A C T A G E O L O G I C A P O L O N I C A

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The author dedicates this paper to the memory of Professor Dr. Jan Samsonowicz, the discoverer of the Bug Carboniferous basin, on the 10th anniversary of his death.

Stratigraphy and paleogeography of the Namurian in the Polish Lowland

ABSTRACT: A description is given of the Carboniferous from the Polish Lowland, with special stress laid on the Namurian whose most complete development occurs in the Lublin Carboniferous basin. The stratigraphy of the Namurian deposits from that area is based on macrofauna — chiefly on goniatites. Most of the goniatite species, particularly the Upper Namurian ones, are here first reported from Poland. This helped to separate the Namurian B from the Namurian C and to distinguish the substages and goniatite zones known from the classical Namurian areas of western Europe. The lithology and the sedimentary processes of the Namurian in the Lublin basin are also reported. A description is, moreover, given of the Carboniferous deposits from north-western Poland, the Sudetes and their forefield, as well as from the Silesia-Cracow basin and the Miechów depression. Some areas outside the Polish territory, i.e. Rügen and Mecklenburg going north-west, and the Lvov--Volhynia basin going south-east are discussed. The Namurian paleogeography in Poland is presented in correlation with the development of the paralic Upper Carboniferous basins in the Subvariscan foredeep of western Europe. The probability of the existence of connections between the Namurian basin of Poland and western and eastern Europe is considered.

INTRODUCTION

Prospecting for mineral resources has been carried out increasingly during the last decade by the Geological Survey of Poland. In addition to supplying clues for the solution of numerous geological and structural problems the prospecting work has also yielded rich material for stratigraphic investigations, i. al. for those of the Carboniferous system.

The material obtained from the Lublin Carboniferous basin has greatly enlarged our knowledge on the deposits of that system. The results have been presented in numerous publications.

The Carboniferous deposits in the Lvov-Volhynia- and the Lublin basins were discovered by Professor Dr. Jan Samsonowicz and it was he who encouraged the present writer to take up the study of this system. Moreover, her elaboration of the earliest post-war borehole material, containing Carboniferous deposits, was likewise carried out under the guidance of Professor Samsonowicz.

All data concerning the Silesian, and still more particularly the Namurian, from the Polish Lowland, accessible by the middle of 1968, have been presented in this work. They are based on the writer's own investigations that had been continued for a full 15 years, as well as on published and archival works of other explorers in this field.

Particular attention has been paid to the Namurian series and its subdivision on the basis of the goniatite fauna most of whose species have never before been identified in Poland.

The preparation and completion of the present paper could be brought to an end thanks to the friendly help of many persons and institutions who kindly provided the writer with borehole material for elaboration.

Special thanks are due to Professor Dr. E. Passendorfer for the gracious assistance offered throughout the preparation of the present paper.

Cordial appreciation also goes to the writer's colleague Dr. L. Teller, for his long co-operation in the elaboration of borehole material and the discussion of pertinent problems.

For the access to borehole material, indispensible for the completion of the present work, sincere thanks must be rendered to the Directors of the Institute of Geology, the Oil Research Survey in Warsaw as well as to the staff of the Oil Research Survey in Piła, Wołomin and Jasło.

The present work has been prepared and completed in the Stratigraphic Laboratory of the Institute of Geological Sciences, Polish Academy of Sciences. Mr. R. Adamik and Mr. S. Tyborowski of the Laboratory's staff must be thanked for the photography and help in illustrations.

During her visits abroad: in Great Britain, France, Belgium, Czechoslovakia and the Soviet Union, the writer was kindly offered the opportunity to discuss a number of stratigraphic problems with various specialists, and to examine Carboniferous profiles and monographic faunal collection. This proved most helpful in the solution of problems on the stratigraphy of the Polish Carboniferous, and the writer desires once more to express her sincere appreciation to all those persons and institutions.

DEFINITION OF THE NAMURIAN AND ITS POSITION IN THE INTERNATIONAL CLASSIFICATION CODE OF CARBONIFEROUS STRATIGRAPHY

The occurrence of the Namurian, as a stratigraphic unit of the Carboniferous system, has been established at successive meetings of the Heerlen Congresses.

The upper boundary of the Namurian was placed during the 1927 meeting of the Heerlen Congress (Jongmans 1928) at the bottom of the marine horizon with *Gastrioceras subcrenatum* (Frech). In the Rhine--Westphalia basin this horizon represents the top of the Sarnsbank layer.

The lower boundary was clearly defined during the 4th Heerlen Congress in 1958 (vide van Leckwijck 1960). It consists of beds characterized by the first appearance of *Cravenoceras leion* Bis.

The mode of determining these two boundaries differs in result of differences in sedimentary conditions during the Lower and the Upper Namurian. In what the upper boundary is concerned, the Carboniferous deposits in this part of the profile are characterized by a predominance of the continental facies. The short lasting episode of marine transgression which very distinctly broke up the monotony of the continental sedimentation, was taken into account while determining the Namurian/Westphalian boundary. The Sarnsbank layer, its bottom included, represents the continental facies of the Namurian, while its top in the marine facies already belongs to the Westphalian (beginning of the Westphalian).

The lower boundary of the Namurian deposits formed during the long-lasting period of marine sedimentation which embraces the entire Lower Carboniferous as well as a part of the Upper Carboniferous. According to the suggestions made at the 4th Heerlen Congress, the Namurian/Visean boundary will probably be more closely determined as new goniatite sites are discovered, containing not only the index species (*Cravenoceras leion* Bis.) but also its subspecies with a more restricted vertical range.

A historical sketch concerning the differentiation of the Namurian, originally in the Belgian province of Namur, is given in the Lexique strat. inter. (1957).

The following subdivisions of the Carboniferous in western Europe were accepted at the 4th Heerlen Congress in 1958:

CARBONIFEROUS

Dinantian (Lower Carboniferous)	Silesian (Upper Carboniferous)
(Strunian) Tournaisian Visean	Namurian Westphalian Stephanian

Chart 1

The stratigraphic subdivisions of the Carboniferous system in USA, NW Europe and USSR

<table>
<tr><th colspan="2">USA</th><th colspan="2">NW EUROPE</th><th colspan="2">USSR</th><th colspan="2">USSR **</th></tr>
<tr><td rowspan="8">PENNSYLVA-NIAN</td><td>Virgilian</td><td rowspan="2">Stephanian</td><td rowspan="10">SILESIAN *</td><td>Orenburgian</td><td rowspan="2">UPPER CARBONIFEROUS</td><td rowspan="2">Gzhelian</td><td rowspan="7">UPPER CARBONIFEROUS</td></tr>
<tr><td>Missourian</td><td>Gzhelian</td></tr>
<tr><td>Desmoinesian</td><td>Westphalian D</td><td rowspan="2">Moscovian</td><td rowspan="5">MIDDLE CARBONIFEROUS</td><td rowspan="2">Moscovian</td></tr>
<tr><td>Atokan</td><td>Westphalian C</td></tr>
<tr><td rowspan="4">Morrowan</td><td>Westphalian B</td><td rowspan="3">Bashkirian</td><td rowspan="3">Bashkirian</td></tr>
<tr><td>Westphalian A</td></tr>
<tr><td>Namurian C</td></tr>
<tr><td rowspan="2">Namurian B</td><td rowspan="3">Namurian (A+B)</td><td rowspan="6">LOWER CARBONIFEROUS</td><td rowspan="3">Namurian (A+B)</td><td rowspan="6">LOWER CARBONIFEROUS</td></tr>
<tr><td colspan="2">lacuna</td></tr>
<tr><td rowspan="4">MISSISSIPPIAN</td><td>Chesterian</td><td>Namurian A</td></tr>
<tr><td>Meramecian</td><td>Visean</td><td rowspan="3">DINANTIAN</td><td>Visean</td><td>Visean</td></tr>
<tr><td>Osagean</td><td>Tournaisian</td><td rowspan="2">Tournaisian</td><td rowspan="2">Tournaisian</td></tr>
<tr><td>Kinderhookian</td><td>Strunian</td></tr>
</table>

* Name for the Upper Carboniferous of Western and Central Europe, suggested by the Polish stratigrapher S. Z. Stopa at the IV Heerlen Congress and accepted by the International Geological Congress at Copenhagen in 1960.

** New proposition of the subdivision of the Carboniferous system in USSR (Stepanov 1968).

In North America the Carboniferous is likewise divided into two parts: the Mississippian and the Pensylvanian, but their boundaries do not coincide with those of the Dinantian and the Silesian in western Europe.

In the USSR the Carboniferous is generally subdivided into three parts: the Lower, Middle and Upper; the Namurian being there included into the Lower Carboniferous. It should be noted that the latest propositions of the Soviet authors suggest the bipartite division of the Carboniferous system (Stepanov 1968).

An attempt to correlate these three modes of classification is presented in chart 1.

The suggestions of American geologists to raise the Mississippian and the Pensylvanian to the rank of systems were not accepted by the Heerlen Congress (Jongmans 1952). Hence, the Carboniferous has retained its rank of a system. According to the resolutions of the 1960 International Congress at Copenhagen, the Dinantian, Silesian, Mississippian, Pensylvanian, the Lower-, Middle- and Upper Carboniferous, are regarded as sub-systems (vide van Leckwijck 1964a), but this term has never as yet been officially accepted.

Units lower in rank, such as the Namurian, are called series in the official nomenclature. Therefore, we should refer to the Namurian series, corresponding to the Namurian period (van Leckwijck 1960, 1964b).

SUBDIVISION OF THE NAMURIAN

At the 2nd Heerlen Congress in 1935, the Namurian was subdivided into 3 units (Jongmans & Gothan 1937): Namurian A, B, C corresponding to stages in chronostratigraphy.

The boundaries of the A, B, C stages had not then been so accurately defined as the lower and upper boundary of the Namurian series.

The Namurian subdvisions were based on goniatites which have been worked out in considerable detail, especially in Great Britain, Belgium and Germany.

The Namurian stages A, B and C are characterized by the following goniatite genera:

Stage	Genus (of goniatites) — index	
Namurian C	*Gastrioceras*	(with symbol G)
Namurian B	*Reticuloceras*	„ „ R)
Namurian A	*Homoceras*	„ „ H)
	Eumorphoceras	„ „ E)

In later works by British geologists the stages were subdivided into goniatite substages, zones and subzones and the boundaries between these stratigraphic members were clearly defined.

The subdivisions for Belgium and Great Britain are shown in chart 2. This chart also specifies the goniatite species that occur in the particular Namurian zones of western Europe.

Chart 3 shows the sequence of the goniatite fauna in the USSR.

As the chairman of the International Carboniferous Stratigraphic Commission, van Leckwijck called upon all the stratigraphers for uniformity in the division of the Carboniferous system into smaller stratigraphic units, at least in what Europe is concerned. With respect to the Namurian of Belgium, he suggested to abandon the subdivision heretofore currently used in Belgian publications: Assise d'Andenne and Assise de Chokier. Van Leckwijck proposes to introduce new subdivisions of the Namurian, such as are now accepted in Great Britain where the name "Millstone Grit" is no longer used as a stratigraphic term for the Namurian.

In the USSR the Namurian is included into the Lower Carboniferous but this is suggested by the general subdivisions of the Carboniferous in that country.

Quite recently some writers in the USSR propose a bipartite division of the Carboniferous. While stressing the great significance of the goniatites in matters of detailed stratigraphy, and discussing their chief evolutionary stages during the Carboniferous, Ruzhencev (1965) arrives at the conclusion that a bipartite division of this system is more correct. A chronological analysis of the evolution of Carboniferous goniatites has led that author to the following conclusions:

1) The lower boundary of the Carboniferous system ought to be placed at the base of the Gattendorfia goniatite stage, the upper one in the top of the Orenburgian stage.

2) Five principal stages are distinguished by the above author in the Lower Carboniferous: Gattendorfia, Tournaisian, Saurian, Viséan and Namurian; four stages in the Upper Carboniferous: Bashkirian, Moscovian, Zhigulevian and Orenburgian.

Quite apart from the views of Soviet authors as regards the lower boundary of the Carboniferous system which is still an open question — as it is in western Europe — they all agree that the boundary between the Lower and the Middle Carboniferous corresponds to that between the Namurian and the Bashkirian.

Besides Ruzhencev (1965) a proposition for the bipartite division of the Carboniferous system is likewise suggested by Stepanov (1968). In his opinion, in the development of foraminifers, corals, goniatites and brachiopods, there are two very distinct evolutionary phases which may be taken as a reliable basis for the differentiation of series. A number of subphases may be observed within these evolutionary phases, reasonably

Chart 2

STRATIGRAPHIC SUBDIVISION AND GONIATITE ZONES OF THE NAMURIAN

Series	Stages Gr. Britain * Belgium **	Zones	Goniatites ***	
Westphalian		G_2 G. subcrenatum	G. subcrenatum /Frech/	
[illegible]	YEADONIAN Lower Gastrioceras Age, G_1	G_1c G. cumbriense	G. cumbriense Bis./B,GB,D,H/, G. crenulatum Bis./B,GB,G,H/ G. ... /B/	A. ... /Hde./ /B/
		G_1b G. cancellatum	G. cancellatum Bis./B,GB,G,H/, G. crenulatum Bis. /B,GB,G/, Ag. carinatum /Frech/ /B,GB,G,H/, G. ... Schmidt /GB,G/	A. ... /Hde./ /B,G,H/
		G_1a R. superbilingue	R. superbilingue Bis./B,GB,G,H/, R. ... /Wright/ /B,GB,G/, ... /Wright/ /GB,G,H/, R. wrighti Hde./B/, G. ... Bis. /GB,G/	Hd. ... /Hind/ /B,GB,G,H/
[illegible]	MARSDENIAN Upper Reticuloceras Age, R_2	R_2b R. bilingue	R. metabilingue Wright /B,GB,G/, R. wrighti Hde./B,GB,G/, R. bilingue /Salt./ /B,GB,G,H/	A. ... /Hde./ /G,H/
		R_2a R. gracile	R. gracile Bis. /B,GB/	Hd. ... /Hind/ /B,GB,G,H/; Hd. ornatum /Foord & Crick/ /B,G/
	KINDERSCOUTIAN Lower Reticuloceras Age, R_1	R_1c R. reticulatum	R. coreticulatum Bis. & Hde./GB,G/, R. reticulatum /Phill./ /B,GB,F,G,H/, R. davisi /Foord & Crick/ /GB,F/, R. striolatum /Phill./ /B,GB,F,G/	Hd. ornatum /Foord & Crick/ /B,GB,G/; Hd. ... /Hind/ /B,GB,G,H/
		R_1b R. eoreticulatum	R. nodosum Bis. & Hde. /B,GB,F,G/, R. regularum Bis. & Hde. /B,GB,F,G/, R. ... Bis. & Hde. /B,GB,F/, R. moorei Bis. & Hde. /GB/, R. ... Bis. & Hde. /GB/, H. moorei Brook. /B,G/, R. eoreticulatum Bis. /GB/, R. dubium Bis. & Hde. /GB/	D. /Paradim./ ... /Phill./ /B,GB/
		R_1a R. circumplicatile /inconstans s.l./	R. subreticulatum /Foord/ /B,GB,G/, R. paucicrenulatum Bis. & Hde. /B,GB/, R. todmordenense Bis. & Hde. /B,GB,G/, R. adpressum Bis. & Hde. /B,GB,F/, R. ... Moore /B,G/, R. ... Bis. & Hde. /GB/, R. circumplicatile /Foord/ /B,GB,F,G/, R. ... Bis. & Hde. /G,B,GB/, R. pulchellum /Foord/ /GB,F,H/, R. ... Bis. & Hde. /GB/, St. ... Hde. /B/, ... Bis. & Hde. /B,GB,F/, R. ... Bis. & Hde. /B,GB/, R. ... Hde. /B,GB,F,G/	Hd. ... /Hind/ /F,H/; R. ... Schmidt /B,GB,F,G/
[illegible]	ALPORTIAN Upper Homoceras Age, H_2	H_2c H. eostriolatum	H. eostriolatum Bis. /GB/, Ht. ... Bis. /B,GB,F,G/	
		H_2b H. undulatum	H. undulatum /Brown/ /GB,G/	
		H_2a H. smithi – Hd. proteum	H. smithi /Brown/ /GB,G/, Hd. proteus /Brown/ /B,GB,F,G/, H. moorei ... /GB/	
	CHOKIERIAN Lower Homoceras Age, H_1	H_1b H. beyrichianum	H. beyrichianum /de Kon./ /B,GB,F,G,H/, H. diadema /Goldf. & Beyr./ /GB,G/, H. ... /Brown/ /B,GB/	
		H_1a H. subglobosum	H. subglobosum /Bis./ /B,GB,F,G,H/	
	ARNSBERGIAN Upper Eumorphoceras Age, E_2	E_2c N. nuculum	N. nuculum Bis. /B,GB,G,H/, ... Dem. /B/, E. bisulcatum ... /GB/	
		E_2b Ct. nitidus	Ct. nititoides /Bis./ /B,GB,G/, Ct. stellarum /Bis./ /B,GB,G/, Ct. fragilis /Bis./ /B,GB/, E. rostratus Yat. /B,GB/, Ct. nitidus /Phill./ /B,GB,G/, Cr. holmesi Bis. /B,GB,G/, E. bisulcatum leitrimense Yat. /B,GB/, E. bisulcatum varicatum Schmidt /B,GB,G/, A. tenuispirale ... /B,GB,G/, A. ... /Phill./ /B,GB,G/, D. /Paradim./ ... /Phill./ /B,GB,G/, Ct. edalensis Bis. /B,GB,F,G/, Ct. ... Hde. /B,GB,G/, Cr. subplicatum Bis. /B,GB/, D. ... Moore /B,GB/	
		E_2a E. bisulcatum s.s.	E. bisulcatum Girty /B,GB,F,G,H/, Cr. gairense Currie /GB/, E. bisulcatum erinense Yat. /B,GB/, E. bisulcatum ferrimontanum Yat. /B,GB/, A. glabrum Bis. /B,GB,G/, Cr. cowlingense Bis. /B,GB,G/, E. bisulcatum grassingtonense Dunh. & Stubbl. /B,GB/, E. ... /Schmidt/ /B,GB,G/	
	PENDLEIAN Lower Eumorphoceras Age, E	E_1c Cr. malhamense	Cr. malhamense /Bis./ /GB,G/, E. ... /Schmidt/ /GB,G/	
		E_1b E. pseudobilingue s.s.	E. pseudobilingue Bis. /GB,G/, E. ... Moore /GB/	
		E_1a Cr. leion	E. ... /GB/, E. ... Yat. /GB/, E. ... Moore /GB/, E. ... Yat. /GB/, E. pseudobilingue ... /early form/ /GB,G/, Cr. leion Bis. /GB,G/, E. /Edm./ pseudocoronula Bis. /GB,G/, E. /Edm./ ... Yates /B/	

Abbreviations: /B/ = Belgium, /GB/ = Great Britain, /F/ = France, /G/ = Germany, /H/ = Holland, A. = Anthracoceras, Ag. = Agastrioceras, Cr. = Cravenoceras, Ct. = Cravenoceratoides, D. = Dimorphoceras, D. /Paradim./ = D. /Paradimorphoceras/, E. = Eumorphoceras, E. /Edm./ = E. /Edmooroceras/, G. = Gastrioceras, H. = Homoceras, Ht. = Homoceratoides, Hd. = Hudsonoceras, N. = Nuculoceras, R. = Reticuloceras.

* Lexique stratigr. intern. 1960; Hudson 1957.

** Lexique stratigr. intern. 1957; Van Leckwijck 1964b.

*** Based on: Bisat 1923, 1924, 1928, 1930, 1932, 1934, 1940, 1950; Bisat & Hudson 1943; Bouckaert 1959, 1960a,b, 1961, 1962, 1963; Bouckaert & Harbot 1960; Bouckaert & Higgins 1963; Bouckaert & Lambrecht 1967; Butcher & Hodson 1960; Currie 1954; Chaland 1960a,b; Demanet 1938, 1941, 1943; Demanet & Van Leckwijck 1960; Dolmer & Grewlich 1959; Doyledot & Delépine 1930; Doremus 1945; Figge 1960; Hodson 1954, 1957, 1959; Hodson & Lavarne 1961; Hodson & Van Leckwijck 1958; Horn 1960; Hudson 1945; Lambrecht 1966; Lambrecht & Van Leckwijck 1959, 1960; Van Leckwijck 1964b, Van Leckwijck & Stockmans 1954; Lexique stratigr. intern. 1963;

suggesting their subdivision into smaller stratigraphic units, i.e. stages. Simultaneously, however, Stepanov stresses the difficulties hampering the separation of the Carboniferous on the basis of the fauna, both in the Donetz basin and Siberia or Kazakhstan. The above author thinks that the bipartite division of the Carboniferous is reliably justified by the general geological development of the Globe at that time. The lower part of that system which precedes the events of the Hercynian orogenv. represented the thalassocratic period. This is characterized by widespread marine transgression whose maximum development occurred during the Viséan. The upper part of that system, connected with the Hercynian orogeny, is characterized by strong differentiation of the paleogeographic conditions and it represents the geocratic period. So distinct a change in conditions, reflected in the paleogeography and sedimentation of the Upper Carboniferous, marks, so to say, a natural boundary not only between the Middle and the Upper Paleozoic but likewise between the individual divisions of the Carboniferous system. Together with other explorers of the USSR, Stepanov includes the Namurian (sensu Namurian A and B) into the Lower Carboniferous, similarly as it is accepted by the American geologists, while the boundary between the Lower and Middle Carboniferous is placed by him at the base of the Bashkirian stage (i.e. at the base of Namurian C of the west-European division). According to Stepanow, the Upper Carboniferous would be represented by the Bashkirian, Moscovian and Zhigulevian stages. He does not think the separation of the Orenburgian stage as fully justifiable. Stepanov's new subdivision of the Carboniferous system is shown in chart 1.

The Namurian in the USSR corresponds to the Namurian A and B, while the Bashkirian is an equivalent of Namurian C and Westphalian A and B of the west European subdivision.

During the last score or so of years the Namurian problem has been greatly stressed by the geologists of the USSR, and its separation has been largely debated.

In 1954 a conference was held in Kiev to discuss the position of the Namurian and its stratigraphic scope in the Carboniferous system with respect to the problem of the boundary between the Lower and the Middle Carboniferous within the European part of the Soviet territory. Numerous papers presented at this conference contained the results obtained from the investigations of various faunal groups (foraminifers, corals, brachiopods, pelecypods, goniatites) and of the flora from profiles bordering on the Lower and Middle Carboniferous in the Donetz basin, the Russian platform, the Lvov-Volhynia basin, the Urals, etc.

Two distinct points of view were comprehensively discussed (vide Trudy soveščanija 1957) concerning the boundary between the Lower and the Middle Carboniferous, and the alternative of retaining or cancelling the Namurian stage in the stratigraphic code of the USSR:

1) One view postulated to retain the Namurian stage (Namurian A and B) and assign it to the Lower Carboniferous (Librovitch, Rotay, Teodorovitch, Semichatova, Pogodina et al.).

2) The other view postulated to cancel the Namurian stage and to include its lower part into the Viséan as a separate stratigraphic unit, while the upper part (Namurian B and C) should be included into the Bashkirian stage of the Middle Carboniferous (Aizenverg, Shulga, Ejnor, Jarceva, Biłyk et al.).

