GEOLOGICAL MAPPING AND PROSPECTING IN NORTH KERULEN TERRITORY, MONGOLIAN PEOPLE'S REPUBLIC

(International Geological Expedition 1976 – 1980)

COMPILED BY

LÁSZLÓ PENTELÉNYI, FERENC SÍKHEGYI,
MIKLÓS KALAFUT, JENŐ CSONGRÁDI,
ISTVÁN ZSÁMBOK

SPECIAL PAPERS

BUDAPEST, 1983/1

INVESTIGATIONS IN FOREIGN COUNTRIES: METHODS AND APPLICATIONS

The manuscript was read by

L. Elsholtz

Editor-in-Chief

M. Deák D. Sc.

Translated by

J. Csongrádi D. Sc.

Translation revised by

B. Kecskés

With original illustrations by the authors

Published by the Hungarian Geological Institute

Reponsible Publisher

G. Hámor D. Sc.
Director
of the Hungarian Geological Institute

INTRODUCTION

On the basis of a COMECON agreement signed in 1975 an International Geological Expedition was organized in the Mongolian People's Republic to perform geological mapping and prospecting for every kind of mineral resources and to perform detailed exploration at the deposits recognized in North-Kerulen territory during the period 1976–80.

In 1976–78, Team N° 1 of the Expedition performed geological mapping on a scale of 1 : 200 000 over an area as large as 8770 km² lying in the northern part of Hentei district near the villages Berh, Batnorov and Batsiret (L. PENTELÉNYI et al. 1978). In 1978–79, Mapping Team N° 6 performed geological mapping on a scale of 1 : 50 000 over an area of 400 km² in the surroundings of the Öndör-Tsagan-Obo mineralization discovered in 1977 as well as exploration in the mineralized area itself (M. KALAFUT et al., 1979). To make clear the possible continuation of the Öndör-Tsagan-Obo mineralization, Team N° 13 worked in 1979–80 to the southwest of the afore-mentioned mineralization over 400 km² area (J. CSONGRÁDI et al., 1980).

In 1980–81 a similar task was to be solved by Team N° 19 which performed geological mapping on 1 : 50 000 scale northeast of the Öndör-Tsagan-Obo mineralization again over 400 km² area (I. ZSÁMBOK et al., 1981).

In addition to the above areas, Fig. 1 also shows those East-Mongolian areas, where on the basis of bilateral agreements Mongolian—Hungarian teams carried out geological mapping before 1976.

The interpretation of aerial photographs and the density of traverses and observation points made it possible to locate and to represent the stratified formations graphically in a very exact way. In case of regional mapping 0.6 observation point and 0.5 km of traverses, in the case of 1 : 50 000 scale mapping 3.6 observation points and 1.7 km of traverses per 1 km² were performed on the average.

Detailed mapping was done by placer and soil sampling techniques in accordance with the regulations that are in force in the Soviet Union. Geophysical surveys were performed by Complex Geophysical Teams N° 3 and N° 10 (A. MADARASI et al., 1978; S. TABA et al., 1980). Gravimetric (0.25 observations/km²), VES (with an AB of max. 2000 m) and refraction seismic measurements were carried out in the course of regional mapping and in addition to these methods IP, magnetic and radiometric measurements were also applied in the exploration areas. On the other hand, the Mapping Teams performed continuous radiometric measurements along the mapping traverses.

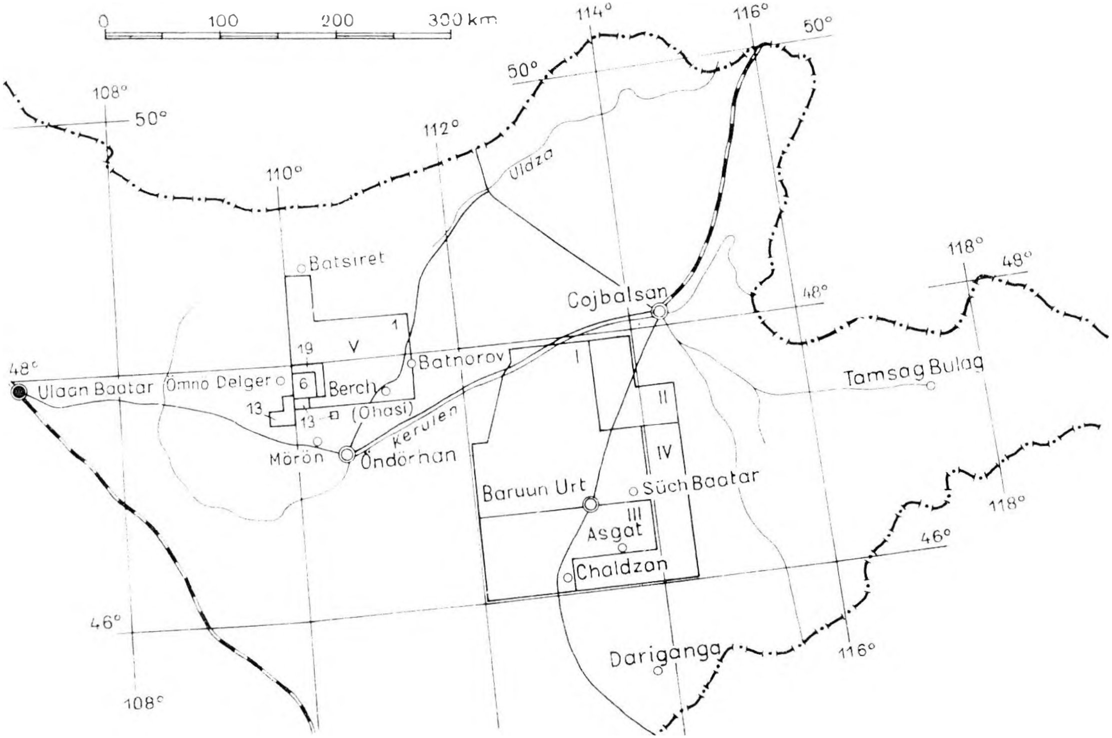


Fig. 1. Geological mapping and prospecting performed by Hungarian geologists in East Mongolia

Mapping areas of the Mongolian—Hungarian Expeditions in Süch Baatar county: I. 1965–1970 (1 : 200 000) II. 1970–1971 (1 : 200 000), III. 1971–1973 (1 : 200 000), IV. 1973–1975 (1 : 200 000).
Mapping areas of the Hungarian Teams involved in the International Geological Expedition in Hentei county: Team N° 1,

GEOGRAPHY

The area mapped by the Hungarian geologists is situated in the southeastern foreland of the Hentei Mountains in Northeastern Mongolia. It is intersected by the Onon—Herlen watershed, which includes also the Öndör-Tsagan-Obo, the highest peak (1682 m) of the territory. North of the watershed in direction of the river Onon a set of ENE striking side-valleys cut into pieces the uplifted Paleozoic—Mesozoic surface. In direction of the river Herlen wide valleys of S-SE strike predominate and separate some larger units. A territory with a mean elevation of 990 m above sea level, the study area has its lowest point in the Berh valley.

In the geographical division of the territory its geological setting was also taken into account. So on the one hand, hilly-rolling landscapes have been distinguished, on the other hand, the large negative relief forms separating the former from one another could be divided into tectonic depressions and erosion valleys in accordance with their geological setting. The distinction of hilly and lowland regions means at the same time the delimitation of erosion and accumulation areas (Fig. 2).

According to the Hydrogeological Atlas of Mongolia, the main part of the territory belongs to the East Mongolian ultracontinental region characterized by cold winters, while the smaller northwestern part is assigned to the moderately continental, so-called Hentei region, also characterized by cold winters.

The climate of the study area is essentially influenced by an extension of the taiga belt to as far as 30–40 km north of the working area. However, the zones of the river Barhu and the Dzun-Belchirin and Delger-Öndör granite intrusions extend deep into this belt, being covered by a dense and contiguous forest vegetation over large areas.

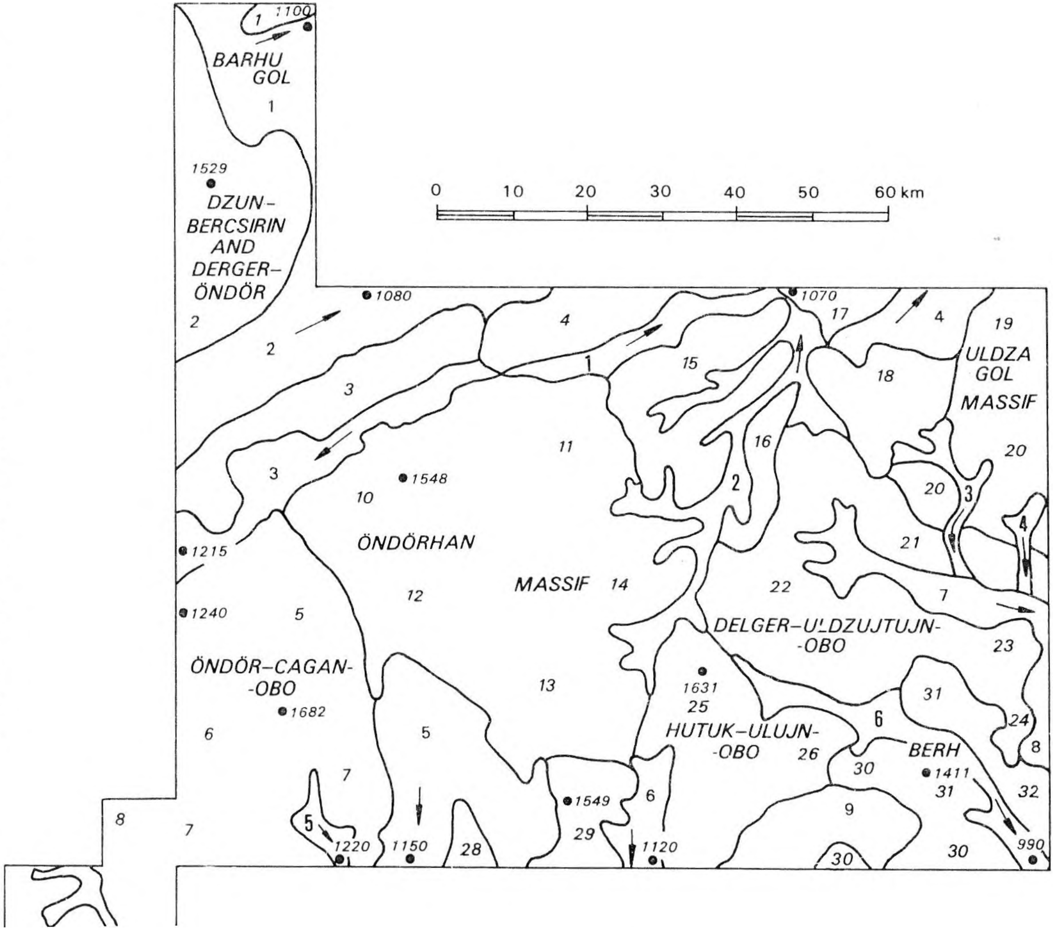
During the field seasons (from May to October) the extremely continental character of the climate manifested itself in the daily and seasonal temperature fluctuations, in the distribution of the moisture and wind action. The highest seasonal temperature fluctuation (53° C) was observed in 1977 (with —15 °C and + 38 °C as extreme values). During the field seasons the area received, as a rule, 280 to 310 mm of precipitation, the only exception was the year 1979 with 360 mm.

The drainage system is rather poorly developed. Permanent water flows are the rivers Susiyn, Barhu and Hurahu feeding the river Onon as well as the Mörön and Targlich rivers flowing into the river Kerulen.

In addition, there are intermittent streams of varying size due to the poor water supply, the heavy evaporation and the lack of impermeable layers under the stream-

Fig. 2. Orographic scheme of the mapping area

Hilly-undulating regions. 1. Mandal-Ula, *2.* Dzun-Belchirin and Delger-Öndör, *3.* Enger-Bulak, *4.* Dzunug Ula. — Öndör-Tsagan-Obo: *5.* Öndör-Tsagan-Obo, *6.* Mandaluin-Obo, *7.* Bain-Munhu-Obo, *8.* Erdeni-Han, *9.* Mörön Gol. — Öndörhan Massif: *10.* Huhuluin-Obo, *11.* Hubin-Undur, *12.* Tahiltuin-Obo, *13.* Mundulu-in-Us, *14.* Tses-Orunk-Burduin-Bulak.—*15.* Ulan-Nur and Barchigaitu.—*16.* Huhu-Tshulu.—*17.* Hangai. —*18.* Batu-Norbo. — Uldza Gol Massif: *19.* Uldzei-Saihan-Ula, *20.* Bain-Dzurihe. — Delger-Uldzuituin-Obo: *21.* Sihitu and Delger-Han, *22.* Hangaituin-Bulak, *23.* Dshargalantuin Godzogor, *24.* Bain-Han-Obo. — Hutuk-Uluin-Obo: *25.* Hutuk-Uluin-Obo, *26.* Chimiduin-Obo, *27.* Hongor-Oroin-Obo. —*28.* Hucilu-Ul.—*29.* Narunguin-Obo. — Berh: *30.* Berh, *31.* Delger-Han, *32.* Buraluin-Ul. — *Tectonic depressions:* 1. Barhu Gol, 2. Hurahu Gol, 3. Sara-Tala, 4. Saihan-Hundei, 5. Carguin-Tala, 6. Isim-Tolgoit, 7. Ehein-Burd, 8. Batu-Norbo, 9. Berh, 10. Sarbogin-Tala. — *Erosion valleys:* **1.** Huiten Gol, **2.** Su suin Gol, **3.** Delger-Han, **4.** Sihitu, **5.** Cum-Burd Gol, **6.** Berh, **7.** Mörön Gol. → Direction of ablation, 1631 ● height mark.



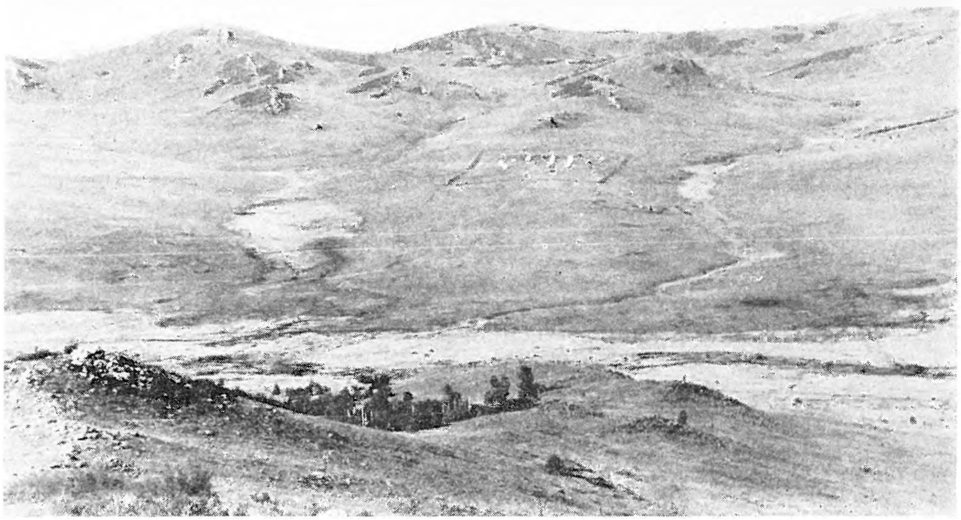


Fig. 3. Marshes near by Dumbe-Baian (camp site of 1977)

beds or to their leakage over short distances. At the border of the main geographical units plenty of springs can be found, most of them with an approximately stable, abundant water yield. Springs of isolated minor hilly areas, however, show a varying yield or are intermittent. As shown by chemical analyses the springwaters are clear and usually of drinking-water quality.

The long-stretching valleys of the Paleozoic granite intrusions are frequently marshy and this is the reason why they are usually uninhabited. Because of their very gentle slope, the Mesozoic grabens are in many cases rather small drainless depressions. They form systems of marshy natron lakes being characterized by badlands and impassable roads when the weather is rainy. The most characteristic type of soil is represented by the rocky skeletal soil in the hilly areas. Also chernozem and brown soils are developed on the northern side of the Paleozoic granite areas and basalt districts, respectively. The piedmont debris cones are characterized by humic sandy soils, while the valleys in the hilly areas carry boggy soils stretching long strikewards. In the grabens and wider valleys mainly alkaline soils, rarely blown-sands can be found (e.g. on the southeastern slope of the Saihan–Hundei).

The flora is represented first of all by a grassy steppe vegetation, but the southernmost representatives of the taiga vegetation (Pinaceae, Betulaceae, Salix) also occur at higher elevations and in the northwestern part of the territory.

In the surroundings of the humid areas marshy vegetation and, less frequently a vegetation constituted by salt-tolerating species can be observed. In some of the depressions large-scale farming activites (growing of rye and wheat) are being run.

The fauna is diversified: rodents, tarbagan, wild hare, fox, wolf, less freq mainly in the N taiga-type regions, deer, alk, lynx and bear. Birds and inse very widely represented. Of the animals dangerous to man a viper-like snake may occur in small numbers. In June and July the horseflies (Tabanus bifarius the mapping almost impossible in forests-covered area.

The southeastern part of the area is crossed by the Öndörhan–Uldza mai of very low quality, over some intervals totally unusable during the field seaso more or less busy country roads connecting the villages and farms are skirti impassable, marshy intramontane valleys and they cross the rivers at fords. Th ges situated in the mapping area (Berh, Batnorov) and in its wider neighbou (Batsiret, Binder, Baian-Adraga, Idermeg, Öndörhan, Mörön, Dsargalthan, Delger) are very important for expeditions working there in respect of food, fuel and medical supplies as well as post office and service facilities.

All of the settlements listed above have post offices while airfields only e Öndörhan, Batsiret and Ömnö Delger. In the agricultural activity traditional live farming shares much more than the grain-growing already mentioned. The industrial activity is fluorite mining at Berh.

GEOLOGY

From the earlier mappings in the study area, the works of the Mapping Team headed by Kalimulin (S. M. Kalimulin et al., 1968) and the Mongolian–Soviet Joint Geological Expedition should be pointed out. Their results provided a suitable basis for the distinction of sedimentary and magmatic complexes and an adequate framework for their correct dating.

The survey area is situated in the North Kerulen Geosynclinal Zone of the Mid-Mongolian Folded System. In our opinion the oldest formations known at present originate from a period preceding the epigeosynclinal stage.

Proterozoic

Middle Proterozoic

Conditionally, the gneiss-migmatite complex observed in the southern part of Hubin–Öndör area has been assigned to the Middle Proterozoic. The very old age of this complex is suggested by its lithological features and structural situation. In addition to the migmatites, granite–gneisses also occur in the same area. Hence it can be supposed that intrusions were already formed during the Proterozoic. Because of the obscuring effect of later volcanism, the problem could not be solved by K/Ar dating so further research is needed.

Late Proterozoic

Forming the "schist envelope" of the Upper Cambrian to Lower Ordovician granite, Upper Proterozoic formations are exposed over the largest area and at the margin of the Öndörhan Massif. In addition, they are associated with granite occurrences to the north and northwest of Öndör-Tsagan-Obo. Another important occurrence associated with granite is known in the northern part of the Uldza Gol Massif at the Uldzei-Saihan-Ula Mountain and minor ones occur on the western margin of the Batu-Norbo area, it the southern part of the Ulan-Nur area in the north near Dzunug-Ula, in the northwest near Delger-Öndör and in the south near Hongor-Oroin-Obo. Reliable separation of these formations is complicated by the lack of fossils, the changing petrological composition, the advanced regional metamc and the contact metamorphism of the granitoids. S. M. KALIMULIN et al. classified the metamorphic formations unconformably overlain by fossiliferous Cambrian beds south of the study area as belonging to the Upper Proterozoi BLAGONRAVOV et al. (1968) subdivided the Upper Proterozoic into two pa Haichingolian and Erendabanian suites on the ground of lithological differen some fossils in the Eren-Daban Mountain to the northeast of the mapping ar same classification can be applied to this area as well.

