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GEOGRAPHICAL AND GEOLOGICAL DATA FROM THE POLISH-MONGOLIAN PALAEONTOLOGICAL EXPEDITIONS

(DOKUMENTACJA GEOGRAFICZNA I GEOLOGICZNA POLSKO-MONGOLSKICH EKSPEDYCJI PALEONTOLOGICZNYCH)

(Plates V—VII)

Abstract. — The localities, at which the field-work of the Polish Mongolian Palaeontological Expeditions was carried out in 1964 and 1965, are described. The position and morphology of each locality, as well as the way of approach are given in each case. Schematic maps of the localities, made with the aid of a geological compass are given, in addition to generalized geological profiles assembled on the basis of detailed profiles. On the maps and profiles, the main fossiliferous localities are shown. Localities in the Eastern Gobi, visited by the 1963 expedition, are not considered; only scarce, poorly preserved material was found there, and the expedition did not return in the following years. A glossary containing the names of all the localities visited, in both the original Mongolian and in English transcription, is given in form of an appendix.

INTRODUCTION

The present account contains descriptions of the localities at which the field-work of the Polish-Mongolian Expeditions was carried out during the years 1964 and 1965. Localities in the Eastern Gobi, visited during a reconnaissance expedition in 1963, are not considered here; then only fragmentary palaeontological specimens were collected in these localities, and field-work was not undertaken there in the following years.

As a rule, throughout this paper English transcriptions of Mongolian names are used. A glossary containing names in the original Mongolian is given in the form of an appendix. In the descriptions of localities, names given at the time of the expedition to denote the type localities are also used. All these names are shown on the included maps.

The geological profiles included were put together on the basis of detailed profiles. They are mostly generalized and show in only a general manner the lithologic types of beds exposed at a particular locality. The resistance to weathering of particular beds marked on the profiles is reflected in the morphology of the slopes.

The maps of localities were made with the aid of a geological compass. On these maps are shown the places from which larger fragments of skeletons and whole skeletons were taken, as well as the areas in which bones were collected.

The term "sayr", used by the authors throughout the text and on illustrations, denotes the dry beds of intermittent streams, characterized by flatness and evenness of the bottom.

Geographic co-ordinates and heights above sea-level are given on the basis of 1 : 200.000 or 1 : 500.000 topographic maps.

The Nemegt Basin as well as the localities Nemegt, Altan Ula, Khatan Khayrkhan, Khaitch, Nareen Bulak, Ulan Ganga, Boongeen Gol, Buylstyeen Khuduk, Khalyun and Tatal Gol are described by GRADZIŃSKI. The descriptions of the Tsagan Khushu and Naran Bulak localities are made by GRADZIŃSKI and LEFELD, that of Bayn Dzak by LEFELD, and those of Begger Noor and Altan Teli by KAŹMIERCZAK.

ACKNOWLEDGEMENTS

The authors acknowledge their gratitude to Dr. MALCOLM C. MCKENNA (American Museum of Natural History, New York), for sending a topographic map of the Bayn Dzak area, made in 1925 during the American expedition organized by the Museum of Natural History, and for permission to publish it and for sending F. K. MORRIS' Field Notebooks. To the Mongolian palaeontologists N. DOVCHIN, D. DASHZEVEG and R. BARSBOLD, thanks are due for supplying information as to the spelling of the Mongolian names, as well as for friendly co-operation in the field. The authors also thank Dr. A. ROZHDESTVENSKY (Palaeontological Institute of the USSR Academy of Sciences, Moscow), for information concerning the work of the Soviet expeditions.

NEMEGT BASIN

The Nemegt Basin (Text-fig. 1) forms the western part of a large intermontaine depression with parallel sides, in the southern part of Gobi Altai.

The basin is bordered in the N by the Gilbent Ula, Nemegt and Altan Ula horst massifs, and in the S by the Tost massif. Khoogsho, an isolated mountain with a characteristic coniform shape, dominates the eastern part of the latter. The Nemegt Basin is 35—45 km wide. The authors take the meridian of the mountain Tsumtsees Khayrkhan (100°12′) as the western border of the Nemegt Basin, while the meridian crossing the salt lake, at which the somon Gurvan Tes was situated up to 1964 (101°36′), forms the eastern limit of the basin. Within these borders, the basin extends from W to E for a distance of about 115 km. It should be emphasized, however, that the basin is open from the W, and that from the point of view of morphology, it extends a further 150 km towards the E.

Across the basin, and approximately along the 100°42′ meridian, runs the local water-shed. The dry beds of intermittent streams (sayrs) in the western part of the basin join to form a main sayr, running parallel to the axis of the basin, towards the E. The western part of the basin is drained by the main sayr, Ekheen Dzooganay Gol, which runs westwards in a longitudinal manner.

The bordering massifs which surround the basin are made up of a complex of older rocks (mainly Paleozoic): metamorphic schists and igneous rocks. The faults around the massifs are younger than the sediments of Upper Cretaceous and Paleocene ages which fill the basin. The ridges of the massifs are distinctly marked in morphology and usually coincide with the lines of the faults. From these ridges with decrease in altitude towards the axis of the basin, classically developed pediments occur.

In the northern part of the basin, within the area occupied by the pediments extending from the Nemegt and Altan Ula massifs, deep incisions eroded by intermittent streams are

in many places developed. The base of each of these is situated several to several tens of metres below the local level of the pediment. In these places close to the pediments, systems of numerous gorges, erosional ridges and monadnock-like hills are developed. These systems cover an area of several to several tens or more square kilometres. In the cliffs, sediments of Upper Cretaceous age are exposed.

The largest system of gorges on the pediment sloping down from the Nemegt massif is situated SSE of Khoboor peak, and was given the name of the Nemegt locality. Within a distance of over a dozen kilometres from this locality towards the W, N and E several smaller exposures occur.

On the S pediment of the Altan Ula massif, four distinct groups of exposures are clearly defined. From E to W, these are:

Locality Altan Ula I consists of a few shallow and weakly differentiated gorges, partly covered by sand dunes. In Soviet literature (ROZHDESTVENSKY,1953), this locality is given as Eastern Altan Ula.

Locality Altan Ula II: the system of gorges begins immediately at the foot of the massif, and the height of exposure in the northern part reaches 100 m, decreasing gradually towards the S. In the northern part of the gorge-system, is the "Dragon's Grave" investigated by Soviet expeditions in the years 1948 and 1949 (ROZHDESTVENSKY, 1953; MARINOV, 1957). This locality is called Middle Altan Ula in Soviet literature.

Locality Altan Ula III consisting of numerous gorges and a few erosional scarps.

Locality Altan Ula IV comprises gorges, separated from the Altan Ula III gorges by a distinct erosional depression, 2—3 km wide. From the W and NW, it is surrounded by a distinct, though strongly dissected scarp.

The Soviet expedition did not reach localities Altan Ula III and IV, and the gorges seen in the far distance were named Western Altan Ula (ROZHDESTVENSKY, personal communication).

Erosional incisions also occur in the pediment sloping down from the S towards the axis of the basin. In these incisions, sediments of Paleocene or Upper Cretaceous age are exposed.

In the middle part of the basin, about 2—4 km S of its axis, a fairly clearly defined erosional scarp runs longitudinally, beginning W of Gurvan Tes, and running westwards as far as the neighbourhood of Ulan Bulak. The scarp is not very strongly differentiated, and in places is not seen at all. In Soviet literature, this zone of exposures bears the name "Red Ridge" (Krasnaya griada) (EFREMOV, 1954; NOVOZHILOV, 1954).

In the western part of the Nemegt Basin (S of the Altan Ula massif), the main sayr of this part of the basin, Ekheen Dzooganay Gol, as well as the sayrs joining it from the S, are as a rule strongly cut into the uppermost pediment surface. A younger, lower pediment surface, making contact with the local erosional base of the bottom in the main sayr, is distinctly marked in this part of the basin. Exposures are seen in the walls of the gorges and in the slopes of the erosional scarps, forming the edge of the lower pediment level, as well as in the sides of monadnock-like hills occurring at this level.

Southwards from the exposures of Altan Ula II, III and IV, a large erosional depression occurs, approximately 6 km in diameter. Two large sayrs lead towards the NW from this depression into the main sayr of Ekheen Dzooganay Gol, while a third sayr extends towards the WNW. The eastern and central parts of the exposures situated within the range and on the ridges of this exposure make up the Ulan Bulak locality, while the western part, situated round the section of the third sayr mentioned, is named the Naran Bulak locality. In both localities, Paleocene sediments are exposed, from beneath which Upper Cretaceous sediments appear towards the NNW.

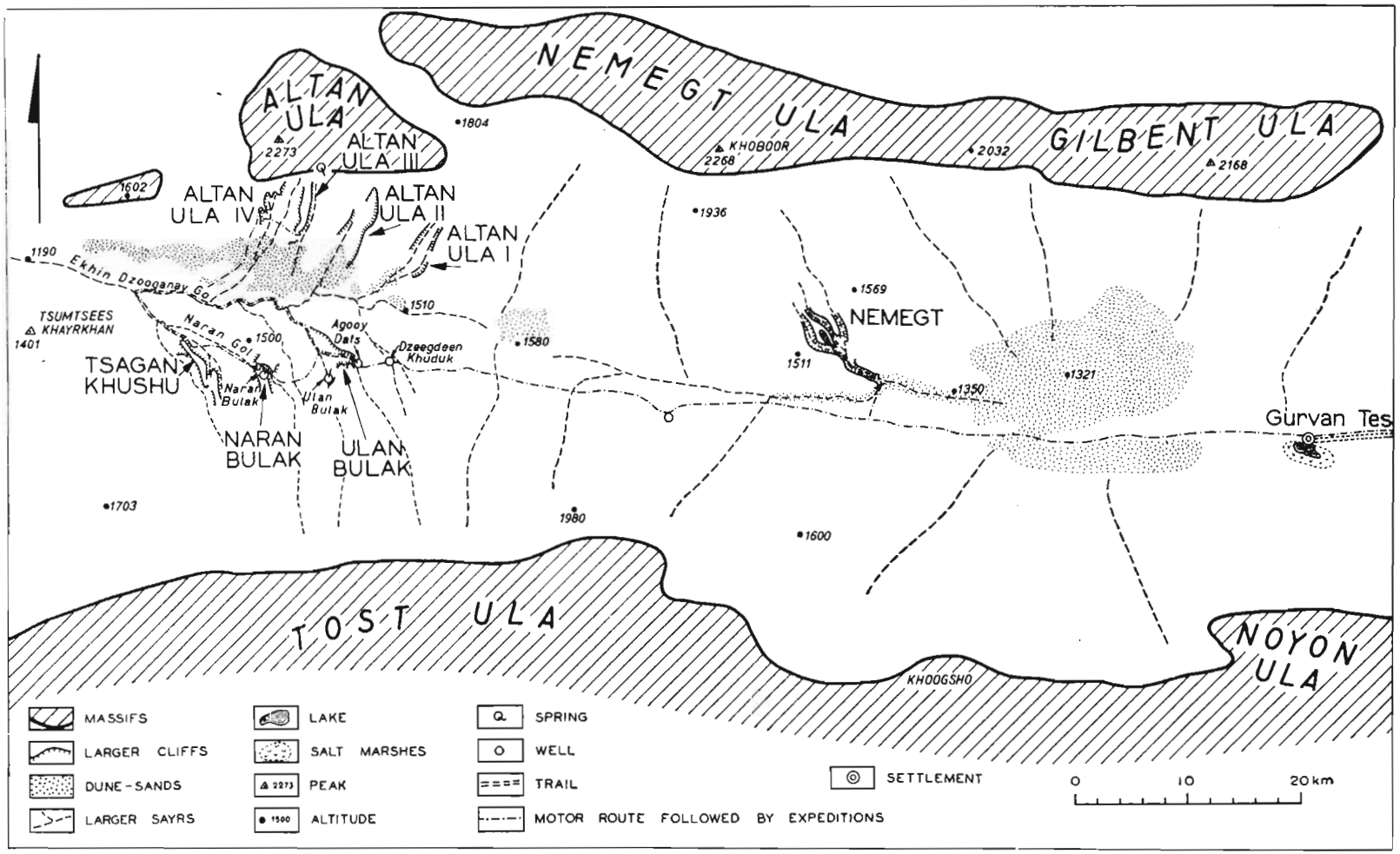

Fig. 1
Sketch-map of Nemegt Basin.

At a distance of about 4 km westwards from the exposures of the Naran Bulak locality, behind a distinct depression (the lower level of the pediment), the exposures of Tsagan Khushu begin. They extend for nearly 5 km towards the NW and end in a characteristic, narrow, monadnock-like ridge. The SE part of the exposures is composed of Paleocene sediments, while in the NW part sediments are of Upper Cretaceous age.

The Upper Cretaceous sediments in the whole area of the Nemegt Basin are defined by the authors as the Nemegt Beds. They are divided into two groups: the Lower Nemegt Beds and Upper Nemegt Beds. They differ in lithology as well as in fauna. The Upper Nemegt Beds represent the zone of *Tarbosaurus bataar* (MALEYEV), *Saurolophus angustirostris* ROZHDESTVENSKY and *Dyoplosaurus giganteus* MALEYEV. The fauna in the Lower Nemegt Beds (which underlie the Upper Nemegt Beds), is very scanty, consisting of fragments of the shells of dinosaur eggs, a few fragments of lizard skulls and a few remains of small dinosaur bones. As these remains are not so far identified, it is impossible to define the Lower Nemegt Beds as a faunal zone. The fauna in the Upper Nemegt Beds indicates that they are of Campanian or Maastrichtian age.

The Lower Nemegt Beds are lithologically similar to the red sandstones of the Djadokhta Formation from Bayn Dzak, the latter being of Turonian or Santonian age (see KIELAN-JAWOROWSKA, 1968). It is possible that the Lower Nemegt Beds are contemporaneous with or somewhat younger than the sandstone of the Djadokhta Formation.

The lower complex is exposed in the eastern part of the Nemegt locality and further eastwards it corresponds to EFREMOV's (1954) "Dumb Series" ("Nemaya tolshcha"). The upper complex is characterized by the occurrence of dinosaur bones. It is exposed in the western part of the Nemegt locality, as well as the areas situated further westwards in the Altan Ula and Tsagan Khushu localities, and also in the central part of the western section of the basin. The Upper Cretaceous sediments of the whole Nemegt Basin dip at a fairly small angle to the SSW. From this, it may be presumed that in the series of localities, situated successively towards the W, increasingly younger elements of the upper complex are exposed. However, it is not possible to exclude completely the influence of vertical displacements caused by younger faults.

The Paleocene sediments in the western part of the Nemegt Basin dip at a fairly low angle southwards. In vertical profile, they are divided into four series, distinctly differentiated in lithology, defined by the authors (see p. 55) as: 1) the Pink Beds, 2) the Lower Red Beds, 3) the White Beds, 4) the Upper Red Beds. The occurrence of these series permits the correlation between Naran Bulak, Tsagan Khushu and Ulan Bulak.

Soviet authors (EFREMOV, 1954; NOVOZHILOV, 1954), on the basis of the fauna found in the sediments of the White Beds, assigned the Tertiary sediments in the localities mentioned to the Eocene. The preliminary determinations of the fauna, found in these sediments during the Polish-Mongolian Palaeontological Expeditions, indicate that the Tertiary sediments exposed in the zone of the western part of the Nemegt Basin, extending from the Ulan Bulak region, through Naran Bulak to Tsagan Khushu, are contemporaneous with those from Khashaat. It is still an open question whether these beds are of Upper Paleocene or Lower Eocene age. In the present paper they are provisionally referred to as Paleocene (see also KIELAN-JAWOROWSKA & DOVCHIN 1968, p. 16). The sediments of the White Beds may be referred to as the zone of *Archaeolambda planicanina* FLEROV, *Pseudictops lophiodon* MATTHEW, GRANGER & SIMPSON, *Paleostylops iturus* MATTHEW & GRANGER.

The route to the Nemegt Basin followed by the Polish-Mongolian expedition led along the trail from Dalan Dzadgad, the centre of the Southern-Gobi aymak through Bayn Dalay and Tsagan Derseen Khure to the salt lake, at which up to 1964 was the centre of the Gurvan Tes Somon.

From there, the road (see Text-fig. 1) to the localities situated in the basin led westwards along a poorly marked trail first of all (about 25 km) along the northern ridge of sands, filling the central part of the basin and next along the northern part of the "Red Ridge".

About 82 km in straight line from Gurvan Tes, the route leads to Dzeegdeen Khuduk well, situated at the bottom of a large sayr. The main sayr of Ekheen Dzooganay Gol and the further to the exposures of Altan Ula I and II may be reached by travelling NW along this sayr.

The main route to other localities in the western part of the basin leads further W (about 3.5 km) and next to the NW (1 km); near the Agooy Dats spring it descends to the bottom of the sayr and continues along the bottom to the point, where it meets the sayr running from the Ulan Bulak (Ulan Dats) spring. From this point across towards the SW, and later westwards, leads the track used by the 1964 expedition. This leads to the big sayr Naran Gol. The further section of this divides the region of exposures belonging to the Naran Bulak locality. The NW limits of the Tsagan Khushu exposures are reached by driving down the sayr towards WNW (5 km from the Naran Bulak spring), and further 4 km across to the W.

The road to the locality Altan Ula IV used by the expedition led all the time downwards along the sayr from the Agooy Dats spring and afterwards down (a little less than 10 km) along the main sayr Ekheen Dzooganay Gol and then up the pediment.

LOCALITY NEMEGT

Location and morphology

The main exposures grouped under the general heading of Nemegt locality is situated in the central part of the pediment, which slopes towards the S from beneath the Nemegt massif. It extends between 101°02′—101°31′ longitude E and 43°28′—43°31′ latitude N at a height of 1450—1550 m above sea-level.

The pediment is here cut by several major gorges and numerous side-gorges, ranging from several to 45 m depth. Towards the SE, they join into one broad (1—2 km) sayr, which leads to the main longitudinal sayr of this part of the Nemegt Basin.

The area of greatest concentration of gorges is about 3 km broad and nearly 5 km long, extending NW-SE. A large part of this area was covered by the investigations in the summers of 1964 and 1965 (Text-fig. 2).

The great Western Sayr bounds the area in the W and SW. Further to the E, behind a distinct erosional ridge is situated the short but broad Central Sayr. Above the ridge bordering the area from the NE rise two monadnock-like hills, the Great Pyramid and Reconnaissance Hill. To the N and E of the ridge lies the large Northern Sayr, which extends to the broad plain of Saksaool Field. The Red Walls, a high dissected scarp, border this field to the N. At the

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Fig. 2

Map of locality Nemegt. Skeletons indicated by numbers:

1 — almost complete, but poorly preserved skeleton of small *Tarbosaurus* sp. (about 4.5 m long); *2* — almost complete skeleton of large *Tarbosaurus bataar* (MALEYEV); *3* — incomplete skeleton of a small representative of *Tarbosaurus* sp.; *4* — incomplete tail of a small (about 2 m long) ornithomimid dinosaur; *5* — partial pelvic girdle of a large ornithomimid dinosaur; *6* — almost complete sauropod skull (65 cm long), *7* — separate, fragmentary bones of an ornithomimid dinosaur, *8* — skull and partial post-cranial skeleton of a new ornitischian dinosaur, *9* — incomplete hind limbs of a comparatively large (about 4 m long) ornithomimid dinosaur, *10* — fragmentary backbone of *Tarbosaurus* sp., *11* — hind limbs and incomplete tail of a comparatively large (about 4 m long) ornithomimid dinosaur, *12* — left hind limb and partial pelvic girdle of a large representative of *Tarbosaurus bataar* (MALEYEV),

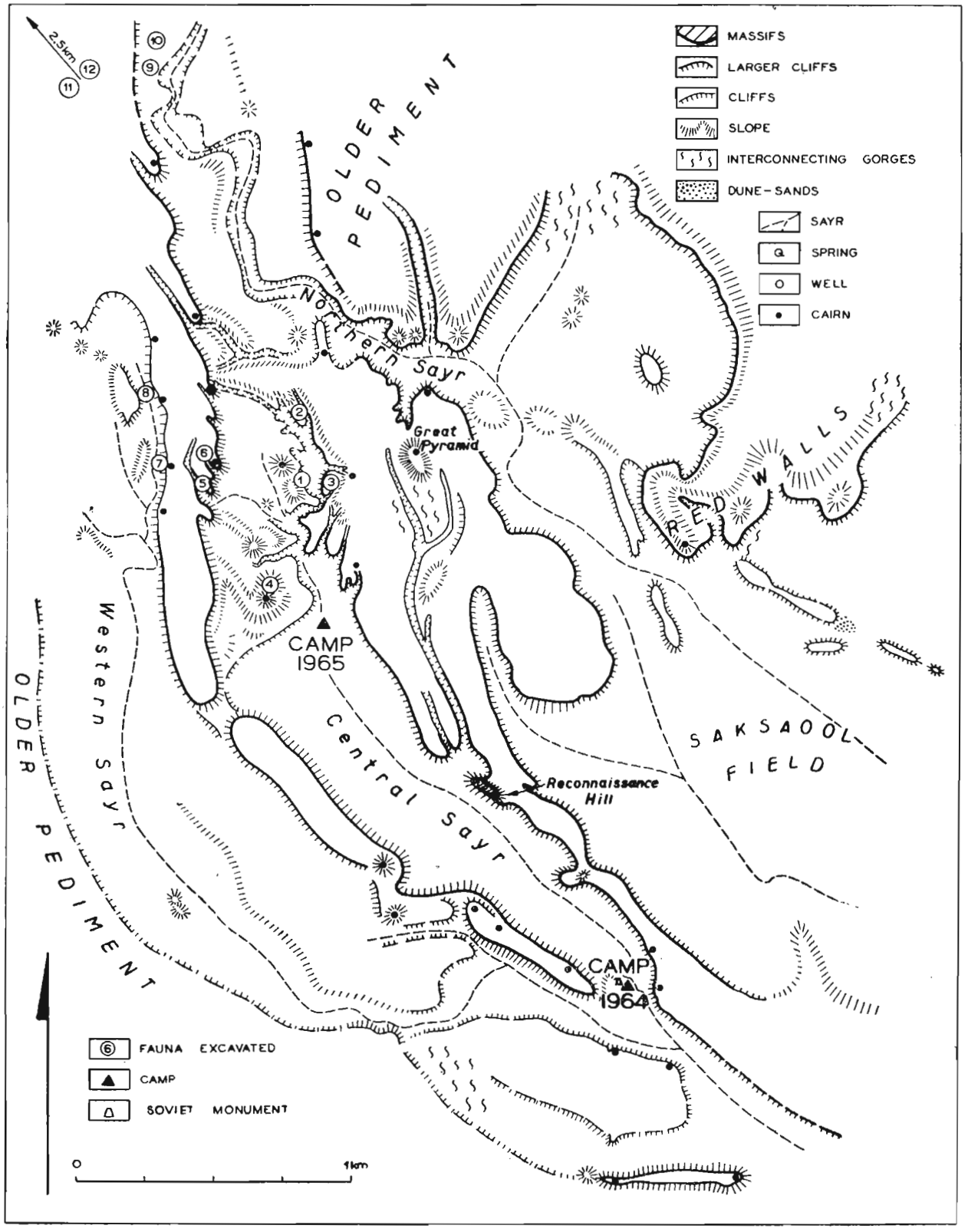

2.5km
MASSIFS
LARGER CLIFFS
CLIFFS
SLOPE
INTERCONNECTING GORGES
DUNE-SANDS
SAYR
SPRING
WELL
CAIRN
OLDER PEDIMENT
Northern Sayr
Great Pyramid
RED WALLS
CAMP 1965
Western Sayr
Central Sayr
SAKSAOOL FIELD
Reconnaissance Hill
CAMP 1964
OLDER PEDIMENT
FAUNA EXCAVATED
CAMP
SOVIET MONUMENT
0
1km

Fig. 2

eastern end of the scarp, a large Eastern Sayr leads on to the Saksaool Field beyond the limits of the plan. In the southern part of the field, the Western Sayr (with the Central Sayr), the Northern and Eastern Sayrs join together, forming one broad sayr, which after 5 km joins with the main sayr of this part of the basin. Directly W of this point, an exposed cliff facing southwards rises to a dozen or more metres in height, and can be seen from the motor-route Gurvan Tes — Ulan Bulak, as a fine point of reference.