At the 4th (1958) Heerlen Congress, also subsequently at the International (1960) Geological Congress at Copenhagen, the Soviet geologists

Chart 3

NAMURIAN GONIATITES OF THE USSR *

LOWER BASHKIRIAN	G.subcrenatum/Frech/ .... G.cf.marianum/Vern.//DB,U,CA/,G.karpinskii Yan./DB,U/,Schartymites barbotanus Vern./DB,U/ Verneuilites verneuili Yan./DB,U/,Verneuilites murchisoni Libr./U/ Branneroceras branneri /Smith//DB/,Stenopronorites uralensis/Karp.//DB,U/ R./Bilinguites/superbilingue Bis./DB,U/,A.aff.vanderbeckei Ludw./DB,CA/ G.cancellatum Bis./DB,U,CA/,G.martini Schmidt/DB,U,CA/,G.cumbriense Bis./DB,CA/
NAMURIAN B	R./Bilinguites/bilingue/Salt.//U/,Ht.divaricatus/Hind//DB,U/,Ht.inostranzewi Karp./DB,U/ Proshumardites karpinskii Raus./U,CA/,Ht.schartymense Libr./U/,Ht.suranense Libr./U/ Proshumardites uralicus Libr./U/,Stenopronorites ferganensis Raus./DB,CA/ R.reticulatum/Phill.//DB,U,CA/,R.murchisoni Libr./U/,Bashkirites discoidalis Libr./DB/ R.eoreticulatum Bis./U/ R.cf.inconstans/Phill.//DB/,H.aff.striolatum/Phill.//DB,CA/
NAMURIAN A	Pseudohomoceras cf.smithi/Brown//U,CA/,Pseudohomoceras latissimum Libr./U/ Pseudohomoceras ugamense Libr./CA/ H.aff.beyrichianum Kon./U/,H.beyrichianum Kon.var.biplex Haug /CA/ H.beyrichianum Kon.var.aff.coronata Haug/CA/ Uralopronorites mirus Libr./U/,A.glabrum/Bis.//CA/ cf.Nuculoceras nuculum Bis./DB/ Ct.nititoides Bis./CA/ Eumorphoceras cf.bisulcatum Girty/CA/ Cr.cowlingense Bis./U,NZ,CA/,Cr.aff.richardsonianum Girty/U,CA/,Cr.inconstans Libr./NZ/ Cr.beschevense Libr./DB/,Proshumardites arcticus Libr./NZ/ Cr.petrencoi Libr./NZ/,Cr.petrencoi var.gorbovensis Libr./NZ/,Cr.septentrionale Libr./NZ/ Cr.arcticum Libr./NZ,U/,Cr.arcticum var.berkhi Libr./U,NZ/,Cr.arcticum var.multistriata Libr./U,NZ/ Cr.arcticum var.aperta Libr./NZ/,Cr.arcticum var.subinvoluta Libr./NZ/ Berkhoceras boreale Libr./NZ/,Irinoceras arcuatum Ruzh./U/,Dombarocanites chancharensis Ruzh./U/ Rhipaeocanites librovitchi Ruzh./U/,Megapronorites sakmarensis Ruzh./U/ Dombarites tectus Libr./U/,Pronorites ex gr.cyclolobus Phill./U/,Ferganoceras dombarense Libr./U/ Metacanites quinquelobus /Kittl//U/,Platygoniatites molaris Ruzh./U/,Praedarelites aktubensis Ruzh./U/

* Based on: Librovitch 1946, 1947, 1957, 1961; Ruzhencev 1958, 1965

Abbreviations:

/DB/ - Donetz Basin, /U/ - The Urals, /NZ/ - Novaya Zemlya, /CA/ - Central Asia

A.-Anthracoceras, Cr.-Cravenoceras, Ct.-Cravenoceratoides, G.-Gastrioceras, H.-Homoceras

Ht.-Homoceratoides, R.-Reticuloceras

agreed not to use the term Namurian in a sense different from that of the 2nd Heerlen Carboniferous Congress (1935) and to give a new name to the division now known in the USSR under the name Namurian.

Experts in the goniatite fauna of the USSR believe it is far more natural to place the upper boundary of the Namurian at the base of substage G_1, than in its top as is currently accepted in western Europe. Both Librovitch (1946, 1947, 1957, 1961) and Ruzhencev (1958, 1965) justify this by the absence of any substantial evolutionary changes in the goniatites between zone G_1 and G_2 (in western Europe now raised to the rank of substages), i.e. at the base of the Gastrioceras subcrenatum zone. Both these authors strongly stress that the most important changes in the evolution of the Carboniferous goniatite fauna are observable at the Viséan/Namurian and Namurian/Bashkirian boundaries. It is hardly possible to quote here all the conclusive arguments brought forward by Librovitch and Ruzhencev in favour of their points of view as regards both the lower boundary of the Carboniferous system and the boundaries of the particular Carboniferous stages. These are based on goniatites which have, indeed, been recognized by authors both from eastern and western Europe as one of the faunal groups most important for the stratigraphy of the Carboniferous.

Several interesting papers by Semichatova (1962, 1964, 1965, 1966) also deal with problems concerning the age and the boundaries of the Namurian and Bashkirian series. On the basis of brachiopods and of the evolution of other faunal groups the above author likewise believes that the boundary between the Lower and the Middle Carboniferous should be placed at the bottom of the Bashkirian stage.

There is much reliable evidence to justify the fact that most authors recognize the great significance of goniatites for Carboniferous biostratigraphy, particularly so of the Upper Carboniferous. Indeed, this fossil group, in spite of its diversity, is characterized by very distinct morphological features, such as outward appearance, ornamentation, shape of aperture, lobe line etc., also by strong vertical variability and wide geographical distribution. Particularly the last character is closely connected with the nature of their individual development. Namely, the young ammonites (Ammonoidea) while hatching were of microscopic dimensions and, in the form of plankton, they could easily be transported over a considerable distance. Though the Ammonoidea require very special facial conditions yet this applies first and foremost to young individuals which, according to Ruzhencev, need calm and shallow waters, such as bays and haffens. Under normal salinity, the mature individuals could exist in diverse facial conditions. To illustrate this Ruzhencev mentions that goniatites are rather rare on the Russian platform, but those encountered there do not in any respect differ from forms in the geosynclinal areas.

Thus, the presence of goniatites in Carboniferous deposits is very helpful in their age determination and correlation with other profiles adequately known. Unfortunately, they do not occur throughout the Carboniferous system, at least — as in Poland — not throughout the profile. Other faunal groups in the Carboniferous either occur seldom or are of small significance. For example, the increasingly clastic character of the deposits in the Upper Carboniferous did not favour the development of corals, so that this group is of little value as an age index. Within the group of marine pelecypods, as a rule most abundantly represented in the deposits, the evolutionary changes take place very slowly. Moreover, with the exception of a few species, they have a great vertical scope so that they are of no value in the differentiation of zones. Freshwater pelecypods are more significant in this respect, if the particular species can be traced over a greater part of the profile.

HISTORY OF INVESTIGATIONS OF THE SILESIAN FROM THE POLISH LOWLAND

The Upper Carboniferous (Silesian) deposits of Poland were first investigated in the Sudetes (Lower Silesia basin) and in the Upper Silesia basin. Because of the presence there of coal seams these areas are of great economic importance and this leads to continuously increasing geological research work.

The large area occupied by the Polish Lowland is relatively the least known. The Paleozoic deposits which occur here at great depths are covered by Mesozoic and Cenozoic rocks of considerable thickness and this hampers their adequate knowledge. Systematic research work in this area was started a few years before the Second World War. It consisted mainly in gravimetric photographs and a preliminary survey of the anomalies in a few boreholes, to a depth of 1,000 m only. Larger-scale investigations of this area were commenced after 1945 in connection with prospecting work for such mineral resources as coal, petroleum and gas.

The investigations of the Carboniferous in the Lowlands date back to the discovery by Samsonowicz of sediments of that system in the Lvov-Volhynia basin, hence they are here discussed more at large (the Lower and Upper Carboniferous jointly).

Certain suggestions, regarding the occurrence of Carboniferous deposits, west of the Ukrainian crystalline massif, have been made by Tetyaev (1912). He based them on the general geological pattern of the European part of the USSR, also on that of central and western Europe. The above author supposes that the area encompassed by the northern margin of the Ukrainian massif and the elevation of Kielce and Sandomierz forms a depression in the substratum of the Mesozoic rocks where

Paleozoic deposits, i.al. those of the Carboniferous, may be present. In Tetyaev's opinion, the Carboniferous sediments here probably resemble those occurring in the Upper Silesia and Donetz basins.

It may be interesting to note here a remark by Choroszewski in the Physiographic Memoirs (Pamiętnik Fizjograficzny) of 1881 (vide Porzycki 1967). Choroszewski namely writes that in a borehole near the village of Pieczenki, between Kowel and Kiwerce, a. 100 km E of the river Bug, large amounts of good quality brown coal were found at a depth of 15 m below Cretaceous deposits and below conglomerates with basalt pebbles, coal which burned like anthracite. It may be presumed that this coal was Carboniferous in age.

The investigations of Samsonowicz, begun in Volhynia, led to the reliably documented discovery there not only of the Carboniferous but, moreover, to that of the Lvov-Volhynia basin and the Lublin basin, these two being really one entity.

Beginning with 1922, Samsonowicz used to find among the basal Cenomanian conglomerates, in the drainage area of the Horyń in Volhynia, black chert pebbles with a Carboniferous fauna. In the vicinity of Ostróg e.g. these pebbles were up to 10 cm in diameter. Such cherts were also known to Samsonowicz from several boreholes in the Horyń basin, as well as from an area lying farther west around Nieświcz. In May, 1931, analogous pebbles were found by him but with diameter twice that mentioned above. The westward increase in dimensions of pebbles occurring on a secondary bed confirmed the suppositions of Samsonowicz that their parent rocks were somewhere in western Volhynia (vide Makowski 1962), in the drainage area of the upper Bug. These opinions were presented at a meeting of Section III of the Polish Academy of Sciences in November, 1931, and published the following year (Samsonowicz 1932). This report contains the first list of Carboniferous fauna obtained from the pebbles, as well as a sketch map where Samsonowicz outlined the occurrence zone of the Carboniferous deposits in a Mesozoic substratum in the western forefield of the Ukrainian massif. The theoretical as well as practical significance of the presence of the Carboniferous within this area was well stressed by Samsonowicz.

Though the presence of the Carboniferous in this area was by then quite doubtless, its exploration did not begin until 1937. The first three boreholes, situated at a distance of 20—27 km SW of Pełcza, reached the Devonian below the Cretaceous. In February 1938, the next borehole, drilled at Haliczany 30 km NW of Pełcza, was the first to reach fossiliferous Carboniferous deposits, without coal, underlying the Cretaceous at a depth of 119 m. This was actually the first perfectly certain confirmation of the presence of the Carboniferous in the Lvov-Volhynia basin postulated by Samsonowicz. Moreover, it proved an important discovery with a bearing on all the subsequent geological investigations carried out on either side of the Bug.

A detailed history of the Carboniferous investigations in this area, carried out up to 1939, has been presented by Makowski (1962) who was at that time working in close cooperation with Samsonowicz.

Boreholes were successively drilled W of a line from Nieświcz to Brody, at Tartaków, Busk, Stojanów, Chołojów, Kozłów and Zawisznia near Sokal. In 1939 also at Lackie, in the south-eastern margin of the Carboniferous range, and at Jaktorów and Zadwórze, east of Lvov. All these boreholes confirmed the presence of the Carboniferous, showing, moreover, that the lower part of that system is represented by a 100 m thick series of limestones with cherts. This was obviously the alimentary area of the chert pebbles which had been transported by running water in pre-Cretaceous time, not only to Volhynia but to Podolia, too. Later on, during the Cretaceous transgression, they were introduced into the basal conglomerates of the Cenomanian.

Additional data obout the Carboniferous from the above boreholes are given by Samsonowicz (1939, 1946), while the results of these investigations are also published in papers by Matveyev (1939—40, 1941).

Farther information concerning the Carboniferous of Volhynia are contained in another paper by Samsonowicz (1951).

The discovery of the Carboniferous in the Bug area aroused considerable interest in Europe (vide Schwarzbach 1949, Bederke 1942).

On the ground of results obtained by Samsonowicz, further investigations were carried out by Soviet geologists in 1940 and 1941. Several boreholes were drilled more closely to determine the thickness of the coal seams. Detailed lithological and paleontological analyses were also made of all the core material from earlier boreholes. The first results of these investigations were published by Aizenverg et al. in 1946.

Research work in the western Ukraine was increasingly extended beginning with 1945, and the area covered by the investigations was considerably enlarged, to include Brześć and Kobryń (White Russia) in the north, Torczyn-Olesko in the east, Zadwórze (Lvov region) in the south, and the river Bug in the west.

In consequence of the data thus obtained the area to be covered by prospecting was subsequently reduced. It had, namely, been established during 1948/49 that the productive Carboniferous coal measures occur in a narrow belt along the Bug, from Ustiług in the north to Mieżreczije in the south. The districts rich in coal then differentiated are those of Volhynia, Sokal, Mieżreczije or Wielkomosty, later on Zabuże (vide Bobrovnik et al. 1962, Zastavnyj 1956).

In view of the fact that Carboniferous deposits had been reached in Poland in borehole Chełm IG-1, it was deemed necessary by the geologists of the USSR to drill additional boreholes along the right bank of the Bug, starting north of Ustiług to the south-western part of the Brześć region in White Russia. The object of these boreholes was to determine the northern range of the Carboniferous deposits in the above area. Two boreholes were drilled in 1957: that of Biereżcy (approximately east of Chełm Lubelski) and that of Huszcza, a little to the north west. Lower Carboniferous sediments were reached in both these boreholes (Pomyanovskaya & Zavyalova 1957). Several other boreholes were later on drilled farther north along the river Bug, at Czerniawka, Iszew, Zabużje, also Tomaszówka and Domaczewo in the Brest region. The Carboniferous was reached in all of them except the last one. In all the other boreholes the Carboniferous deposits rest on members older than the Devonian. The Lower and Upper Carboniferous deposits have, moreover, been reached in borehole Wydranka south of Ustiług.

Thirty years have passed since the discovery of the Carboniferous in the Lvov-Volhynia basin, and since the investigations of that system were begun. During that time the range of the Carboniferous in the western part of the Soviet Ukraine has been determined and several coal mines have been built in the productive measures. The Carboniferous stratigraphy has not, however, been unquestionably elaborated. There are many controversial problems such as the Devonian/Carboniferous boundary, the differentiation and subdivision of the Namurian, its boundaries, etc.

The paleontological data (mostly concerning the pelecypods, foraminifers, also the macro- and micro-flora) are given in papers by Brazhnikova et al. (1956), Bobrovnik et al. (1962), Gurevich et al. (1963), Shulga (1953, 1954, 1962), Shulga & Kozhich-Zelenko (1965). The geology of the Lvov-Volhynia basin was discussed by Khizhniakov (1963, 1964), and others.

The Carboniferous Lvov-Volhynia basin passes west of the river Bug into the Polish territory.

The outbreak of the Second World War put a stop to the detailed studies of the pre-war borehole material initiated by Samsonowicz. During the German occupation, only one borehole was drilled in 1941/42 within the area here considered, namely that at Strzyżów on the Bug, to a depth of 830 m, where Viséan and Namurian deposits were reached. Data from this borehole were published by Schwarzbach (1944, 1949), but they only covered sediments down to a depth of 752,4 m. In the above writer's opinion, sediments below that depth represent the older Paleozoic and it was Samsonowicz who worked them out (1953). The results of his work were published together with those obtained by Korejwo (1958a) in her second elaboration of the Viséan and the Namurian. The oölitic rocks of the Bug Carboniferous were discussed by Bocheński, Bolewski & Michałek (1955).

Borehole Chełm IG-1, (situated 50 km NW of Strzyżów), scheduled by Samsonowicz, was drilled in 1954/55 by the Geological Institute during the preliminary stage of research work on the deep substratum of south-eastern Poland. Its object was to ascertain the possibilities of a westward extension of the coal basin in the upper course of the river Bug. Lower Westphalian deposits — down to the Viséan — were pierced below the Jurassic and above the Lower Devonian at a depth between 580.2 and 1,207.7 m. Its stratigraphy was worked out by Korejwo in 1958 on the basis of macrofauna and the resulting data were published jointly with the report on microfauna, microflora and petrography (Budkiewicz et al. 1960). The Carboniferous spores from borehole Chełm IG-1 have been elaborated by Karczewska (1967).

By 1962 a number of additional boreholes had been drilled in the Lublin region by the Geological Institute: Tyszowce IG-1, Kosmów IG-1, Teptiuków IG-1, Husynne IG-1, Kaplonosy IG-1, Radzyń IG-1, Łuków IG-1, Bystrzyca IG-1, Dorohucza IG-1, Żyrzyn IG-1, Magnuszew IG-1 and Żebrak IG-1 (fig. 1).

The stratigraphy of the Carboniferous deposits from some of the boreholes has been worked out; that from Żebrak by Bojkowski & Müller (1960), from Tyszowce by Żelichowski (1961), from Bystrzyca by Korejwo (1962 [1]).

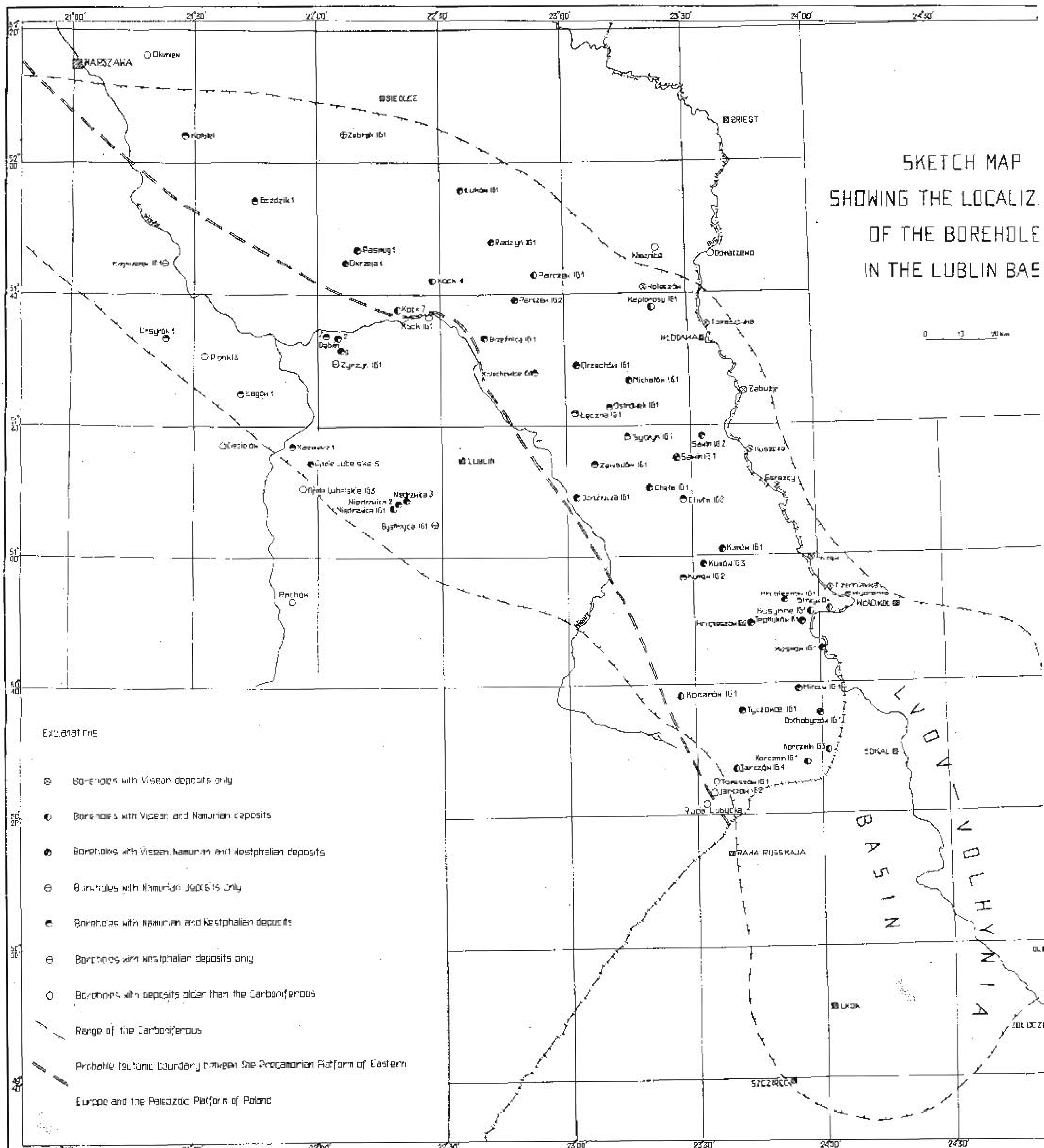
Since 1960 the elaboration of Carboniferous deposits from the Lublin basin has been taken over by the Upper Silesia Field Station of the Geological Institute at Sosnowiec. Descriptions of the lithology, petrography, stratigraphy and coal measures from the above named boreholes have been published in a team work by Bojkowski, Cebulak, Jachowicz, Migier & Porzycki (1966a).

On the basis of these data the presence has been observed within the Lublin basin not only of series analogous with those discovered in the Lvov-Volhynia basin (from the Dinantian to the Lower Westphalian) but also of younger series, including Westphalian C and D. The Carboniferous deposits, from the Upper Viséan to the uppermost Westphalian, also contain coal intercalations varying in thickness.

Since 1962, the drillings undertaken in the Polish Lowlands by the Geological Institute and the Oil Research Survey have been extended increasingly in connection with petroleum and gas prospecting. Carboniferous sediments have so far been found in some scores of boreholes and new drillings are under way.

The most recent data on the Carboniferous from the Lublin basin are contained either in published or archival papers. Those concerning the Carboniferous from borehole Niedrzwica IG-1 are discussed in articles by Miłaczewski (1966, 1968), also by Miłaczewski & Niemczycka (1967). The stratigraphy of the Paleozoic deposits from borehole Rachów on the

[1] To be published in 1969.


SKETCH MAP
SHOWING THE LOCALIZ
OF THE BOREHOLE
IN THE LUBLIN BAS
WARSZAWA
SIEDLCE
BRIEST
LUBLIN
WŁODAWA
RAWA RUSSKAJA
LVOV — VOLHYNIA
BASIN
Explanations
Boreholes with Visean deposits only
Boreholes with Visean and Namurian deposits
Boreholes with Visean, Namurian and Westphalian deposits
Boreholes with Namurian deposits only
Boreholes with Namurian and Westphalian deposits
Boreholes with Westphalian deposits only
Boreholes with deposits older than the Carboniferous
Range of the Carboniferous
Probable tectonic boundary between the Precambrian Platform of Eastern
Europe and the Paleozoic Platform of Poland
21°00'
21°30'
22°00'
22°30'
23°00'
23°30'
24°00'
24°30'

Vistula has been revised by Pajchlowa and Żelichowski (1966), deposits there previously assigned to the Carboniferous are referred to the Devonian. Data on the Carboniferous from boreholes Komarów IG-1, Jarczów IG-4, Korczmin IG-1, also the stratigraphy of the Carboniferous, i.al from boreholes Tomaszów Lub. IG-2, Kaplonosy IG-1 and Holeszów IG-1 have been described by Żelichowski (1966, 1967, 1968a) (fig. 1).

The stratigraphy of the Carboniferous deposits from borehole Kołbiel 1 has been worked out by Korejwo & Teller (1965); it is also given by Karnkowski (1965). The stratigraphy of the Carboniferous from boreholes Niedrzwica IG-2 and 3, Opole Lub. 5, Dęblin 7, Kazimierz 1, Pasmug 1 and Okrzeja 1 has also been described by Korejwo & Teller (1967b, c, d, e; 1968a, f, h, i, j). The Carboniferous materials obtained from boreholes Niedrzwica 4, Dęblin 2 and 9, Kock 4 and 7, Ursynów 1 and Goździk 1 are now being elaborated by the same authors (fig. 1).

Data respecting the thickness and lithology of the particular Carboniferous series from the other boreholes in the Lublin basin have been published in papers by Porzycki (1966, 1967), Dembowski & Porzycki (1967), and Dembowski (1968).

The Carboniferous deposits in the Chojnice-Koszalin zone and the region of Kołobrzeg in north-western Poland (Western Pomerania) were not known until about 1960. The Dinantian was first reached in borehole Bobolice 1 (Poborski & Cimaszewski 1961, Żelichowski 1962) and borehole Biały Bór 1 (vide Żelichowski 1968b). In an earlier borehole, Chojnice 2, calcareous sediments bearing a fauna of corals and brachiopods were reached under Zechstein conglomerate, between 3,047.55 and 3,197.3 m. By Samsonowicz (vide Tokarski 1959b) these had been assigned to the Strunian, while Pajchlowa (1964) thinks they are Famennian in age.

Some interesting data with regard to the occurrence of the Carboniferous within the area here considered were obtained from boreholes drilled in 1966—1968.

The Lower Carboniferous has been found in borehole Babilon 1, Brda 1, Wierzchowo 3 and 4 (Korejwo & Teller 1968c, d, e), also in Gozd 1 (vide Łobanowski 1968) (fig. 2).

The higher members of the Carboniferous have been encountered in boreholes Wierzchowo 1 (Żelichowski 1968b), Koszalin IG-1 (vide Dadlez 1965b, Bojkowski et al. 1966b, Żelichowski 1968b), also further west in the region of Kołobrzeg in borehole Ustronie IG-1 (vide Dadlez 1967a, Żelichowski 1968b), also in Karcino and, possibly, in the just completed borehole Grzybowo 1, now under elaboration.