Metamorphic greenschist facies is characteristic of the Upper Proteroz mations but rock types of higher-grade metamorphism (mesometamorphic on occur. The predominant strike directions are often pointed to the margins granite massifs. The occurrences are limited to a wide NE–SW striking zo owing to denudation, Proterozoic formations are missing within it from the of the main part of the Lower Paleozoic granite intrusions.

Formations of the Haitschingolian and Erendabanian Suite can be fo gether in some places only, where a depositional unconformity is likely b them. This feature hardly can be proved during survey traverses owing to the grade of metamorphism and to granitic injections, migmatitic zones, respecti

Rocks of the **Haitschingolian Suite** in the vicinity of the granites are c metamorphosed ones: mica-, quartz-sericite-, hornblende-, graphite-, silica-l schists, amfibolite, subordinately greenish-gray lineated slaty siltstones, mic sandstones, quartzites in some places with marbled limestone and graphite-l marble lenses. Above the granite batholiths the formation of different kinds of neisses is characteristic.

Overlying older formations are unknown, but their contact-metamor occurrences are usually exposed to the surface of Lower Paleozoic, rarely of C ferous intrusions. They can be overlain by Upper Proterozoic Erendabanian ((han Massif), Upper Proterozoic to Lower Cambrian volcano-clastics (Ön Massif) or carbonate rocks (Delger-Öndör), Lower Devonian sedimentary (Öndör-Tsagan-Obo), Permian volcanics (Isim-Tolgoit), Mesozoic volcanic an mentary rocks (Delger-Öndör in the northeast) and Neogene sedimentary (northwest of the Öndörhan Massif).

The formations belonging to the Haitschingolian Suite are characteri spectively by the greenschist-, rarely by the amfibolite facies of regional metamo and by the contact metamorphic alterations of different intensity. Charac lithological composition and thickness of the Haitschingolian Suite observed eastern Öndörhan Massif from the base upwards:

gneisses approx	300 m
biotite schists approx	100 m
mixed, lineated sandstones approx	200 m
mica schists approx	200 m
gray micaceous schists approx	100 m
lineated folded shales approx	150 m
sericite schists approx	50 m
hornblende schists approx	50 m
micaceous folded schists approx	150 m
bluish-gray quartzite approx	20 m

lineated, micaceous, siliceous, fine-grained
sandstones approx 150 m

The thickness of the this suite is about 1500 m. Manifested by shades of gray the stratification can be poorly identified on the aerial photographs and the light coloured zones (of acidic volcanic origin) characteristic of the upper suite are missing.

Most of the main rock types known from the Haitschingolian Suite can also be found in the **Erendabanian Suite,** an important difference is, however, the appearence of altered acidic to intermediate volcanics (porphyroids, porphyritoids). The latter originate from liparite- and dacite porphyries and, in part, from tuffs. Sandstones occur more frequently as compared to the lower suite, while gneisses connected to granites are only of local importance. The beds alterante more frequently here and metamorphism seems to be of a lower grade. They occur often on the surface of the Lower Paleozoic granites or are contactized by these granites. Devonian micro-granites and gabbro dykes have pierced also these beds in some places (Fig. 4). The Erendabanian beds overly the lower suite in the northwestern part of the Öndörhan Massif, north of Tsuhuluin-Obo. Among the overlying formations of the Erendabanian beds occur Upper Proterozoic to Lower Cambrian and Middle to Upper Devonian formations (Uldzei-Saihan-Ula), Permian volcanics (eastern part of the Öndörhan Massif) and sediments (Munduluin-Us), finally Upper Cretaceous (Uldzei–Saihan–Ula) and Neogene (nortwestern part of the Öndörhan Massif) sediments. The maximal thickness of the Erendabanian is about 2000 m. These formations can not be clearly distinguished on the aerial photographs from the lower suite, nevertheless the existence of light acidic volcanic bands is characteristic. As compared to the Upper Proterozoic–Lower Cambrian formations the light volcanic bands are scarcer, but the folded structure visible even on the aerial photographs is more pronounced.

Late Proterozoic to Early Cambrian

These formations are wide-spread, but their occurrence is most frequent in the north near Hutuk–Uluin–Obo and Barchigaitu and farther south, on the south-western and southeastern margin of the Öndörhan Massif.

Paleontological evidence proving the age of the formations came to light only south of the mapping area (Lower Cambrian limestone with Archaeocyathus mentioned by V. A. Amantov, 1966a, b; S. M. Kalimulin et al., 1968) and north of it (*Osaglia tenuilamellata* Reitl., oncolites reported by V. A. Amantov, V. A. Blagonravov, K. N. Koniuskov in N. A. Marinov et al., 1973).

The formations of this suite can be subdivided into two facies-types: volcano-terrigenous and carbonate-terrigenous-volcanogenic sequences. In contrast with earlier beliefs these two types are not distinctly separated in time from one another, rather they may be considered complementary facies. The maximal thickness of the two sequences is between 2000 to 3000 m.

The *volcano-terrigenous sequence* is a little more wide-spread compared to the other one. Main rock types are basic, intermediate and acidic volcanics, phyllitized

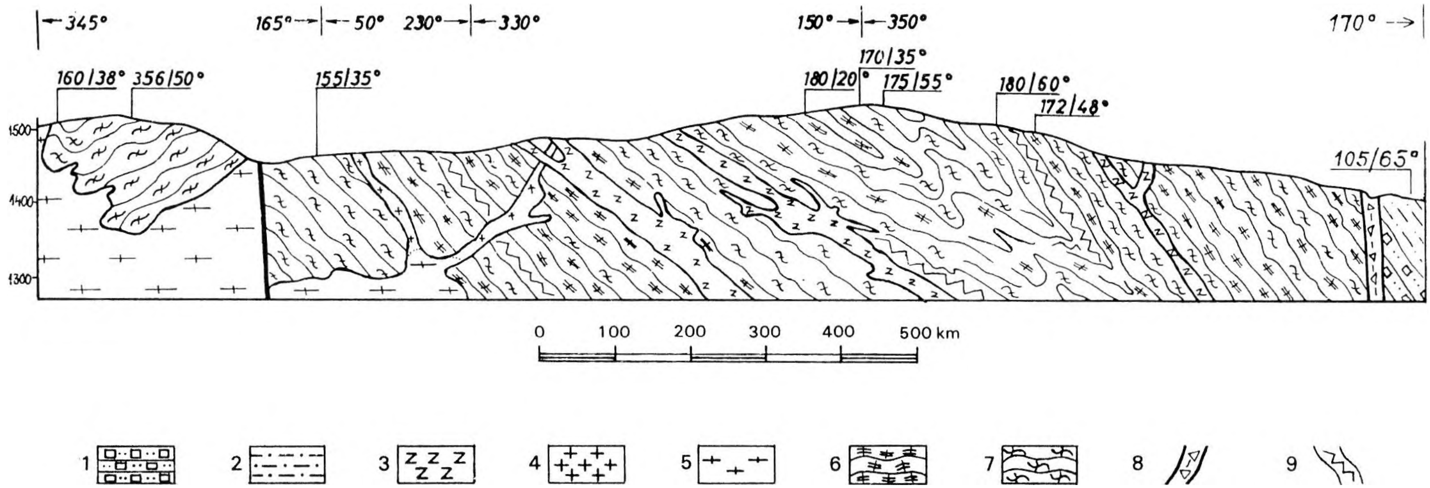


Fig. 4. Geological section of the Upper Proterozoic Erendabanian Suite SW of Erdeni-Han (compiled by G. Bencze and I. Zsámbok)

Lower Devonian: 1. medium-grained arkose, *2.* siltstone. — *Middle to Upper Devonian: 3.* gabbro. — *Upper Cambrian to Lower Ordovician: 4.* microgranite, *5.* granite. — *Upper Proterozoic: 6.* quartz schist, *7.* mica schist. — *8.* Tectonic breccia, *9.* mylonite.

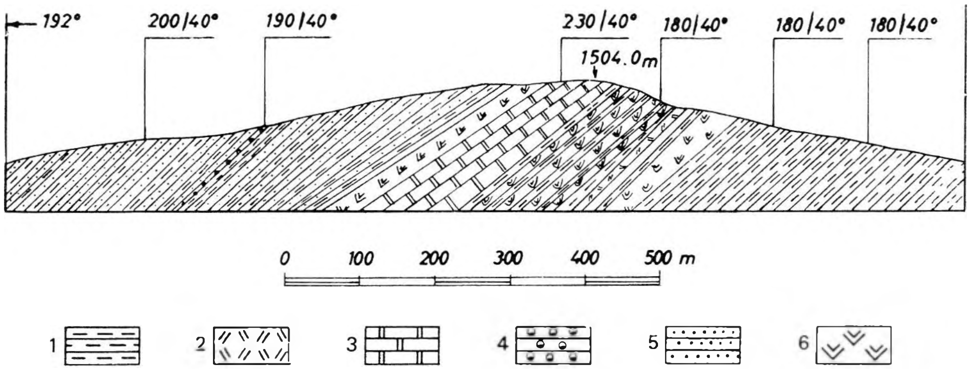


Fig. 5. Geological section of the Upper Proterozoic-Lower Cambrian formations S of the Öndör-Tsagan-Obo

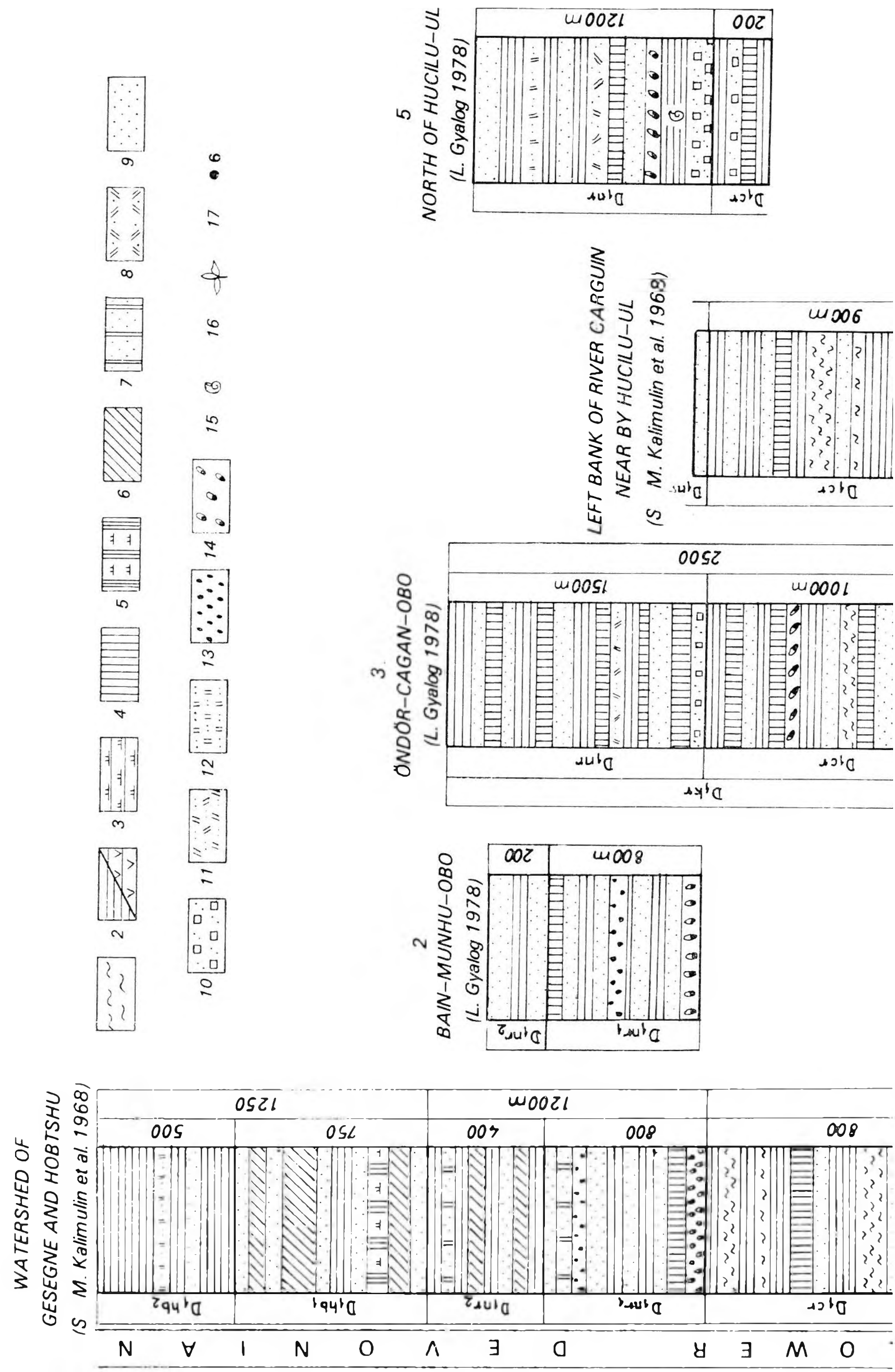
1. Dark gray chlorite-bearing actinolite schist, *2.* light gray rhyolite porphyry, *3.* grayish-white quartzite, *4.* yellowish-gray medium-coarse-grained sandstone, *5.* greenish-gray pyroxenite.

shales, siltstones and sandstones of different grain-size and matrix. By chance also conglomerates, chlorite-actinolite schists, quartzite and pyroxenite are found (Fig. 5). In most cases the stratigraphic footwall beds are missing because the formations in question overlie various Paleozoic granite intrusions being affected by more or less heavy contact-metamorphic alterations. Exceptions are in the southwestern part of the Öndörhan Massif and on its northern and northeastern margins, where they are lying on the Haitschingolian and probably Erendabanian formations, respectively.

The Upper Proterozoic to Lower Cambrian formations are overlain by the rocks of the carbonate-terrigenous-volcanic sequences (Dzunug-Ula), Lower Devonian (north of the Öndör-Tsagan-Obo) and Middle to Upper Devonian (Batu-Norbo) sediments, Permian acidic volcanics (Hutuk-Uluin-Obo)—frequently also as penetrating bodies—and Mesozoic volcanics and sediments (Hangai, Huhu-Tsulu, Narunguin-Obo, Berh).

On the basis of the composition of the submarine volcanic constituents the sequence could be subdivided into an older bed of basalto-andesitic composition and a younger one of andesite-dacite-liparitic composition. The former has its best outcrops on the southwestern margin of the Öndörhan Massif and north of Öndör-Tsagan-Obo, while the latter has it near Dzunug-Ula. It is to be noted, that some of the volcanics show subvolcanic features (altered diabases also known), on the other hand, some of them may have been metamorphosed to various kinds of schists. The intermediate to basic varieties were sericitised or altered to greenstones, the acidic ones to porphyroids. The sequence has about a maximum of 2000 m thickness and it is characterized by a frequent alteration of light gray to grayish-white bands with a distinct strike visible on the aerial photographs.

In the *carbonate-terrigenous-volcanogenic sequence* the metamorphosed volcanogenic interbeddings are less frequent. This sequence is composed mainly of mica schists, silicified shales, siltstones, tuff snadstones and conglomerates of different grain-size. Its occurrences are connected to that of the other sequence, with a more



WATERSHED OF GESEGNE AND HOBTSHU
(S M. Kalimulin et al. 1968)
2 BAIN-MUNHU-OBO
(L. Gyalog 1978)
3. ÖNDÖR-CAGAN-OBO
(L. Gyalog 1978)
LEFT BANK OF RIVER CARGUIN NEAR BY HUCILU-UL
(S M. Kalimulin et al. 1968)
5 NORTH OF HUCILU-UL
(L. Gyalog 1978)
1250
500
750
1200m
400
800
800
200
800m
2500
1500m
1000m
900m
200
1200m
LOWER DEVONIAN

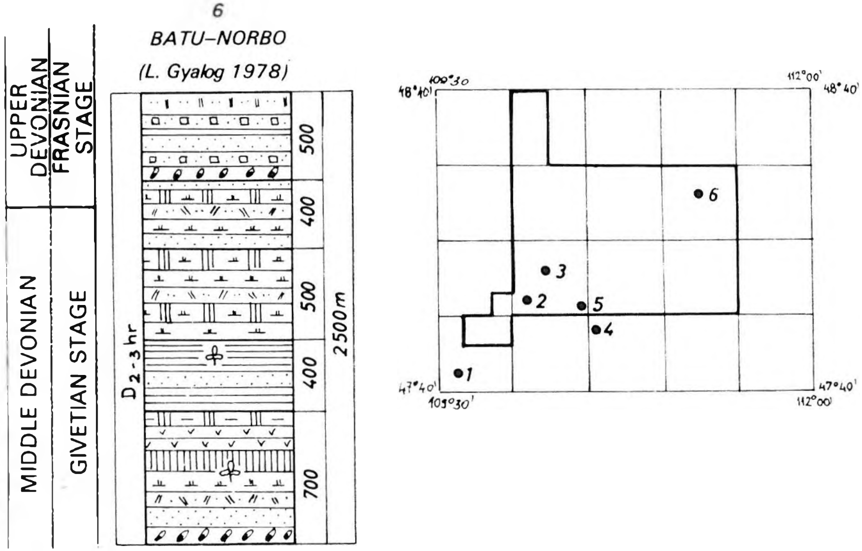


Fig. 6. a, b Characteristic sections of Devonian formations

1. Phyllite, *2.* shale/limonite-bearing shale, *3.* silicified shale, *4.* siltstone, *5.* silicified siltstone, *6.* sandstone and siltstone, *7.* sandstone with siltstone interbeddings, *8.* acidic volcanic tuff, *9.* sandstone, *10.* arkose, *11.* tuff-sandstone, *12.* silicified sandstone, quartzite, *13.* gravellite, *14.* conglomerate, *15.* fauna, *16.* flora, *17.* site of the section.

limited areal extension, however. The same statements hold true of the form underlying it, but the hanging wall may be represented by Silurian formations de ed with an unconformity at Dzunug–Ula. In the same place a weakly metamorp limestone interbedding of 50–80 cm thickness with dark and light-gray stri known. In the surroudings of Huhu–Tsulu and Delger–Öndör the carbonate sedi of the sequence predominate in form of dark gray, in some places pelitic, in places bituminous or graphitic, marbled limestone. Near Delger–Öndör at the co of the Carbonaceous granite some weak skarnous alternation with magnetite-be bodies can be observed. In the southwestern part of the Uldza Gol Massif bitumi graphitic siltstones and shales are characteristic. The maximal thickness of tl quence is 1800 m.

On the aerial photographs first of all the limestone interbeddings will one's eye with their white colour, in some places with poorly visible foldings. Pale differently eroded beds of the clastic parts of the sequence alternate frequently. can be distinguished from the Upper Proterozoic formations by their more w folded structure and from the Silurian ones by the existence of the carbonate beddings.

