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MARIAN DUMICZ *, EWA TOMCZYKOWA **, LUDWIK WÓJCIK ***

On the occurrence of Middle Cambrian Trilobites in the Khobdo Region (Western Mongolia)

(*Pl. XII—XVII, 3 Figs.*)

ODKRYCIE TRYLOBITÓW ŚRODKOWEGO KAMBRU W REGIONIE KOBDO (MONGOLIA ZACHODNIA)

(Tabl. XII—XVII, 3 fig.)

Abstract. Six members have been distinguished in the geosynclinal formation occurring in the Khobdo region, Western Mongolia: 1 — greenstone schists, 2 — quartzite conglomerates and sandstones, 3 — diabase tuffs, 4 — siliceous tufogenic schists, 5 — limestones, 6 — diabase tuffs and diabases. Trilobites of the familiae Paradoxididae and Solenopleuridae, typical of the Atlantic province, and characteristic of the Early Middle Cambrian, were found in the fourth member.

INTRODUCTION

In 1963 the Polish Geological Expedition, led by Dr E. Rutkowski, carried on geological research in the Mongolian People's Republic in the vicinity of Lake Khar-us-noor, situated in a boundary zone between the Great Lakes Basin and Mongolian Altai (Fig. 1). A trilobite fauna of Middle Cambrian age, so far unknown to occur in the area of Mongolia, was found during cartographical works in the Khobdo region, west of the Lake Khar-us-noor. The trilobites were found and preliminarily determined by L. Wójcik. Both tectonical interpretation and cartographical outline of the fossiliferous member are presented on a geological map (Fig. 2) by M. Dumicz, mainly on the basis of his own observations supplemented by L. Wójcik's and Olszewski's materials.

The individual authors contributed to the present paper as follows: literature review, lithological description, description of the fossiliferous member and of tectonic structure have been prepared by L. Wójcik and M. Dumicz; determination and description of trilobite fauna is presented by E. Tomczykowa; the conclusions are drawn by all three authors.

The trilobites described in this paper are stored in the collections of

* Wrocław 2, ul. Cybulskiego 30, Katedra Geologii Ogólnej Uniwersytetu Wrocławskiego.

** Warszawa, ul. Rakowiecka 4, Instytut Geologiczny.

*** Wrocław, ul. Świerczewskiego 74, Zakład Geologii Ogólnej i Petrografii Politechniki Wrocławskiej.

the Geological Institute Museum under the numbers IG.1140.II.1—48. Specimens of osaggiae are in the palaeontological collections of the Department of General Geology and Petrography, Wrocław Institute of Technology under the numbers 1—2 (M).

LITERATURE REVIEW

Until 1961, the age of the supracrustal formations of the Khobdo region was regarded as pre-Cambrian and Middle Palaeozoic age, and infracrustal bodies (granitoids) transecting them were so far assigned to Variscan and Late Caledonian orogenies. In the Khobdo region two rock formations different in age were distinguished by I. A. Marinov (1957): pre-Cambrian meso- and epi-metamorphic formation, and Upper Silurian formation, mainly of effusive-sedimentary origin. V. G. Vasilev et al. (1959) presented the faunistic documentation elaborated previously by P. P. Sizova (1935) for the Silurian formations of the western shore of Lake Khara-Usu, situated east of Khobdo. A. Kh. Ivanov (1961) distinguishes two structural-facial zones in the north-western part of the Mongolian Altai, i.e. the western zone that corresponds to the Central Altai, and the eastern zone that comprises the south-eastern slopes of these mountains, including the Khobdo region. As far as the latter zone is concerned, Ivanov distinguishes pre-Cambrian formations with phyllite and „phyllite-like" series, and Silurian formations differentiated into orthogeosynclinal facies („phyllite-like" schists, greenstones and porphyries) and epicontinental facies (sandstones and shales). Granitoid bodies occurring in these rock formations are regarded by N. A. Ivanov as Late Caledonian and Late Variscan in age. According to this author, both Cambrian and Ordovician periods correspond here to a sedimentary hiatus. K. L. Volochkovich (1961), in turn, refers the Khobdo area to the so-called Tsagan-noor synclinorium composed of Upper Ordovician, Silurian and Devonian geosynclinal deposits. Granitoids that are found within this unit are assigned by him to both pre-Silurian and Devonian periods. All the authors mentioned above refer the Khobdo region to the Variscan orogen.

According to N. A. Amantov et al. (1962), the Khobdo area is situated in the Kharkheeraa fold zone built of geosynclinal Cambrian and Ordovician formations, which are unconformably overlain by Silurian and younger rocks developed in epicontinental facies. The main folding process of this zone is related by these authors to the Late Caledonian orogenic movements. To these movements are also referred numerous granitoid massives, the largest of which are found in the vicinity of Khobdo.

The geological development of the Kharkheeraa zone is similarly explained also by W. W. Bezzubtsev et al., (1963) who assign it to the Late Caledonian orogeny.

K. L. Volochkovich and A. N. Leontev (1964) follow the opinion previously expressed by K. L. Volochkovich (1961) as concerns the scheme of the Khobdo region development.

Four main development stages have been distinguished in the Khobdo region, and in the adjacent part of the Mongolian Altai by M. Dumicz and J. Don (1969). These are: 1 — Early Proterozoic stage that comprises supracrustal and infracrustal crystalline rocks; 2 — Late Proterozoic — Cambrian stage represented by folded geosynclinal formations affected by granitization processes during the Salair foldings; 3 — Middle Palaeozoic stage, characterized by developed epicontinental rock complexes, and 4 — post-Middle Palaeozoic stage disclosing continental features.

Two discoveries of fauna were helpful in distinguishing the above development stages, i.e. Middle Cambrian trilobites encountered in the Khobdo region and described in the present paper by L. Wójcik, and Silurian graptolites found to occur in the near-Khobdo part of the Mongolian Altai, discovered by J. Kirschke (1969).

LITHOLOGY

The geosynclinal formation of the Khobdo region display a considerable lithologic variation, both vertical and lateral. In the vertical section six lithologic complexes differring mainly in the proportion of tufogenic material may be distinguished. These are:

1 — greenstone schists,
2 — quartzite sandstones and conglomerates,
3 — diabase tuffs,
4 — siliceous tufogenic schists,
5 — limestones,
6 — diabase tuffs and diabases.

At the contact with the granitoids of Salair age, these complexes are altered into crystalline schists (Fig. 1).

Greenstone schists. Rocks of this type represent the oldest exposed lithostratigraphic member of the geosynclinal formations occurring in the cores of anticlinal structures in the vicinity of Khobdo. These are fine-crystalline, grey-green rocks with distinct platy or leaflike jointing. Under the microscope they show granolepido-clastic texture with the relicts of pyroclastic textures, and distinct schistosity. The schists are composed mainly of quartz, accompanied by chlorite, epidote, plagioclase and calcite, locally also by actinolitic hornblende. Locally the schists are associated with fine-crystalline metadiabases which display relics of ophitic textures. These metadiabases are composed of: epidote, quartz, chlorite and albite. The total thickness of the greenstone schists and of the accompanying metadiabases amounts to 1200 m at least.

Quartzite sandstones and conglomerates. This rock complex rests rather unconformably on the greenstone schists and occurs within the limbs of folds. In the south-eastern part of the area studied, these formations are about 150 m thick while in the north-western part (Fig. 1) their thickness ranges up to 1200 m. The grain size of these rocks varies laterally. In the south-eastern part of this area fine-grained sandstones predominate, passing towards the north-west into coarse-grained conglomerates. These rocks are grey or greenish-grey in colour, their structure being more or less directional, expressed by the elongation of quartzite grains and pebbles.

As a rule, the mineral composition of both sandstones and conglomerates is similar. In the grey coloured varieties are found quartz grains, fragments of quartzite and siliceous rocks, and numerous fine mica flakes. Among the greenish-grey variaties the components mentioned above are accompanied by iron oxides and chlorite. Locally secondary calcite occurs in fissures.

The described rocks frequently contain intercalations and interbeddings

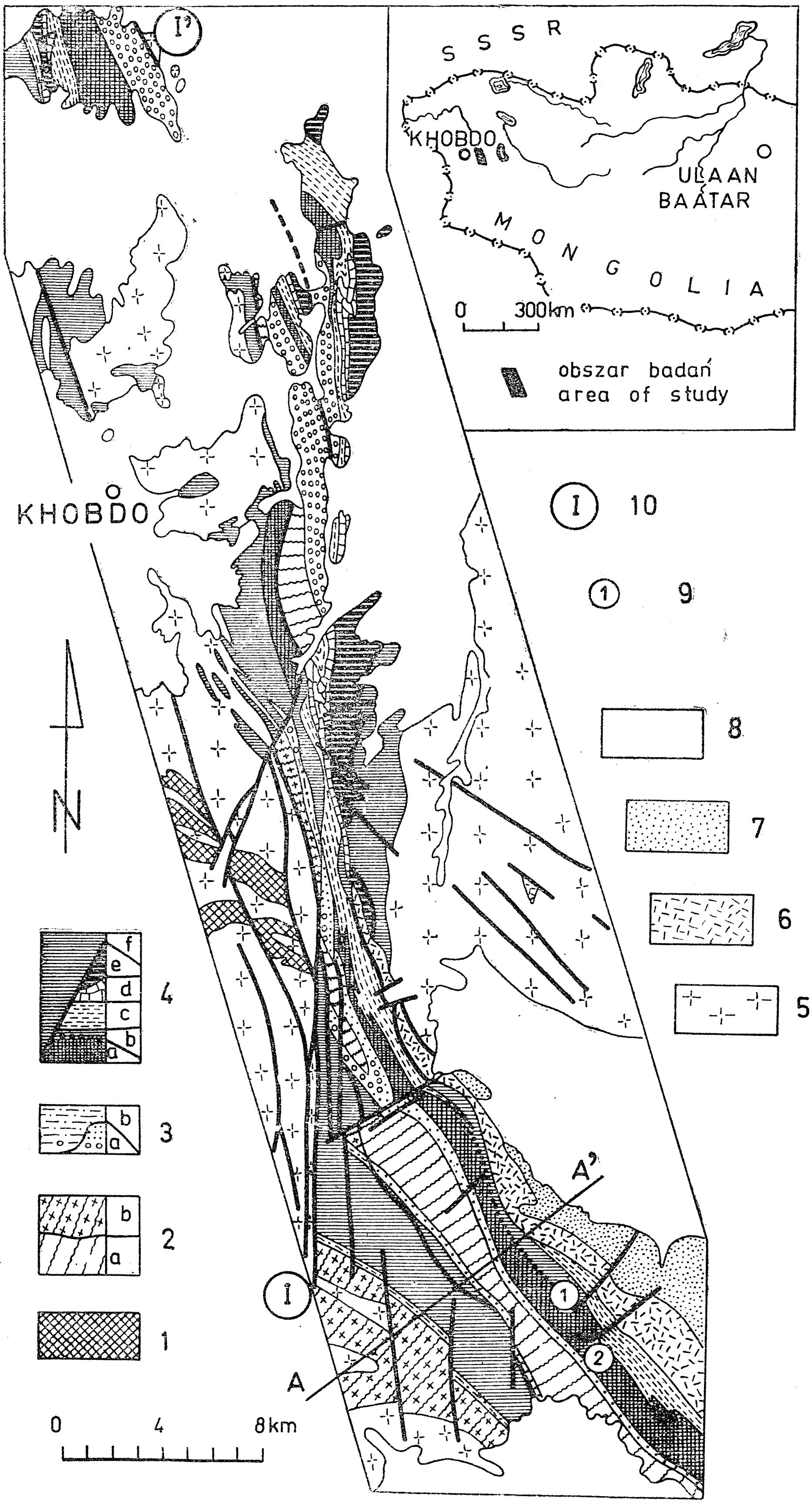


Fig. 1. Mapa geologiczna i przekrój okolic Kobdo. Starszy proterozoik: 1 — paragnejsy i migmatyty. Młodszy proterozoik — kambr: 2a — łupki zieleńcowe; 2b — amfibolity i łupki łyszczykowe; 3a — piaskowce i zlepieńce kwarcytowe; 3b — kwarcyty i metazlepieńce; 4a — tufy diabazowe; 4b — zlepieńce tufowe; 4c — krzemionkowe łupki tufogeniczne; 4d — wapienie; 4e — tufy diabazowe i diabazy; 4f — łupki krystaliczne. Plutonizm salairski: 5 — granitoidy. Ordowik (kambr górny): 6 — zlepieńce, melafiry