The results of boreholes in the Polish Lowland have given rise to more general speculations concerning sedimentation, tectonics and the possibilities there may be of the occurrence also in the Carboniferous strata, of such mineral resources as coal, gas and petroleum. This is dealt

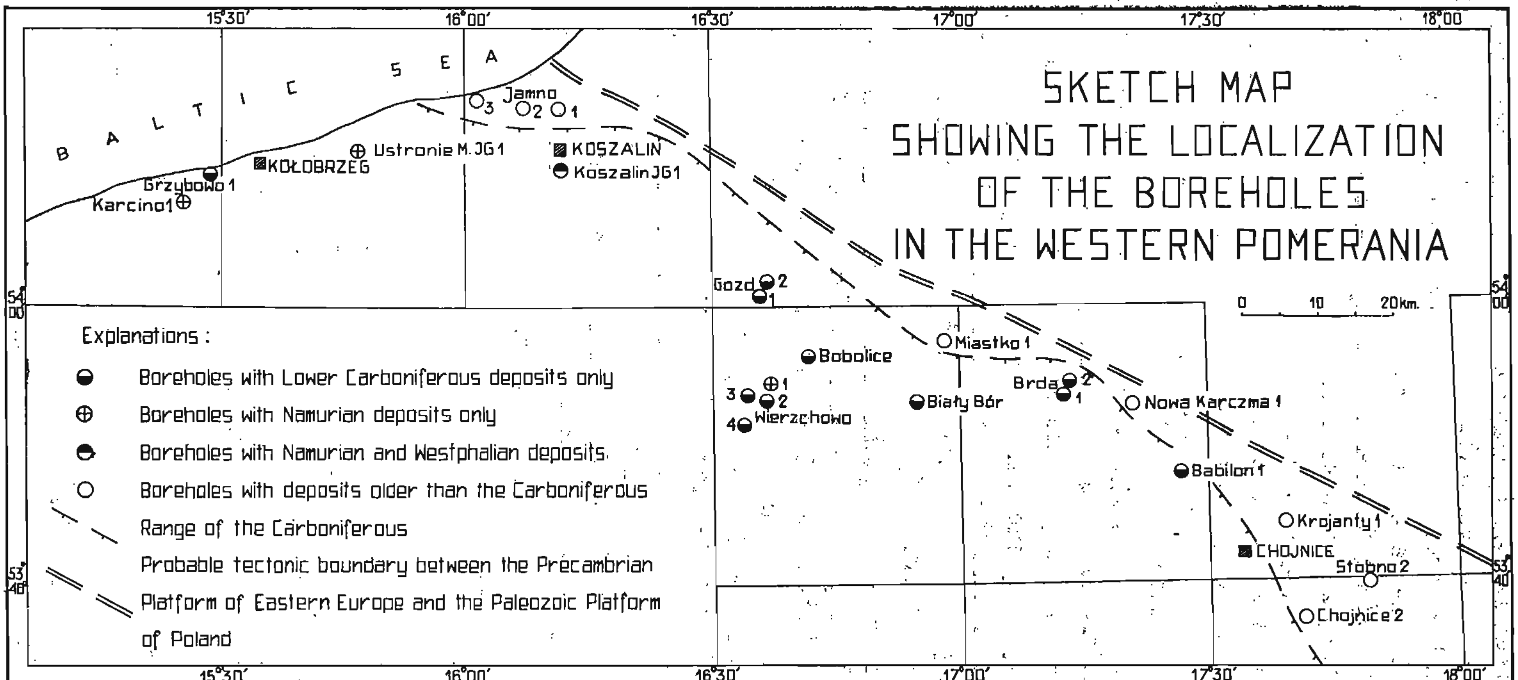

SKETCH MAP
SHOWING THE LOCALIZATION
OF THE BOREHOLES
IN THE WESTERN POMERANIA
BALTIC SEA
15°30′
16°00′
16°30′
17°00′
17°30′
18°00′
54°00′
53°40′
0 10 20km.
Jamno
Ustronie M. JG 1
KOŁOBRZEG
KOSZALIN
Koszalin JG 1
Grzybowo 1
Karcino 1
Gozd
Miastko 1
Bobolice
Brda
Biały Bór
Wierzchowo
Nowa Karczma 1
Babilon 1
Krojanty 1
CHOJNICE
Słobno 2
Chojnice 2
Explanations :
Boreholes with Lower Carboniferous deposits only
Boreholes with Namurian deposits only
Boreholes with Namurian and Westphalian deposits
Boreholes with deposits older than the Carboniferous
Range of the Carboniferous
Probable tectonic boundary between the Precambrian Platform of Eastern Europe and the Paleozoic Platform of Poland

Fig. 2

with in papers by: Areń (1964, 1967), Bojkowski (1960a, 1966b), Bojkowski & Jachowicz (1963), Czermiński & Znosko (1967), Dadlez (1965b, 1967a, b), Dadlez et al. (1968), Dembowski (1968), Dembowski & Porzycki (1967), Depowski & Pożaryski (1967), Jachowicz (1968), Korejwo (1958b), Krassowska (1966), Miłaczewski & Niemczycka (1967), Miłaczewski & Żelichowski (1968), Müller (1961), Niemczycka & Żelichowski (1961), Porzycki (1967), Pożaryski (1964), Znosko (1965a, 1966), Znosko & Pajchlowa (1968), Żakowa (1964, 1968).

THE CARBONIFEROUS IN THE LUBLIN BASIN

General information

The Lublin area or the so called Carboniferous basin of Lublin, covering the south-eastern margin of Mazowsze, the southern margin of Podlasie and the Lublin basin, occupies that part of the Polish Lowland in SE Poland where the Carboniferous deposits have been relatively best studied.

The Carboniferous sediments here have been encountered in numerous boreholes (fig. 1).

Data on the Carboniferous from the Lublin basin have been taken from papers elaborated by authors mentioned on p. 621—623 or they are based on the investigations of the present writer carried out either independently or in cooperation with Dr. L. Teller.

According to the information now available, the following is a general outline of the occurrence range of the Carboniferous. In the NE it has been found in borehole Holeszów IG-1 (north-west of Włodawa); in the N in borehole Żebrak IG-1 (south-east of Siedlce) and in borehole Kołbiel 1 (near Otwock); in the NW on the left bank of the Vistula in borehole Magnuszew IG-1 (east of Warka) and in borehole Ursynów 1 (near Kozienice). Farther SE (on the right bank of the Vistula) sub-Mesozoic outcrops of the Carboniferous have been encountered in borehole Kazimierz 1, Opole Lub. 5, Niedrzwica IG-1, Bystrzyca IG-1 and Komarów IG-1. SE the marginal outcrops of the Carboniferous have been found in boreholes Jarczów IG-4 and Korczmin IG-1. Eastwards the Carboniferous sediments pass into the Lvov-Volhynia basin (fig. 1), while in the Polish territory the left bank of the Bug forms an artificial boundary of their range.

It is thus seen that this region of Poland embraces one of the largest Carboniferous basins. Though the western boundary of its occurrence range is not yet known, the Carboniferous deposits do undoubtedly stretch farther to the north-west, plunging below increasingly thicker series of younger deposits (e.g. in borehole Magnuszew, the top of the Carboniferous occurs at a depth of 2,102.0 m).

The Carboniferous sediments, encountered within boundaries outlined as above, are represented both by the Dinantian (Middle and Upper Viséan) and the Silesian (Namurian and Westphalian). So far, no uppermost Carboniferous (Stephanian) sediments have been observed.

The Carboniferous deposits (reliably established Upper Viséan, possibly also the Middle Viséan) transgressively overlie sediments varying in age. In the N they occur on the Silurian (boreholes Kołbiel 1, Żebrak IG-1, Kaplonosy IG-1, Goździk 1, on the Cambrian (borehole Radzyń IG-1) or the Precambrian (boreholes Łuków IG-1, Holeszów IG-1); in the E they rest on the Lower Devonian (boreholes Sawin IG-1, Chełm IG-1, Dorohucza IG-1); in the SE and the W on the Upper Devonian (vide chart 5).

In the top of the Famennian fossiliferous limestones in a number of profiles there occurs a complex of sediments whose age is controversial. It has been referred to the Devonian, the Tournaisian, more recently to the Strunian (Miłaczewski & Żelichowski 1968, Miłaczewski 1968). This complex is developed in two facies. It consists either of dolomitic deposits (dolomite series) or of clastic deposits variegated in colour (variegated series) represented chiefly by siltstones, mudstones intercalated by sandstones or conglomerates with pebbles of sedimentary rocks. The thickness of the deposits here considered ranges from a few metres to over three hundred metres.

It is noteworthy that tuffite-volcanite covers, indicating pre--Carboniferous volcanic activities, occur in the base of the Carboniferous deposits. As a rule they rest on various Paleozoic members, even on the Precambrian and are represented either by diabases or by volcanic tuffs or sandy sediments mixed with a tuffite substance (Porzycki 1967). The tuffoidal deposits, when encountered in boreholes, occur invariably in the base of the Upper or the Middle Viséan, independently of the age of the underlying rocks. In borehole Radzyń IG-1, in the base of this type of sediments, there occur deposits of the Cambrian; in borehole Kaplonosy IG-1 those of the Silurian (Żelichowski 1968a); in borehole Dorohucza IG-1 those of the Lower Devonian; in borehole Niedrzwica IG-1 the uppermost Devonian (Miłaczewski 1966, Miłaczewski & Niemczycka 1967, Miłaczewski & Żelichowski 1968); analogously in boreholes Niedrzwica 2 and 3 (Korejwo & Teller 1967b, c; 1968a) and in borehole Kock 7. Moreover, tuffoidal sediments have been encountered in boreholes Parczew IG-1, Brzeźnica IG-1 (Dembowski & Porzycki 1967, Porzycki 1967) and borehole Korczmin IG-3.

Two zones, one folded, the other platform-like, are readily distinguished within the old Paleozoic deposits in the substratum of the Lublin Carboniferous basin (vide figs. 1 and 2). The line dividing these two zones (comp. Znosko 1965a) is connected with the existence of a deep tectonic fracture forming the tectonic boundary between two major structural units: the Precambrian platform of eastern Europe and the Paleozoic platform of central and western Europe (strictly speaking its substratum folded during the Caledonian orogeny). After analysing a large amount of geophysical material and investigating the development of Paleozoic deposits and borehole data, it has been accepted (Znosko 1965a, 1966; Czermiński & Znosko 1967) that, in the Polish territory, the Precambrian platform embraces the eastern part of the Lublin basin, Podlasie, Mazury, also the eastern and the north-western Pomerania. The boundary of the platform runs SE-NW, approximately along the line from Ruda Lubycka — Tomaszów Lubelski — Dorohucza, south of Warsaw and farther to the NW in the direction of Włocławek, Toruń and Koszalin (Znosko & Pajchlowa 1968, Teller & Korejwo 1968, Teller 1969).

The zone of deep tectonic fractures extending along the line traced above divides Poland into two areas whose paleogeographic and tectonic developments differ distinctly.

East of the above mentioned zone the crystalline substratum is mantled by undisturbed, mostly horizontally lying deposits (independent of the stratigraphic gaps) of the younger Precambrian, Paleozoic (and Meso-Cenozoic) characterized by epicontinental development.

West of the zone of tectonic fractures, the crystalline substratum occurs at much greater depths of the order of several thousand metres. The development of old-Paleozoic deposits in this area is geosynclinal in character, hence they are considerably thicker and tectonically strongly disturbed, forming a zone of Caledonian foldings. In the zone here considered which also embraces the western part of the Carboniferous Lublin basin, younger Paleozoic deposits with a stratigraphic gap and angular unconformity rest on an old-Paleozoic substratum which shows a Caledonian consolidation.

This specific position of the Carboniferous Lublin basin within two structurally different units had a certain effect on the development of the Carboniferous sedimentation. It is reflected in the much greater thicknesses of the Carboniferous series lying in the zone outside the Precambrian platform and in its tectonic disturbance (continuous deformations and faults).

Within the Lublin basin the Lower Carboniferous is represented by faunally established Upper or even, here and there, Middle Viséan. The lower members of that stage are missing. The Viséan deposits are developed as limestones, often organogenic, bearing a rich fauna of brachiopods, pelecypods, or as mudstones and siltstones with subordinate sandstone intercalations and thin coal seams (in the eastern part). In the north-eastern margin of the basin (Radzyń, Parczew, Holeszów, Kaplonosy) the thickness of the Viséan is hardly a few up to a score or so metres, while to the south and the west it increases gradually reaching its maximum of a. 400 m in the western part of the basin in the vicinity of Niedrzwica.

The Namurian deposits which are a continuation of the Upper Viséan sedimentation dominate in thickness and occurrence range over the other Carboniferous members. They will be discussed in greater detail in a separate chapter.

The Namurian sediments gradually pass into younger deposits of Westphalian age which have been encountered in most of the Carboniferous profiles in the Lublin basin. They are absent only from the northernmost (borehole Żebrak IG-1), the north-eastern (boreholes Holeszów IG-1, Kaplonosy IG-1), the eastern and south-eastern (boreholes Strzyżów, Husynne IG-1, Korczmin IG-1, Korczmin IG-3 and Jarczów IG-4) parts of the area here considered.

In what concerns the Westphalian deposits, its lower members have been encountered in all boreholes, while the upper ones occur in boreholes Magnuszew IG-1 and Żyrzyn IG-1 only. The total thickness of the Westphalian is not known because its upper parts were eroded during a major sedimentary break, resulting from a post-Upper Carboniferous but pre-Jurassic (locally only pre-Permian) uplifting of the area here under consideration. This had been caused by vertical synorogenic movements, probably associated with the Asturian phase of the Variscan orogeny.

The Westphalian deposits which had escaped erosion, range in thickness from a score to some hundreds metres in the east. Towards the west and the north-west their thickness increases to over 700 m in the region of Dęblin, more than 900 m at Magnuszew and about 1,380 m at Żyrzyn. The Westphalian sediments display a rather monotonous siltstone--mudstone development with sandstone intercalations and numerous coal seams (particularly so in the eastern part of the basin). In the lower parts thin carbonate intercalations and zones bearing a marine fauna are still encountered, while in the upper part they represent a typically limnic series.

The total thickness of the Carboniferous deposits observed in the Lublin basin ranges from over 1,760 m in the west (region of Dęblin) to a few hundred metres in the east and some tens or even only a score of metres in the marginal parts of the basin. Taking into account, however, that not all the Carboniferous members have so far been reached within the Lublin basin, and that those that have been reached, for example the Westphalian in borehole Żyrzyn IG-1, are about 1,380 m thick, it may reasonably be supposed that the total thickness of the Lower and Upper Carboniferous in the area under consideration, particularly so in its NW part, may be up to or even more than 2,500 metres.

Besides some rather thin Quaternary and Tertiary series, the deposits which makê up the Carboniferous cover, are Permian to Cretaceous in age. In the N and NW parts (boreholes Łuków IG-1, Żebrak IG-1, Kołbiel 1, Magnuszew IG-1, Ursynów 1) the various stratigraphic members of the Carboniferous are overlaid by sediments of the Permian, in the remaining area by the Jurassic deposits, while Cretaceous rocks occur only towards the east in the vicinity of Hrubieszów.

The Lvov-Volhynia basin of the USSR, an eastern extension of the Lublin basin (fig. 1) is characterized by a similar development of the Carboniferous system. Deposits of this age have been encountered there in numerous boreholes. From the north this basin is confined by a fault running slightly north of the town of Wladimir Wol. North of this fault the presence of the Lower Carboniferous has been observed only in a few boreholes within a narrow belt along the right bank of the river Bug. The eastern boundary of the occurrence range of the Carboniferous system is now placed along a line running from Torczyn (slightly W of this village) to Olesko — Zołoczew — Gorodok. The southern occurrence range of the Carboniferous is not known because S of Lvov it plunges to great depths. The SW boundary is a tectonic one and stretches along the line from Szczyrec — Rawa Ruska (Bobrovnik et al. 1962, Shulga & Kozhich--Zelenko 1965). Towards the west the Carboniferous deposits gradually plunge deeper and deeper and pass into Polish territory. The Carboniferous deposits of the Lvov-Volhynia basin, together with the underlying Paleozoic series, have a general WSW trend and their sub-Mesozoic outcrops form submeridionally directed zones, from the oldest in the east to the youngest in the west. The Carboniferous deposits lie unconformably on various Devonian members and only in the northern part of the Lvov--Vylhynia basin do they transgressively occur on older rocks: the Silurian in borehole Huszcza, the Ordovician in borehole Zabuż'je, the Cambrian in borehole Bereżcy. In addition to Quaternary and Tertiary rocks, the deposits covering the Carboniferous are also of Cretaceous and Jurassic age.

The Lower Carboniferous is represented by Upper Tournaisian sediments which are unconformably overlaid by deposits of the Middle and Upper Viséan, the Namurian and the Bashkirian with coal-bearing strata from the Upper Viséan. The total thickness of the Carboniferous deposits in the Lvov-Volhynia basin ranges from 800 to 1,100 metres. Similarly as the eastern part of the Lublin basin, the Lvov-Volhynia basin lies within the Precambrian platform, and the Carboniferous deposits, particularly beginning with the Namurian, display strong resemblance as regards their lithology, thickness and the presence of coal as intercalations or seams.

Characteristics of the Namurian

Namurian and Westphalian series have been differentiated in the Silesian sediments of the Lublin basin. In what the occurrence range, the thickness and the richness of fauna are concerned, the Namurian dominates over the other Carboniferous members and it is relatively better known. It seems noteworthy that, in several profiles, the Namurian deposits conformably resting on the Upper Viséan, grade into the Lower Westphalian. This has made it possible to trace the total thickness and to determine the boundaries between the faunally established deposits, overlying or underlying the Namurian series.

The stratigraphy of the Namurian series in the Carboniferous Lublin basin, studied on the fauna and flora there, permitted the distinction of the Lower (A) and Upper (B + C) Namurian. The macrofaunal habitus of the series here considered and the occurrence range of the individual species is given after Bojkowski, Korejwo, Korejwo & Teller (comp. p. 621—623).

No faunal descriptions are given because of the fact that these are forms known and described by a number of authors from the various Namurian areas of Europe.

The more important Namurian fossils identified by the present writer (with the exception of trilobites identified by dr. H. Osmólska from the Institute of Paleontology of the Polish Academy of Sciences), are specified in chart 4 and figured in plates I—XLVI.

The Namurian fauna identified by Bojkowski, Musiał and Tabor from boreholes Kosmów 1, Teptiuków IG-1, Husynne IG-1, Dorohucza IG-1 (Krasnystaw), Żebrak IG-1 and Radzyń IG-1, is specified in a paper by Bojkowski (1966a).

The Namurian macrofauna from the Lvov-Volhynia basin is presented in papers by Shulga (1953, 1962), Brazhnikova et al. (1956).

On the basis of paleontological data the Namurian in the paralic facies of Poland has so far been divided into the Lower Namurian (A) and the Upper Namurian (B + C). In spite of the presence of an abundant and fairly diversified fauna, the separation of the Upper Namurian into stages B and C, as well as their subdivision into smaller units such as substages or zones, was hardly possible before the goniatites had been found in the Upper Carboniferous profiles of the Lublin basin. Several species, heretofore not recorded in Poland, have been found over the

Chart 4

NAMURIAN FAUNA OF THE LUBLIN BASIN	Namurian A	Namurian B	Namurian C
ANNELIDA			
Beloraphe kochi (Ludwig)		+	+
Campylites carbonarius (Mc Coy)		+	+
BRACHIOPODA			
Orbiculoidea ingens Demanet	+		
Orbiculoidea missouriensis (Shumard)		+	
Orbiculoidea cf. *missouriensis* (Shumard)		+	+
Lingula mytilloides Sowerby		+	+
Lingula squamiformis Phillips	+	+	
Lingula cf. *parallela* Phillips	+		
Chonetes (Rugosochonetes) aureolus Schwarzbach	+		
Chonetes (Rugosochonetes) brinkmanni Schwarzbach	+		
Plicochonetes waldschmidti Paeckelmann	+		
Tornquistia polita (Mc Coy)	+		
Linoproductus sp.		+	+
Productus concinnus Sowerby		+	
Camarotoechia pleurodon raricosta (Phillips)	+		
Pugnax sp.	+		
Spirifer bisulcatus oystermouthensis Vaughan	+		
LAMELLIBRANCHIATA			
Anthraconeilo oblonga (Mc Coy)	+		
Anthraconeilo laevirostrum (Portlock)	+	+	
Anthraconeilo undulata (Phillips)		+	
Anthraconeilo transversalis (Klebelsberg)	+		
Nuculopsis gibbosa (Fleming)	+		
Nuculavus luciniformis (Phillips)	+		
Nuculavus ostraviensis (Klebelsberg)	+		
Polidevcia attenuata (Fleming)	+		
Polidevcia vasiceki Kumpera, Prantl & Ružička	+		
Polidevcia sharmani (Etheridge)	+		
Phestia bellicostata (Schwarzbach)	+	+	
Parallelodon tenuistriatus (Meek & Worthen)	+		
Leiopteria thomsoni Portlock		+	
Myalina sublamellosa Etheridge	+	+	
Myalina cf. *dorlodoti* Demanet		+	
Myalina cf. *pernoides* (Portlock)		+	
Posidoniella cf. *minor* (Brown)	+		
Posidoniella elongata Hind	+	+	
Aviculopinna carbonaria Demanet	+		
Posidonia corrugata (Etheridge)	+	+	
Posidonia cf. *radiata* Hind	+		
Aviculopecten cf. *gentilis* Sowerby	+		
Streplopteria ornata (Etheridge)	+		
Streblochondria condrustinse (Demanet)	+		

(*Chart 4 — continued*)

NAMURIAN FAUNA OF THE LUBLIN BASIN	Namurian		
	A	B	C
Obliquipecten costatus Yates	+		
Pernopecten cf. *carboniferous* (Hind)	+		
Curvirimula belgica (Hind)	+	+	
Curvirimula cf. *truemani* (Korejwo)	+	+	
Curvirimula samsonowiczi (Korejwo)	+	+	
Anthracomya lenisulcata Trueman	+	+	+
Anthracomya cf. *lenisulcata* Trueman	+	+	+
Anthraconaia perlongata Pastiels		+	
Anthraconaia williamsoni (Brown)	+	+	
Anthraconaia tchernyshevi Korejwo	+	+	
Carbonicola lenicurvata Trueman		+	+
Carbonicola pseudacuta Trueman		+	+
Janeia primaeva (Phillips)	+	+	
Janeia cf. *primaeva* (Phillips)	+		
Grammysiopsis variabilis (Mc Coy)	+		
Edmondia josepha de Koninck		+	
Edmondia cf. *jacksoni* Demanet	+		
Solenomorpha minor rotundata Schwarzbach	+		
Solenomorpha parallela (Hind)	+		
Solenomorpha lanceolata Shulga	+		
Sanguinolites cf. *tricostatus* Portlcck		+	
Sanguinolites interruptus Hind	+		
Sanguinolites clavatus (Etheridge)	+	+	
Sanguinolites cf. *angustatus* (Phillips)	+		
Prothyris scotica Wilson	+		
GASTROPODA			
Euphemites urii (Fleming)	+	+	
Euphemites spiralis (Phillips)	+		
Knightites (Retispira) hibernicus (Weir)	+		
Knightites (Retispira) silesiacus (Schwarzbach)	+		
Knightites (Retispira) decussatus (Fleming)	+		
Knightites (Cymatospira) moravicus (Klebelsberg)	+	+	
Straparollus (Euomphalus) straparolliformis (Kleb.)	+	+	+
Agnesia sp.		+	
Soleniscus (Macrochilina) primogenius (Conrad)	+		
Soleniscus sp.	+		
Naticopsis sp.	+		
Donaldina sp.	+		
SCAPHOPODA			
Plagioglypta sp.	+	+	
CEPHALOPODA			
"*Orthoceras*" *calamus* de Koninck	+		
"*Orthoceras*" *martinianum* de Koninck	+	+	
"*Orthoceras*" *steinhaueri* Sowerby		+	

(*Chart 4 — continued*)

NAMURIAN FAUNA OF THE LUBLIN BASIN	Namurian A	Namurian B	Namurian C
Cycloceras kionoforme Demanet	+		
Brachycycloceras cf. *scalare* Goldfuss		+	
Perigrammocerus sulcatum (Fleming)	+		
Tylonautilus cf. *nodosocarinatus* Roemer	+		
Coelonautilus sp.	+	+	
Stroboceras cf. *stygiale* (de Koninck)	+		
Stroboceras bisulcatum (de Koninck)	+		
Metacoceras cf. *perelegans* Girty			+
Eumorphoceras cf. *pseudobilingue* Bisat	+		
Eumorphoceras ex gr. *bisulcatum* Girty	+		
Cravenoceras cf. *malhamense* Bisat	+		
Cravenoceratoides nitidus (Phillips)	+		
Cravenoceratoides cf. *edalensis* (Bisat)	+		
Cravenoceratoides nititoides (Bisat)	+		
Cravenoceratoides sp.	+		
Homoceras ex gr. *beyrichianum* (de Koninck)	+		
Homoceras cf. *beyrichianum* (de Koninck)	+		
Homoceras cf. *subglobosum* (Dolle)	+		
Homoceras cf. *henkei* Schmidt		+	
Homoceras cf. *moorei* Bouckaert		+	
Homoceratoides varicatus Schmidt		+	
Homoceratoides cf. *mutabile* Bisat & Hudson		+	
Homoceratoides sp.		+	
Reticuloceras cf. *umbilicatum* Bisat & Hudson		+	
Reticuloceras adpressum Bisat & Hudson		+	
Reticuloceras cf. *adpressum* Bisat & Hudson		+	
Reticuloceras todmordenense Bisat & Hudson		+	
Reticuloceras cf. *todmordenense* Bisat & Hudson		+	
Reticuloceras bilingue (Salter)		+	
Reticuloceras superbilingue Bisat			+
Reticuloceras sp.		+	
Gastrioceras ex gr. *cancellatum* Bisat			+
Gastrioceras cf. *cumbriense* Bisat			+
Agastrioceras cf. *carinatum* (Frech)			+
Anthracoceras paucilobum (Phillips)	+		
Anthracoceras cf. *paucilobum* (Phillips)	+		
Anthracoceras arcuatilobum (Ludwig)		+	+
Anthracoceras sp.	+		
Dimorphoceras (Paradimorphoceras) cf. *looneyi* (Phillips)	+	+	
Dimorphoceras sp.	+		
ARTHROPODA			
Paladin cf. *eichwaldi* (Fischer)	+		
Paladin mucronatus (Mc Coy)	+		
Particeps scoticus Reed	+		
Isaura (Lioestheria) cf. *striata* (Münster)		+	
Carbonita sp.	+		

(Chart 4 — continued

NAMURIAN FAUNA OF THE LUBLIN BASIN	Namurian A	Namurian B	Namurian C
Carbonita cf. *fabulina* (Jones & Kirkby)	+		
Richterina sp.	+		
Jonesina sp.	+		
CONODONTA			
Hindeodella sp.		+	
HYOLITHIDA			
Hyolithes sp.	+		
COLEOLIDAE			
Coleolus cf. *carbonarius* Demanet	+		
PISCES			
Cladodus sp.	+	+	
Megalichthys cf. *hibberti* Agassiz			+
Megalichthys sp.			+
Strepsodus cf. *sauroides* Binney		+	
Strepsodus sp.		+	+
Rhabdoderma elegans (Newberry)		+	+
Rhabdoderma sp.		+	+
Elonichthys sp.		+	+
Rhadinichthys sp.		+	+
Acrolepis sp.	+		

last few years, facilitating a closer division of the Silesian. The Namurian stratigraphy, based on goniatites, is discussed separately.