Silurian

The formations classed into this unit extend only in a narrow zone fron northeast to the Dzunug–Ula area. In this predominantly clastic sequence no f is found, but from the similar sediments of Bailzit Hill situated outside the map area V. A. Amantov et al. (1973) quoted Upper Wenlockian to Lower Ludlc brachiopods collected by E. A. Modzalejevskaya and E. B. Vladimirskaya N. A. Marinov et al.). In the lower part of the steeply dipping folded sequen northeastern to southwestern strike silicified shales of ferro-manganous impregna predominate, but farther up they are followed by coarse-granied sediments, ma by silicified sandstones. They are underlain by Upper Proterozoic to Lower Camb formations and overlain by Mesozoic basalts and Quaternary sediments respecti Their thickness does not exceed 300 to 400 m here. On the aerial photographs formations in question can be distinguished only by the lack of the white limes interbeddings from the underlying formations.

Devonian

This unit is represented first of all by sedimentary formations: by Lower De nian in the southwestern part of the area and by Middle to Upper Devonian sedim in the northeastern part of the area. Fig. 6 shows the main Devonian facies type

Lower Devonian

Kerulen Series

V. A. AMANTOV–N. A. MODZALEVSKAYA (1966) were the first, followed by S. M. KALIMULIN et al. (1968), to collect and indentify a Lower Devonian fauna in the Kerulen–Cenhir Gol–Mörön Gol area. The terrigene to marine Kerulen Series was subdivided into Cargingolian, Narintajian, Hobtshuian and Iheharanurian Suites. From these only the Iheharanurian could not be identified. The Kerulen Series shows a flyschlike habit. On the aerial photographs it is of pale gray colour and an alternation of wider, lighter (silicified) bands with darker ones is characteristic. The Devonian dykes are particularly conspicuous, having been attacked by selective erosion.

The Cargingolian and Narintajian Suites can be studied in the broader surroundings of Öndör-Tsagan-Obo and near Hucilu-Ul. The Cargingolian Suite forming the lowermost part of the Kerulen Series is composed predominantly of fine-grained sediments: shales, siltstones, siliceous slates, subordinately fine to medium-grained arkoses. The Narintajian Suite is characterized by more coarse-grained arkoses and partly pebbly sandstones. In addition to the Carbonaceous granite Devonian plutons have also penetrated the slightly folded layers (Fig. 7) and induced contact metamorphism in some places.

In most cases the above-mentioned suites could be subdivided into subsuites and formations respectively:

Lower Cargingolian Subsuite: coarse-grained, slightly lineated arkosic gravellites (fine-grained conglomerate), sandstone, subordinately with interbeddings of siltstone and phyllite (500 m).

Upper Cargingolian Subsuite: shale, siltstone with fine-grained arkose interbeddings, lineated gravellite lenses, sometimes silicified sandstone (500—700 m).

Lower Narintajian Subsuite, Lower Formation: fine-grained, arkosic, micaceous or polymictic sandstone, rarely with interbeddings of silicified, dark gray to black siltstone and shale, sometimes of coarse-grained sandstone and gravellite lenses respectively (500 m). 2000 m southwest of the 1119.3 mark of the Bain-Munhu area the following fauna characteristic of the lower part of the Lower Devonian has been collected:

Crinoids (determination by A. I. POLOSIHINA): *Facetoctinus quinquespinosus* (STUK.), *Costatocrinus monocostatus* (STUK.), *Costatocrinus bicostatus* (STUK.), *Anthinocrinus raricostatus* YELT. et DUB., *Mediocrinus* cf. *rugatre* (STUK.), *Pennatocrinus subpennatus* (YELT.), *Anthinocrinus radialis* (STUK.), *Medinecrinus radialis* (YELT.), *Asperacrinus echinatus* (YELT.), *Podoliocrinus nikiforovae* (YELT.), *Tastjicrinus paneicostatus* (YELT.). — Brachiopods (determination by G. T. USATINSKAIA and E. A. PAVLOVA): *Yridistrophia?* sp., *Leptostrophiidae*, *Rhynchonellidae*, *Howellelle?* sp.

Lower Narintajian Subsuite, Upper Formation: medium- to coarse-grained, mainly arkosic, occasionally micaceous sandstone, subordinately with interbeddings of fossiliferous siltstone, rarely silicified (600 m).

Upper Narintajian Subsuite: an alternation of siltstone and fine-grained, mainly arkosic (sometimes silicified) sandstone with fossils in some places and with tuff-

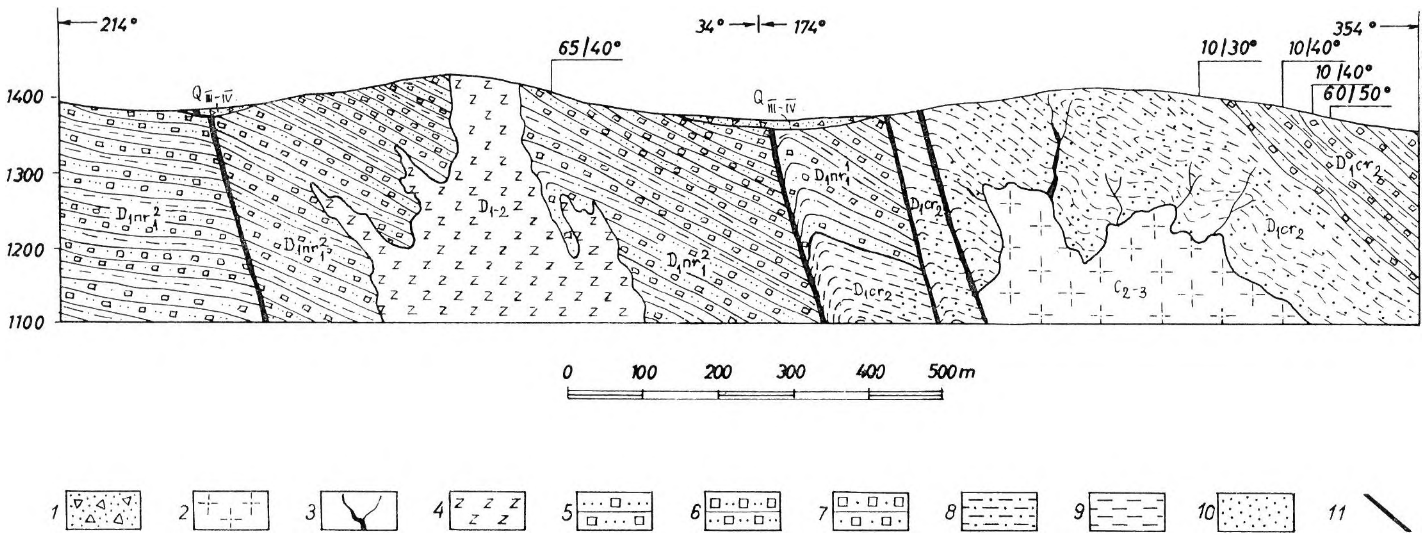


Fig. 7. Geological section of the Lower Devonian Cargingolian and Narintajian Subsuites SW of Erdeni-Han (compiled by G. Bencze and Zs. Peregi)

Quaternary III–IV.: *1*. deluvial sediments. — *Middle to Upper Carboniferous*: *2*. granodiorite, *3*. quartz vein.— *Lower to Middle Devonian*: *4*. gabbroid intrusion, *5*. coarse-grained arkose, *6*. medium-grained arkose, *7*. fine-grained arkose, *8*. siltstone, *9*. shale. — *10*. Contact metamorphism, *11*. fault.

sandstone and rhyolite porphyry tuff interbeddings (500–600 m). One of the most representative outcrops can be found in the surroundings of the Tshandagan-Obo (Fig. 8).

The **Hobtshuian Suite** was only proved in a limited extension on the left bank of the Mörön-Gol in the surroundings of the Hara-Öndör (Fig. 9). S. M. KALIMULIN et al. (1968) assigned it to the Lower Hobtshuian Subsuite, but detailed mapping revealed that the northwestern part of the facies in question belongs to the Upper Hobtshuian Subsuite.

The **Lower Hobtshuian Subsuite** is represented by fine-grained arkoses with thin siltstone interbeddings (500 m), on the other hand the **Upper Hobtshuian Subsuite** is predominantly constituted by thinly laminated siltstone, subordinately with interbeddings of fine-grained arkosic and silicified sandstone. It contains a Brachiopoda fauna at Hara-Öndör (750 m). G. T. USATINSKAJA and E. A. PAVLOVA identified Atrypacea sp. from the poorly preserved material collected there.

Middle to Upper Devonian

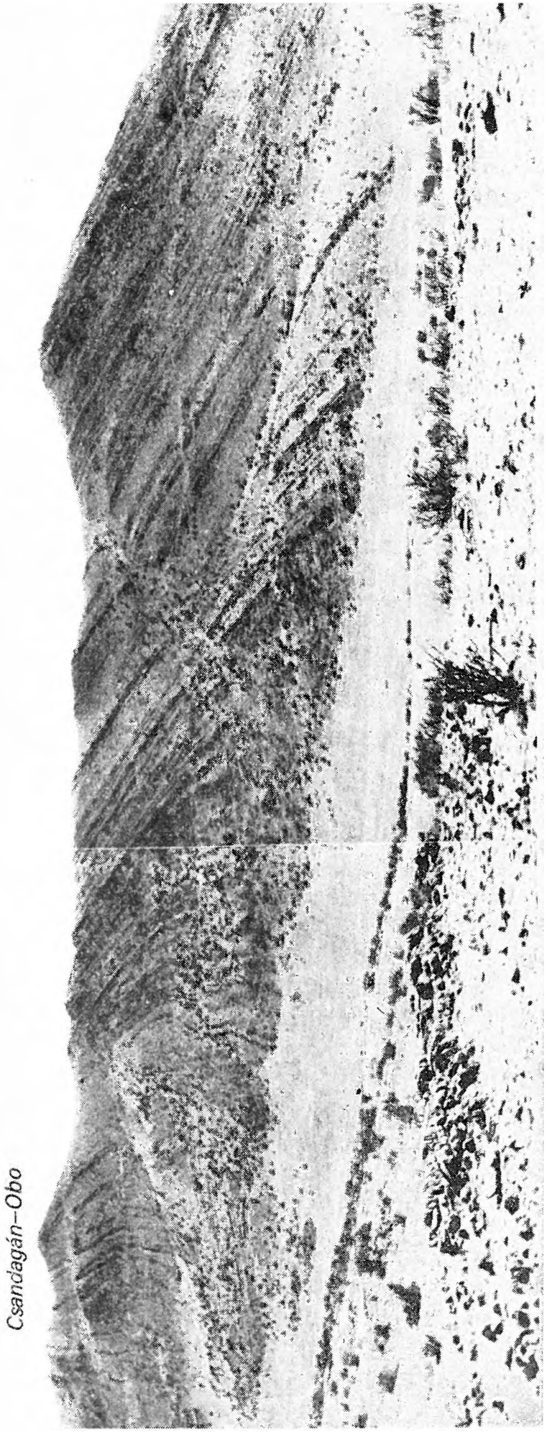
Hardzanian Series

The extension of the Hardzanian Series is limited to the Uldza Gol Massif in the northeastern part of the mapping area and the Batu-Norbo, Sihitu, Delger-Han units respectively. Predominantly clastic formations belong to the series. According to the determinations of A. L. JURINA the Psylophita and Lepidophyta remnants found in this formations are of Middle Devonian Givetian age, but the highest part of the sequence probably was already formed at the beginning of the Upper Devonian. Lower Paleozoic granites, Upper Proterozoic and Upper Proterozoic to Lower Cambrian formations occur in their foot-wall, while Permian and Mesozoic volcanics or Mesozoic sediments overlie them.

Main rock types are: coarse-grained, silicified arkosic sandstones with thin interbeddings of conglomerate and black siliceous shales, siliceous slates and siliceous silstones with interbeddings of fine-grained sandstone. In the fine-grained sediments fossil plants are frequent. A characteristic feature is the limonite and hematite content, and quartzites are formed in the course of heavy silicification. In the lower and upper parts of the series fine-grained tuffite and even thin interbeddings of acidic tuffs are known. These data refer to the neritic-continental origin of these formations.

North of the Ihe-Modotu Hill marks referring to the oxidation zone of a polymetallic ore showing can be observed. Along the cleveage planes and fractured zones limonite incrustations and fissure infills and, in some places, manganous coating and concretions are common. In the eastern part of Batu-Norbo the sequence contains graphite-bearing shaly clay and silt with a graphite content of about 8–15%. They probably originated as a result of the metamorphism of some carbonaceous sediments.

The bulk of the formations representing the lower part of the Hardzanian Series is Givetian, only a part of them extend into the Frasnian Stage. Their thickness is about 2500 m. On the aerial photographs they are characterized by the frequent alternation of light gray and darker bands and in some places by a distinct foliation. More heavily silicified and coarse-grained layers can be traced for a long distance.


Csandagán–Obo

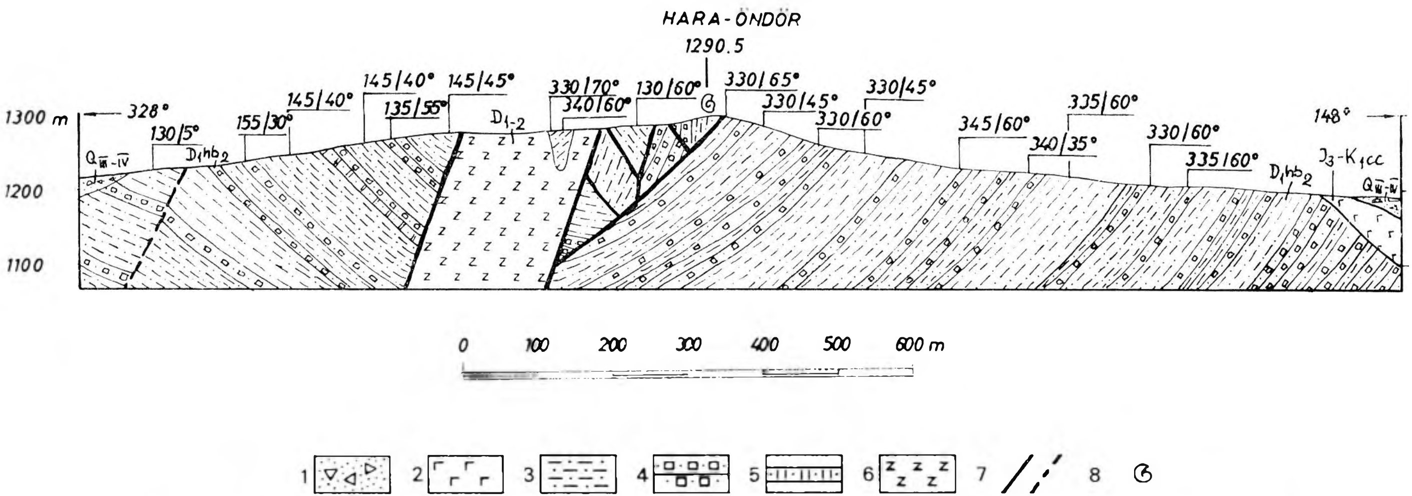
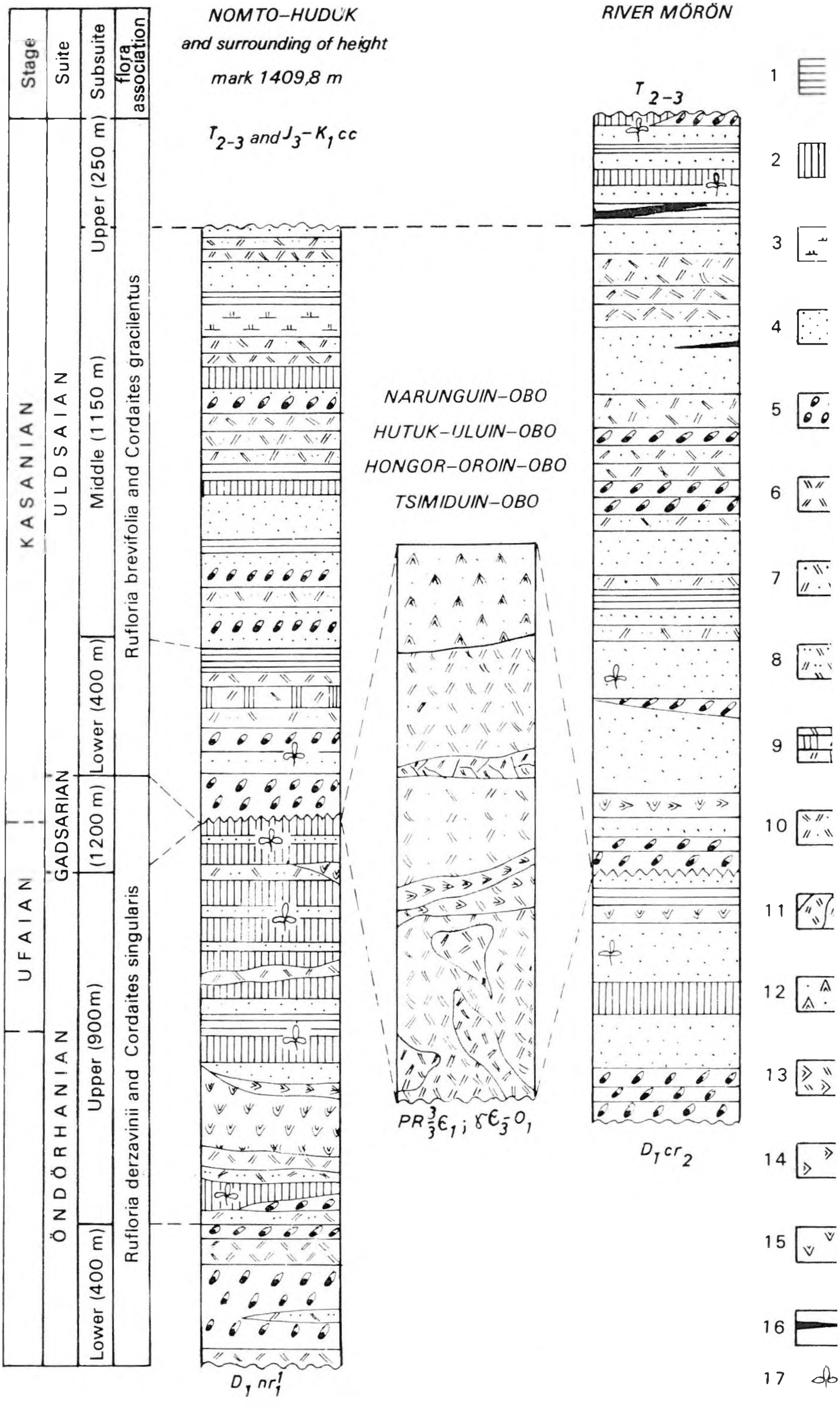


Fig. 9. Geological section of the Hobtshuian Subsuite on the left bank of the river Mörön (compiled by G. BENCZE and ZS. PEREGI, 1978)

Quaternary III–IV.: 1. deluvial sediments. — *Upper Jurassic to Lower Createceous: 2.* basalt, *3.* jointed siltstone. — *Lower Devonian: 4.* fine to medium-grained arkose, *5.* fine-grained silicified sandstone. *Lower to Middle Devonian: 6.* gabbroids. — *7.* Fault, *8.* faunal occurrence.