The way of approach to the Nemegt locality leads from Gurvan Tes towards the W (see p. 37). After about 40 km it was found necessary to drive off the track directly northwards, in the direction of the exposure mentioned above, and to continue on its eastern side into a broad sayr and along this latter (first towards the NWW, and later towards the NW) to the southern part of the Saksaool Field. From here, the route followed swings westwards along the bottom of the Western Sayr. The route provides no difficulties for field-vehicles and is accessible for one-wheel drive cars.

History of research

The exposures of the Nemegt locality were discovered in 1946 by the first reconnaissance expedition of the USSR Academy of Sciences, and next were investigated during the following expeditions in the years 1948 and 1949 (EFREMOV, 1954).

In summer 1964, the Polish-Mongolian expedition worked here from 13 to 27 July, and in summer 1965, from 29 July to 16 August. The excavation-work was carried out in the area covered by the plan (Text-fig. 2). Searches were made for fauna in the exposures of the Red Walls and in the monadnock-like hills in the southern part of the Saksaool Field. Furthermore, the area was surveyed over a radium of 10 km E and W from the camps and to the edge of the Nemegt massif.

Geology

The Upper Cretaceous sediments in the exposures of the Nemegt locality, as well as in its environs, dip gently to the SSW at an angle of $1^1/_2°$. On the other hand, the surface of the pediment has a dip of about $1^1/_2°$ towards S. Regarding this, the older, lowerlying beds are exposed in the NE part of the locality, and the younger beds in the SW part. The observations made show that the section given by EFREMOV (1954, p. 18, Fig. 4) is incorrect.

In the Nemegt locality are exposed Upper Cretaceous sediments which represent the higher part of the complex of the Lower Nemegt Beds and the lower part of the complex of the Upper Nemegt Beds (Pl. V, figs. 1—2). In the area covered by the plan, a vertical profile of sediments, about 85 m (Text-fig. 3) in total thickness can be seen. In the profile, three series of sediments differing in lithology are distinguished. The lowermost series belongs to the complex of the Lower Nemegt Beds, while the Passage Series as well as the Upper Series belong to the complex of the Upper Nemegt Beds.

The lowermost series consists mainly of fine-grained sandstones, sometimes mudstones. They form beds of thickness varying within the limits from several scores of centimetres to 3 metres, and are separated by markedly thinner beds of mudstones, generally sandy. The sandstones have a brick-red colour, while the mudstones are of somewhat darker reddish-brown colour. Because of relatively extensive consolidation, the sediments of the series described, as a rule, form very steep and often completely vertical walls of gorges, and on the slopes of monadnock-like hills, they are in some places strongly cut by erosional furrows. The sediments of the lower series are exposed in the lower parts of rocky faces in the N of Saksaool

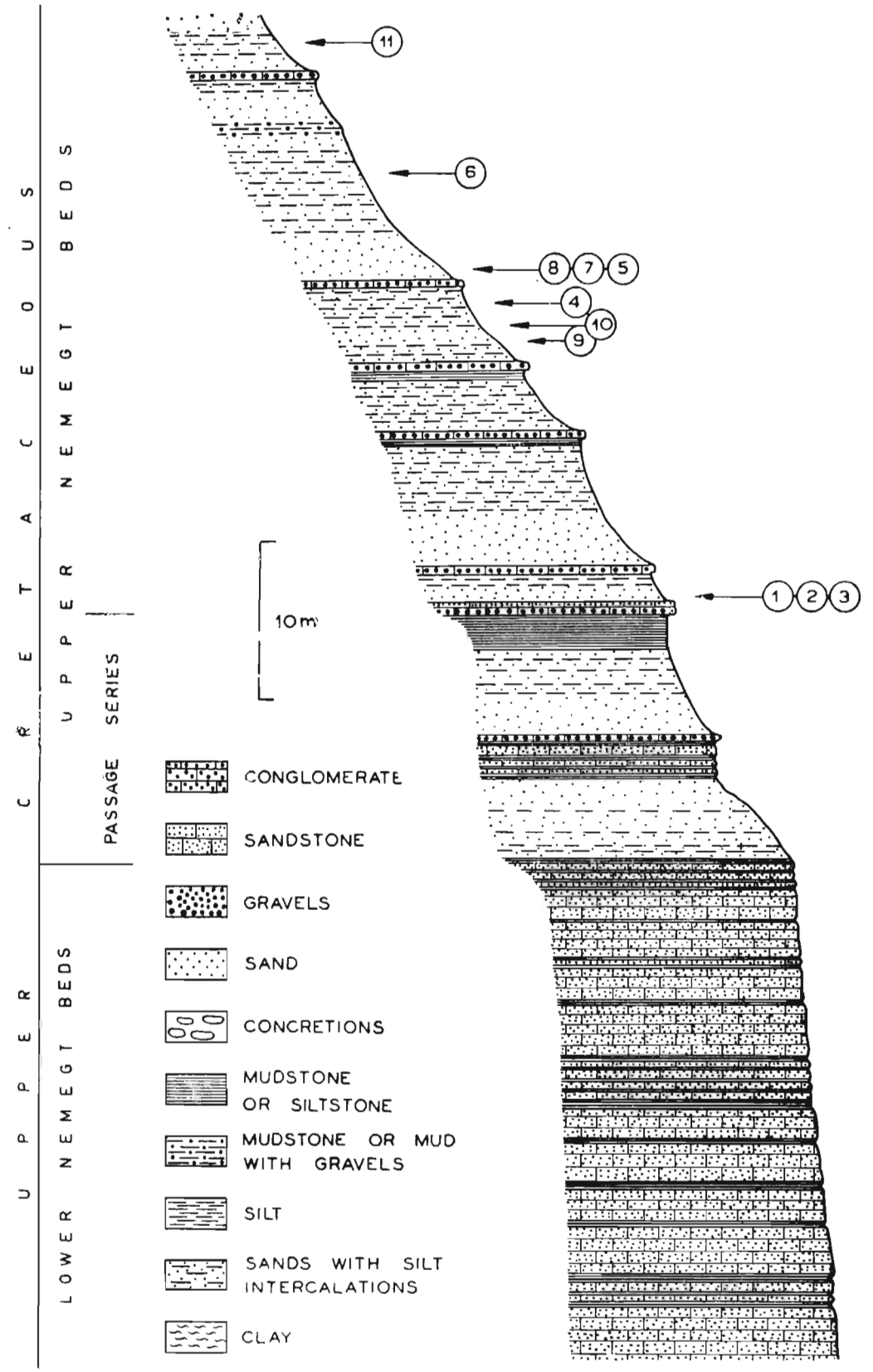


Fig. 3. Geological profile of Upper Cretaceous sediments at Nemegt locality. For explanation of numbers, see Fig. 2, p. 39. (Skeleton 12 — near 11).

Field and in the Northern Sayr. The observed thickness of the series in the Nemegt locality is about 30 m, though no doubt the true thickness is much greater.

The Passage Series in the Central Sayr region is 16 to 18 m thick. It consists of beds light in colour, with yellowish, fine and medium-grained sands and siltstones, greenish and beige silts, as well as beds of red mudstones. Furthermore, there also occur here thin (of several tens of centimetres) beds of intraformational conglomerate or gravel consisting mainly of siltstone and mudstone pebbles and small limestone concretions. In addition to the sediments mentioned, in the Passage Series, there are also developed single beds and lenses of sandstone and mudstone beds, lithologically identical to those of the lower series. All the beds of the series described above show a great horizontal variability, marked either in wedging out of beds or in considerable, lithological changes along the lateral extent of beds. In a NE direction, the thickness of the whole series decreases, and at the same time the number of beds of Lower Series--type increases. Some parts of the sandstone and gravel beds are cemented by $CaCO_3$, forming beds of sandstones and conglomerates several or several tens of centimetres in thickness. In the morphology such beds are clearly marked in the form of characteristic shelves (denudation terraces on the steep slopes of the gorges). Usually sands and sandstones exhibit cross-bedding of trough type.

The Upper Series is characterized by the absence of sandstone and siltstone beds of lower series type, as well as by the presence of only a few, relatively thin beds of red mudstones. Fine and medium-grained sands, containing in some places thin intercalations of intraformational conglomerates or gravels, muds, silts and sometimes siltstones, clearly predominate here. The colours and the lithological character of the sediments are identical with these of the Passage Series. Cemented beds of sandstones and conglomerates also occur here. The observed thickness of the sediments in the Upper Series is about 35 m in the region of the Nemegt locality.

The Passage Series is exposed in the upper part of the Red Walls, on the slopes of the Northern Sayr and in the lower part of the slopes of the Central Sayr. The upper series is mainly exposed in the upper part of the slopes of the Central Sayr, as well as in the Western Sayr.

Fragments of dinosaur bones occur in the light-coloured (mainly sandy and gravel) beds of the Passage Series. The principal occurrence of bones and above all, complete skeletons of dinosaurs is present within the Upper Series. In the lower part of this series, a horizon may be distinguished, which yielded the majority of skeletal materials found by the expedition. The comparison of fauna is given in the explanations to Text-fig. 2.

LOCALITY ALTAN ULA IV

Location and morphology

The main concentration of gorges covers an area between 100°26′—100°28′ longitude E, and 43°34′—43°36′ latitude N, and is 1570—1700 m above sea-level.

Fig. 4

Map of locality Altan Ula IV. For morphological explanation, see Fig. 2, p. 39. Skeletons indicated by numbers: *1* — pelvic girdle of an unidentified, large, quadrupedal dinosaur, *2* — partial backbone of a carnivorous dinosaur, *3* — single, incomplete bones of an armoured dinosaur, *4* — almost complete skeletons of a huge sauropod dinosaur, about 20 m long, *5* — fragmentary tail of large individual of *Dyoplosaurus* sp., *6* — two incomplete skulls of *Tarbosaurus* sp., *7* — incomplete fragments of a skeleton of a large armoured dinosaur, *8* — partial skeleton of a small ornithomimid dinosaur, *9* — incomplete mandible of *Tarbosaurus* sp., *10* — partial skull of an armoured (?) dinosaur, *11* — partial pelvic girdle of large *Tarbosaurus* sp., *12* — partial skull of large *Tarbosaurus* sp.

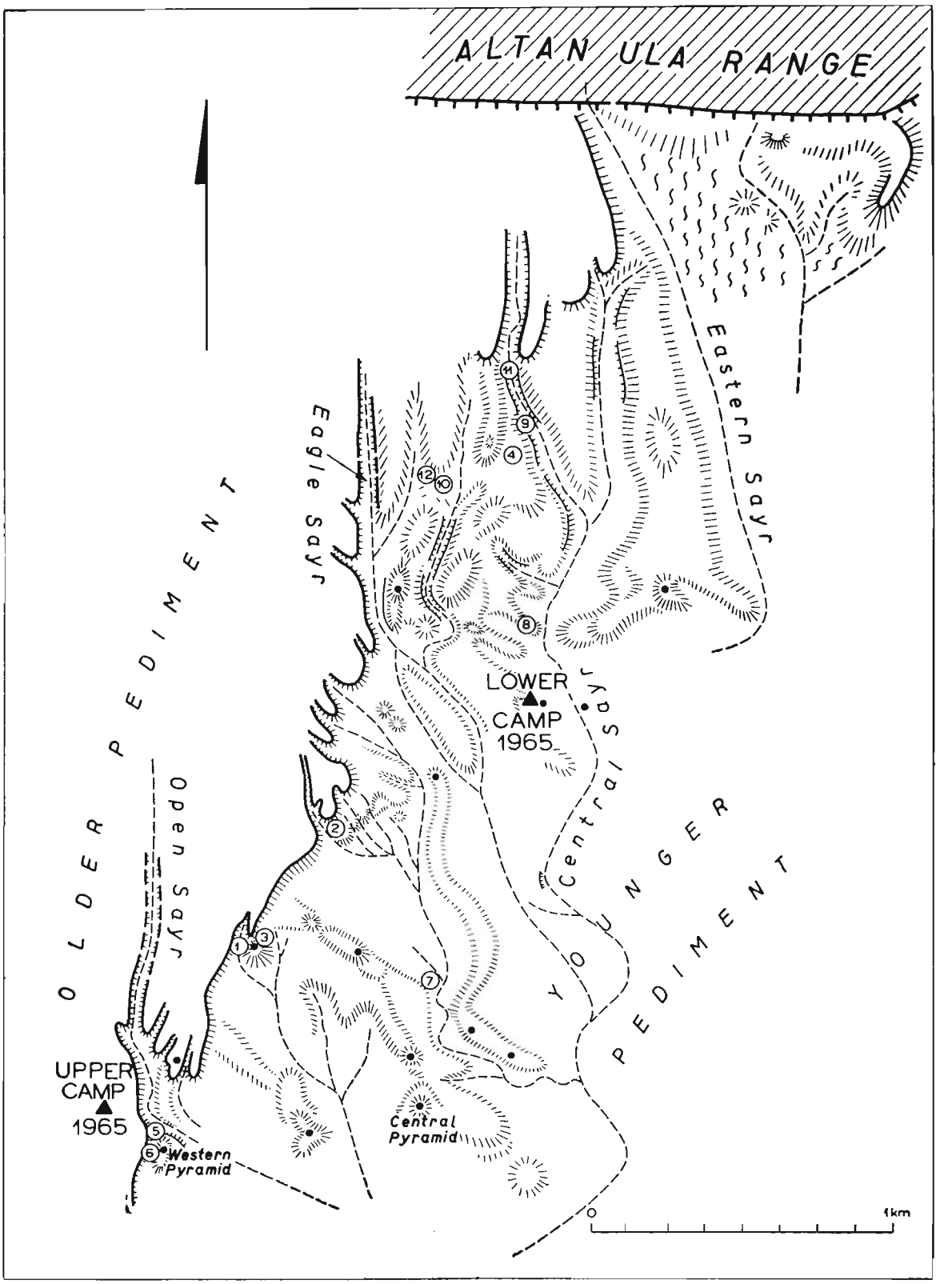

ALTAN ULA RANGE
Eastern Sayr
Eagle Sayr
Open Sayr
Central Sayr
OLDER PEDIMENT
YOUNGER PEDIMENT
LOWER CAMP 1965
UPPER CAMP 1965
Western Pyramid
Central Pyramid
1km

Fig. 4

The Altan Ula IV locality is the most westerly group of gorges, cut into the pediment at the foot of the Altan Ula massif. Further to the W spreads the relatively flat, unexposed surface of the pediment. In the eastern part of the locality, the exposures begin directly on the edge of the massif, and in the western part at a distance of a few hundred metres from the edge.

The main sayr leading from the exposures to Ekheen Dzooganay Gol sayr is closed in its lower part by a zone of sands and dunes. This zone extends longitudinally with respect to the main basin in the lower and central parts of the pediment, forming a major obstacle on the route to localities Altan Ula III and IV.

The erosional scarp of the pediment runs from NNE to SSW and is cut by successive, larger and smaller gorges. Beyond the pediment scarp extends a large, erosional depression (the lower level of the pediment) in which monadnock-like hills and ridges occur.

The work of the expedition was carried out in an area extending from beneath the foot of the massif southwards for a distance of about 3.5 km and 2.5 km in width (see Text-fig. 4). The height of exposure in the slopes of the gorges and the sharp-crested hills here reaches usually from a dozen or more to 40 m, while somewhat bigger exposures are found only in the NE part of the locality.

The lower level of the pediment is accessible by car along the first larger sayr from the western side. This sayr was called the Open Sayr. Directly to the S from its mouth, at a distance of 70 m from the scarp of the pediment (older pediment), is a prominent hill, the Western Pyramid. Large gorges, occurring in succession towards the NE, are the Eagle Sayr and the Central Sayr.

The route followed to the locality led from the Agooy Dats spring (see p. 38) down along the bottom of the sayr to the Ekheen Dzooganay Gol sayr, and then 10 km westwards along its bottom. From here the track turned upwards, first towards ENE and then to NE and N; after about 11 km it led to the upper camp. The greatest difficulty to be overcome in last section of the road is the zone of sands and dunes occurring halfway. This part of the route may be crossed only in field-vehicles with experienced drivers at the wheel. The track to the lower camp led further along the surface of the pediment 1.5 km northwards and next down to the S along the bottom of the Open Sayr, then across, passing from the S around the sharp-crested hills (Central Pyramid) and upwards, northwards along the Central Sayr.

In the course of work, water was taken from Dzeegdeen Khuduk well (see-Text-fig. 1, p. 36).

History of research

The locality Altan Ula IV was investigated for the first time during the reconnaissance on 6 July, 1964, and the fragments of skeletons found then were excavated on 10 and 11 July. The main work was carried out by the expedition in 1965 in the period 8 June to 27 July 1965.

Geology

The Upper Cretaceous sediments in the exposures of locality Altan Ula IV dip towards SSW at an angle of $1^1/_2°$. The inclination of the surface of the pediment is about $1^1/_2°$—2° towards S.

A vertical profile of sediments of about 75 m total thickness may by seen in the exposures. The slopes in the northern part of the Central Sayr form the profile, in which the greatest thickness is seen (Text-fig. 5).

The whole complex of sediments shows great variability, both laterally and vertically, and on the basis of lithological features it was not possible to recognize subdivisions, which

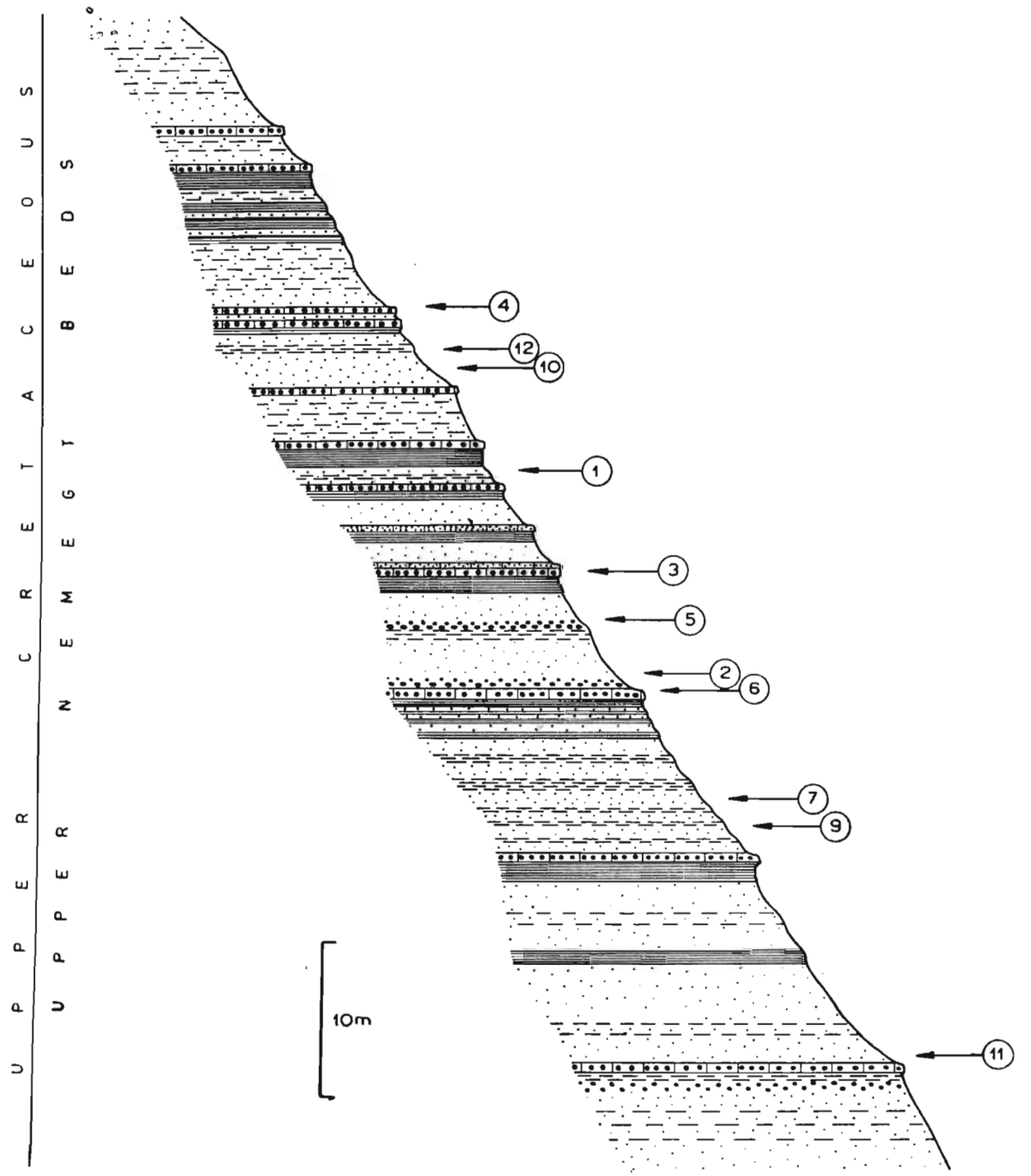


Fig. 5
Geological profile of Upper Cretaceous sediments at locality Altan Ula IV. For explanation, see Fig. 3, p. 41. Skeletons denoted by numbers, for explanation, see Fig. 4, p. 43.

could be traced throughout the whole locality. It is only possible to distinguish these in the case of particular, closely situated exposures.

Light-coloured sands, silts and siltstones predominate in the Upper Cretaceous sediments in locality Altan Ula IV. There occur also mudstone beds, mostly red. Thin beds of sandstones and intraformational conglomerates are subordinate. Due their resistance, however, these sandstones and conglomerates stand out in morphology as characteristic rocky shelves and denudation terraces on the slopes.

The sands, as a rule, are medium and fine-grained, rarely coarse-grained, more or less feldspathic. They are light-coloured, yellowish, beige, yellow or red. As a rule, they are calcareous and contain silty materials. They form complexes of beds of total thickness ranging from one to a few metres. The thickness of individual beds is not great and fluctuates between several and several tens of centimetres. Usually, the beds show cross-bedding of trough type. In some beds of medium and coarse-grained sands, pebbles of siltstones and mudstones are present. The diametres of these range from a few millimetres to several cm, and even some tens of centimetres. In the lower parts of such beds often occur layers of intraformational conglomerates, in which besides pebbles of mudstones and siltstones mentioned, light-coloured, calcareous concretions predominate. The latter are more or less rounded and usually range from a few to a dozen or more millimetres in diameter.

Silts and siltstones occur mainly as thin intercalations with indistinct boundaries. They are greenish, light olive or beige in colour.

The mudstones form beds 0.5 to 2 m in thickness. They are greenish, grey or red. As a rule, in the mudstones randomly distributed white, calcareous concretions occur. Frequently, above a mudstone bed, lies a bed of intraformational conglomerate or sandstone with load structures on the sole surfaces.

Occasional, large pebbles of igneous and metamorphic rocks occur in some beds of sand with gravel and in some intraformational conglomerate beds.

