genera, of which *Merycopotamus* is a possible ancestor of hippopotamus.

Hippopotamidae, with the exception of *Hippopotamus* (*H. iraviaticus* Falconer et Cautley from the Irrawaddy series, correlative with Middle Siwalik beds), are represented by *Hexaprotodon*, a more primitive form possibly affiliated with *Merycopotamus*.

Camelidae (genus *Camelus*) appear only in Upper Siwalik Quaternary beds.

Tragulidae are represented by a primitive *Dorcabune* (Lower- and Middle Siwalik) and *Dorcatherium* (Middle Siwalik, progressing to African *Hyaemoschus*), also *Tragulus* (Middle Siwalik, eastern branch).

Cervidae: two species of genus *Cervus* in Upper Siwalik beds.

Giraffidae. India is a center of the giraffes' development which proceeded during the Siwalik deposition; present here are representatives of all three sub-families:<sup>74</sup> *Paleotraginae* (*Girafokeryx* from Lower Siwalik beds); *Sivatheriinae* (*Bramatherium*, a number of species *Hydaspidotherium*, *Vishnutherium*, *Sivatherium*, *Indrathierium*) and *Giraffinae* (*G. priscella* Matth.) from Lower Siwalik beds, and *G. punjabiensis* Pilgrim from the Upper Siwalik. Present in Lower Siwalik beds also is a representative of *Palaemeryoidea* (*Propalaemeryx sivalensis* Lydekker).

Bovidae. Present in Middle Siwalik beds are representatives of genera *Gazella* (*porrecticornis* Lydekker), *Taurotragus* (*latidens* Lydekker), *Perimia* (*falconeri* Lydekker), *Boselaphus*

(*lydekkeri* Pilgrim), *Tragocerus* (*punjabicus* Pilgrim, *perimensis* Lydekker), and *Proleptobos* (*birmanicus* Pilgrim), with some of them now existing in Africa.

This is the general outline of the Siwalik fauna from South Asia, from the results of its latest processing. This fauna was developed in situ, to a considerable extent; it was a development center for some South Asian groups (Suidae, Giraffidae). Two stages can be differentiated, for the time being, in its Tertiary history - one related to the Chinji beds (Lower Siwalik); the other, to the Dhok Pathan beds (Middle Siwalik). A third stage is as young as the Quaternary (Upper Siwalik). Related to that is the triple division of the South Asian continental section.

As to the correlation of these sediments with the corresponding European and North American intervals, we have already mentioned that this cannot be firmly established, as yet.

In correlating the Siwalik and European faunas, the former should be assigned to a rather long interval, from Middle Miocene to the Pleistocene. The Miocene aspect of the Lower Siwalik fauna is expressed in the presence of various *Dryopithecus* species, *Hyaenodonta*, primitive cats, mastodons, *lystriodonts*, and other primitive pigs, *anthracotheria*, *Macrotherium*, and primitive Bovidae.

However, appearing in this fauna also is *Hipparion*, supposedly an immigrant from America, and a later one at that. This leads some authors to regard the Siwalik faunas as "relict," i. e. betraying their more ancient appearance.

Burma, the second area of the Hipparion distribution, yields very scarce material on the history of Hipparion fauna in South Asia. Here, Tertiary deposits form a narrow belt along the coast, and a wider belt in the central part, along the Irrawaddy valley.<sup>75</sup> In the beginning of the Tertiary, this was a marine embayment, gradually replaced by a river delta, with marine nummulitic and oyster beds changing to fresh-water deposits (sands, clays, conglomerates) carrying plant and vertebrate remains. On their basis, this section can be divided into several formations: present at the base, where fresh-water beds still occur in the marine, are the Pondaung beds, of the Upper Eocene; they are overlain by Oligocene and Miocene Pegu beds (see footnote 2, p. 14), and then by lower Irrawaddy beds - a thick sequence of red beds with a Hipparion fauna similar to that of the Siwalik Hills Dhok Pathan beds. Higher up, there are Pleistocene Upper Irrawaddy beds.

