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LATER SEDIMENTS OF THE DESERT BASINS OF CENTRAL MONGOLIA¹

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A preliminary notice of the discovery of Cretaceous and Tertiary strata, based on studies of a small sedimentary basin at Iren Dabasu within the first 265 miles of exploratory travel of the Third Asiatic Expedition, was published as No. 42, American Museum Novitates, August 7, 1922. The expedition subsequently covered approximately 3000 miles of scientifically unknown territory in Mongolia, crossing the Gobi Desert twice, reaching as far north as Urga, the capital, near the Siberian frontier, as far west as Sain Noin Khan and Tsagan Nor, and finally crossing the easterly range of the Altai Mountains with its bordering desert basins, in a side journey, as far south as the Gurban Saikhan. From these advance positions the return course was by a new route to Kalgan, nearly 1000 miles distant from the last general camp at Tsagan Nor. (See accompanying map for itinerary.)

Special and first attention was given to the later sedimentary strata which seemed to promise reptilian and mammalian fossils. But the continuous route study that was conducted by the geologic staff, no matter how rapidly or erratically the expedition moved, has given basis also for an outline both of the older geologic features, the structural and deformational detail of the later fossil-bearing sedimentary formations of the desert basins and of the still later physiographic history.

An advance summary of the stratigraphy of the later sediments is the purpose of this present statement. Other numbers are to be prepared, one for the older geologic features and one for the physiography.

The observations forming the basis of this study were made between April 19 and September 19, 1922 and cover the whole field season, including the work at Iren Dabasu already announced.²

I.—GENERAL GEOLOGIC FEATURES

Central Mongolia is structurally a series of later sedimentary basins underlain by a floor of more ancient rocks. These basins of later sedi-

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²No. 42, American Museum Novitates, August 7, 1922.

mentary strata are separated one from another by stretches of open ground where these same ancient floor-rocks form the surface. This floor has a very complicated structure, its members ranging in age from Archæan to Jurassic time. In mid-Mesozoic time, after repeated earlier mountain folding and extensive igneous activity, the region was peneplaned, and it is this old peneplane surface that has been warped and faulted to make the basins which hold the sediments of later age, now proven to be exceptionally good fossil ground.

Since that time the region has never been subjected to mountain folding again, but it has been deformed by warping and faulting more than once, and it is these successive disturbances that give the clearest breaks and the sharpest changes in the several series of later strata. Wherever the deformation is confined to gentle warping the strata lie almost flat. Here and there, however, deformation has been more violent, so that the earlier strata stand steeply tilted and beds of succeeding formations lie on their upturned edges.

In such places the latest beds are formed in part from the waste of the exposed portions of beds still lying immediately beneath, and the break thus made between two physically distinct series helps materially in marking and following important formational limits. Thus there are occasional sharp unconformities within the later series of sediments themselves, but the evidence of it is not general. In the same region there are places that show only obscure disconformity or no apparent stratigraphic break at all, so that one can not readily tell where the dividing line should be. This obscurity is all the more troublesome because a majority of the beds of the later series seem to be almost barren of fossils. Only here and there are fossils abundant or characteristic enough to serve as basis for age discrimination.

Thus, in the very best structural areas, some members of the stratigraphic succession are missing, whereas at the places least disturbed, which ought to exhibit the most complete stratigraphic column, the earlier strata are usually covered so deeply with successive sedimentary accumulations that it is quite impossible to find an exposed section of the underlying beds.

It was found also that sedimentation did not continue to the very present time, but was broken by a deformational epoch judged to be at about the close of the Pliocene. The Pleistocene, therefore, has been a period of erosion in practically all of the region traversed. Denudation processes of that time have not only stripped off all sedimentary cover from large areas of the old floor, but, incidentally, long-continued ero-

sion developed a new peneplane on the later sediments, and, within some of the basins, where deformation still continued, a new and comparatively deep dissection has been accomplished. This has given a typical badland topography in certain areas, where extensive exposures of basin strata can be seen.