Stage
Suite
Subsuite
flora association
KASANIAN
UFAIAN
ULDSAIAN
GADSARIAN
ÖNDÖRHANIAN
Upper (250 m)
Middle (1150 m)
Lower (400 m)
(1200 m)
Upper (900m)
Lower (400 m)
Rufloria brevifolia and Cordaites gracilentus
Rufloria derzavinii and Cordaites singularis
NOMTO-HUDUK
and surrounding of height
mark 1409,8 m
T_{2-3} and J_3-K_1cc
$D_1nr_1^1$
NARUNGUIN-OBO
HUTUK-ULUIN-OBO
HONGOR-OROIN-OBO
TSIMIDUIN-OBO
$PR_3^3Є_1$; $\gamma Є_3-O_1$
RIVER MÖRÖN
T_{2-3}
D_1cr_2
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17

Permian

Formations of the Permian System are limited almost exclusively to the southern part of the mapping area. In the course of earlier activities (S. M. KALIMULIN et al., 1968; M. V. DURANTE, 1976) three suites were separated. As a result of our more detailed mapping their stratigraphical position became more exact or further subdivisions are distinguished. The characteristic facies types are shown in Fig. 10.

The volcano-sedimentary formations of the **Öndörhanian Suite** are developed near Bain-Munhu-Obo in the southwest. Near Nomto-Huduk and the altitude mark of 1409.8 m it is subdivided into two subsuites:

Lower Subsuite: predominantly conglomerate with interbeddings of tuff sandstone and rhyolite porphyry referring to a beginning volcanism (400 m).

Upper Subsuite: fine- to medium-grained, tuff-bearing and polymictic sandstone with interbeddings of fossil plant-bearing siltstone, rhyolite porphyry, rhyolite tuff, subvolcanic rhyolite porphyry and andesite porphyrite (300 m).

M. V. DURANTE (1976) recorded the following floral assemblage: *Sphenopteris* ex gr. *tunguskana* (SCHM.) ZAL., *Rufloria derzavinii* (NEUB.) S. MEYEN, *Crassinervia kuznetskiana* NEUB., *Nephrosis* cf. *integerrima* (SCHM.) ZAL.

Beds occurring on the left bank of the Targilch-Gol are shown in a geological section (Fig. 11.) Fossil plants recovered from the thin-bedded siltstones have been determined by M. V. DURANTE as follows: *Paracalamites* ex gr. *vicinalis* RADCZ., *Cordaites* aff. *latifolius* (NEUB.) S. MEYEN, *C.* ex gr. *latifolius* (NEUB.) S. MEYEN, *Phyllotheca* sp., *Bardocarpus?* sp., *Vojnovskia* sp.

This floral assemblage represents the Lower Permian Series and to some extent also the Ufaian Stage.

Represented almost exclusively by volcanics, the **Gadzarian Suite** is considerabley widespread in the study area, and it is constituted by both effusive and subvolcanic varieties as follows: rhyolite porphyry, rhyolite porphyry tuff, lava breccia, ignimbrite, rhyodacite porphyrite, dacite porphyrite, trachyrhyolite porphyry-tuff (about 1200 m). No fossils were found here, but the floral assemblage recognized earlier to the south of the place in question indicated the upper part of the Ufaian Stage and the lower part of the Kazanian Stage respectively. In the area under discussion the upper part of the suite characterized by acidic volcanics is developed.

The volcano-sedimentary formations of the **Uldzaian Suite** can also be studied in the southwestern part of the area both in the surroundings of Nomto-Hudak and the altitude mark of 1409.8 m and on both sides of the River Mörön. Its detailed makeup is illustrated by the stratigraphic columns (Fig. 10) and the geological sections (Fig. 12). In our estimation its whole thickness is about 1800 m.

Fig. 10. Characteristic sections of Permian formations (compiled by L. PENTELÉNYI and J. CSONGRÁDI)

1. Shale, argillite, *2.* siltstone, *3.* silicified shale, quartzite, *4.* sandstone, *5.* conglomerate, *6.* rhyolite porphyry *7.* rhyolite—porphyry-tuff, *8.* tuff sandstone, *9.* tuff aceous siltstone, *10.* rhyolite porphyry-tuff with ignimbrite interbeddings, *11.* rhyolite porphyry lava breccia, *12.* trachyrhyolite porphyry-tuff, *13.* rhyolite-dacite porphyrite, *14.* dacite porphyrite, *15.* andesite porphyrite, *16.* coal seam, *17.* flora occurrence.

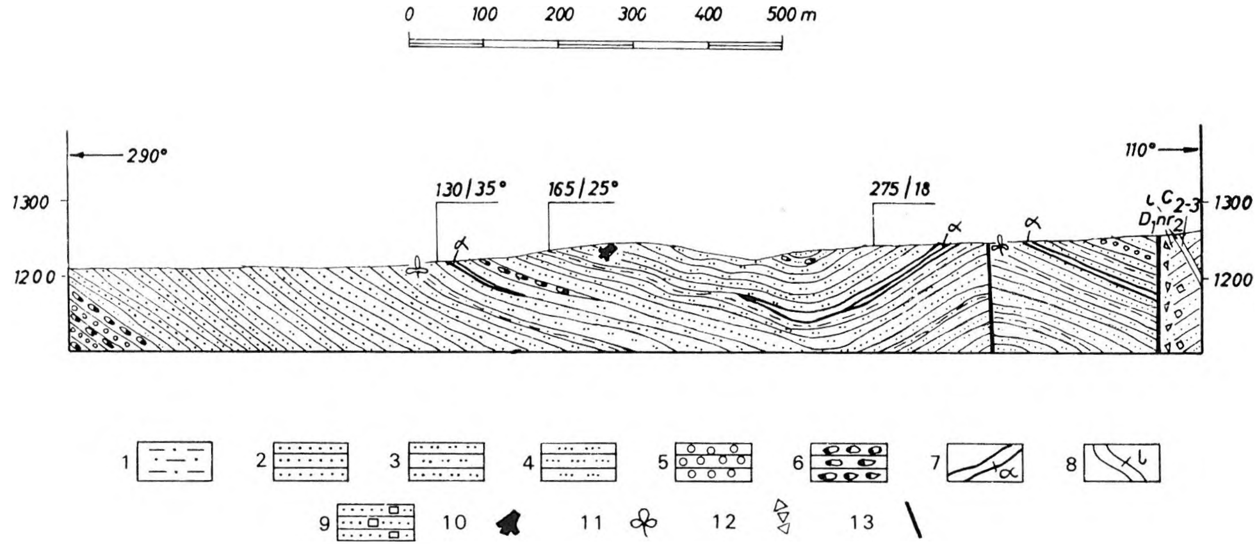


Fig. 11. Geological section of the Öndörhanian Suite on the left bank of river Targilch (compiled by F. SIKHEGYI, 1979)

Lower Permian: 1. dark-gray siltstone, *2*. fine-grained sandstone, *3*. medium-grained sandstone, *4*. coarsegrained polymictic sandstone, *5*. gravellite, *6*. conglomerate, *7*. andesite porphyrite. — *Middle to Upper Carbonaceous: 8*. aplite. — *Lower Devonian: 9*. fine-grained, in some places arkosic sandstone. — *10*. Silicified log, *11*. plant prints, *12*. tectonic breccia, limonitization, *13*. fault.

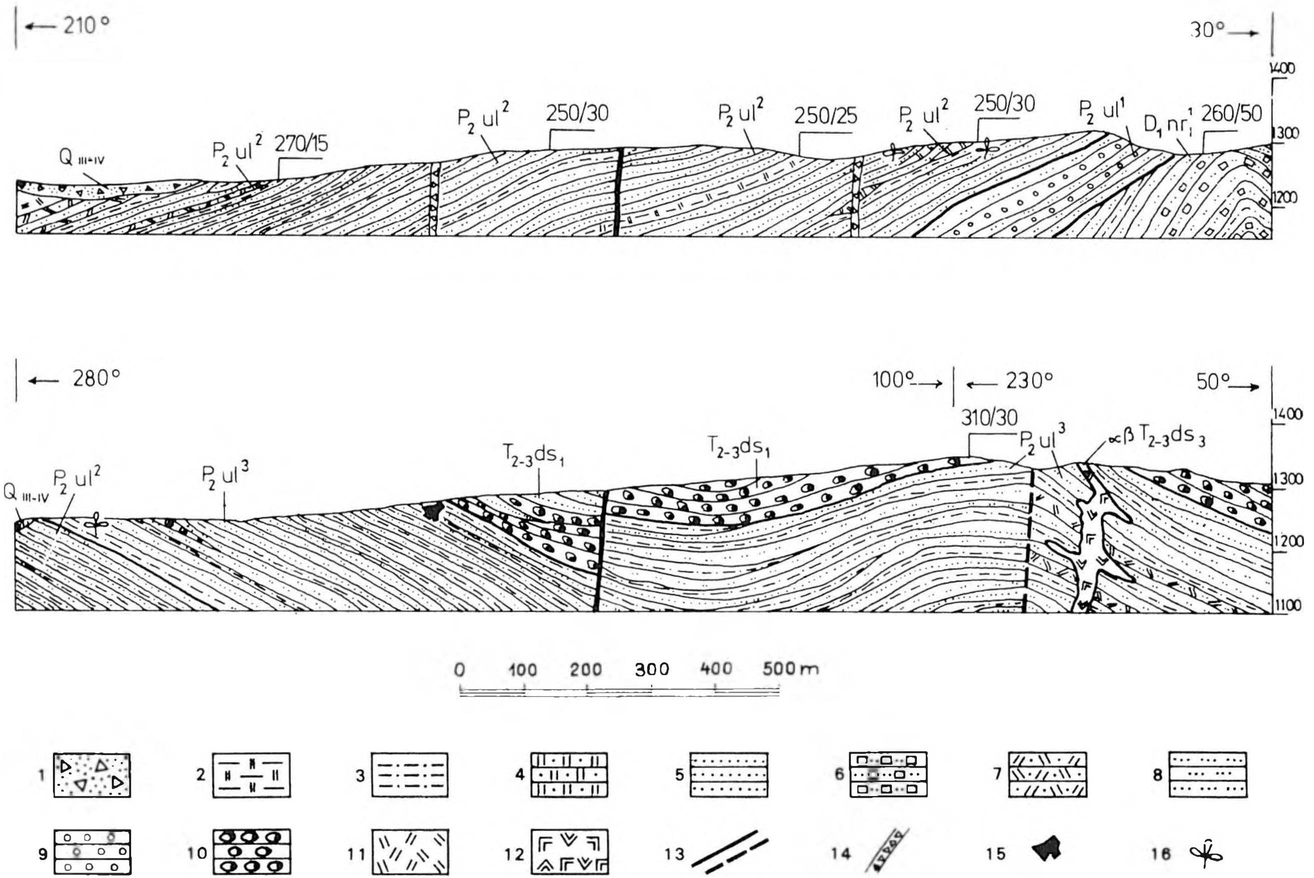


Fig. 12. Geological section of the Uldzaian and Dasibalbarian Suites on the left bank of river Mörön (compiled by R. MARTON and F. SÍKHEGYI, 1978)

1. Deluvial-proluvial sediments, *2.* silicified argillite, *3.* siltstone, *4.* silicified siltstone, *5.* fine- and mediumgrained polymictic sandstone, *6.* fine- and medium-grained arkose, *7.* fine- and medium-grained tuffaceous sandstone, *8.* coarse-grained polymictic and volcanomictic sandstone, *9.* gravellite, *10.* conglomerate, *11.* rhyolite porphyry, *12.* andesito-basalt porphyrite, *13.* fault, *14.* tectonic breccia, *15.* silicified log, *16.* plant prints.

S. M. KALIMULIN et al. (1968) and M. V. DURANTE (1976) identified this suite with the nian Stage on the basis of its fossil flora. This statement was verified by the fossil flora and fauna collected by us from the upper subsuite of the Mörön-Gol valley:

Fossil flora (determinations by M. V. DURANTE): *Pecopteris* ex gr. *anthriscifolia* (GOEPP. *Cordaites* ex gr. *gracilentus* (GOREL) S. MEYEN, *Cordaites* sp., *Crassinervia* ex gr. *ovifolia* *Cladostrobus* sp., *Tungussocarpus* ex gr. *gracilentus* (GOREL) S. MEYEN.

Brachiopods (determination by G. T. USHATINSKAJA and E. A. PAVLOVA): *Neospirifer*

On the aerial photographs the stratification of the Permian volcano-sedime formations of light gray tone is well visible. Their contour lines can be followe a long distance and they are disturbed only in the vicinity of the subvolcanic b of a white shade.

Triassic

Middle to Upper Triassic

Triassic sediments and volcanics are spatially connected with the occurr of Permian formations. Their belonging to the **Dasibalbarian Suite** is evid by the Keuper flora found in them (S. M. KALIMULIN et al. 1968). They are deve most completely on the middle reaches of the Mörön-Gol river, where they c the Uldzaian Suite (Fig. 12). Three formation groups are separated here, which be interpreted as subsuites:

Lower Formation Group: conglomerate, gravellite, coarse-gr sandstone, subordinately volcanomictic and polymictic fine-grained sandston siltstone (550 m). The bulk of the pebbles has come from Permian volcanics (Fig

Middle Formation Group: this is introduced by acidic lava Rhyolite porphyry is overlain by conglomerate and coarse-grained sandstone interbeddings of siltstone. From the latter ones *Sphaenobaerie* sp. remnants recovered (determination by I. A. DOBRUSKINA), which are characteristic repr tatives of the Middle to Upper Triassic Keuper flora (250 m).

Upper Formation Group: fine-grained polymictic sandstone interbeddings of andesite porphyrite and subordinately, rhyolite porphyry. I upper part of the sequence conglomerate and siltstone alternate with sand (650 m).

The total thickness of the Dasibalbarian Suite is estimated at 1400 to 14 In terms of petrographic characteristics the acidic and intermediate volcanics c Hoir Dsotlic were also assigned to this unit.

On the aerial photographs Triassic formations get individualized with a outline from the surrounding granites and the younger basalts but they can b tinguished only by field observations from the Devonian and Permian forma showing a similar banded pattern.

Fig. 13. Pudding-conglomerate from the Dasibalbarian Suite on the right bank of the Mörön Gol (photo by F. SÍKHEGYI, 1979)

Jurassic

In the course of our mapping activity—using the results of the earlier geological expeditions—we have applied a threefold subdivision of the Jurassic.

Lower sedimentary suite Middle intermediate to acidic effusive-pyroclastic suite	Hamarhuburinian (or Möröngolian) Series
Upper sedimentary-pyroclastic (Sarilinian) suite	lower part of the Cholbaisanian Series

Lower sedimentary suite: Only a few of the conglomerate occurrences of limited extension have been assigned to this unit in the Hurahu-Gol valley and near Tahiltuin-Obo and Hutuk-Uluin-Obo. They overlie the granite, Proterozoic formations or Permian rhyolite porphyry with an unconformity. The lower sediments are overlain by a younger Jurassic acidic effusive sequence. Its thickness does not exceed 80 m.

Middle intermediate to acidic effusive-pyroclastic suite:

This sequence is deposited with discontinuity and angular unconformity on the Paleozoic formations, in some cases on Jurassic basal conglomerates near Tahiltuin-Obo, Hutuk-Uluin-Obo and Berh. Both its one-time hanging wall and e part of the sequence in question are lost to erosion, but it is probably more wides| beneath Cretaceous volcanic and sedimentary formations.

In the lower member of the suite andesites and andesite basalt porphyrit their tuffs and flood-tuffs alternate. This member is developed above the basis-co merate to the southwest of Tahiltuin-Obo (Fig. 14).

The middle member is predominated by trachyte porphyry, rhyolite-f porphyry, their tuffs and trachyandesite porphyrite. Within the acidic effusives sandstones and tuff-conglomerates are also known.

The upper member is characterized by trachyrhyolite porphyry, orthophy their tuffs.

The total thickness of the Hamarhuburinian (or Möröngolian) Series is est ed at 600 to 800 m. The middle volcanic sequence can be hardly distinguished the younger acidic volcanics showing the same pattern on the aerial photographs

Upper sedimentary-pyroclastic (Sarilinian) sui The Sarilinian Suite comprising the lower part of the Cholbaisanian Series was fo in Kimmeridgian–Tithonian time (M. S. NAGIBINA–N. P. ANTIPOV, 1978). A surface only minor outcrops of it could be distinguished in the eastern part o mapping area, but we suppose that it also takes part in the construction of the l Mesozoic basins. This suite overlies the granite or Paleozoic formations with an a lar unconformity and are overlain, in their turn, by effusives assigned to the Tsa sabian Suite. The sequence is composed mainly of an alternation of conglome pebble-bearing sandstone, tuff-bearing sandstone with exterial moulds of fossil pl rhyolite tuff, subordinately spherulitic rhyolite. The thickness of the suite is estin at 100 to 250 m. On the aerial photographs it can be well readily deciphered stratification detectable on the field is impressive, occasionally manifesting itself through the thin Quaternary blanket.

Cretaceous

Started in the Middle Triassic, the Mesozoic activation developed full and it came to an end in the Eary Cretaceous. As a result of our activity the fo tions belonging to this unit are classified more exactly than before.

On the surface the **Tsagantsabian** effusive-sedimentary **Suite** forming the u part of the Cholbaisanian Series occurs over one third of the mapping area, but ling and geophysical results proved its presence in basins covered by younger ments too. Its accumulation began at the end of the Tithonian Stage and its bulk formed in the Valanginian. In the course of the mapping the Tsagantsabian fo tions were subdivided into sedimentary-effusive, effusive and effusive-sedimer members. Because of the uniformity of the volcanics in most occurrences any str raphic division of the sequence would have required more scrutiny so the Tsaga bian Suite on our map has been shown undivided. In any case after an alternati sedimentary and volcanic beds with different frequency the volcanic activity culn tes in the middle part of the suite, where sedimentary interbeddings if any, are s

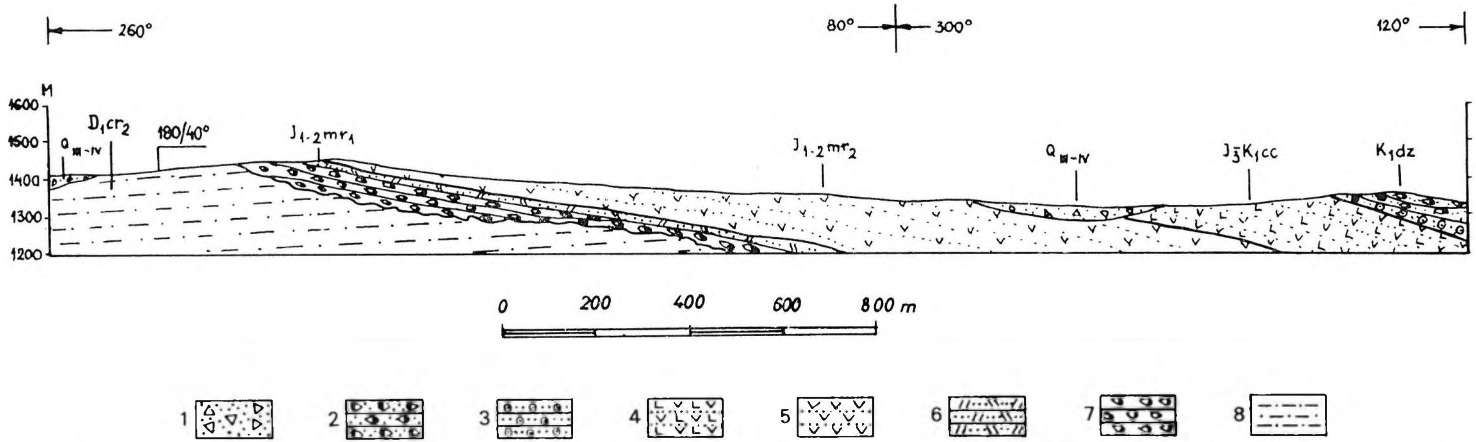


Fig. 14. Geological section at Dzosuin-Bulak (Devonian, Jurassic and Cretaceous formations) (compiled by D. DSHARGALSAJHAN)

Quaternary III–IV.: 1. deluvial and proluvial sediments. — *Cretaceous: 2.* conglomerate, sandy pebbles, *3.* pebbly sand. — *Upper Jurassic: 4.* basalt, andesito-basalt.— *Lower to Middle Jurassic: 5.* andesite, andesitodacite, *6.* coarse-grained tuff-bearing sandstone, *7.* conglomerate. — *Lower Devonian: 8.* siltstone.