The non-goniatite fauna is fairly abundant, the pelecypods and gastropods being the predominant fossils while brachiopods are less common. The remaining faunal groups are represented by extremely few species (vide chart 4). The above fauna has a wide geographical range and it is known from numerous Namurian areas of Europe, i. al. Great Britain, Belgium, Holland, northern France, Germany, the USSR (Aizenverg et al. 1960; Böger & Fiebig 1962, 1963; Brazhnikova et al. 1956; Demanet 1938, 1941, 1943; Dorlodot & Delepine 1930; Dorsman 1945; Fiebig 1964; Fedotov 1932; Gurevich et al. 1963; Lambrecht 1966; Lapina 1962a, b; Pastiels 1960, 1964; Ramsbottom 1959; Schlömer 1967; Schmidt & Teichmüller 1956; Tchernyshev 1931, 1951; Trueman & Weir 1946—1955; Weir 1960, 1966, 1968; Wilson 1960, 1961, 1962a, b, 1963, 1967 etc.).

On the basis of the macrofauna worked out by the writer, the presence of a complete profile of Namurian A, underlying the paleontologi-

Chart 5

THE CARBONIFEROUS DEPOSITS CONTAINED IN BOREHOLES OF THE LUBLIN BASIN

Borehole	Deposits overlying the Carboniferous	Depth of the top and the bottom of the Carboniferous	Thickness in metres: Westphalian	Namurian C	Namurian B	Namurian A	Deposits underlying the Namurian	Deposits underlying the Carboniferous
Kołbiel 1	P_1	2044.9 - 2400.0	100.6		209.3		A	S
Żebrak IG-1	P_1	1295.5 - 1360.9			65.4		A	S
Goździk 1	P_1	1677.5 - 2195.0	296.0		221.5		B	S
Łuków 1	P_1	810.4 - 906.0	7.6		72.6		V_3	pЄ
Pasmug 1	J	1035.0 - 1630.0	165.0		310.0		V_3	D_3
Okrzeja 1	J	1424.0 - 1810.0	196.0		355.0		V_3	D_2
Radzyń IG-1	J	676.2 - 936.6	29.0		164.3	66.3	V_3 *	Є
Kock 7	J	864.5 - 1182.5				132.5	V_3 *	D_3
Parczew IG-1	J	606.0 - 981.3			131.4	95.2	V_3 *	S
Parczew IG-2	J	677.4 - 1214.5	289.1		129.5	61.3	V_3	
Holeszów IG-1	J	422.0 - 431.0					V_3	pЄ
Kaplonosy IG-1	J	402.6 - 439.0				36.4	V_3 *	S
Bresbnice IG-1	J	766.0 - 1247.9	156.7		167.6	88.9	V_3 *	
Orzechów IG-1	J	625.5 - 1165.0	190.5		165.8	121.7	V_3	[illegible]
[illegible] IG-1	J	599.6 - 1202.0	209.6		155.7	198.4	V_3	D_3
Kolechowice IG-1	J	782.0 - 1402.0	477.0		114.5	30.0		
Ostrówek IG-1	J	627.0 - 1253.2	437.0		96.2	43.0		
Łęczna IG-1	J	707.0 - 1250.0	521.0	22.0				
Spiczyn IG-1	J	650.1 - 1300.0	385.9		113.0	155.0		
Sawin IG-2	J	520.3 - 938.3	53.7		106.5	207.1	V_3	D_1
Sawin IG-1	J	529.5 - 1285.6	181.2		130.7	140.6	V_3	S
Lewadów IG-1	J	680.6 - 1100.2	343.4		76.2			
Chełm IG-2	J	707.9 - 1304.0	336.5		153.2	106.6		
Chełm IG-1	J	580.2 - 1209.7	94.3		115.6	309.1	V_3	D_1
Dorohucza IG-1 /Kazimierzówka/	J	795.7 - 2354.4	942.2		209.1	30?.0	V_{3+2} *	D_1
Kumów IG-1	J	562.2 - 1166.6	120.6		176.7	305.9	V_3	? D_1
Kumów IG-3	J	691.4 - 1492.5	208.7		220.8	377.8	V_3	? D_2
Kumów IG-2	J	766.0 - 1585.0	380.0	735.0				
[illegible] IG-1	Cr	477.5 - 1195.6	137.0		173.5	236.4	V_3	D_3
Strzyżów	Cr	484.6 - 755.0				254.4	V_{3+2}	**
Husynne IG-1	Cr	504.0 - 809.4				320.0	V_3	**
Teptiuków IG-1	Cr	421.5 - 1033.0	65.5		125.1	285.3	V_3	**
Hrubieszów IG-2	J	805.0 - 1585.5	108.3		208.2	342.8	V_3	D_3
Łasków IG-1	Cr	385.3 - 1067.9	66.9		144.7	352.1	V_3	**
Mircze IG-1	Cr	448.4 - 1362.0	79.9		283.3	354.4	V_3	** D_3
Bojnobyczów IG-1	Cr	439.0 - 1309.3	22.4		277.2	364.3	V_3	**
Tyszowce IG-1	J	790.7 - 1790.1	149.3		234.1	485.9	V_3	** D_3
Korczmin IG-3	Cr	432.0 - 1355.0			593.0		V_3 *	** D_3
Korczmin IG-1	Cr	580.0 - 1345.0			550.0		V_3	**
Jarczów IG-4	J	965.0 - 1777.0			495.0		V_3	** D_3
Komarów IG-1	J	1085.2 - 1935.0				674.2	V_3	D_3
Bystrzyca IG-1	J	1140.0 - 1766.0			147.6	278.0		
Niedrzwica 3	J	1137.0 - 2506.1	195.5	215.2	143.3	526.7	V_{3+2} *	** D_3
Niedrzwica 2	J	1251.0 - 2362.4	66.0	178.0	157.0	370.5	V_{3+2} *	** D_3
Niedrzwica IG-1	J	1198.7 - 2176.6				585.1	V_{3+2} *	** D_3
Opole Lub. 5	J	1170.6 - 2327.5	136.5	241.5	175.0	376.0	V_{3+2}	** D_3
Kazimierz 1	J	1663.0 - 2064.0	175.0		165.0	139.0		
Żyrzyn IG-1	J	1175.0 - 2555.4	1380.4					
Dęblin 2	J	1134.0 - 2080.0	738.0		608.0	323.0	V_3	D_3
Dęblin 9	J	1144.0 - 2867.0	746.0		600.0	320.0	V_3	D_3
Dęblin 7	J	1244.0 - 2864.5	536.0		549.2	455.2		
Jezyków 1	P_1	1758.0 - 2216.0	142.0		316.0		D_1	D_1
Magnuszew IG-1	P_1	2102.0 - 3003.0	901.0					

Cr - Cretaceous, J - Jurassic, P_2 - Upper Permian, P_1 - Lower Permian, V_3 - Upper Visean, V_{3+2} - Upper and Middle Visean, D_3 - Upper Devonian, D_2 - Middle Devonian, D_1 - Lower Devonian, S - Silurian, O - Ordovician, Є - Cambrian, pЄ - Precambrian

* Tufaceous series, ** Strunian

Continuous lines indicate observed Namurian profiles.
Symbol IG indicates boreholes drilled by the Geological Institute.
Figure without the symbol IG denotes boreholes drilled by the Oil Research Survey.

cally established Upper Namurian and overlying the Upper Viséan, has been observed in boreholes Chełm IG-1, Niedrzwica 2 and 3, Opole Lub. 5 and Dęblin 2 and 9. Deposits of Namurian A, possibly also the lowermost members of Namurian B, have been reached in borehole Strzyżów. A practically complete Namurian A profile has been found in boreholes Bystrzyca IG-1 and Dęblin 7. Moreover, deposits of the Lower and Upper Namurian have been reached under the Westphalian and above the Upper Viséan in boreholes Pasmug 1 and Okrzeja 1. Owing, however, to the lack of index fossils, the Namurian series there has not been subdivided. In borehole Kazimierz 1, similarly as in borehole Kock 7, only the Lower Namurian sediments have been reached.

The Upper Namurian (B + C) sediments, underlying the faunally established Westphalian and overlying the Lower Namurian deposits, have been encountered in boreholes Niedrzwica 2 and 3, Opole Lub. 5, Chełm IG-1, Dęblin 7, Dęblin 2 and 9, Kazimierz 1.

In the first three of the boreholes just mentioned, it has, moreover, been possible for the first time to differentiate Namurian B and Namurian C deposits on the basis of goniatites (vide chart 5) in the Upper Namurian series.

In the other boreholes, elaborated by the present writer in co-operation with Dr. L. Teller, only certain Upper Namurian members have been encountered. The lower members of Namurian B have been reached in borehole Bystrzyca IG-1. The uppermost Namurian C, possibly also a part of Namurian B have been reached under the Westphalian and above the Silurian in boreholes Goździk 1 and Kołbiel 1, also under the Westphalian and above the Lower Devonian in borehole Ursynów 1.

The complete Namurian series or some of its members have, moreover, been encountered in numerous boreholes in the Lublin basin, now being worked out by other authors. The thickness of the particular profiles shown in chart 5 are given after Bojkowski, Cebulak, Dembowski, Miłaczewski, Porzycki, Żelichowski and Korejwo & Teller.

Namurian A deposits are known in Poland not only from the Lublin basin, but from the Upper Silesia basin, too (both from Polish and Czechoslovakian territory). Their descriptions, together with those of the associated fauna, have been worked out fairly long ago. The macrofauna from the Upper Silesia basin has been investigated by Bojkowski (1958, 1959, 1960b, 1961, 1967), Czarniecki (1959), Klebelsberg (1912), Korejwo (1954), Kozioł (1954), Makowski (1937), Kotas & Malczyk (1966), Musiał (1967), Musiał & Tabor (1964), Ružička & Vasiček (1957), Ružička & Bojkowski (1961), Ružička & Řehoř (1964), Řehoř & Řehořova (1962), Schwarzbach (1937), Tabor (1967), and others.

The lower part of the Namurian has, moreover, been encountered in the north-eastern margin of the Upper Silesia basin, namely in the Miechów depression (Bukowy 1964a, Bojkowski & Bukowy 1966, Bojkowski & Jachowicz 1964, Korejwo & Teller 1968c). The lower members of Namurian A have likewise been found in the substratum of the Fore-Sudetic monocline (Żelichowski 1964a, c, Korejwo & Teller 1965b), probably also in Western Pomerania (Bojkowski et al. 1966b, Dadlez 1967a, Żelichowski 1968b) where the upper members of the Namurian have been encountered, too.

Deposits of the Upper Namurian (B + C) in the paralic facies, have, so far, been reported in Poland from the Lublin basin and partly from Pomerania, because the Upper Namurian in the Upper Silesia basin (similary as the entire Upper Carboniferous in the Lower Silesia basin) is developed already in the limnic facies, i.e. without a marine fauna. The stratigraphy of these deposits has been determined on floristic data rather than on the fauna of freshwater pelecypods.

The Namurian stratigraphy in the Lvov-Volhynia basin is as follows. On faunal evidence, the Lischnya beds (Namurian A) and the Bug beds (Namurian B) have been distinguished by Shulga (1962) in the Namurian series. According to that author, the Morozovichi beds of the Bashkirian stage are the equivalent of Namurian C of the west European division. The higher members of that stage corresponding to the Westphalian of western Europe are represented by the Paramov and Krechevo beds (see chart 7). A closer stratigraphic correlation of the Namurian from the Lublin basin and the Lvov-Volhynia basin is hampered because the macrofauna in the latter area is represented chiefly by pelecypods. Brachiopods are extremely rare and only two goniatite species have been encountered in the Lower Namurian deposits.

The fauna mentioned by Shulga from the Lvov-Volhynia basin reasonably suggests that the Ivanichi beds (possibly also a part of the underlying Poryck beds), which have been assigned to the Upper Viséan, are an equivalent of the lowermost Namurian, i.e. of substage E_1 (Pendleian) of the Lublin basin. This may be reliably explained both by the lithological development of the deposits from the above beds (terrigenous sediments with a few limestone intercalations) and by the associated fauna. Though Shulga mentions the presence of *Gigantoproductus* aff. *latissimus* (Sow.) never reported from Poland above the Viséan, but in Scotland e.g. it is known from the Lower Namurian (Wilson 1967). The remaining brachiopods and pelecypods have a greater vertical range and are known from the Lower Namurian, too.

The 55—105 m thick Lischnya beds, occurring in the western part of the Lvov-Volhynia basin and by Shulga referred to Namurian A on the presence of the goniatites *Cravenoceratoides* cf. *stellarus* (Bisat), *Cravenoceratoides nititoides* (Bisat), *Anthracoceras* cf. *paucilobum* (Phill.) and *Dimorphoceras* sp., also of pelecypods, are an equivalent of substage E_2 (Arnsbergian) in the Lublin basin. On faunal evidence, quoted by Shulga, the higher-lying Bug beds represent in that author's opinion the Namurian B, 70—120 m thick, in its middle part containing the maximum of the coal-bearing layers. They seem to correspond to those deposits of the Lublin basin which had been referred to the upper part of Namurian A, possibly also to the lowermost part of Namurian B. Shulga does not exclude the occurrence in the Lvov-Volhynia basin of a sedimentary hiatus which could partly correspond to substages H_1 and H_2. This, however, remains an open question.

Above the Bug beds, in the westernmost part of the here considered Lvov-Volhynia basin, i.e. within an area bordering on Poland, the presence has been observed of deposits which the USSR geologists refer to the Bashkirian stage of the Middle Carboniferous. The lowermost member of that stage is represented by the Morozovichi beds, according to Shulga this being an age equivalent to Namurian C of western Europe. The higher members: the 50—55 m thick Paramov beds, and the a. 100 m thick Krechevo beds, which terminate the Carboniferous sedimentation in the Lvov-Volhynia basin, are said to correspond to Westphalian A and the Lower Westphalian B of western Europe.

On the basis of macrofauna (marine and freshwater pelecypods), cited by Shulga from the Bashkirian stage, the present writer thinks that both, the Morozovichi and the Paramov beds, still represent the Namurian series of the Lublin basin, namely the upper part of Namurian B and Namurian C. The uppermost beds, i.e. the Krechevo beds may already represent the lowermost members of Westphalian A. The presence is noted there of the characteristic pelcypod *Dunbarella papyracea* (Sow.). In the Lublin basin this species has been encountered in deposits of Westphalian age. In other Carboniferous basins this species also occurs in the Westphalian. Indeed, Dembowski & Porzycki (1967) suppose that there are no equivalents of the Westphalian stage in the Lvov-Volhynia basin.

Shulga's (1962) correlation of the Lvov-Volhynia basin with the Donetz basin is given in chart 7. This chart also presents the correlation of the Namurian of Poland with the Lvov-Volhynia basin, as interpreted by the present writer.

Namurian stratigraphy based on goniatites

Introductory remarks

The accurate determination of Carboniferous stratigraphy on the basis of borehole material, also a subdivision of this system into stages, and still more so into smaller stratigraphic units, often meets with considerable difficulties. First and foremost this is due to incomplete coring, moreover, some fragments of the profiles are either completely unfossiliferous or even if fossiliferous they do not always reliably determine the age of the deposits. Hence, in most profiles, the boundaries between the particular stages or substages are defined on the basis of lithological or geophysical data.

The identification of the fauna and the determination of the stratigraphy of profiles from the first boreholes drilled in the Lublin basin (boreholes Strzyżów, Chełm IG-1, Bystrzyca IG-1) was heavily hampered by the lack of faunal material comparable with forms known and described from other countries. During the Second World War all the faunal collections in Poland had been destroyed, among them the finest specimens of the fauna from boreholes Strzyżów which had been identified by Schwarzbach.

The Upper Carboniferous fauna from boreholes is, on the whole, poorly preserved and its identification is difficult. Usually, this fauna is of minute dimensions and it is preserved either as counterparts or flattened moulds. Specimens, all complete and showing their ornamentation, are rare, not to say anything about the lack of any adequate knowledge concerning the interior structure.

The Carboniferous fauna varies considerably in its stratigraphic value. The cephalopod group, particularly so the goniatites, is most significant for the Upper Carboniferous. They are, namely, characterized by a widespread geographical distribution and a limited vertical range, and this permits not only the definition of stages and substages but the differentiation of the particular goniatite zones. The subdivision of the Carboniferous into stages, substages, zones etc. also their boundaries, have been based on goniatites in agreement with the resolutions of the International Carboniferous Congresses. This subdivision has been determined on the basis of profiles known, in the first place, from outcrops, as is the case in the basins of England, Belgium and Rhine-Westphalia. The particular goniatite zones there, and the faunal zones in general can be traced very accurately both horizontally and vertically.

In Poland such exposures are lacking from the Silesian strata, and more specially so from its higher members (in the paralic facies). Both, the Upper Namurian and the Westphalian with a marine fauna are known only from boreholes.

Other faunal groups, such as the brachiopods or pelecypods of the Upper Carboniferous, often have a greater vertical range, and are, therefore, with the exception of certain species, of little stratigraphic value. Attempts at correlation of this fauna with other regions are likewise difficult. During the last years, a tendency has been manifesting itself to differentiate new species, subspecies and their varieties, solely on the basis of insignificant morphological differences. At the same time these forms do not seem to be endemic, particularly in the case of the European Carboniferous strata. It is an undoubted fact that the sea basins, even if they did not form one united basin, had been interconnected at certain periods, hence their fauna could migrate more or less freely.

During her visits, i.al. to Great Britain (Wales, central and north England, Scotland), Belgium, France, Czechoslovakia and the USSR, the present writer has been offered opportunities to compare and check up most of the faunal remains she has identified with typical forms from monographic collections. Inspection of the fauna from exposures and still more so from borehole cores from the various European areas, also the discussions with specialists in this field, proved of great assistance in the writer's subsequent research work. Moreover, it permitted the revision of earlier faunal identifications and the introduction of greater stratigraphic accuracy, particularly on the basis of goniatites observed in certain profiles of the Lublin basin. In result of the revision it has been determined that a complex of sediments from borehole Chełm IG-1, previously referred already to the Lower Westphalian (Korejwo 1960), still represents the uppermost Namurian. Moreover, it permitted a more exact determination of the Namurian/Westphalian boundary which had been arbitrarily accepted by the writer. It is now accepted that in borehole Chełm IG-1, Namurian A is represented between 1,099.25 and 790.10 m, Namurian B + C between 790.1 and 674.5 m, while Westphalian A is said to occur higher up to a depth of 580.2 m. Previously, the deposits from a depth between 1,099.25 and 733.25 m were currently assigned to the Namurian.

Several goniatites from borehole Strzyżów had previously been identified by the writer as representatives of the genus *Reticuloceras* (Korejwo 1958a). On the basis of later comparable material, however, the writer has concluded that these forms probably belong to another genus, possibly the *Dimorphoceras*. This does not, however, change the stratigraphy of the Namurian, defined at that time, as has been confirmed by the remaining fauna.

Substages and goniatite zones

The knowledge of the Namurian goniatites of Poland, similarly as of those from the Westphalian strata, has so far been most inadequate as compared with England and other areas of western Europe. The first and foremost reason thereof is their extremely rare occurrence in comparison with the representatives of other macrofaunal groups. Moreover the state of preservation of goniatites from borehole profiles does not always permit their accurate identification. The lobe line, for instance, has never been observed (in the Upper Carboniferous). Hence the assignment of the particular forms is made solely on outer morphological features. Obviously, this suggests the greatest caution in specific identification, while generic identification does not allow any great accuracy in age determination of Namurian deposits.

In western Europe, most particularly in Great Britain, Belgium and Germany, where the goniatites occur in great abundance, the stratigraphy of the Silesian has been defined with the greatest accuracy. In Poland however, the majority of species, particularly of the Upper Namurian ones, have been reported for the first time from the Lublin basin. This permitted the differentiation of Namurian B and C (in least in some profiles), as well as the separation of the particular substages and zones in the Namurian series. To a certain extent this has made up for the deficiency in the Polish sequence of goniatite zones and has led to a closer correlation of the Polish Namurian with other classic Silesian areas of Europe.

The following is a specification of the Namurian goniatite fauna, identified by the present writer from the particular boreholes, giving the depth at which they occur. Photographs of the fauna are shown in plates XXIV—XLIII.

Opole Lub. 5

2,045.0—2,041.0 m *Cravenoceras* sp.

1,935.0—1,929.0 m *Anthracoceras paucilobum* (Phill.).

1,357.2—1,357.0 m *Agastrioceras* cf. *carinatum* (Frech) (pl. XXXVII, figs. 1 and 2), *Gastrioceras* ex gr. *cancellatum* Bis. (pl. XXXVIII, figs. 1 and 2).

Niedrzwica 2

1,511.5—1,505.5 m *Reticuloceras bilingue* (Salt.) (pl. XXXIV, figs. 3 and 4; pl. XXXV, fig. 1), *Reticuloceras* sp. (pl. XXXIV, fig. 2).

1,410.0—1,409.8 m *Reticuloceras superbilingue* Bis. (pl. XXXVI, figs. 1—5), *Anthracoceras arcuatilobum* (Ludw.) (pl. XL, figs. 4 and 5).

Niedrzwica 3

2,220.7—2,218.2 m *Dimorphoceras* sp.

2,002.0—1,999.0 m *Homoceras* cf. *subglobosum* (Dolle) (pl. XXVII, figs. 3 and 4).

1,699.0—1,693.0 m *Reticuloceras* cf. *bilingue* (Salt.) (pl. XXXV, fig. 2), *Reticuloceras* sp., *Anthracoceras* sp.

1,554.7—1,554.0 m *Reticuloceras superbilingue* Bis. (pl. XXXV, fig. 3).

1,553.7—1,553.2 m *Gastrioceras* cf. *cumbriense* Bis. (pl. XXXVIII, fig. 2).

Dęblin 7

2,594.8—2,593.8 m *Eumorphoceras* cf. *pseudobilingue* Bis. (pl. XXIV, figs. 1—4), *Cravenoceras* cf. *malhamense* Bis. (pl. XXIV, figs 5 and 6), *Cravenoceras* sp.

2,569.2—2,565.0 m *Eumorphoceras* ex gr. *bisulcatum* (Girty), *Anthracoceras* sp., *Dimorphoceras* sp.

2,513.7—2,507.7 m *Cravenoceratoides nitidus* (Phill.) (pl. XXV, figs. 6—8), *Cravenoceratoides* cf. *edalensis* (Bis.) (pl. XXVI, figs. 1—4), *Anthracoceras paucilobum* (Phill.) (pl. XXXIX, fig. 2), *Dimorphoceras* sp.

2,507.7—2,501.7 m *Homoceras* cf. *subglobosum* (Dolle) (pl. XXVII, fig. 2), *Homoceras* sp., *Anthracoceras paucilobum* (Phill.), *Dimorphoceras* sp.

2,501.7—2,498.4 m *Homoceras* cf. *beyrichianum* (de Kon.) (pl. XXVIII, figs. 3 and 4), *Anthracoceras paucilobum* (Phill.) (pl. XXXVIII, fig. 4), *Dimorphoceras (Paradimorphoceras)* cf. *looneyi* (Phill.) (pl.XLI, fig. 5), *Dimorphoceras* sp. (pl. XLII, fig. 1).

2,471.2—2,470.2 m *Homoceras* ex gr. *beyrichianum* (de Kon.) (pl. XXVII, fig. 5).

2,438.2—2,437.3 m *Homoceras* cf. *mutabile* Bis. & Huds. (pl. XXIX, figs. 4—6).