After determining these facts about the geologic structure of the region, it was a comparatively simple matter to discriminate between the more promising and the less promising areas. The edges of active basins or the interiors of basins large enough to be affected by internal deformation are particularly suitable places for detailed study. The vicinity of areas of high relief, indicating as they do extensive deformation of the ancient rock floor, are also places with some of the desirable geologic elements. The simpler small warp-basins, not much disturbed, may carry just as important beds, but, unless these beds now form the surface or lie very near to the surface, there is little chance of seeing them, and only a small stratigraphic range is likely to be exposed.

The itinerary of the expedition led across many basins of this sort. These will be indicated in the forthcoming reconnaissance report. Some are only a few miles across from rim to rim and so little deformed that there is no apparent break in the monotonous relief of the slightly rolling country. Some also are not dissected at all. A few large basins, however, were entered, and one nearly a hundred miles across proved to carry later strata several thousand feet in total thickness. This lies just north of Baga Bogdo of the Altai mountain range. It proved to be especially prolific and helpful in both structural and paleontological returns. Here the party spent several weeks in working out critical points in the structure and stratigraphy of the later sediments and in making extensive collections.

In this basin a plainly marked unconformity separates a lower series of dinosaur-bearing sediments from younger, overlying, mammal-bearing strata. In addition to this, the successive warpings and internal deformations of the basins were such as to give most suggestive help in further subdivision and definition of the successive series of associated strata between the mid-Mesozoic peneplanation and Pleistocene conditions. These are represented in the accompanying tabulation. Corresponding or complementary occurrences at other places are included also under their locality designations. There is still too little certainty about their inter-relations to attempt closer correlation at the present time. As the fossil collections are worked over, and especially as larger collections are secured, it will undoubtedly be possible to make much closer correlation of these locality finds.

II.—STRATIGRAPHY OF THE LATER SEDIMENTS

By "later sediments" is meant all of the sedimentary formations that have accumulated in the deformation basins since the post-Jurassic penneplanation. The lower members total at least 2000 feet in thickness and carry fossil remains indicating Mesozoic age.

In certain localities there is above this Mesozoic series a distinct unconformity which separates these formations from overlying ones whose fossil content indicates Tertiary age. The total thickness of this uppermost series is at least 5000 feet in the Tsagan Nor Basin.

Although the Tsagan Nor Basin proved to be the most favorable of all for structural subdivision, altogether five distinct basins have contributed to the general summary of stratigraphic relations. The chief items of this subdivision and structural relation may be briefly indicated as follows:

1.—THE IREN DABASU BASIN

As indicated in the first communication, this basin is shallow, the beds lie practically flat, and the breaks between formations whose fossil content indicates wide difference in age are exceedingly obscure.

The geologic column covering this Iren Dabasu relation is as follows:

Uplift and Erosion					
Penneplanation					
TERTIARY	Miocene or later	Upper barren sands Rhinoceros gravels	The Houldjin Formation	The "Gobi Series" of Obruchev	
	Pre-Miocene	Upper barren sandstones Lophiodont-bed	Irdin Manha Formation		
Physical and Faunal Break					
CRETACEOUS	Upper barren members Dinosaur beds		Iren Dabasu Formation		
Great Unconformity					
PRE-CRETACEOUS	Old-rock floor, deformed, metamorphosed and penneplaned			Probably the Nan-k'ou Series of von Richthofen	

The lowest beds furnish abundant dinosaur remains and are certainly Mesozoic in age. Not more than 100 feet above the beds furnishing these dinosaurs lie a series of looser sandy strata and shales, in one member of which rhinoceros remains and the first bones of *Baluchitherium* were found. Twenty miles distant, but still within the same general structural basin, beds are exposed which furnish remains indicating that they are lower and of somewhat greater age than those furnishing *Baluchitherium* and rhinoceros, although they belong also to the Tertiary series.

2.—THE TSAGAN NOR BASIN

North of Baga Bogdo, a very prominent mountain group forming a part of the eastward extension of the Altai mountain range, there is a very extensive sedimentary basin not less than 75 miles across from north to south and of still greater extent east and west. It is in part a down-warped and in part a down-faulted basin which has suffered additional subsequent internal deformation. These later deformations have furnished particularly favorable structural conditions for tracing the major breaks and exposing nearly the whole of the stratigraphic succession.