<sup>72</sup>E.H. Colbert. Siwalik Mammals in the American Museum of Natural History. Trans. Amer. Philos. Soc., N.S., XXVI, 1935, 29-36.

<sup>73</sup>W.D. Matthew. Critical Observations Upon Siwalik Mammals. Bull. Am. M.N.H., vol. LVI, art. VII, 1929.

<sup>74</sup>Colbert, 1935.

<sup>75</sup>E.H. Colbert. Fossil Mammals from Burma in the American Museum of Nat. Hist., Bull. Am. M.N.H., vol. 74, Art. VI, 1938.

Present in Lower Irrawaddy beds are: Equidae - *Hipparion antilopinum* Falc. et Caut.; Rhinocerotidae - *Aceratherium lydekkeri* Pilgrim; Suidae - *Tetraodon minor* Pilgrim; Giraffidae - *Hydasphtherium birmanicum* Pilgr., *Vishnutherium iravaticum* Lydekker; Bovidae - *Pachyportax latidens* Lydekker, and *Proleptobos birmanicus* Pilgr.

These are, briefly, the Hipparion fauna data obtained from Asia. As we have seen, Hipparion is accompanied by a definite "Hipparion fauna" of rhinoceri, proboscidea, giraffes, antelopes, some carnivores, etc. It differs from an older mammalian fauna accompanying *Anchitherium*, both morphologically - being a higher evolutionary stage - and ecologically - being related to different environment: its distribution was determined by the change from a predominantly forest Middle Miocene landscape to a steppe. Individual elements of the Hipparion fauna are genetically related to forms of a preceding fauna, although much of its origin is still obscure. While it is largely true that it was formed in Asia, the time of the appearance of this new and progressive steppe fauna and of Hipparion itself remains obscure.

In his time, Osborn<sup>76</sup> outlined the picture of the Hipparion distribution, from its beginning in both Europe and North America - at the end of the Miocene, in his opinion. In America, *Hipparion* appeared simultaneously with *Protohippus* (both forms being adapted to open steppes) as immigrants from the north - probably from British Columbia or North Asia - and both forms persisted along with representatives of their ancestral forms (*Merychippus* and the more ancient *Parahippus*) and with *Hypohippus*, the sylvan horse. *Hipparion* alone appeared in Europe and only in China was it accompanied by *Hypohippus*.<sup>77</sup>

New and abundant material has been collected in the last 30 years, and still the history of the Hipparion fauna is not quite clear. One reason for that is the lack of a comprehensive study of Hipparion remains to determine the sequence of its morphological changes;<sup>78</sup> another reason is

<sup>76</sup>Osborn. The Age of Mammals, 1910, pp.297, 299, 309, 332, 333, 471, 556.

<sup>77</sup>Osborn, 1910, p.279.

<sup>78</sup>The literature contains references (W.D. Matthew. Correlation of the Tertiary formations of the Great Plains. Bull. Geol. Soc. Amer., 35, 1924, 743) that American material of Hipparion is studied by Frick. However, no results of his work have been published, as yet.

<sup>79</sup>This American tendency for raising the age level of sediments is well expressed in the work of their Asian expedition which identified the forms collected as younger than they turned out to be later on, after a correlation with other Eurasian forms. It is enough to mention the Baluchitherium beds, first identified as Miocene and now dated as Middle Oligocene; the Tung Gur beds, allegedly Pliocene, turn out to be Miocene, etc.

<sup>80</sup>In the Haug tabulation, the Sarmatian culminates the Vindobonian stage divisible (reading upward) into the Helvetian, Tortonian, and Sarmatian substages.

<sup>81</sup>Corresponding to the Upper Sarmatian in Switzerland are fresh-water Molasse, of the Eningen beds with *Anchitherium*. The corresponding beds are missing in the Rhone valley (see above), possibly because marine conditions persisted here to the close of the Vindobonian.

the lack of coordination in stratigraphic scales of the Old and the New World.

