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The Russian–Mongolian expeditions and research in vertebrate palaeontology

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Introduction

Central Asia attracted the attention of palaeontologists after Tertiary mammals had been found in continental sediments. At first, Richthofen (1877) argued that Central Asia had been flooded by a huge sea which produced marine deposits, the so-called Khankha deposits. Borisyak (1915) predicted that Mongolia would be a storehouse of palaeontological treasures, based on his study of Tertiary mammals in adjacent Kazakhstan, and on the discovery of a brontothere tooth in Tertiary rocks on the Plateau Khooldzin, south of Iren Dabasu Lake, Inner Mongolia, China, by Vladimir Obruchev in 1892 (Obruchev, 1893). Borisyak expected rich finds of Tertiary mammals in Mongolia, since he considered that Central Asia was the centre of origin of Cenozoic mammals. These prognoses stimulated the Central Asiatic Expedition of the American Museum of Natural History in the 1920s, and the environs of Iren Dabasu Lake were the first area investigated; here the Expedition discovered a Cretaceous fauna of dinosaurs and Paleogene and Neogene mammals (Granger and Berkey, 1922).

Why is Mongolia so rich in remains of ancient vertebrates? During the past 200 Myr, since the early Mesozoic, the territory of Mongolia was never covered by the sea. The arid continental climate of the past 30 Myr has not encouraged the formation of a thick soil cover, nor the development of vegetation, and has generated strong erosion by water, wind, and temperature change. Rapid sedimentation, associated with significant water supplies and broken relief, occurred for significant periods of time in the Cretaceous, Paleogene, and Neogene over a large part of southern Mongolia, and this promoted the preservation of fossils. Moderate tectonic activity has generated small escarpments which reveal much of the thickness of the sedimentary succession. The absence of Pleistocene ice sheets meant that the ancient deposits were not erased. Thus, in Central Asia, there is a nearly continuous series of lake and river deposits containing continental biota, beginning in the Late Jurassic, and in some places in the Late Triassic.

The territory of Mongolia extends nearly 2400 km from east to west and nearly 1300 km from north to south. Most of Mongolia is a middle-level mountain plateau with average heights 1000–1200 m above sea level. In the southern half of the country, mountain ridges of the Mongolian and Gobi Altai with heights from 1500 to 4000 m above sea level, lie on either side of extended depressions, filled with Mesozoic and Cenozoic deposits, the products of erosion of the surrounding high countries (Murzaev, 1948). In these depressions the main palaeontological riches of Mongolia are buried.

Abbreviations

ARAS, Archives of the Russian Academy of Sciences; AS USSR, Academy of Sciences of the USSR; F, Fund of the ARAS; CAE, Central Asiatic Expedition of the American Museum of Natural History; L, List of the ARAS; MAS, Mongolian Academy of Sciences; MPE, Mongolian Palaeontological Expedition of the Academy of Sciences of the USSR; MPR, Mongolian Peoples' Republic; P, Page of the ARAS; PIN, Palaeontological Institute of the RAS; RAS, Russian

Academy of Sciences; RMPE, Joint Russian–Mongolian Palaeontological Expedition; SMPE, Joint Soviet–Mongolian Palaeontological Expedition; U, Deposition Unit of the ARAS.

The first discoveries of Mesozoic and Cenozoic vertebrate sites

From 1922 to 1930, the Central Asiatic Expedition of the American Museum of Natural History (CAE), under the leadership of Roy Chapman Andrews, worked in Mongolia. They found Late Cretaceous faunas of vertebrates (*Protoceratops*, small carnivorous dinosaurs, clutches of dinosaur eggs, mammals) at the Bayan Zag site in Southern Mongolia and Early Cretaceous dinosaurs (*Psittacosaurus*) and fishes in the Andai Khudag and Öösh sites in the Lakes Valley of Central Mongolia. The CAE also opened the Palaeocene Gashato site near Bayan Zag and the Oligocene Ardyn Ovoo (= Ergil Ovoo, = Ergiliin Zoo) site in south-eastern Mongolia and the Tatal Gol site in the Lakes Valley, which produced many new Paleogene mammals. Berkey and Morris (1927a, b) divided the Cretaceous deposits of Mongolia into 13 formations, and they considered that Late Cretaceous climates were arid and semi-desert, though in the Early Cretaceous epoch was more humid with many lakes, a wide river network, and rich vegetation.

Practically simultaneously with the CAE, Soviet geologists began searching for minerals in Mongolia as technical assistance to the young Mongolian Republic. The full story of the geological exploration of Mongolia and adjacent regions of China by Russian and Western scientists has been told by Marinov (1967). From this book, we will summarize the main projects by Soviet scientists.

From 1925 on 1932 geological expeditions of the Academy of Sciences of the USSR to Mongolia were led by I.P. Rachkovskii. These expeditions investigated rich Tertiary vertebrate sites in Western and Eastern Mongolia and Cretaceous dinosaur localities in Eastern Mongolia (Kupletskii, 1926; Lebedeva, 1926, 1934; Rachkovskii, 1928; Rachkovskii and Lebedeva, 1932; Belyaeva, 1937). In 1925, a geological expedition led by B.S. Dombrovski from the Far-Eastern University of Vladivostok conducted research in Central and Eastern Mongolia. It did some work on the new large dinosaur sites (Dombrovski, 1926). Further expeditions of Soviet scientists conducted researches in Mongolia from 1920 to 1930. The geographers and hotanists A.D. Simukov, E.M. Murzaev, A.A. Yunatov, and B.M. Chudinov found Cretaceous dinosaurs in the Southern Gobi. In the Eastern Gobi, 20 sites of Paleogene mammals and Cretaceous dinosaurs were found by the geologists A.P. Chaikovskii, A.N. Alekseichik, N.I. Delnov, and Yu.S. Zhelubovskii (Marinov *et al.*, 1973), and later, some of these data were used by I. Efremov.

Mongolian Palaeontological Expedition (MPE) of the Academy of Sciences of the USSR, 1946–1949

At the end of 1940, the Scientific Committee of the MPR sent a letter to the director of the PIN, A. Borisyak, inviting him to organise a palaeontological expedition to Mongolia in 1941. The offer was agreed with the Praesidium of the AS USSR and by the Council of the Peoples' Commissars of the USSR, and money was allocated for the expedition. Yu.A. Orlov was nominated chief of the expedition, and I.A. Efremov vice-chief. Plans for the expedition included equipment for 10 people and an estimated duration of 3.5–4 months of field work, covering Southern Mongolia, the Trans-Altai and Middle Gobi, and Western Mongolia. Three GAS-AA motor trucks were received. However, because of a delay in the receipt of foreign passports for travel outside the USSR, the expedition could not leave Moscow at the end of May, as was planned, and it was postponed to 1942 (ARAS; F. 1712; L. 1; U. 18; pp. 1–38.). Then, in June 1941, Germany attacked the USSR, and clearly the work of the MPE had to be postponed.

As early as the end of 1945, Yu. Orlov submitted a request to run the Palaeontological expedition to Mongolia to the Praesidium of the AS USSR. This petition was accepted by the Council of Ministers of the USSR (Resolution N 2051 PC of February 16,

1946) and on March 28, 1946, the Praesidium of the AS USSR gave an order for the organization of the MPE for a period of seven months (ARAS; F. 1712; L. 1; U. 73.; pp. 1 and 8). The expedition left Moscow at the beginning of August, 1946. On August 10th it reached Ulaanbaatar, and on September 1st began to work at Bayan Zag. The leader of the MPE was now I.A. Efremov, and Yu.A. Orlov was its scientific adviser. The preparators J.M. Eglon and M.F. Lukiyanova also worked in Mongolia on the first expedition, as did the scientists K.K. Flerov, V.I. Gromov, and A.A. Kirpichnikov. The 1946 MPE worked for 2.5 months in the field. In Dalanzadgad, a forwarding base with stocks of petrol was created, from which forwarding routes extended over the whole of Southern and Eastern Mongolia. The motor vehicles travelled a total of 4700 km. The expedition returned to Ulaanbaatar on November 4th, and left for Moscow by rail on January 7th, 1947.