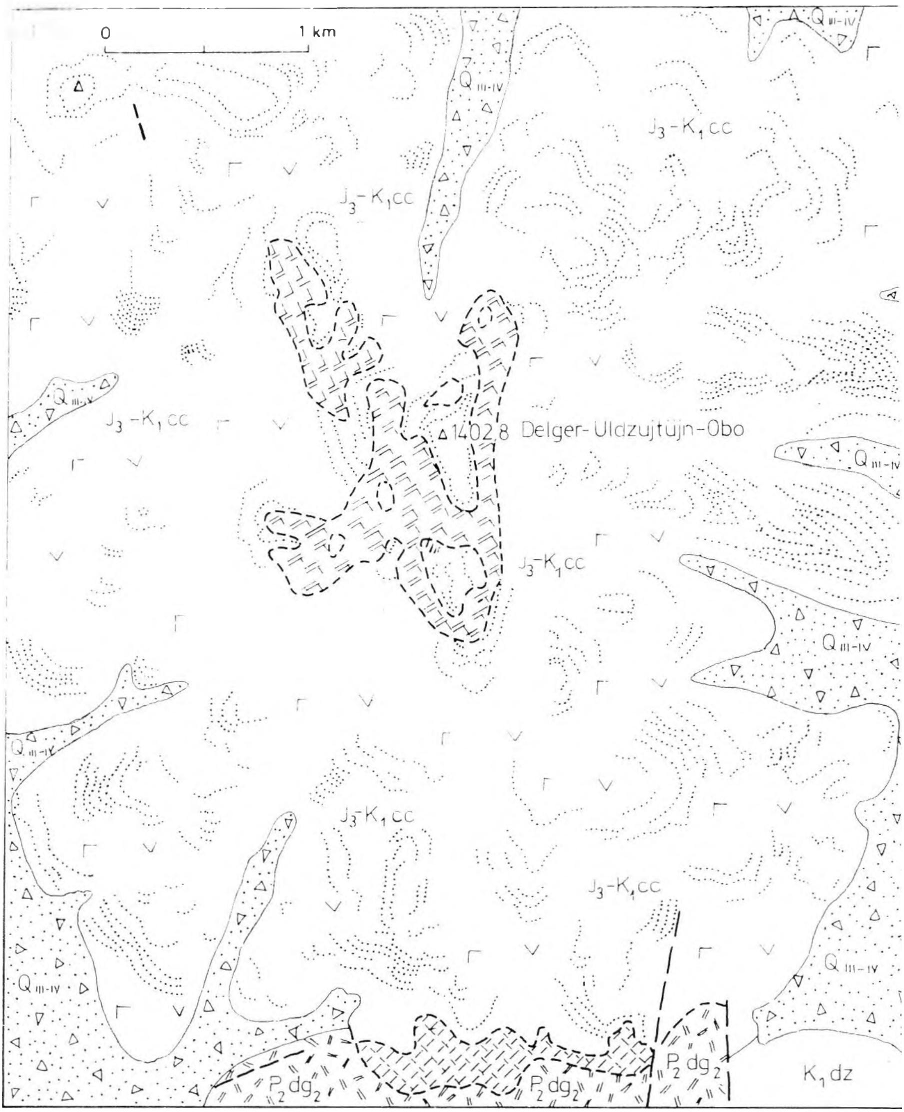


Fig. 15. Lavaflows of the Tsagantsabian (J_3-K_1-cc) andesito-basalt near by Delger-Uldzuituin (on the basis of aerial photographs, compiled by G. GRIM, 1978)

With decreasing volcanic supplies the lava flows get gradually scarcer and then va and the Dzunbainian Suite evolves gradually as clastic beds gain predominance.

Main rock types of the Tsagantsabian Suite are: amygdaloidal basalt, ande: basalt (Fig. 14), andesite and their tuffs, acidic effusives and tuffs of limited amo tuff-sandstones, pebble-bearing sandstone, conglomerate rarely with of fossil p imprints. The total thickness is estimated at 1500 m. It rests on the surface of

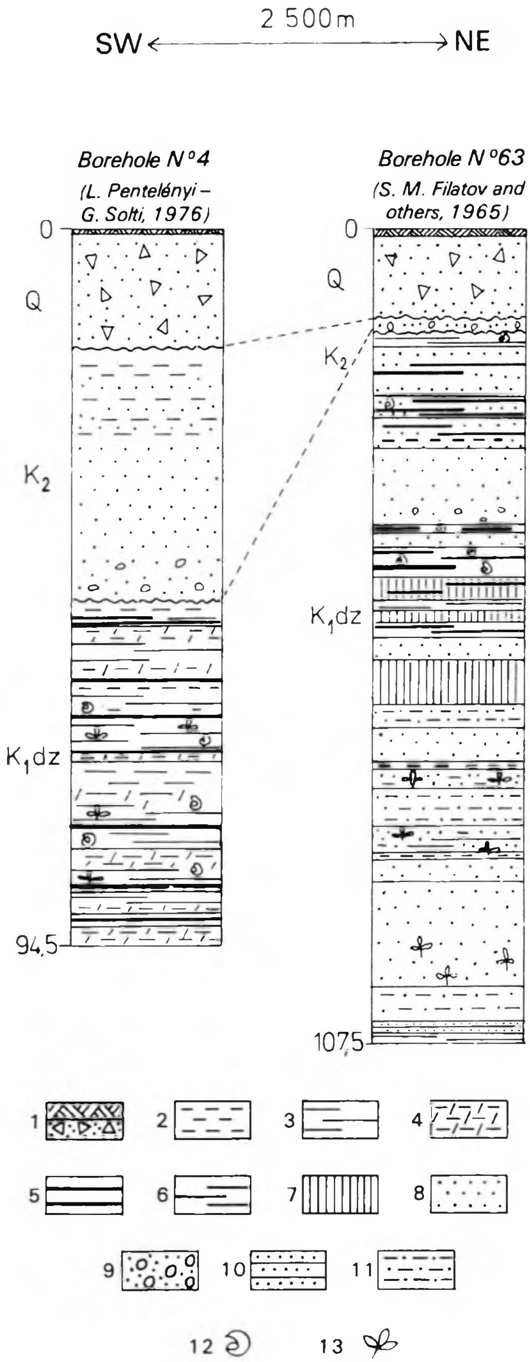


Fig. 16. Sequence of the Shinhudukian Subsuite (K_1dz) based on the boreholes N° 4 and N° 63 of the Berh Basin

1. Quaternary gravel, *2.* clay, *3.* shaly clay, *4.* bentonitic clay, *5.* coal seam, *6.* coaly shaly clay, coaly shale, oil shale, *7.* siltstone, *8.* sandstone, *9.* pebbly sandstone, *10.* sandy shale, *11.* argillaceous sand, *12.* fauna, *13.* flora occurrence.

Sarilinian sequence or on the eroded surface of the Proterozoic Basement, a overlain by formations of the Dzunbainian Suite and possibly by Upper Creta or Neogene sediments.

Formations of this unit are well detectable on the aerial photographs. covered by basalt and andesitobasalts with their darker gray shades are readil tinguishable from any other Cretaceous formation. Lava flows show a disti striped pattern, also the one-time directions of the lava flow movement can be (Fig. 15). Tuff and tuffite layers sharply differ with their light colour shades fror lava flows. On the aerial photographs the stratification is conspicuous even in ca burial, though it remains hidden from the eyes of a geologist working on the fie

In the basin areas the **Dzunbainian Suite** evolves in general step by step the Tsagantsabian Suite and a weak erosion or angular unconformity only c subordinately. The Dzunbainian Suite is overlain by Upper Cretaceous, Neoger Quaternary sediments. It is predominantly composed of sediments. In most it can be located on the basis of the interpretation of aerial photographs.

As regards as the age and division of this suite our results support the opi of M. S. NAGIBINA (1977): the Sinhudukian Subsuite corresponds to the Hauteriv Barremian Stages and the Huhtukian Subsuite to the Aptian-Albian Stages.

The best profile of the **Sinhudukian Subsuite** is provided by the boreh drilled in the Berh Basin (Fig. 16). The sequence is overlain by Upper Cretac terrestrial clastic sediments and composed of an alternation of clay, siltstone, bonaceous clay, combustible shale and bentonitic clay referring to sedimentatio a lacustrine-marshy environment.

From the 27.6–34.4 m interval of the borehole Berh N° 63 deepened in the context of the rite exploration the following ostracods have been identified (S. M. FILATOV et al., 1965): *Limn ridea tumulosa* LUBIMOVA, *Lycopterocypris* cf. *infantilis* LUBIMOVA.

From the 48.4–94.8 m interval of the borehole N° 4 put down by our expedition a lot of pc preserved, compressed mollusc shell fragments and carbonized, allochtonous fossil plants embe in laminated, thinly laminated clays came to daylight. (The major part of the carbonaceous la was poorly cored.) We observed also Pectinaries, which built up their skeleton almost exclusive ostracod.

The mollusc-conchostraca (Phyllopoda) assemblage found here is characteristic of the hudukian Subsuite (determination of G. G. MARTINSON and E. K. TRUSOVA):

Mollusca: *Bithynia subleachi* MART., *Daurina ovalis* KOL. — Conchostraca: *Bairdestheri quialta* OLEYN, *B. chii* (KOB.–KUS.), *B. elongata* (KOB.–KUS.), *B.* ex gr. *middendorfi* (JONES), *B. sin sis* CHI, *B. takechenensis* (KOB.–KUS.), *Bairdestheria* sp.

As a result of the palynological study F. GÓCZÁN proposed an Upper Hauterivian—Lc Barremian age for the interval in question and it supports the assignment to the Sinhudukian Subs as well. The taxa identified by F. GÓCZÁN are:

Cyathidites minor COUPER, *Leiotriletes* sp., *Trilites* sp., *Cardioangulina* sp., *Stereisporites* *Maculatisporites* sp., *Undulatisporites* sp., *Concavissimisporites punctatus* (DELC.–SPRUM.) BREN *Obtusisporites concavus* POCOCK, *O. martinovae* GÓCZÁN, *Verrucosisporites* sp., *Leptolepidites ve catus* COUPER, *Klukisporites* sp., *Cicatricosisporites australensis* (COOKSON) R. POT., *C. minor* (BOL GÓCZÁN, *Densoisporites globosus* GÓCZÁN, *D. circumundulatus* (BRENNER) PLAYFORD, *D. mi rugulatus* BRENNER, *Osmundacidites* cf. *longirimosus* (KLIMKO) GÓCZÁN, *Inaperturopollenites gigan* GÓCZÁN, *Araucariacites* sp., *Perinopollenites elatoides* COUPER, *Praeconiferaepollenites rudisac* GÓCZÁN, *P. primisaccus* GÓCZÁN, *Variavesiculites mongolicus* GÓCZÁN, *Simplisaccus martync* GÓCZÁN, *Inevolutisaccites piceoides* MARTINOVA, *Sulcatisporites magnificus* GÓCZÁN, *S. mtsedli* GÓCZÁN, *S. ilineae* GÓCZÁN, *Brachisaccus grandis* GÓCZÁN, *B. microsaccus* (COUPER) MÄDL *B. mtsedlisviliae* GÓCZÁN, *B. maljavkinae* GÓCZÁN, *Rudisaccites saueri* GÓCZÁN, *Rugubivesicul* *valdereductus* GÓCZÁN, *Schisosaccus podocarpiformis* GÓCZÁN, *Sch. symmetricus* GÓCZÁN, *Sch. cretaceous* GÓCZÁN, *Sch. enormis* GÓCZÁN, *Parvisaccites radiatus* COUPER, *P. rugulatus* GÓCZÁN, *Vitreisporites pallidus* (REISS.) LESCHIK, *Pteruchipollenitest thomasii* COUPER, *Alisporites valanjinicus* (ROWN.) GÓCZÁN, *A. rotundiformis* (MALJ.) GÓCZÁN, *A. similis* (BALME) DETTMAN, *Podocarpidites potomacensis* BRENNER, *P. major* COUPER, „*Oblatinella*" *mongolica* GÓCZÁN, *Classopollis torosus* (REISS.) COUPER, *Ephedripites chaloneri* BRENNER, *E. fusiformis* GÓCZÁN, *Equisetosporites rousei* POCOCK, *Botryococcus braunii* KÜTZG.

Accordingly, the flora of the area in question is represented mainly by coniferous trees and ferns. The Cicatricosisporites refer to a tropical—subtropical monsoon climate. From the algal remains of the marshy vegetation the hydrocarbon-producing species *Botryococcus braunii* KÜTZG. is present throughout the sequence and it occurs in abundance at 49 m depth.

According to the results of technological tests (G. SOLTI, 1980) oil shale recovery, in addition to the coal from the Sinhudukian Subsuite, looks promising. The total thickness of this subsuite is about 400 to 700 m.

The **Huhtukian Subsuite** seems to evolve gradually from the sinhudukian Subsuite, though we did not find any outcrop where this phenomenon could be observed directly. Best possibility for studying dark brownish-red, occasionally gravelly-detrital clay and silt layers of the subsuite is offerred by the lower interval of the borehole N° 8 put down in the upper stretch of the Sara-Tala valley. From these terrestrial-alluvial-marshy sediments plant and fish moulds came to daylight. The latter ones are assigned to the Neocomian by G. G. MARTINSON.

The total thickness of the subsuite is estimated at 150 to 300 m. Our results also support the viewpoint of S. M. NAGIBINA (1977) concerning the olivine basalts penetrating both the volcanics of the Cholbaisanian Series (Fig. 17) and the sediments of the Dzunbainian Suite, so they represent the final development stage of the Late Mesozoic structures. *K/Ar* dating performed on basalt samples from the foot of Delin-Obo gave in 111 and 113 million years respectively, showing a very good coincidence with the Aptian–Albian age of the Huhtukian Subsuite based on stratigraphic considerations.

Upper Cretaceous

Being poorly exposed, the Upper Cretaceous formations are difficult to study on the field and their identification on aerial photographs is also complicated. Presumably Upper Cretaceous so-called blanket-pebble used to cover a considerably large area, nowadays, however, it can be traced mostly in basin areas thank to the boreholes deepened there.

The loose sediments composed of pebbles, sands, red-clays and detrital material overlie the formations of Dzunbainian Suite unconformably and they can be overlain by Neogene or Quaternary sediments. The whole suite is characterized by a brownish-red colour referring to an oxidative environment. According to the borehole logs and geophysical measurements its thickness can be about 100 to 200 m.

As an important stratigraphic result, the existence in East-Mongolia of sediments of Danian age was for the first time proved by palynological study of samples from the 73.5—75.0 m interval of the borehole Sara-Tala N° 8 mentioned above.

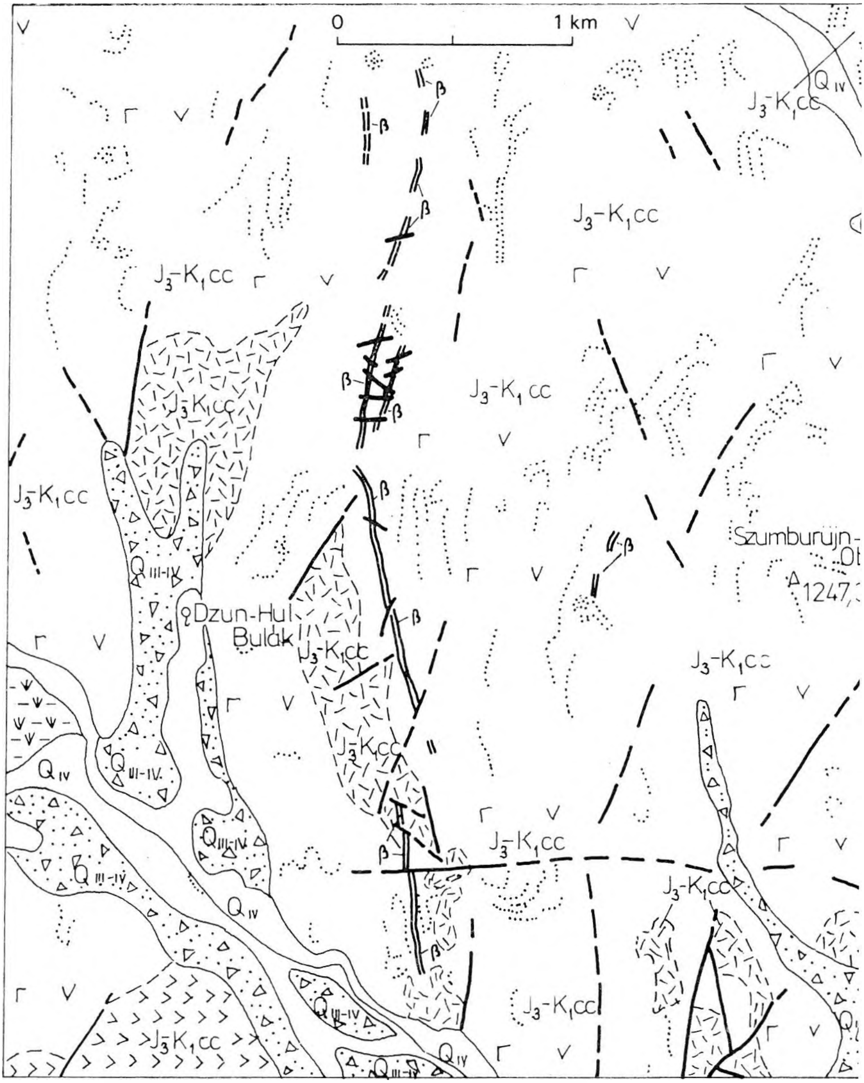


Fig. 17. Olivine-basalt dykes penetrating Tsagantsabian effusives W of Sumburuin-Obo (on th
of aerial photographs compiled by G. GRIM, 1978)

The taxa identified by F. GÓCZÁN are as follows:

Leiotriletes cf. *rotundus* DÖRING, *Stereisporites (Distzonosporis)* sp., *Stereisporites* sp., *latisporites asiaticus* GÓCZÁN, *Concavisporites* sp., *Obtusisporites corniger* (BOLKH.) POCOCK, (*sporites* sp., *Taurocisporites* sp., *Microfoveolatisporites globosus* GÓCZÁN, *M. undulatus* G(*Foveolatisporis* sp., *Retitriletes varireticulatus* GÓCZÁN, *R. parvimurus* DÖRING, *Retitrilet* *Maculatisporites* sp. (cf. *maculatus* DÖRING), *Converrucosisporites* sp., *Coptospora mongolica* G(*Verrucosisporites* cf. *optimus* MANUM, *V.* cf. *septentrionalis* MANUM, *Couperisporites* cf. *con* (COUPER) POCOCK, *C.* cf. *tabulatus* DETTMANN, *Apiculatisporites* sp., *Clivisporites* cf. *reti* (BOLKH.) R. POT., *Densoisporites perinatus* COUPER, *Densoisporites* sp., *Reticulatisporites a*

Brenner, *Callialasporites* cf. *limbatus* (Balme) Sukh.-Dev., *Sulcatisporites ilinae* Góczán, *Schizosaccus symmetricus* Góczán, *Schizosaccus* sp., *Rudisaccites* sp., *Alisporites similis* (Balme) Dettmann, *Podocarpidites radiatus* Brenner, *Monosulcites* cf. *epakros* Brenner, *Ginkgocycadophites* sp., *Cycadopites* sp., *Ephedripites* cf. *virginaensis* Brenner, *Triporopollenites* sp., cf. *Polyporopollenites* sp., *Ulmoideipites* cf. *planeraeformis* Anderson, *Integricorpus striatus* (Mtsedl.) Stanley, *Alnipollenites* sp., *Zelkovaepollenites* sp.