In Europe the stratigraphy of Tertiary deposits has been compiled from marine deposits, in comparison with which the continental deposits presented a thin and broken sequence. In America, continental formations with a land fauna are not in contact with the marine, and their stratigraphy has been built up independently. As a result, it appears that the American time scale is somewhat raised, as compared with the European.<sup>79</sup>

In the Old World, too, even the most elaborate time scales are not free from elements which may be misleading: the freshening of the Mediterranean basin proceeded at different times in different places, and at different rates; this hampers the correlation, inasmuch as Pontian and Sarmatian deposits are named by their facial similarity rather than by their age.

The stratigraphic relationship of Upper Tertiary deposits in the former Mediterranean basin province is, briefly, as follows. In the Rhone valley of France, the marine Mediterranean section ends with the Tortonian; it is followed by the Pontian (transitional continental) representing (according to Haug) the upper part of the Middle Neogene (Middle Neogene - second half of the Miocene). They are followed by another marine interval (Plaisancian - Lower Pliocene), etc.

Related to Pontian deposits (i. e. Upper Miocene) of France is the Hipparion fauna.

East of there, beginning in the Vienna basin and perhaps as far as Switzerland, the Tortonian and Lower Pontian begin to be overlain by Sarmatian<sup>80</sup> brackish water deposits with a fauna of *Ceritae* and *Ervilla podolica*, followed by Pontian or Congeria beds, and then by beds with *Paludina*. Present along with the brackish water mollusk fauna in Sarmatian deposits is a vertebrate land fauna with *Anchitherium aurelianense* Cuv. and *Mastodon angustidens* Cuv. The overlying Pontian carries a Hipparion fauna.<sup>81</sup>

Sarmatian deposits with *Ervilla podolica* extend east of the Vienna basin, across the Pannonian basin which duplicates its structure (we do not go into the specific details of either); farther on, they are widely developed along the south margin of the Russian plain, in the Crimea, Caucasus, and farther east.

Here, the *E. podolica* beds are locally more marine than in the Vienna basin and are overlain by a thick section of the same nature. The *E. podolica* beds constitute a lower formation (Lower Sarmatian) of the Sarmatian basin in the Russian plain; they are followed by Middle Sarmatian (with *Maetra fabreana*) and Upper Sarmatian (with *Maetra caspia*) - by Meotian beds - and only then by the Pontian (Congeria). In the contemporaneous Pannonian basin, the Sarmatian (= Lower Sarmatian) with *E. podolica* was followed by thick Congeria (= Pontian) beds whose lower part<sup>82</sup> corresponds to Haug's Pontian (i. e. belongs to Upper Miocene), while the upper part - beginning with the Congeria rhomboidea beds - belongs to Upper Pliocene. Pontian deposits of the south Russian section begin with the Congeria rhomboidea beds, i. e. belongs to Lower Pliocene. By the same token, the Middle and Lower Sarmatian sections, as well as the Meotian, should be correlated with the Congeria beds of the Pannonian basin - or to Haug's Pontian stage; i. e. it belongs to Upper Miocene.<sup>83</sup> The Hipparion fauna appears here in Middle Sarmatian and is best developed in the Meotian.

We have discussed the stratigraphic relations of Upper Tertiary deposits of Europe, first to demonstrate that the Hipparion fauna occurs there in the Upper Miocene (of the present Europe; probably somewhat earlier in the former; second, in order to demonstrate the inconsistency of the view (Koenigswald) which - on the basis of an erroneous concept that our Upper Sarmatian is older than the Western European Pontian - seeks to deny us the presence of Sarmatian sites of the Hipparion fauna.<sup>84</sup>

Thus, according to the present stratigraphic concepts, Hipparion of the Old World is older than in North America where it is unknown before the beginning of the Pliocene. At the same time, it is a common belief that family Equidae developed in North America, while the Old World witnessed but periodic appearances of such immi-

grants as *Anchitherium*, *Hipparion*, and horse itself.