The MPE in 1946 carried out reconnaissance and prospecting on three main routes (Efremov, 1948, 1949; Orlov, 1952). North of Dalanzadgad, a northern group of routes included surveys at Bayan Zag, and the new Late Cretaceous sites Ulaan Öösh and Algui Ulaan Tsav were opened up. The western group of routes passed the foot of the Gilbent, Nemegt, and Altan Uul ridges and their surrounding depressions. In this direction, the rich Late Cretaceous dinosaur sites Nemegt and Altan Uul were opened, and the important Naran Bulag site with Paleogene mammals was found. The Late Cretaceous Shiregiin Gashuun site with crocodiles, north of Nemegt, and the Paleogene Gashato site were also surveyed. South of the Nemegt Ridge, in the region Noyon Sum, I.A. Efremov opened a section of continental Permian deposits, many kilometres long, with the remains of plants and trunks of cordaites (Efremov, 1952). On the eastern route from Dalanzadgad to Sainshand, new Late Cretaceous sites with dinosaurs were found at Bayan Shiree, Khamaryn Khural, Khar Hötöl, and Tüshleg, and excavations were also made at the Paleogene Ergil Ovoo locality, found by the CAE (Figure 13.1).

Despite the fact that the first MPE was essentially a reconnaissance trip, it was outstandingly successful, both in terms of finds of Paleogene mammals and Late Cretaceous fossils. New large dinosaur sites were discovered in the Southern and Eastern Gobi. Particularly important were the finds in the Upper Cretaceous rocks of hadrosaurs and sauropods, as well as large terrestrial carnosaurs and ankylosaurs, generally unknown from the Old World, and abundant finds of fossil trees, crocodiles, and fishes. These fossils all suggested to the Soviet geologists that in the Late Cretaceous Central Asia was covered with extensive lakes, bogs, and large rivers, opposite to the usual view that these territories had experienced arid conditions since the Mesozoic.

The whole of 1947 was devoted to the preparation of the second expedition. A main task of this expedition was excavation at Nemegt and Bayan Shiree with large numbers of workers and large numbers of trucks. The trucks, equipment, and drivers were sent from Moscow to Ulaanbaatar in November 1947, and in December the expedition leaders arrived. The field base at Dalanzadgad was set up during the severe Mongolian winter with stocks of equipment and petrol, and one of the field teams began work in the Eastern Gobi in March, 1948. The second MPE ran for 11 months in 1947–1948, and participants included 16 employees of PIN and 10 hired hands (ARAS; F. 1712; L. 84; U. 28). I.A. Efremov continued as leader, and Yu.A. Orlov as scientific adviser. The scientists present were N. Novozhilov, J. Eglon, A. Rozhdestvenskii, and E. Maleev, the preparators were M. Lukiyanova and V. Presnyakov, and the drivers were V. Pronin, T. Bezborodov, N. Vylezhanin, I. Likhachev, and others.

The expedition left Ulaanbaatar for the Eastern Gobi on March 18th. Work at Bayan Shiree and Ergil Ovoo continued until April 20th, and at the same time remains of large sauropods, carnivorous dinosaurs, and turtles were found at the Lower Cretaceous Khar Hötöl locality, south of Sainshand. In the same region, fossil Cretaceous wood with huge vertical trunks of *Taxodium* were found. After April 20th, the main excavating team began work at Bayan Zag and, from the beginning of May, moved to the Nemegt locality. The skeletons of a huge hadrosaur (*Saurolophus angustiros-*

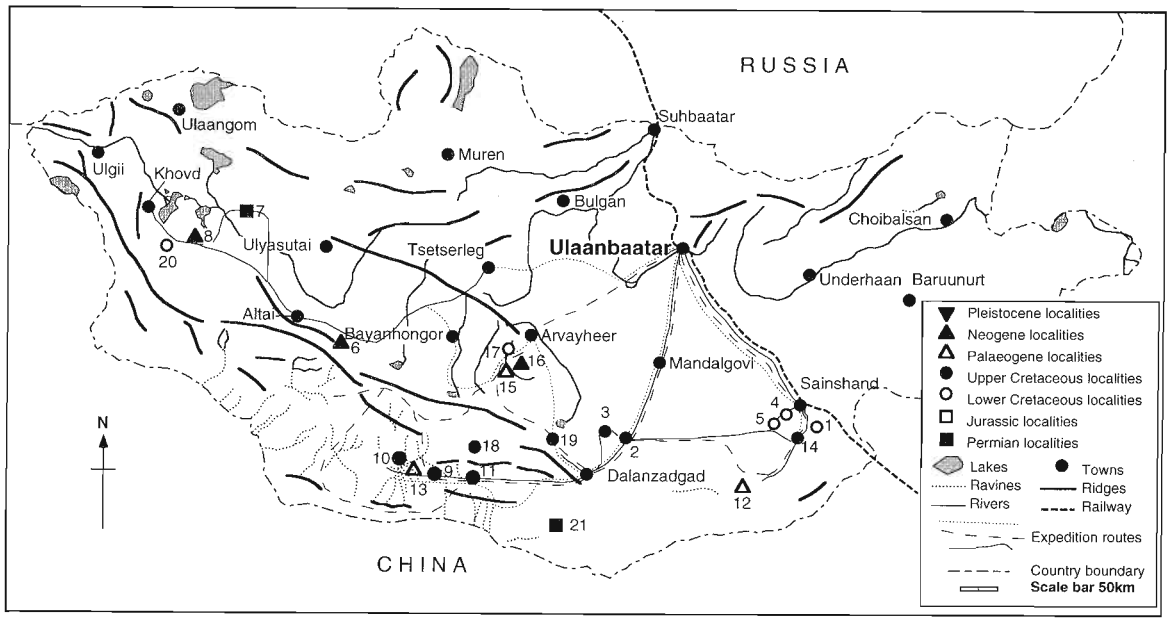

Figure 13.1. Mongolian Palaeontological Expedition of the Academy of Sciences of the USSR, 1946–1949. Map of the routes, localities, and newly discovered fossiliferous areas. Compiled by I. Efremov for Marinov (1967), with some additions. Localities: 1, Khamaryn Khural; 2, Algui Ulaan Tsav; 3, Ulaan Öösh; 4, Khar Hötöl; 5, Tushilge; 6, Beger Nuur; 7, Tsast Bogd; 8, Altanteel; 9, Altan Uul; 10, Tsagaan Uul; 11, Nemegt; 12, Ergil Ovoo; 13, Naran Bulag; 14, Bayan Shiree; 15, Tatal Gol; 16, Loo; 17, Andai Khudag; 18, Shireegiin Gashuun; 19, Bayan Zag; 20, Osh Nuur; 21, Noyon Sum.

tris), small carnivorous dinosaurs, isolated skulls of dinosaurs, huge turtles, crocodiles, and fishes were excavated. In Altan Uul, the Dragon's Tomb site was opened, where complete skeletons of *Tarbosaurus* and *Saurolophus* with the remains of fossilized skin were dug out. West of this site a new rich Late Cretaceous site, Tsagaan Uul (later named Tsagaan Khushuu), was opened. In Nemegt and Altan Uul, work continued nearly all summer and autumn. At the same time, a prospecting trip set out into western regions of the Southern Gobi, through the Trans-Altai Gobi, with a route through the Lakes Valley. Productive sites were not found south and west of Nemegt, but to the north, around the Mongol Altai Mountains, extensive outcrops of Lower Cretaceous sediments were exposed. North of Nemegt, at the bottom of the Ih Bayan Uul Mountains, vertebrates were found in the Eocene. The Lower Cretaceous Öösh Nuur and Andai Khudag localities, and the Oligocene Tatal Gol, and Miocene Loo localities, which had been opened by the CAE, were surveyed in the Lakes Valley. At the end of the season, there was a further excavation at Ergil Ovoo in the Eastern Gobi. The 1948 MPE covered 14000 km in total (Figure 13.1). Everyone returned to Moscow at the end of October (ARAS; F. 1712; L. 1; U. 97).