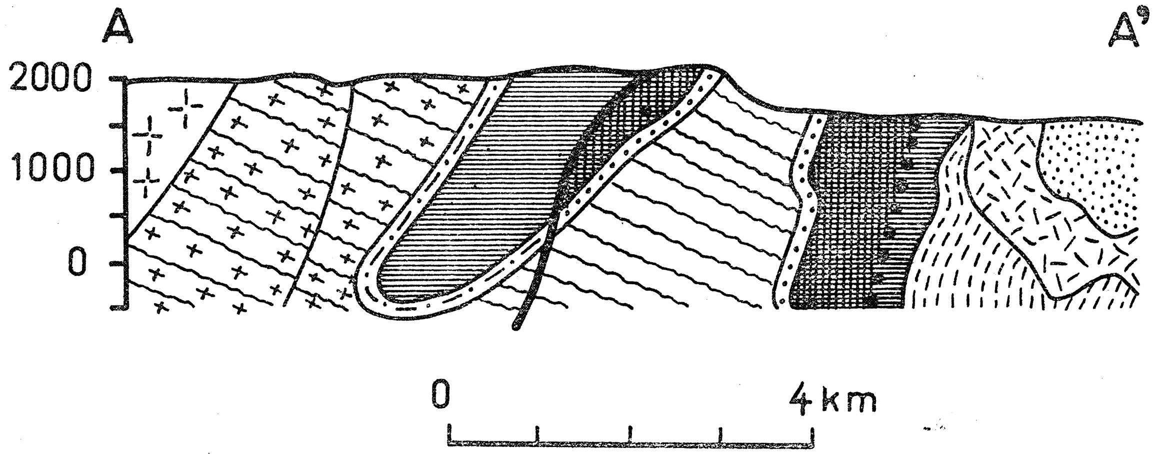
of arenaceous phyllites and porphyroids. The arenaceous phyllites are characterized by platy jointing and by pelitic or psammitic texture. They are composed of quartz and rare plagioclases, quartz pelite, fine sericite and chlorite flakes. The porphyroids reveal mainly porphyroblastic texture and directional structure expressed by the orientation of micaceous minerals. The porphyroids consist of quartz and plagioclase porphyroblasts embedded in fine-crystalline quartz-sericite matrix.

Diabase tuffs. In the studied area these formations are several hundred metres thick. Diabase tuffs rest conformably on the quartzite conglomerates and sandstones described above. At places, they are accompanied by tuff conglomerates and by numerous intercalations of tufogenic schists.

The diabase tuffs are dark green in colour and reveal fine-grained texture and massive structure, locally slightly directional. They consist of cryptocrystalline matrix composed of chlorite substance, epidote, as well as iron oxides and hydroxides, and of plagioclase and quartz phenocrysts.

The tuff conglomerates contain fragments and pebbles of volcanic rocks embedded in a fine-crystalline tufaceous mass, the mineral composition of which is almost the same as that of the tuffs described above.

Tufogenic schists appear in diabase tuffs as interbeddings several metres thick. They are dark green, willow green or violet in colour. Their texture is fine-grained, and structure reveals schistosity. It seems, however, that the schistosity of these rocks is secondary, caused by dynamical processes. These schists are composed of a cryptocrystalline rock matrix consisting of quartz, chlorite and iron oxides, and of larger mineral fragments represented by quartz aggregates and single grains of plagioclase



i ich derywaty. Sylur: 7 — zlepieńce łupki ilaste i margle. Trzeciorzęd i czwartorzęd: 8 — piaski, żwiry, głazy; Inne oznaczenia: 9 — strefa dyslokacyjna Kobdo; 10 — stanowiska z fauną trylobitową

Fig. 1. Geologic map and section of the vicinity of Khobdo. Older Proterozoic: 1 — paragneisses and migmatites. Younger Proterozoic-Cambrian: 2a — greenstone schists; 2b — amphibolites and mica schists; 3a — quartzite sandstones and conglomerates; 3b — quartzites and meta-conglomerates; 4a — diabase tuffs; 4b — tuff conglomerates; 4c — siliceous tufogenic schists; 4d — limestones; 4e — diabase tuffs and diabases; 4f — crystalline schists. Salair plutonism: 5 — granitoids. Ordovician (Upper Cambrian): 6 — conglomerates, melaphyres and their derivates. Silurian: 7 — conglomerates, shales and marls. Tertiary and Quaternary: 8 — sands, gravels, pebbles. Other explanations: 9 — Khobdo dislocation zone; 10 — sites with trilobite fauna

and epidote. Certain varieties, particularly mottled ones, contain effusive rock fragments lenticular in shape.

S i l i c e o u s t u f o g e n i c s c h i s t s. Both facially and stratigraphically the complex of these rocks interfingers with the diabase tuff complex described above, particularly in the north-western part of the described area. Moreover, the complex reveals some interbeddings of quartz sandstones and conglomerates.

Stratigraphically, the complex of siliceous tufogenic schists represents an important lithological unit, mainly on account of the Middle Cambrian trilobites that appear in it. These fossils occur in the schists either as single specimens (Pl. XII—XVI) or in large groups (Pl. XVI, Fig. 7). The rocks here considered are dark green, willow green and grey in colour. Locally are found banded varieties built of alternating green and light grey laminae. Owing to their schistose structure they split up along the plane of original stratification into plates of various thickness.

These formations consist of fine quartz — feldspar pelite embedded into cryptocrystalline matrix consisting of chlorite and iron oxides.

In the exposures situated in the north-western area, occur varieties of the siliceous tufogenic schists, rich in calcite. The calcite appears here as laminae alternating with chlorite bands. Moreover, there are found numerous banks of diabase tuffs that gradually pass into schistose rocks. Both their lithological development and mineral composition resemble those of tuffs from the lower members of the geosynclinal rocks discussed before.

Quartz conglomerates and sandstones that accompany the siliceous tufogenic schists are known mainly from the south-eastern area of the region studied. These distinctly bedded rocks are green, grey-green or brown-grey in colour. The thick beds show graded bedding and are intercalated with unequigranular, poorly sorted sandstones with interbeddings of violet-red tufogenic schists.

These rocks are composed of quartz pebbles, grains of quartz and siliceous rocks, accompanied by abundant fine light-mica flakes and feldspar grains. Quartz and siliceous rock pebbles range up to 4 cm in diameter, and are well rounded. Granular material of the conglomerates and sandstones is cemented with clay-sericite substance, with an admixture of chlorite and epidote.

C r y s t a l l i n e l i m e s t o n e s. These formations occur immediately above the siliceous tufogenic schists. In the north-western part of the area considered (Fig. 2), their thickness amounts to about 400 m, gradually decreassing towards the south-east, to a few tens of metres only. As a rule, these are fine-crystalline rocks, white, greenish or brown in colour. The colour depends upon their mineral composition. White limestones consist almost completely of calcite, accompanied by a few quartz grains and single chlorite scales. Greenish limestones disclose, beside calcite and quartz, also abundant chlorite and epidote grains. Where iron oxides appear, the rocks are grey-green, showing a brownish tint. The limestones frequently are intercalated with laminae and beds of light green calcite--chlorite schists, and locally contain aggregates of magnetite and hematite.

The limestones contain fossil algae represented by osaggiae (Pl. XVII, Figs. 1 and 2). These fossils are spherical or ellipsoidal in shape, and frequently reach up to 2 cm in diameter. In thin slides they reveal concentric structure due to the alternating thin lamellae that differ in having lighter or darker colours.

Diabase tuffs and diabases. The next complex of diabase tuffs and diabases, distinguished by the present authors, forms the uppermost member of the geosynclinal formation exposed on the surface in the Khobdo region. Often these rocks contain large limestone lenses with osaggiae. This complex is mostly found in the north-western and middle parts of the region. In a south-eastern direction it is unconformably overlain by Upper Cambrian (?) and Ordovician deposits. Diabase tuffs are fine-grained, dark green and violet in colour. Locally, they pass into a conglomerate-like series. The rocks here considered disclose porphyritic texture, and consist of fine-grained chlorite-epidote matrix, with an admixture of ore minerals, labradorite phenocrysts, and epidote and chlorite aggregates, quartz and calcite grains, as well as subrounded effusive rock relics.

The diabases occur locally and probably form covers conformable with bedding. They are characterized by greenish-grey tint and porphyritic texture. The fine-crystalline matrix of these rocks consists of plagioclase, quartz, pyroxene and iron oxide grains, enclosing densely disseminated phenocrysts of labradorite, and of pyroxene, the pseudomorphs of which are filled with secondary chlorite.

Fine-crystalline limestones that occur in the diabase tuffs in the form of thin intercalations and lenses, lithologically resemble the limestones described above.

Crystalline schists. At the contact with the granitoids of Salair age, a part of the geosynclinal formation of the Khobdo region was subject to strong recrystallization, and altered into crystalline schists. The alteration zone is fairly wide, and generally runs obliquely to the direction of beds. The crystalline schists disclose a distinct petrographical change that for the most part is a result of lithological nature of parent rocks. Amphibolites predominating over paragneisses and mica schists, are represented by two varieties, are characterized by distinct schistosity and green-grey colour, the other being massive. The green-grey variety of the amphibolites is fine-grained, and on the planes of schistosity amphibole prisms are present arranged along one plane only, but with varying orientation. The mineral components that constitute these amphibolites form both the fine grained matrix of the rock, and larger crystals. The fine grains are represented by quartz, plagioclase, chlorite, rarely also by epidote, sericite and biotite, the larger ones — mainly by amphiboles constituting ca 40 volume per cent of the rock. Garnet grains and plagioclase porphyroblasts are found in minor quantities.

As a rule, the variety of dark green massive amphibolites is equigranular and predominantly structurally isotropic. Hornblende amounts forms ca 50 volume per cent. Plagioclase about 35 percent and the quartz content does not exceed 13%. Both ore minerals and apatite are accessory constituents.

Among the amphibole rocks described above are also found, although rarely, varieties that resemble paragneisses and mica schists. The former ones usually consist of quartz, plagioclase and chlorite, whereas the mica schists contain, beside quartz, chlorite, sericite and biotite, accompanied by epidote.

DESCRIPTION OF PROFILE WITH TRILOBITE FAUNA

Two sites with trilobite fauna have been discovered in the geosynclinal formations of the Khobdo region. The sites encountered in the southern part of the area considered are shown on the geologic map (Fig. 1) by means of symbols 1 and 2. At site 1, the trilobite fauna is abundant and well preserved, whereas at site 2, it is poor and tectonically deformed. Both sites lie within the overturned limb of an anticline. Thus it may be seen (Fig. 1) that the younger rocks of the section plunge here beneath the older ones.