According to this floral assemblage the Late Cretaceous subtropical climate must have changed owing to a general decrease in temperature, so that the vegetation characteristic of the Senonian died away completely.

Neogene

In accordance with some earlier observations (V. A. Blagonravov et al., 1975) the mappers assigned to the Pliocene the redbrown loose terrestrial-fluviatile clastic sediments occurring over 100 km^2 along the river Hurahu and the Sara-Tala valley. The Neogene sediments are underlain by the Proterozoic–Paleozoic basement or andesitobasalts belonging to the Tsagantsabian Suite, and overlain by Quaternary sediments. Their most impressive outcrops can be found in the Dumda-Baian Gol valley, where a sequence—deposited on the basalt—composed of the alternation of loose conglomerates, sandy pebbles, pebble-bearing sands, tufite-bearing sandstons with fossil plant imprints, purple gray bentonite-bearing clay and sand layers can be observed. Clay beds are subordinated, sediments of coarser-grain size predominate. The poorly preseved fossil plants were not suitable for determination, so we can only rely upon the petrological analogies and the bedding characteristics. The dip of strata (120–150/30–40°) steeper than the natural slope is striking, being due to postdepositional tilting.

Neither the interpretation of aerial photographs, nor the geophysical parameters enable the distinction of the Neogene from the Dzunbainian and Upper Cretaceous sediments.

Quaternary

Interpretation of aerial photographs was the main tool for the distinction of the Quaternary sediments. We have no direct evidence of their more exact age. The traditional classification into glacials (separated by interglacial intervals) cannot be used in East-Mongolia. Deluvial-proluvial, lacustrine, marshy and fluviatile sediments distinguished from one another genetically have been formed under semiarid climate up to the present time. Eluvial and colluvial deposits are not shown separately. The remnants of barchans composed of wind-blown sands suggesting an arid climate (Saihan-Hundei), are thought, however, to be older.

INTRUSIVE MAGMATISM

The extension of the intrusive formations is considerable, constituting ꞔ one-third of the whole mapping area. Of course, the virtual size of the intrusion derground is larger than at the surface. Plutonic complexes are presented in ter the classification proposed by G. GRIM (Fig. 18).

The **Lower to Middle Cambrian intrusive complex** is represented by elon dyke-like bodies of limited size. The largest of them intruded along fissures an be traced for about 6.5 km along the strike and over 150 to 200 m in width o SE margin of the Hutuk-Uluin-Obo area. Similar but smaller intrusions can b served in the western part of the Tses-Orunk-Burduin-Bulak area, the northeast of the Munduluin-Us area and the southern part of the Berh area. Their form within the area covered by Upper Proterozoic–Lower Cambrian sediments is re to the birth of narrow graben-like structures with axes diagonal to the prol shoreline of the Baikalian–Early Caledonian geosyncline and the regional stril the sedimentary sequences. The age determination was to some extent supporte the fact that the pluton in question had been penetrated by aplite dykes of the U Cambrian–Lower Ordovician complex on the southeastern margin of Hutuk-U Obo. Rocks belonging to the Lower-Middle Cambrian complex are fine- to med grained pyroxene, hornblende-pyroxene or hornblende-biotite gabbrodiorites. ordinate potash feldspar suggests a transition to syenites and monzonites. A rel to the basic magmatites of the Upper-Proterozoic to Lower Cambrian sequen supposed. On the aerial photographs their darker shade of gray contrasts w sharp contour against their surroundings.

The **Upper Cambrian to Lower Ordovician intrusive complex** is compose large batholiths (Öndörhan, Uldza Gol, Berh), which form both the solid earths and the substratum to the Mesozoic formations over much of the mapping In the northwest they are bounded by a deep-seated fault zone (Hurahu Gol B subparallel to the strike of the Middle Mongolian Folded Range (Fig. 2 and Rift valleys formed in the course of Late Jurassic block-faulting dissected the viously homogenous plutons into pieces. Intrusions of this age penetrated the fc Upper Proterozoic to Lower Cambrian sequence getting them contact-metamorp ed. Their dating has been enhanced by the Lower Silurian (Dzunug-Ula) and D nian (Öndör-Tsagan-Obo, Uldza Gol Massif) sediments unconformably overl them. This intrusive complex is characterized by migmatization, hybridization xenoliths occuring in large number in the endocontact facies (Fig. 19). In the exo

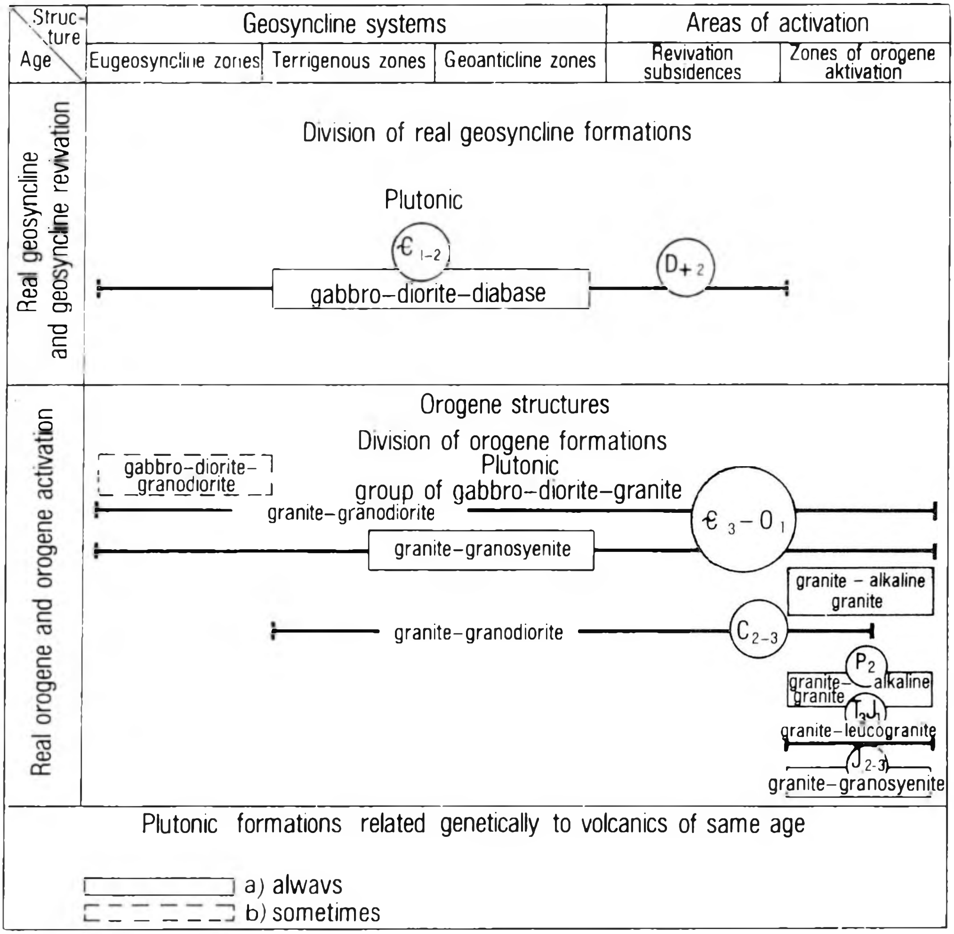


Fig. 18. Classification of plutonic formations (after J. A. BORZAKOVSKI, compiled by G. GRIM, 1978)

tact zones feldspathized, migmatitized, injected crystalline schists, gneiss-like rocks and hornfelses are wide-spread. At the contacts of limestones skarnification is common (Delger-Öndör, Öndör-Tsagan-Obo).

In the massifs produced by Early Caledonian synorogenic magmatic activity four groups of rocks formed after one another can be observed.

1. Gabbrodiorites—quartzdiorites, rarely granodiorites (only at the pluton-margins)
2. Granites—leukogranites
3. Granites—granosyenites
4. Granite—alkaline granite transitions (subalkaline granites and alaskites), alkaline granites

In addition to the predominance of the granites it is characteristic that the alkali content increases in the younger phases and in the dyke phases. Rocks of the main intrusive phase are leucocratic, medium- to coarse-grained granites. The supplementary

Fig. 19. Migmatite xenolith-bearing endocontact facies of the Upper Cambrian to Lower Ordov intrusive complex in the northwestern part of the Öndörhan Massif at the 1581 height mark (photo by L. Pentelényi, 1977)

and dyke phases are represented by fine to medium-grained, often porphyric, biot biotite-hornblende-bearing granites. Beside the aforementioned ones granite porph pegmatite, microgranite, aplite, lamprophyres, quartz veins and sometimes a su kaline alaskite type and rarely, alkaline granites play role in the dyke phase. plutons are eroded to a limited extent and this is shown by the large extension of granite porphyries and the endo-exocontact facies.

In case of an advanced erosion of the covering the intrusions can well be in preted owing to a cleavage network of characteristic pattern. Most of the *K/Ar* determinations (13 pieces) were performed on samples from this complex. The res show a rather large dispersion. Their detailed interpretation was done by Á. Kov and G. Grim (1980).

Minor gabbro—diabase intrusions belonging to the **Devonian intrusive com** are situated as sills or cores of anticline folds along a broken curve open to the w mainly in the Öndör-Tsagan-Obo area. Their sill-like intrusions sometimes also oc in Upper Proterozoic sequences (Fig. 4). The length of the elongated bodies is ab 1 to 2 km at the surface. In case of comparatively large bodies the rock struct is subvolcanic at the surface, but a few metres farther inwards it is getting to b characteristic intrusive one.

On the aerial photographs they are separated by disturbance or disappeara of the strike markings of the Devonian sediments.

Massifs classified as belonging to the **Middle to Upper Carboniferous intrusive** complex are batholiths of great size (Dzun-Belchirin, Mandal-Ula, Mandaluin-Obo). In the case of Mandaluin-Obo the lower age limit of the intrusive is represented by their active contact formed with the Lower Devonian sediments and their upper age limit is given by the overlying Permian volcano-sedimentary sequences. The Dzun-Belchirin and Mandal-Ula massifs can only be compared with country rocks identifiable only with difficulty and of more limited extension. In fact these are fault-boundaries. The massifs are covered with forests complicating their study too. Rocks of the poly-phase complex are representatives of the granodiorite-granite group (Fig. 18). Gabbrodiorites belonging to the first phase form only small bodies, dykes at the margin. Granodiorites, adamellites, biotite-hornblende and biotite-granites of the second (main) phase form the bulk of the massifs. Biotitic and leucocratic granites of the third (supplementary) phase form dykes of small extension most frequently along faults.

Granodiorites of the main phase are medium to coarse-grained, granites found in the central parts of the massifs are usually medium-grained, and granites of the supplementary phase are fine-grained. Rock types of the dyke phase are: granite- and granodiorite porphyrites, diorite porphyrites, fine-grained granites, microdiorites, and rarely, aplites and pegmatites. The granodiorites of Mandaluin-Obo is 280 million year old according to the *K/Ar* dating.

The Mandaluin-Obo intrusion can well be interpreted on the aerial photographs with the aid of the distinct exocontact zones (also here a characteristic fissure network occurs). In the case of the Mandal-Ula and Dzun-Belchirin intrusion, however, aerial photographs can hardly be used because of the dense vegetation.

Other intrusive complexes can be regarded as intrusive members of volcanic-plutonic complexes. Relatively small bodies of the **Upper Permian intrusive complex** are associated first of all with occurrences of Permian volcanics (Gadzarian Suite) in the Berh, Chimiduin-Obo, Munduluin-Us and Batu-Norbo areas. The small intrusion of Bain-Han-Obo also belong to the same complex.

The subsequent intrusion of Munduluin-Us has penetrated an intrusive complex of Upper Cambrian to Lower Ordovician age and the outcrop of the latter is surrounded by its dyke swarm appearing along curved faults. With the small intrusion of Bain-Han-Obo penetrating a granite complex of the same age a tungsten-molybdenum mineralization of quartz vein-greizen type is connected.

The Permian intrusives at Berh and Delger-Han are mainly overlain by Lower to Middle Jurassic formations, yet in the case of Delger-Han an active contact with the older biotite-hornblende-bearing granites can be identified. Granite porhpyry to quartz-porphyry transitional members show relations to the effusives. The Upper Permian massifs are composed of leucocratic and subalkaline, predominantly medium-grained granites. Small bodies in the marginal parts of the intrusion are of more basic composition while in the dyke phase aplites, microgranites, quartz veins occur.

In case of Munduluin-Us *Rb/Sr* dating proved the Upper Permian age (204 ± 23 and 259 ± 58 million years). The same method gave a result of 240 ± 12 million years for the Bain-Han intrusion.

On the aerial photographs the Upper Permian intrusions are usually well separated from the sedimentary and volcanic formations but delimitation tov intrusions of different age is difficult.

The **Upper Triassic to Lower Jurassic intrusive complex** is represented b Barchin-Ula intrusion situated at the southeastern margin of the Dzun-Belchirin There was not observed any intrusive contact and the leucocratic medium-gr granite turns step by step into the surrounding Middle to Upper Carboniferous med grained biotite-granite. Therefore the separation was done conditionally on the of *K/Ar* results (195 million years).

Granitoids of the **Middle to Upper Jurassic intrusive complex** are limite the Delger-Han area where their active contact with the Upper Permian intrusiv known. Their upper age limit is supported by the fact that fine-grained granite nosyenite pebbles originated from here can be found in the sediments of the D bainian Suite. These acidic hypabyssal rocks are difficult to distinguish from Lower to Middle Jurassic subvolcanic varieties. A number of transitional faci known.

Along the contact with the older granitoids silicification and, along the cor with the Jurassic volcanics, argillitization can be recognized.

This complex is represented mainly by fine-grained granites, which change granosyenites in the western part of the Delger-Han Massif. Near Suchuin-B the transition from granosyenites to subvolcanics of similar habit is gradual in s other places, however, an active contact was also observed. Going towards the r gins of the intrusions the alkali content increases. Unfortunately the aerial ph graphs were, on account of their poor quality, not well interpretable here.

GEOLOGICAL HISTORY AND STRUCTURAL EVOLUTION

The mapping area belongs to the North Kerulen Block of the Central Mongolian Folded Zone. The structural units shown in Fig. 20 are in accordance the geological history and they can be considered as individual evolutionary stages:

— Geosynclinal stage (from the Late Proterozoic to the Permian)
— Orogenic activation stage (Permian)
— Mesozoic activation (revival) stage (from the Triassic to the Late Cretaceous)
— Platform stage (Late Cretaceous—Cainozoic)
— Cainozoic activation stage (Pliocene—Pleistocene)

Geosynclinal stage

The existence of a geosynclinal subsidence in the Late Proterozoic is certain. This seems to have been formed from the end of the Middle Proterozoic onwards but both subsidence and sedimentation were most intensive at the end of the Late Proterozoic and the beginning of the Cambrian. In the early part of the Late Proterozoica terrigene, land-derived carbonate sediments accumulated in the geosyncline (Haitschingolian Suite) and they were heavily metamorphosed during the Cambrian foliation phase and the intrusion of the granites. Predominantly finegrained, the sediments of considerable thickness (1500 m) suggest uniformly fast subsidence and a quiet sedimentation keeping up with it.

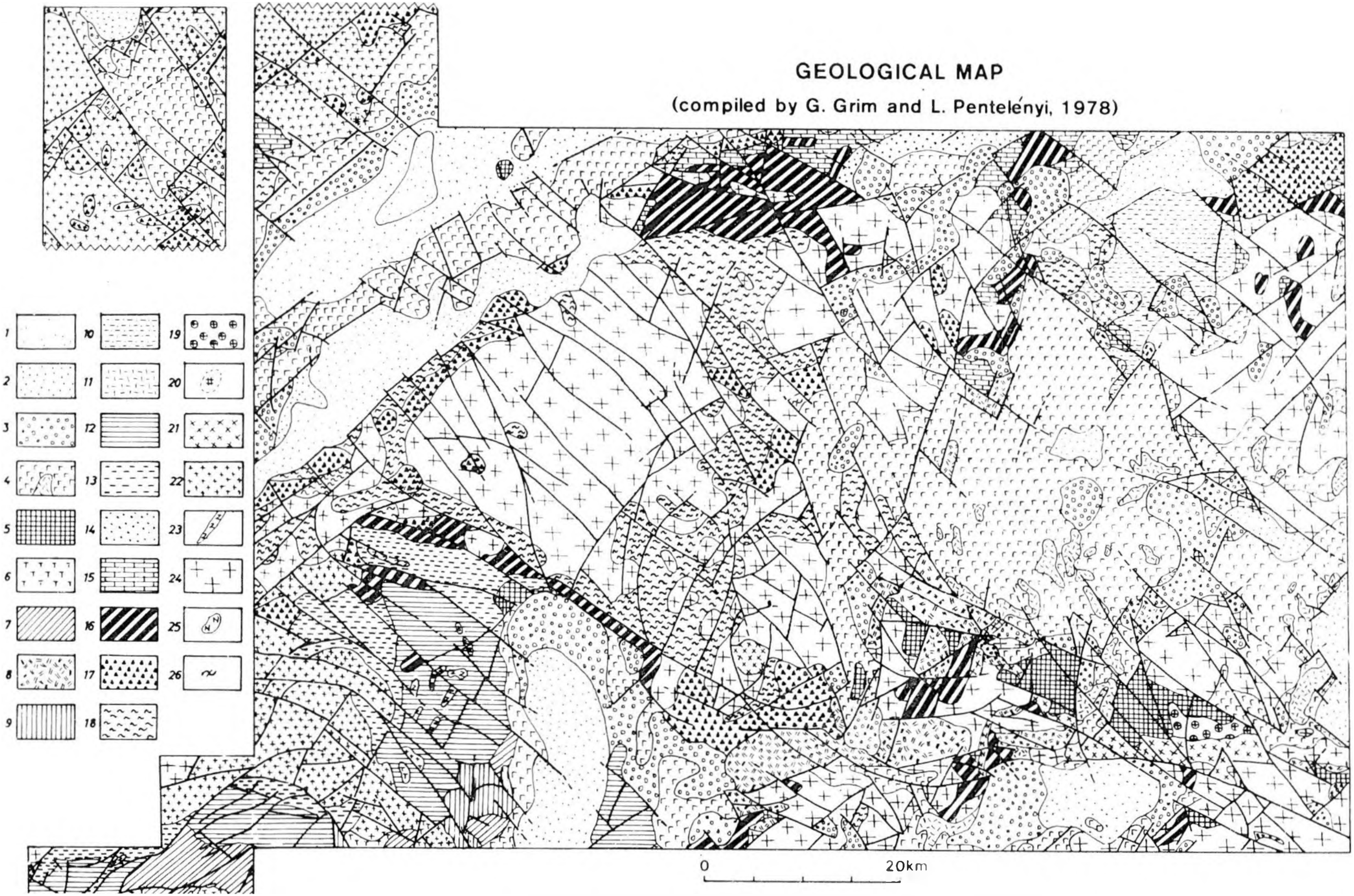
In the later part of the Late Proterozoic (Erendabanian Suite) coarse-grained sediments and effusives (porphyroids, porphyritoids) also play a role in a less uniform terrigenous-volcanogenic sequence with a total thickness of 2000 m. This sequence is already not characterized by such an advanced metamorphism than the formations underlying it and the effects of the granite intrusion are not so heavy either.