The second MPE obtained extraordinary materials of various dinosaurs, including complete skeletons of huge specimens 25–30 m in length, crocodiles, turtles, and mammals. In addition, detailed observations on the taphonomy of fossil-bearing river channels that ran into the large lake basins, and on the palaeogeography of dinosaur occurrences on the extensive lowlands of ancient Mongolia, covered with woods and bogs, and crossed by the rivers and covered by the lakes. It is necessary, however, to note that I.A. Efremov was wrong about the low palaeontological potential of the regions west of the Nemegt

Depression and south of the Gilbent Ridge, since some major discoveries were made there in the 1970s to 1990s.

In 1949, the MPE worked in the field from June 11th to September 23rd, and this time it consisted of 33 people, including the labourers. The scientific structure was the same as in 1948. The first trip was devoted to the search for vertebrates in the Beger Nuur Depression, the Zereg Depression, and the Gui Suin Gobi Depression. The rich Miocene Beger and Pliocene Altanteel mammal localities were opened up there, and Miocene vertebrates were also found at the western foot of the Jargalantyn Mountains, at the Öösh Ridge, 50 km from Khovd town. The Tertiary deposits here overlie Lower Cretaceous, where isolated remains of sauropods were found. In the region of the Tsast Bogd Mountains (Figure 13.1), continental Permian deposits were surveyed, but these yielded only plant remains. At the end of July, the expedition made short trips to the south-east in the region of Sainshand, to the Khar Hötöl locality, and to the south, to collect small dinosaurs from the Bayan Zag locality. After August 1st, large excavations were resumed in the Nemegt Depression at the Nemegt, Altan Uul, and Tsagaan Uul sites, and these yielded two skeletons of the large hadrosaur *Saurolophus*, two skulls, the skull of a young specimen, and blocks with fossilized skin of these dinosaurs. After the end of work on the Cretaceous sites, excavations continued at the Paleogene sites of Naran Bulag, Ulaandel Uul, and Tatal Gol, in the same region to the west, north, and east of the Nemegt Ridge. These yielded magnificent specimens of mammals, turtles, and fishes. On October 4th, all members of the expedition returned to Ulaanbaatar (ARAS; F. 1712; L. 1; U. 111).

In 1950, a last expedition to Mongolia was planned, but unexpectedly, in May, when the equipment had already been sent to Ulaanbaatar, the government of the USSR terminated the MPE and transferred all facilities, including trucks, to an agricultural expedition (ARAS; F. 1712; L. 1; U. 8 4). The reasons for this decision are still not clear. The sole surviving witness of those events, B. Trofimov, explains them as probably the result of diplomatic games connected with the People's Republic of China, which had just been created.

In the end, then, the MPE worked for three seasons. Its main achievements were the excavation of diverse Late Cretaceous dinosaurs, especially in the Nemegt region, and of Palaeocene and Early Eocene vertebrates, the division of the Cretaceous faunas into three groups, the collection of new evidence about the palaeogeography and climate of Mongolia in the Cretaceous, and discovery of evidence against arid conditions (Efremov, 1948, 1949, 1950, 1952, 1953, 1954a, b, 1955; Efremov *et al.*, 1954). The history and results of the MPE have been described in detail by Efremov (1963), as well as by Rozhdestvenskii (1957, 1969), Chudinov (1987), and Lavas (1993).

Joint Soviet (Russian)–Mongolian Palaeontological Expedition

In 1964 the MAS invited B.A. Trofimov and P.K. Chudinov, employees of the PIN, to inspect the Bügiin Tsav locality, found by the Mongolian arats a little north of the Altan Uul Ridge. This Late Cretaceous locality has turned out to be one of the richest dinosaur sites in Mongolia, with many complete and partial skeletons of large and small dinosaurs exposed on the surface, although initial estimates of its richness (Chudinov, 1966; Trofimov and Chudinov, 1970) were rather exaggerated. Subsequently, large excavations at Bügiin Tsav by the SMPE and other expeditions produced magnificent turtles, interesting birds and mammals. Bügiin Tsav has now become an important palaeontological attraction for foreign tourists.

The Polish–Mongolian Palaeontological Expedition operated in Mongolia from 1963 to 1971, at first led by J. Kultchitskii, and then by Z. Kielan-Jaworowska. Rinchen Barsbold was Chief of the Expedition on the Mongolian side. These expeditions were notable for retrieving skeletons of large dinosaurs, for further developing Late Cretaceous sites in the Nemegt Depression, but especially for collecting large numbers of specimens of mammals and lizards at Bayan Zag and other localities of the Late

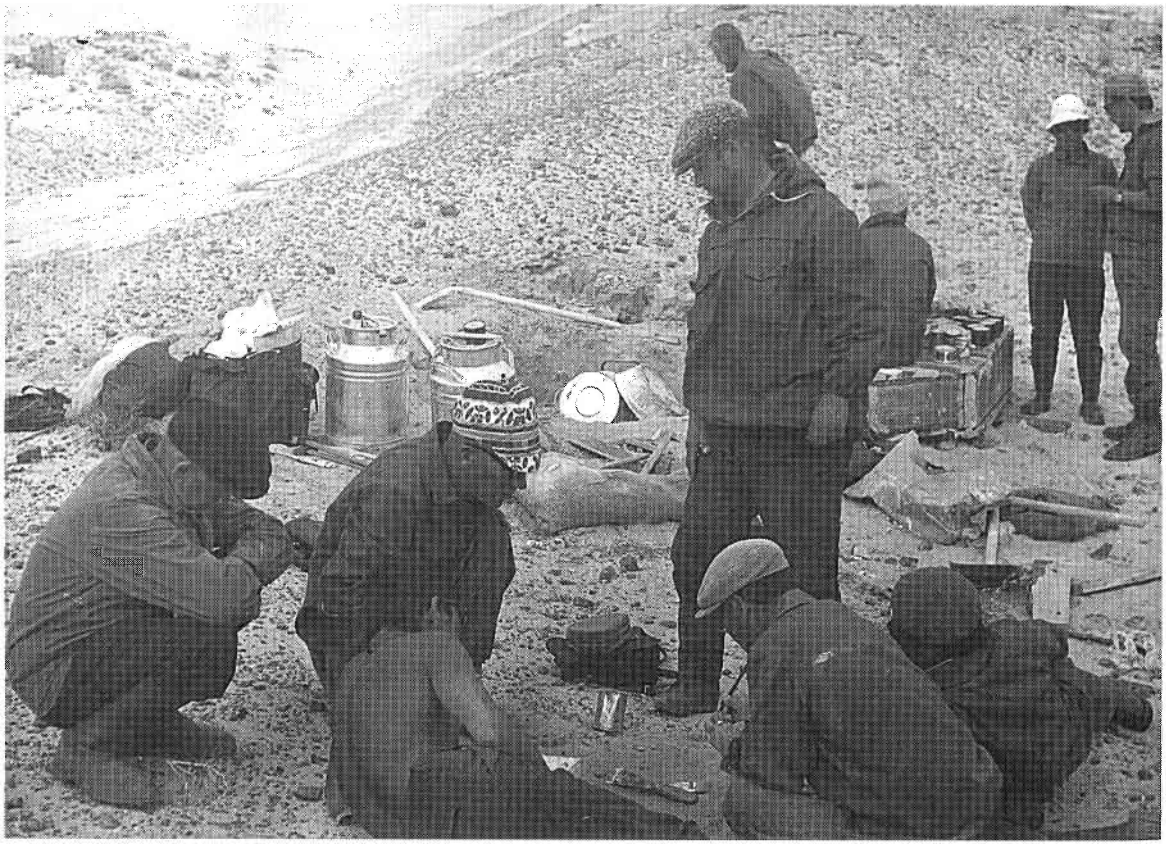

Figure 13.2. Excavations at the Tögrögiin Shiree locality, Ömnögov Aimag, Upper Cretaceous, Baruungoyot Svita, in September, 1969. From the left, M. Bragin, A. Tchangtoomoor, P. Chudinov, G. Namsray, N. Radkevich, A. Ponomarenko, A. Perle, I. Luk'yanov, P. Narmandakh and R. Barsbold. Photo by E. Kurochkin.