For example, in the midst of the basin itself there are two smaller mountain blocks that have suffered uplift and have been involved in the distortion since the earliest beds were laid down. One of these is the Mt. Uskuk block, and on its borders a distinct unconformity can be traced between the beds forming the earliest series and all those of later age.

At a still later time, after more than 3000 feet of Tertiary sediments had been laid down on the eroded surface of the preceding series, this interior block suffered another deformation adjustment which turned these beds almost up on end along the chief flexure margins. Deposition continued, however, in the same basin somewhat farther to the south, between Uskuk and the Baga Bogdo border. It appears also that Baga Bogdo itself was raised to its maximum height during this later time, contributing much of itself to these latest sedimentary accumulations.

Subsequent peneplanation beveled off the upturned edges of the strata along the flexure lines and reduced practically the whole basin to a monotonous erosion level, remnants of which are still preserved with residual gravel cover so smooth that one can drive anywhere on them. But, still later, this peneplane was warped enough to cause complete rejuvenation of the streams and initiate a new cycle of erosion, which has extensively developed ravines, gorges, and typical badland topography

in the most favored localities, thus exposing all of these structural features that have been described.

The major formational units distinguished in this basin are typically developed in localities somewhat separated from each other. Thus a certain formation is best exposed in the Ondai Sair, another along the Hsanda Gol, and yet another in the hills of Hung Kureh. For convenience of reference these locality names are attached to the corresponding formational units, the chief characteristics of which are given below:

(a). *THE ONDAI SAIR FORMATION.*—This is a series of thin-bedded, slightly deformed sandstones and black paper shales. The sandstones range in color from white to buff or yellowish, but are rarely red. Although there are variations from this description, they are of little importance, because at every point in this area the rather coarse-grained, moderately indurated, cross-bedded and thin-bedded and plain sandstone beds are very prominent indeed, and alternating with them in much smaller amount are black, carbonaceous shales, some of which are of remarkably fine paper-shale quality. An occasional bed of shale has such a perfect structure that the laminæ split apart almost as true as the leaves of a book and have preserved in them remarkably delicate fossil forms.

The formation, therefore, is to be regarded as a sandstone-paper shale formation. It was noticed that in this locality the basal members are more persistently sandstones and that the uppermost members carry a larger proportion of paper shales. It is not at all certain, however, that these relations would hold for other areas.

Formations believed to belong to the same series, though probably not to the same horizon, found at several other places, were largely reddish sandstones. At one other place, however, nearly a thousand miles distant on the road between Iren Dabasu and Mt. Tuerin, a similar series of sandstones and paper shales was discovered. Although in that case there was not sufficient fossil evidence found to prove their age, they are now believed to belong to the same series and perhaps to the Ondai Sair horizon. Their petrographic similarity, considering the rarity of this type of sediment, is suggestive at least.

The fossil content of the Ondai Sair is as follows: a dinosaur of *Camptosaurus* type; rib of a large dinosaur; insects, including mosquitoes and butterflies; a small form of fish, probably *Lycoptera*; fragments of crustacea; and a thin-walled form of phyllopod crustacean, probably *Estheria*.

This indicates age at least as old as the Cretaceous, perhaps the Lower Cretaceous or Comanchian, rather than the Upper Cretaceous. In

this locality, at Mt. Uskuk, the series is sharply delimited by an unconformity, above which no fossils of this type are to be found; and it is limited also below by a much greater unconformity, beneath which lies folded strata with coal beds, conglomerates, and intrusives, all judged to be of Jurassic age, as well as many still older formations.