In the absence of a profound morphological study of Hipparion remains, which alone can clarify the sequence of its representatives in various provinces, all attempts to solve this problem are purely speculative.

There are two schools of thought on the migration paths of Hipparion. According to one (Pilgrim, Teilhard de Chardin, Stirton), Hipparion appeared in the Old World, at the close of the Miocene, as offspring of some representatives of *Merychippus*, which had migrated earlier to Asia; *Neohipparion* and *Nanippus* appeared in America, in the beginning of the Pliocene, from other representatives of the same *Merychippus*. That Miocene Hipparions of the Old World could not have had an American ancestor is well demonstrated (according to Pilgrim) by the status of knowledge of the American Tertiary continental section, which precludes the possibility of overlooking any Hipparion ancestors; on the other hand, the Asian Tertiary section is so little known that finding such ancestors is quite possible. Known from the Pacific coast of North America are Hipparions (*H. mohavense* Merriam) related to the Chinese; it is possible that they migrated from North Asia or Alaska. On the other hand, the most primitive American Hipparion *gratum* Leidy, supposed to be a missing link between *Merychippus* and Hipparion (Colbert) turns out to be *Nanippus* (Stirton) rather than *Hipparion*.

Consequently, this view holds as irrefutable that the oldest representatives of the Old World Hipparion belong to older beds than those containing the first American Hipparion. Several conclusions have been made on those premises - apparently plausible but in fact quite arbitrary and unsupported by actual data.

The second, and the most widely shared, view (Matthew, Colbert, Lewis, etc.) is based on the assumption that the entire history of Equidae ran its course in America, with Hipparion a migrant from there to the Old World. According to this view, the American origin of Hipparion has been corroborated by actual data, namely by the presence of form transitional from *Merychippus* to Hipparion.<sup>85</sup> The presence of the Old World Hipparion in beds older than those of

<sup>82</sup>V. Laskarev. Sur Équivalents du Sarmatien Supérieur en Serbie. 1924, Belgrad.

<sup>83</sup>A correlation table for Upper Tertiary deposits of Western and Eastern Europe was first presented by the late Academician Andrusov. It has been refined (as given here) by Prof. Laskarev.

<sup>84</sup>This concept is contradicted not only by the correlation scheme cited above but also by the presence in the U.S.S.R. of sites where sandstones with a Hipparion fauna are interbedded with marine deposits carrying an Upper Sarmatian fauna, such as the Eldar site, etc.

<sup>85</sup>It has been pointed out before that the association of *H. gratum*, the most primitive of this series, with genus *Hipparion* is open to argument.

America may be explained by the lack of concordance in the Old and New World stratigraphic scales. As a result, some authors (Colbert) quite boldly rename as Pliocene, the European Upper Miocene with the related and most ancient Hipparions of the Old World; the others (Lewis) seek to transfer the American horizons with first Hipparions to Upper Miocene.

At the present state of processing the paleontological material, both these interpretations are as arbitrary as the first view.

Unquestionably, this problem will not be solved without a painstaking study of old material and of new and more abundant paleontological and stratigraphic data, together with the working out of a number of theoretical principles of correlating marine and continental deposits.

As we have seen, some light on the history of the Hipparion fauna had been shed recently, particularly by the study of Chinese data. This is true at least for some elements of that fauna (rhinoceri, Proboscidea), while its main form, the Hipparion, remains inadequately known, with all the immense volume of material on it. A considerable portion of this material is in possession of the Soviet paleontologists who, therefore, fall heir to this difficult and responsible task.

A major contribution to the Hipparion history is one of Pilgrim's latest works<sup>86</sup> where he develops his views, given above, supporting them by a detailed analysis of the Siwalik faunas; in so doing, he correlates them with European faunas, zoologically rather than stratigraphically, as it was done before. We are especially interested in its description of the Chinji fauna.