Bystrzyca IG-1

1,701.5—1,700.9 m *Eumorphoceras* ex gr. *bisulcatum* (Girty) (pl. XXV, fig. 1).

1,574.9—1,574.7 m *Cravenoceratoides* sp. (pl. XXVII, fig. 1).

1,558.1—1,550.1 m *Anthracoceras* cf. *paucilobum* (Phill.) (pl. XXXIX, figs. 4 and 5), *Anthracoceras* sp., *Dimorphoceras* sp.

1,410.5—1,407.0 m *Homoceras* cf. *beyrichianum* (de Kon.) (pl. XXVIII, fig. 5).

1,381.3—1,381.2 m *Homoceras* cf. *henkei* Schmidt (pl. XXVIII, fig. 1), *Reticuloceras* cf. *adpressum* Bis. & Huds. (pl. XXXI, fig. 4; pl. XXXII, fig. 4).

1,381.0—1,378.0 m *Reticuloceras* cf. *todmordenense* Bis. & Huds. (pl. XXXIII, fig. 2), *Reticuloceras* cf. *adpressum* Bis. & Huds. (pl. XXXII, fig. 2), *Reticuloceras sp.*, *Anthracoceras arcuatilobum* (Ludwig) (pl. XL, fig. 3).

1,374.7—1,371.0 m *Homoceratoides varicatus* Schmidt (pl. XXIX, fig. 1), *Homoceratoides* sp. (pl. XXIX, fig. 3; pl. XXX, fig. 1), *Reticuloceras todmordenense* Bis. & Huds. (pl. XXXIII, fig. 1), *Reticuloceras* cf. *todmordenense* Bis. & Huds. (pl. XXXIII, fig. 3; pl. XXXIV, fig. 1), *Reticuloceras adpres-*

sum Bis. & Huds. (pl. XXXI, fig. 1), *Reticuloceras* cf. *adpressum* Bis. & Huds. (pl. XXXI, figs. 2 and 3; pl. XXXII, fig. 1), *Reticuloceras* cf. *umbilicatum* Bis. & Huds. (pl. XXX, figs. 3—6), *Reticuloceras* sp. (pl. XXXIII, fig. 4; pl. XXXIII, figs. 4 and 5), *Anthracoceras arcuatilobum* (Ludw.) (pl. XL, figs. 1 and 2), *Dimorphoceras (Paradimorphoceras)* cf. *looneyi* (Phill.) (pl. XL, fig. 6; pl. XLI, figs. 1—4), *Dimorphoceras* sp.

1,359.6—1,359.4 m *Reticuloceras* sp., *Homoceratoides* sp. (pl. XXIX, fig. 2).

Kazimierz 1

2,062.4—2,060.0 m *Homoceras* cf. *beyrichianum* (de Kon.) (pl. XXVIII, fig. 2).

1,758.6—1,753.1 m *Homoceras* cf. *moorei* Bouck. (pl. XXVIII, fig. 6).

Kołbiel 1

2,194.6—2,190.7 m *Gastrioceras* sp.

Goździk 1

2,130.8—2,129.0 m *Dimorphoceras* sp. (pl. XLII, figs. 2 and 3).

Chełm IG-1

939.1—938.0 m *Cravenoceratoides nitidus* (Phill.) (pl. XXV, figs. 2—5), *Anthracoceras* sp. (pl. XXXVIII, figs. 6 and 7), *Dimorphoceras* sp. (pl. XLII, figs. 4 and 5).

926.5—925.6 m *Cravenoceratoides nititoides* (Bis.) (pl. XXVI, figs. 5 and 6), *Anthracoceras paucilobum* (Phill.) (pl. XXXVIII, fig. 3).

923.4—923.1 m *Anthracoceras paucilobum* (Phill.) (pl. XXXVIII, fig. 5; pl. XXXIX, fig. 1).

682.5—680.5 m *Gastrioceras* cf. *cumbriense* Bis. (pl. XXXVI, fig. 6; pl. XXXVII, figs. 3 and 4), *Homoceratoides* sp. (pl. XXX, fig. 2).

Namurian A

As is currently accepted, the Namurian begins with the first appearance of the species *Cravenoceras leion* Bis.

Cravenoceras leion Bis., characteristic of the lowermost (E_1a) zone of the Namurian, has never as yet been encountered in the profiles of the Lublin basin. It is not, however, excluded that this form may have been present among the goniatite remains from the lowermost Namurian of the Lublin basin, but that the unsatisfactory state of preservation of the available specimens hindered their specific identification. The occurrence in the Lublin basin of the species under consideration seems all the more probable that it has been found in borehole Gołonóg (Bojkowski 1967) in Upper Silesia.

Cr. leion Bis. has been reported from Great Britain (Bisat 1928, 1950; Yates 1962) and Germany (Schmidt 1934, Patteisky 1959, Horn 1960, Figge 1968). In Belgium, Demanet (1941) has described it from the Lower Namurian. When comparing the Lower Namurian goniatites from Ireland and Belgium, Yates (1962) suggested that Belgian forms previously referred by Demanet to substage E_1, are probably E_2 in age. A revision of the identification of the above fauna from the lowermost part of the Namurian in the Dinant synclinorium of Belgium, made by Ramsbottom (vide van Leckwijck 1964b) also by Bouckaert & Higgins (1963), shows that the oldest zones of the Namurian in Belgium represent the higher substage — E_2, i.e. the Arnsbergian, while the form identified as *Cravenoceras leion* Bis. actually belongs to another species, the *Cravenoceras cowlingense* Bis.

In the lower part of substage E_1, called Pendleian, above the zone Cr. leion, occurs the zone Eumorphoceras pseudobilingue (s.s.) i.e. E_1b, whose index species bears the same name. Fairly numerous representatives of this species have been encountered in the Lublin basin (borehole Dęblin 7). Their state of preservation impedes closer identification, all the more so that several subspecies have been differentiated within the species itself (Bisat 1928, Horn 1960). In this connection the forms encountered in borehole Dęblin 7 have been identified as *Eumorphoceras* cf. *pseudobilingue* Bis.

E. pseudobilingue Bis. (s.s.) has likewise been found in the Upper Silesia borehole Gołonóg (Bojkowski 1967), and *E.* cf. *pseudobilingue* Bis. in borehole Ostrzeszów in the substratum of the Fore-Sudetic monocline (Żelichowski 1964a, tabl. I, fig. 3).

Just above *E.* cf. *pseudobilingue* Bis., *Cravenoceras* cf. *malhamense* Bis. has been found in borehole Dęblin 7. This borehole excepted, the last named species has never before been reported in Poland (Korejwo & Teller 1968f). It is characteristic of the uppermost zone (E_1c) of the Namurian A substage E_1 and has been recorded from England (Bisat 1924, 1928, 1950) and Germany (Schmidt 1934, Patteisky 1959, Horn 1960).

Within the Lublin basin, the higher goniatite zones of Namurian A, belonging to substage E_2, i.e. the Arnsbergian, are represented by the following species:

Eumorphoceras ex gr. *bisulcatum* (Girty) encountered in boreholes Dęblin 7 and Bystrzyca IG-1.

Cravenoceratoides nitidus (Phill.) encountered in boreholes Chełm IG-1 and Dęblin 7.

Cravenoceratoides cf. *edalensis* (Bis.) from borehole Dęblin 7 and *Cravenoceratoides nititoides* (Bis.) from borehole Chełm IG-1.

Eumorphoceras bisulcatum (Girty) has, moreover, been encountered in borehole Dorohucza IG-1 (Krasnystaw) at a depth between 2,124.5 and 2,129.1 m (Bojkowski 1966a, tabl. I, fig. 13) while *Cravenoceratoides nititoides* (Bis.) is mentioned by that author from borehole Husynne IG-1 from a depth of 488.9 m. *Cravenoceratoides nitidus* (Phill.) is the only species out of those here considered that has been found outside the Lublin basin, in the marine Gaebler horizon, i.e. in the upper part of substage E_2 in the Upper Silesia basin (Bojkowski 1967). All the above species are known from the lower part of Namurian A in western Europe and they are the index-forms for substage E_2 i.e. the Arnsbergian, representing zones E_2a and E_2b respectively (Bisat 1924; Schmidt 1925, 1934; Demanet 1941; Hudson 1945; Dorsman 1945; Patteisky 1959, Chalard 1960a, b; Yates 1962; Bouckaert 1961; Bouckaert & Higgins 1963; van Leckwijck 1964b and others). Zone E_2c which is the highest one of substage E_2 has not as yet been encountered within the Lublin basin.

No goniatites at all have been observed in the upper part of Namurian A of the Upper Silesia basin, hence arises the problem whether substages H_1 and H_2 are present in the Polish part of that basin. Bojkowski (1967) thinks there is no such index fauna there to reliably suggest the presence of these substages, and he leaves the problem of the uppermost part of Namurian A an open question. Hartung & Patteisky (1960), also Havlena (1964) suggest the presence of the uppermost Namurian A in the Ostrawa-Karwina region of Upper Silesia. Patteisky believes the Gaebler horizon to be the equivalent of its lowermost part and thus to correspond to the Homoceras striolatus zone. Havlena, on the other hand, on paleobotanical grounds, assigns to this part of the profile not only the marine Gaebler horizon but the underlying Roemer horizon too.

The goniatites of the Lower Namurian A in the Upper Silesia basin are shown in chart 6 after Bojkowski (1967).

The upper part of Namurian A, established on a goniatite fauna, has been observed in Poland only in the Lublin basin. The following representatives of the genus *Homoceras* have been encountered there: *Homoceras* cf. *subglobosum* (Dolle) in boreholes Dęblin 7 and Niedrzwica 3; *Homoceras* ex gr. *beyrichianum* and *H.* cf. *beyrichianum* (de Kon.) in boreholes Dęblin 7, Bystrzyca IG-1 and Kazimierz 1. Moreover, Bojkowski (1966a) has observed the presence of *H. beyrichianum* (de Kon.) in boreholes Teptiuków IG-1 (at 692.0—693.5 m) and borehole Husynne IG-1 between

Chart 6

NAMURIAN GONIATITES OF POLAND

Stages	Substages	[illegible] BASIN /K. Korejwo/ — Zones		LUBLIN BASIN /K. Bojkowski 1966/		UPPER SILESIA BASIN /K. Bojkowski 1967/	
WESTPHALIAN A		G_2 G. subcrenatum /Frech/				Lack of marine fauna	UPPER NAMURIAN /Ruda/
NAMURIAN C	YEADONIAN /G_1/	G_1c G. cf. cumbriense Bis. G_1b G. ex gr. cancellatum Bis., Ag. cf. carinatum /Frech/, Gastrioceras sp. G_1a R. superbilingue Bis., R. cf. superbilingue Bis., Gastrioceras sp.	Homoceratoides sp. A. arcuatilobus /Ludw./	Ag. carinatum /Frech/ A. aff. arcuatilobus /Ludw./ Hl. divaricatus /Hind/			
NAMURIAN B	MARSDENIAN /R_2/	R_2b R. bilingue /Salt./, R. cf. bilingue /Salt./ R_2a ?	Anthracoceras sp. Homoceratoides sp. Anthracoceras sp.				
	KINDERSCOUTIAN /R_1/	R_1c ? R_1b ? K. moorei Bouck. R. todmordenense Bis. & Huds., R. cf. todmordenense Bis. & Huds. R. adpressum Bis. & Huds., R. cf. adpressum Bis. & Huds. R_1a R. cf. umbilicatum Bis. & Huds., St. mutabile Bis. & Huds. H. cf. bewesi Bouckaert	Reticuloceras sp. Hl. variegatus Schmidt A. arcuatilobus /Ludw./ Homoceratoides sp. D. /Pared./ cf. looneyi /Phill./ Dimorphoceras sp.				
NAMURIAN A	ALPORTIAN /H_2/	H_2c H_2b ? H_2a		?		Lack of goniatites	LOWER NAMURIAN
	CHOKIERIAN /H_1/	H_1b H. ex gr. beyrichianum /de Kon./, H. cf. beyrichianum /de Kon./ H_1a H. cf. subglobosum /Bisat/	Homoceras sp. A. paucilobus /Phill./ Dimorphoceras sp. D. /Pared./ cf. looneyi /Phill./	H. beyrichianum /de Kon./ H. cf. diadema /Goldf. & Beyr./ H. aff. diadema /Goldf. & Beyr./	A. paucilobus /Phill./ Homoceras sp.		
	ARNSBERGIAN /E_2/	E_2c ? E_2b Ct. nititoides /Bis./ Ct. nitidus /Phill./ E_2a Ct. cf. edalensis /Bis./ E. ex gr. bisulcatum Girty	Cravenoceratoides sp. A. paucilobus /Phill./ Anthracoceras sp. Dimorphoceras sp.	Ct. nititoides /Bis./ A. tenuispirale /Lee./ D. aff. looneyi /Phill./ A. lineam Frech, E. lunula Knopp E. bisulcatum Girty	A. paucilobus /Phill./	Cr. nitidus /Phill./, A. paucilobus /Phill./ Cr. simplex Knopp, D. /Pared./ cf. looneyi /Phill./ Sudeticeras ostraviense Patt. A. discus Frech	
	PENDLEIAN /E_1/	E_1c Cr. cf. malhamense /Bis./ E_1b E. cf. pseudobilingue Bis. E_1a ?	Cravenoceras sp.			E. pseudobilingue Bis. Cr. aff. bobrownikense Patt. Cr. leion Bis., G. /Metad./ [illegible] zone	

409.2 and 409.5 m (Bojkowski 1966a, tabl. I, fig. 19). The two genera just mentioned are characteristic of substage H_1 (zones H_1a and H_1b), i.e. the Chokierian, and are known from England, Germany and Belgium (Bisat 1924; Schmidt 1934; Demanet 1941; Hodson 1954, 1957; Hodson & van Leckwijck 1958; Patteisky 1959). Moreover, *Homoceras* aff. *diadema* (Goldf. & Beyr.) and *H.* cf. *diadema* (Goldf. & Beyr.) (vide Bojkowski 1966a) are reported from boreholes Husynne IG-1 (409.2—409.5 m), Kosmów IG-1 (707.0—713.0 m) and Teptiuków IG-1 (692.0—693.5 m). According to Patteisky this species is associated with *H. subglobosum* (Dolle) and *H. beyrichianum* (de Kon.), possibly also higher up, but in any case it is connected with substage H_1.

All the goniatite species hereto considered are characteristic of substage E_1 (Pendleian), E_2 (Arnsbergian) and H_1 (Chokierian) of Namurian A.

No equivalents of the uppermost substage of the Lower Namurian, i.e. H_2 (Alportian) have so far been established on goniatites either in the Lublin basin or elsewhere in Poland.

In addition to the index forms mentioned above, representatives of the genera *Anthracoceras* and *Dimorphoceras* have also been found in the Lublin basin. Their vertical range is, however, markedly greater. *Anthracoceras paucilobum* (Phill.) occurs in practically all the profiles of the Lublin basin and it is connected with Namurian A. This forms is also often present in the Lower Namurian A of the Upper Silesia basin (Bojkowski 1967), moreover, it was found in borehole Marszowice 1 within the Miechów depression (Korejwo & Teller 1968b) and in the substratum of the Fore-Sudetic monocline (borehole Tarchały 1) (Korejwo & Teller 1965). *A. paucilobum* (Phill.) is very common in the Lower Namurian of western Europe (Bisat 1934, Currie 1954, Patteisky 1959).

Dimorphoceras (Paradimorphoceras) cf. *looneyi* (Phill.) is fairly common in the Namurian profiles of the Lublin basin. Similarly as in western Europe, this form occurs both in Namurian A and the lower part of Namurian B (Schmidt 1934, Moore 1939, Demanet 1941).

Namurian B

Deposits of the Upper Namurian (B + C) in the paralic facies, established on a goniatite fauna, have, so far, been found in Poland solely in the Lublin basin. A more detailed division and the differentiation of substages were made possible on the basis of goniatites from the genera *Reticuloceras* and *Gastrioceras*. Representatives of the former of these genera were first recorded in Poland in 1962 from borehole Bystrzyca IG-1 (Korejwo 1969). They are: *R.* cf. *umbilicatum* Bis. & Hudston, *R. adpressum* Bis. & Huds., *R.* cf. *adpressum* Bis. & Huds., *R. todmordenense* Bis. & Huds., *R.* cf. *todmordenense* Bis. & Huds. The species just mentioned are known from western Europe and they represent zone R_1a of substage R_1 (Kinderscoutian) of Namurian B (Bisat & Hudson 1943, Hudson 1945, Bouckaert 1960a, van Leckwijck 1946b, Patteisky 1959, Patteisky & Schönwalder 1960, and others). In the same zone there also occurs *Homoceratoides* cf. *mutabile* Bis. & Huds., found in borehole Dęblin 7. This form is known from Belgium, England and Morocco (Bisat & Hudson 1943, Bouckaert & Owodenko 1965).

Borehole Kazimierz 1 has yielded *Homoceras* cf. *moorei* Bouck. This species was discovered in Belgium in a higher zone, i.e. R_1b of the substage here considered, later on also encountered in Germany (Bouckaert 1960a, Bouckaert & Herbst 1960). The above species of the genera *Homoceras* and *Homoceratoides* have likewise been reported for the first time from Poland (Korejwo & Teller 1968f, 1968h).

It is also interesting to note the presence of *Homoceratoides varicatus* Schmidt in boreholes Bystrzyca IG-1 in deposits referred to the Namurian substage R_1. Musiał (vide Bojkowski 1966a) mentions this form from borehole Radzyń IG-1 where it occurs between 718.0—720.0 m in Upper Namurian sediments. *Homoceratoides varicatus* Schmidt has a great vertical range; in western Europe it is encountered in Namurian B and C, and even in the Westphalian.

The above species reasonably suggest the presence of the equivalents of zones R_1a and R_1b of western Europe. The uppermost zone R_1c of substage R_1 (Kinderscoutian) has not as yet been established in Poland.

The Upper Namurian B in the Lublin basin is characterized by *Reticuloceras bilingue* (Salt.) and *R.* cf. *bilingue* (Salt.). Both these forms have been found in boreholes Niedrzwica 2 and 3 (Korejwo & Teller 1967e, 1968a). In Great Britain, Belgium, Holland and Germany, the species *R. bilingue* is regarded as the index form of zone R_2b of the upper part of substage R_2 i.e. the Marsdenian (vide Patteisky 1959).

Namurian C

Namurian C is represented in the Lublin basin by the following forms: *Reticuloceras superbilingue* Bis., reported from borehole Niedrzwica 2; *R.* cf. *superbilingue* Bis. from borehole Niedrzwica 3; *Gastrioceras* ex gr. *cancellatum* Bis. and *Agastrioceras* cf. *carinatum* (Frech) from borehole Opole Lub. 5 and *Gastrioceras* cf. *cumbriense* Bis. from boreholes Niedrzwica 3 and Chełm Lub. IG-1 (Korejwo & Teller 1967e, 1968a). Out of the species just mentioned, only *Agastrioceras carinatum* (Frech.) has so far been encountered in deposits currently assigned to the Upper Namurian (B + C), in borehole Kosmów IG-1 at a depth of 492.6 m (vide Bojkowski 1966a, tabl. IV, fig. 11).

In the west European division of the Namurian, the species mentioned above represent its uppermost part, i.e. substage G_1, called the Yedonian and zones G_1a, G_1b and G_1c respectively (Nevill 1956, 1961; Patteisky 1959, 1965; Ramsbottom & Calver 1962; van Leckwijck 1964b; Rabitz 1967, and others).

On the ground of a decision of the 1927 Heerlen Congress, the next goniatite zone containing *Gastrioceras subcrenatum* (Frech) is regarded as the age equivalent of the lowermost member of Westphalian A. In Poland this form was first reported from boreholes Niedrzwica 2 and 3 (Korejwo & Teller 1967e).

Anthracoceras arcuatilobum (Ludw.) is another representative of the genus *Anthracoceras* noteworthy to be mentioned here; it was encountered in boreholes Bystrzyca IG-1 and Niedrzwica 2, also Chełm IG-1, while *A.* aff. *arcuatilobum* (Ludw.) is mentioned by Bojkowski (1966a) from boreholes Kosmów IG-1 and Radzyń IG-1. The latter species has a great vertical range and within the Lublin basin it is found both in the Upper Namurian and the Lower Westphalian. A similar range is displayed by this form in western Europe (vide Patteisky 1959, 1965).

Descriptions of the goniatite fauna from the Namurian deposits of the Lublin basin suggests that we are dealing here with the equivalents of all the substages distinguished in western Europe, with the exception of the Alportian (H_2), i.e. the uppermost substage of Namurian A. It is not excluded, however, that boreholes drilled in future will fill up this gap in the goniatite succession of Poland. Obviously, not all the zones of the particular substages have so far been faunally established.

All the Namurian goniatites recorded from Poland and identified by the present writer or by other authors, are specified in chart 6, while chart 2 shows all the index goniatite forms on which the Namurian stratigraphy of western Europe has been based.

The present writer's description of the Namurian goniatite fauna and its range is based on west European literature. The Namurian goniatites of the USSR have been described by Librovitch & Ruzhencev from the Donetz basin, the Urals, Novaya Zemlya and Central Asia (Librovitch 1946, 1947, 1957, 1961; Ruzhencev 1958, 1965). As is shown in chart 3, in spite of a great number of endemic forms, the goniatite fauna described by these authors also contains species and genera permitting correlation with the goniatite substages characteristic of the Lower and Upper Namurian of western Europe.

With the exception of pelecypods and rare brachiopods, very few macrofaunal data are available from the nearest region, the Lvov-Volhynia basin adjacent to the Lublin basin. Goniatites have been found in the Lishnya beds which Shulga (1962) refers to Namurian A. They are: *Cravenoceratoides* cf. *stellarus* (Bis.) and *Anthracoceras* cf. *paucilobum* (Phill.), *Anthrococeras* sp. and *Dimorphoceras* sp. The first two species are characteristic of the middle zone of substage E_2 of Namurian A. The higher substages, that is H_1 and H_2 of the Lower Namurian have not as yet been documented. No goniatites have been encountered in the Upper Namurian deposits of the Lvov-Volhynia basin.

Lithology and sedimentation of the Namurian deposits

The widest geographical distribution of the Namurian deposits is observed in the Lublin basin where they occur chiefly as productive measures. They are characterized by a predominance of aleuritic-pelitic rocks, i.e. of siltstones and mudstones. The coarse-clastic sediments, similarly as the carbonate rocks, are rather subordinate in the Namurian. Moreover, as compared with the Viséan sediments, the Namurian coal deposits are considerably thicker.

The siltstones, often represented by a series a score or so of metres thick, are of grey or dark-grey colour. They are parallel- or cross-bedded, often laminated by lighter sandy material. The bedding planes are more often than not covered with carbonized plant detritus and abundant mica.

The mudstones are dark-grey, chiefly with conchoidal fracture, occasionally showing platy parting. Black, silky or coaly mudstones are fairly common, but brown ones, slightly bituminous, or beige ones with nodular structure, occur, too. Both, the mudstones and siltstones contain here and there animal and non-marine plant remains. Soils with stigmaria beds are also common. They consist of siltstones or mudstones with numerous appendices and relicts of stigmaria.

Here and there the mudstones and siltstones contain fine oölites or sideritic sphaerolites. Besides oölites, iron compounds occur either as pyrite in the form of grains and crystals also nodules occasionally intercalating the rocks, or as concretions and intercalations of siderite. As a rule, the siltstones pass into mudstones very gradually. The siltstones occurring in the Upper Namurian are characterized by major agglomerations of kaolinite and biotite.

The sandstones are mostly white to greyish in colour, equigranular, seldom calcareous, here and there conglomeratic and contain siltstone- and mudstone pebbles. The sandstones are thick-bedded, in parts laminated by mudstone-siltstone material. Mica (biotite and muscovite) is fairly abundant, particularly so on the bedding planes, sideritic concretions are present, too. Coaly streaks, carbonized flora and coal fragments are also common. The Upper Namurian sandstones are often greywack--polycmitic in character. We might mention here the sandstones packed with mica that are called the „silvery" sandstones in the Lvov basin. In the Lublin basin, the bottom of the „silvery" sandstones is arbitrarily accepted as the boundary between the Lower and the Upper Namurian.

The Namurian carbonate rocks represent a very small percent of the rock content. In the lower parts of the Namurian they occur as layers some metres thick, while in the upper parts as thin intercalations. The limestones are grey, fine-crystalline, partly dolomitic, with veinlets of calcite. Some parts of the limestones are marly, occasionally they contain an admixture of bituminous substance. Organodetrital limestones are less common.

The description given above is a generalized one. More detailed accounts of the lithology and petrography of the deposits are given in papers by Bocheński, Bolewski & Michałek (1955); Budkiewicz, Stoch & Wrochniak (1960) and Cebulak & Porzycki (1966), and Porzycki (1966, 1967).