At the site where the geosynclinal formations contain schists with trilobites the section begins with the fine-grained quartzite sandstones, grey in colour and tectonically foliated. Abundant fine mica flakes are macroscopically visible on the planes of schistosity. The quartzite sandstones, about 150 m thick, pass into tufogenic variegated schists of violet-green tint. These latter begin a considerably thicker (up to 1000 m) complex of diabase tuffs with schist intercalations. The diabase tuffs forms beds frequently exceeding ten metres in thickness, while the schists intercalations are only several metres thick. The tufogenic schists are fine--grained, light-coloured, splitting into fairly thick plates with rough surfaces. In the top part of the profile appear beds of diabase tuffs of greenish--brown colour, often bearing small volcanic bombs that distinctly differ from the finer-grained matrix.

The tuff formations are immediately overlain by a 50 m thick bed of grey-green tufogenic sandstones. These sandstones change from coarse-grained at the base to fine-grained at the top, passing into a complex of

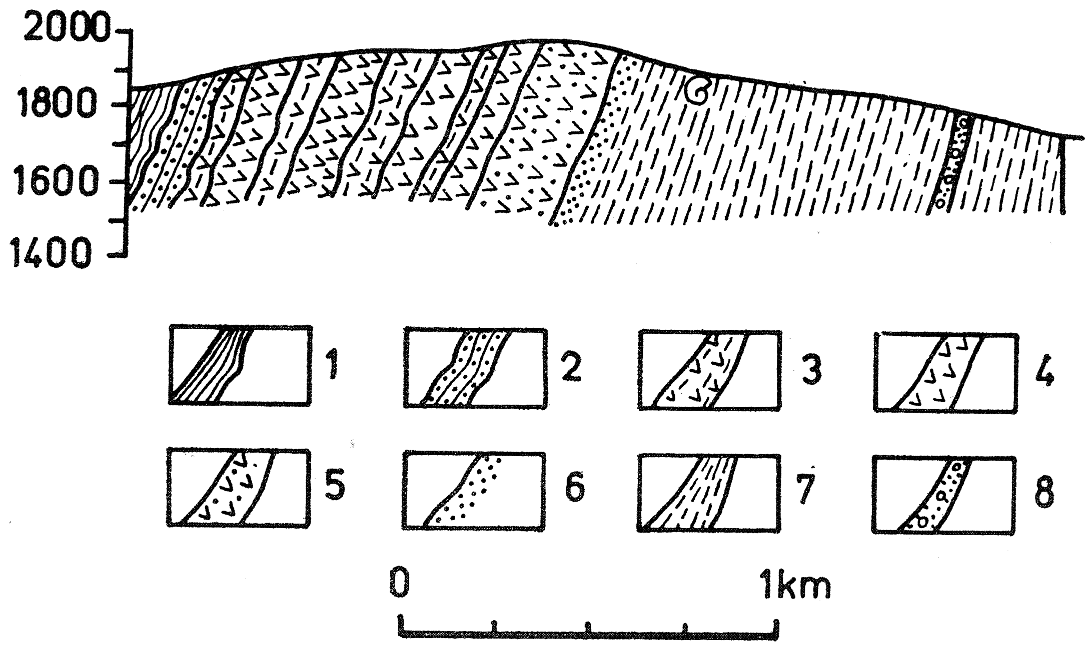


Fig. 2. Przekrój kambryjskich utworów w rejonie Kobdo. 1 — łupki zieleńcowe; 2 — piaskowce kwarcytowe; 3 — łupki tufogeniczne; 4 — tufy diabazowe; 5 — tufy zlepieńcowe; 6 — piaskowce tufogeniczne; 7 — łupki krzemionkowe; 8 — piaskowce zlepieńcowate

Fig. 2. Cross section through Cambrian formations in the Khobdo region. 1 — greenstone schists; 2 — quartzite sandstones; 3 — tufogenic schists; 4 — diabase tuffs; 5 — conglomeratic tuffs; 6 — tufogenic sandstones; 7 — siliceous schists; 8 — conglomerate-like sandstones

siliceous tufogenic schists, about 1250 m in thickness. These are green rocks that reveal platy parting along the planes of stratification.

In the higher beds of the green schists banded schists appear, built up of light grey or greenish laminae that alternate with greenish laminae. At places they are accompanied with conglomerate-like quartz sandstones, grey in colour. These schists do not show platy jointing. The trilobite fauna was found in the above complex of siliceous schists near the base of this member.

In the described profile (Fig. 2) the siliceous tufogenic schists are unconformably overlain by Ordovician conglomerates.

DESCRIPTION OF TRILOBITES

Faunistic material collected in the vicinity of Khobdo comprises approximately 60 specimens of trilobites.

Family: Paradoxididae Hawle a. Corda 1847
Subfamily: Paradoxidinae Hawle a. Corda 1847

Genus: *Eccaparadoxides* Šnajdr 1957.

Type species: *Paradoxides pusillus* Barrande 1846

The genus *Paradoxides* Brongniart 1822 has been subdivided by Šnajdr (1957, 1958) into four different genera which, as concerns most species, have not been used so far. In the genus *Eccaparadoxides* only the type species has been cited, whereas Šnajdr refers to this genus a considerable amount of species including *Paradoxides oelandicus* Sjögren 1872. The present author favours the subdivisions suggested by Šnajdr, particularly as concerns the genera *Eccaparadoxides* and *Hydrocephalus* that reveal adequately characteristic features, which diffe: them from *Paradoxides sensu stricto.*

Eccaparadoxides oelandicus (Sjögren 1872)

Pl. XII, Figs. 1—5; Pl. XIII, Figs. 1—12

(IG.1140.II.1—17)

1872 *Paradoxides ölandicus* Sjögren; Sjögren, *Geol. För. Förch.*, Bd. 1, No. 5, p. 72, Pl. 5, Fig. 1

1877 *Paradoxides ölandicus* Sjögren; Linnarsson, *Geol. För. Förch.*, Bd. 3, No. 12, pp. 354—355, Pl. 14, Figs. 1—6

1929 *Paradoxides ölandicus* Sjögren; Strand, *Norsk geol. tidsskr.*, V. 10, p. 350

?1934 *Paradoxides* cf. *ölandicus* Sjögren; Cobbold, *Phil. Trans.* ser. B, V. 223, p. 348, Pl. XLIII, Figs. 4—6

1935 *Paradoxides ölandicus*? Sjögren; Lake, *Palaeontogr. Soc. Pt.* IX, V. 88, No 3, p. 224, text-fig. 3

1936 *Paradoxides oelandicus* Sjögren; Westergård, *Sver. geol. Under.* ser. C, No 394, Å. 30, No 1, pp. 33—35 and 51—52, Pl. II, Figs. 1—11; Pl. III, Figs. 1—6

1959 *Paradoxides oelandicus* Sjögren; Orłowski, *Bull. Acad. Pol. Sc.,* Cl. III, V. 7, No 6, pp. 441—442, Pl. I, Figs. 1—5.

Material: 2 incomplete specimens, 7 incomplete cranidia, 6 free cheeks, 3 incomplete thoraxes, including 1 with pygidium.

Dimensions (in mm):	I IG.1140.II.6	II IG.1140.II.14	III IG.1140.II.3
Length of glabella	14.5	20	32
Width of glabella across anterior lobe	7	14	21
Width of glabella across L_1	5	10	16

Remarks: *Eccaparadoxides oelandicus* (Sjögren 1872) is wide-spread and stratigraphically very important, but so far described only generally. No detailed comparisons were made, although many species are considered as similar to *E. oelandicus*, or even assigned to the group of this species. Here belong: *Eccaparadoxides pinus* (Holm MS, emend. Westergård 1966), *E. quadrimucronatus* (Holm MS, emend. Westergård 1936) and *E. bidentatus* (Westergård 1936). These species are very similar to each other and differences consists only in the form of posterior margin of pygidium that is straight and entire, or has a changing amount of marginal spines (Westergård 1936).

According to the description of Linnarsson (1877), *E. oelandicus* has four glabellar furrows: S_1 and S_2 being joined, S_3 and S_4 — short. In the adult specimens of this species only S_1 and S_2 are distinct. Both S_3 and S_4 observed in the young specimens disappear, probably during their growth, as it is the case in all species of the genus *Eccaparadoxides*, except for *E. pusillus* (Barrande 1846) and *E. insularis* (Westergård 1936).

The Mongolian specimens of *E. oelandicus* (Sjögren 1872) differ from the Scandinavian ones mainly in having other length-width relation. According to Westergård (1936, pp. 34—37), cranidia of *E. oelandicus* and *E. pinus* always are slightly wider than long. On the other hand, among the Mongolian specimens this relation is, as a rule, inverted. Similarly, also the Middle Cambrian specimens from Poland, referred by Orłowski (1959) to *P. oelandicus*, are longer than wide. Glabella of the group *E. oelandicus* widens forward, but the differences in width (tr.) across the anterior lobe, and across L_1, are not considerable. The length of glabella, in turn, is always greater than maximum width, this according to the present author, being an important characteristic feature of all species of *Eccaparadoxides*, as it is distinctly shown by the dimensions of glabella, given for the individual species discussed in this paper.

The amount of the segments of thorax does not exceed 17. Between the axial furrow and fulcrum the width (tr.) of the interior part of pleura is, among the Mongolian specimens, lesser than that (tr.) of axis, and is half as wide as the entire pleuron. On the other hand, the interior part of pleura of *E. oelandicus* is, according to Westergård (1936), two-thirds as wide as the axis, and half as wide as the axis of *E. pinus*, this forming from one-third to one-fifth of the entire width of pleuron.

As far as the materials studied are concerned, the shapes of both axis and posterior margin of pygidium are difficult to establish since there exists only 1 specimen having almost a complete pygidium (Pl. XII, Fig. 4). The posterior margin of pygidium of this specimen does not show any spines, and is truncated straight, like the one of the specimens of *E. pinus* (Westergård 1936, Pl. VI, Fig. 9). Among the species of the *E. oelandicus* group both the shape and the length of pygidium axis are highly differentiated. Giving the genetic diagnosis of *Eccaparadoxides*, Šnajdr

(1957, 1958) also states that the axis is half as long as the pygidium. This mainly concerns two species: *E. pusillus* (Barrande 1846) and *E. insularis* (Westergård 1936). The axis of the other species in this genus is longer.

The species *Paradoxides suboelandicus* Poletaeva 1955, found to occur in Western Siberia is closely related to the group *Eccaparadoxides.* Particularly two specimens presented by Poletaeva (1955, p. 111, Pl. XI, Figs. 8d) strongly resemble Mongolian specimens of *E. oelandicus.* On the other hand, the species shown in Pl. XI, Fig. 8a, also assigned by Poletaeva to the species *P. suboelandicus,* is more related to *E. mongolicus* n.sp., described below.

Also *E. harknessi* (Hicks 1871) from the Middle Cambrian of South Wales (Lake 1919, pp. 217—218, Pl. XXVII, Fig. 3), resembles the species *Eccaparadoxides oelandicus* (Sjögren 1872). It has connected S_1 and S_2 and long palpebral lobes, its cranidium being longer than wide.

To the group *E. oelandicus* belongs also the Spanish species *E. mureroensis* (Sdzuy 1958), which, although comes from a part of the sedimentary basin remote from the Mongolian area, displays a great similitude to the Mongolian specimens.