Cretaceous. The expedition discovered such important Late Cretaceous localities as Tögrögiin Shiree and Khulsan, and the finds of Pachycephalosauria, *Gobipteryx*, and Cretaceous bird embryos gave new directions to the palaeontology of Mongolia.

From 1967, the Joint Soviet–Mongolian Geological Expedition of the AS USSR and MAS began to work in Mongolia. The geologists G. Martinson, E. Devyatkin, A. Sochava and V. Shuvalov worked on palaeontological aspects of the Mesozoic and Cenozoic, discovered some new vertebrate localities, and collected a number of new fossil vertebrates. The Mongolian palaeontologists R. Barsbold, D. Dashzeveg, P. Khosbayar and T. Tomurtogoo began their scientific careers working with the Soviets on this expedition. This expedition and the SMPE worked in close collaboration, and results were published in many joint papers and several monographs (Devyatkin, 1981; Martinson, 1982; Yanovskaya *et al.*, 1977).

At the end of 1960, Yu.A. Orlov addressed the Praesidium of the AS USSR with an offer to organize palaeontological researches in the system of the MAS. On a slip of paper, someone has written that there were no palaeontologists in Mongolia, although there is a palaeontological division in the State Museum. A proposal was made to organize joint palaeontological expeditions for five years in 1961–1965, and to use this to prepare two or three Mongolian palaeozoologists (ARAS; F. 1712; L. 1; U. 320; P. 1–2, P. 4–6). However, because of bureaucratic and political delays, this idea

Figure 13.3. R. Barsbold and G. Namsray prepare the skeleton of *Protoceratops* for plastering, at the Tögrögiin Shiree locality, September, 1969. Photo by E. Kurochkin.

was achieved only after the death of Yu.A. Orlov in 1966, when the Praesidium of the AS USSR made a decree on August 5th, 1968 about the organization of a Joint Soviet–Mongolian Palaeontological Expedition. A. Vologdin, Corresponding-member of the AS USSR, was nominated as chief of the SMPE and K. Flerov as scientific adviser (ARAS; F. 1712; L. 1; U. 320; P. 37–38). However, the main organizational work for the start of the SMPE were carried out by the director of the PIN, N. Kramarenko, and by the scientific researchers V. Zhegallo and Yu. Voronin. R. Barsbold was head of the SMPE on the Mongolian side.

In the following synopsis, attention will focus on the Mesozoic projects of the SMPE. The SMPE began work in 1969, when more than 40 people left Ulaanbaatar for the South Gobi in seven trucks and jeeps. The expedition was divided into an excavating team led by E.N. Kurochkin and an exploratory team led by V. Zhegallo, the Vice-Chief of the SMPE. Participants in the first season of field work included P. Chudinov, M. Shishkin, V. Sukhanov, A. Ponomarenko, M. Erbaeva, V. Reshetov, N. Kalandadze, R. Barsbold, A. Perle, E. Khand, P. Narmandakh, G. Namsray, and others, as well as many drivers, technicians, and students from Moscow and Ulaanbaatar. The main camp of the vertebrate teams was located at the Bayan Zag locality, but the main excavations took place at the Tögrögiin Shiree locality, about 40 km from Bayan Zag (Figures 13.2 and 13.3). In this season, the SMPE explored numbers of known Cretaceous, Paleogene, and Neogene localities in South, Central, and Western Mongolia. Field work finished by the middle of October, when strong night frosts start in the South Gobi (Figure 13.4). However, the discovery of the

Figure 13.4. Excavations at the Alag Teeg locality, Ömnögov' Aimag, Upper Cretaceous, Baruungoyot Svita, October 10th, 1969. From the left, G. Namsray, V. Reshetov, I. Luk'yanov, S. Kurzanov, and N. Radkevich. Photo by E. Kurochkin.

Lower Cretaceous Guchinus (then named Höövör) locality with a rich fauna of mammals (Figure 13.5) and lizards, and the Late Cretaceous Alag Teeg locality with numerous ankylosaurs, as well as the richest Eocene locality, Khaichin Uul II, made this beginning of the SMPE very successful, even though most of the Soviet participants had not had field experience in Mongolia before (Kurochkin *et al.*, 1970).

From 1970 to 1979, the SMPE prospected and excavated fossil vertebrates all over Mongolia for 2–4 months each year. There were 3–6 field crews, in total 30–40 people in 10–15 trucks (Figure 13.6). R. Barsbold remained the Chief of the SMPE from the Mongolian side all those years; on the Soviet side, after the first two years, N. Kramarenko headed the Expedition, and then Yu. Voronin, Yu. Popov, V. Sysoev, V. Reshetov and I. Manankov were consecutively heads of the SMPE and RMPE. Academician L. Tatarinov was scientific adviser of the Expedition from 1975. Leaders of field teams were V. Reshetov, R. Barsbold, E. Kurochkin, V. Tverdokhlebov, S. Kurzanov, E. Dmitrieva, V. Ochev, N. Kalandadze, V. Zhegallo, D. Dashzeveg, E. Sychevskaya, I. Novodvorskaya, Yu. Tzybin and V. Yakovlev. In addition, many technicians and drivers from the PIN participated: V. Veselkin, V. Dorofeev, N. Radkevich, N. Frolkin, V. Chistoganov, V. Pronin, I. Likhachev, M. Bragin, L. Galukhina, I. Luk'yanov, and others. A number of Russians with Mongolian citizenship participated in the SMPE during the early years, and, during the first five years, many students from Saratov State University, Moscow University, and Perm' University took part in field work. Some of these students later became employees of the PIN, and others went to a variety of professional appointments throughout the USSR.