The problem of the coal-productivity of the deposits in the area under consideration is discussed by Dembowski & Porzycki (1967). They show clearly that the northern part of the eastern region of the Lublin basin is the most promising one. In the southern part, the Viséan, Namurian and Westphalian deposits contain fairly numerous but thin intercalations and seams of coal never thicker than 1.2 metres. This is chiefly coking coal but the largest quantities of commercial coal occur in Upper Namurian and Westphalian strata. In the northern part of the Lublin basin, most of the coal seams are partly connected with the Upper Namurian, but first and foremost with the Westphalian where the coal seams are from 0.8 to 3 m thick. With a few exceptions these are all energetic coals. This most promising region lies in the eastern part of the Lublin basin, approximately north-west of Chełm Lubelski and stretches in the direction of Radzyń.

Dembowski & Porzycki (1967) propose to call this coal-bearing region the Lublin Coal Basin.

As compared with those of the Viséan, the Namurian deposits are characterized by a lower percent content of marine sediments, and by a dominance of detrital rocks. Prior to the Viséan but subsequently to the Devonian or the Tournaisian? the Lublin basin was subjected to emersion followed by erosion and denudation which affected the lower members of the Carboniferous and even older deposits.

Another marine transgression took place during the Middle or Upper Viséan. After that time, sediments of great thickness were deposited in result of the continuous general lowering of the area. The sedimentation continued throughout the Upper Carboniferous, the Stephanian excepted.

During the Viséan, the vertical movements were less strong, resulting in a long lasting stabilization of marine conditions as is indicated by thick series of limestones or mudstones bearing a rich and diversified fauna. The Viséan was a period of the maximum subsidence, hence also of the maximum marine transgression within this area.

During the Namurian, the subsidence was also rather strong, and of considerable amplitude. This caused frequent changes in the sedimentary conditions which passed from marine to continental ones and the other way about. These movements were accompanied by uplifts in the alimentary area which was feeding the basin with terrigenous material. This accounts for the diversified type of the deposits (mudstones, siltstones, sandstones). During the uplifting movements, the periods of emersion above the sea level, associated with continental conditions, occurred more frequently, particularly in the eastern part of the basin. Sometimes they lasted so long as to favour the accumulation of large amounts of plant, coal-building material. Hence, the accumulation of coal was preceded by continental conditions when vegetation flourished luxuriantly. Thus, the formation of peatbogs took place at the time of the subsidence of the near-shore lowland, directly before marine transgression. The termination of the process of peat formation was usually caused by it being overflooded by the sea, because the coals are chiefly covered either by limestones or mudstones with a marine fauna.

These coals are autochthonous as is suggested by the presence in their bottom of the rootlet bed gradually passing into coal. The small thickness of the deposits may be explained either by the short duration of the continental conditions or by the relatively poor development of vegetation in the peatbog. Here and there the coal is replaced by an equivalent deposit, i.e. coaly shale. Fairly often the presence may be noted of a rootlet bed without coal in the top. This may be accounted for i.al. by the coal being eroded owing to sea transgression, as is reliably confirmed by the presence of deposits with a marine fauna in the top of the rootlet bed above which the coal had probably been eroded. The rootlet beds are chiefly represented by mudstones or siltstones, laminated by appendices of stigmaria. These had been formed within a low lying region — a peatbog of a slowly subsiding near-shore area where the subsidence was continually being compensated by the supply of terrigenous material from the adjacent land. This fact impeded a satisfactory development of plants and the formation of coal. In cases where the coal deposits were preserved it may reasonably be supposed that the sinking of the near-shore peatbog occurred very slowly, so much so that the accumulated vegetable matter did not suffer erosion.

The nature of the Carboniferous deposits, especially that of the Lower Namurian (lacking coal or with very thin coal seams), indicating a continuous lowering of the sea bottom without phases of stagnation or breaks in sedimentation, suggests that the sedimentation was probably taking place in the littoral zone of the basin. During the prevalence of marine conditions, the area here considered consisted chiefly of off-shore shoals or lagoons, here and there communicating with the open sea. Limestones or mudstones — occasionally siltstone deposits — were laid down there. The Namurian limestones were probably deposited near to the shore line, possibly in short-lasting lagoons which would account for the small thickness of the carbonate deposits. As compared with the mudstones, the limestones displayed a somewhat weaker subsidence of the bottom of the basin. The isolation of the lagoons was responsible for their abnormal salinity and this in turn was a disadvantage to the development of the fauna.

Mudstones, hence the pelites occurring in the Namurian (and the Lower Westphalian) must have formed in calm waters intermittently communicating with the open sea, as is suggested by their fauna, i.al. consisting of goniatites and thin-shelled pelecypods.

That part of the basin adjacent to its bottom, where clay deposits were laid down, was often poorly aerated and contaminated by sulfuretted hydrogen, as is suggested by the concretions and grains of pyrite profusely dispersed in the rock, and by the pyritized shells of the fauna.

From time to time some part of the basin became cut off and de-salted, causing the appearance of brackish or freshwater (non-marine) fauna. This took place mostly in the upper part of the Namurian (Korejwo 1954, 1957). The appearance of the freshwater fauna suggests a long continued limnic facies, usually followed by a continental, frequently coal-bearing facies.

The alternation of the marine and continental deposits indicates a cyclic formation of the whole Carboniferous series, from the Viséan to the Lower Westphalian. Certain bed-complexes re-occur in regular succession and this is particularly characteristic of the paralic basins. The problem of cyclic sedimentation during the Carboniferous was discussed by the writer in papers published in 1958a, b.

The cyclic sedimentation of deposits in the area under consideration is interpreted by the cyclothem (cycle) beginning at the moment of a sudden and strong subsidence of the sedimentary area, followed by shallowing and finally by the formation of peat.

The complete (ideal) cyclothem consists of several phases and its picture (going from the top) is as follows:

4. coal which terminates the cyclothem;

3. continental deposits with a rootlet bed in the top, suggesting rapid sedimentation and filling in of the basin up to the sea level (stagnation of the subsidence movements);

2. brackish deposits (with a brackish or non-marine fauna), suggesting a shallowing and de-salting of the basin;

1. marine deposits suggesting a sea ingression.

The thickness of the Namurian deposits in the Lublin basin varies (in the case of the full profile overlying concordantly the Upper Viséan and underlying the Westphalian). It is as follows: in the east, within a belt running from Hrubieszów to Chełm it is over 400 m thick and gradually decreases in the direction of Parczew where it hardly attains 210 m; to the west and south the thicknesses increase: in borehole Jarczów IG-4 it is 695 m, in boreholes Tyszowce-Komarów 647—718 m; in the vicinity of boreholes Niedrzwica 2 and 3, also of Opole Lub. 5 it exceeds 780 m. To the north-west the thickness still increases to attain 900 m in the region of Dęblin (chart 5).

The above data indicate that the Lublin basin, especially in its western part, had an extremely mobile bottom, subject to nearly continuous lowering. The basin was situated in the littoral or shallow-neritic zone (especially in the east), here and there in the deeper-neritic zone (in the west). The observed presence of a continuous complex of Upper Viséan, Namurian and Lower Westphalian deposits, in places over 1,700.0 m thick, reflects the general subsidence of the whole area during the Carboniferous.

THE CARBONIFEROUS IN WESTERN POMERANIA

In north-western Poland, Carboniferous deposits have been reached in boreholes drilled by the Oil Research Survey and the Geological Institute in the course of the last decade. Data have thus been obtained regarding the occurrence of sediments of this age west of the Precambrian East-European platform, i.e. in the regions of Chojnice-Koszalin and of Kołobrzeg in Western Pomerania (fig. 2).

The Carboniferous (under the Zechstein) was first reached in borehole Bobolice 1 at a depth from 2,742.0—3,005.3 m. The profile of these deposits is described in papers by Poborski & Cimaszewski (1961) and Żelichowski (1968b). It consists of two complexes: the lower one is silty-marly, the upper carbonate-dolomitic. The lower complex, built of grey siltstones, here and there calcareous or dolomitic with interbeddings of marly limestones, contains oölitic intercalations in its bottom parts. The presence of an abundant macrofauna suggests its Tournaisian age.

Owing to the lack of index forms, it is hardly possible to determine the age of the upper, 155 m thick complex which is developed as dolomitized oölitic limestones with intercalations of siltstone, occasionally those of sandstone. It may belong to the Upper Tournaisian, or perhaps already to the Viséan (Żelichowski 1968b).

In an earlier borehole Chojnice 2, calcareous deposits, bearing a fauna of brachiopods and corals, have likewise been reached below the Zechstein, at a depth between 3,047.55 to 3,197.3 metres. By Samsonowicz (vide Tokarski 1959b) they were referred to the Strunian, while Pajchlowa (1964) regards them as Famennian.

In borehole Biały Bór, between 2,632.0 and 2,800.0 m, silty-marly deposits have been encountered below the Zechstein. Similarly as in Bobolice, they contain oölitic layers. The microfauna identified by Woszczyńska (vide Żelichowski 1968b) indicates the Tournaisian age of the deposits.

Additional data concerning the occurrence of the Carboniferous in north-western Poland were obtained from boreholes drilled between 1966 and 1968. These boreholes have not, so far, been fully worked out, hence, the data are incomplete, sometimes even fragmentary.

In borehole Babilon 1 (12 km NW of Bobolice), between 2,618.7 and 3,193.2 m, under the Permian and above the Famennian, there occurs a complex of deposits developed as dark marly limestones, or grey compact, crystalline ones. They yielded an abundant fauna that permitted to distinguish the Tournaisian and the Strunian; the thickness of the latter is a. 200 m (Korejwo & Teller 1968d).

In borehole Brda 1 (19 km NW of Babilon 1), below the Permian and above the Upper Devonian, at a depth between 2,158.0 and 2,610.0 m there occur, faunally established, Viséan and Tournaisian sediments (Korejwo & Teller 1968c). They are developed as brown cherry-coloured, calcareous fine grained sandstones and greyish-beige or greenish siltstones, intercalated by black calcareous mudstones or grey limestones.

In borehole Brda 2, now being drilled, Carboniferous deposits have been reached at a depth of 2,140.0 metres.

In borehole Wierzchowo 3 (a little to the SW of borehole Bobolice 1), below the Zechstein, between 3,301.2 and 3,401.4 m, the limestones are greyish-beige, fine crystalline, with interbeddings of black calcareous mudstones in the top part, and, in the bottom of pinkish greywacke sandstones also interbedded by black mudstones and siltstones. On faunal evidence the profile of the deposits from this borehole underlying the Zechstein has been accepted as partly an equivalent of the Upper Viséan (zone $Go_{\alpha-\beta}$) perhaps also of the Middle Viséan (Korejwo & Teller 1968e).

Viséan sediments have also been reached in borehole Wierzchowo 2. It is noteworthy to mention here how significant is the presence in borehole Wierzchowo 3 of faunal remains reliably indicating the Carboniferous age of the deposits, because analogous deposits, previously found at 3,255.0 m in borehole Wierzchowo 1, had been assigned to the Rothliegendes. A re-examination of these deposits (several tens metres of variegated siltstones, mostly yellowish, interbedded by grey siltstones with plant detritus) led to the discovery of ostracods. According to Woszczyńska (vide Żelichowski 1968b) they reasonably suggest the Lower Namurian age.

Borehole Wierzchowo 4, completed in October 1968, may supply very interesting information. It should be noted that, so far, this is the deepest borehole in Poland. Upper Devonian deposits have not been pierced to the bottom depth of 5,016.0 metres. The conglomerates between a. 3,951.0 and 4,019.0 m, underlying the Zechstein, belong probably to the upper part of the Rothliegendes. Analogous deposits are known from several boreholes in Rügen and north-eastern Mecklenburg. Below the conglomeratic series, down to a depth of 4,900.0 m, occur brown-red mudstones and siltstones, also calcareous beige coloured sandstones, grading downwards into a series of dark mudstones and marly or fine-crystalline limestones. The stratigraphy of these deposits is under elaboration, most probably, however, they belong to the Carboniferous, and below 4,900.0 m perhaps to the Upper Devonian (according to the writer's preliminary identification).

In borehole Gozd 1, N of Bobolice, the Devonian deposits underlying the Permian have not been pierced to the bottom depth of 3,235.4 metres. The top part of these deposits, between 2,358.0 and 2,573.0 m, consisting of mudstone-sandstone rocks, often variegated, and interbedded by limestone intercalations, did not yield any fauna except one poorly preserved brachiopod fragment of the genus *Schelwienella*, found at the bottom. The absence of fauna remains, naturally impedes an accurate age determination of these deposits. Taking, however, into account the distinct change in lithology at the boundary with the underlying, faunally determined deposits of the Famennian, they may reasonably be supposed Lower Carboniferous in age (vide Łobanowski 1968).

In the neighbouring borehole Gozd 2, now being drilled, the presence at 2,331.0 m has been noted of Carboniferous deposits underlying the Zechstein. They are represented by variegated or grey sandstones with intercalations of siltstones and mudstones. A thin coal seam was found at 2,530.4 metres. Lower down there is a predominance of carbonate sediments which, below 2,975.0 m, are probably Devonian in age.

Borehole Koszalin IG-1 (Bojkowski, Cebulak, Jachowicz, Migier & Porzycki 1966b) seems very interesting owing to the presence of the Upper Carboniferous. Grey, silty-sandy deposits, with mudstone occasionally variegated intercalations, underlie the Zechstein, between 2,336.5 and 3,012.0 metres. Intercalations of tuffite rocks are encountered in the mudstones, while interbeddings of calcareous-dolomitic siltstones are very rare. At a depth of ca. 2,531.0 m, a 0.1 m thick intercalation of coal and coaly mudstones has been encountered. Plant remains are fairly abundant throughout this series. The fauna found in a score or so of intercalations between 2,365.1 and 2,996.1 m has been identified by Bojkowski.

Between 2,365.1 and 2,667.5 m there occur: *Orbiculoidea missouriensis* (Shum.), *Lingula mytilloides* Sow., *L. elongata* Dem., *L. elliptica* Dem., *Phestia stilla* (Mc Coy), *Sanguinolites occidentalis* Meek & Hayden, *Edmondia laminata* (Phill.), *Pterinopecten* cf. *rhytmicus* Jacks., *Anthraconaia lenisulcata* (Truem.), *Anthraconauta minima* Past., *Murchisonia* sp., *Mourlonia* sp., *Donaldina* sp., *Spirorbis pusillus* Mart., Ostracoda, remains of crinoids and scales of fishes, i.al. *Rhizodopsis sauroides* (Williamson), *Rhadinichtys* sp.

Between 2,697.5 and 2,813.9 m the fauna consists of *Lingula mytilloides* Sow., *L. elongata* Dem., *Orthotetes hindi* Thom., *Polidevcia sharmani*

(Ether.), *Phestia stilla* (Mc Coy), *Protoschizodus antiquus* (Hind), *P. axiniformis* (Phill.), *Sanguinolites* cf. *angustatus* (Phill.), *Anthraconaia lenisulcata* (Truem.), *Anthraconauta minima* Past., *Ptychomphalus* cf. *intermedius* Kon., *Coleolus* cf. *carbonarius* Dem., *Cycloceras kionoforme* Dem., also fish remains, i.al. *Elonichthys denticulatus* Traquair, *E. robinsoni* Hibb., *E. aitkeni* Traquair, *Megalichthys* sp.

Between 2,830.7 and 2,842.9 m worm structures are numerous, lower, at 2,987.6 m *Edmondia laminata* Phill. A pelecypod of the genus *Edmondia* was the only fossil found between 2,992.3 and 2,996.1 m.

Most of the above forms have a great vertical range, hence comes the difficulty of a closer age determination of the deposits which yield them. In Bojkowski's opinion the identified faunal remains reasonably suggest the Upper Carboniferous (Namurian and Westphalian) age of the sediments down to 2,812.0 metres. Żelichowski (1968b) supposes that in borehole Koszalin IG-1 the top parts of the Carboniferous, to a depth of a. 2,400 m, belong to the Westphalian, while Upper and Lower Namurian sediments occur lower down to the bottom of the borehole.

In the opinion of Migier, who has identified the macrofloral remains from the borehole under consideration, Viséan deposits are represented between 2,512.6 and 2,910.0 m, while Jachowicz thinks that, on the basis of microspores, practically the whole Carboniferous series (the top part excepted) is referable to the Dinantian. It is thus seen that the age of the Carboniferous deposits in borehole Koszalin IG-1 is controversial.

Thanks to drillings, the Carboniferous Koszalin zone is also traceable farther west into the region of Kołobrzeg.

In borehole Ustronie IG-1 (E of Kołobrzeg), below the Zechstein, between 3,105.3 and 3,180.6 m there occurs a complex of sandy deposits interbedded by mudstones and siltstones. The mudstones are with sideritic inclusions and intercalations of marly limestones. All that complex is rather variegated in colour. According to Woszczyńska (vide Dadlez 1965a, 1967a; Żelichowski 1968b) the ostracods present in carbonate deposits indicate the Lower Namurian age.

In this region, the Carboniferous has, moreover, been found directly under the Permian and above the Upper Devonian, in two boreholes: Karcino 1 where Upper Carboniferous sediments have been reached between 2,558.0 and 2,615.0 m, and borehole Grzybowo 1 now being worked out. In the latter borehole, the presence is noted under the Zechstein, between 2,643.0 and 2,704.0 m of variegated siltstones with thin intercalations of pinkish sandstones. Lower down to a depth of 3,088.2 m occur dark grey marly limestones interbedded by calcareous mudstones bearing a fauna of corals and brachiopods Lower Carboniferous in age. At a depth from 3,112.9 to 3,177.0 m have been found fine-grained calcareous greenish sandstones with intercalations of mudstones and limestones; also coarse-grained arkose sandstones. Lower down, to the bottom depth of the borehole, i.e. 3,303.2 m dark grey marly limestones have been reached with a fauna of Devonian brachiopods. It is not excluded that in borehole Grzybowo 1, similarly as in borehole Babilon 1, the profile passes from the Lower Carboniferous through the Strunian to the Famennian.

As may be seen from the above, data on the Carboniferous deposits from the substratum of north-western Poland are still rather general and they have not as yet been fully worked out. Nevertheless, even the mere discovery within this area of nearly all the members of the Carboniferous system, i.e. the Westphalian, the Namurian, the Viséan and the Tournaisian, as well as a thick Strunian directly overlying the Famennian, is of great value in the reconstruction of paleogeographical conditions. In view of the fact that no complete profile of the particular stages of the Dinantian or the Silesian has as yet been pierced, some fragments excepted, their thicknesses can be hardly determined, particularly since the descriptions of the faunal materials are not yet complete while some boreholes are still being drilled.

The preliminary data now available suggest, however, that the Lower Carboniferous is at least 500 m thick, while the Upper Carboniferous is probably thicker. It may also be reasonably inferred that the Carboniferous deposits in NW Poland are a link connecting the Lublin--Lvov area with the German Lowland.

The presence of Paleozoic sediments, i.al. thick Lower and Upper Carboniferous series underlying various Permian members, have, indeed, quite recently been observed in numerous boreholes in Rügen and NE Mecklenburg.

Data from these boreholes are given in papers by German authors (Kölbel 1963, Daber 1963, Albrecht & Goldbecher 1964, Jubitz 1967, Albrecht 1967, Knüpfer 1967, Knüpfer & Weyer 1967, Korich 1967, Pensold 1967, Rost & Schimanski 1967, Weyer 1968). Some information, especially respecting the thickness of the Upper Paleozoic strata in Rügen or in Mecklenburg are contained in published or archival works by Polish authors (Dadlez 1965a, 1967a; Dadlez et al. 1968; Żelichowski 1968b, c).

The presence of the Carboniferous in Rügen was first reported in 1962 from the southern part of the Wittow peninsula and from the Jasmund area. Later drillings have also confirmed the presence of the Carboniferous in central and southern Rügen and in Mecklenburg.

The Dinantian has been found in boreholes Wiek and Lohme (N Rügen), also in Rügen 2 and Rügen 4 (central Rügen). The last of these boreholes is the only one where Carboniferous sediments have been pierced without, however, the Devonian being pierced to the bottom depth of the borehole, i.e. to 4,500 metres.

The presence of algae and of a rich and diversified fauna in the

Dinantian have reliably suggested the distinction of the Middle and the Upper Tournaisian, also that of the Lower, Middle and Upper Viséan (Knüpfer & Weyer 1967, Weyer 1968).

According to the data now available, the total thickness of the Dinantian in Rügen exceeds 1,300 m. Lithologically, the Tournaisian is represented chiefly by dark mudstones and marls with subordinate limestone intercalations. The lower part of the Viséan is characterized by the occurrence of grey and brown limestones interbedded by mudstones. Here and there these are oölitic limestones. The Upper Viséan series is characterized by marly and silty deposits with subordinate limestone intercalations. Cyclic sedimentation is observed, too. Besides the Middle and Upper Tournaisian, only the Lower and Middle Viséan are faunally well documented, while in the upper part of the Viséan, though containing abundant fossil remains, lacks such index forms as *Dibunophyllum* sp. or *Gigantoproductus* sp. On the presence of conodonts, the deposits in the top part of the Dinantian have been referred to the Upper Viséan zone $Go_{\beta-\gamma}$ (Knüpfer & Weyer 1967).

Lower Carboniferous deposits are characterized by intrusions of igneous rocks represented by diabase veins of various thickness (Albrecht 1967, Jubitz 1967).

The Silesian, resting on the Dinantian, has also been observed in the north of Mecklenburg in a belt from Prerow (the Darss peninsula) as far as the vicinity of Greifswald. Most probably it is also present farther east as far as the island of Uznam, but, since the boreholes have not as yet pierced the Lower Permian it has not been reached as yet.

The total thickness of the Silesian locally exceeds 2,000 m. Two Silesian series are distinguished here. The lower is called the „grey series" (Graue Folge), the upper — the "red series" (Rote Folge). Stratigraphically, the position of these series is somewhat doubtful and their mutual boundary is accepted chiefly on lithological evidence.

The lower series is represented by grey siltstones, frequently intercalated by variegated mudstones or light-grey sandstones characterized by the presence of rootlet beds, thin coal seams and plant remains.

The upper series differs from the lower one in a greater number of sandstone intercalations, reddish colouration (due to abundant hematite), the absence of coal seams and absolute lack of fauna.

The grey series used to be regarded as the equivalent of Westphalian A, B and C, the red one as that of Westphalian D and of the Stephanian.

The two above series are characterized by the presence of conglomeratic intercalations and intrusions of igneous rocks.

The Upper Carboniferous is covered here by the Rothliegendes which consists of two complexes: the lower one is eruptive, the upper one sedimentary and developed mainly as conglomerates.

The presence of reliably established Westphalian strata (grey series) has been observed in northern Rügen where it occurs below the terrigenous Zechstein and above the Dinantian in borehole Wiek, while in borehole Lohme it occurs under the red series and above the Dinantian. In central and southern Rügen, the Westphalian sediments have been found in the base of the red series in borehole Rügen 2, overlying the Dinantian, also in Rügen 4 above the Dinantian and the Devonian. Much deeper down, Westphalian deposits have been reached below the red series in boreholes Barth 1, Greifswald, Grimmen 6 and Richtenberg 4 of north-eastern Mecklenburg.

The sediments of the grey series used to be assigned to the Westphalian, indicating a sedimentary gap between the Lower and the Upper Carboniferous (lack of the Namurian). Weyer (vide Żelichowski 1968c) has quite recently observed in borehole Barth 1 (Mecklenburg) the presence within the grey series of ostracods, freshwater pelecypods and goniatites indicating substages H and R_1. This would mean the occurrence in this borehole of deposits of the upper part of Namurian A and those of the lower part of Namurian B. Taking into consideration that the grey series has not been pierced in borehole Barth 1, the presence of the Lower Namurian members here may be reasonably supposed. In borehole Lohme (northern Rügen), the age of the limestones, directly underlying the deposits of Westphalian A, has faunally been determined as Upper Viséan (Knüpfer & Weyer 1967). According to Helms (vide Daber 1963), however, the conodonts present there are known not only from the Upper Viséan but from the lower part of Namurian A, too. Hence, the early Namurian age of the top part of these limestones is borehole Lohme cannot be altogether excluded. Future drillings in this region of NE Germany will, perhaps, clear up whether the Silesian sedimentation was a continuation of that in the Lower Carboniferous which seems rather probable. The sedimentation may have changed its character from a marine one (Dinantian) into paralic (grey series) and limnic (red series).

The upper red series has been observed in all the boreholes discussed above, borehole Wiek of north Rügen excepted; it rests conformably on the grey series (lower one). Borehole Prerow in Mecklenburg is the only one where it has not been pierced.

Hence, the Upper Carboniferous deposits of the north-eastern German Lowland, occurring in Rügen and northern Mecklenburg below a Permo-Mesozoic cover, are developed in a limnic or paralic facies, while the Lower Carboniferous sediments are in a typically marine facies. The Carboniferous deposits rest almost horizontally (dips range from 5 to 10°). Their thickness increases considerably from 675 m in northern Rügen to over 2,400 m in central Rügen. When we consider that in Mecklenburg the thickness of the Upper Carboniferous (never yet pierced) is up to 2,000 m, it may reasonably be supposed that, in the area here discussed, the Carboniferous strata may attain a thickness of several thousand metres. This would suggest greater intensity of movements responsible for the deepening of the pre-Permian sedimentary basin whose marginal shore lay somewhere in the vicinity of northern Arcona. According to Albrecht (1967), during the Upper Carboniferous or the Lower Rothliegendes, Rügen was affected by "germano-type" movements — reflecting the Variscan orogeny — which resulted in the splitting up into blocks of the Devonian-Carboniferous complex. The magma may have migrated then along deep fractures, and major igneous covers may have formed varying considerably in lateral and vertical range. With these movements may have also been associated intrusions of diabases, dioroporphyrites and granoporphyries which are quite common in Carboniferous deposits.