The beds and whole complexes of beds in the sediments described are continuous only over relatively short distances, as a rule, wedging out over a dozen to several scores of metres. They display numerous, fairly shallow washouts. The greatest lateral extension is seen in the complexes of conglomerate and mudstone beds. In exceptional cases, they may be traced over a range of a few hundred metres.

The skeletons or larger skeletal fragments found by the expedition, as a rule, occurred in such a way as to bear a distinct relationship to the beds of gravelly sands or intraformational conglomerates. In such beds, the lower part of the skeleton was found, while the rest was enclosed in sediments of finer grained fraction. Single dinosaur bones are also encountered most frequently in beds of the coarse-grained fraction in the siltstones. Small fragments of bones are encountered in sands and conglomerates. A list of dinosaur remains, excavated by the expedition at locality Altan Ula IV, is given in the explanation to Text-fig. 4.

In a few conglomerate beds of the Altan Ula IV area, there were found poorly preserved moulds and impressions of crustaceans.

In some beds of sand, sandstones or conglomerates occur fragments of calcified fossil tree-trunks.

LOCALITY ALTAN ULA III

Location and morphology

The exposures extend over the area between 100°28′40″—100°30′ longitude E, and 43°34′20″—43°37′ latitude N, at altitudes ranging from 1550 to 1750 m above sea-level. The zone

of exposures in a longitudinal direction is about 1.5 km wide and southwards it extends for more than 6 km (Text-fig. 6). To the W and E, the zone of exposures is delimited by dissected erosional scarps. In the upper part of the sayr eastwards from the exposures is the Yama Us Bulak spring.

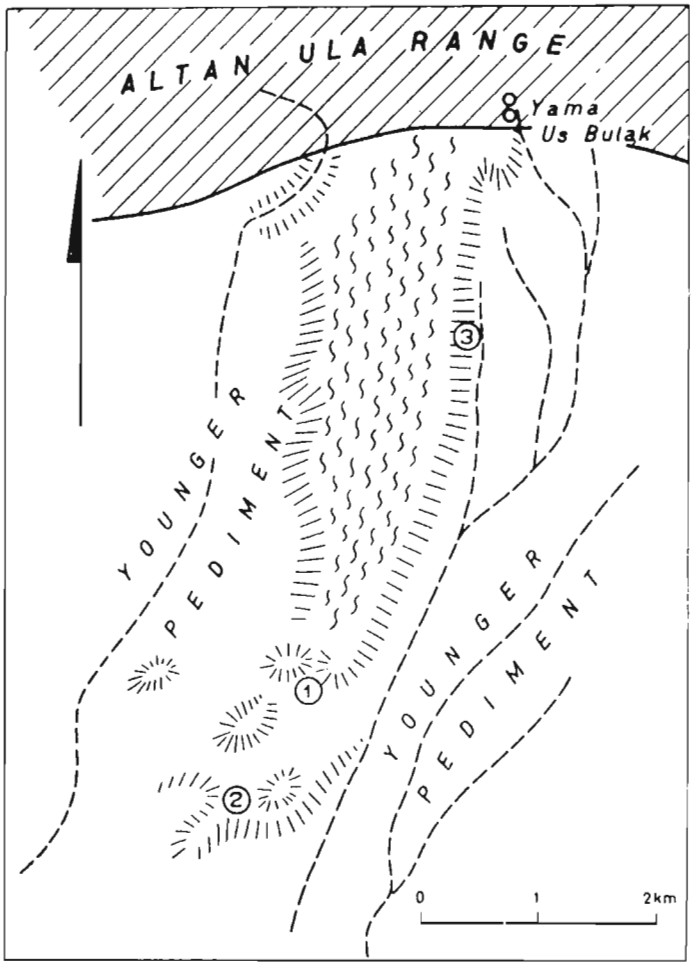


Fig. 6
Sketch-map of locality Altan Ula III. For morphological explanation, see Fig. 2, p. 39. Skeletons indicated by numbers: *1* — fragmentary skeleton of large *Tarbosaurus* sp., *2* — extremely long (2.5 m) fore limbs and shoulder girdle of an unknown theropod dinosaur, *3* — fragmentary skeleton of large *Tarbosaurus* sp.

The route followed by the expedition to the southern part of the exposures led from locality Altan Ula IV, from the bottom of the Central Sayr (near the Central Pyramid) across to the ESE, in the direction of the visible, though poorly defined pass.

History of research

The NE part of the exposure was investigated on 23 July, 1964, during a reconnaissance expedition to localities Altan Ula II and III. The field-work was carried on from the main base camp in Altan Ula IV during a few days in June and July of 1965. Three large skeletons of dinosaurs were dug out (see Text-fig. 6).

Geology

In the area of locality Altan Ula III, Upper Cretaceous sediments belonging to the Upper Nemegt Beds are exposed. As in Altan Ula IV, they dip SW at an angle $1^1/_2°$ and have the same lithological character.

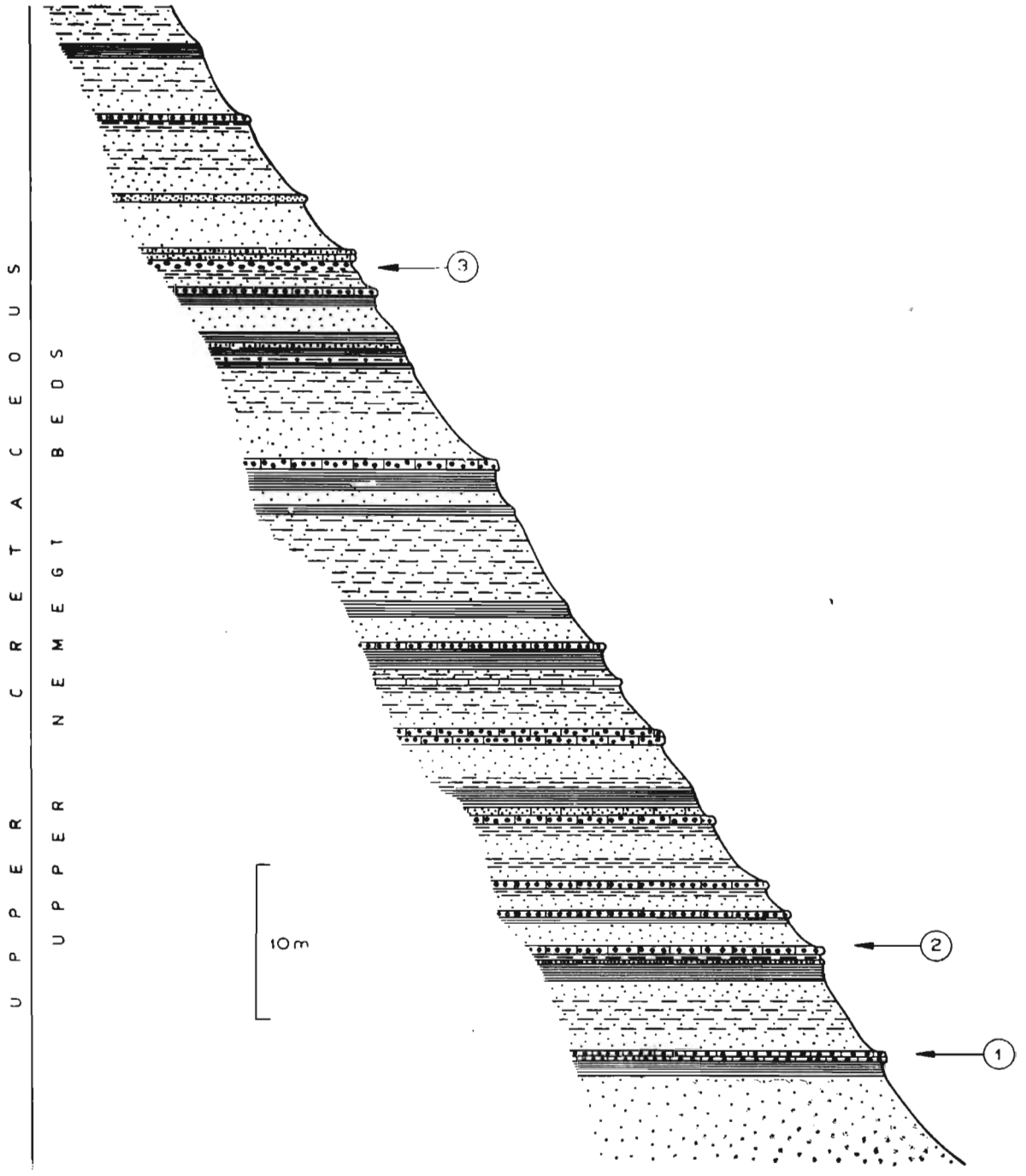


Fig. 7
Geological profile of Upper Cretaceous sediments at locality Altan Ula III. For explanation, see Fig. 3, p. 41. Skeletons indicated by numbers, for explanation, see Fig. 6, p. 47

The lower part of the enclosed profile (Text-fig. 7) was constructed on the basis of particular profiles of the southern exposures, and the upper part from a profile of the northern-eastern exposures.

The bones of the three skeletons found (see Text-fig. 6) were located in conglomeratic sandstones, passing upwards into sands.

LOCALITY TSAGAN KHUSHU

Location and morphology

The main exposures are situated between 100°21′—100°23′30″ longitude E and 43°27′40″—43°29′20″ latitude N at an altitude of 1380 to 1450 m above sea-level.

Exposures occur on both sides of the ridge, which extends from SE to NW (Text-fig. 8*A*). The surface of this ridge is a remnant of the older pediment level in this part of Nemegt Basin. From the E and NE, the ridge is bordered by an erosional scarp. At the foot of the scarp is a depression marking the lower level of the pediment developed round the lower section of Naran Gol Sayr. At one-third of the distance from the SE, the ridge is cut by a relatively short but wide sayr, called the White Sayr by the expedition; this runs from S to N. In addition to a depression connected with the sayr mentioned, the Tsagan Khushu ridge is bordered in the SW by an extensive depression, in which smaller hills occur. This part of the ridge is in the shape of a wedge pointing to the NW (Text-fig. 8*B*). The end of the ridge is cut on both sides by shallow gorges. Here the ridge is at its highest, rising to about 70 m above the depression formed by the lower level of the pediment which surrounds it.

The route taken by the expedition to get to locality Tsagan Khushu led either: 1) from the Naran Bulak region in the E (see p. 38), or 2) from the camp at Altan Ula IV, down along the pediment to Ekheen Dzooganay Gol Sayr, further along it (about 6 km) to the W, then towards the SE up the Naran Gol Sayr (4 km) and across in the direction of the ridge, formed by the NW part of exposures.

History of research

The Tsagan Khushu locality was discovered by the Mongolian Palaeontological Expedition of the USSR Academy of Sciences in 1948, and was investigated in the years 1948 and 1949 (EFREMOV, 1954; ROZHDESTVENSKY, 1953).

The field-work of the Polish-Mongolian Palaeontological Expeditions was mainly carried out in 1964, from 18 June to 11 July. On 5—6 and 13—16 July 1965, reconnaissance trips were made from the camp in Altan Ula IV to Tsagan Khushu.

Geology

In the NW part of the locality, Upper Cretaceous sediments are exposed and, in the SW, Paleocene sediments occur. The contact between these sediments is visible on the ridge at a distance of about 2.5 km SE from Tent Hill.

Upper Cretaceous sediments

The Upper Cretaceous sediments dip at a fairly low angle (1½°) towards SSW. They belong to the Upper Nemegt Beds (Text-fig. 9). In the sediments, mainly silts, siltstones and mud-

stones, as well as sands are represented. Less frequently, thin beds of sandstones and sporadic intraformational conglomerates occur. The sediments show considerable vertical, as well as horizontal variation in lithology.

The sands are most frequently fine-grained (rarely medium-grained) and are usually feldspathic. They often contain a mixture of silty material. The thicknesses of particular beds are not great and range from a few to several scores of centimetres. Usually the beds show

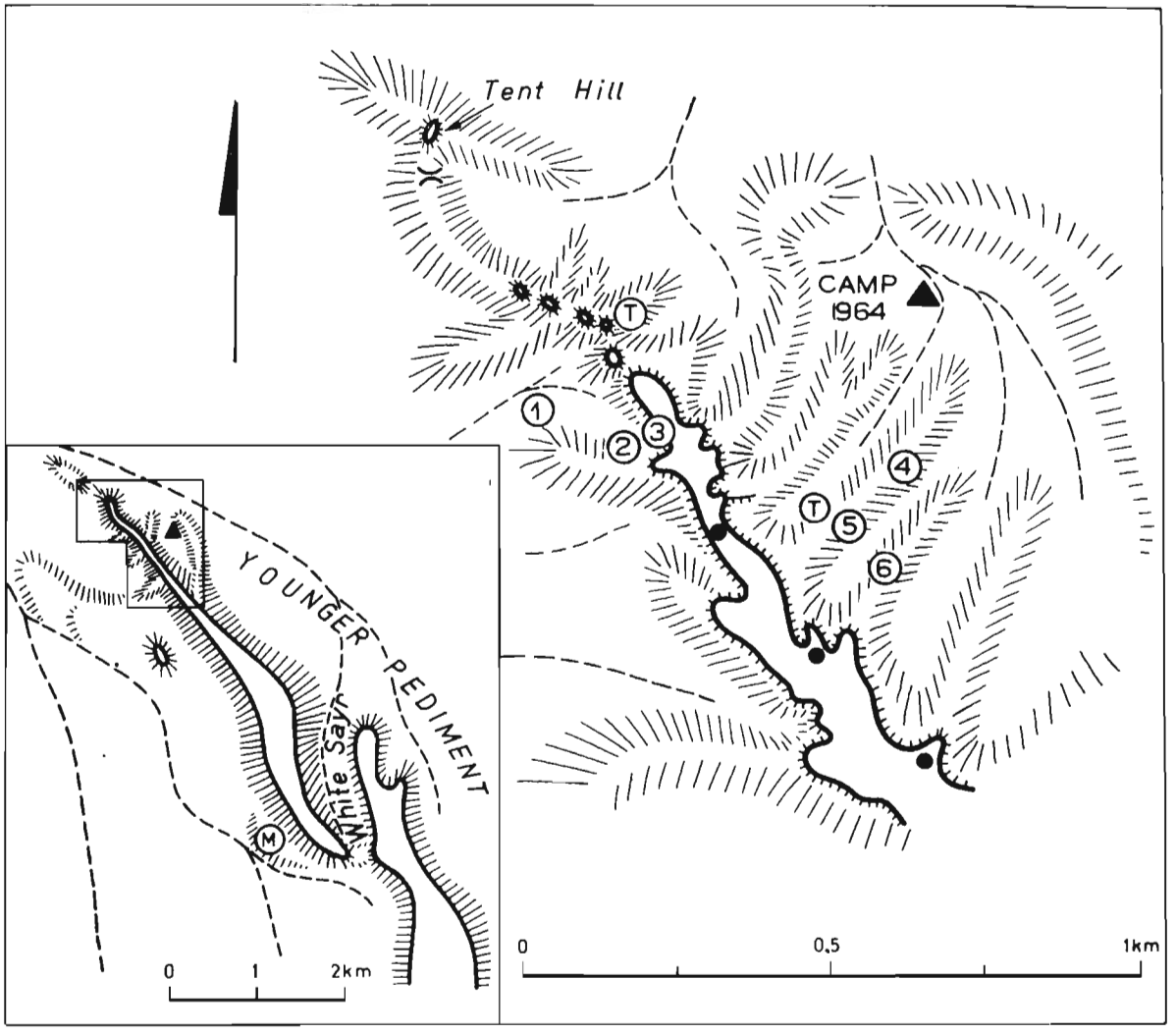


Fig. 8

Map of locality Tsagan Khushu. *A* — generalized sketch-map showing exposures of Cretaceous sediments in NW part of Tsagan Khushu locality, *M* — lens with numerous bone-fragments of small mammals, *B* — NW part of locality Tsagan Khushu. Skeletons indicated by numbers: *1* — incomplete skeleton of a large (about 5 m long) ornithomimid dinosaur, with poorly preserved skull, *2* — almost complete, well preserved skeleton of comparatively small representative (7 m long) of *Tarbosaurus bataar* (MALEYEV), *3* — incomplete skeleton (hind limbs, pelvic girdle and skull) of an ornithomimid dinosaur, *4* — almost complete skeleton of large *Tarbosaurus* sp., *5* — fragments of ribs of *?Tarbosaurus* sp., and hind limb of *Tarbosaurus* sp. found close to each other, *6* — hind limb of an ornithomimid dinosaur, *T* — numerous skeletons of tortoises. For morphological explanation see Fig. 2, p. 39.

cross-bedding of trough type. The beds occur in complexes of thickness, ranging from one to a few metres. In some sand beds, pebbles of siltstone and mudstone are seen. The sands have bright colours, showing various shades of grey and yellow. Red streaks frequently occur in yellow sands. Coarse-grained sands or intraformational gravels, which consist of pebbles of mudstone and siltstone and also of fragments of calcareous concretions, often fill shallow washouts.

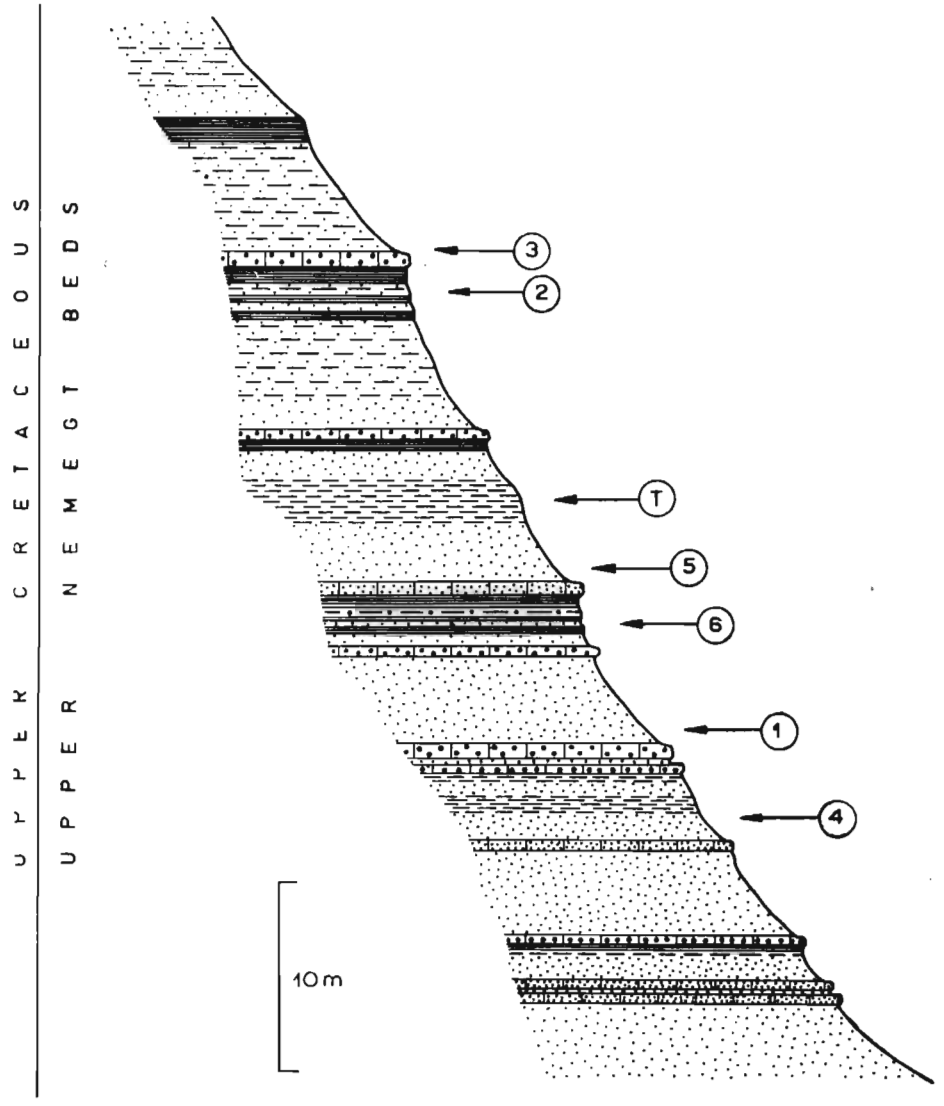


Fig. 9
Geological profile of Upper Cretaceous sediments at locality Tsagan Khushu. For explanation, see Fig. 3, p. 41. Skeletons indicated by numbers, for explanation, see Fig. 8, p. 50.

Some parts of the sandy sediments are firmly cemented by calcium carbonate and form thin beds of sandstones, which because of their greater resistance to weathering, are distinctly marked in the morphology of the slopes.

The silts, muds and siltstones form generally thin sets of intercalations within the sandy sediments. They are greenish, bright olive, or beige in colour.

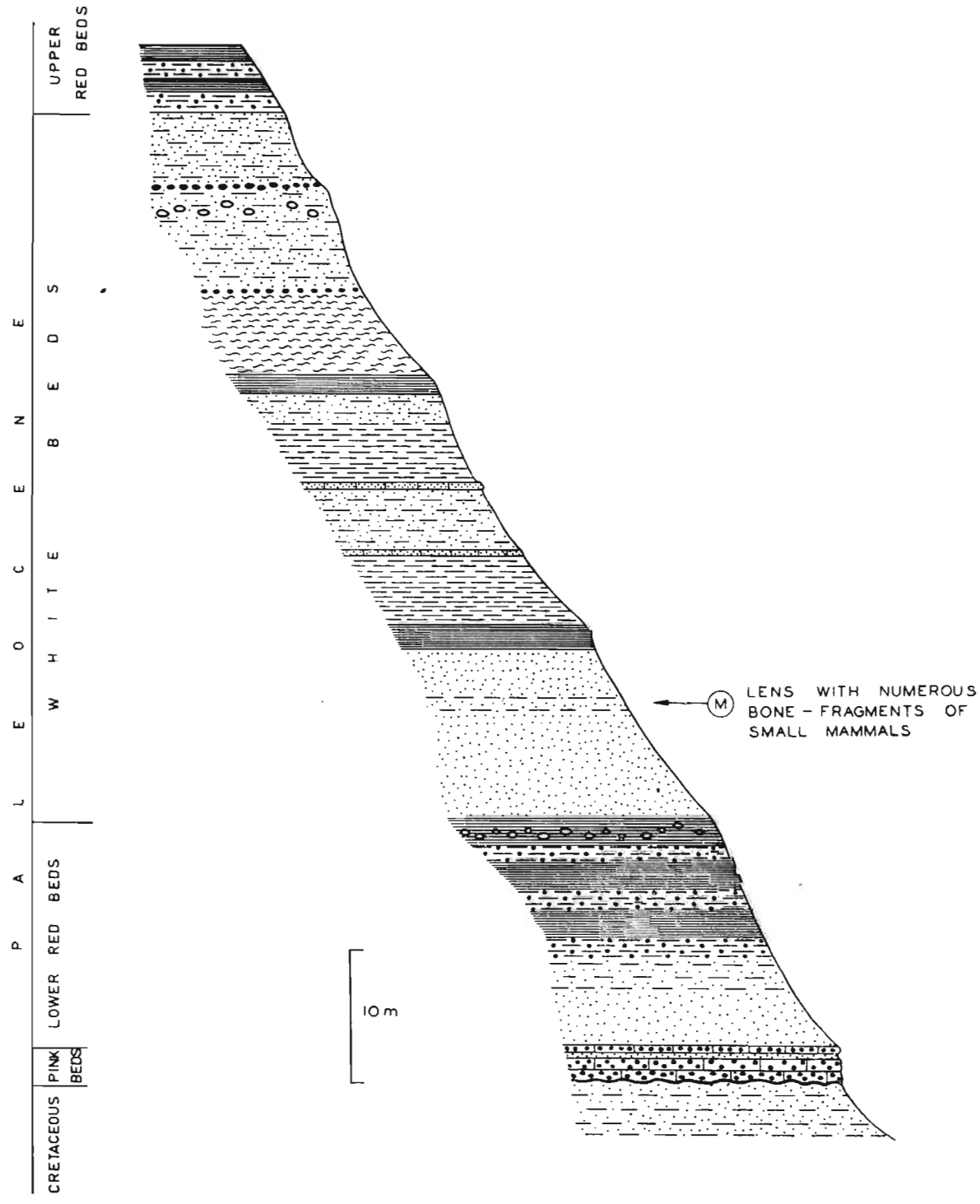


Fig. 10
Geological profile of Paleocene sediments at locality Tsagan Khushu. For explanation, see Fig. 3, p. 41.