Occurrence: *E. oelandicus* (Sjögren 1872) is an index species characteristic of the lower part of Middle Cambrian in the Atlantic province. The early Middle Cambrian, i.e. the zone *E. oelandicus,* is subdivided into two sub-zones: 1 — *E. insularis* and 2 — *E. pinus,* while *E. oelandicus* is found to occur in both zones. The zone *E. oelandicus* is known from Scandinavia, Great Britain, Poland and Western Mongolia.

Eccaparadoxides insularis (Westergård 1936)

Pl. XIV, Figs. 1—6 (IG.1140.II.18—24)

1936 *Paradoxides insularis* Westergård; Westergård, *Sver. geol. Under.* ser. C, No. 394, Å. 30, No 1, pp. 39—40, Pl. VII, Figs. 1—9

1959 *Paradoxides insularis* Westergård; Orłowski, *Bull. Acad. Pol. Sc.* V. 7, No 6, p. 443, Pl. II, Figs. 2—3

Material: 3 almost complete cranidia, 3 incomplete thoraxes

Dimensions (in mm):	I IG.1140.II.18	II IG.1140.II.21
Length of glabella	19	26
Width of glabella across anterior lobe	17	19
Width of glabella across L_1	10	12

Specimens assigned to this species correspond to the description given by Westergård (1936, pp. 39—40). A little smaller difference between the width and length is characteristic of the Mongolian specimens. The species *E. pusillus* (Barrande 1846) is most related to *E. insularis* (Westergård 1936); Šnajdr (1958), however, does not draw comparisons between these species, similarly as he does not compare the type species (*Paradoxides pusillus* Barrande 1846) with the species assigned to the genus *Eccaparadoxides* Šnajdr 1957. The specimens of *E. insularis* from the Cambrian of Poland (Orłowski 1959) are poorly preserved, thus Orłowski, probably by mistake, notes the occurrence of 5 glabellar furrows, since type specimens are characterized by the occurrence of 4 furrows only (Westergård 1936, p. 39, Pl. VII, Figs. 1, 2a, 3, 5, 8, 9).

Mongolian specimens assigned to *E. insularis* have a slightly narrower (sag.) occipital ring than Scandinavian ones. The node is absent. Three fragments of thorax, presented in Pl. XIV, Figs. 4—6, are poorly preserved, but most probably they belong to the species *E. insularis*.

Occurrence and stratigraphy: *Eccaparadoxides insularis* (Westergård 1936) determines the lower zone of the lower part of Middle Cambrian. It is known to occur in Scandinavia, Poland and Western Mongolia.

Eccaparadoxides mongolicus n. sp. Tomczykowa

Pl. XV, Figs. 1—3 (IG.1140.II.29—31)

Holotype: Pl. XV, Fig. 3
Type horizon: Middle Cambrian, lower part of the *Eccaparadoxides oelandicus* zone.
Type locality: Western Mongolia, Khobdo region, vicinity of Lake Khar-us-noor.
Derivatio of the name: mongolicus — from Mongolia.
Material: 3 cranidia, 1 incomplete hypostoma.
Dimensions (in mm):

	I IG.1140.II.29	II IG.1140.II.30	III IG.1140.II.31
Length of glabella	11	31	43
Width of glabella across anterior lobe	6	17	24
Width of glabella across L_1	5	14	19

Diagnosis: Cranidium elongated and narrow. Glabella long and narrow, tapering, slightly widening forward. S_1 and S_2 separated.

Description: Cranidium in frontal view tapering. Glabella elongated and narrow. S_1 not connected, wide and deep, slightly oblique backwards. S_2 also not connected, almost horizontal, showing a slight deviation forwards. Anterior lobe slightly widened, its width slightly exceeding the half of the length of glabella, distinctly tapering in front. Anterior border slightly convex, regular in width, among adult specimens separated with distinct preglabellar furrow, bending aside backwards, giving conical shape to the frontal outline of cranidium. Among the young specimens border is almost flat, preglabellar furrow shallow and indistinct. Palpebral lobes large and wide. Fixed cheeks narrow (tr.), interocular cheek forms nearly one-third (tr.) of the width of glabella measured at the same level. Occipital ring forms almost one-sixth of the glabella length. Occipital furrow almost completely shallow in the central part. Posterior furrow wide and deep. Hypostoma narrow (sag.), occupying nearly a half of the width (tr.), slightly convex. Posterior margin almost straight, scarcely bent backwards. Surface of hypostoma covered with horizontal wrinkles. Subrounded posterior angles do not pass into spines like in the other species of this genus. Free cheek, thorax and pygidium unknown.

Remarks: *Eccaparadoxides mongolicus* n.sp. differs from the remaining species of this genus mainly in the shape of glabella and in the frontal outline of glabella and cranidium. None of the species known so far is characterized by a conical shape of both cranidium and glabella which, moreover, is very narrow and elongated. A slightly similar conical shape of glabella has been observed in one specimen of *Paradoxides suboelandicus* Poletaeva (1955, Pl. XI, Fig. 8a). However, the frontal outline of cranidium of this specimen is almost straight, its occipital furrow being deep and straight, and S_1 and S_2 connected. This feature approaches it to the group of *E. oelandicus.*

The same rock fragment, which contains the cranidium of *E. mongolicus* n.sp. described above, also reveals an incomplete thorax, long and narrow, with a very narrow (tr.) axis. However, the poor state of preservation does not permit a more detailed discussion of this fragment.

Occurrence: Western Mongolia, Khobdo region, lower part of Middle Cambrian.

Eccaparadoxides sp.

Pl. XV, Figs. 4—8 (IG.1140.II.31—36)

Material: 2 incomplete cranidia, 2 fragments of thorax, 1 pygidium with 3 posterior segments of thorax.

Dimensions (in mm):	I IG.1140.II.32	II IG.1140.II.33
Length of glabella	16	19
Width of glabella across anterior lobe	10	13
Width of glabella across L_1	8	10

Description: Length and width of cranidium equal. Glabella widened in front, distinctly convex above fixed cheeks and anterior border. S_1 and S_2 connected, arched backwards along axial line. Anterior lobe covers two--thirds of glabella. Occipital ring forming nearly one-fifth of width of glabella. Occipital furrow not deep, fairly wide, bent along axial line slightly forwards. Anterior border flat, wide, somewhat widened on the sides, with a shallow furrow in the middle, parallel to the margin. Palpebral lobes long, fixed cheeks narrow, interocular cheeks covering less than half of width of glabella across L_1. Number of segments unknown. Width of thorax only slightly diminishes backwards. Axis convex, wide, almost as wide as pleura. Exterior part of pleura narrow (tr.), almost half as wide as interior pleura, sharply curving and narrowing backwards, and passing into an sharp spine. Pygidium length considerably exceeding its width. Long axis cylindrical and convex, width one axial ring, only slightly narrowing backwards, about half the width of pygidium. Posterior margin flat and subrounded.

Remarks: *Eccaparadoxides* sp. differs from the remaining species of this genus in having other shape of anterior border which is wide, flat, with a furrow in the middle. Moreover the wide axis of thorax and cylindrical axis of pygidium are highly characteristic.

A considerable length of pygidium axis is typical of *Paradoxides sacheri* Barrande 1852, but it distinctly narrows backwards. Specimens presented in Šnajdr's paper (1958, Pl. XVI, Figs. 6, 9, 12, 14) and determined as *Acadoparadoxides sacheri* (Barrande 1852), slightly resemble *Eccaparadoxides sp.* Šnajdr even suggests that the species *Paradoxides suboelandicus* Poletaeva (1955) belongs to the genus *Acadoparadoxides.* However, the close relation between the Siberian species and *Eccaparadoxides oelandicus* (Sjögren, 1872), stressed also by its specific name and by a partial resemblance to *E. mongolicus* n.sp., seem to suggest that it belongs rather to the genus *Eccaparadoxides.* Distinct axis of pygidium, more or less narrowing backwards, may be observed in the specimens described by Orłowski (1959) from the Middle Cambrian of Poland, and determined by this author as *Paradoxides kozłowskii* and

P. samsonowiczi. However both the poor preservation state and the incompleteness of description do not permit a close comparison with these specimens.

The last but one segment of thorax in *Eccaparadoxides* sp., shown in Pl. XV, Fig. 6, seems to be terminated with two spines. This, most probably, is due to crushing that resulted in the overlapping of two segments, and suggests the presence of the two spines.

Occurrence: Western Mongolia, Khobdo region, lower part of Middle Cambrian.

Hydrocephalus Barrande 1846; emend. Šnajdr 1958

The genus *Hydrocephalus* established by Barrande (1846, 1852) was accepted in the later papers as a synonym of *Paradoxides* Brongniart 1822, and this has been accepted also in the Treatise on Invertebrate Paleontology (1959). Šnajdr (1958) returned to the old notion of Barrande, and explained, on the basis of ontogenetic development, the differences that exist between these two genera. As far as the adult individuals are concerned, these differences are also highly distinctive, and adequate to separate the genera considered.

Hydrocephalus carens Barrande 1846

Pl. XV, Figs. 9—10; Pl. XVI, Figs. 1—5

(IG.1140.II.37—43, 46)

1958 *Hydrocephalus carens* Barrande; Šnajdr, *Rozpr. Ustr. Ust. Geol.* sv. 24, s. 130—139, Pl. XXIV, obr. 1—38; Pl. XXV, obr. 1—21; Pl. XXVI, obr. 1—11; Pl. XXVII, obr. 1—10; Pl. XXVIII, obr. 1—2; Pl. XXIX, obr. 1; Pl. XXX, obr. 1; Pl. XLII, obr. 1—3, 5, 7, 8; obr. 17, 23—26 in text. Here older synonyms.

Material: 6 cranidia, several incomplete cheeks

Dimensions (in mm):

		I	II	III
	IG.1140.II.	41	40	42
Length of glabella		10	16	20
Width of glabella across anterior lobe		12	19	23
Width of glabella across L_1		8.5	14	18

Remarks: The material collected from the Middle Cambrian formations of Mongolia contains cranidia almost two times wider than long. The glabella of these specimens is strongly widened in front, so that the maximum width of anterior lobe is greater than the length of glabella. S_1 and S_2 are deep narrow and connected, S_3 and S_4 are short, but distinct. These are features allowing to assign the described specimens to the species *Hydrocephalus carens* Barrande 1848. They differ from the Bohemian specimens, but the differences may be only due to a deformation of the Mongolian specimens. On the glabella of one specimen (Pl. XV, Fig. 9), S_1, S_2 and S_3 are connected. As far as the species *Hydrocephalus carens* is concerned no connected S_3 are found. May be, this is a result of specific variability.

Occurrence: Czechoslovakia, lower part of Middle Cambrian, Eccaparadoxides pusillus zone; Western Mongolia, Khobdo region, lower part of Middle Cambrian.

„*Paradoxides*" sp.

Pl. XIV, Figs. 7—10; Pl. XVI, Fig. 7 (IG.1140.II.25—28, 44)

Material: 4 free cheeks. Accumulation of trilobite fragments.

Remarks: Very characteristic free cheeks are as long as wide and have a very wide border forming a half of the free cheek. They have short and thick sharp spine bent towards the axial line. Somewhat similar cheeks are described by Orłowski (1955, p. 445, Pl. I, Figs. 9—10) from the Middle Cambrian of Poland. However, their border is slightly narrower, and spines are a little longer. Orłowski suggests that they belong to the *E. oelandicus* group. However, the specimens of the cheeks discussed above surely do not belong to any Scandinavian species.