At the present preliminary stage of investigations of the Carboniferous system in NW Poland, as well as in view of the still incomplete descriptions of that system in NE Germany, closer comparisons are hardly possible. The data now available reasonably suggest that deposits both of the Dinantian and the Silesian in Poland are characterized by rather small thicknesses.

The Devonian deposits have been reached in Rügen in one borehole: Rügen 4. The tracing, however, of the passage of the Devonian into the Carboniferous is by no means simple owing to the presence of diabases in the transition interval. In Western Pomerania, the gradual passage from the Devonian to the Carboniferous has been traced in borehole Babilon 1 (where the faunally established Strunian and Tournaisian rest on the Famennian), also in borehole Brda 1 (with the Lower Viséan and Tournaisian on the Upper Devonian), probably also in boreholes Gozd 1 and Wierzchowo 4 (now under elaboration).

On the whole, the Tournaisian and Viséan deposits show a similar development in Western Pomerania and in eastern Germany except that in Western Pomerania the sand content is higher and no intercalations of diabases or other igneous rocks have so far been found. Moreover, in neither area has the passage been observed from the Dinantian to the Silesian, though, as has already been mentioned, certain Namurian members have been found in borehole Barth 1 (Mecklenburg). Hence, in Rügen for example, the supposed sedimentary gap between the Viséan and the Westphalian may be erosive and not tectonic in character as has so far been accepted (Albrecht 1967).

In NW Poland only some incomplete Silesian members have so far been reached. In their lithological development they are partly comparable with the grey series (for example the deposits from boreholes Koszalin IG-1 and Ustronie IG-1). In the grey series of NE Germany, however, there occur frequent intercalations of coal (up to 1 m thick), while in NW Poland (Pomerania) only one, extremely thin coal seam has been observed in boreholes Koszalin IG-1 and Gozd 2. No data are so far available as regards the occurrence of igneous rocks within the area mentioned above so characteristic of the Silesian sediments in Rügen and Mecklenburg (if no account be taken of the tuffite intercalations from borehole Koszalin IG-1). Neither have any age equivalents of the red series been so far encountered in NW Poland. It is, however, probable that the higher Upper Carboniferous strata are present there, particularly so within the occurrence zone of the Rothliegendes.

A detailed description of the fauna will most probably be helpful in the correlation of Carboniferous deposits from the area here discussed, moreover, it may allow to trace in Western Pomerania the passage from the Dinantian to the Silesian. In view of the controversial age of deposits from borehole Koszalin IG-1, it may be supposed that the Viséan grades into the Namurian in that very profile, neither is it excluded that an analogous situation exists in borehole Ustronie IG-1.

During Carboniferous time, NW Poland and NE Germany undoubtedly lay within the same sedimentary basin. On the data of the thickness and depth of occurrence of the young Paleozoic deposits it may reasonably be supposed that Western Pomerania was situated in a rather shallower zone of that basin and that its bottom was somewhat mobile, as is indicated by the thickness of the Carboniferous sediments. On the other hand, however, the complicated Variscan or post-Variscan tectonics of this area cut up by numerous faults, were certainly responsible for the shiftings in the mutual position of the particular blocks. This caused the persistance of some Carboniferous members in the submerged areas, while in other, elevated regions, they were subject to erosion. In some regions of Western Pomerania the Lower Carboniferous may have been followed up by emersions, hence deposits of the Zechstein or the Rothliegendes rest on various members of the Lower Carboniferous, even on the Devonian or older sediments.

BRIEF DESCRIPTION OF THE SILESIAN OCCURRENCE AREAS IN POLAND (OUTSIDE THE POLISH LOWLAND)

Outside the Lublin basin and Western Pomerania, the Upper Carboniferous is also known elsewhere in Poland from natural outcrops and boreholes. Among the most important of these occurrence areas are the Sudetes with their forefield, the Silesia-Cracow region and the Miechów depression.

The literature on the Carboniferous of these regions is very rich and only a few of the synthetic works can be mentioned here, such as Czarnocki (1935), Jachowicz (1968), Książkiewicz, Samsonowicz & Rühle (1965), Małkowski (1937), Oberc (1960), Siedlecki (1954), Sokołowski (1967), Teisseyre, Smulikowski, Oberc et al. (1957). Other, still more recent papers containing new data are quoted in the text.

The Sudetes and their forefield

In this area, the Upper Carboniferous has, so far, been known only from the Intra-Sudetic depression and its presence has only very recently been reported from the North-Sudetic depression (Milewicz 1962) and from the substratum of the Fore-Sudetic monocline (vide Sokołowski 1967). In what the pre-Permian substratum is concerned the Fore-Sudetic monocline is still very inadequately known.

In the Intra-Sudetic and North-Sudetic depressions, the Silesian deposits are characterized by a complete lack of marine fauna, hence they are limnic in character and they represent (with certain gaps) a profile from Namurian A to the Lower Stephanian. The stratigraphy here is based chiefly on macro- and microflora and only freshwater pelecypods have occasionally proved helpful.

Numerous new data have been contributed by sedimentological, tectonic, and still more so, palynological studies. They allowed the age determination of some so far controversial rock complexes from the two above depressions. Some of the papers dealing with this question are by: Dziedzic (1966, 1968), Grocholski & Augustyniak (1968a, b), Górecka (1968).

Within the Intra-Sudetic depression the productive measures of the Silesian are associated with the Namurian and the Westphalian. They occur in several basins, such as that of Wałbrzych, Jugow — Nowa Ruda and Słupiec which are known under the joint name of the Lower Silesia Coal Basin. The Upper Carboniferous deposits either rest conformably (Dziedzic 1966, 1968), on the Dinantian (Upper Viséan), or directly on the gabbro of Nowa Ruda, while along the northern margin of the Intra--Sudetic depression they are here and there in contact with the gneisses of the Sowie Góry Mts.

The lowermost member of the Silesian consists of the Wałbrzych beds, known from the vicinity of Wałbrzych and Wolibórz. These are developed as conglomerates, unequigranular sandstones, siltstones and mudstones, also as coal seams. Their thickness ranges from 300 m in the central part of the Wałbrzych basin to 250 m in the vicinity of Wolibórz.

On the palynological studies carried out by Krawczyńska-Grocholska (1960, 1966) and Górecka (1961) the Wałbrzych beds have been assigned to Namurian A. Górecka (1968) is inclined to regard the top part of the Wałbrzych beds from the vicinity of Biały Kamień as Lower Namurian B.

On the Wałbrzych beds, partly unconformably and transgressively, rest the Biały Kamień beds which are characterized by coarse-clastic sediments containing two coal seams. The most typical development of these beds has been observed in the vicinity of Biały Kamień and Wałbrzych. Their lower part is built of coarse-clastic sediments displaying features of molass deposits. At the base of this complex the size of pebbles is up to 30 cm. In the upper part the material grows finer-grained and siltstone- and mudstone intercalations make their appearance. The thickness of the Biały Kamień beds ranges from 300 to 350 m, decreasing considerably to the SE and thinning out in the region of Nowa Ruda — Słupiec. Palynological studies have shown that the Biały Kamień beds represent Upper Namurian B and C and a part of the Lower Westphalian A (Górecka 1968, Krawczyńska-Grocholska 1966).

It should be mentioned here that, in the vicinity of Nowa Ruda and Słupiec, at the base of the Westphalian strata, there occur sediments formed in result of the weathering of the gabbro massif; they contain i.al. intercalations of refractory shales. In age these deposits correspond to the Biały Kamień beds (after J. Oberc). Other authors, such as Don or Dziedzic regard them as older (Lower Carboniferous or Devonian) (vide Grocholski & Augustyniak 1968a, b).

The Biały Kamień beds grade upwards into the Żacler beds. In the Intra-Sudetic depression (on the Polish side) these beds attain their most complete profile in the Wałbrzych basin and their thickness exceeds 900 m. They also occur in the vicinity of Lubawka, Borówno, Ludwikowice — Nowa Ruda, Nowy Dzikowiec and Słupiec, but their thickness there is considerably reduced. They are characterized by strongly differentiated lithology. The lower part of the Żacler beds, referred to Westphalian A, is developed as silty-sandy deposits with numerous coal seams, separated by a barren series of conglomeratic thick-bedded sandstones. The upper part, representing Westphalian B, is characterized by coarse-clastic deposits.

The Żacler beds are overlain by the Glinik beds which are characteristic by the reddish colour of their coarse-clastic and fine sediments, the absence of coal and the presence of variegated intercalations of mudstones. The conglomerates are made up of pebbles from the lower-lying Żacler, Biały Kamień and even Culm beds, while rocks of volcanic origin are present, too. The sedimentation of the Glinik beds took place at the moment of the great intensity of the Asturian phase, associated with volcanic activity suggested by the presence of tuffs and porphyry breccias. The thickness of the Glinik beds ranges from 600 m in the Wałbrzych region to 175 m in the vicinity of Wolibórz. Stratigraphically the Glinik beds represent the Upper Westphalian, perhaps also the Lower Stephanian (Grocholski & Augustyniak 1968a, b). In the Upper Westphalian of the Nowa Ruda area, silicified (allochthonous) tree trunks are often encountered (Dziedzic 1959, 1966).

In the Intra-Sudetic depression the uppermost member of the Upper Carboniferous is represented by the Ludwikowice beds (Grocholski & Augustyniak 1968a). Three complexes have been differentiated here: the red polymictic conglomerates, the tabular sandstones and finally the siltstones and mudstones (the so called lower Anthracosia shales). The macro- and microfloral remains in these strata reasonably suggest their Stephanian age. This is also confirmed by the presence of numerous freshwater pelecypods, *Anthraconaia prolifera* (Watson), recently found in borehole Rybno S-5 (Augustyniak, Górecka et al. 1968). This species has previously been reported from the Lower Stephanian in the Saar and Lorraine basins. The Ludwikowice beds are most completely developed in the SE part of the basin (in the vicinity of Nowa Ruda) where they are ca. 350 m thick; to the NW they decrease in thickness and thin out to the SE of Wałbrzych.

In the light of the above data, the stratigraphic boundary between the Stephanian and the Rothliegendes runs above the beds with *Anthraconaia prolifera* (Watson). These beds have, so far, been currently referred to the Lower Permian, and only in 1961 were they recognized by Don as the equivalent of the Stephanian (vide Grocholski & Augustyniak 1968b). In the Intra-Sudetic depression, Permian sedimentary and volcanic deposits overlie various members of the Silesian (Westphalian, Stephanian).

In the North-Sudetic depression, the presence of Upper Carboniferous sediments has been observed but a few years ago (Milewicz 1962). These deposits occur in a narrow belt along the southern margin of the area under consideration, from Świerzawa in the east to the NE of Zgorzelec. Previously they were referred to the Lower and Middle Rothliegendes. Lithologically they represent brown conglomerates and sandstones, also dark mudstone deposits, occasionally calcareous. On the presence of freshwater pelecypods from the genus *Anthraconaia*, and of microspores, the above deposits have been accepted as equivalents of Westphalian B, Westphalian D and the Stephanian (Milewicz 1965, 1968; Milewicz & Górecka 1965).

Drillings carried out by the Oil Research Survey have revealed the presence of Carboniferous sediments (both Dinantian and Silesian) in the substratum of the Fore-Sudetic monocline (as this unit was called by Tokarski in 1958). Until now the Carboniferous deposits has been just reached below the Rothliegendes in numerous boreholes. In most cases these deposits are silty-muddy and sandy, often reddish-brown in colour, more often than not slightly metamorphosed and disturbed (variable dips). The literature dealing with the area here considered is very rich, but only that concerning the post-Carboniferous sediments. The data on the Carboniferous have been taken from the rather scarce publications, partly also from archival papers (vide Sokołowski 1967 for a specification of all the boreholes drilled up to the year 1965/66).

Paleontologically established Dinantian sediments, representing various Upper Viséan members, have been encountered in the following boreholes of the Ostrzeszów region: Ostrzeszów 1 (Tokarski 1959a, Żelichowski 1964a); Mąkoszyce 1 (Korejwo & Teller 1967a) and Marcinki IG-1 (Korejwo & Teller 1968g). Dinantian deposits have also been observed in the Ostrów Wlkp. region, i.al. in boreholes Uciechów 1 (vide Sokołowski 1967), Sulmierzyce 1 and Lamki 1, also in borehole Sułów 1 (Korejwo & Teller 1966, 1967a) in the vicinity of Rawicz. In the western part of the area under consideration, deposits, probably Lower Carboniferous in age, have been found i.al. in boreholes Wschowa 1, Wichów 1 and Klępinka 1 (Żelichowski 1964c) and in borehole Brzozów 1 (Sokołowski 1967).

In the south-eastern part of the substratum of the Fore-Sudetic monocline, the Carboniferous has been encountered in borehole Wołczyn IG-1 (being drilled). The deposits occurring at a depth from 817.0—1,264.0 m have been identified by the writer as Upper Viséan on the presence, of *Goniatites* cf. *intermedius* (Kob.).

The faunally established deposits of the Lower Silesian have been found only in boreholes Ostrzeszów 1 and Tarchały 1.

In borehole Ostrzeszów 1, below the Rothliegendes and above the Viséan, at a depth between 1,751.0—1,936.0 m the occurrence is noted of mudstones and siltstones, chiefly red tinted, with intercalations of greywacke sandstones. The dip of the beds is between 5 and 15°. The bottom part of the deposits has yielded the goniatite *Eumorphoceras* cf. *pseudobilingue* Bisat, suggesting the Lower Namurian age (Żelichowski 1964a).

In borehole Tarchały 1 (a few kilometres to the SE of Ostrów Wlkp.), a series of variegated siltstones and mudstones, here and there strongly metamorphosed, has been reached at a depth between 1,828.9 and 1,850.2 metres. The dip of the beds here ranges from 45 to 90 degrees. In addition to carbonized plant remains a fauna has also been found, i.al. *Posidonia* cf. *corrugata* Ether. and *Anthracoceras* cf. *paucilobum* (Phill.). The above series has been assigned to the lower part of Namurian A (substage E_2) (Korejwo & Teller 1965). As compared with the Namurian from Ostrzeszów, the Carboniferous from the Tarchały 1 borehole represents a higher member.

In borehole Rawicz 1, between 1,586.3 and 1,606.3 m, a complex of grey siltstones with sandy streaks dipping at an angle of 45—50° has been encountered below horizontally lying deposits of the Rothliegendes. These deposits bear only very few and more closely indeterminate plant remains. On lithological comparisons they are believed by Żelichowski (1964c) to correspond to the top beds of the Lower Namurian reached at Ostrzeszów.

In borehole Marcinki IG-1, S of Ostrzeszów, Carboniferous sediments were reached between 1,734.1 and 3,402.0 m (borehole still being drilled), developed as sandstones, siltstones and mudstones with a subordinate admixture of conglomeratic rocks. The whole complex is strongly tectonically disturbed and shows varying dips (occasionally up to 90°) and slightly metamorphosed sediments. Between 2,159.7 and 3,402.0 m a goniatite fauna has been found reliably suggesting the assignment of the deposits from this depth to the Upper Viséan (zones Goγ and Goβ). It is hardly possible to say anything about the age of the overlying series.

A fragmentary goniatite specimen from the genus *Dimorphoceras*, found at 1,832.8 m cannot be specifically identified. This genus may occur both in the Upper Viséan and in the Namurian. Taking into account the great thickness of the sediments here considered (456 m) as well as the thickness of zone Goγ in the Upper Viséan in borehole Ostrzeszów (240 m) and that in borehole Lamki 1 (229 m) — without the zone being pierced — it may be reasonably suggested that the top part of the Carboniferous deposits from borehole Marcinki IG-1, may, partly at least, represent already the Upper Carboniferous (Lower Namurian), though paleontological evidence is lacking (Korejwo & Teller 1968g).

Over 30 years ago, Carboniferous deposits were reached in borehole Leśna SE of Kluczbork. Assman (vide Żelichowski 1964c) referred them to the Dinantian, chiefly on the absence of coal seams and the presence of flora with the species *Lepidodendron veltheimi* Sternb.

According to Żelichowski (1964c) it is not excluded that the deposits from Leśna may also represent Lower Namurian A.

The Upper Carboniferous (Silesian) deposits in the substratum of the Fore-Sudetic monocline have, so far, been inadequately studied. It is not unlikely that more detailed investigations will show the Upper Carboniferous age of the bottom parts of the Rothliegendes, similarly as is the case in the North-Sudetic depression where palynological studies have led to the differentiation of the upper members of the Silesian, i.e. of the Westphalian and the Stephanian.

The present distribution of the Carboniferous deposits in the substratum of the Fore-Sudetic monocline was affected by later major tectonic-erosional changes introduced during the Variscan and the Alpine orogenies.

The Silesia-Cracow region

The description of this area covered not only the proper Upper Silesia basin, delimited by the Upper Carboniferous exposures and the line of the Carpathian overthrust and its part covered by the Carpathian flysch, but also the NE margin of that basin (Miechów depression). Boreholes in the latter region have reliably established the presence of Namurian deposits; redeposited coal pebbles, probably Westphalian in age, have been found in Jurassic and Triassic rocks.

In the Upper Silesia basin (also called the Silesia-Cracow basin), the Silesian strata rest on the Culm in the west and, partly on coaly limestone in the east. The Silesian outcrops occur between Zabrze — Chorzów — Mysłowice — Mikołów and Jaworzno. In the north-eastern part of the basin, the above sediments crop out from the vicinity of Kozłowa Góra to Dąbrowa Górnicza — Gołonóg and Zagórze. Namurian and Westphalian deposits are found in the above outcrops while Stephanian sediments are known from the eastern part of the basin where they occur as small single exposures in the vicinity of Chrzanów, Alwernia and Szczakowa. Outside the exposures the Silesian also occurs below younger deposits: in the north below the Triassic, in the central and southern parts below the Tertiary.

The Upper Carboniferous of the Upper Silesia basin consists of two formations. The lower one is paralic, with a total thickness of ca. 3,500 m and belonging to Namurian A; the upper is limnic, over 4,000 m in thickness, belonging to Namurian B and C, also to the Westphalian.

The lowermost part of the Upper Carboniferous of the Upper Silesia basin consists of a group of marginal series encompassing the basin on the west, north and east, as well as the south (below the Carpathian flysch). They attain their maximum thickness of 3,000 m in the west, towards the east it is reduced to 1,500—1,000 m and to a few hundred metres towards the south. The marginal series are developed as siltstones, mudstones and sandstones containing numerous coal seams. Here and there occur characteristic horizons of tuffite rocks, e.g. whetstone. The marginal series is characterized by sedimentation of the paralic type, because it contains numerous horizons with marine or freshwater faunas.

On the basis of its lithology and the character of the fauna, the marginal series has been divided into smaller stratigraphic units. From the bottom upwards they are the beds of Kyjovice, Petřkovice, Hrušov and Poruba. These subdivisions are used in the western part of the basin, while a different nomenclature is used for beds in the north-western and eastern parts (Bojkowski 1967; Stopa 1967; Jachowicz 1967, 1968).

On the basis of the marine and freshwater faunas and of the mega- and microflora, the deposits of the marginal series are referred to the Lower Namurian (Namurian A). The diversified abundance of the fauna, chiefly goniatites, has suggested the differentiation within the marginal series of the goniatite substages E_1 and E_2, i.e. the lower part of Namurian A. No data are, however, available concerning the equivalents of substages H_1 and H_2 which characterize the upper part of the Namurian.

The boundary between the Upper Viséan and the Lower Namurian has been traced in borehole Puńców in the south-west of the basin under the Carpathian flysch (Korejwo 1959, vide Konior & Tokarski 1959), in borehole Borek Szlachecki (Bojkowski 1967) in the south-east, and in borehole Gołonóg (Bojkowski 1959, 1961; Czarniecki 1959) in the north-east.

The next member of the Silesian is represented by the anticlinal series (or the Zabrze beds), already limnic in character (lack of horizons with a marine fauna). This series is characterized by rather smal thicknesses, ranging from 250 m in the vicinity of Zabrze in the west to a score or so metres near Dąbrowa Górnicza in the east. It contains, however, some thick coal seams merging towards the east into one seam 24 m in thickness. The anticlinal series rest conformably (with very few signs of outwash) on beds of the marginal series but they occupy a smaller area than the latter, being absent from the eastern part of the basin. Lithologically they are developed as sandstones and conglomerates with minor interbeddings of silty-muddy rocks. On floristic data the anticlinal series (Zabrze beds) have been assigned to Namurian B (Jachowicz 1967, Stopa 1967).

The synclinal series, lying higher up, is divided into a lower and an upper complex (vide Jachowicz 1968). The lower complex comprises the Ruda beds developed as unequigranular sandstones, often arkose, here and there conglomeratic, and the Orzesze beds represented by silty-muddy sediments with minor sandstone intercalations. The upper complex consists of the Łaziska and the Libiąż beds built up of sandstones and conglomerates. Thick coal seams occur in both complexes.

On the basis of mega- and micro-flora, also of freshwater pelecypods, it has been accepted that the lower part of the Ruda beds represent the uppermost stage of the Namurian series — Namurian C, while the upper part and the Orzesze beds represent the Lower Westphalian (Westphalian A and B). The Łaziska beds correspond to Westphalian C, the Libiąż beds to Westphalian D.

The Ruda beds as well as the lower and middle parts of the Orzesze beds have persisted in the western and north-eastern parts of the basin, while the higher members of the Orzesze beds are present in the central and eastern areas of the basin. The maximum western thickness of the Ruda beds is c. 850 m, that of the Orzesze beds exceeds 1,200 metres. In the east, partly in the south-east, the thickness of the Ruda and the Orzesze beds decreases markedly. Its greatest reduction is observed to the east and south-east of the line Jaworzno — Brzeszcze — Wisła. In the Cracow area and on the Vistula (in boreholes between Oświęcim and Skawina) the absence is noted of the Ruda beds (similarly as of the anticlinal series) and of the lower parts of the Orzesze beds, while the upper parts of the Orzesze beds rest directly on the marginal series. The Łaziska beds (Westphalian C) and the Libiąż beds (Westphalian D) have been distinguished in the uppermost Westphalian deposits of the Silesia--Cracow region. Lithologically they are characterized by reddish sandstone deposits with conglomerate intercalations, also by thick coal seams. In the central part of the basin, the Łaziska beds lie conformably on the Orzesze beds; their thickness decreases to the east. The Libiąż beds, c. 400 m thick, are known only from the eastern part of the basin.

Stopa (1967) has suggested certain changes in the division of the Silesia-Cracow Carboniferous. They relate to the synclinal series whose lower part he differentiates into the Ruda beds (Namurian C), while in the higher part (from the bottom upwards) he distinguishes the beds of Załęże (Westphalian A), of Mikołów = the Orzesze and Łaziska beds (Westphalian B), of Chełm (Westphalian C) and of Libiąż (Westphalian D).

The sedimentation of the productive measures ended in Westphalian D in result of the Variscan orogeny (Asturian phase) which is responsible for the folding of the Carboniferous (and Devonian) deposits. After emersion the area here considered was subjected to erosion and denudation. In this connection, the coal-bearing formation is unconformably and with a stratigraphic lacuna (absence of the top part of Westphalian D and of Stephanian A) covered by the terrestial sediments of Kwaczała-Karniowice, 100—150 m in thickness. These sediments have long been regarded as Permian and Siedlecki (1954, 1958) was the first to assign them to Stephanian B and C. The lower part of these sediments is represented by the Kwaczała arkose which occurs between Kwaczała — Libiąż — Chełm — Jaworzno — Siersza and Karniowice. It consists of thick arkose sandstones intercalated by gravels and red muds. Frequently they contain silicified araukaria trunks. North of the above belt of outcrops are the Karniowice sandstones [2], more fine-grained than the arkoses. They are covered by a several metres thick layer of Karniowice sinter (a freshwater travertine limestone bearing a rich flora in situ, also freshwater gastropods). The Karniowice sinter (2—6 m) is found in the vicinity of the villages of Karniowice and Filipowice and it occupies an area of a. 6 sq. km.

Thus, the Upper Carboniferous (Silesian) of the Silesia-Cracow area represents (with minor lacunae), all the stages. The lower Silesian member (Namurian A) is developed in the paralic facies, the higher one (Namurian B and C, also Westphalian A, B, C and D) in the limnic and continental (Stephanian B and C) facies.

At the base of the lower member we can observe a marked change in the floristic assemblage, particularly in the mega- and micro-flora. The sea ingressions into the basin come to an end at that time. In the stratigraphic interpretation, this paleobotanical break between the paralic and the limnic series of the Silesian in the Silesia-Cracow area is identified with the boundary between the Lower Namurian (A) and the Upper Namurian (B + C). In the western part of the area here considered, have persisted chiefly the older Silesian deposits (Namurian and Westphalian), while in the central and still more in the eastern parts the younger members (Upper Westphalian — here and there the Stephanian) rest on greatly reduced older members (occasionally with a sedimentary gap).