The mudstones form beds, the thickness of which ranges between a dozen or more centimetres to 1.5 m. They frequently show an admixture of a smaller or bigger amount of sandy material. The colour of the mudstones is most frequently red, olive, blueish, or greenish. In the mudstone beds randomly distributed calcareous concretions occur relatively frequently. They are light in colour, usually pink, and the diameter is over a dozen millimetres in length.

The dinosaur skeletons or larger fragments of skeletons excavated by the expedition (Text-fig. 8B) were found in complexes of sand beds, which sometimes contained thin intercalations of silts. Usually, the lower part of the skeleton was situated in a bed of coarse-grained sand or intraformational gravel. Completely preserved shells of tortoises occur in great numbers in one complex of fine-grained beds of silty sands.

Paleocene sediments

The sediments of Paleocene age are exposed in the south-eastern part of the locality Tsagan Khushu. The best exposures are situated on the slopes of the White Sayr, as well as to the S and W of it. The higher part of the profile of Paleocene sediments is exposed SE of White Sayr. The Paleocene sediments dip S at an angle of 1—1½°.

In the area described, all four series of Paleocene sediments distinguished by the authors in Nemegt Basin are to be seen (Text-fig. 10). From the bottom upwards they are: the Pink Beds, the Lower Red Beds, the White Beds and the Upper Red Beds. Lithologically, the sediments of these different series are generally developed in much the same way, as the analogous sediments in the Naran Bulak locality (see p. 55). The thickness of the pink conglomeratic series is 2—3 m. The Lower Red Beds (mudstones) are about 16 m thick, and the White Beds are about 52 m thick. The upper surface of the Upper Red Beds (mudstones) was not found. The exposures of these sediments extend further southwards. It may be assumed that the thickness of the latter sediments is at least 120 m, but almost certainly it is much larger.

Palaeontological material was found in the sediments of the White Beds. The main area, in which bones of small mammals occur, is situated about 1 km W of the upper margin of the White Sayr, in a range of small hills at the foot of an erosional scarp (Text-fig. 8*A*). The bones were found in a thin (15 cm) lenticular deposit of sand, containing abundant, fine-grained debris of greenish siltstones. The lens occurs in a thick complex of white sand beds.

Furthermore relatively numerous bones of mammals were found in the southern part of the White Sayr. They come from sandy, calcareous siltstones in the upper part of the White Beds.

LOCALITY NARAN BULAK

Location and morphology

The main group of exposures lies between 100°26′—100°27′30″ longitude E, and 43°27′30″—43°28′30″ latitude N, at an altitude of between 1460 and 1530 m above sea-level.

The exposures extend on both sides of the middle section of Naran Gol sayr (Text-fig. 11). The top surfaces of hills, situated N and S of this section of the sayr, are remnants of the former, uppermost pediment level and are covered by a layer of gravels, several metres thick, firmly cemented in places.

High on the south slope of the sayr, directly under a bed of this kind of conglomerate is

the Naran Bulak Spring (called here Naran Dats). Beneath it, part of the slope is covered by bushy grass, forming a bright green spot, visible from a distance of many kilometres.

NW from the hill on the slope, where the spring begins, narrow ridge extends, dissected into many smaller hills, and named by the expedition the Southern Ridge. Two prominent hills were called: Southern Sphinx and Western Bastion.

The deep, narrow ravine named the Viper Ravine cuts into the right (northern) slope of Naran Gol sayr. At its mouth there can be seen remnants of a stone enclosure. Directly southwards from the upper part of this gorge, occurs an isolated hill in the shape of a yurt, which was named the Eastern Bastion.

History of research

The Naran Bulak locality was discovered during the Mongolian Palaentological Expedition of the USSR Academy of Sciences in 1948, and research was carried out here in the years 1948 and 1949 (EFREMOV, 1954; NOVOZHILOV, 1954).

The research of the Polish-Mongolian Palaeontological Expeditions was carried out in this area at intervals in 1963, but mainly in 1964, from 12 June to 2 July.

Geology

In the area of locality Naran Bulak, the authors distinguished four series within the Paleocene sediments (Text-fig. 12): 1) the Pink Beds, 2) the Lower Red Beds, 3) the White Beds, 4) the Upper Red Beds. The Pink Beds of the present authors correspond to the Sandstone-Conglomerate Series of NOVOZHILOV (1954, p. 35, beds 1 and 2), the Lower Red Beds — the sandy-clayey Purple Bed (*l. c.*, p. 36, bed 3), which forms the lowest level of the White Beds (sandy-clayey) of this author; the White Beds correspond to the upper levels (4—11) of the beds mentioned, and the Upper Pink Beds to the beds (12) reddish brown, sandy-clayey Boombin Nooru Beds.

On the area covered in the map, only the three lower series distinguished by the authors are exposed: the Upper Red Beds are exposed further southwards about 1.5 km to the SE and SW from Naran Bulak Spring.

The sequence of Paleocene sediments dips southwards at an angle of 1—1 ½°. It rests discordantly on sediments of Upper Cretaceous age. The lower surface is relatively smooth. The contact between the Cretaceous and Paleocene sediments is exposed in the lower part of the Naran Gol section, as well as on the area covered by the map.

The Pink Beds are 4 to 5 m thick. They consist of beds of conglomerates in which predominate detritus and pebbles of white and pinkish limestones. The maximal diameter of the latter reaches 40 mm. The conglomerates are rich in sandy-limy cement. Among the conglomerates, occur beds of coarse and medium-grained sandstones or pink, yellow and sometimes red sands.

The Lower Red Beds, of approximately 20 m thickness, consists of red sands and mudstones. Here also occur rare, thin beds of brown sandstones, sometimes with small (10 mm diameter) pebbles of metamorphic rocks and igneous rocks, which are rounded to a small extent only. In the upper part of the series, a horizon with nodules occurs, containing calcareous concretions of pink colour, the diameter of which reaches 10 cm.

The White Beds are altogether about 48 m thick. They consist mainly of sands, silts and muds and subordinate siltstones, loams, mudstones, gravels, sandstones and conglomerates. The sediments show great lithological variation in the horizontal and vertical profiles. The

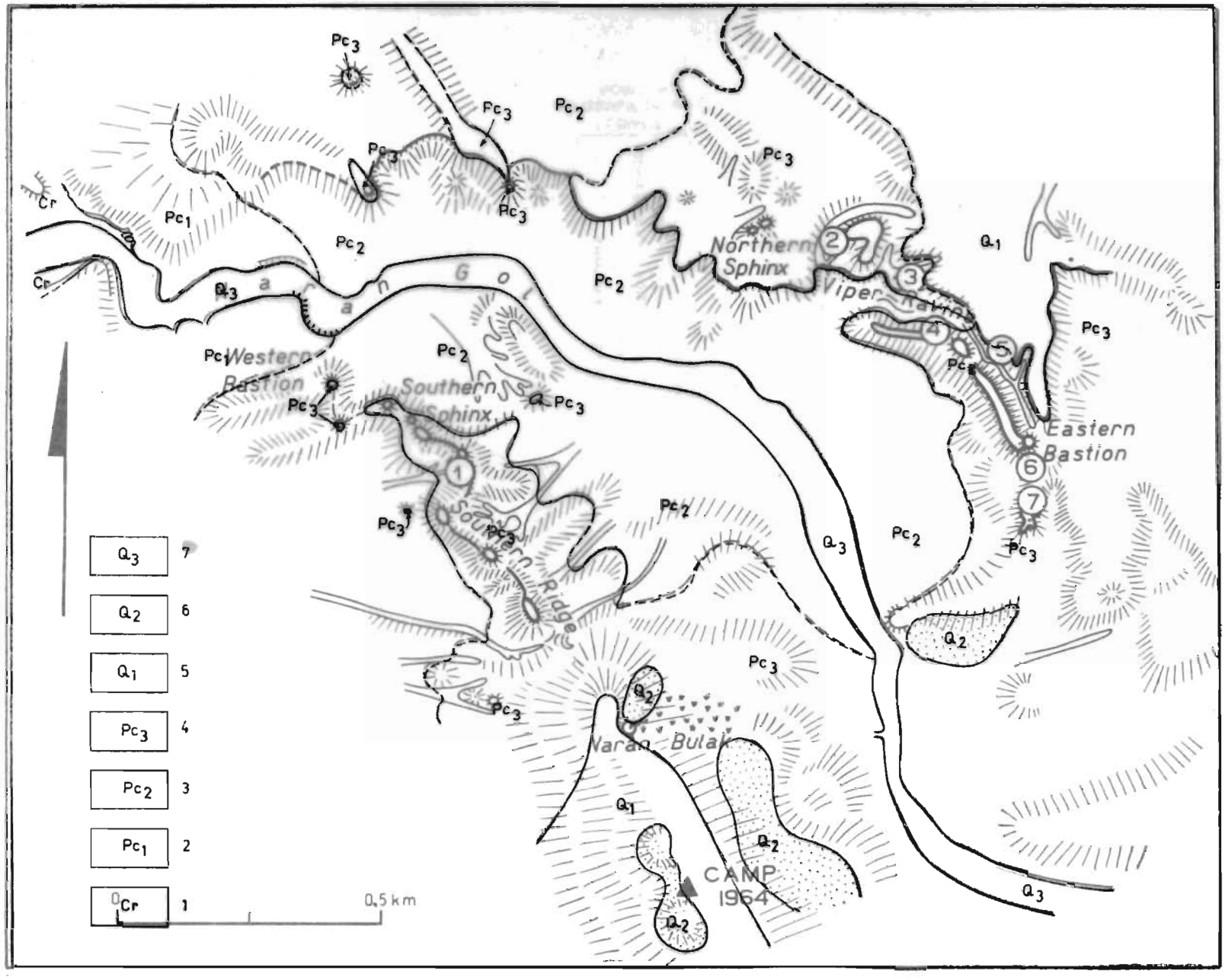


Fig. 11

Map of locality Naran Bulak. Upper Cretaceous: *1* — Upper Nemegt Beds; Paleocene; *2* — Pink Beds, *3* — Lower Red Beds, *4* — White Beds; Quaternary: *5* — conglomerates, *6* — dune-sands, *7* — alluvial deposits. Numbers in circles explained on Fig. 12. For morphological explanation, see Fig. 2, p. 39.

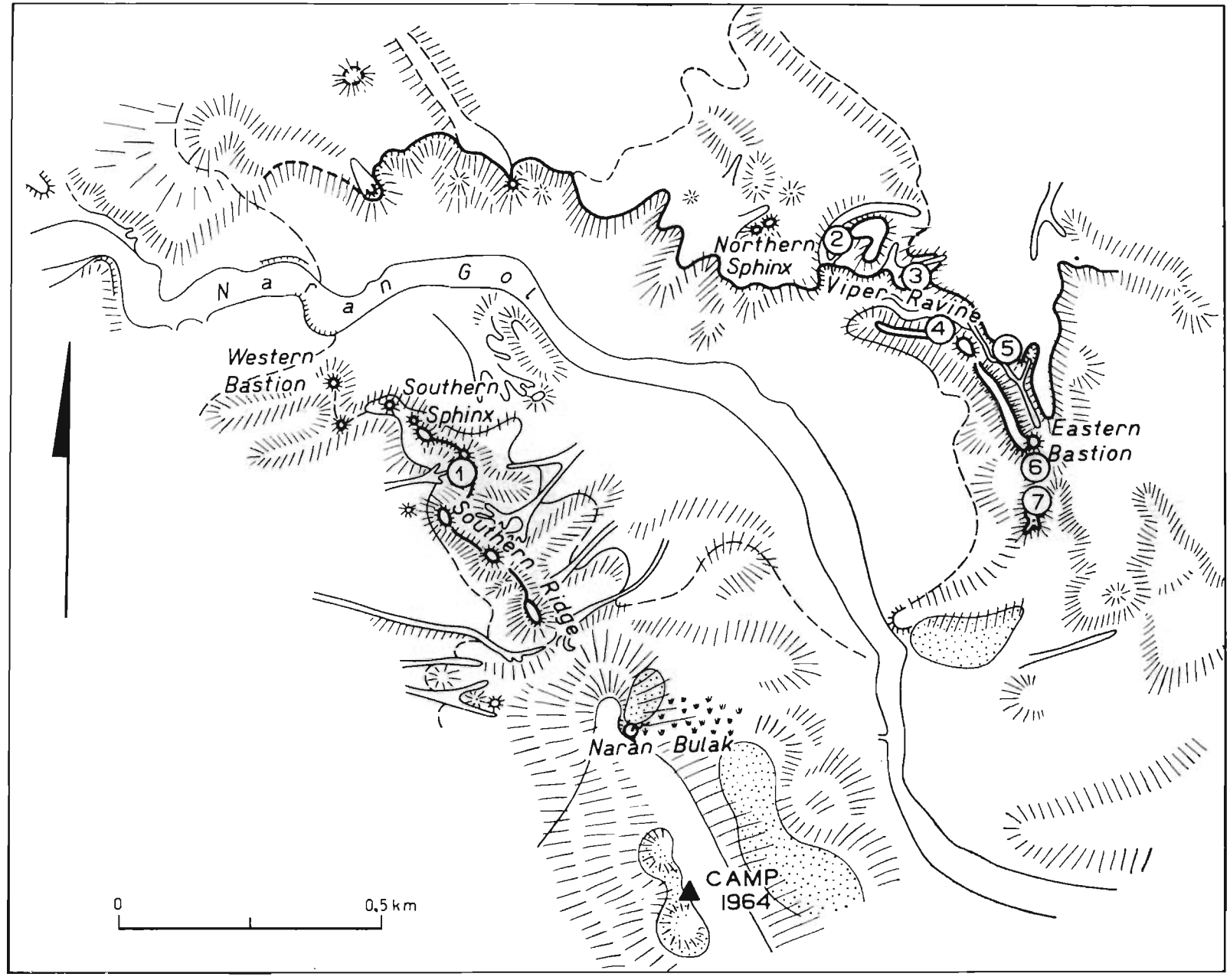


Fig. 11

Map of locality Naran Bulak. Upper Cretaceous: *1* — Upper Nemegt Beds; Paleocene; *2* — Pink Beds, *3* — Lower Red Beds, *4* — White Beds; Quaternary: *5* — conglomerates, *6* — dune-sands, *7* — alluvial deposits. Numbers in circles explained on Fig. 12. For morphological explanation, see Fig. 2, p. 39.

sands are light in colour: white, light yellow, greenish, or light grey. Fine and medium-grained sands predominate. The medium and coarse-grained sands often contain siltstone and silt debris. As a rule, the sands are feldspathic. Cross-bedding is commonly encountered, and nearly always is of trough type. Complexes of sand beds, with only thin intercalations of silt and siltstones, reach 8 m thickness.

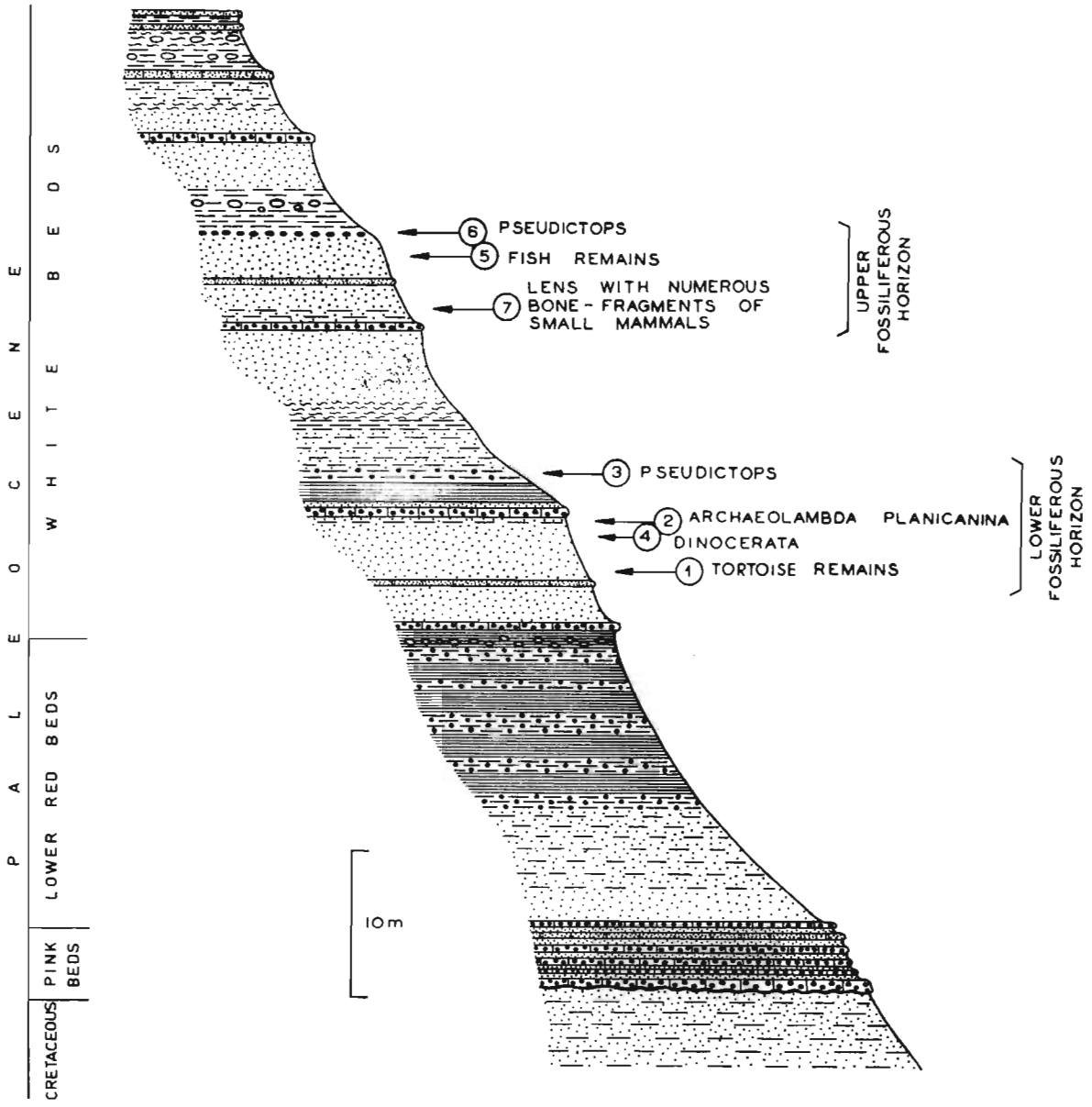


Fig. 12
Geological profile of Paleocene deposits at locality Naran Bulak. For explanation, see Fig. 3, p. 41.

The silts, siltstones and mudstones are most frequently light greenish or bright grey, sometimes beige, and exceptionally reddish grey. They form either thin beds, reaching at the most a few centimetres situated between the complexes of sand beds, or groups of thicker beds

with thin sandy intercalations. Among these beds, clay intercalations also occur, similar in colour to the silts. In some silt or mud beds, small calcareous concretions can be seen.

In the White Beds there are also to be seen layers and lenticular intercalations of gravel. They consist of mudstone and siltstone fragments and poorly rounded calcareous concretions enclosed in sandy material. Occasionally, small, poorly rounded fragments of metamorphic and igneous rocks are found in the gravels.

The sands or gravels are sometimes strongly cemented, and in this case, they form beds of sandstones and conglomerates. The thicknesses of such beds are usually over a dozen centimetres, reaching a maximum of 0.5 m, and they are distinctly marked in the morphology of the hills, forming characteristic shelves or denudation terraces. The beds of sandstones or conglomerates are not extensive; they wedge out or laterally pass into poorly cemented sands or gravels.

The Upper Red Beds consist mainly of red, and often sandy mudstones.

The fauna collected by the Polish-Mongolian Expedition is entirely from the White Beds. The bones of larger mammals were, as a rule, found in sand and gravel beds, bones of tortoises and fish in sand beds, sandstones and silts. An accumulation of small mammal bones was found in a thin (10 cm) lenticular body of medium-grained sand with mudstone fragments and reaching a few centimetres thickness.

In the Paleocene beds of Naran Bulak, the expeditions recognized two fossiliferous horizons, designated as the Lower Fossiliferous Horizon and Upper Fossiliferous Horizon. In the Lower Fossiliferous Horizon prevail remains of Pantodonta, Dinocerata and *Pseudictops lophiodon* MATTHEW, GRANGER & SIMPSON, while in the upper one, in addition to *Pseudictops lophiodon*, the following fauna of small mammals is found: *Eurymylus laticeps* MATTHEW & GRANGER, *Paleostylops iturus* MATTHEW & GRANGER, and *Prionessus lucifer* MATTHEW & GRANGER. The vertical distance between the Lower and Upper Fossiliferous Horizons is about 13 m. It seems that the apparent differences between the faunal assemblages of both horizons are rather accidental, and therefore both levels together are designated here as the zone of *Archaeolambda planicanina* FLEROV, *Pseudictops lophiodon* MATTHEW, GRANGER & SIMPSON and *Paleostylops iturus* MATTHEW & GRANGER.

LOCALITY ULAN GANGA

Location and morphology

The Ulan Ganga exposures are situated in an intermontaine basin, about 92 km ESE in straight line from Dzahooy Somon. The geographic co-ordinates of the locality are: 97°31′30″ longitude E and 44°40′30″ latitude N. The altitude is about 1400 m above sea-level.

Directly to the S of the exposures, is the western margin of a low ridge, named Khayrkhan Ula Somon. The exposures extend along the lowest part of the basin near its southern margin. They are formed by erosional scarps about 10 m high, cut into the surface of the pediment and the sharp-crested hills, bordering from N and S the main, undistinctly marked sayr about 1.5 km wide and running from E to W.

At a distance of 1—2 km N of the exposures, from W to E an indistinct trail runs from Baynender Somon to Dzahooy Somon. From this trail, the exposures are barely visible.

History of research

The locality was discovered on 8 August, 1964, during the Western Reconnaissance. Bones were collected on the surface in 6 hours, mainly in the southern part of the exposures (Text-fig. 13).