(b). THE HSANDA GOL FORMATION.—Along the Hsanda Gol, a dry, sandy stream-course leading from Mt. Uskuk through the Ondai Sair locality southward past Loh to the bottom of the basin of Tsagan Nor at the foot of Baga Bogdo, the finest series of Tertiary deposits thus far examined in the whole of Mongolia are exposed. They lie unconformably upon the uneven erosion surface of the Mesozoic Ondai Sair formation just described, and are deeply cut into by recent erosion, which has developed a fine badland topography for several miles along the course of the stream. This stream-course crosses also a strong flexure, along which the basin itself has been deformed, and there the earlier beds are turned up nearly on edge. It is possible, therefore, to examine and measure this formation in detail.

This whole succession of beds along the Hsanda Gol, from the base at Ondai Sair to the topmost beds at Loh, a distance of about fifteen miles, is here included in the Hsanda Gol formation. They are prevalently yellowish conglomerates and pebbly sands at the base, and vary greatly in quality. This type constitutes at least 800 feet of the lowermost portion of the formation. The succeeding members above include alternating beds of sands, marls, clays and clayey sands of variegated colors, chiefly red, yellow, and white, with no apparent system or uniformity of succession. The high colors are strikingly shown in the middle portion of the formation, where the badland structure is best developed, and where the most clayey and least hardened members occur. The uppermost beds are prevalently sands and clayey sands inclined to be reddish in color, some beds of which are fairly well indurated.

Altogether, a thickness of approximately 3000 feet has been measured and estimated from measurements, a large proportion of which has been inspected in detail.

The upper portion of the formation carries fossils. In certain layers fossils are abundant with many individuals but not very great range of forms. The middle and lower members are largely barren. In the lower third, the yellowish conglomerates, no fossils whatever were found. Higher in the series an occasional find was made, but only certain of the upper members were found to be prolific, and the age determination is based on them. The formation is judged to be of Miocene age. Whether

the whole thickness of 3000 feet to the very bottom is also Miocene is, of course, not known; but in the failure to find any physical break or any faunal evidence on which to base any other determination, we have chosen to regard the whole succession as a unit.

Thousands of fossil specimens were secured in this ground, particularly in the vicinity of Loh, ten miles downstream from Ondai Sair, and in the vicinity of the so-called Grand Gorge, a corresponding erosion exposure ten miles farther to the west. The forms recognized in the field, taken from these beds, are as follows:

Baluchitherium, a fine skull nearly five feet long, and other rhinocerids; rodents by the hundreds; artiodactyls; insectivores; and carnivores.

(c.) **THE HUNG KUREH FORMATION.**—In the very bottom of the basin of Tsagan Nor, between the lake itself and the foot of Baga Bogdo, still younger beds overlie those of the Hsanda Gol. They constitute a series of whitish and yellowish sands and clayey sands at the base, which are overlain by coarser, gravelly sands and conglomerates of great variety and thickness. These beds are not as well exposed as are those of the Hsanda Gol; and, on this account, the complete succession cannot be so well determined. It has been possible, however, to measure more than 1000 feet, and a reasonable estimate would be approximately 2000 feet in the type locality, the hills of Hung Kureh.

These hills stand above the average peneplane level and formed originally a low monadnock group which has been redissected by later erosion. On the extreme margin next to the mountain of Baga Bogdo the upper beds become coarsely conglomeratic. An exposure of 800 feet in total thickness occurs in the hills immediately facing the central canyons of the Baga Bogdo front.

As a whole, this series of beds which we regard as a single formation is almost barren. An occasional bed, however, does carry fossil remains. This is particularly true of the lowermost portion of the formation, within 200 or 300 feet of the base, where yellow, iron-stained sands and white sand beds are the prevailing type. There is apparently no real break in the succession, the conglomerates in this case marking the influence of the adjacent rising mountain mass of Baga Bogdo, which furnished alluvial fan type of materials to the adjacent basin sediments. These uppermost beds, therefore, may be appropriately referred to as alluvial fan conglomerates. They doubtless interlock with the finer sediments washed down from the opposite direction, derived from the erosion of simpler sediments within the deformed basin itself. It is this intermixture that constitutes the Hung Kureh formation.

Although the beds of this formation are not so prolific in fossils as are those of the Hsanda Gol, they are, nevertheless, sufficient to indicate a Pliocene age and include a wide variety of forms. We have, therefore, set off this member as the Hung Kureh formation, limited at the base by a conformable contact with the Miocene Hsanda Gol formation, and at the top by the present erosion surface.