A mass accumulation of cranidia and of other trilobite fragments in the rock specimen shown in Pl. XVI, Fig. 7, cannot be determined in a more detailed way but they reflect the abundance of the fauna that lived in this area at the beginning of Middle Cambrian. This is emphasized by the fact that this fauna is of Atlantic type only, thus coming from an area situated far west of the Khobdo region.

Occurrence: Western Mongolia, Khobdo region, lower part of Middle Cambrian.

Family: Solenopleuridae Angelin, 1854
Subfamily: Solenopleurinae Angelin, 1854

Genus: *Solenopleura* Angelin, 1854

Solenopleura sp.

Pl. XVI, Figs. 8—10 (IG.1140.II.45—45a, 47)

Material: 2 negatives of incomplete cranidia.

Remarks: Among the trilobites assigned to the family *Paradoxididae* the present author has found barely two badly damaged fragments that may be referred to another family. These specimens belong to the genus *Solenopleura,* and can hardly be determined, bearing only a slight resemblance to the species *Solenopleura cristata* Linnarsson 1877.

Occurrence: Western Mongolia, Khobdo region, lower part of Middle Cambrian.

TECTONICS

The knowledge of the lithological succession in the geosynclinal formations of the Khobdo region is of fundamental importance for the reconstruction of the geological structure of the area studied.

In the Khobdo region and in the adjacent part of the Mongolian Altai three main geological units of a NW-SE direction have been distinguished. These are: the Khobdo anticlinorium (middle unit), the Doot synclinorium (south-western unit), and the Khar-us-noor synclinorium (north-eastern unit). These units are cut by a tectonic zone (Khobdo dislocation) that runs obliquely in a meridional direction across the Khobdo area (Fig. 1).

The geosynclinal formations of the Khobdo region are part of the Khar-su-noor synclinorium. They are unconformably overlain by the epicontinental Ordovician ? (+Upper Cambrian?) deposits, and by the Silurian deposits evidenced faunistically. Both metamorphic and granitization processes affected only the geosynclinal formations, while the products of their alteration are found within the molasse-like Ordovician (+Upper Cambrian?) deposits.

The extension of the geosynclical formations in the investigated area of the Khar-us-noor synclinorium outlines a form that resembles a reversed letter „S", placed in a N-S direction (Fig. 1), i.e. in the north-western and south-eastern parts they show a NW-SE direction, and in the middle part they follow to the tectonic zone of Khobdo which runs in the north-south direction. Their dips are directed towards W and SW, under an angle of about 50—80°.

It may be inferred from the observations presented above that the tectonic processes produced here monoclinal forms modified in their course by the Khobdo dislocation zone.

In the vicinity of Khobdo this zone enters the area of the Khar-us-noor synclinorium, and divides it into two parts, the eastern and the western one, that considerably differ in the character of their geological structure. In the east fold forms predominate, while in the west large-scale overthrusts are present.

A short description of the tectonic forms of the Khar-us-noor synclinorium, built up of geosynclinal formations, is presented below.

Fold elements situated east of the Khobdo dislocation are best developed along the cross section A—A′ (Fig. 1). Here, four fold structures occur, i.e. two anticlines and two synclines striking in the NW-SE direction, monoclinally dipping towards SW at an angle of about 50—80°. These structural elements have been reconstructed on the basis of the age succession of the rocks, and of small tectonic forms. A tectonical analysis of the latter, as well as the observations of granitoids aiming at the determination of their relation to the mantle rocks, point to the Salair age of the fold forms in this part of the synclinorium. However, the Ordovician (+Upper Cambrian?) and Silurian formations, found to occur in the core of the syncline situated at Lake Khar-us-noor, are characterized by another tectonic plan related, however, to the main structures of the Salair foldings.

The western area of the Khar-us-noor synclinorium is situated within the Khobdo dislocation zone (vicinity of Khobdo and of the lower Buyant-gol river course). As compared with the eastern parts of the synclinorium its geologic structure is more complex. The fold elements, entering the area from south-west, are longitudinally dissected by faults of the Khobdo dislocation zone. The faults are of strike-slip nature, since horizontal displacements of rock masses took place along their planes. The direction of tectonic transport was here approximate to meridional, west wings of these faults being displaced northwards, as compared with the east ones. Such a disjunctive reworking of the Salair fold structures is, at certain sites, responsible for a triple repetition of the stratigraphical succession of the geosynclinal formations, as for example on the eastern bank of the lower Buyant-gol river course. This cartographical picture suggests the existence of large-scale overthrusts here. In fact, these are strike-slip faults, produced within the dislocation zone of Khobdo.

The age of this dislocation zone may be determined on the basis of the data obtained from the area of its southern extension (outside of the area studied), where it joins the so-called Tolbo-noor fault. According to W. A. A m a n t o v et al. (1962), W. W. B e z z u b t s e v et al. (1963) and L u v s a n - D a n z a n (1963), this fault had been first formed in the beginning in the pre-Cambrian, and later was several times rejuvenated. This tectonic zone was particularly active at the time when the Tolbo-noor granites were formed. These granites are referred by J. Don et al. (1968) to the Caledonian-Variscan boundary, since they cut both Ordovician and Silurian formations, their pebbles being wide-spread in the Etrouengt ? coal-bearing formation.

At the contact of the Tolbo-noor and the Khobdo tectonic zone, some faults of the Khobdo system cut the Tolbo-noor granitoids, the other ones terminating at the boundary of the granitoids (J. Don et al. 1968).

The above observations demonstrate that the origin of the Khobdo dislocation zone dates back to the time from before the formation of the Tolbo-noor granites. Its rejuvenation took place after the formation of these granites.

CONCLUSIONS

In the geosynclinal formations of the Khobdo region only the oldest greenstone schist complex seems to be separated by an orogenic phase from the remaining five younger complexes connected by sedimentary passages. The existence of this phase is, among others, proved by the presence of a complex of quartzite conglomerates and sandstones, more than 1000 m in thickness appearing above the greenstone schists. It is now difficult to ascertain to what extent this phase affected the complex of greenstone schists, since the later Salair folding processes entirely obliterated the traces of earlier deformations.

After the deposition of the quartzite conglomerate and sandstone complexes, basic volcanic activity began, resulting in the formation of a diabase tuff complex. Shortly after this, the volcanic intensity decreased, and the diabase tuff complex passes upwards into a complex of siliceous tufogenic schists with a rich trilobite fauna.

Both the abundance of the trilobite fauna of the family Paradoxididae and the presence of two specimens of *Solenopleura* sp., proving a distinct relation of these deposits with the sedimentary area of the Atlantic zone, are the most important fact presented in this paper. The sedimentary basin of the lower part of Middle Cambrian must have had favourable conditions for fauna development, and suitable connection with the north--western and northern areas (Vologdin 1957) resulting in a close connection with the Atlantic province. At that time, the sedimentary basin must have covered a fairly wide area, since single trilobite specimens of *Eccaparadoxides oelandicus* and *E.* ex gr. *oelandicus* are known to occur in Gorna Shoryia, Tuva, Upper Altai and Salair (Chernysheva 1965). On the other hand, the lack of the representatives of Pacific type fauna proves that this area must have been completely isolated from the influences of the sedimentary basin of the Pacific zone that distinguished itself by a completely different fauna and extended in the neighbourhood area, north-east of the Khobdo region (Vologdin, 1957).

The complex of siliceous tufogenic schists is overlain by limestones with algal fossils represented by osaggiae. Later on, basic volcanic activity was resumed resulting in the formation of a thick complex of diabase tuffs and diabases. Limestone lenses with the fragments of osaggiae, found to occur in this complex, are an evidence that it was formed rather in a shallow basin. The trilobite fauna allows to determine the approximate age of the series that appear above and below the fossiliferous member. Since it was found at the base of the siliceous, tufogenic schists, it may be supposed that, as a whole, these schists are of Middle Cambrian age. To the Middle Cambrian probably belong also the two younger geosynclinal complexes linked by sedimentary passages, i.e. that of limestones and that of diabase tuffs with diabases.

The age determination of the older member is more difficult. The diabase tuff member underlying the fossiliferous Early Middle Cambrian rocks, probably belongs, as a whole, or in its basal part at least, to the Lower Cambrian. May be, the next lower complex of quartzite conglomerates and sandstones still belongs to the Lower Cambrian, though it may also be older in age (Vendian). The age of the greenstone schist complex is also controversial. The regional observations made in the borderland, between the Mongolian Altai and Great Lakes Basin in the vicinity of Yesenbulak (M. D u m i c z, J. D o n, 1968) allow us to state that the greenstone schist complex here considered should be related to the Riphean or to a transition period from the Vendian to the lower part of the Lower Cambrian (M. D u m i c z and J. D o n, 1968). The orogenic phase that separates this complex from that of the quartzite conglomerates and sandstones may correspond either to the Riphean foldings (Riphean--Vendian boundary), or to the Early Salair foldings (within the Lower Cambrian).

Epimetamorphic phenomena characteristic of the geosynclinal formations of the Khobdo region, and a partial alteration of these rocks into crystalline schists and granitoids should be related to the period of Salair foldings, since the metamorphic and plutonic processes comprise here all rock complexes up to the Middle Cambrian inclusive, while their alteration products are found as pebbles in the Ordovician (+Upper Cambrian?) deposits that unconformably overlie both the geosynclinal formations of Middle Cambrian age and the granitoids.

Department of Stratigraphy
Laboratory of Palaeozoology
Geological Institute
Warszawa

Department of General Geology and Petrography
Institute of Technology, Wrocław

Translated by
Romuald Żyłka

STRESZCZENIE

W geosynklinalnych utworach regionu Kobdo w Zachodniej Mongolii wyodrębniono sześć kompleksów skalnych: 1. łupki zieleńcowe, 2. zlepieńce i piaskowce kwarcytowe, 3. tufy diabazowe, 4. krzemionkowe łupki tufogeniczne, 5. wapienie, 6. tufy diabazowe i diabazy. W kompleksie czwartym zostało znalezione około 60 okazów trylobitów. Określono tu następujące gatunki: *Eccaparadoxides* sp., *E. oelandicus* (S j ö g r e n, 1872), *E. insularis* (W e s t e r g å r d, 1936), *E. mongolicus* n. sp., *Hydrocephalus carens* B a r r a n d e, 1846, *Paradoxides* sp., *Solenopleura* sp. Trylobity te charakteryzują dolną część kambru środkowego i świadczą o ścisłym powiązaniu obszaru Kobdo z basenem prowincji atlantyckiej.

W geosynklinalnych utworach regionu Kobdo jedynie kompleks najstarszy, łupków zieleńcowych zdaje się być oddzielony fazą górotwórczą od pozostałych pięciu młodszych kompleksów, które łączą się z sobą przej-

ściem sedymentacyjnym. Na istnienie wspomnianej fazy wskazuje przede wszystkim pojawienie się nad kompleksem łupków zieleńcowych kompleksu zlepieńców i piaskowców kwarcytowych o miąższości dochodzącej ponad 1000 m.

Z obserwacji regionalnych zebranych z pogranicza Ałtaju Mongolskiego i Kotliny Wielkich Jezior wnosić można, że kompleks łupków zieleńcowych należy wiązać z ryfejem bądź z okresem przejściowym od wendu do dolnych ogniw kambru dolnego (M. Dumicz, J. Don, 1969). Faza górotwórcza zaś dzieląca ten kompleks od kompleksu zlepieńców i piaskowców kwarcytowych odpowiadać może fałdowaniom ryfejskim (przełom ryfeju i wendu), bądź fałdowaniom wczesnosalairskim (w obrębie kambru dolnego).