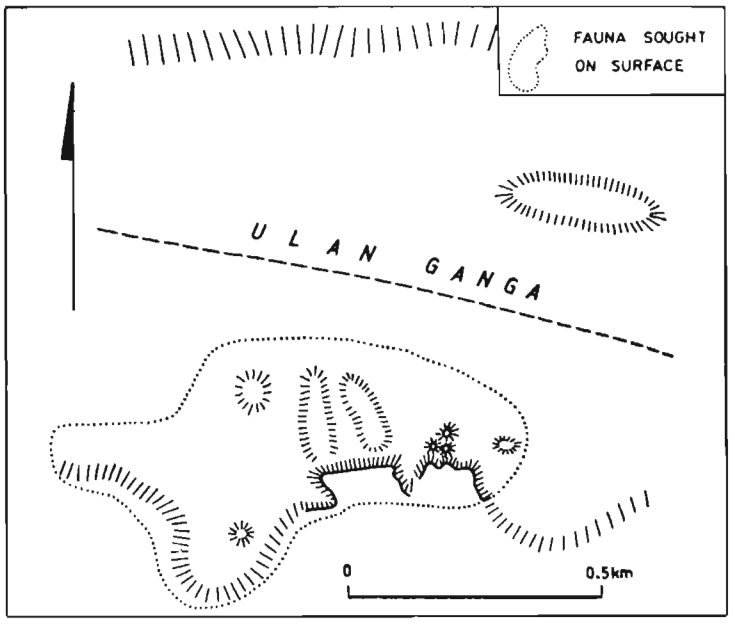


Fig. 13
Sketch-map of locality Ulan Ganga. For morphological explanation, see Fig. 2, p. 39.

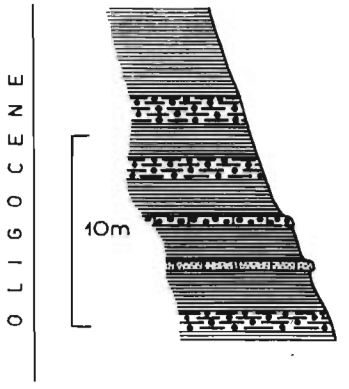


Fig. 14
Geological profile of Oligocene sediments at locality Ulan Ganga. For explanation, see Fig. 3, p. 41.

Geology

The Oligocene sediments of the Ulan Ganga locality (Text-fig. 14) are mainly developed as red mudstones in a fresh, consolidated state and without distinct bedding. When weathered, they occur as finely angular debris and cover the complete surface. Locally, intercalations of poorly cemented sandstones and conglomerates occur among the mudstones.

LOCALITY NAREEN BULAK

Location and morphology

The exposures of this locality are situated in an intermontaine basin, 25 km to WNW from the Ulan Ganga locality (see p. 57). The geographic co-ordinates of the locality are:

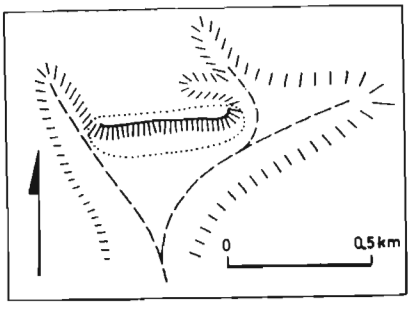


Fig. 15
Sketch-map of locality Nareen Bulak. For morphological explanation, see Fig. 2, p. 39, and Fig. 13, p. 58.

97°21′ longitude E and 44°52′ latitude N, and the altitude is slightly less than 1400 m above sea-level. They are to be found 3 km NW from the Nareen Bulak swamp. The exposures are formed by a 6—8 m high erosional scarp poorly dissected, and longitudinally following in height to the S. It extends for about 0.5 km, closing from N the distension of the sayr (Text-fig. 15).

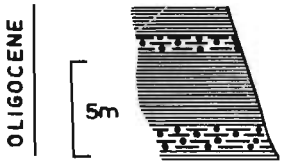


Fig. 16
Geological profile of Oligocene sediments at locality Nareen Bulak.
For explanation, see Fig. 3, p. 41.

History of research

The locality was investigated on 8 August, 1964, during the Western Reconnaissance and was exploited (bones found on the surface) in four hours of the following day.

Geology

The Oligocene sediments of the Nareen Bulak locality were developed as red mudstones (Text-fig. 16). When fresh they are hard and consolidated, but when weathered, they break into sharp-edged fragments and then disintegrate.

LOCALITY KHATAN KHAYRKHAN

Location and morphology

The exposures are situated in the western part of the basin in which Dzahooy Somon lies. The geographic co-ordinates are approximately: 96°20′ longitude E and 44°54′ latitude N,

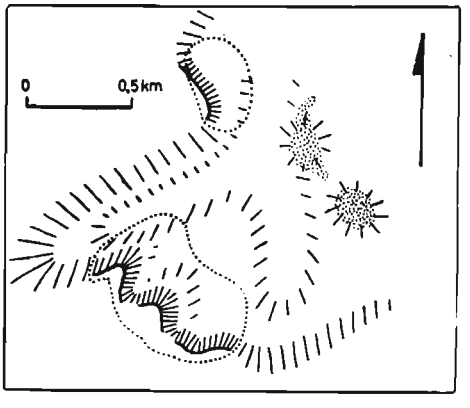


Fig. 17
Sketch-map of locality Khatan Khayrkhan.
For morphological explanation, see Fig. 2, p. 39, and Fig. 13, p. 58.

and the altitude is about 1200 m above sea-level. 10 km W to the exposures rises a granite massif, Khatan Khayrkhan, and about 2 km to the N — the southern border of an area of scrub land in the middle part of the basin.

The exposures of the Khatan Khayrkhan locality are cut into the surface of the pediment (Text-fig. 17) as an erosional scarp up to 20 m high. There are no vertical cliffs here, and only in the southern part of the locality there are steeper slopes, a few metres in height.

The route to the exposures leads eastwards from the northern foot of the Khatan massif, along an old disused caravan trail, which runs along the southern border of the scrub land. The exposures are clearly seen from the trail, which runs westwards from Dzahooy Somon.

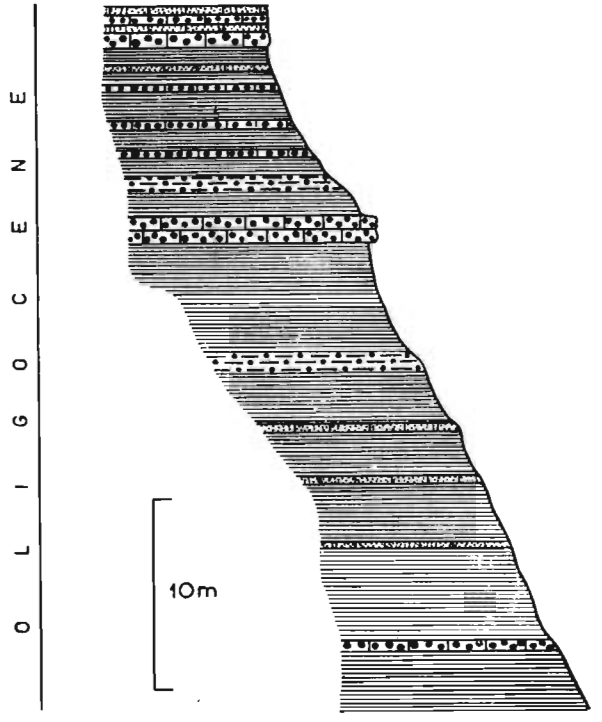


Fig. 18
Geological profile of Oligocene sediments at locality Khatan Khayrkhan.
For explanation, see Fig. 3, p. 41.

History of research

The exposures were discovered during the Western Reconnaissance on 13 August, 1964, and were exploited in a few hours. The bones were collected from a surface covered by weathered rock fragments.

Geology

The Oligocene sediments exposed in the Khatan Khayrkhan locality are developed as calcareous mudstones of red or orange-red colour (Text-fig. 18). The mudstones contain rare thin interlayers with admixtures of sandy material.

LOCALITY BOONGEEN GOL

Location and morphology

The exposures are situated in the upper part of the pediment from beneath the Atch Bogdo massif northwards.

The geographic co-ordinates of the central, exploited part of the exposures are: 95°24′ longitude E and 44°56′ latitude N, and the altitude is about 2100 m above sea-level. These exposures are located about 4 km to the WNW from Buin Brigade (former Altay Somon).

The exposures are on the bottom and slopes of a large erosional depression, cut into about 50 m beneath the surface of the pediment (Text-fig. 19). From the N the exposures are not visible.

The way to the exposures leads along a trail towards WNW from Buin Brigade. From the place, where the trail turns northwards, exposures are seen extending westwards.

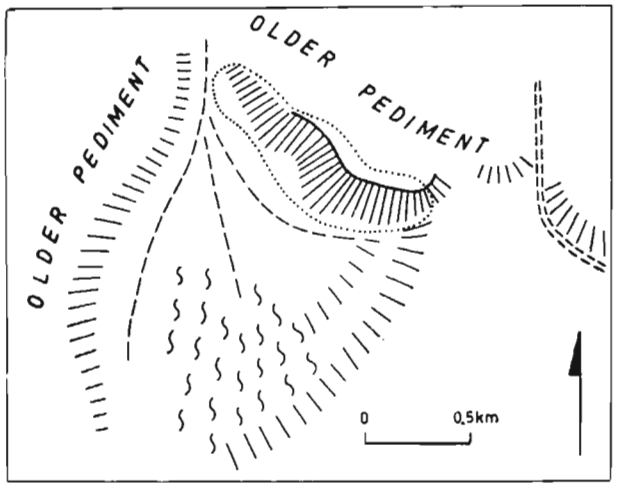


Fig. 19
Sketch-map of locality Boongeen Gol. For morphological explanation, see Fig. 2, p. 39, and Fig. 13, p. 58.

History of research

The exposures were discovered during the Western Reconnaissance. They were exploited (collecting on the surface) during a few hours in 16 August, 1964.

Geology

A mudstone series is exposed with numerous inclusions and beds of conglomerate and coarse-grained sandstone (Text-fig. 20). The mudstones are red in colour when fresh, consolidated and hard, on weathering they disintegrate into little, fine debris. The intercalation of the mudstones is indistinctly marked. In some mudstone beds occur small pebbles, a few or several tens of millimetres in diameter of crystalline rocks, which show a slight degree of rounding. In the lower part of the profile, sandstone and conglomerate beds occur, subordinately. In the upper part, a thick bed of conglomerate (1.5 m thick) and coarse-grained sandstone, greyish in colour, is distinctly marked. The maximum diameter of pebbles, occurring in this

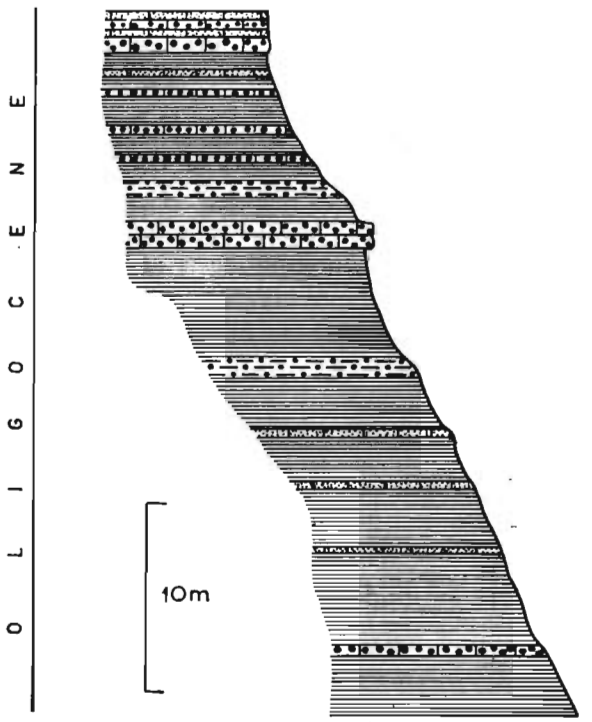


Fig. 20
Geological profile of Oligocene sediments at locality Boongeen Gol. For explanation, see Fig. 3, p. 41.

part, reaches 20 cm. The mudstones above this bed are definitely brighter in colour (orange-red) and they contain numerous inclusions of conglomerate.

The beds dip northwards at an angle 6°.

LOCALITY KHAITCH BULAK

Location and morphology

This locality is situated within the area of the eastern border of the Alag Noor basin. Its geographic co-ordinates are 94°54′ longitude E and 45°13′ latitude N, with an altitude of about 1400 m above sea-level. The exposures lie on the left side of a deep, relatively narrow gorge trending SE-NW (Text-fig. 21). Along this, a trail runs from E to W from a basin, situated to the N of the Atch Bogdo massif, in the direction of Lake Alag Noor. The exposures stretch about 1.5 km from a grove, which covers the bottom of the gorge up to where its mouth opens to a plain. In the lower part of the sayr is a spring, Khaitch Bulak. The exposures are clearly visible from the motor-trail, and their western part is seen from the plain Alag Noor.

The way of approach led from the E along the trail.

History of research

The exposure was found during the Western Reconnaissance on 16 August, 1964, and was exploited in a few hours, the following day.

Geology

The right, NE slope of the gorge, and the lower part of the left slope in the lower part of the gorge, are built of a series of metamorphic rocks with intrusions of granite. On the left,

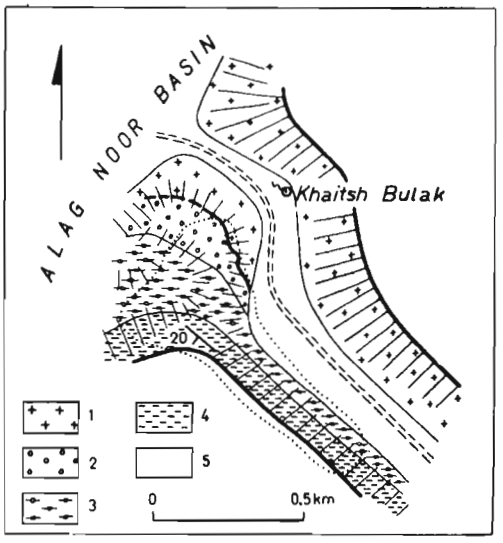


Fig. 21

Map of locality Khaitch Bulak. *1* — crystalline rocks; Oligocene: *2* — Lower Series, *3* — Central Series, *4* — Upper Series; Quaternary: *5* — alluvial deposits. For morphological explanation, see Fig. 2, p. 39, and Fig. 13, p. 58.

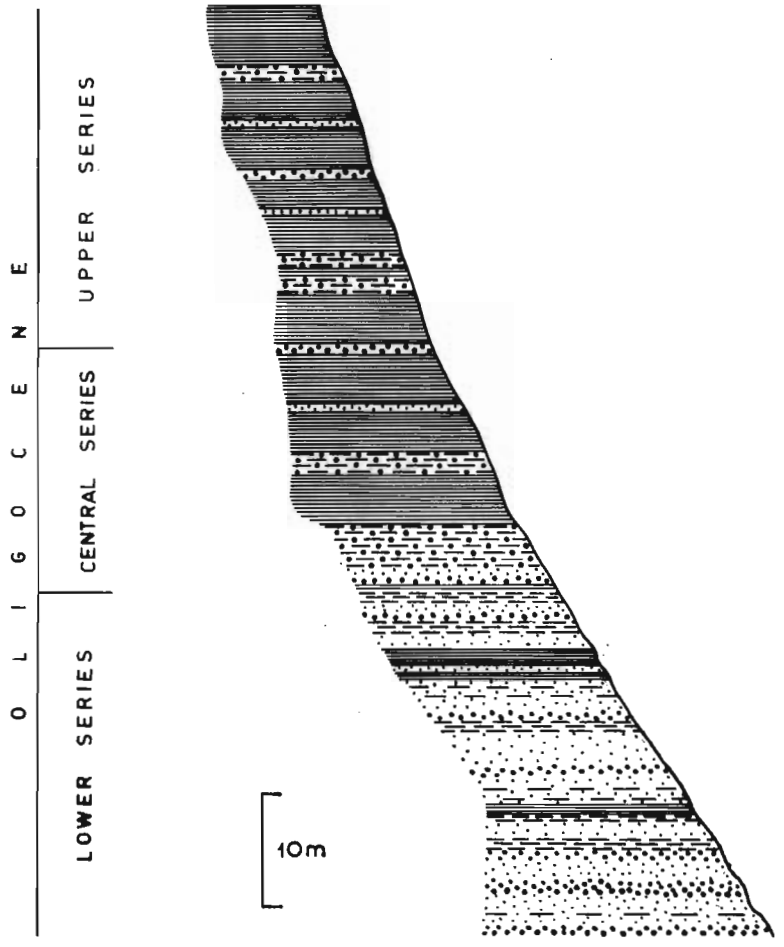


Fig. 22

Geological profile of Oligocene sediments at locality Khaitch Bulak. For explanation, see Fig. 3, p. 41.

SW side, at a height of about 45 m, sediments of Oligocene age dip SE at an angle of 20—25°. The contact between the crystalline rocks and the sedimentary series is presumably stratigraphic. However, the possibility of a fault here should not be excluded.

The Oligocene sediments exposed in the slope of the gorge are divided into three clearly differentiated series (Text-fig. 22). The Lower Series, about 20 m thick, consists of light coloured, coarse-grained sands among which occur numerous intercalations with pebbles and blocks of granite, as well as metamorphic rocks reaching a maximum diameter of 60 cm. In the sands, occur subordinate beds of green and red silts and mudstones.

The Central Series, about 25 m thick, is seen as red mudstones, in which slight interdigitation of gravels and coarse-grained sands occurs.

The Upper Series consists of mudstones, orange in colour, and a little sandy in some places.

LOCALITY KHALYUN

Location and morphology

At a distance of a few kilometres N from the axis of Khalyun Basin, is a longitudinal zone of exposures, about 30 km long. Half way along this zone of exposures is situated Khalyun Somon. The part of the exposures explored during the Western Reconnaissance lies about 8 km E of the Khalyun Somon (Text-fig. 23). The geographic co-ordinates are approximately 96°20′ longitude E and 45°56′ latitude N, and the altitude is about 1650 m above sea-level.

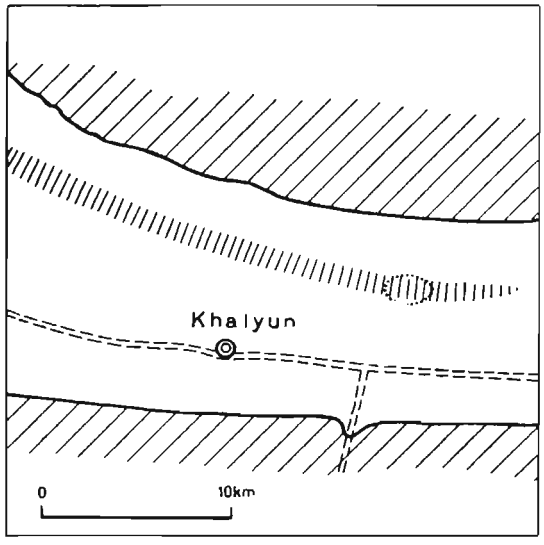


Fig. 23
Sketch-map of Khalyun Basin. For morphological explanation, see Fig. 1, p. 36, Fig. 2, p. 39, and Fig. 13, p. 58.

The exposures form a series of hills cut in the S by short gorges. The exposures are well visible from the bottom of the basin, along which an E-W trail runs from Begger Somon to Khalyun Somon, and further NW to a place called Bayn.