In this region no deposits of consequence are preserved above the Hung Kureh formation. The Pleistocene, or at least the period following the deposition of the Hung Kureh formation, was a period of erosion; and no sediments are preserved except very insignificant accumulations of comparatively recent time along the stream courses, where the disappearing streams drop their load or where newer fans are reaching out from the mountain blocks.

The fossil content of the Hung Kureh, as identified in the field, is as follows: a few fragments of horse; a few bones and egg-shell fragments of a very large bird, probably *Struthiolithus*; a large cervid; mastodon; and rhinoceros.

3.—THE ULAN NOR AND NEIGHBORING BASINS

Eastward from Tsagan Nor for several hundred miles there is no mountain barrier. The Altai mountain range continues along on the south side, and at first glance the whole region to the north appears to be a single basin. If one follows it, however, with enough care to unravel its structural detail, it is found that the basin sediments are not continuous but that the ancient rock floor comes to the surface at several places, separating the region into individual, smaller basins. Thus it happens that on the north side of Artsa Bogdo, a hundred miles east of Tsagan Nor, there is another large sedimentary basin; and, one hundred miles still farther east, yet another. The dividing barriers are scarcely more conspicuous than the monotonous basin surface itself, but the sediments are not continuous. As would be expected from such circumstances, the sediments that do occur in adjacent basins are not necessarily of the same age or type. In the shallower basins there is good chance of finding the earlier formations, representing Mesozoic strata, and in the deeper ones one is almost certain to find both Mesozoic and Tertiary.

(a). THE ASHILE FORMATION.—Such conditions are found in both of the basins to the east. In that one lying to the north of Artsa Bogdo, at the locality known as Ashile, a series of reddish and buff, fairly well indurated sands and sandstones were found. Certain members of this series carry dinosaur remains, indicating Mesozoic age. This is the Ashile formation of the accompanying table.

(b) THE DJA-DOCH-TA FORMATION.—In the vicinity of Ulan Nor, at the locality Dja-doch-ta, along the Kwei-wa-ting Trail, a series of somewhat similar red sands and clayey sands were found, which again carried a rare species of dinosaur and a variety of undetermined fossil material. One entirely new form has been described recently by Granger and Gregory under the name *Protoceratops andrewsi*. Because of the strikingly different fossil content, these beds are also given a separate designation, and because of the very primitive character of the forms it is believed that they may well be lower and older than even those of Ondai Sair. This unit is, therefore, given the locality name, the Dja-doch-ta formation.

In the trip across the desert basin south of the Altai, between Artsa Bogdo and the Gurban Saikhan, a very similar series of reddish sandstones was encountered, and on the northern margin of the Gurban Saikhan uplift itself at least 600 feet of upturned conglomeratic and coarse cross-bedded sands are well exposed. No fossils were found at the Gurban Saikhan locality; and, on this account, there is no way to determine just how these beds may be related to others just described. They may deserve a descriptive name, such as the Gurban Saikhan conglomerates; but there is no way of placing them at any particular horizon in the column. Their physical character and general structural relations indicate close relationship to the Ashile and Dja-doch-ta, and they doubtless belong to the same group of Mesozoic strata referred to in this tabulation as the Shamo Series.

Most of the beds of this whole complicated basin region are barren, but here and there certain ones are prolific and tell essentially the same story. On the basis of these few finds these formations are all regarded as Mesozoic in age; and because of the difference between this material, both as to fossil content and rock quality, they are judged to be the equivalent of neither the Ondai Sair beds encountered to the west, in the Tsagan Nor Basin, nor the Iren Dabasu, farther to the east. The Dja-doch-ta beds at least are probably Lower Cretaceous in age.

In the Ashile formation were found a sauropod of very large size, and a dinosaur of *Camptosaurus* type.

In the Dja-doch-ta formation were found a few fragments of a bird, and an entirely new form of dinosaur, since described under the name *Protoceratops andrewsi*.