Po zdeponowaniu kompleksu zlepieńców i piaskowców kwarcytowych do głosu dochodzi działalność wulkanizmu zasadowego, z którą wiąże się powstanie kompleksu tufów diabazowych. Wulkanizm ten traci wnet na intensywności i kompleks tufów diabazowych przechodzi ku stropowi w kompleks tufogenicznych łupków krzemionkowych z bogatą fauną trylobitową, a ten z kolei w kompleks wapieni ze szczątkami glonów reprezentowanych przez osagia. W dalszym stadium rozwojowym zostaje ponownie wznowiona działalność wulkanizmu zasadowego i powstaje miąższy kompleks tufów diabazowych i diabazów.

Ponieważ fauna trylobitowa stwierdzona została w spągu tufogenicznych łupków krzemionkowych, stąd można wnosić, że należą one w całości do kambru środkowego. Prawdopodobnie do kambru środkowego należą również łączące się z nimi sedymentacyjnie dwa młodsze kompleksy geosynklinalne to jest wapieni oraz tufów diabazowych i diabazów. Kompleks tufów diabazowych spoczywający zaś bezpośrednio pod udokumentowanymi faunistycznie dolnymi ogniwami kambru środkowego należy prawdopodobnie, jeśli już nie w całości, to przynajmniej w partiach spągowych do kambru dolnego. Kolejny niższy kompleks zlepieńców i piaskowców kwarcytowych być może wchodzi jeszcze do kambru dolnego, chociaż nie jest wykluczone, iż może być on nieco starszy — mianowicie wieku wendyjskiego.

Obserwowane powszechnie zjawiska epimetamorfozy w geosynklinalnych utworach regionu Kobdo oraz częściowe przeobrażenie tych skał w łupki krystaliczne i granitoidy wiązać należy z okresem fałdowań salairskich. Wymienione bowiem procesy metamorficzne i plutoniczne obejmują kompleksy skalne do kambru środkowego włącznie, produkty zaś ich przeobrażeń znajdują się jako otoczki w osadach ordowickich (plus górny kambr?), spoczywających niezgodnie na geosynklinalnych utworach środkowokambryjskich, a w tym również i na granitoidach.

Katedra Geologii Ogólnej
Uniwersytetu Wrocławskiego
Wrocław
Instytut Geologiczny
Warszawa

Zakład Geologii Ogólnej i Petrografii
Politechniki, Wrocław

WYKAZ LITERATURY
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OBJAŚNIENIA TABLIC
EXPLANATION OF PLATES

Tablica — Plate XII

Eccaparadoxides oelandicus (Sjögren 1872)

Fig. 1. Policzek ruchomy X 1 (IG.1140.II.5)
Fig. 1. Free cheek X 1 (IG.1140.II.5)
Fig. 2. Kranidium niekompletne X 1 (IG.1140.II.3)
Fig. 2. Incomplete cranidium X 1 (IG.1140.II.3)
Fig. 3. Toraks niekompletny X 1 (IG.1140.II.4)
Fig. 3. Incomplete thorax X 1 (IG.1140.II.4)
Fig. 4. Toraks z pygidium X 1,5 (IG.1140.II.1)
Fig. 4. Thorax with pygidium X 1,5 (IG.1140.II.1)
Fig. 5. Prawie kompletny okaz X 1 (IG.1140.II.2)
Fig. 5. Almost complete specimen X 1 (IG.1140.II.2)
Wszystkie okazy pokrywane chlorkiem amonu
All the specimens covered with ammonium chloride
Fot. J. Modrzejewska

Tablica — Plate XIII

Eccaparadoxides oelandicus (Sjögren 1872)

Fig. 1. Krandium X 1 (IG.1140.II.6)
Fig. 1. Cranidium X 1 (IG.1140.II.6)
Fig. 2. Kranidium młode X 3 (IG.1140.II.7)
Fig. 2. Young cranidium X 3 (IG.1140.II.7)
Fig. 3. Kranidium niekompletne (zmniejszone X 1) (IG.1140.II.8)
Fig. 3. Incomplete cranidium (dimin. X 1) (IG.1140.II.8)
Fig. 4. Kranidium młode X 3 (IG.1140.II.9)
Fig. 4. Young cranidium X 3 (IG.1140.II.9)

Fig. 5. Kranidium dorosłe X 1 (IG.1140.II.14)
Fig. 5. Adult cranidium X 1 (IG.1140.II.14)
Fig. 6. Policzek ruchomy X 1 (IG.1140.II.15)
Fig. 6. Free cheek X 1 (IG.1140.II.15)
Fig. 7. Policzek ruchomy X 1 (IG.1140.II.16)
Fig. 7. Free cheek X 1 (IG.1140.II.16)
Fig. 8. Policzek ruchomy X 1 (IG.1140.II.13)
Fig. 8. Free cheek X 1 (IG.1140.II.13)
Fig. 9. Toraks niekompletny X 1 (IG.1140.II.12)
Fig. 9. Incomplete thorax X 1 (IG.1140.II.12)
Fig. 10. Policzek niekompletny X 1 (IG.1140.II.17)
Fig. 10. Incomplete cheek X 1 (IG.1140.II.17)
Fig. 11. Prawie kompletny okaz X 1 (IG.1140.II.10)
Fig. 11. Almost complete specimen X 1 (IG.1140.II.10)
Fig. 12. Szczątek kranidium X 1 (IG.1140.II.11)
Fig. 12. Fragment of cranidium X 1 (IG.1140.II.11)
Wszystkie okazy pokrywane chlorkiem amonu
All the specimens covered with ammonium chloride
Fot. J. Modrzejewska

Tablica — Plate XIV

Eccaparadoxides insularis (Westergård 1936)

Fig. 1. Kranidium X 1 (IG.1140.II.18)
Fig. 1. Cranidium X 1 (IG.1140.II.18)
Fig. 2. Kranidium niekompletne X 1 (IG.1140.II.20)
Fig. 2. Incomplete cranidium X 1 (IG.1140.II.20)
Fig. 3. Kranidium prawie kompletne X 1 (IG.1140.II.21)
Fig. 3. Almost complete cranidium X 1 (IG.1140.II.21)
Fig. 4. Niekompletny toraks X 1 (IG.1140.II.22)
Fig. 4. Incomplete thorax X 1 (IG.1140.II.22)
Fig. 5. Niekompletny toraks X 2 (IG.1140.II.23)
Fig. 5. Incomplete thorax X 2 (IG.1140.II.23)
Fig. 6. Niekompletny toraks X 1 (IG.1140.II.24)
Fig. 6. Incomplete thorax X 1 (IG.1140.II.24)

„*Paradoxides*" sp.

Fig. 7. Policzek ruchomy X 1 (IG.1140.II.25)
Fig. 7. Free cheek X 1 (IG.1140.II.25)
Fig. 8. Policzek ruchomy X 1 (IG.1140.II.26)
Fig. 8. Free cheek X 1 (IG.1140.II.26)
Fig. 9. Policzek ruchomy X 1 (IG.1140.II.27)
Fig. 9. Free cheek X 1 (IG.1140.II.27)
Fig. 10. Szczątek policzka ruchomego X 1 (IG.1140.II.28)
Fig. 10. Fragment of free cheek X 1 (IG.1140.II.28)
Wszystkie okazy pokrywane chlorkiem amonu
All the specimens covered with ammonium chloride
Fot. J. Modrzejewska

Tablica — Plate XV

Eccaparadoxides mongolicus n.sp. Tomczykowa

Fig. 1. Młode kranidium X 1 (IG.1140.II.29)
Fig. 1. Young cranidium X 1 (IG.1140.II.29)

Fig. 2. Kranidium X 1 (IG.1140.II.30)
Fig. 2. Cranidium X 1 (IG.1140.II.30)
Fig. 3. Kranidium — holotyp X 1 (IG.1140.II.31)
Fig. 3. Cranidium — holotype X 1 (IG.1140.II.31)

Eccaparadoxides sp.

Fig. 4. Niekompletne kranidium X 1 (IG.1140.II.32)
Fig. 4. Incomplete cranidium X 1 (IG.1140.II.32)
Fig. 5. Kranidium kompletne X 1 (IG.1140.II.33)
Fig. 5. Complete cranidium X 1 (IG.1140.II.33)
Fig. 6. Pygidium i trzy ostatnie segmenty toraksu X 1,5 (IG.1140.II.34)
Fig. 6. Pygidium and three last segments of thorax X 1,5 (IG.1140.II.34)
Fig. 7. Niekompletny toraks X 1 (IG.1140.II.35)
Fig. 7. Incomplete thorax X 1 (IG.1140.II.35)
Fig. 8. Niekompletny toraks X 1 (IG.1140.II.36)
Fig. 8. Incomplete thorax X 1 (IG.1140.II.36)

Hydrocephalus carens Barrande 1846

Fig. 9. Prawie kompletne kranidium X 1 (IG.1140.II.37)
Fig. 9. Almost complete cranidium X 1 (IG.1140.II.37)
Fig. 10. Policzek ruchomy X 1 (IG.1140.II.38)
Fig. 10. Free cheek X 1 (IG.1140.II.38)
Wszystkie okazy z wyjątkiem fig. 6 pokrywane chlorkiem amonu
All the specimens, except for Fig. 6, covered with ammonium chloride
Fot. J. Modrzejewska

Tablica — Plate XVI

Hydrocephalus carens Barrande 1846

Fig. 1. Kranidium X 3 (IG.1140.II.39)
Fig. 1. Cranidium X 3 (IG.1140.II.39)
Fig. 2. Kranidium X 1 (IG.1140.II.40)
Fig. 2. Cranidium X 1 (IG.1140.II.40)
Fig. 3. Kranidium X 2 (IG.1140.II.41)
Fig. 3. Cranidium X 2 (IG.1140.II.41)
Fig. 4. Kranidium X 1 (IG.1140.II.42)
Fig. 4. Cranidium X 1 (IG.1140.II.42)
Fig. 5. Kranidium X 1 (IG.1140.II.43)
Fig. 5. Cranidium X 1 (IG.1140.II.43)
Fig. 6. Policzek ruchomy X 2 (IG.1140.II.46)
Fig. 6. Free cheek X 2 (IG.1140.II.46)

„*Paradoxides*" sp.

Fig. 7. Masowe występowanie szczątków trylobitów X 1 (IG.1140.II.44)
Fig. 7. Mass accumulation of tribolite fragments X 1 (IG.1140.II.44)

Solenopleura sp.