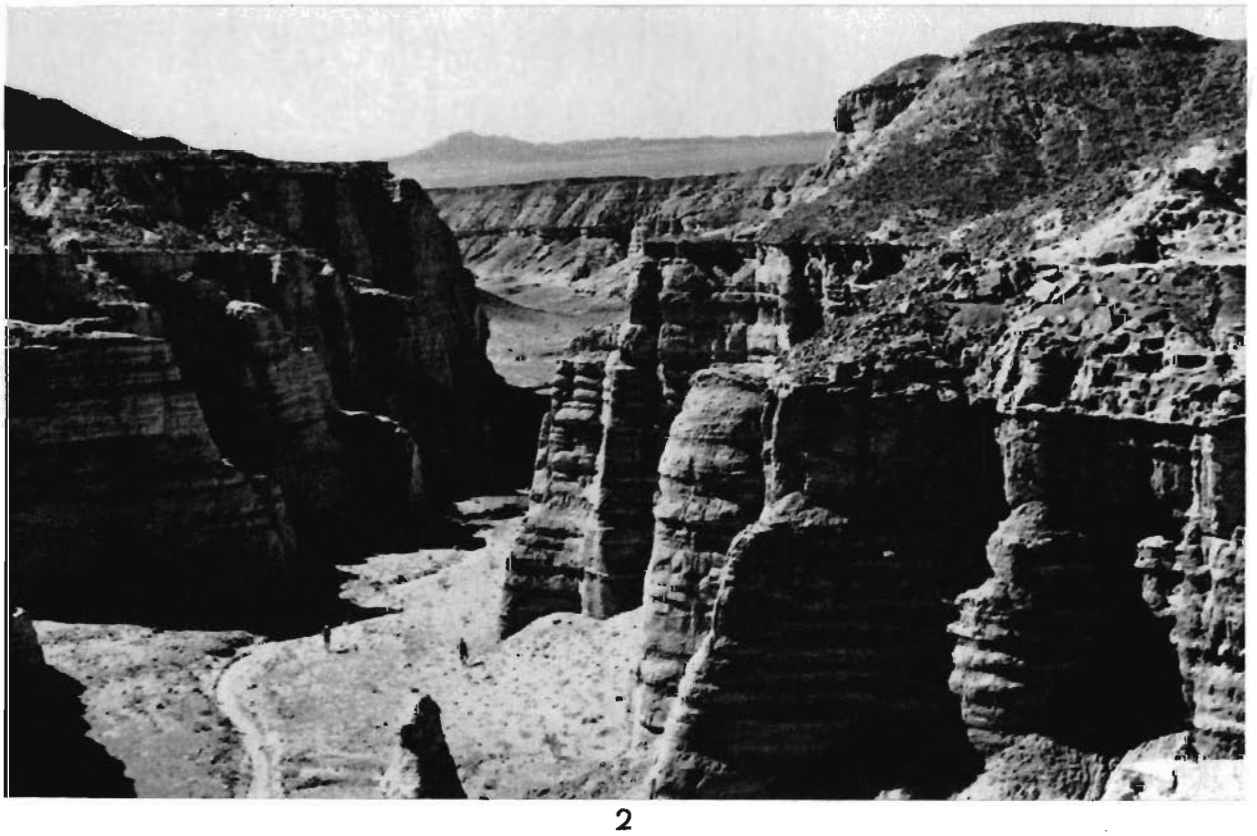
PLATES

R. GRADZIŃSKI, J. KAŹMIERCZAK & J. LEFELD: GEOGRAPHICAL AND GEOLOGICAL DATA

PLATE V

Photo: R. Gradziński

1

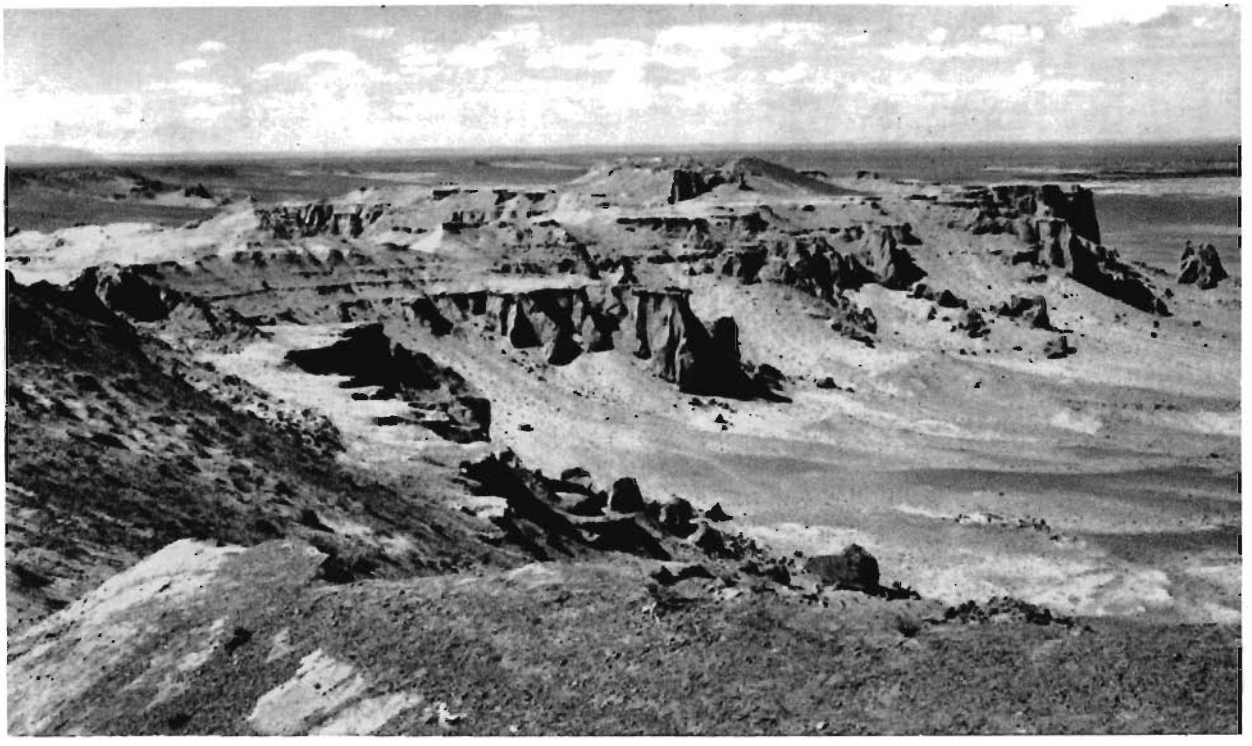


2

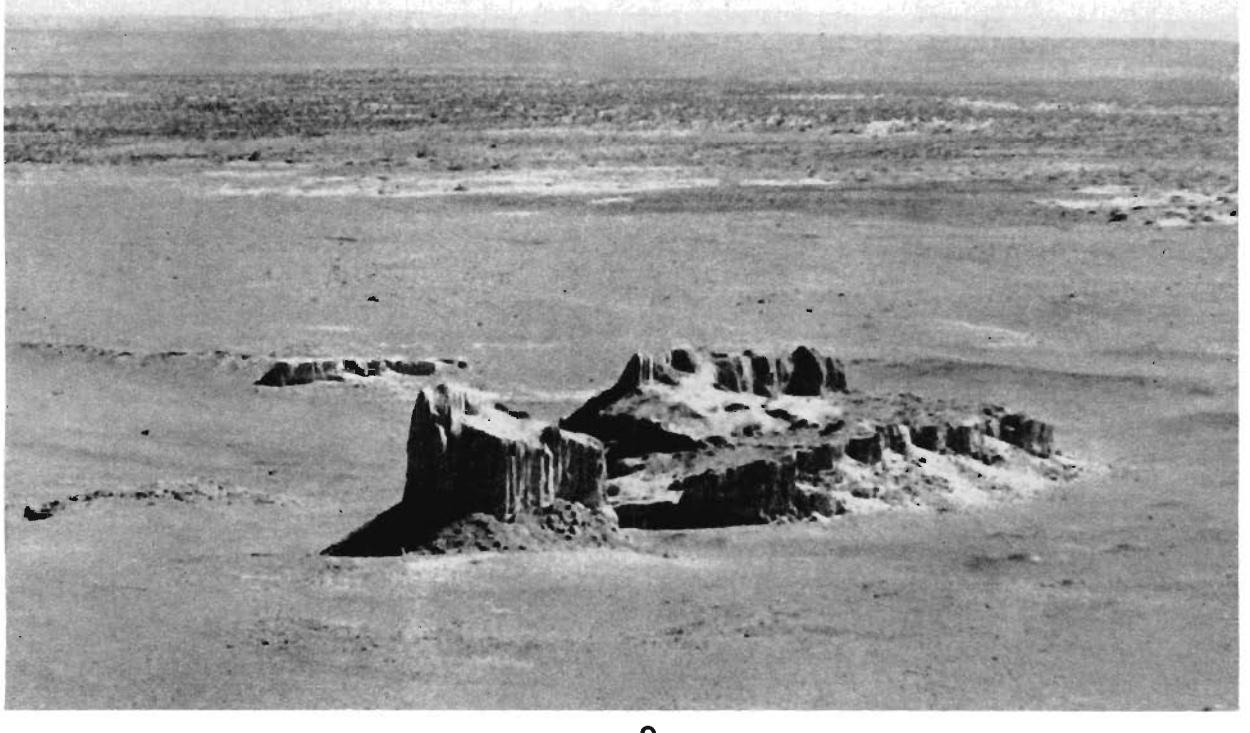
R. GRADZIŃSKI, J. KAŹMIERCZAK & J. LEFELD: GEOGRAPHICAL AND GEOLOGICAL DATA

PLATE VI

Photo: J. Lefeld



1



2

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R. GRADZIŃSKI, J. KAŹMIERCZAK & J. LEFELD: GEOGRAPHICAL AND GEOLOGICAL DATA

PLATE VII

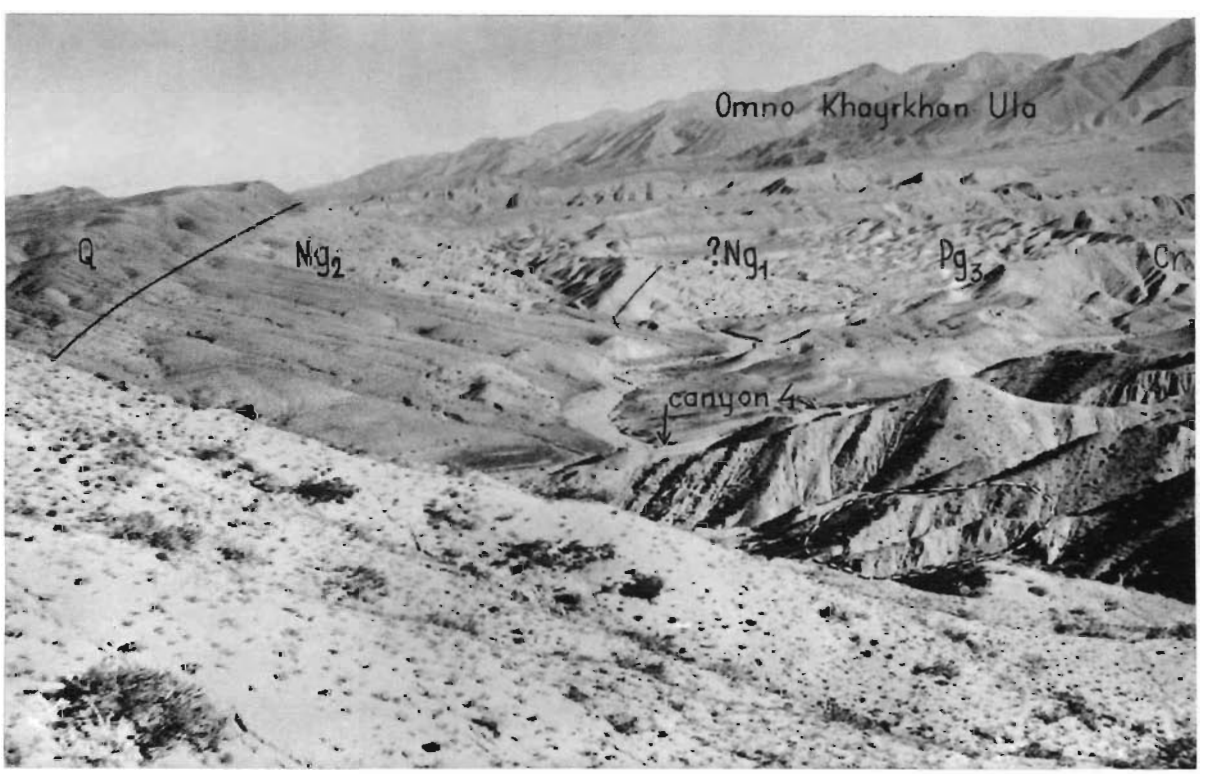
Page

Fig. 1. Begger Noor Basin. Exposures of Tertiary sediments at southern part of the basin 72

Fig. 2. Locality Altan Teli. View from southeast at Cretaceous and Tertiary sediments of northeast part of the Dzereg Valley. For explanation, see Fig. 34, p. 74, and Fig. 2, p. 39 75

Photo: J. Kaźmierczak

1



2

History of research

The locality was discovered during the Western Reconnaissance. The bones were collected on the surface on 18 and 19 August, 1964, in a total time of 10 hours.

Geology

The sequence of Oligocene sediments, which is exposed in the locality investigated, consists of alternating silt, mud and mudstone beds with red (carmine and cinnabar), and light colours,

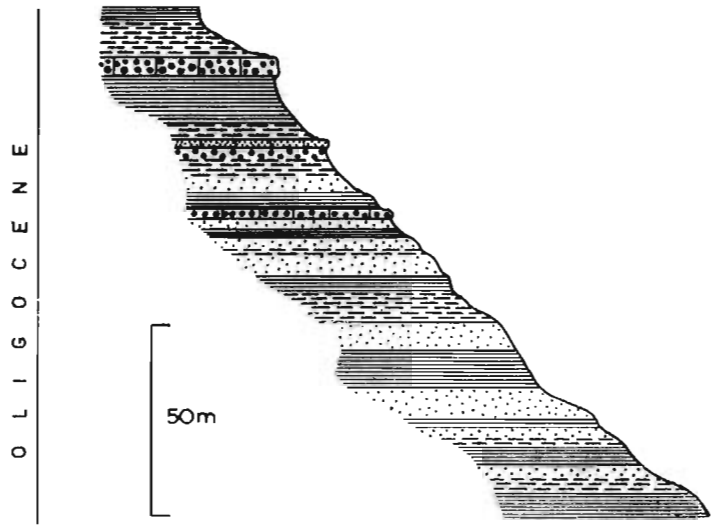


Fig. 24
Geological profile of Oligocene sediments at locality Khalyun. For explanation, see Fig. 3, p. 41.

sometimes completely white, and sometimes also reddish feldspathic sands, as well as gravels and conglomerates (Text-fig. 24). The beds dip NE at an angle of 15—25°.

LOCALITY BUYLSTYEEN KHUDUK

Location and morphology

The locality is situated in the Valley of Lakes, about 25 km N from the eastern border of Lake Tsagan Noor. The geographic co-ordinates of the exposure are: 101°31′ longitude E and 45°24′ latitude N, and the height above sea-level is about 1600 m.

The main exposure extends southwards, and runs longitudinally about 1.5 km (Text-fig. 25). It consists of a cliff about 60 m high dissected by shallow gorges. The remaining exposures at a height of 10—20 m extend along the western ridge bordering the sayr and run southwards down from the main exposures.

The exposures are well visible from the trail which leads from Lake Tsagan Noor, NE to Gunnaryeen Somon; this trail runs at a distance of about 3 km E of the exposures.

History of research

The locality was discovered during the Western Reconnaissance. It was exploited (bones collected on the surface) in a few hours on 25 August, 1964.

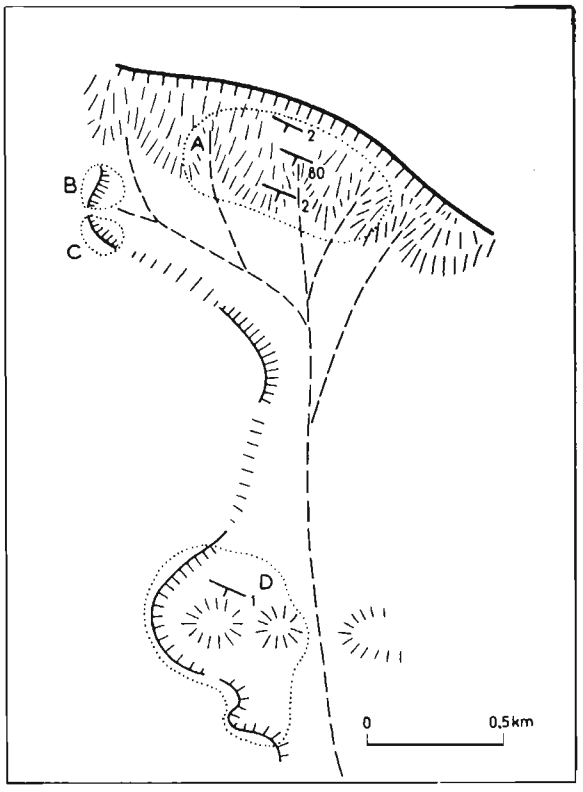


Fig. 25
Sketch-map of locality Buylstyeen Khuduk; *A-D* sites of fossil searching. For morphological explanation, see Fig. 2, p. 39, and Fig. 13, p. 58.

Geology

In the northern exposures, a series of red mudstones and white feldspathic sands occurs, among which are numerous gravel inclusions. They contain pebbles of igneous and metamorphic rocks, the diameter of which reaches 35 cm at the most. Among the pebbles, granite and quartz predominate. Besides the red mudstones, beds of dark mudstones and siltstones, grey and grey-violet in colour, are also encountered (Text-fig. 26).

The beds of a considerable part of the main exposure either stand almost vertically or they dip southwards. This is due to the flexure which trends towards 110°. Besides the flexure to the N and S, the beds lie almost horizontally.

In the exposures on the western side of the sayr, mudstones of intense brick-red colour predominate, sometimes interbedded with light-brown sands and sandstones.

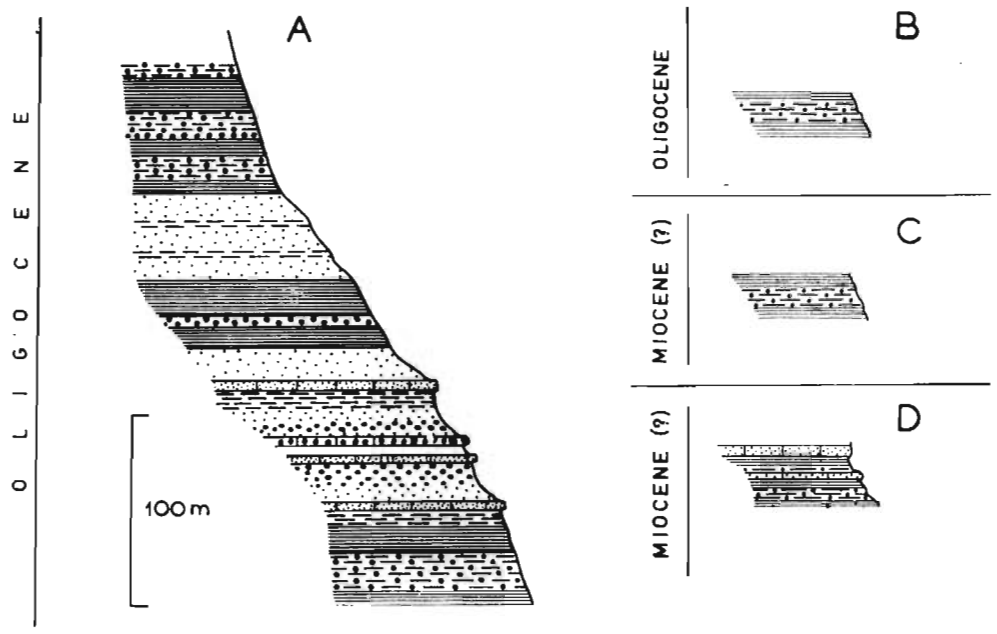


Fig. 26
Geological profiles of Oligocene and Miocene sediments at locality Buylstyeen Khuduk; *A-D* see Fig. 25. For explanation, see Fig. 3, p. 41.

LOCALITY TATAL GOL

Location and morphology

The Tatal Gol locality is situated on the northern pediment of the basin of Tsagan Noor Lake, at a distance of about 16 km NNE from the eastern bordering ridge. The geographic co-ordinates of the central exposures are: 101°35′ longitude E and 45°17′ latitude N, and the altitude is about 1400 m above sea-level (Text-fig. 27).

The exposures occur on the slopes of Tatal Gol Sayr and in many short side-gorges, which cut into it. The height of the exposures is 10—15 m.

The southern part of the exposures is well seen from a distance of a few kilometres to the SW (i.e. from the side of Lake Tsagan Noor).

The approach to the exposures from W and SW, from the trail Tsagan Noor Lake — somon Gunnaryeen, across the relatively smooth surface of the pediment, presents no difficulties.

History of research

The exposures of Oligocene in the basin of Lake Tsagan Noor were discovered in 1922 by an American expedition (Berkey & Morris, 1927). The Oligocene sediments were called the Hsanda Gol formation; they are exposed in the region of the Tatal Gol Sayr, as well as in that of the Hsanda Gol Sayr, which is situated further E in the distance of about 15 km. This area is figured in two maps (Berkey & Morris, 1929, Pls. 18—19).

The Oligocene exposures in this area, particularly in the region of Tatal Gol Sayr, were afterwards exploited in 1948 and 1949 by Soviet expeditions (Efremov, 1954).

The research of the Polish-Mongolian Expedition was carried out in the Tatal Gol locality on 25 and 26 August, 1964, on the way back from the Western Reconnaissance. Bones (mainly of small mammals) were collected exclusively from the surface.

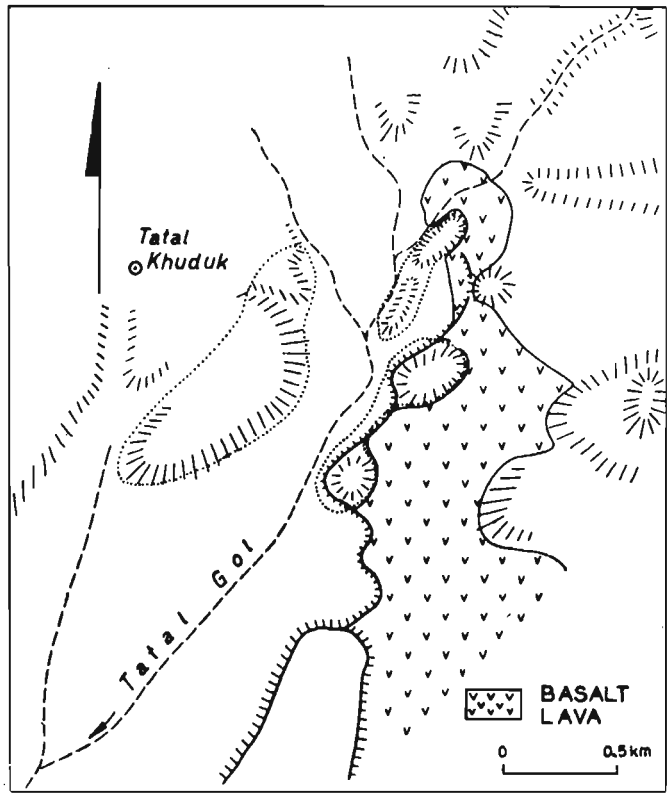


Fig. 27
Map of locality Tatal Gol. For morphological explanation, see Fig. 2, p. 39, and Fig. 13, p. 58.

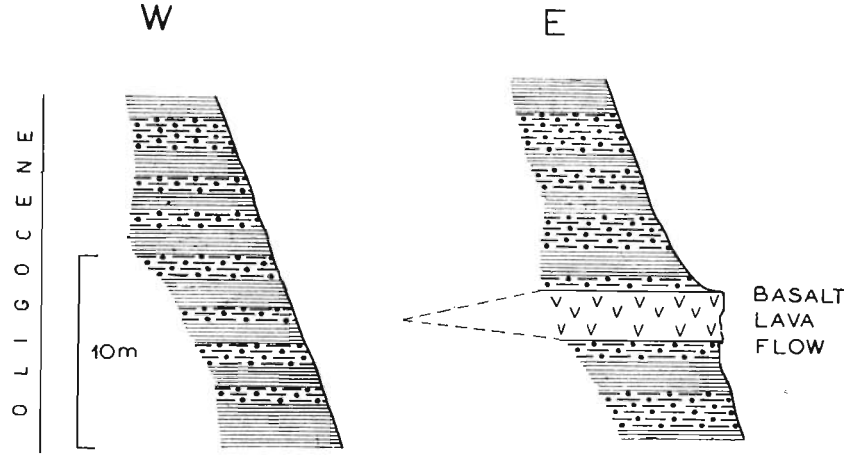


Fig. 28
Geological profiles of Oligocene sediments at locality Tatal Gol. For explanation, see Fig. 3, p. 41.

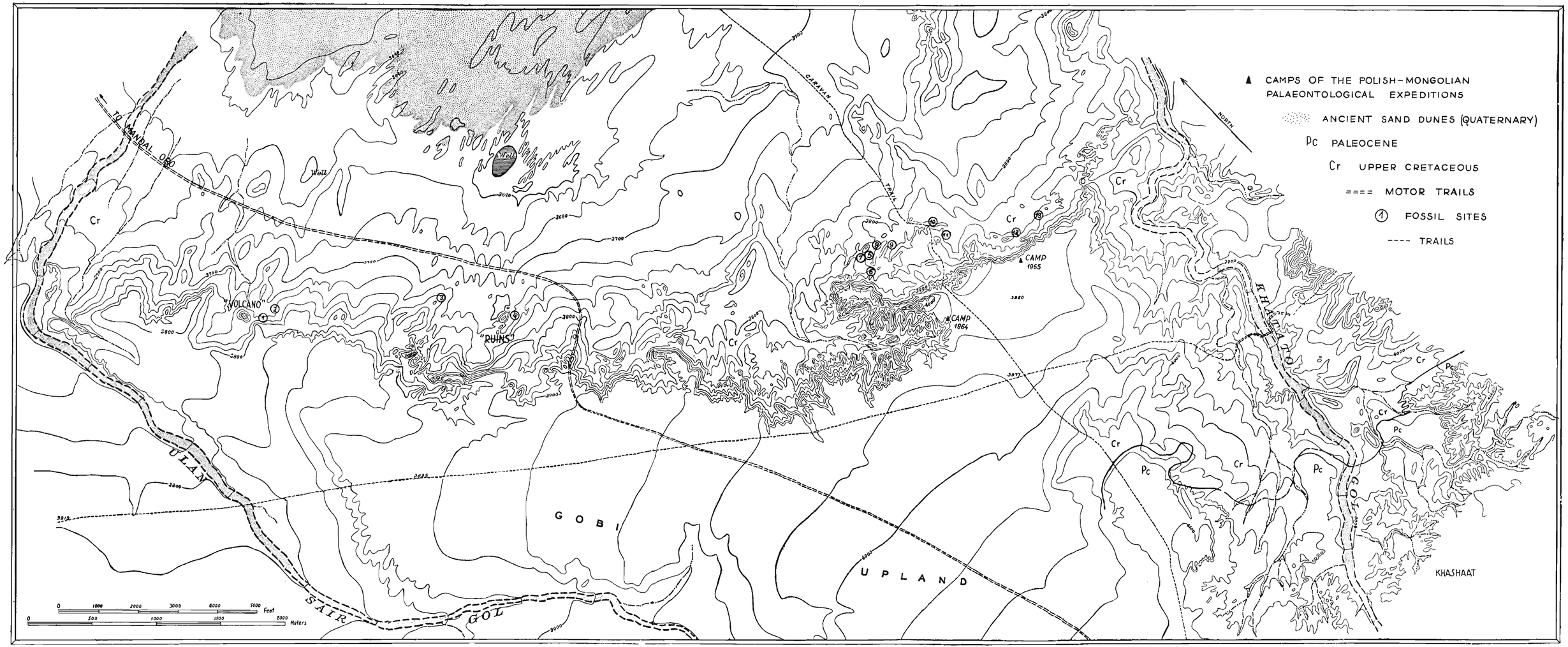


Fig. 29

Geological map of the Bayn Dzak and Khashaat area showing principal fossil sites. Topography by L.B.Roberts, 1925, control by F. B. Butler and H. O. Robinson. Contour intervals in feet. (Courtesy of the American Museum of Natural History, New York). Geology by J. Lefeld, 1965.