In latest Proterozoic times the bottom of the geosyncline was dissected into greater and smaller subsidence zones owing to intensive tectonic movements. Simultaneously, a submarine volcanic activity began. Two main facies types have evolved: a volcanogenic-terrigene and a carbonate-terrigene-volcanogenic one. The latter one is more common and the duration of its deposition was longer too.

The total thickness is a max of 3400 m. At the beginning the volcanic activity was of basic to intermediate composition but later—when even explosions accom-

GEOLOGICAL MAP

(compiled by G. Grim and L. Pentelényi, 1978)



Legend to *Fig. 20.*

Stages of structural evolution		Stratigraphic units	Intrusive complexes
Geosyncline $PR_2 - \epsilon_2$		gneiss-migmatite formation (PR_2) *26* terrigenous-carbonate (Haitshingolian) suite (PR_3^1) *18* terrigenous-volcanogenic (Erendabanian) suite (PR_3^2) *17* volcanogenic-terrigenous carbonate-bearing suite ($PR_3^3 - \epsilon_1$) terrigenous-volcanogenic facies ($PR_3^3 - \epsilon_1$) *16* carbonate terrigenous volcanogenic facies ($PR_3^3 - \epsilon_1$) *15*	supposed, but unsure intrusions Early Caledonian cycle of initial magmatism: small intrusions of gabbrodiorites (ϵ_{1-2}) *25*
Late Caledonian tectonic phase $\epsilon_3 - O_1$			synorogenic Late Caledonian granitoids: large (gabbro-diorite)-granite batholiths ($\epsilon_3 - O_1$) *24*
Geosyncline regeneration $S_1 - C_1$		terrigenous sequence (S_{1-2}) *14* flysch-like (Kerulen) series: fine-grained clastic (Cargingolian) suite (D_1) *13* coarser-grained clastic (Narintajian) suite (D_1) *12* fine-grained clastic (Hobtshuian) suite (D_1) *11* molassoid (Hardzanian) series (D_{2-3}) *10*	Early-Hercynian subvolcanic gabbro-diabase small intrusions (D_{1-2}) *23*
Hercynian tectonic phase C_{2-3}			synorogen Hercynian granitoids: large granite-granodiorite plutons (C_{2-3}) *22*
Late Paleozoic orogen activation $P_1 - T_1$		volcanogenic-terrigenous (Öndörhanian) suite (P_1) *9* volcanogenic (Gadzarian) suite (P_2) *8* volcanogenic-terrigenous (Uldzaian) suite (P_2) *7*	small subsequent granite intrusions (P_2) connected clearly to the Upper Permian volcanism *21*
Mesozoic revivation	early stage $T_2 - J_2$	terrigenous-volcanogenic (Dasibalbarian) suite (T_{2-3}) *6* terrigenous-volcanogenic (Hamarhuburian) series (J_{1-2}) *5*	small granite intrusion (T_3 J_1)? *20* small hypabissal granite-granosyenite intrusions connected to Jurassic volcanic activity (J_{2-3}) *19*
	late stage $J_3 - K_1$	terrigenous-volcanogenic (Cholbaisanian) series ($J_3 - K_1$): sedimentary-pyroclastic (Sarilinian) suite ($J_3 - K_1$) } *4* sedimentary-effusive (Tsagantsabian) suite ($J_3 - K_1$) } *4* sedimentary (Dzunbainian) suite (K_1) *3*	
Platform stage $K_2 - K_z$		continental clastic formation (K_2) *2*	
Kainozoic activation $N_2 - Q_1$		continental clastic formation (N_2) *1*	

panied the effusive activity—it changed into a more acidic one. In a number (subvolcanic bodies were formed, which show a transition to the hypabyssal rc the intrusive complex of the same age. In the advanced stage of development geosyncline in the Lower to Middle Cambrian minor gabbro diorite bodies o gated shape were already formed, but the large-scale synorogenic intrusive a finishing the epigeosynclinal stage took place simultaneously with the main fo movements or followed it at the end of the Cambrian and at the beginning Ordovician. In accordance with the dissected structure mentioned above not on but several granitoid plutons of different size were formed. Following the de ment of plutons fault systems came into being both in the older geosynclinal f tions and the intrusive bodies. The position of the microgranites, aplites, pegn representing the dyke phase is controlled by these fault systems. Important fl and polymetallic mineralizations are connected with the Upper Cambrian to l Ordovician granitoids and their contacts to older rocks. By the middle of the vician the area had been consolidated and its folded structure had been formed. some parts of the geosyncline regenerated and superimposed subsidences were fo In the Silurian (Wenlockian–Ludlovian Stages) marine transgression resulting ferromanganese-bearing, siliceous pelitic–psammitic sedimentation of 300–4 thickness advanced from the northeast to the Dzunug-Ula area.

In the Devonian Period considerably larger areas were again covered by In the Early Devonian a marine-terrigene sequence (Kerulen Series) of consid thickness (max 3400 m) was accumulated in the southwestern part of the ma area near Öndör-Tsagan-Obo, Bain-Munhu-Obo, Mörön Gol and Hucilu-Ul.

The formations of the Kerulen Series in the mapping area can be subdi into an older, predominantly fine-grained sequence and a younger, predomir coarse-grained one. The former corresponds to the Cargingolian, the latter t Narintajian Suite. Their thickness is respectively 1000 and 1200 m.

On the left bank of the Mörön Gol fine-grained, fossiliferous marine sedi of the Hobstshuian Suite representing the uppermost part of the Kerulen Series also proved in a thickness of 1200 m. We consider to be Devonian the subvol hypabyssal diabase-gabbro intrusive bodies (dykes and sills of different size) penetrate very densely the marine-terrigene Kerulen Series in question.

During the Middle to Late Devonian (Givetian–Frasnian Stages) the s western bay of a larger sedimentary basin spread well into the mapping area, different kinds of clastic sediments of 2500 m thickness accumulated (Hardza Series) with thin tuff interbeddings in the lower and upper parts of the sequence fact That the grain size is getting coarser, as one proceeds upwards, suggests a r sion. South of Batu-Norbo graphite-bearing shaly clays and siltstones origin from the metamorphism of carbonaceous sediments are known. The fossil plant occurring in considerable amount in some places refer to a continental environm

During the Middle to Late Carboniferous the Hercynian intrusive activity c the geosynclinal evolution stage taken in a wider sense. As a result of the poly- intrusive activity plutons of medium size came into being accompanied by ext dyke swarms in the Mandaluin-Obo, Dzun-Belchirin and Mandal-Ula areas.

Orogenic activation stage

The new orogenic stage of the evolution of the study area can be characterized by an intensification of effusive and intrusive activities during the Permian. As a result of heavy tectonic movements the area was broken into blocks and a volcanic activity started mainly in the southern parts. This activity continued with shorter or longer interruptions up to the end of the Permian. Permian granite intrusions are in a close genetic and areal relationship with the volcanics here. The tungsten mineralization of Bain-Han is connected with an Upper Permian granite intrusion.

In the Lower Permian a northeastern bay of an extended sedimentary basin with a volcano-sedimentary sequence of 700 m thickness (Öndörhanian Suite) formed in the southwestern part of the mapping area (Bain-Munhu-Obo). Variegated by acidic and intermediate volcanics and distrubed by subvolcanic intrusions, the sequence contains a lot of fossil plant prints giving evidence of the extension of the sedimentation from the Early Permian to the Ufaian.

Providing at first intermediate and then acidic products the Permian volcanism culminated in the Late Ufaian and Early Kasanian (Gadsarian Suite). In the area of our mapping activity only the upper part characterized by acidic volcanics of a thickness of 1200 m was developed without almost any sedimentary interbeddings.

Still during the Kasanian Stage a considerable part of the Lower Permian sedimentary basin mentioned before started to subside and the transgression again arrived at the margin of the mapping area. At the bottom of the sequence of the Uldzaian Suite fossiliferous marine sediments occur. With increasing role of the tuffogenous and acidic volcanic rocks the sedimentation was simultaneously step by step getting to be lagoonal and continental type. Mudflow marks and a lot of fossil plants referring to tropical climate are characteristic. In some places coal deposites were formed (coal deposit of Mörön Gol). Regression was promoted by the quick and strong morphogenetic effect of the volcanism too. The upper part of the volcano-sedimentary (Uldzaian) sequence is only developed by the Mörön Gol. During the Tatarian Stage the whole mapping area was already continental and this condition did not change in the Early Triassic either.

Mesozoic activation (revival) stage

The beginning of Mesozoic activation is indicated by the Middle to Upper Triassic volcanics and Upper Triassic to Lower Jurassic intrusion. Triassic sediments and volcanics in the southern part of the Bain-Munhu-Obo and on both sides of the Mörön Gol occur in areas built up of Permian formations. The age of the Dasibalbarian sequence of 1500 m thickness is proved by the Keuper flora found there. Most of the Triassic volcanics are subvolcanic.

During the Lower Jurassic splitting into blocks was continued, some parts of the area subsided and a strong volcanic activity took place, followed by formation of hypabyssal-subvolcanic magmatites in the higher members of the Jurassic. The whole thickness of the Hamarburinian (or Möröngolian) Series is estimated at 680 m and one can suppose that they also play role in the setting of the basement of larger basins.

The movements took place at the end of the Jurassic and the beginning Cretaceous already led to the formation of the modern appearance of our m area in main lines. Systems of step faults brought about Cretaceous basins s NE–SW and perpendicularly to it and exceeding even 1500 m in depth. Fol the large-scale movements—mainly along the rifting lines of the basin marg very heavy volcanic activity was again developed. Whereas during the Kimmeri Tithonian Stage of accumulation the Sarilian complex of 100 to 120 m thickr the subsiding basins was only interrupted by a few volcanic episodes, the vc activity culminating at the end of the Tithonian and during the Valangian yielded partly acidic pyroclastics and lava flows, but intermediate to basic anc effusives predominated. The size of the stratovolcanics is characterized by tl that the intermediate to basic effusives of the Tsagantsabian Suite with an esti thickness of 1500 m are interrupted by an insignificant amount of sedimentary beddings (NE–SW striking rift valley of the river Hurahu). Acidic volcanics– nating with basic ones—play the most important role in the nearly isometric te depression of Delger-Uldzuituin-Obo.

In the upper part of the Tsagantsabian Suite the sedimentary interbe are rather frequent, being followed after the stop of the volcanic activity by th ments of the Dzunbainian Suite. Consequently, after the volcanism had stoppe subsidence of most basins continued and molasse type terrestrial-lacustrine sedi of considerable thickness accumulated in them during the late Early Cretaceou

The lower (Sinhudukian) subsuite evolves with coarse-grained rocks grade into pelites up in the profile. The pelites contain a characteristic lacu mollusc and ostracod fauna and an abundant spore—pollen assemblage indica subtropical—tropical climate. In the upper part of the sequence thin coal s oil-shale layers and interbeddings of bentonite and tuffite can also be found thickness of the sequence representing the Hauterivian–Barremian Stages is 400 to 700 m.

The upper (Huhtukian) subsuite is characterized by terrestrial-fluvial-m clay and clastic sediments. Representing the Aptian and Albian Stages, the sul is about 150 to 300 m. The olivine basalts penetrating the Tsagantsabian eff can be assigned to the same time span.

Platform Stage

By the end of the Early Cretacous the essential tectonic movements had e in the mapping area and the Platform Stage began. Represented by variegated consolidated sands, pebbles and gravels, the Upper Cretaceous sediments accumu in a thickness of 100 to 200 m. Probably, they formed a blanket which origi covered a larger area, but nowadays in many places they are observed to be rec to eroded remnants. In the northeastern part of the Sara-Tala the presence of D sediments could also be proved with the aid of the rich spore–pollen material.

Cainozoic activation stage

During the post-Cretaceous movement the mapping area emerged considerably above the base level of erosion and a long-lasting denudation period succeeded. During the Pliocene redbrown fluvial, loose clastic sediments variegated by redeposited tuff material and plant prints were deposited in the Hurahu Basin. Faults and tiltings which can be observed on the layers are proving tectonic movements—mainly along older tectonic features—on the Pliocene–Pleistocene boundary. During the Pleistocene and Holocene in addition to the denudation of the uplifted areas eolian, marshy, deluvial, proluvial and alluvial sedimentation took place in the piedmont areas, basins and valleys.

The structural pattern of the mapping area is marked by a blockfaulting added to the above-mentioned lineament traceable along the river Hurahu (Fig. 20). The blockfault structure was produced during geosynclinal regeneration by an older NE–SW and a younger NW–SE striking fault system. Subordinately, N–S and E–W striking fault systems and curved faults can be observed. The latter were mostly formed along regenerated tectonic depressions and subsequent intrusions.

EXPLORATION

The study area belongs to the East Mongolian Metallogenetic Province, m to its Central Mongolian Zone. The area northwest of the fault zone boundin Öndörhanian Massif in the northwest is a part of the Mongolian–Transbaik Zone. The East Mongolian Metallogenetic Province related to the Early Caled structures is important mainly on account of the associated fluorite deposits. To ler extent, rare and base metal mineralizations are also linked to this province.

Here only the more important deposit will be presented from the study (Fig. 21). In this brief account the main stress is laid on those deposits of econ interest discovered by our Teams, while the occurrences of less economic int and mineralizations not verified by detailed mapping up to now are passed over.

The area is poor in energetic resources. As a continuation of the b l a c k c deposit explored by N. N. Nosikov in 1940 on the right bank of the Mörön (N. A. Marinov et al. 1977) in the upper regressive sequence of the Upper Per Uldzaian Suite a few coal-bearing clay layers occur. Technological tests prove ash content of 35 to 40%, considerably exceeding the admissible concentration. calorific value fluctuated between 14 and 21 000 kJ/kg. Because of the limited e sion and the unfavourable analytical results the new occurrences have been qual as not promising which is in accordance with the earlier results.

In spite of its poor core recovery the borehole N° 4 deepened in the Berh E has shown that the Dzunbainian sediments are possible sources of fuels. In the i vall from 48 to 94 m in addition to weakly cored brown coal seams (according t reflectivity measurements they were classified as lustrous b r o w n c o a l, gas and light coal) a number of oil shale interbeddings were observed with an org matter content of 6 to 25%. One third of the latter is recoverable and it gives reaso classify these o i l s h a l e s as being of poor to medium quality (G. Solti, 1

An i r o n occurrence was found on the westernmost margin of the map area on the left bank of the Hurahu Gol at Delger-Öndör. It seems to be of sin sedimentary origin as the ore of the Nabtshatuin Gol occurrence reported by Litjenko (N. A. Marinov et al., 1977), being the earlier unknown easternmost body of the latter. The deposit is situated in Upper Proterozoic limestones intr by Carbonaceous granites. The contact zone of the intrusion is poorly devel without any mineralization.

On the basis of field observations and geophysical measurements the ore b has a length of 450 m and a width of about 200 m and is situated conformable to

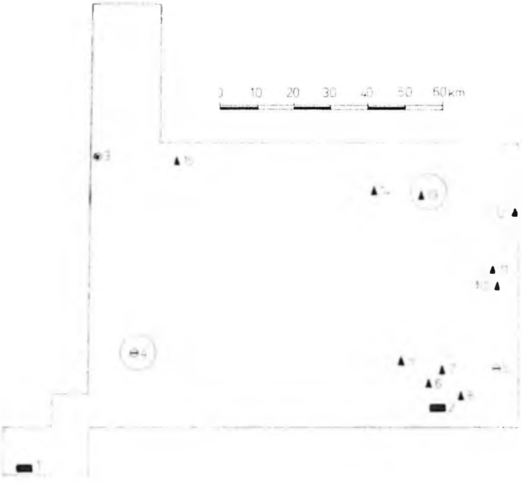


Fig. 21. Raw material occurrences

Permian coal: *1.* Mörön-Gol. — *Lower Cretaceous* brown coal and combustible shale: *2.* Berh Basin. — *Upper Proterozoic* sedimentary iron ore: *3.* Delger-Öndör. — Rare-metal sulphide occurrence: *4.* Öndör-Tsagan-Obo.— Wolframite-bearing quartz veins: *5.* Bain-Han. — Fluorite veins: *6.* Berh, *7.* Berh-North, *8.* Delger-Han, *9.* Chimiduin-Obo, *10.* Kovalevskoie, *11.* Havtgai, *12.* Bain-Dzurihe, *13.* Huli-Holbo, *14.* Barcaga-Obo, *15.* Hurahu Gol. — ○ Deposits with economic reserves discovered by the Hungarian Team.

bedding of the limestone. The ore is constituted by frequent alternation of jasper-quartzite and hematite-magnetite bands. The magnetite and hematite bands are 0.5 to 15 mm thick and often enriched in lenses parallel to the original bedding. The ore bands are foliated together with the host rock from a micro-scale to forms of up to 100 m in size. On the basis of the analysis performed on bulk samples the average iron content of the ore body fluctuates between 30 and 35%. The economic importance of the occurrence can only be determined in accordance with the earlier-examined ore reserves situated farther west.

Out of the rare-earth elements mineralizations the Öndör-Tsagan-Obo deposit is most important because of its peculiar origin and perspective. Beside wolframite and beryl of increased concentration it is the sulphide minerals that are present here in considerable percentage. Among the latter a characteristic association is represented by the pyrite-arsenopyrite-chalcopyrite-pyrrhotite paragenesis. Connected with gabbroids, this type of association may be of even industrial value, itself alone, in a number of deposits. In case of these sulphide-bearing occurences propylitisation (meso-epithermal metasomatism) is the predominant alteration type. At Öndör-Tsagan-Obo, however, a higher-temperature paragenesis with mica, wolframite, molybdenite was superimposed to the sulfide association mentioned before. This fact refers to a kind of temperature inversion.

While rare-metal deposits are usually connected to granite intrusions, in this case no granite intrusion that might be thought to be responsible for the ore mineralization can be identified either at the deposit, or in its relatively more extended neighbourhood. Consequently, it cannot even be found out whether the mineralization took place in the exocontact zone or in the so-called envelope. It should be underlined of course, that the pertinent area itself was affected in a larger sense by considerable acidic magmatic processes, from the Proterozoic to the Mesozoic Era.

The basic feature of the deposit is its being situated completely in the schists of the Lower Devonian Kerulen Series. All of the schists originated from argillaceous or fine-grained, arenaceous, terrigenous clastic rocks, excepting a few thin (max 20 m of thickness) sandstone horizont observed in the uppermost part of the sequenc considerable silica content of the schists is responsible for the compact habit rock. In some places the concentration of silica has led to the formation of an a pure quartzite. These varieties are usually lighter in colour and they are patterr winding, irregular, greenish chlorite bands.