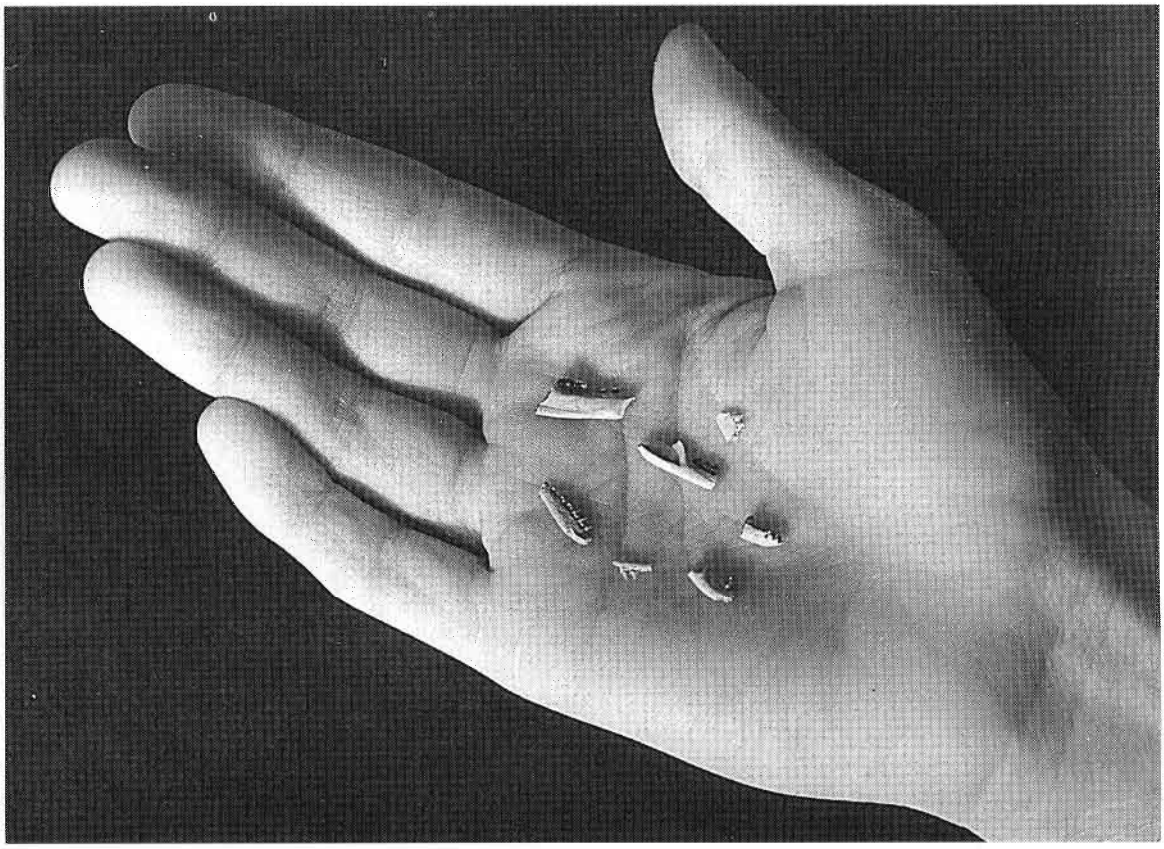

Figure 13.5. Jaw fragments of symmetrodonts and triconodonts found in 1969 at the Höövör locality, Övörkhangai Aimag, Central Mongolia, Lower Cretaceous, Andaikhudag Svita. Photo by E. Kurochkin.

Large excavations were carried out at the Lower Cretaceous Höövör and Hüren Dukh localities, and at the Upper Cretaceous Tögrögiin Shiree, Hermiin Tsav, Alag Teeg, Nogoon Tsav, Guriliin Tsav, Baishin Tsav, and Amtgai sites. Fishes, insects, and plants were collected widely in Lower Cretaceous deposits of Central and Western Mongolia. The East-Gobi team of the SMPE (E. Kurochkin) opened up in 1971 a completely new region of Lower Cretaceous deposits, the Züünbayan Svita, 150 km south-east of Sainshand. Here, in the localities Gashuuny Khudag, then renamed Khamaryn Us (Kalandadze and Kurzanov, 1974), and Tsakhiurt, good dinosaur specimens were found, including magnificent complete skeletons of *Psittacosaurus*. Champsosaurs were found for the first time in Asia at the Hüren Dukh site. Different groups of fishes were found at all horizons in the Cretaceous and Cenozoic. Early Cretaceous mammals and lizards were discovered, and thousands of bones were collected at Höövör. Clutches of huge sauropod eggs were collected at the Algui Ulaan Tsav locality (Figure 13.7). Rich faunas of vertebrates were discovered and excavated at the Late Palaeocene and Early Eocene Naran Bulag and Tsagaan Khushuu, at the Middle Eocene Khaichin Uul II–V, and at the Early Oligocene Ergileen Zoo (= Ergil Ovoo) localities (Figures 13.8 and 13.9). A number of fossil birds were found in the Lower Cretaceous and in all horizons of the Cenozoic. Rich localities with leaf floras of Late Palaeocene and Middle Eocene age from the Naran

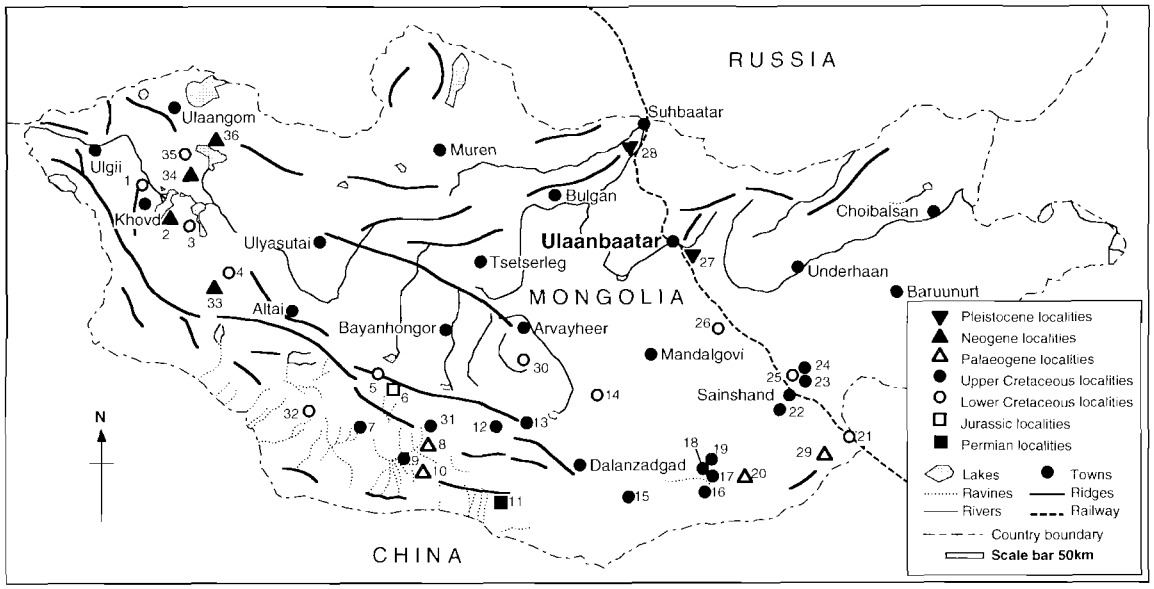

Figure 13.6. Joint Soviet–Mongolian Palaeontological Expedition of 1969–1979. Map of the localities, fossiliferous areas, new localities, and field teams. Compiled by E. Kurochkin. Localities: 1, Myangat; 2, Zagsokhairkhan; 3, Altanteel; 4, Gurvan Ereen; 5, Böön Tsagaan; 6, Bakhar; 7, Nogoon Tsav; 8, Khaichin Uul; 9, Hermiin Tsav; 10, Naran Bulag; 11, Sainsar Bulag; 12, Üüden Sair; 13, Tögrögiin Shiree and Alag Teeg; 14, Shine Khudag; 15, Shilt Uul; 16, Shar Tsav; 17, Baisbin Tsav; 18, Amtgai; 19, Khongil Ovoo; 20, Ergiliin Zoo and Bayan Tsav; 21, Khamaryn Us; 22, Khongil Tsav; 23, Teel Ulaan Uul; 24, Baga Tariach; 25, Mogoin Bulag; 26, Hüren Dukh; 27, Nalaih; 28, Shaamar; 29, Khoyor Zaan; 30, Höövör; 31, Bügiin Tsav; 32, Dösh Uul; 33, Sharga; 34, Chono Kharaih; 35, Tatal Yavar; 36, Hirgis Nuur.

Bulag and Khaichin Uul sites have given important information on environments at that time (Figure 13.10).