Skeletons indicated by numbers: *1* — partial skull of a small crocodile, *2* — partial skull and fragmentary skeleton of a small crocodile, *3* — partial skull of *Protoceratops andrewsi*, *4* — pelvic girdle and partial backbone of a small *Protoceratops*, *5* — skull and postcranial skeleton of *Pinacosaurus* sp., *6* — pelvic girdle and incomplete hind limbs of a large ankylosaurid dinosaur, *7* — partial skull of *Protoceratops andrewsi*, *8* — partial skeleton of a small individual of *P. andrewsi*, *9* — partial skeleton of a small individual of *P. andrewsi*, *10—12* — partial skull of *P. andrewsi*, *13* — partial skeleton of *P. andrewsi*.

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Geology

In the central part of the exposures, where the research of the Polish-Mongolian Expedition was carried out, the Oligocene sediments are developed in the form of brick-red mudstones, in some places sandy (Text-fig. 28). On the left, eastern slope of Tatal Gol Sayr occurs a covering layer of basalt lava 1.5—2.5 m thick; it wedges out westwards and due to this it is not exposed on the right slope of the sayr.

The bones were found throughout the whole profile of Oligocene sediments on both sides of Tatal Gol Sayr, in beds lying both above and beneath the surface of basalt lava.

LOCALITY BAYN DZAK

Location and morphology

The escarpment at Bayn Dzak (Pl. VI, figs. 1—2) is situated at 44°12′ latitude N and 103°44′ longitude E of Greenwich, at an altitude about 1200 metres above sea level.

Bayn Dzak is situated approximately in the middle of a sedimentary basin that lies between the Gurvan Saikhan mountain range in the S, and the Lake Ulan Noor and the town Mandal Obo in the N. This basin is filled with Cretaceous, Paleocene and younger continental deposits. The Upper Cretaceous rocks crop out in an escarpment over 10 km long and in some places 50 metres high. The general trend of the escarpment is WNW-ESE. The highest group of cliffs was called by the American Expedition of 1922 "The Flaming Cliffs" (ANDREWS,1932; BERKEY & MORRIS, 1927) (see also map Text-fig. 29). Northwards from the escarpment of Bayn Dzak, lies an extensive desert basin covered with Quaternary deposits (BERKEY & MORRIS, 1927; ANDREWS, 1932). Numerous ravines and small canyons cut the escarpment along its course.

A trail runs through the Gobi Upland which descends down the escarpment (see map Text-fig. 29) and stretches across the desert basin approximately northwards to Mandal Obo. Southwards it runs towards the Second Brigade, a small Mongol co-operative lying about 8 km S of the Flaming Cliffs. From the Second Brigade, a fairly good trail leads southwards to Dalan Dzadgad, the center of the South Gobi aymak. Westwards another trail connects the Brigade with a small village of Bulgan, where there is a large well.

An old caravan trail runs through the Bayn Dzak area, descending the escarpment E of the Flaming Cliffs (see map Text-fig. 29). The best way to reach Bayn Dzak is to follow the trail from Dalan Dzadgad to the Second Brigade.

History of research

The escarpment of Bayn Dzak was first explored in 1922 by the Central Asiatic Expedition of the American Museum of Natural History. The Americans worked there also in 1923 and 1925 (BERKEY & MORRIS, 1927; ANDREWS, 1932). On the basis of numerous reptile finds, they stated that these deposits are of Upper Cretaceous age (zone of *Protoceratops andrewsi* GRANGER & GREGORY), and called them the Djadokhta Formation. The place was then visited and explored by the Palaeontological Expedition of the USSR Academy of Sciences in 1948 (NOVOZHILOV, 1954). The Polish-Mongolian Reconnaissance Expedition visited Bayn Dzak in 1963, and then the locality was explored by two Polish-Mongolian Expeditions in 1964 and 1965 respectively (KIELAN-JAWOROWSKA & KOWALSKI, 1965; LEFELD, 1965; KIELAN-JAWOROWSKA, 1966).

In the vicinity of Bayn Dzak (about 15 km towards NW) lies a place called Bor Hunto, which was first visited by MORRIS in 1923 (MORRIS, unpublished Field Notebook VII, pp. 36—37, courtesy of the American Museum of Natural History), who reported Upper Cretaceous deposits with ceratopsian remains from there, quite similar to those of Bayn Dzak. Further towards NW (some 25 km from Bayn Dzak) at Tugruk (Tuguru-gu — in MORRIS' unpublished notebook), a section of possibly Paleocene deposits with Upper Cretaceous at base was investigated by MORRIS (MORRIS, unpublished Field Notebook VII, pp. 38—46). The latter place was then visited by DASHZEVEG and NIKOLOFF in 1964 (NIKOLOFF & HUENE, 1966). NIKOLOFF reported Tugruk as situated 47 km NW from Bayn Dzak. The Cretaceous deposits at Tugruk were erroneously assigned by NIKOLOFF to the Lower Cretaceous.

Geology

The escarpment of Bayn Dzak provides an excellent series of exposures. Several profiles were investigated, the best of these being that of the Flaming Cliffs (Text-fig. 30). The profile there shows the maximal number of beds because this is the highest point in the crest of a slight tectonic elevation. The Cretaceous strata dip gently at about 1° or less to S and SE. The age of these beds is still an open question. KIELAN-JAWOROWSKA (1968, p. 173) suggests Coniacian-Santonian.

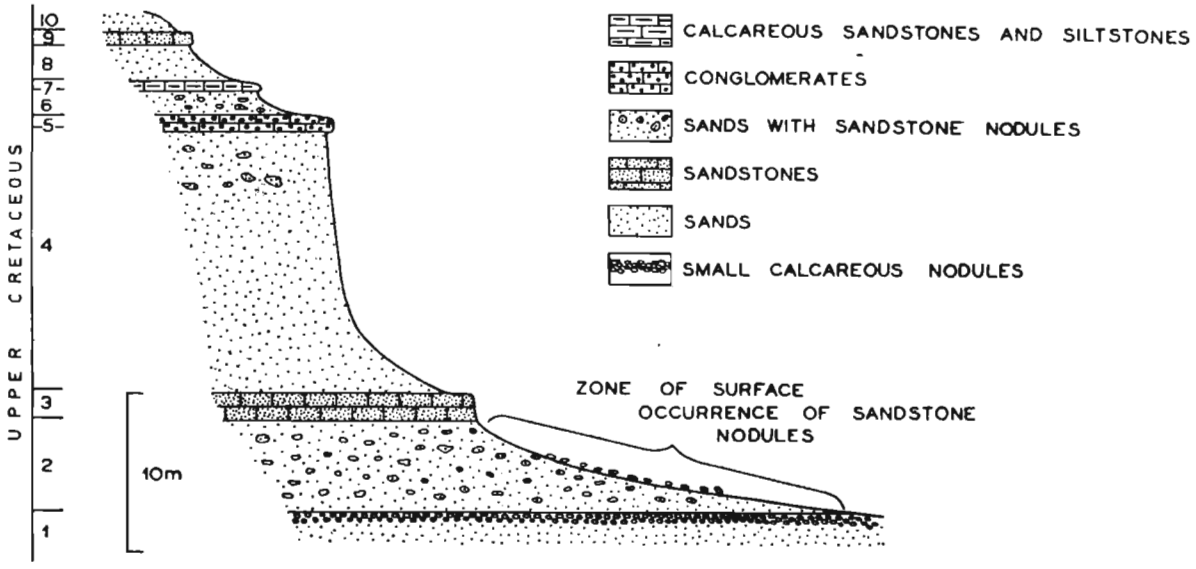

Fig. 30
Geological profile of Upper Cretaceous sediments at locality Bayn Dzak.

The Upper Cretaceous series at Bayn Dzak consists of reddish-orange, poorly diagenised, usually unstratified sands (BERKEY & MORRIS, 1927). In the top of the series three or four calcareous horizons occur. Some horizons of sands are strongly cemented, with a calcareous matrix. Also, in the poorly diagenised sands, numerous hard sandstone nodules occur at various horizons. These nodules were termed "sandstone concretions". The cementation is secondary and postdepositional. The total thickness of Upper Cretaceous deposits at Bayn Dzak is about 70 metres.

The Upper Cretaceous sequence at Bayn Dzak is as follows:

1. Reddish-orange sands, with small and closely spaced (3—4 cm in diameter), white-calcareous nodules. In some places, the layer appears as a conglomerate, composed almost entirely of these white nodules. This bed crops out only in one point on the desert basin floor, some 1500 metres N from the Flaming Cliffs. The bottom of this bed is not seen and its thickness is therefore unknown.

2. Orange to moderate reddish-brown sands, containing scattered small reddish-brown sandstone nodules, known as "concretions". The sands have practically no cement. The cement of the nodules is calcareous. Dinosaur remains of *Protoceratops andrewsi* GRANGER & GREGORY (mostly skulls) and *Pinacosaurus* sp. were excavated from this horizon by the Expedition in 1964 and 1965. All mammal skulls (except one) come from this horizon (see KIELAN-JAWOROWSKA, 1968). These mammal remains come from three fields. The largest field that yielded the majority of these findings, lies at the base of the Flaming Cliffs and was called "The Main Mammal Field". The second one is called "The Ruins" and is situated 2500 metres NW of the Flaming Cliffs. The third mammal field lies near a monadnock called "The Volcano", situated 2000 metres NW of the Ruins. All mammal remains were found in sandstone nodules. The known thickness of this layer is about 10 metres. These sands are particularly unresistant to weathering because of their poor cementation. Locally thin layers of hard, cemented orange-pink sandstone occur within this horizon, in the Main Mammal Field.

3. Reddish-brown sandstones exhibiting numerous cavities on weathered surfaces and almost uncemented sand. The sand is very similar to that of layer No. 2. The cement of the sandstone is calcareous and epigenetic in origin. On weathered surfaces, this sandstone seems to be cavernous. No skeletal remains were found in this horizon. The arenaceous material of this layer seems to be the same as that of the layer No. 2. The thickness of this layer varies from 4 to 7 metres. In fact this is not a separate layer, but a rather level of epigenetic cementation of the same sand as that of the layer No. 2. Nests of dinosaur eggs were found in this horizon. The eggs have smooth surfaces. Some are large (13 cm long), while others are smaller (about 8 cm). Rarely very small, inner casts of eggs occur, but without the shell, which must have dissolved during diagenesis. The latter „eggs" are approximately 2 cm long. They occur together in groups, but were never found in regular nests.

4. Orange-brick to reddish-brown, poorly diagenised sands. The arenaceous material is the same as that of layer No. 2. Large arenaceous nodules are scattered within this layer, occurring mostly in the top part. Thousands of small nodules (approximately 3—5 cm in diameter) can be found throughout the horizon. In places (particularly on the western side of the Flaming Cliffs) some concretionary layers of sandstone occur. A nest of large eggs with corrugated shells was found almost at the top of this horizon. Also a multituberculate skull came from there. Locally, a thin layer of conglomerates analogous to those of No. 5 can be seen in this horizon.

5. Conglomerates consisting of small (0.5—1.5 cm) white-pinkish, calcareous nodules, which serve there as pebbles, and orange-pink sand. Some pebbles are of crystalline, igneous rocks. Cross-bedding can be seen in some places. The thickness of this layer is usually 0.4—1.5 m, but this layer disappears completely towards NW.

6. Orange-brick to reddish-orange-brown sands. Many small, arenaceous nodules occur within this layer. The material of this layer does not contain calcareous cement, but the nodules do. The thickness is about 4 metres.

7. White marls. Compact marls form the upper part of this horizon, containing little sand. The rock looks as if a calcareous substance had penetrated down through the sands. Just below these marls, the sands exhibit many small, marly nodules. Undoubtedly this is a stage in the development of the calcareous cement.

8. Orange-brownish sands (grains less than 0.5 mm in diameter). Calcareous cement does not occur everywhere. Nests of eggs have been found in this bed. Also one turtle is known from here.

9. Moderate reddish orange-pink sandstones. Sand grains 0.2—0.6 mm in diameter. Scarce calcareous cement is present. The cementation of this horizon is clearly epigenetic. The thickness is about 0.7 m.

10. Reddish-orange-brown sands (sand grains 0.2—0.4 mm). Small sandy nodules usually occur in this layer. This is the highest Upper Cretaceous horizon cropping out at Bayn Dzak.

LOCALITY BEGGER NOOR

Location and morphology

The geographic co-ordinates of Begger Noor locality are: 96°49′ longitude E and 45°54′ latitude N. The exposures are situated at a heigh of about 1600 m above sea-level.

The Begger Noor Basin forms a morphological depression bounded in the N by the granite massifs of Serkh Ula and Tayshiren Ula, and from the S by the Mongol Altai ridge. The long axis of the basin runs in a NW-SE direction. A salt lake occupies the central part of the basin and into this runs the small river Dzost. Salt marshes, which periodically dry up, occupy a large area round the lake.

The main exposures of Neogene sediments are situated in the NW part of the basin, where they form several groups of steepsided hills and in the southern part, where they give rise to a long zone along the Mongol Altai pediment (Pl. VII, fig. 1). The system of exposures on the northern side of Begger Noor Lake was not investigated by the Polish-Mongolian group in 1965.

The most convenient way of approach to the western part of the basin is from the centre of the aymak Yessen Bulak, through Duta Daba pass and the Naran locality. The first camp of the 1965 expedition was in the gorge with a stream, in the southern belt of the exposures, and afterwards it was transfered to the group of NW exposures, westwards from the fork in the road leading in the direction of Yessen Bulak and Khalyun (Text-fig. 31).

History of research

The Tertiary series in Begger Noor Basin were examined by RAZUMOWSKA (1946). She defined the Red Shales, sandstones and conglomerates covering the washed out surface of the Lower Cretaceous sediments as Miocene. In the western part of the basin RAZUMOWSKA collected remains of mammals among which RIABININ (cf. RAZUMOWSKA, 1946, p. 108) distinguished representatives of Carnivora, Proboscidea and Cavicornia. Further work at the Begger Noor locality were carried out during the Soviet Palaeontological Expedition in 1949 (ROZHDESTVENSKY, 1954), and Geological Expedition in 1965 (DEVYATKIN & LISKUN, 1966). The Tertiary sediments were divided then into two complexes; the Lower Complex of red, sandy clays, and the Upper Complex of grey-yellow sandstones and gravels with concretions containing bones. In the Upper Complex, *Serridentinus gobiense* OSBORN & GRANGER (ALEXEYEVA, 1959) and *Aceratherium gobiense* BELAYEVA (BELAYEVA, 1960) were found and described, approximately defining the age of the sediments containing them as Upper Miocene to Lower Pliocene.

The Polish-Mongolian group worked for 8 days in the Begger Noor Basin in summer, 1965, mainly in the NW zone of exposures. A search for fauna was also carried out in the southern zone of exposures, as far as the foot of Mongol Altai.

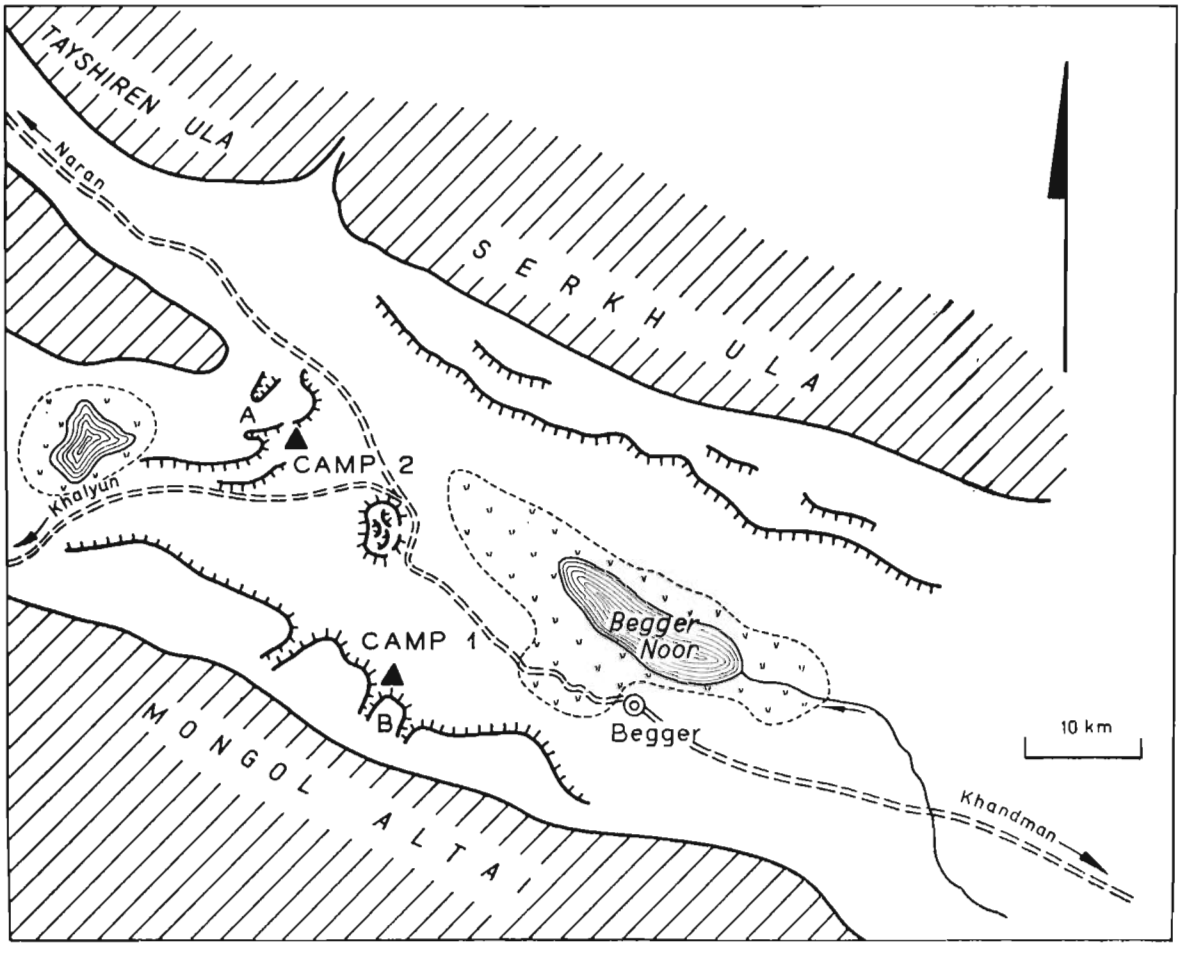

Fig. 31
Sketch-map of Begger Noor Basin. For morphological explanation, see Fig. 2, p. 39, and Fig. 13, p. 58.

Geology

The Tertiary sediments of the Begger Noor Basin display significant evidence of tectonic activity, which is manifested in small faults and in the assemblages of microtectonic elements. Almost horizontally lying beds are to be seen only in exposures in the central part of the valley. In the direction of Mongol Altay the dip increases rapidly, on borders exceeding 60° SSE. A distinct deviation from the horizontal position of a thick cover of Quaternary series proves the existence of very young eperogenic movements in this area. The supply of material from the crystalline massifs surrounding Begger Noor valley is marked only in the Quaternary sediments. The areas of alimentation for the Tertiary sediments are to this unknown.

In the area covered by the present study, a profile of sediments reaching about 300 m in total thickness is exposed. The richest profile was provided by a southern group of exposures (Text-fig. 32).

1) Variegated beds, comprising sandy clays and green-grey sands, in which *Estheria middendorfi* var. *sinensis* CH. was found by TSHERNYSHEVA (cf. RAZUMOVSKA, 1946, p. 108) giving a Lower Cretaceous age for these sediments.

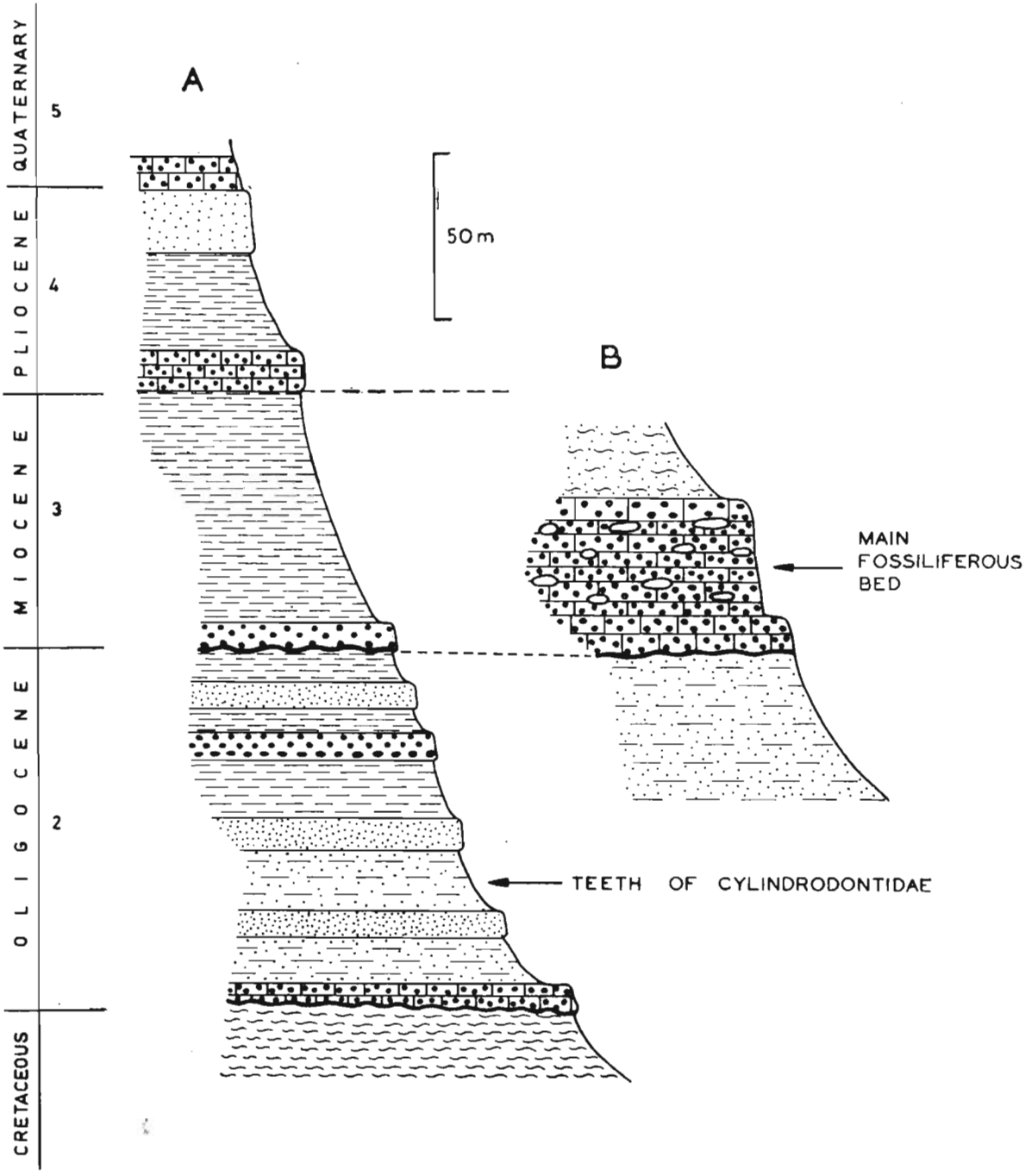

Fig. 32
Geological profiles at Begger Noor Basin: *A* — S part of the basin, *B* — NW part of the basin. For explanation, see Fig. 3, p. 41.