The homogenous-looking schists are dark gray-, bluish gray—almost blac colour. In thin sections the cleveage planes are always well-shown by the or position of the mica flakes and chlorite. The mineralogical composition is simple: recrystallized silica (quartz), biotite, sericite, chlorite and rarely g In addition to the angular quartz, zircon and stained apatite grains refer to a ter source probably originated from acidic volcanics. Latter minerals are alway ordinate in amount. Varieties of the schists are characterized by the predomi of two or three rockforming minerals and one of them is always recrystallized q The mineralogical composition often changes. Fine-grained dissemination of m tite, ilmenite, rutile (these latter two are usually altered into leucoxene) and s des—mainly pyrite—are characteristic. The ore minerals are surrounded by q fine-grained fluorite and carbonate aggregates.

Within the schist sequence a lot of gabbroid bodies can be found. Their is connected to the formation of the Kerulen Depression, so their age is Lower nian too. These dykes are mainly fine-grained, rarely medium-grained, som porphyric magmatites. Within a body there are several varieties grading int another. According to their relic structures they can be classified as gabbros, dia prismatically grained gabbro-diorites or diabase porphyrites. The main rockfo minerals of the gabbroids are plagioclase and pyroxene, but they could onl seldom survive propylitization without being altered. The pyroxene crystals are v replaced by actinolites and chlorites, while the feldspars have changed into a oligoclase in composition. The plagioclases are also replaced by zoizite-epidot carbonate aggregates.

Biotitic alteration of the gabbroids can be interpreted as a result of th metamorphism. The gabbroids contain considerable amounts of magnetite, tit and apatite. The sulphidization of the gabbroids is very intensive. Thread-thin fills and minor interfingering aggreagates of pyrite, chalcopyrite, pyrrhotit arsenopyrite are especially well-developed in the root zones of the intrusive b The sill-like, conformable gabbro bodies extending for a few hundred meters wards are not characterized by sulphide mineralization. The sulphide minerali of the gabbroids is also accompanied by silicification. The younger mosaic surrounds the sulphide grains and simultaneously a rearrangement of biotite place resulting in coarse-grained aggregates and chainlike features. The sulphid tent of the gabbroids considerably exceeds that of the schists of sedimentary On the basis of the high sulphide concentration of the gabbroids the dissem sulphide mineralization can be interpreted as a result of a hydrothermal activit took place soon after the intrusion of gabbroids (the so-called Paleozoic mine tion phase). The complex rare-metal mineralization was formed with a consid delay in the Early Mesozoic. The *Rb/Sr* age of the muscovite associated with t minerals is 210±8 million years (ATOMKI, Debrecen) and 173±6 million ye measured with the *K/Ar* method (NILZG, Moszkva), respectively. These da reliably the Upper Triassic-Lower Jurassic age of the rare-earth mineralization (Early Mesozoic mineralization phase, V. I. Kovalenko, M. I. Kuzmin, 1974).

Position and shape of the ore bodies are obviously determined by the internal structure of the sequence composed of Lower Devonian schists and gabbroids (Fig. 22).

The schist sequence is heavily folded. Elongated folds striking in northwestern direction can be traced with a fold-length to fold-width ratio of 2 : 3 and an extension of a few kilometers. At the deposit these folds are cut into blocks by transverse faults and between the blocks movements of at least 100 to 150 m vertical amplitude can be recognized. It is noteworthy that the mineralization within a block penetrates with a steep dip the gently dipping schist layers. A transverse cleavage system and dynamometamorphic zone conformable to the ore body are proved to be the main controlling factors of the mineralization. The older, mainly disseminated sulphide mineralization and the younger, predominantly veined rare-metal mineralization are telescopically interrelated in space and a part of the older ore substance of deep-situated host rocks may have been reworked into the younger veins.

The ore bodies are composed of the following minerals: wolframite, scheelite, sphalerite, magnetite, haematite, ilmenite, quartz, albite, actinolite, zoizite, epidote, muscovite, biotite, sericite, chlorite, calcite, siderite, beryl, fluorite, topaz, sphene and, rarely, bornite, azurite, goethite, hydrogoethite in the poorly oxidized ores.

The tungsten content of the disseminated, veinlet-bearing stockwork-type ore bodies is poor in accordance with the character of the mineralization. This concentration is about the marginal value of workability or slightly exceeds that, but considerable concentrations of other metals *(Li, Ag, Mo, Cu, Pb, Zn)* will be taken into account when an economic decision will be made. According to the recent exploration results of a Bulgarian Team working there now the mineralization continues both along the strike and dip. The deepest borehole (650 m) did not penetrate the ore zone in total thickness, yet the results proved a vertical change in the ore composition (decreasing tungsten and increasing molybdenum content). A special feature is the extremely high concentration of silver measured in the cores from the boreholes put down on the margin of the rare-metal mineralization. These data give way to suppose the existence of a third mineralization phase.

The Bain-Han w o l f r a m i t e mineralization is connected to the apical zone of a small Permian granite intrusion. This mineralization was discovered by A. N. Marinov (1944). In 1976 our Team started to study this mineralization and Bulgarian specialists finished the detailed mapping in 1978. As a result of our work 17 ore-bearing quartz veins and about 10 gently dipping quartz-greisen-bearing bodies are known. The veins vary from 0.1 to 4.0 m in thickness and are composed of coarse-grained quartz and idiomorphic crystals of wolframite with a length of more than 10 cm. The greisenized rocks along the veins and the separate greisen bodies contain wolframite, molybdenite, cassiterite, bismuthinite, beryl, scheelite, and fluorite, in addition to rockforming muscovite and quartz. Because of the low grade of the mineralization and the limited extension the ore bodies do not present an economic interest.

A number of f l u o r i t e occurrences and mineralizations were known earlier already, but as a result of our fieldwork some new deposits were added to the old ones. The mapping area is situated in the North-Kerulen Ore District of the East

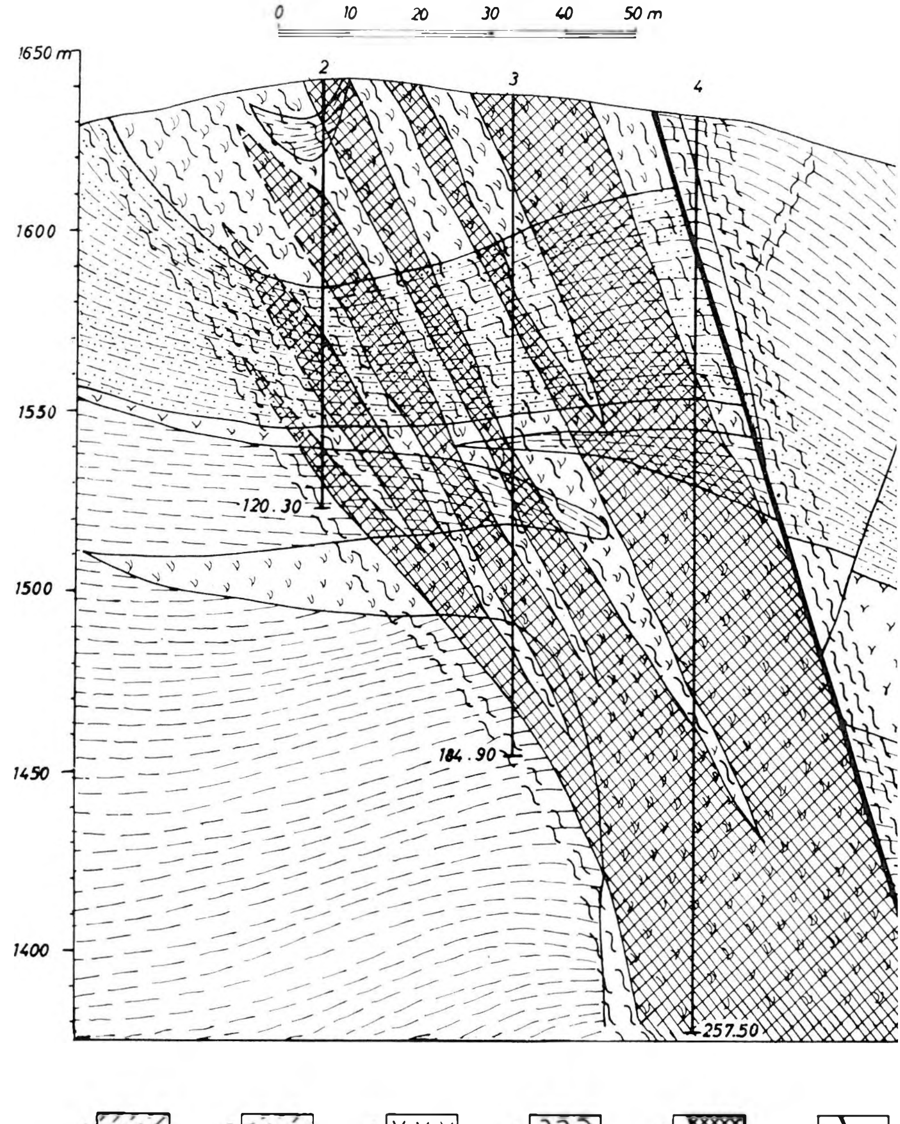


Fig. 22. Geological section of the Öndör-Tsagan-Obo rare-metal mineralization (compiled by M
LAFUT, 1979)

Lower Devonian: 1. silica-, biotite-, chlorite-, in some places sericite schists originated from argill rocks, *2.* schists originated from siltstone or sandstone.— *Lower to Middle Devonian: 3.* albitised, act sed, chloritised, carbonatised gabbroids. — *4.* Dynamometamorphic zone, well-developed clevage *5.* ore body, *6.* fault.

Mongolian Fluorite Belt, where a number of fluorite mines are known. These deposits can be found in the eastern part of the area, near the villages Batnorov and Berh. Their description is known from the literature, so here we restrict ourselves to listing them (Fig. 20).

As a result of our activity three important fluorite deposits have been discovered:

The host rock of the Huli-Holbo fluorite veins is a medium-grained cataclastic plagiogranite covered by Tsagantsabian basalt in the north. The main fluorite vein uncovered by trenches strikes to 120–300° with a subvertical dip and it has a thickness of 1.2 to 1.7 m. Other veins of the mineralized zone of 20 m width are thinner and their CaF_2 content is also less than the 45 to 50% of the main vein. On the basis of the fragments found on the surface the mineralized zone can be traced over 200 to 300 m along its strike and on the aerial photographs it can be seen to continue even on the hill situated farther southeast.

Examination of the makeup of the fluorite veins has led to distinction of the following stages of development:

Stage 1 = formation of coarse-grained massive fluorite and simultaneous alteration of the host rock. Maximal size of crystals can be 4 to 5 cm, they are purple and applegreen-coloured.
Stage 2 = in the middle of separated quartz veins and of fluorite veins an alternation of crypto-crystalline quartz and fluorite.
Stage 3 = hydrothermal alteration along fissures with dark purple fluorite veinlets of a few centimeters thickness.

On the left bank of the river Susuin near Barcaga-Obo quartz-fluorite veins of submeridional strike can be observed in Lower Paleozoic medium to coarse-grained granites. The veins are cut into pieces of a few 10 m length by transversal faults. The main vein uncovered by trenches has a width of 0.6–1.6 m with an almost vertical dip. The fluorite content of the bulk samples changes between 25 and 35%. The structure and geological situation of the vein—excepting the extensive cutting up—are very similar to those of the Huli-Holbo occurrence.

A third important fluorite mineralization is the so-called Hurahu Gol occurrence on the right bank of the river Hurahu. Its first description was given by N. T. Grashdantsev (1952), but later thematic and summarizing studies did not touch it. According to the results of trenching the geological setting is as follows: the horst-like structure is composed of a steeply dipping, NE–SW striking calcareous siltstone of probably Upper Proterozoic to Lower Cambrian age. On the top of this formation some remnants of an eroded Jurassic conglomerate can be found. The primary fluorite mineralization—similarly to the two other cases mentioned before—was formed in two or three phases. The quartz-fluorite vein with a subvertival dip can be traced over 300 m along the strike and it is accompanied by parallel fluorite veins of about 100 m length. The thickness of the vein is 2.5–3.0 m and the massive fluorite is of a good quality. Probably in connection with the Cretaceous volcanism the fluorite-generating process was repeated and the Jurassic conglomerate was penetrated by veins of 0.05 to 2.0 m thickness. These veins show the same strike as the older ones, but their composition considerably differs from that of the older ones. The younger veins contain predominantly fine-grained and, in some places, coarse crystalline quartz elc according to the axis of adular and dark purple fluorite suggestive of a low n ization temperature. The CaF_2 concentration is very low. The significance of tl phase is due to the peculiar mineral assemblage observed to the west of tł Somon fluorite deposit recently discovered. Thus the deposit has been propo further detailed investigation.

Soil sampling in the whole mapping area gave no remarkable result. P results proved the existence of a placer monazite occurrence quoted from the so part of the Munduluin-Us area by N. T. GRASHDANTSEV in 1952—with a max zite content of 170 g/m^3 accompanied by other radioactive and rare-earth mi

SUMMARY

The mapping teams organized by the Hungarian Geological Institute as part of the International Geological Expedition working in the Mongolian People‘s Republic performed complex geological mapping and prospecting of an area of 8770 km^2 on a scale of 1 : 200 000 and of an area of 1200 km^2 at 1 : 50 000 in the North Kerulen territory during the period of 1976 to 1980.

Among the *stratigraphic results* the reliable identification and delineation of various Upper Proterozoic to Lower Cambrian sequences and facies, in spite of the rather intensive metamorphism, are remarkable. We consider the detailed classification—mostly based on paleontological evidence—of the Lower Devonian Kerulen Series, the Permian Öndörhanian and Uldzaian Suites and the Triassic Dashibalbarian Suite to be an important result. Paleontological and radiometric age determinations provided a lot of valuable data to a more correct knowledge of Cretaceous stratigraphy and especially that of the Dzunbainian Suite. For the first time in Eastern Mongolia, the existence of sediments of Danian age could be proved by palynological methods.

Intrusions of considerable extension were classified into *seven intrusive complexes* using a number of *K/Ar* and *Sr/RB* datings. The large batholiths are composed of Upper Cambrian to Lower Ordovician granitoids and Middle to Upper Carbonaceous intrusive complexes.

Out of the *exploration results* the economic importance of the discovered mineralizations the **rare-earth-bearing** stockwerk-type **deposit of Öndör-Tsagan-Obo** and the **fluorite venis of Huli-Holbo** has been pointed ont by the Mapping Team.

BIBLIOGRAPHY

The manuscripts are asterisked

AMANTOV V. A. 1966a: Problematic questions of the Late pre-Paleozoic stratigraphy of the western part of the Mongol-Okhotsk area in the light of new geological results (In Russian). — Izv. Zabaik. fil. Geogr. ob.-va SSSR. Chita. 2. (1): 13–28.

— 1966b: First discovery of Lower Cambrian deposits in eastern Mongolia (In Russian). — In MARINOV N. A. 1966: Materialy po geologii Mongolskoi Narodnoi Respubliki. — Moscow.

BIAMBA ZH. et al. 1980: A new form of collaboration between COMECON member-countries in the field of geology (In Russian). — In MARINOV N. A. et al. 1980: Geologiya i poleznye iskopaemye Mongolskoi Narodnoi Respubliki. 1.: 8–19. Moscow.

*BLAGONRAVOV V. A. et al. 1968: Geology and mineral resources of the Uldza and Kerulen Interfluve and the Erendaban Range (In Russian). — Archives of the Ministry of Geology, Ulan Bator.

— 1975: Geological map of eastern Mongolia, scale 1: 500 000 (east of the 102° meridian) (In Russian). — GUTK.

*CSONGRÁDI J. et al. 1980: Geology and mineral resources of the region of the middle reaches of the Mörön Gol in NE Mongolia. (A report on the results of a 1 : 50,000-scale follow-up survey by Team N°. 13) (In Russian). — NFE Archives. Ulan Bator.

DURANTE M. V. 1976: Paleobotanical evidence of Carboniferous and Permian stratigraphy in Mongolia. (In Russian). — Moscow.

*GRAZHDANTSEV N. G. et al. 1952: Geology and mineral resources of the Onon and Kerulen Interfluve. (In Russian). — Archives of the Ministry of Geology, Ulan Bator.

GRIM G.–MADARASI A.–GUTI T. 1981: Some characteristic tectonic features in the eastern part of the North Kerulen geoanticline zone, Mongolia. — Földt. Közl. 111. (2): 350–361. — Budapest.

*KALAFUT M. et al. 1979: Geology and mineral resources of the Öndör-Tsagan-Obo ore indication area in NE Mongolia. (Report on the results of a 1 : 50 000-scale follow-up survey by Team No. 6) (In Russian). — NFE Archives, Ulan Bator.

*KALIMULIN S. M. et al. 1968: Geology and mineral resources of the Middle Kerulen Basin. (Report on the results of geological mapping at a scale of 1 : 200 000, 1966–67.) (In Russian). — Archives of the Ministry of Geology, Ulan Bator.

KOVÁCH Á.–GRIM G. 1980: Latest information on the absolute age of intrusive bodies in the North Kerulen zone, eastern Mongolia (In Russian). — In MARINOV N. A. et al. 1980: Geologiya i poleznye iskopaemye Mongolskoi Narodnoi Respubliki. 1.: 109–114. — Moscow.

*MADARASI A. et al. 1978: Report on the results of gravimetric and complex geological investigations in the North Kerulen district of NE Mongolia (In Russian). — NFE Archives, Ulan Bator.

MARINOV N. A. et al. 1973—77: Geology of the People's Republic of Mongolia. I—III. (In Russian.)— Moscow.

NAGIBINA M. S. et al. 1977: Basic features of the stratigraphy and geological history of Mongolia's Mesozoic structures (In Russian). — In Proceedings of the Soviet-Mongol Geological Research Expedition. 22. — Moscow.

NAGIBINA M. S.–ANTIPOV M. P. 1978: Early versus Late Mesozoic structures in the Kerulen river basin (NE Mongolia) (In Russian.). — Geotektonika, 5–6.: 119.

*PENTELÉNYI L. et al. 1978: Geological structure and mineral resources of the North Keruler in NE Mongolia. (Report on the results of mapping work at 1 : 200 000 by Team (In Russian.). — NFE Archives, Ulan Bator.

SOLTI G. 1980: The Dzunbain Beds of Lower Cretaceous age in the Berkh area, E Mon; Russian). — In MARINOV N. A. et al. 1980: Geologiya i poleznye iskopaemye Mo Narodnoi Respubliki. 1.: 70–73. — Moscow.

*TABA S. et al. 1980: Report on the results of gravimetric and complex geophysical measure North Kerulen district in NE Mongolia (on the activities of Complex Geophysic No. 10) (In Russian). — NFE Archives, Ulan Bator.

*ZSÁMBOK I. et al. 1981: Geology and mineral resources on the upper reaches of the rivers T Gol and Tsum-Burt-Gol, E Mongolia. (Report on the results of follow-up surv 1 : 50 000 by Team No. 19) (In Russian). — NFE Archives, Ulan Bator.

CONTENTS

HU ISBN 963 671 024 4

Kiadja a Magyar Állami Földtani Intézet
Felelős kiadó: DR. HÁMOR GÉZA igazgató
Terjedelem: 5,6 (A/5) ív Példányszám: 1000

1564/83 Franklin Nyomda, Budapest
Felelős vezető: Mátyás Miklós igazgató