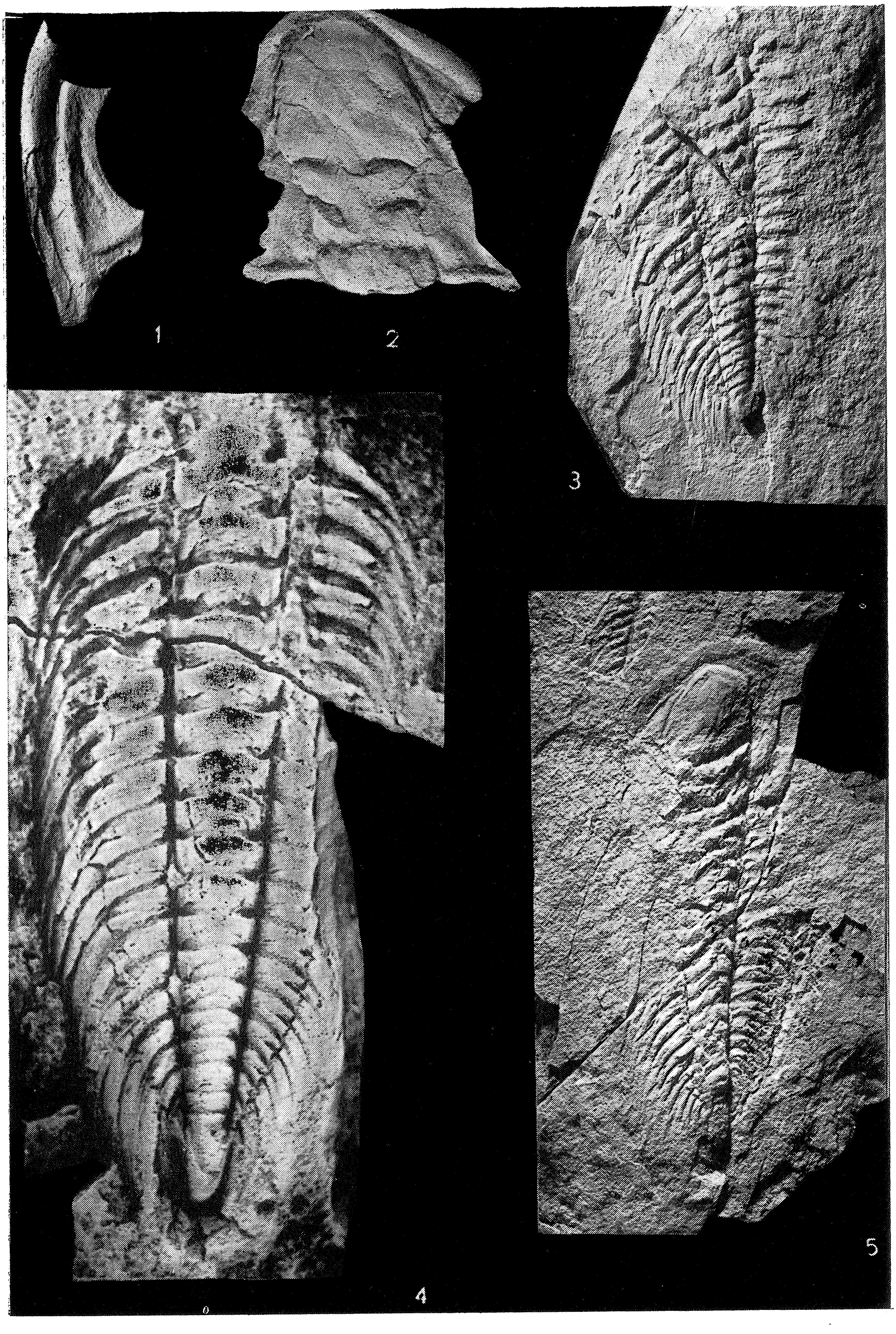
Fig. 8. Negatyw niekompletnego kranidium X 3 (IG.1140.II.45)
Fig. 8. Negative of an incomplete cranidium X 3 (IG.1140.II.45)
Fig. 9. Odlew lateksowy niekompletnego kranidium X 3 (IG.1140.II.45a)
Fig. 9. Latex cast of an incomplete cranidium X 3 (IG.1140.II.45a)
Fig. 10. Inny negatyw kranidium X 3 (IG.1140.II.47)
Fig. 10. Other negative of cranidium X 3 (IG.1140.II.47)

Wszystkie okazy pokrywane chlorkiem amonu
All the specimens covered with ammonium chloride
Fot. J. Modrzejewska

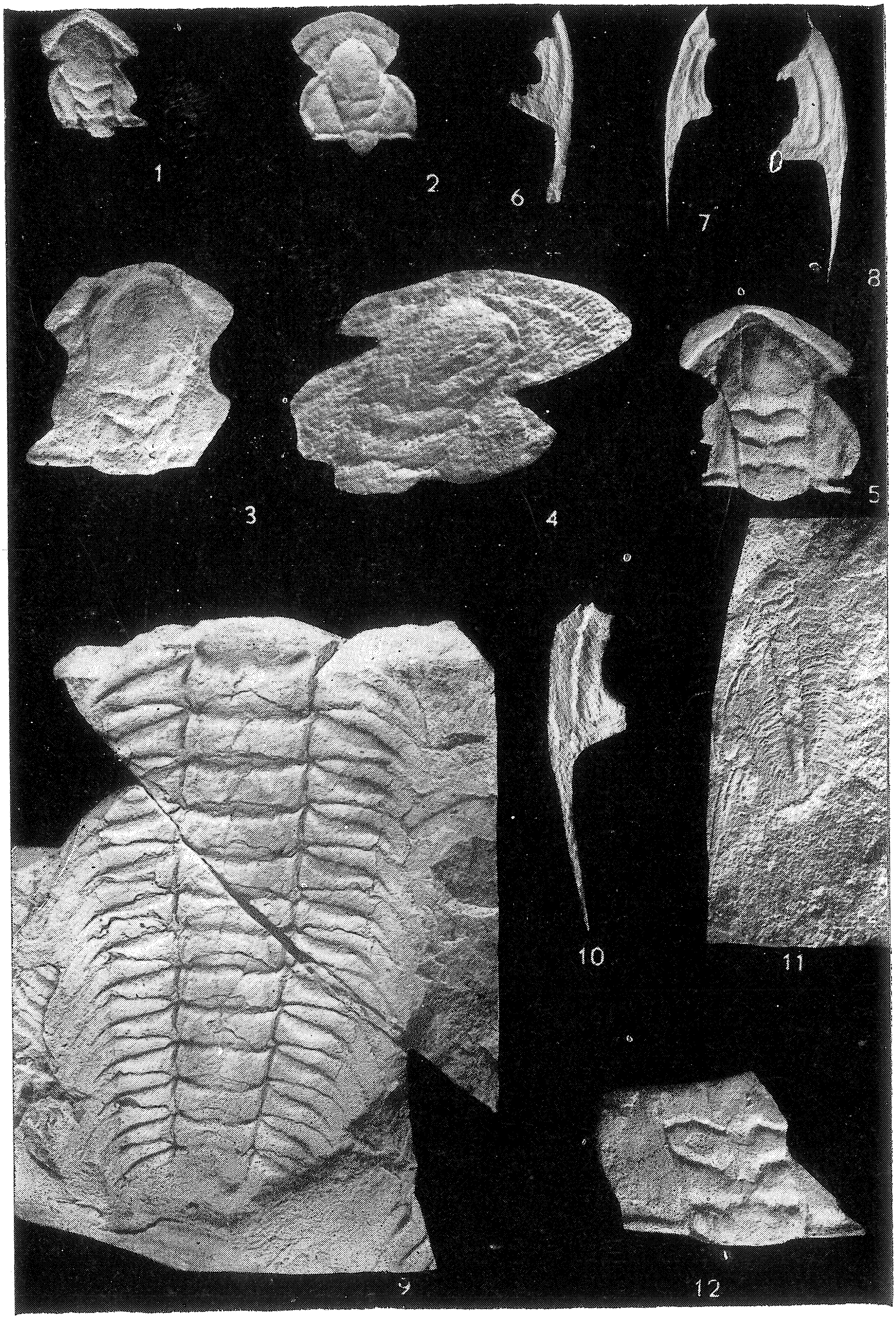
Tablica — Plate XVII

Fig. 1. Osagie 1(M)
Fig. 1. Osaggiae 1(M)
Fig. 2. Osagie 2(M)
Fig. 2. Osaggiae 2(M)

Wielkość naturalna
Natural size
Fot. P. Szczypek



M. Dumicz, E. Tomczykowa, L. Wójcik



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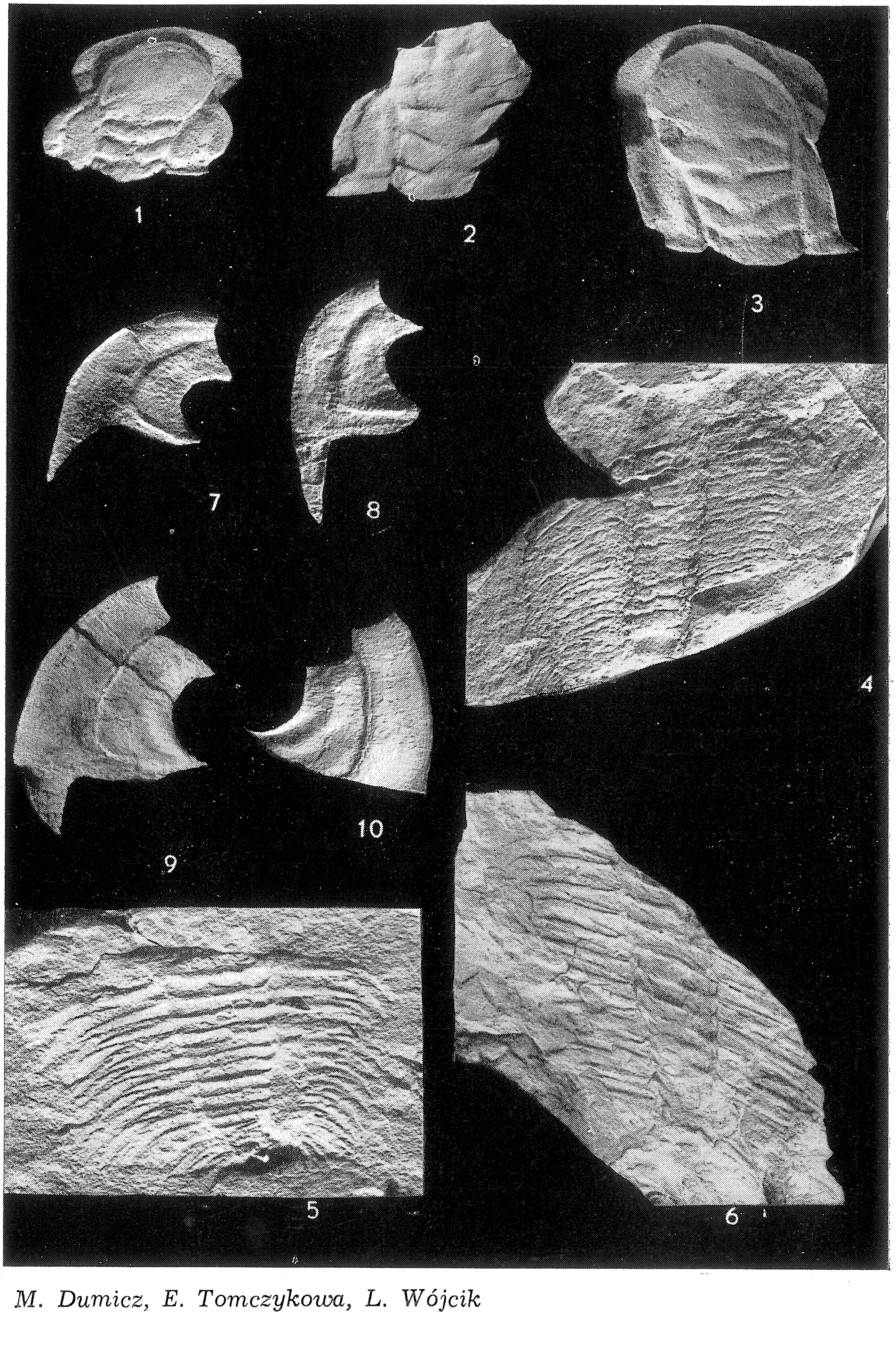