2) The Red Beds, consisting mainly of red sandy silts, sands gravels and sandy conglomerates, which lie on the eroded sandy shales of Lower Cretaceous age. Soviet geologists (ROZHDESTVENSKY, 1954) grouped this series and the one lying above into one complex of Mio-Pliocene sediments.

In the sandy silts of the Red Beds in the southern zone of exposures, teeth of Cylindrodontidae were found. These are forms characteristic for the Oligocene only. Both the high clay content and the strong red colour of the sediments are characteristic features of Oligocene lacustrine facies, known from numerous other localities in Mongolia. Between the Red Beds and the overlying complex is a distinct erosional boundary and a small discrepancy of angles, amounting to 3—5° on the average. The total thickness of the complex varies between 80 and 110 m.

3) The Yellow Beds comprises weakly cemented sandy conglomerates of mainly quartz and quartzite in the lower part, which pass gradually upwards into yellow-grey gravels and cross-bedded sands. The pebbles and grains show a high degree of rounding and sorting, which latter is often emphasized by well developed graded bedding. The bones occur mainly in epigenetic, calcareous sandy gravel concretions, irregularly distributed within the unconsolidated sediment. The sizes of the concretions vary from a few centimetres to a metre; though the majority lies in the range of 30—50 cm. The shapes of the concretions are very irregular, spherical or elliptic and rarely disc-like. The concretions in all cases display bedding, closely corresponding to that in the surrounding sediment and differing only in the greater degree of lithification. Crushed bones are often badly preserved. The primary structure of the bones is usually destroyed, as a result of the replacement of calcium phosphate by iron compounds.

The Yellow Beds, with concretions containing bones, is fully developed in the exposures of the NW part of the Begger Noor valley; in the southern part, concretions do not occur and the quantity of coarse clastic material decreases, to be replaced by silt-clay sediments. Thus the Mio-Pliocene sediments of the Begger Noor valley are developed in two facies: alluvial (northern) and lacustrine (southern). Transitional sediments between the facies cannot be seen because of the lack of exposures. It seems, however, that the present day proximity of both facies is due to tectonic activity.

The Yellow Beds end in greenish-yellow, clayey sands, with numerous inclusions of green-grey clays. The total thickness of the Yellow Beds in the most complete profile is about 70—80 m.

4) Beds of grey-yellow siltstones and fine-grained sands, resting on sandy conglomerates. These sediments show great vertical, as well as horizontal variability. The average thickness is about 60 m.

5) The thick clastic sediments of Quarternary talus and washed out Pleistocene moraine.

LOCALITY ALTAN TELI

Location and morphology

The exposures of the Altan Teli locality are situated in the Dzereg Valley; their geographic co-ordinates are 93°10′ longitude E and 47°06′ latitude N, and they lie at an altitude of about 1800 m above sea-level.

The Dzereg Valley forms a broad depression, with the axis running NW-SE. In the S, it is bordered by the Baatar Khayrkhan massif, and in the N by the Omno Khayrkhan Ula massifs (in the E) and Jargalant Khayrkhan (in the W). The exposures of Cretaceous and Ter-

tiary occur as a long belt of hills along the southern foot of the Omno Khayrkhan Ula and Jargalant Khayrkhan massifs. South of the first massif there is a large group of exposures, known from the times of the Soviet Palaeontological Expedition in 1949 as the Altan Teli locality. The locality takes its name from a somon, then situated about 10 km SW from the excavations. Further in the NW direction, the exposures of the Oshih locality are situated. These latter were not reached by the Polish-Mongolian group in 1965.

The area exploited by the Polish-Mongolian group in 1965 lies at a distance of about 5 km to NW from the road joining the Darbi and Dzereg somons, measured from the point

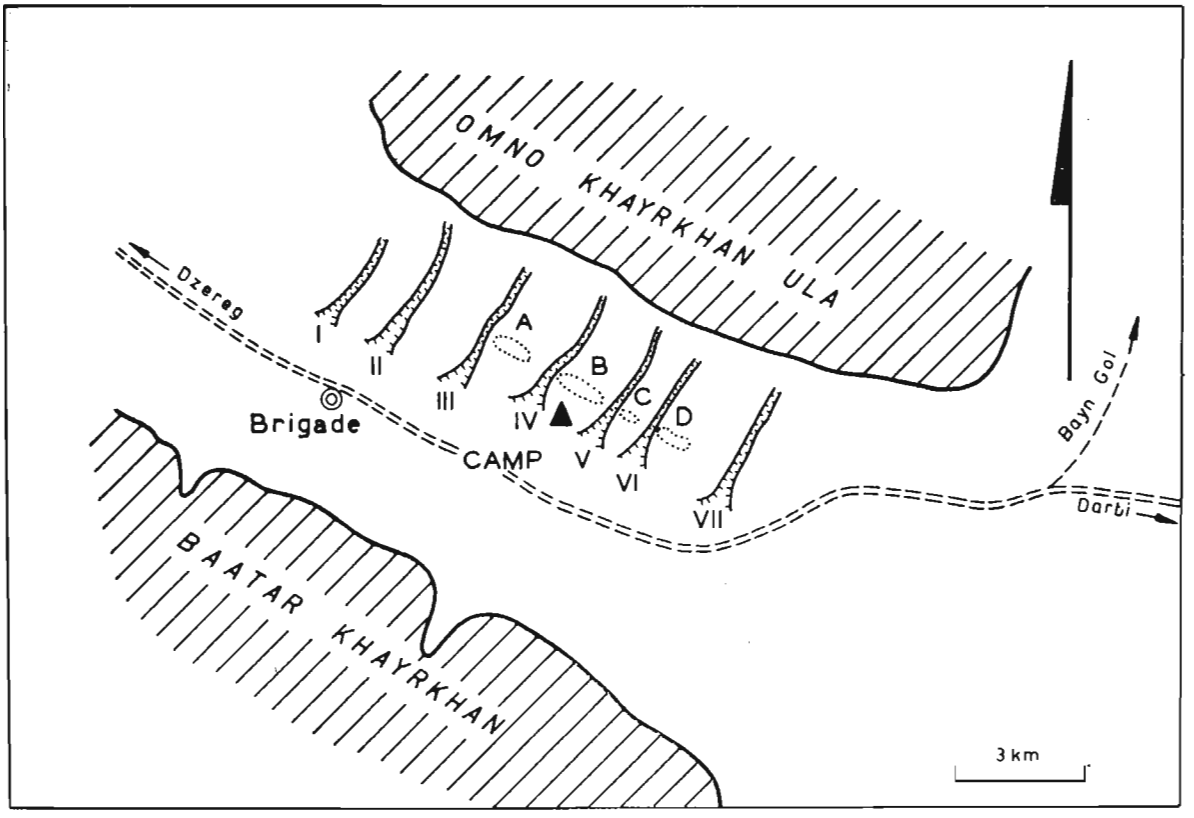

Fig. 33
Sketch-map of locality Altan Teli. I—VII main gorges. For morphological explanation, see Fig. 1, p. 36, Fig. 2, p. 39, and Fig. 13, p. 58

at which the road passes from the northern to the southern side of the valley. The location of the areas exploited is shown in a plan (Text-fig. 33). The eastern zone of Cretaceous sediments and Tertiary sediments is cut by a system of gorges. The main gorges are generally perpendicular to the long axis of the valley. The main work was carried out in the Bone Horizon, exposed between the gorges indicated on the map by the numbers III—VII. Direct approach to the exposures is possible only using trucks.

History of research

The Altan Teli locality was discovered by the Soviet expedition in 1949. From the rich material collected, only *Samotherium mongoliense* GODINA, 1954, was described up to now.

On the basis of preliminary findings, the Soviet palaeontologists recognized the group of mammals from Altan Teli as Lower Pliocene or Miocene (ROZHDESTVENSKY, 1954; DEVYATKIN & LISKUN, 1966; ZHEGALLO, 1966).

The Polish-Mongolian group stayed in the area of Altan Teli exposures for 2 weeks in August 1965, carrying out exploitation work at 4 points along the Main Bone Horizon. For the purpose of making a short review of the Oshih locality, work was also carried out at the distance of about 60 km NW of Altan Teli.

Geology

Cretaceous and Tertiary sediments in the Altan Teli exposures form an anticlinal fold with axis trending parallel to the ridge of Omno Khayrkhan Ula massif (Pl. VII, fig. 2). The western part of the anticline is asymmetrical, distinctly leaning northwards with a slightly compressed northern limb. The eastern part is symmetrical and sinks gradually beneath the cover of Quaternary sediments. The main horizon with fragments of vertebrates is exposed in the southern limb of the anticline (Text-fig. 34). The average azimuth of the strike of beds is 133—150° and the angle of dip 30—90°.

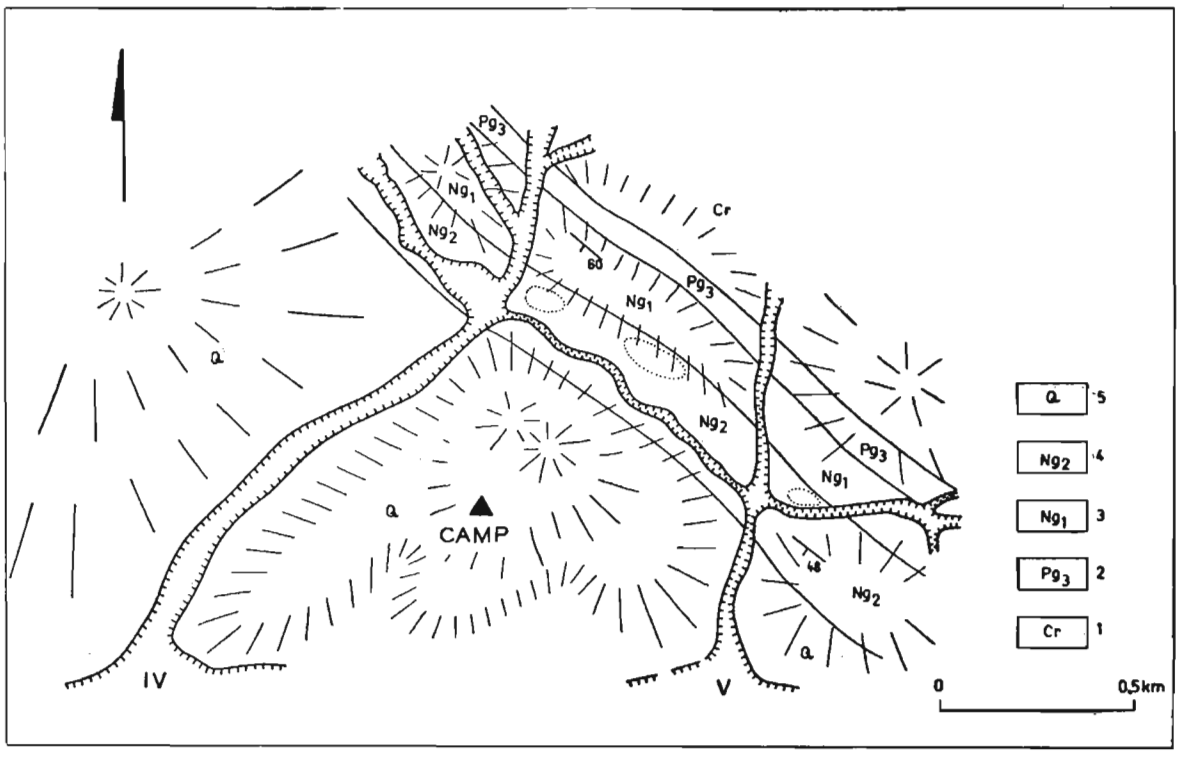

Fig. 34
Geological map of locality Altan Teli. *1* — Cretaceous, *2* — ?Oligocene, *3* — Miocene, *4* — Pliocene, *5* — Quaternary. For morphological explanation, see Fig. 2, p. 39.

Along the gorges cutting the anticline perpendicular to the strike, a profile of sediments of total thickness about 650—700 m may be observed (Text-fig. 35).

1) The complex of red and greenish clayey sandstones and clays forming the core of the Altan Teli anticline. The lowest part of this complex contains numerous intercalations of comp-

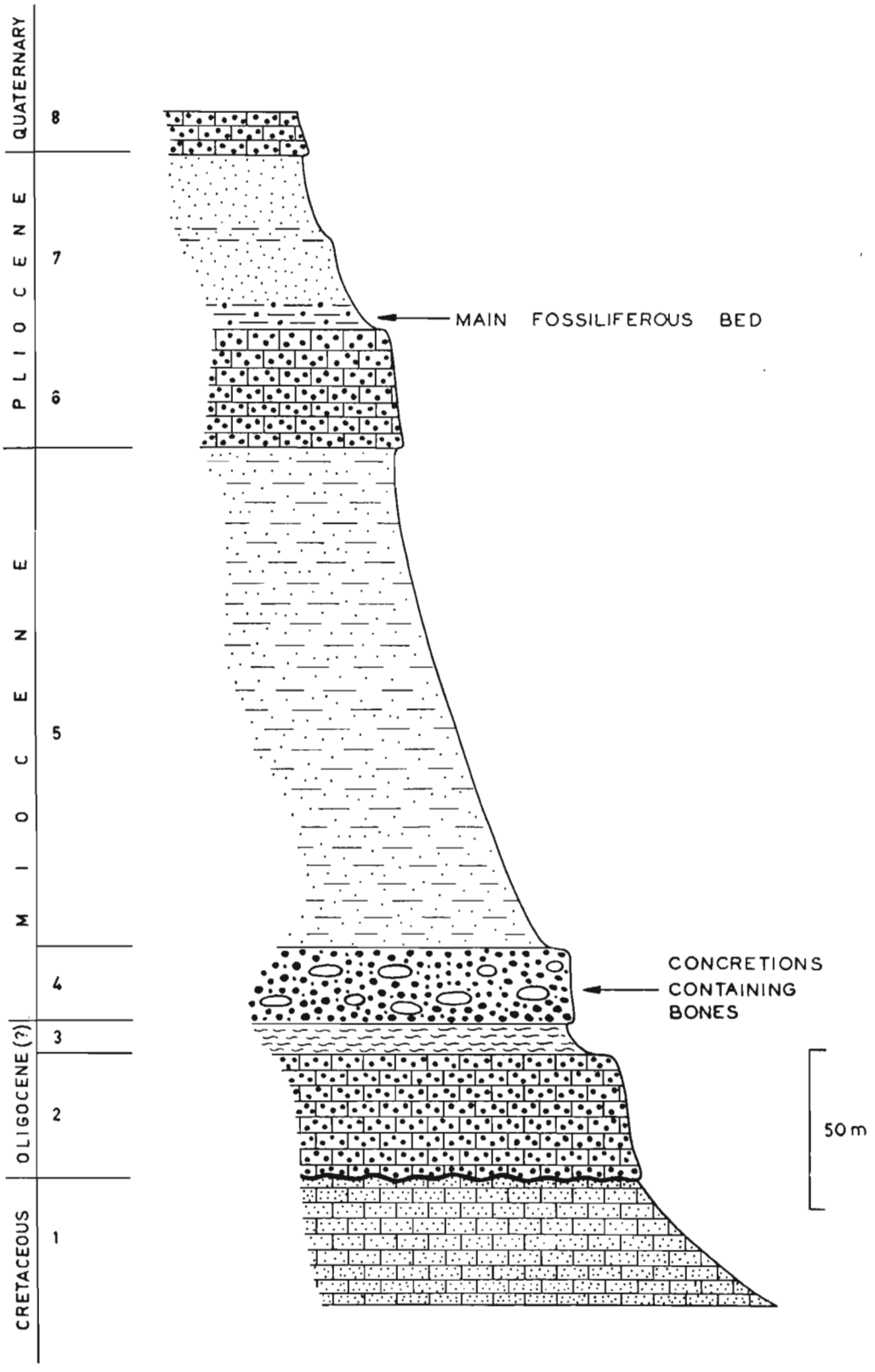

Fig. 35

Geological profile of Cretaceous and Tertiary sediments at locality Altan Teli. For explanation, see Fig. 3, p. 41.

act, fine-grained, grey sandstones. In one of these sandstone beds, dinosaur remains from the Sauropoda group were found in 1949. These latter permitted the determination of the age of the sediments as Cretaceous, most probably Upper Cretaceous (ROZHDESTVENSKY, 1954). This complex also yielded a collection of shellfish and phyllopods elaborated by NOVOZHILOV (1953). The Altan Teli complex of Cretaceous sediments approaches in lithologic and faunal character the sediments of Altan Ula, with which it most probably should be correlated. The thickness of the complex is about 300—330 m.

2) The series of light yellow sandy conglomerates, with pebbles of white quartz, grey quartzites and brightly coloured metamorphic rocks. The sediment is poorly cemented by a ferruginous and siliceous cement. The thickness of the series varies from 30 to 60 m.

3) The 8—10 m thick series of red and somewhat calcareous clays with sporadic inclusions of sands, gravels, occasionally pink marls. The stratigraphic position of these sediments, as well as the position of the last mentioned conglomerates, is not clear because of the lack of palaeontological data. Lithologically, these sediments show a great similarity to the Oligocene Red Beds in the Begger Noor valley and the Shargayn Gobi area. A reduction in the thickness of this series in the Altan Teli area was probably caused by later erosion by washing out.

4) The series of yellow-grey sands and gravels, cross-bedded with epigenetic concretions identical with those in the Begger Noor Basin. In one of the concretions, a fragment of a rhinoceros jaw with two molars was found. This belongs to the genus *Aceratherium*, characteristic for the Miocene. The thickness of the series is about 20 m.

5) The series of light grey and greenish siltstones and finegrained clayey sands with a few interbeds of grey marks. In the sediments of this series fragments of undetermined bones were found. The thickness is about 180 m.

6) The series of grey poorly cemented sandy conglomerates, in which single pebbles reach a maximum diameter of 40 cm. The conglomerates are interbedded in some places with coarse-grained and somewhat clayey sandstones. The thickness varies considerably from 30—45 m.

7) The series of grey-yellow sands and gravels with intercalations of sandy silts. In the lower part of the series, the Main Bone Horizon is situated in calcareous siltstones (Text-fig. 35). Fragments of vertebrates occur as rich assemblages located within the sediment in elongate lenses, over several tens of metres in length. The thickness of the bone bed never exceeds 2 m. The manner of grouping and the relatively varied distribution of skeletal elements shows a deposit of taphocoenosis type. The bones on the surface are almost completely destroyed by weathering. Because of this, exploitation was carried out by digging trenches and tunnels a few metres deep. The depths of the tunnels was limited by the high angle of dip of the beds. The fragments of representatives of particular groups were deposited in a selective manner. In one of the points exploited, about 90 per cent of the skeletal elements was made up of rhinoceros remains (mainly skulls). At another point, almost only *Hipparion* was found and at still another, only turtles. The Altan Teli bone deposit is of alluvial type, and was formed after the decay of the bodies of the animals, the skeletal elements being distributed by current and finally deposited selectively according to their weight and size. The thickness of the whole series is about 55 m.

8) Coarse clastic Tertiary sediments occur as talus and washed glacial moraine.

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APPENDIX

GLOSSARY

OF MONGOLIAN PLACE-NAMES WITH ENGLISH EQUIVALENTS

Agooy Dats	Агуй Дац
Alag Noor	Алаг Нуур
Altan Teli	Алтан Тээл
Altan Ula	Алтан Уул
Arts Bogdo	Арц Богд
Arvaykher	Арвай Хээр
Atch Bogdo	Аж Богд
Baatar Khayrkhan	Баатар Хайрхан
Baga Bogdo	Бага Богд
Bayn Dalay	Баян Далай
Bayn Dzak *	Баян Дзак
Baynender	Баянөндар
Bayn Gob	Баянгобь
Bayn Gol	Баян Гол
Baynkhongor	Баянхонгор
Bayn Leg	Баянлиг
Bayn Shireh	Баян Ширээ
Begger	Бэгэр
Begger Noor	Бэгэр Нуур
Bogd Somon	Богд Сум
Boombat Khayrkhan	Бумбат Хайрхан
Boongeen Brigad	Бунгийн Бригад
Boongeen Gol	Бунгийн Гол
Buheen Gol	Бөхийн Гол
Bulgan	Булган
Buylstyeen Khuduk	Буильстийн Худаг
Dalan Dzadgad	Далан Задгад
Darwee Somon	Дарви Сум
Dzag Somon	Заг Сум
Dzahooy Somon	Захуй Сум
Dzamyn Sayr	Замын Сайр
Dzaram Bulak	Зарам Булаг
Dzeegdeen Khuduk	Зигдийн Худаг
Dzereg	Зэрэг
Dzoolon Ula	Зөөлөн Уул
Dzoon Bayn	Зуунбаян
Edrengyeen Nuru	Эдрэнгийн Нуруу
Ekheen Dzooganay Gol	Эхийн Зууганай Гол
Erdenedalay	Эрдэнэ Далай
Ergel Obo = Ergelyeen Dzo **	Эргел Овоо Эргэлийн Зоо
Gobi Altai	Говь — Алтай
Gua Teg	Гуа Тээг
Gunnaryeen	Гуннарийн
Gurvan Saikhan	Гурван Сайхан
Guvan Tes	Гурван Тэс
Ikhe Bogdo Ula	Их Богд Улл
Khaitch	Хайч
Khalyun	Халиун
Khamarin Khural	Хамрын Хурал
Khan Khongor	Хан Хонгор
Kharaat Ula	Харат Уул
Khar Khutul Ula	Хар Хутул Уул
Khar Teg	Хар Тээг
Khashaat ***	Хашаат
Khatan Bulak	Хатан Булаг
Khatan Khayrkhan	Хатан Хайрхан
Khayrkhan Ula Somon	Хайрхан Уул Сум
Khevsgel	Хөвсгөл
Khoboor	Хобур
Khongil Tsav	Хонгил Цав
Khoogsho	Хөгшөө
Khulst	Хуласт
Loh	Ло
Mandal Gob	Мандал Говь
Mandal Obo	Мандал Овоо
Naran Bulak (Dats)	Наран Булаг (дац)
Nareen Bulak	Нарийн Булаг

* Referred to in American literature as Shabarakh Usu.

** Reffered to in American literature as Ardyn Obo.

*** Reffered to in American literature as Gashato.

Nareen Tel	Нарийн Тээл
Nemegt Ula	Нэмэгт Уул
Nemegtyeen Khotgor	Нэмэгтийн Хотгор
Noyon	Ноён
Ondai Sayr	Ондойн Сайр
Oshih	Оош (Ойш)
Sayn Shand	Сайн Шанд
Serkh Ula	Сэрх Уул
Sevrey	Сэврэй
Shabarakh Usu	Шаврын Ус
Shand Gol (Hsanda Gol)	Шанд Гол
Sulan Kher	Сулан Хээр
Tatal Gol	Татал Гол
Tayshiren Ula	Тайширин Уул
Tshandman	Чандман
Tost	Тост
Tsagan Derseen Khuduk	Цааган Дэрсний Худаг
Tsagan Khushu	Цааган Хушуу
Tsel Somon	Цээл Сум
Tsogt Obo	Цогт Овоо
Tsumtsees Khayrkhan	Цумцас Хайрхан
Tushleg	Тушлэг
Ulan Bator	Улаанбаатар
Ulan Bulak (Dats)	Улаан Булаг (дац)
Ulan Ganga	Улаан Ганга
Ulan Noor	Улаан Нуур
Ulan Sayr	Улаан Сайр
Yessen Bulak	Есөн Булаг