There are doubtless higher beds, some of which must be of Tertiary age, in these easterly basins; but at the places crossed by the Expedition none of these is well exposed and no collections could be made from them.

As the Expedition passed northward, keeping on the east side of Ulan Nor, sediments continued for more than seventy-five miles; but in this whole distance, which was covered in less than a day, no specific determinations could be made beyond the fact that the underlying rocks represent the later sedimentary series and must correspond closely with some of those already seen in more favorable localities.

4.—ARDYN OBO

South of Sair Usu, on the main Kalgan-Uliasutai Trail, several basins carry later sediments. The general nature of the formations can generally be seen, but only in two or three localities are there extensive exposures of these later sediments, where exploration would be certain to furnish good fossil evidence. Both the earlier, Mesozoic, and the later, Tertiary, series are represented and a few new forms were found whose significance is not yet determined.

One of the better localities is at Ardyn Obo. Here a great escarpment, surmounted by that inevitable guidepost of the desert, an Obo, stands 300 feet above the general level of the plain over which the trail passes; and for many miles the edges of the flat-lying strata are exposed. They are rather loose and slightly indurated sandstones and clayey sands of considerable variety of texture, quality, and color. In the upper members of this series of beds fossils were secured, the chief items of which are several fine specimens of rhinoceros and numerous fragments of turtles.

This content is judged to indicate mid-Tertiary age, not very different from that of the Miocene beds of Hsanda Gol, or the Houldjin formation of Iren Dabasu. It is not possible with the present evidence, however, to correlate the Ardyn Obo beds with either of the others, and it may very well be, indeed, that they belong to an entirely different horizon in the same series. It seems best, therefore, to preserve the locality name in the ARDYN OBO FORMATION.

5.—SHARA MURUN

A hundred miles farther south another basin carries fossiliferous strata. The sedimentary area is very large and the best exposures occur along the borders of a 200-foot escarpment. At this place were found titanotheres remains very like those found at Irдин Manha early in the summer, in the Iren Dabasu area. These seem to be, therefore, early Tertiary in age, perhaps as early as Eocene.

Still farther south, on the very borders of Kalgan, a great series of later sedimentary strata furnished a few reptile fragments. Too little work was done at these places to warrant further description or classification of beds. They deserve careful inspection.

SUMMARY

It appears from this listing of the formational units distinguished by locality and structural features that there are at least four formations of locality significance of late Mesozoic age, presumably Upper and Lower Cretaceous, and four formations belonging to the Upper Tertiary, including beds of Miocene and Pliocene age. The early Tertiary is much less fully represented, or else is represented by formations not yet furnishing adequate fossil criteria. Only the Irdin Manha formation, in the Iren Dabasu region, and the beds of Shara Murun, one of the basins on the Uliasutai Trail, have been placed earlier than the Miocene on fossil evidence. It may be, of course, that the lower barren beds of the Hsanda Gol are pre-Miocene also; but for this there is no direct evidence.

This is an additional reason for grouping these scattered formational units into definite series. There are no used or published terms that have suitable limitations for this purpose. Obruchev's "Gobi Series" was used by him to include all sorts of later sedimentary beds, without age distinction. Von Richthofen's term "Khan-Khai Beds" has been used in the same way for all of the later sediments, without more intimate discrimination.

Perhaps it is not advisable to disturb usages of this sort, which have at least the merit of being fixed. But, since these terms were not originally based on fossil evidence and have been used only as a convenient field term for general purposes, it may be permissible to continue to use them as good general terms for all of the later sediments as defined in this communication, and, when referring to smaller groups of formations or specific portions of the later sedimentary column, to make use of more accurately defined and delimited terms.

If this is done, the preference, perhaps, should be given to the term Khan-Khai, which is much the older one. But the error of interpretation involved in the name makes it less appropriate than Obruchev's Gobi Series. Von Richthofen thought that the name Khan Khai meant deposits of an evaporating sea and used it with that significance. None of these sediments, however, have such an origin. All are strictly continental in origin. On this account Obruchev's Gobi Series

is a much better term. Gobi means desert basin, and Gobi Series therefore is a very suitable name for the desert basin deposits.