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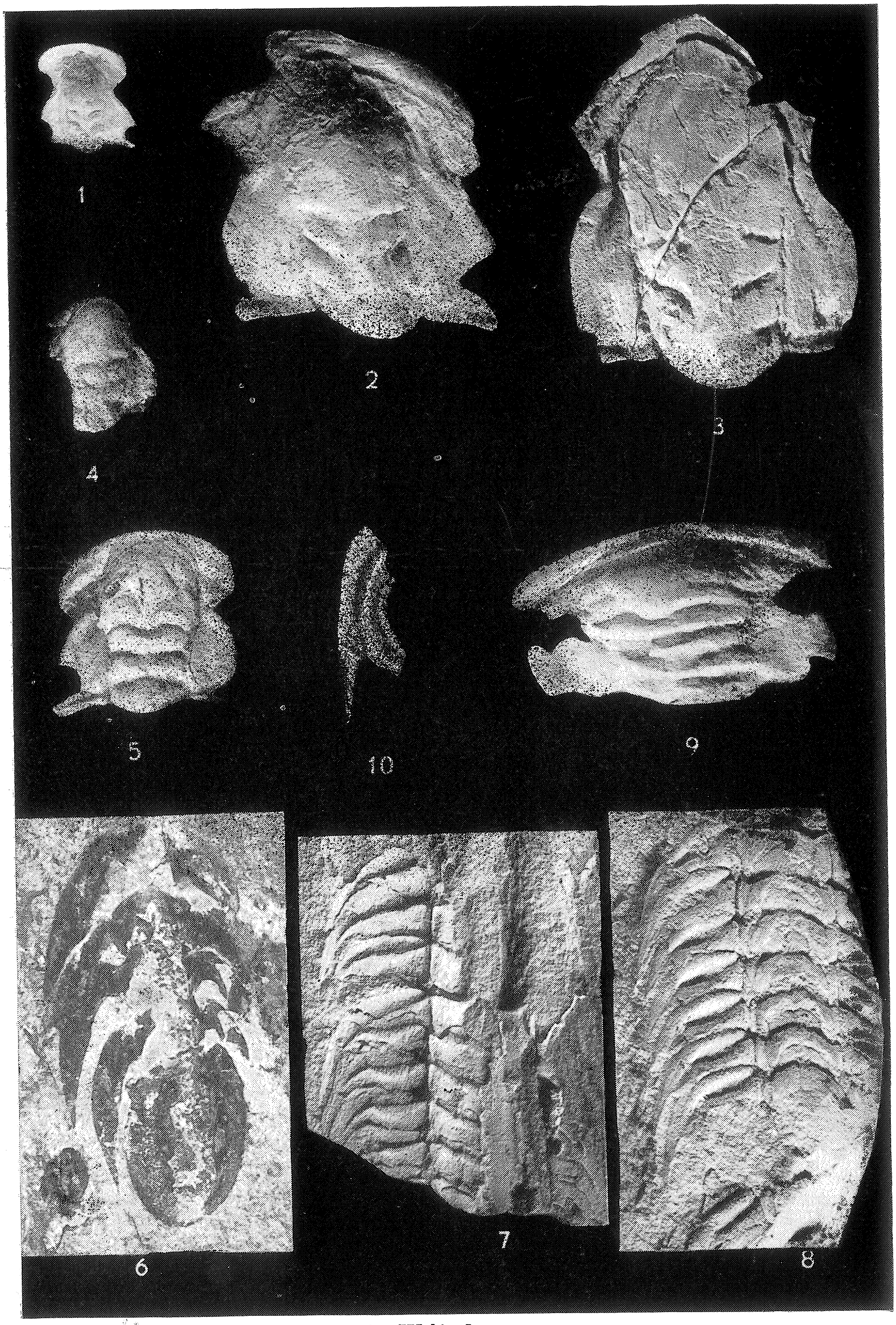

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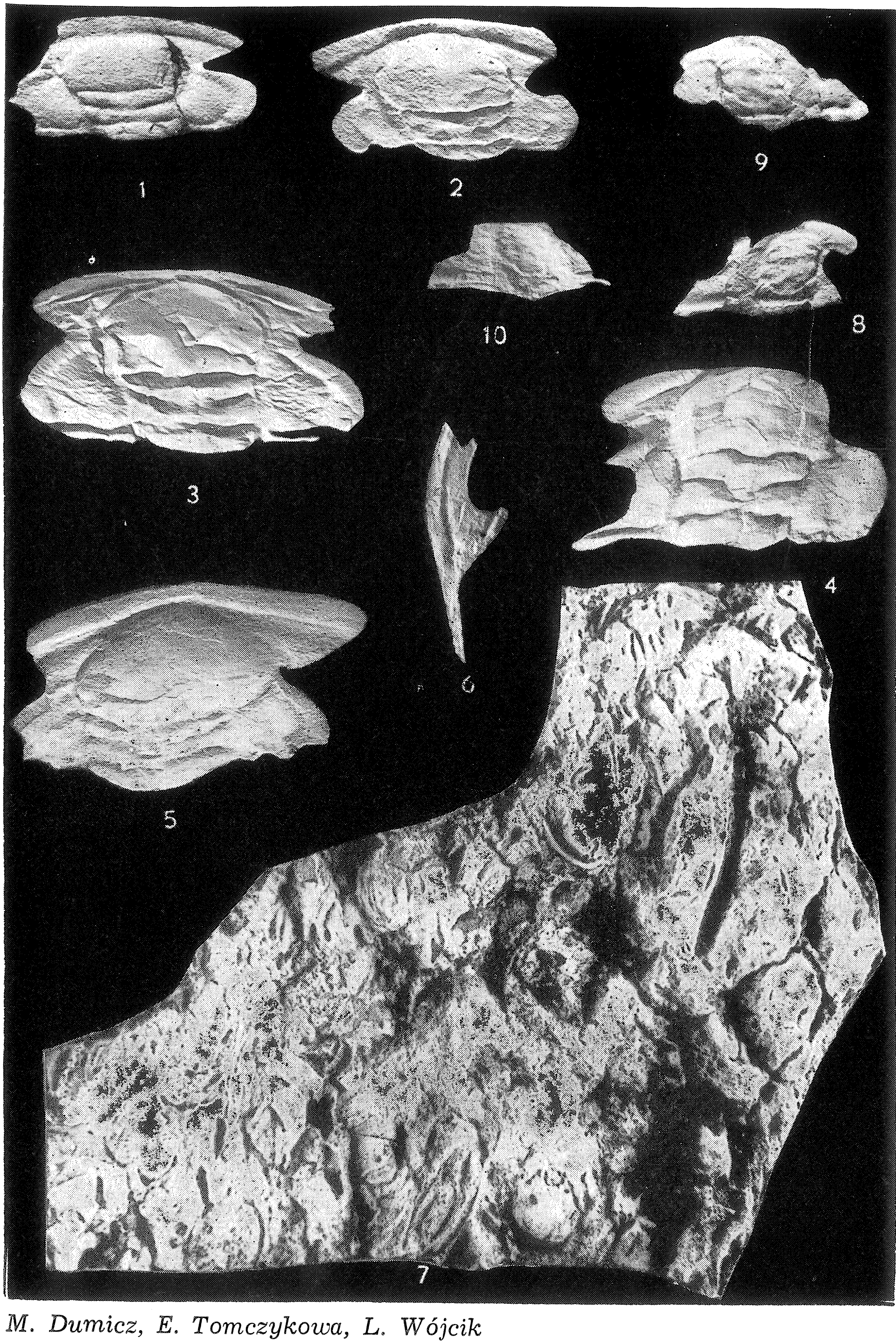

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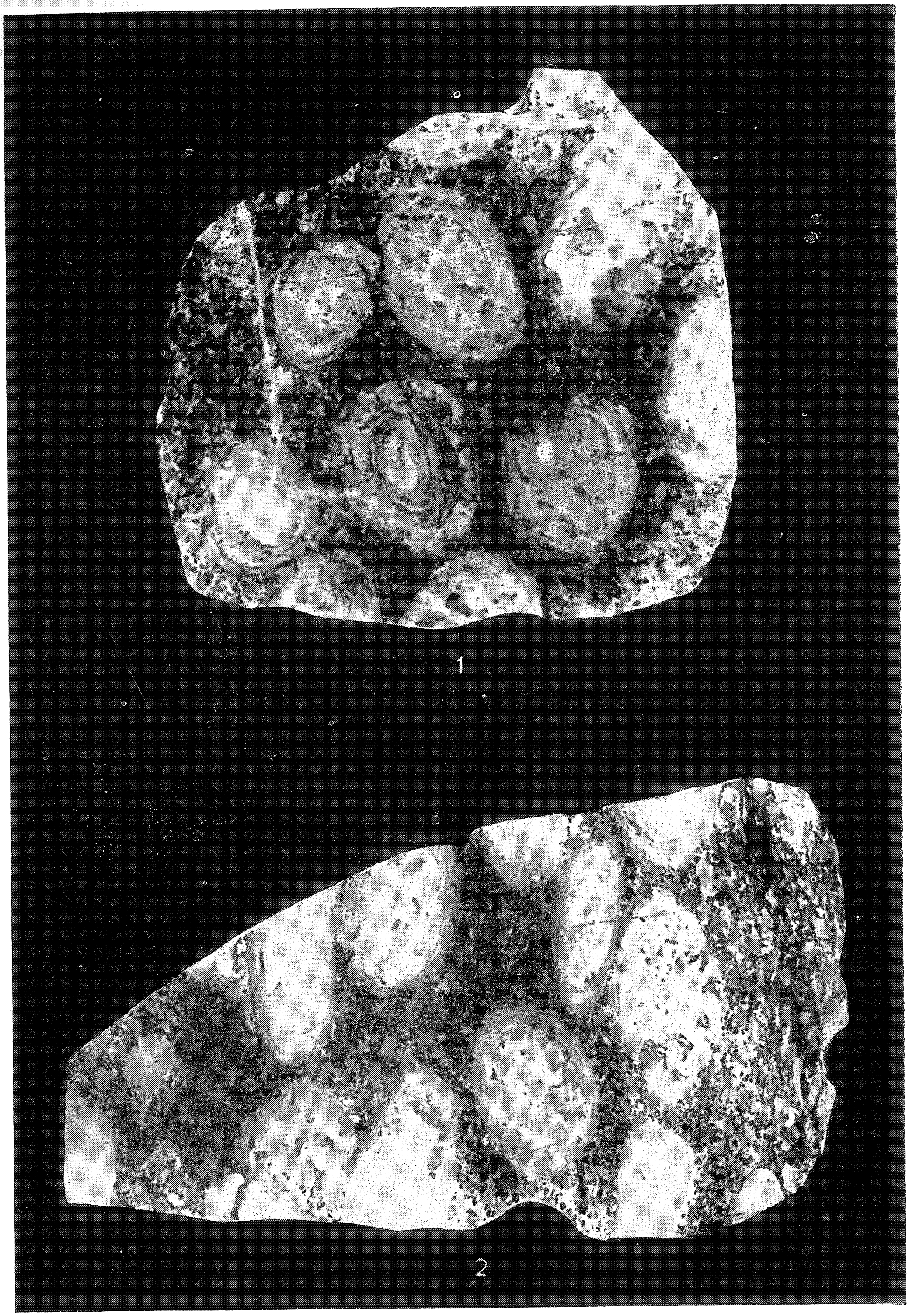

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