As we have seen, the Chinji fauna is the oldest Hipparion-bearing fauna of Asia; in the U. S. S. R., such a fauna is as late as Sebastopol. In the Sebastopol fauna, however, we find along with Hipparion, a typical assemblage of the "Hipparion fauna" which, as such,<sup>87</sup> populates all of Asia and Europe, replacing an earlier fauna. This is the fauna where Hipparion appears for the first time.<sup>88</sup> The Chinji beds are overlain by the Nagri and then by the Dhok Pathan

formations. In the Dhok Pathan beds we already deal with a typical "Hipparion fauna." In their fauna, the Nagri beds are intermediate between the Nagri and Dhok Pathan. Consequently, the Dhok Pathan beds correspond to a time when the newly formed "Hipparion fauna" spreads widely and extremely rapidly throughout Europe.

A comparative study of Hipparion representatives from various horizons and provinces will thus constitute a check of the details of Pilgrim's tabulation.

Appearing in America was a form parallel to the Old World Hipparion (Neo-hipparion). Not to be ruled out, however, is the possibility of some Chinese Hipparions migrating to North America (H. richthofeni Koken) by way of Alaska, and their distribution in western states, as pointed out above.<sup>89</sup>

This is the present status of the history of "Hipparion faunas."

There are no other data than given above, for the history of various other faunas existing in the Pliocene (Bessarabian, Russillon, etc.) and including representatives of Hipparion; and what material there is has been processed to a much smaller extent than for older faunas. Like the lower boundary, the upper boundary of the Hipparion representatives' distribution, is obscure (the change from Hipparion to horse). The drawing of the upper and lower boundaries of the Hipparion distribution, along with establishing the consecutive development stages for this fauna, is the task for the future.

## LIST OF ABBREVIATIONS

|               |  |
|---------------|--|
| Am. M. N.     | American Museum Novitates              |
| Ann. M. N. H. | Annals and Magazine of Natural History |
| Ann. Pal.     | Annales de Paléontologie               |
| Bull. Ac. Sc. | Bulletin de l'Académie des Sciences    |

<sup>86</sup>G.E. Pilgrim. Are the Equidae Reliable for the Correlation of the Siwalik with the Cenozoic Stages of North America? Surv. India, v. 73, pt. 4, 437; pt. 2, 472, 1938.

<sup>87</sup>The Sebastopol fauna still is somewhat different, in its specific composition, from a typical (Meotian) fauna accompanying the Hipparion.

<sup>88</sup>Pilgrim believes that the Chinji fauna is contemporaneous with the European Grive St. Alban, or even younger, but in any event older than the Sarmatian (l.c., 1938, 462).

<sup>89</sup>In his subsequent work (Geol. Magaz., 1940, 1-27), Pilgrim tries to coordinate the American and European sections of Hipparion sites.

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|--------------------|---|---------------|---|
| Bull. Am. M. N. H. | Bulletin of the American Museum of Natural History            | IAN           | Izvestiya Akademii Nauk                           |
| B. S. N. M.        | Bulletin de la Société des Naturalistes de Moscou             | Mem. S. N. M. | Memoires de la Société des Naturalistes de Moscou |
| DAN                | Doklady Akademii Nauk   | Nat. Hist.    | Natural History                                   |
| G. M.              | Nat. History of Central Asia v. II, Geology of Mongolia, 1927 | Pal. Ind.     | Palaeontologia Indica                             |
| Yezh. R. P. O.     | Yezhegodnik Russkogo Paleontologicheskogo Obshchestva         | P. S.         | Palaeontologia Sinica                             |
|                    |   | Pr. S. G.     | Problemy Sovetskoy Geologii                       |
|                    |   | Tr. PIN       | Trudy Paleontologicheskogo Instituta              |

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## EDITOR'S NOTE

The complete monograph in which this paper by A. A. Borisiak appears has been translated. The remainder of the work consists essentially of A CATALOGUE OF LAND MAMMALS OF THE U. S. S. R., compiled by Ye. I. Belyaeva. The translation will be made available through the AGI Translations Office at a price and form to be announced.