The dinosaur finds were especially rich. In addition to *Protoceratops* (Figure 13.11), *Tarbosaurus*, and *Saurolophus*, genera that had been found before, the SMPE recovered new ankylosaurs, many different small and middle-sized theropods, Early Cretaceous iguanodontids, and complete skeletons of *Psittacosaurus*. New families of dinosaurs, the Oviraptoridae, Garudimimidae, Harpymimidae, Segnosauridae, Enigmosauridae, and Avimimidae were described on the basis of specimens collected by the SMPE (Perle, 1979; Barsbold, 1983; Kurzanov, 1987). Many sites also produced large collections of eggs and eggshells of dinosaurs and birds, some with embryos, and these provided the basis for an extensive systematic and structural study of eggshells (Mikhailov, 1987, 1991, 1992, 1994). These results have created for Mongolia glory as the territory with the richest and most diverse fauna of dinosaurs in the world. The work of the SMPE focused on three questions: 1, the sequence of vertebrate faunas in the second half of the Mesozoic and in the Cenozoic; 2, faunal changes at the Mesozoic–Cenozoic boundary; and 3, discovery of new animals and new faunas (Barsbold *et al.*, 1971; Kramarenko, 1974).

The results of the expeditions were published in a series of transactions of the SMPE (Dmitrieva, 1971, 1977; Kurochkin, 1971; Sychevskaya and Lebedev, 1971; Zhegallo, 1971, 1978; Solov'ev and Shimanskii, 1978; Anonymous, 1979; Krasilov, 1982). After 10 years of work of the SMPE, 11 volumes of the transactions of the expedition were issued. Scientific sessions of the SMPE met annually, and more than 100 scientific papers were submitted by Mongolian and

Figure 13.7. N. Frolkin prepares some sauropod eggs from the Algui Ulaan Tsav locality, Dundgor Aimag, Upper Cretaceous, Nemegt Svita, 1969. Photo by E. Kurochkin.

Soviet experts. After 10 years of work, anniversary scientific conferences of the SMPE were held in Moscow and in Ulaanbaatar, at which 17 Soviet and six Mongolian scientists gave reports. At the Ulaanbaatar conference, a palaeontological exhibition was arranged, in which about 20 complete skeletons of Cretaceous dinosaurs and Mesozoic mammals were displayed; these are now on show at the State Museum of Mongolia or in the collection of the Geological Institute in Ulaanbaatar.

During the next 10 years (1980–1989), the SMPE continued more detailed development of certain sites (Figures 13.12–13.14). Rinchen Barsbold took a large Mongolian team in several trucks to Mesozoic sites, and D. Dashzeveg each season headed a separate group on the Paleogene sites in the East, Central, and South Gobi. S. Kurzanov or Yu. Gubin headed the Mesozoic teams, investigating Cretaceous sites in the East, Central, and South Gobi, and V. Reshetov continued to explore Paleogene and Mesozoic localities in the South and Central Gobi. N. Bakhurina and E. Sychevskaya, with separate teams, began collecting pterosaurs and fishes, and with great success. Some seasons, the palaeobotany team of N. Makulbekov worked at Mesozoic and Paleogene sites. Two of the most interesting discoveries were the Upper Cretaceous Üüden Sair locality, south of the eastern end of the Arts Bogd Ridge, and the Upper Jurassic locality Shar Teeg, south-east of Altai Sum (Figure 13.12). The first produced avimimid remains, and the

Figure 13.8. The combined field team of the Joint Soviet–Mongolian Palaeontological and Geological Expedition at the Sevkhul Khudag camp site in July, 1970, Ergiliin Zoo locality, Dornogov' Aimag. From the left, E. Devyatkin, I. Liskun, D. Dashzeveg, I. Kuzikov, M. Sytin, V. Kocherzhenko, E. Kurochkin, N. Radkevich, Z. Shalneva, A. Saitsev, M. Borisoglebskaya, V. Zhegallo, A. Tchangtoomoor and V. Kutyrkin. Photo by E. Kurochkin.

second turns out to be the richest Late Jurassic site for plants, insects, fishes, reptiles, and amphibians, including one of the latest temnospondyls. The SMPE had occasionally surveyed the Upper Permian deposits south of Noyon Sum, but for the first time in 1989 the team of S. Kurzanov found terrestrial tetrapods at the Sainsar Bulag site.

Publications from this decade of the SMPE include the monographs of Yanovskaya (1980) on brontotheres, Badamgarav and Reshetov (1985) on the Paleogene of Southern Mongolia, Sychevskaya (1986, 1989) on fossil fishes, Kurzanov (1987) on avimimids, Tumanova (1987) on ankylosaurs, and Efimov (1988) on crocodilians. Collected papers on the fossil vertebrates of Mongolia were also published (Trofimov, 1971; Tatarinov, 1979, 1981, 1983; Kurochkin, 1988). Thirty-nine volumes of transactions of the SMPE were published up to 1989, of which 19 were devoted wholly or mainly to vertebrates. In 1989, a conference was held in Ulaanbaatar to mark the twentieth jubilee of the SMPE (Anonymous, 1989), and a further large palaeontological exhibition was presented by the Soviet side of the SMPE, with many new mounted skeletons of dinosaurs and fossil mammals.

Since 1990, the work of the SMPE decreased sharply for financial and political reasons. Only one or two small teams work each year for short spells collecting vertebrates. From the 1992 expedition onwards, the programme was named the Russian–Mongolian Palaeontological Expedition. Forty-five volumes of the transactions of the RMPE have been published up to 1995.

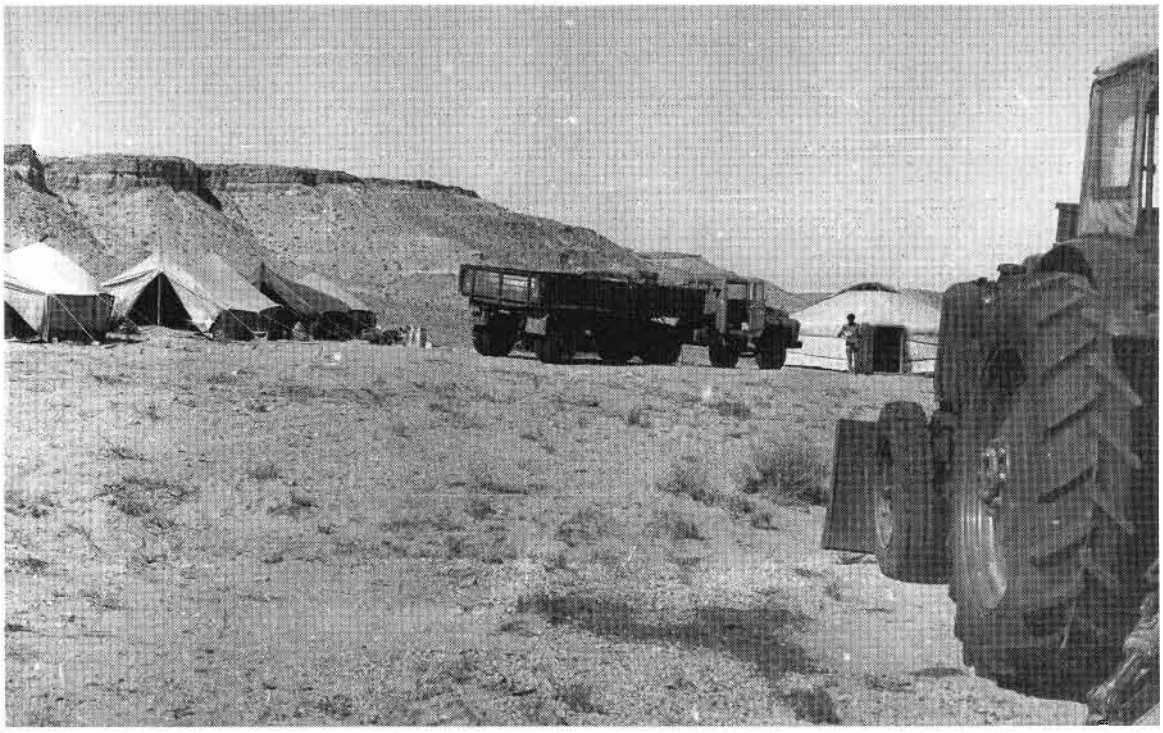

Figure 13.9. Field camp of the Joint Soviet–Mongolian Palaeontological Expedition at the Sevkhul Khudag site in 1970, Ergiliin Zoo locality, Dornogov' Aimag. The Lower Oligocene Ergiliinzoo Svita outcrops in the background with the Hetsüü Tsav beds (upper cover sandstone) at the top of the outcrop, the alluvial upper member of the Ergiliin Zoo beds, and the lacustrine lower member of the Ergiliinzoo beds at the base of the outcrop. Photo by E. Kurochkin.