It would be particularly appropriate if these older terms could be used for the larger divisions, corresponding to systems, leaving all other terms to be used for smaller groups and individual formations. In any case, there will be little cause for confusion if the significance of each is kept clear. With this object in view, the following terms are proposed for the smaller groups:

- 1.—The Tsagan Nor Series (Upper Tertiary).
- 2.—An unnamed series (Lower Tertiary).
- 3.—The Shamo Series (Upper Mesozoic).

The Tsagan Nor Series is intended to include formations of Pliocene and Miocene age, or the Upper Tertiary. To it belong the units already described as the Hung Kureh, Hsanda Gol, Ardyn Obo and Houldjin formations.

Another series ought to include the Lower Tertiary, or the pre-Miocene Tertiary. Thus far, the only formations classified in this series are the Irdin Manha and the beds of another basin, the Shara Murun, farther west. Others, however, are certain to be added as the work proceeds. Perhaps a better name than has yet been proposed for this series will be suggested by the coming season's work.

The Shamo Series is pre-Tertiary. It is intended to include the Cretaceous beds overlying the great unconformity above the folded and eroded Jurassic. The units distinguished in the field are the Iren Dabasu, Ondai Sair, Ashile, and Dja-doch-ta formations.

The geologic column showing these groupings and relations is given in the table, p. 15.

It is entirely likely that some of these separately designated formations overlap in time, so that the sum of all the thicknesses given is not an accurate statement of the total column. Making all due allowance, however, for such probability, it appears that no less than 6000 to 8000 feet of later sedimentary strata are accounted for in the complex series of later sediments lying above the great post-Jurassic unconformity in the Gobi region of Mongolia.

All of the formations named are distinguished by characteristic fossil content, but great thicknesses of strata that are barren are included with them. The region has proved to carry not only a prolific fossil fauna but one that is also of unusual scientific interest and significance; and the field is capable of furnishing immensely greater returns in this direction. All are of strictly continental type. No evidence of marine invasion was found anywhere.

		Quaternary		Uplift and Erosion	
		Peneplanation			
CENOZOIC	TERTIARY	Upper Tertiary	Pliocene	Hung Kureh Formation (<i>Mastodon</i> and <i>Cervus</i>)	2000'
			Miocene	The Tsagan Nor Series	Hsanda Gol Formation (<i>Baluchitherium</i> and rodents)
		Ardyn Obo Formation (<i>Rhinoceros</i>)		500' ±	
	Lower Tertiary	Oligocene Eocene		Houldjin Formation (<i>Rhinoceros</i>) and <i>Baluchitherium</i>	50' +
				Irdin Manha Formation (Lophiodont beds)	50' +
				Shara Murun Formation (Titanotheres beds)	
Unconformity					
LATE MESOZOIC	Upper Cretaceous	The Shamo Series		Iren Dabasu Formation (Dinosaurs)	150' ±
	Lower Cretaceous			Ondai Sair Formation (Dinosaurs and insects)	500' +
				Ashile Formation (Dinosaurs)	1000' ±
				Dja-doch-ta Formation (Dinosaurs)	300' +
Great Unconformity					
EARLY MESOZOIC	Jurassic		A great thickness of conglomerates, sandstones and volcanics		

 The "Khan Khai Beds" of von Richthofen
 The "Gobi Series" of Obruchev

The Expedition has found that later sediments of this general range are abundant in the Gobi region. They all occur in basin-like depressions, but not all are well enough exposed by later erosion to be open to examination. It has been our good fortune, however, to find excellent exposures of certain parts of the series.

The determined formations are so well distributed through the Upper Mesozoic and Tertiary column, and are related to the general

sedimentation and deformation history of the Gobi region in such a way as to promise ultimately a practically complete and continuous succession from Lower Cretaceous to Pleistocene time. Even the Pleistocene, which is an erosion blank in the Northern Gobi, ought to be represented in certain adjacent regions farther south and east, where deposition continued while these northerly basins were being peneplaned and re-dissected.