Main results of the RMPE

From the beginning, the SMPE/RMPE has been a complex expedition, involving clashes of individual personalities, and a complex set of geological and palaeontological objectives. In addition to the teams seeking fossil vertebrates, there were also large groups working on marine faunas from the Precambrian to the Upper Palaeozoic. Perhaps, over its long span, the RMPE was the largest set of expeditions in the history of palaeontology, in terms of the numbers of employees, the technical support (numerous motor vehicles, bulldozers, explosives and compressors), and the materials obtained.

Several major achievements of the RMPE can be noted.

1. A great diversity of faunas and floras existed during the Mesozoic and Cenozoic in Mongolia.
2. Dinosaur evolution can now be viewed in a new light, with Central Asia as a major region for their evolution. Three groups of theropods were endemic to Mongolia, the Oviraptoridae, Deinocheiridae and Therizinosauridae (Segnosauria) (Barsbold, 1983; Barsbold *et al.*, 1989). New data were obtained for the study of hadrosaurs, ankylosaurs, psittacosaurs, and protoceratopsians. RMPE specimens formed the basis of 25 new species of dinosaurs, and several higher taxa, as well as 19 forms of dinosaur eggshells, which had some stratigraphic value (Mikhailov, 1991, 1992).
3. Data were obtained on other groups of reptiles: turtles (Sukhanov, this volume), crocodiles

Figure 13.10. Excavations in deposits of the lacustrine lower member of the Ergiliin Zoo of the Lower Oligocene Ergiliinzoo Svita in the Novozhilov Hills site, Ergiliin Zoo locality in 1971. Photo by E. Kurochkin.

(Efimov and Storrs, this volume), pterosaurs (Unwin and Bakhurina, this volume), and lizards (Alifanov, this volume).

4. Important bird specimens were found from the Lower Cretaceous to the Upper Neogene. Lower Cretaceous birds and a number of bird feathers from many localities demonstrated the early beginning of modern birds and the existence of Enantiornithes in the Lower and Upper Cretaceous of Mongolia (Kurochkin, 1995, 1996). Hesperornithids were also discovered in the Cretaceous. Among Cenozoic birds, especially rich collections were obtained from the Palaeocene, Lower Oligocene (Kurochkin, 1981), and Upper Miocene (Kurochkin, 1985).
5. Extensive data were obtained on mammals of the Cretaceous and Paleogene. The RMPE discovered a magnificent fauna of Lower Cretaceous mammals in the Höövör locality where placental insectivores prevailed, but also multituberculates, triconodonts, symmetrodonts, and pantotheres (Trofimov, 1978, 1980, 1981; Kielan-Jaworowska *et al.*, 1987, and this volume; Dashzeveg *et al.*, 1989; Kielan-Jaworowska and Dashzeveg, 1989). The outstanding discovery was a complete skeleton of the new Late Cretaceous marsupial *Asiatherium reshetovi* from the Üüden Sair locality (Trofimov and Szalay, 1994). The RMPE also found the rich Late Palaeocene fauna at Tsagaan Khushuu and the Middle Eocene fauna of Khaichin Uul in the South Gobi (Reshetov, 1979; Badamgarav and Reshetov, 1985). This work also provided information for correlation of the Paleogene in Central Asia and North America. The RMPE provided evidence that, in the Aptian–Albian, Central Asia was one of major centres of the adaptive radiation of placental mammals.
6. The RMPE investigated huge areas of fossiliferous mudstone and bituminous shale deposits of the great Lower Cretaceous lakes of Central and Western Mongolia. Detailed inventories of these localities was conducted mainly by the palaeoen-

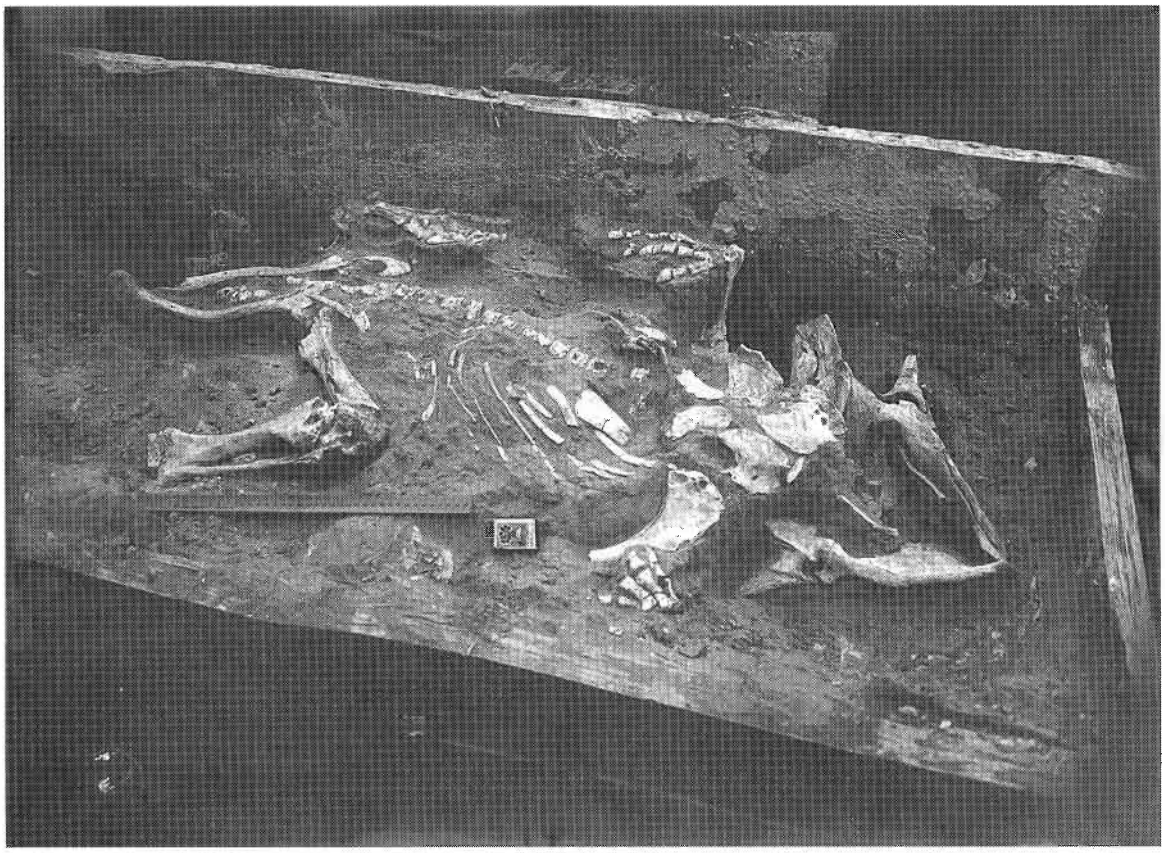

Figure 13.11. Monolith with a skeleton of *Protoceratops andrewsi* from the Tögrögiin Shiree locality, Ömnögov' Aimag, Upper Cretaceous, Baruungoyot Svita, 1969. Photo by E. Kurochkin.

tomologists of the SMPE (Yu. Popov and A. Ponomarenko). These sites yielded rich collections of insects, fishes, plants, and the very important finds of birds, and tens of their feathers. Monographs were published on the fauna, ecosystems, geology, and palaeogeography of the Manlai, Gurvan Ereen, Myangat, Böön Tsagaan, Kholboot, and other localities (Kalugina, 1980; Rasnitsyn, 1986; Sinitsa, 1993).

7. The collection of vertebrates and plants at the same Upper Cretaceous and Paleogene sites, and the discovery of the most ancient angiosperms in the Neocomian were also major achievements of the RMPE (Krasilov, 1982; Makulbekov, 1988).
8. The RMPE found a number of new vertebrate localities dating from the Late Jurassic to the Pleistocene, many in regions which had not been investigated before (Figures 13.2 and 13.3). A number of sites were opened for palaeontology by the RMPE, although information on finds of bones came first from Mongolian arats or geologists. Most important were the Early Cretaceous Höövör and Hüren Dukh localities, where the expedition worked in 1969 and 1970. In 1971 the East-Gobi team found a new area with the Züünbayan Formation, south-east of Sainshand, where the rich Khamaryn Us (= Gashuuny Khudag) locality with complete skeletons of *Psittacosaurus* and new ankylosaurs and sauropods (Kurzanov and Kalandadze, 1974). In 1971 also the

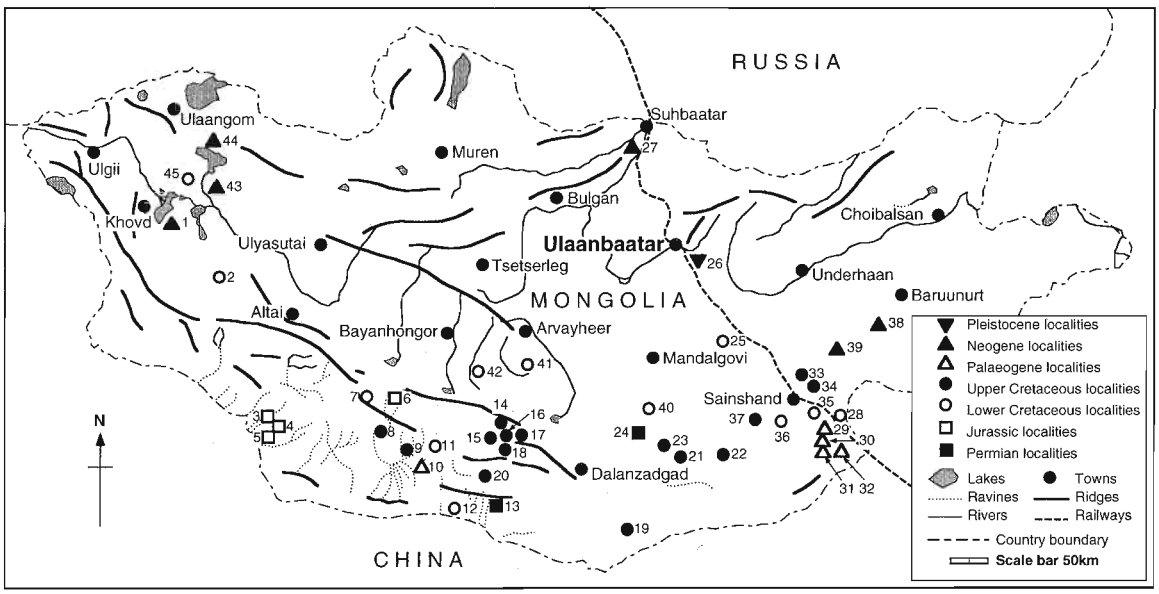

Figure 13.12. Joint Soviet (Russian)–Mongolian Palaeontological Expedition in 1980–1995. Map of the localities, fossiliferous areas, new localities, and field teams. Compiled by E. Kurochkin. Localities: 1, Yavar; 2, Gurvan Ereen; 3, Shar Teeg; 4, Khatan Sudal; 5, Elstiin; 6, Bakhar; 7, Kholboot; 8, Nogon Tsav; 9, Hermiin; 10, Tsagaan Khushuu; 11, Altan Uul; 12, Ih Shunkht; 13, Sainsar Bulag; 14, Yagaan Shiree; 15, Bor Khovil; 16, Zamyn Khond; 17, Khongil; 18, Üüden Sair; 19, Shilt Uul; 20, Khulsan; 21, Baishin Tsav; 22, Ölgii Khiid; 23, Amtgai; 24, Tavan Tolgoi; 25, Hüren Dukh; 26, Nalaih; 27, Shaamar; 28, Tsakhiurt; 29, Mergen; 30, Tsagaan Tsav; 31, Alag Tsav; 32, Khoyor Zaan; 33, Baga Tariach; 34, Teel Ulaan Uul; 35, Khamaryn Khural; 36, Khongil Tsav; 37, Khar Hötöl; 38, Baruunurt; 39, Indyn Uul; 40, Manlai; 41, Höövör; 42, Builyastyn Khudag; 43, Zavkhan; 44, Hirgis Nuur; 45, Tatal Gol.

RMPE opened the rich Late Cretaceous Baishin Tsav locality and two smaller ones, Amtgai and Shar Tsav, in the same area in the eastern region of the South Gobi, with vertebrates of the Bayanshiree Svita (Turonian–Coniacian). Important also was the find in 1970 of the huge Hermiin Tsav locality of Barungoyotian age (Campanian) on the eastern edge of the Trans-Altai Gobi, where various dinosaurs, lizards, mammals, and birds were found later. The Late Jurassic locality Shar Teeg, in the south-western corner of Mongolia, found by the RMPE in 1984, is a very large locality, with lacustrine and alluvial facies, where various animals and plants were found.

9. The excavations of the RMPE produced not only major scientific materials, but also many fine museum skeletons for exhibition, as seen in the halls of the Museum of the Palaeontological Institute in Moscow and the State Museum in Ulaanbaatar.
10. A further important achievement of the RMPE has been in training; through the expeditions, whole new generations of Russian and Mongolian palaeontologists who have received experience of field work, scientific work, and joint scientific co-operation. Many dissertations were based on materials extracted by the RMPE, including 12 Candidates of Sciences (Ph.D.) and three Doctors of Sciences (D.Sc.) at the PIN RAS and eight dissertations of Candidates of Sciences and two Doctors of Sciences at the Geological Institute of MAS. The training of Mongolian palaeontologists since the MPE in the late 1940s has been very important. For example, B. Luvsandazan began as a student on one of I. Efremov's expeditions, and he

Figure 13.13. Field camp at the Baishin Tsav locality, east of Ömnögov' Aimag, in August 1985, Upper Cretaceous, Baruungoyot Svita. Photo by S. Kurzanov.

later became an Academician and Director of the Geological Institute of MAS, and scientific adviser to the RMPE. In the years of the RMPE, a large group of excellent palaeontologists has developed in the MAS, and they now conduct independent research on various animal groups and engage in independent international co-operation.

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Figure 13.14. Excavations at the Khongil locality, Ömnögov' Aimag, in 1985 for the skeleton of an ankylosaur, Upper Cretaceous, Baruungoyot Svita, 1985. From the left, S. Kurzanov, K. Mikhailov and G. Vinogradov. Photo by S. Kurzanov.

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