The most southern occurrence area of the productive Carboniferous is near Ostrawa and Karwina (in Czechoslovakian territory) moreover, rather near the surface, it occurs i.al. at Czechowice, Brzeszcze, Spytkowice and Bachowice near Zator. SW of these occurrence areas the Upper

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[2] On the basis of new plant remains found by I. Lipiarski (1966, 1967) the Filipowice sandstones are referred by him to the lowermost part of the Upper Westphalian A. According to that author the Karniowice sandstones are also Westphalian in age.

Carboniferous underlies at considerable depths the Miocene deposits overthrust by those of the Cretaceous and the Carpathian Paleogene. For example in Cieszyn-Silesia, the Carboniferous is present at a depth of 1,032 m in borehole Zamarski, at 645 m in borehole Puńców and at 533 m in Cieszyn. This shows that towards the south the Carboniferous descends below the Carpathians, but its range is unknown. Most probably, the area where the productive Carboniferous measures accumulated, stretched rather far east of the Silesia-Cracow area. This is suggested by pebbles from this formation and coal pebbles that are encountered in the Carpathian flysch as far as Sanok and Przemyśl.

Zerndt (1933) was the first to carry out megaspore studies of coal blocks from the Western Carpathians whose age he defined as Westphalian.

The suggestions of Nowak and Książkiewicz, later on of Bukowy, as regards the possibility of the existence of a coal basin not necessarily connected with the Upper Silesia basin, were based on the presence of the Carboniferous exotics.

The Miechów depresion

The eastern range of the Upper Carboniferous in the Upper Silesia basin has long attracted the attention of geologists. The presence of Silesian deposits E of the Dębnik ridge was suggested by Zaręczny as far back as in 1894, more recently by Siedlecki (1954). According to the latter author, the exotics encountered in flysch deposits had been supplied by the Carboniferous of the above region.

New data have been made available by the recent investigations of the eastern and north-eastern margins of the basin. Direct or indirect evidence is brought forward concerning the occurrence in this area not only of the Dinantian but also of certain members of the Silesian.

To the east the Siewierz-Krzeszowice zone where the Devonian and Lower Carboniferous deposits occur on the surface, Upper Carboniferous sediments without coals have been reached in boreholes Mrzygłód near Zawiercie, Bębło near Ojców and Trojanowice near Cracow (Ekiert 1957; Bukowy 1960, 1961b). In boreholes Bębło and Mrzygłód the Silesian deposits rest on the Silurian (Siedlecki 1962). Much earlier pebbles of coal had been reported in the same area from the base of the Jurassic in borehole Dąbie near Cracow (Różycki 1953). Moreover, small coal fragments were encountered in boreholes Batowice, Sułkowice (Krasieniec) and Imbramowice (vide Bukowy & Jachowicz 1964). In borehole Imbramowice the Silurian is unconformably overlaid by Westphalian or Stephanian deposits. These, similarly as in borehole Bębło, are developed as sandstones and arkose conglomerates (Bukowy 1964b). Farther E, in the western part of the Miechów depression, poorly rounded fragments of Carboniferous shales and of coal were found in borehole Słomniki IG-1. The microspore analyses of coal suggest the Lower Westphalian age (Bukowy & Jachowicz 1964). In borehole Łobzów (Szreniawa), NW of Słomniki, small coal fragments have been found in limestones of the Upper Callovian, while bigger coal pebbles (up to 8 cm in diameter) have been found in the underlying conglomerate of the Middle Callovian. This conglomerate, a. 4 m thick, occurs in the top of Triassic limestones and consists chiefly of fragments of coal and those of shales with impressions of calamites. The spore-and-pollen coal assemblage from borehole Łobzów is typical of the uppermost Westphalian, i.e. Westphalian C and D (Bukowy & Jachowicz 1964). It is interesting to note that an analogous assemblage had been previously observed in the Upper Westphalian of the Bug basin (Jachowicz 1964), moreover, it is known from many other European basins. According to Jachowicz, it differs, however, from a contemporaneous assemblage in the Upper Silesia basin.

The presence of redeposited coal fragments among Mesozoic deposits may indicate the occurrence of higher Silesian members in the Miechów depression or in its close neighbourhood. Suggestions concerning the presence of Carboniferous productive measures in the Miechów depression have already been advanced by Bukowy (1958). They were based on an analysis of Carboniferous exotics in the Carpathian flysch from the vicinity of Dębica and Rzeszów.

Borehole data have confirmed Bukowy's suggestions, so far, however only the lower Silesian members (Namurian) without coal have been observed. Borehole Słomniki IG-1, drilled in 1959—61 is that most important, since dark-grey mudstones and siltstones, intercalated by sandstones, occur below the Jurassic and above the Upper Viséan between 638.5—727.0 m. Plant detritus are the only organic remains found there. The above deposits (without coals) have been assigned to the Lower Namurian (Bukowy 1961a, 1964a, b; Bojkowski & Bukowy 1966; Bukowy & Jachowicz 1964).

In 1966/67, in borehole Marszowice 1 (some kilometres S of Słomniki), faunally established Namurian deposits were found under the Jurassic and above the Upper Viséan at a depth from 532.5 to 728.0 metres. The above is a complex of dark mudstones with numerous slickensides, carbonized plant detritus and fairly abundant fauna indicating the Lower Namurian age (Korejwo & Teller 1968b).

In the near-by borehole Koniusza 1, at a depth between 717.7 and 1,478.2 m only Upper Viséan deposits have been reached under the Jurassic.

Several other boreholes were drilled NE of the ones just mentioned, but the presence of the Carboniferous (Lower Carboniferous) has been observed in only two of them. In borehole Skalbmierz 3, Upper and Middle

Viséan deposits (Kicuła & Żakowa 1966) occur under the Triassic, probably also under the Permian, and above the Devonian, between 1,441.4 and 2,030.0 metres. Deposits analogous in age have also been reached in borehole Strożyska 5, farther east, where they occur under the Permian and above the Devonian between 1,673.0 and 1,875.0 m (Bednarczyk, Korejwo et al. 1968).

Hence, it is quite probable that, after the Lower Namurian, the area under consideration long continued to be emersed. Here and there, the continental period persisted until the Permian, the Triassic or the Jurassic. Erosion affected various members of the Carboniferous, here and there they were completely denuded.

The presence among Mesozoic deposits, of redeposited Westphalian pebbles, reasonably suggests the occurrence of higher Silesian members in the Miechów depression or in its neighbourhood. Tectonic speculations concerning the geological structure of the Paleozoic in the eastern margins of the Upper Silesia basin have led Bukowy (1964a) to suppose that the alimentary basin from which the coal fragments are brought may lie still farther NE of the Upper Silesia basin.

POLISH NAMURIAN IN THE BACKGROUND OF EUROPEAN PALEOGEOGRAPHY

The Variscan orogeny that continued from the Devonian, throughout the Carboniferous and the Permian, has printed an indelible stamp on the paleogeography of Europe. While in the Lower Carboniferous, open--sea conditions prevail both in western and eastern Europe, they are altered conspicuously already at the close of the Dinantian so that the sea retreats considerably in result of major Variscan events, particularly of the Sudetic phase in western Europe.

In the northern forefield of the gradually uplifted Variscan massif, a foredeep was formed stretching from Great Britain, across northern France, Belgium, Holland, Germany, Poland, part of Czechoslovakia and the south-western Ukraine of the USSR. In this intermittently deepening Subvariscan foredeep, material brought from the denuded areas of the mountain massifs was deposited to a great thickness. In the Namurian and the Lower Westphalian, the sediments are paralic in character and contain productive coal measures. It is only in Scotland, the Polish Lublin basin, and the Lvov-Volhynia and Donetz basins of the USSR that coal seams are known already from the Upper Viséan.

Thus, the above foredeep is connected with continuous paralic basins, characterized by cyclic sedimentation and formed north of the Variscan massifs. This continuous chain of paralic Carboniferous sediments differs from deposits of the same system occurring farther south in intramountainous depressions of the Variscan massifs. Limnic coal basins formed there such as those in the Central French massif or the Saar, Pilzno and Lower Silesia basins.

The Silesian sediments, laid down in the Subvariscan foredeep during the Asturian diastrophism of the Variscan orogeny in results of tectonic or epeirogenic movements, have been either folded or uplifted and this accounts for the absence in the paralic basins of deposits younger than the Westphalian.

The post-Variscan movements in this area were chiefly of the block-tectonics type.

In the British Isles, the sedimentation of the Carboniferous deposits took place within a basin lying south of the old North-Atlantic continent which comprised N Scotland, partly also northern Ireland. The vicinity of this land undoubtedly affected the sedimentation of the Namurian, particularly so in Scotland and northern England. The Namurian basin, lying to the south of the above continent, was divided by the Irish-Welsh-Brabant massif. Because of the uplifting movements at the turn of the Dinantian into the Silesian this massif formed a barrier impeding free faunal migration between the two parts of the basin and had some bearing on facial differentiation. The Irish-Welsh-Brabant massif stretched from southern Ireland across Wales as far as the Brabant area on the Continent. Farther south, the sea basin of south-western England was connected with the Franco-Belgian basin extending far to the east.

In Scotland, partly also in northern England (Northumberland), the Namurian deposits which are a continuation of the Viséan, are developed in a characteristic and rather different facies than elsewhere in Great Britain. Namely, they consist chiefly of limestones bearing an abundant fauna of brachiopods while in the Lower Namurian pelecypods and goniatites are less common (Wilson 1967). The limestones are interbedded by clay shales (often calcareous) and by sandstones. In the higher parts of the profile the number of sandstone interbeddings increases, the material becomes coarser-grained and resembles the sandstone typical of the Millstone Grit series. Coal seams are found in the area here considered already from the Viséan.

The widest distribution of the Namurian series, as well as its relatively most complete development, are observed in the Pennine range in Yorkshire, Lancashire, Derbyshire and Staffordshire (Moseley 1954, Bisat & Hudson 1943, Earp et al. 1961, Johnson 1960, Johnson et al. 1962, Ramsbottom et al. 1962, Smith et al. 1967).

Moreover, various Namurian members are known in Ireland (Hodson 1954, 1957, 1959; Nevill 1956; Hodson & Lewarne 1961; Yates 1962; Brennand 1965), in South Wales (Ware 1939, Owen & Rhodes 1960), also in Devon and Cornwall (Butcher & Hodson 1960). In the Pennine region, mudstone deposits intercalated by sandstones rest conformably on the Viséan, while in Yorkshire, partly also in Ireland and South Wales, they lie transgressively on various horizons of the Viséan or even older deposits.

The Lower Namurian sediments are, on the whole, represented by mudstones and siltstones containing a fauna of goniatites and pelecypods. There are a few carbonate intercalations with brachiopods and corals, sandstones occur, too.

The Upper Namurian series is represented by the so called Millstone Grit. Its thickness decreases markedly from north to south, from 1,000 m in Northumberland to 200 m in Wales. It is built of coarse-grained sandstones, here and there conglomeratic, with thin intercalations of mudstones containing a marine fauna. Towards the top the number of mudstone intercalations decreases and coal seams make their appearance. The mineral composition of the sandstones here varies. To the north of the Brabant massif the sandstones consist of coarse- and medium-grained arkoses with pebbles of metamorphic and volcanic rocks. South of the above massif, in South Wales, the series consists of quartz and sandstones, quartzites and conglomerates.

Throughout the Namurian series a very abundant goniatite fauna is present in the mudstone intercalations and frequent calcareous concretions. Thanks to these fossils it was possible to carry out a detailed stratigraphy of the region and to differentiate the substages and goniatite zones and subzones (vide chart 2).

The Namurian is also known in France (Bassin du Nord et du Pas--de-Calais) where it is developed as ampelite (bituminous) shales and sandy-muddy deposits bearing a fauna i.al. of goniatites. These two complexes are separated by a series of coarse-grained sandstones (Gres de Suchemont) and by sediments of stigmaria soils (Zone de Murs) with coal seams. The thickness of the Namurian varies, ranging from 60 m in the west to 600 m in the east in the Valenciennes region (Chalard 1960a, b).

In Belgium, similarly as in France and England, at the end of the Viséan and the beginning of the Namurian, the carbonate facies with brachiopods and corals changes into a mudstone one with goniatites and pelecypods. Mudstone intercalations appear already in the Upper Viséan and this part of the profile has been distinguished by Demanet (1958) under the name of passage beds (couches de passage). The sediments of the Lower Namurian (whose old name is Assise de Chokier), sometimes transgressively lying on the Viséan or even the Famennian (Bouckaert 1967), are developed as mudstones or ampelites without coal. The sediments of the Upper Namurian (formerly known as Assise d'Andenne) are represented by sandstones with interbeddings of limestones and with coal seams. The fauna is abundant both in the Lower and the Upper Carboniferous (Demanet 1941, 1943). On the basis of goniatites the same substages and goniatite zones as in England have also been established in Belgium (vide van Leckwijck 1964b). The thickness of the Namurian, which occurs in Belgium in the synclinorium of Dinant, the massif of Vesdre and Theux, in the synclinorium of Namur and the Campine region, varies from 330 m in the Charleroi region of the west to 400 m in the Liège region towards the east, while at Campine it is 695 metres.

To the SE, in Holland (Limburg), the thickness of the Namurian increases to 750 m while lithologically its deposits resemble those in Belgium. The Lower Namurian (the Gulpen group) is developed as mudstones with interbeddings of limestones in the lower part and those of sandstones and quartzites higher up. The Namurian B sediments (Epen group) and those of Namurian C (Ubachsberggroup) are represented by mudstones and sandstones, but the coal seams do not make their appearance until Namurian C (Dorsman 1945).

In the near-by Aachen region, in German territory, the coals make their appearance a little earlier, i.e. in Namurian B. The Carboniferous sediments of the Aachen region are a link connecting the Franco-Belgium and Rhine-Westphalia provinces (Hodson & van Leckwijck 1958, Bouckaert & Herbst 1960). In the Namurian we distinguish the Walhorn beds and the Wilhelmine horizon, divided up by a well marked conglomerate layer from the higher-lying Krebs-Traufe horizon. Lithologically and faunally the a. 800 m thick Namurian deposits of the Aachen region resemble those of Belgium.

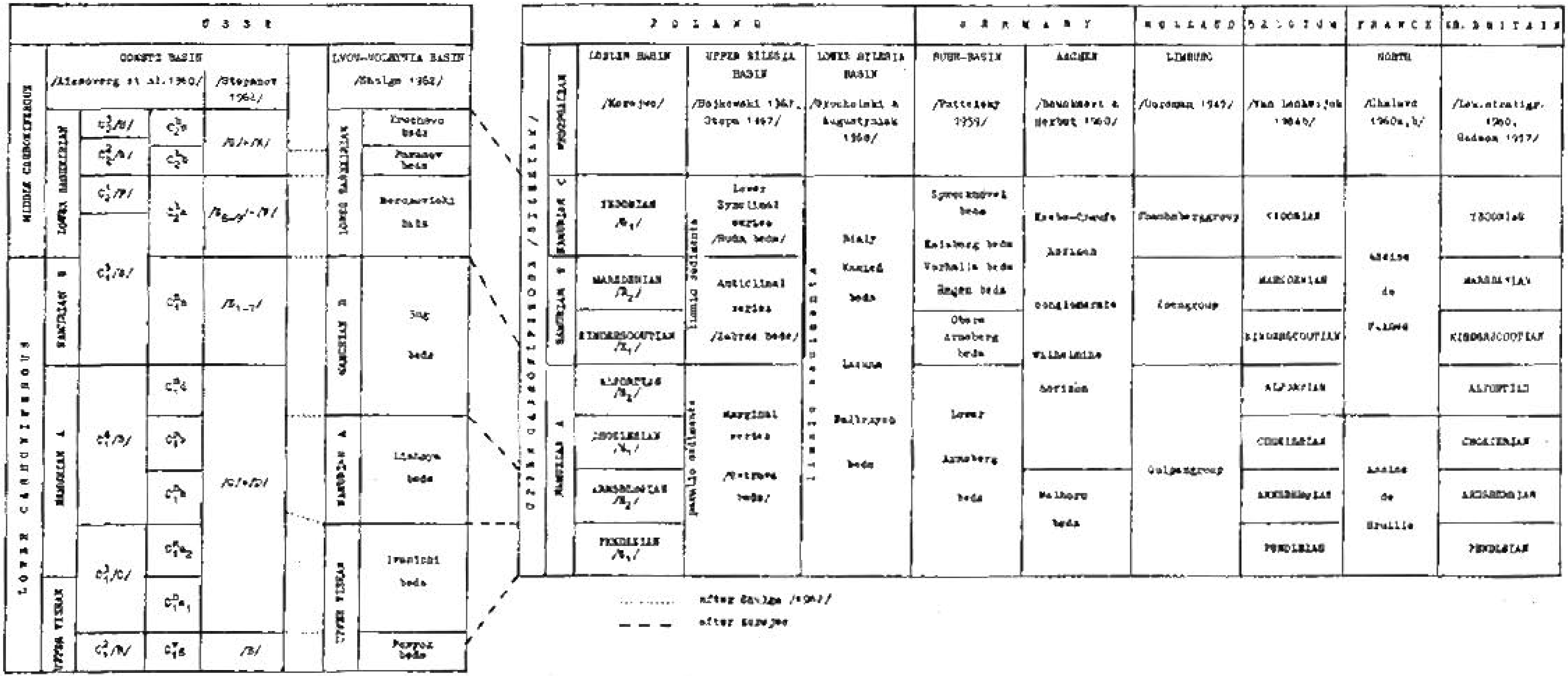
In the Ruhr basin of Westphalia, immensely thick (2,500 m) deposits were laid down during the Namurian. Lithologically they do not much differ from the underlying Culm deposits. The Namurian (Paproth & Teichmüller 1961) A and B is without productive measures. Previously they were called Flözleeres in counter-distinction to the coal-bearing layers of Namurian C known as Flözführende (Kukuk 1938). The Namurian sediments are developed as alum, sandy or muddy shales, arkose sandstones, greywackes and conglomerates. The Namurian deposits have now been subdivided into a number of lithostratigraphic series (chart 7), while on the basis of goniatites the same substages and zones have been distinguished here as in the provinces previously discussed (Patteisky 1959).

The Carboniferous deposits of the Rhine province and Westphalia plunge N and NE to great depths below the Permo-Mesozoic cover of the German Lowland. Boreholes of the last few years have shown the presence of the Carboniferous in NE Mecklenburg and in the island of Rügen (comp. p. 656—659).

Data concerning the Namurian of the above area are still very fragmentary and it is hardly possible to discuss the thickness of this series represented by such paralic sediments as fossiliferous siltstones and mudstones, sandstones interbedded by conglomerates and thin coal seams.

Chart 7

CORRELATION OF THE POLISH NAMURIAN SUCCESSION WITH SOME EUROPEAN SECTIONS



The Carboniferous deposits of NE Germany are undoubtedly connected with contemporaneous deposits encountered in NW Poland.

In Poland, Carboniferous marine transgression was strongest at the beginning of the Upper Viséan time (Bojkowski 1960a, 1966b; Żelichowski 1964b; Żakowa 1964, 1968; Znosko & Pajchlowa 1968).

The alimentary areas of Poland at that time probably occupied a part of the Precambrian platform of eastern Europe and — in S Poland — the Western Sudetes, the Pra-Carpathians and the Holy Cross Caledonides with their eastern extension (vide fig. 3). Only in the Intra-Sudetic depression has there persisted a relict basin, partly desalted in the uppermost Viséan. Thus the Viséan basin was delimited from NE by the Precambrian platform, from SW and S by the Caledonides of the Sudetes and the Pra-Carpathians intermittently overflooded by the sea. Islands probably existed in this basin, and they, too, were alimentary areas, such as in the vicinity of Pionki, Ciepielów, Opole Lub. and Kock in the Lublin region, or in the region of Przedbórz in the southern part of the Miechów depression. Marine sedimentation continues in the Viséan basin and conditions differ slightly only in the Lublin basin which is intermittently emersed as suggested by thin coal seams or coaly shales encountered in the Upper Viséan.

Towards the close of the Upper Viséan, the marine and land topography in Poland gradually changes — similarly as throughout western Europe — in result of the Sudetic phase of the Variscan diastrophism (Bojkowski 1960a, 1966b; Jachowicz 1968; Znosko & Pajchlowa 1968).

During the Lower Namurian, the area occupied by land in SW Poland increased owing to the uplifting of the Fore-Sudetic block. Only over a small area of the Intra-Sudetic depression does exclusively limnic sedimentation persist throughout the Upper Carboniferous, resulting in the deposition of conglomerates, siltstones, mudstones and sandstones with coal seams (Wałbrzych beds). The western part of the Eastern Sudetes is uplifted while the western Pra-Carpathian area, partly overflooded during the Upper Viséan, is fairly well marked in the Lower Namurian, and in the south delimits the Upper Silesia basin.

The denuded area of the old Paleozoic massif in south-eastern Poland gradually enlarged so as to cover the present Holy Cross Mts. region (vide fig. 4).

The sea basin continues to persist everywhere also in Poland. It is subject to intermittent shallowings, paralic sedimentation is taking place along its variable shore line. In the Silesia-Cracow region sandy-silty deposits are laid down. They are interbedded by mudstones containing a marine fauna and coal seams (the marginal series or Ostrawa beds). The paralic facies is also characteristic of the lowermost Namurian deposits encountered in the Miechów depression. The sea basin stretches far out to the south-east. On one side it may have been connected with the Lvov-Volhynia basin, on the other — with that of Lublin. The Namurian A deposits are developed as siltstones, mudstones with interbeddings of limestones and intercalations of sandstones and with rather

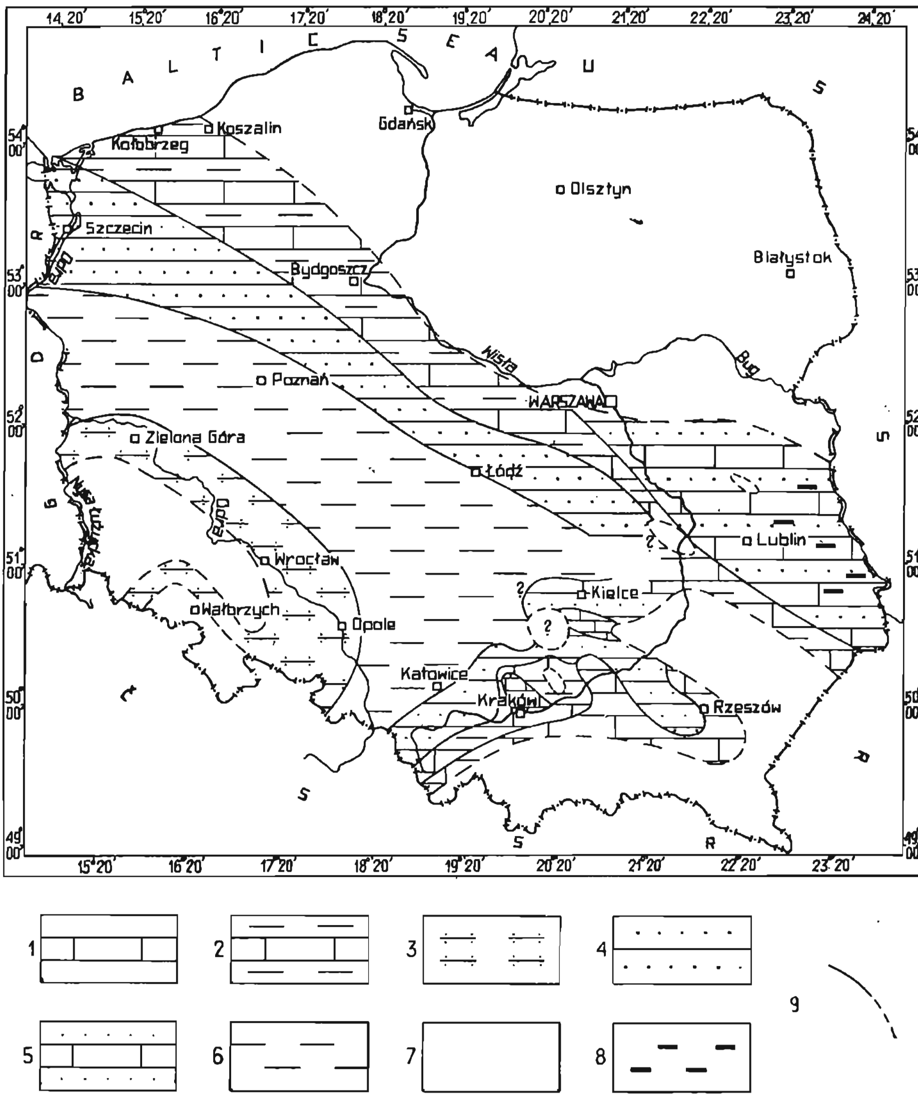


Fig. 3

Palaeogeographic sketch map of the Upper Visean (after H. Żakowa 1964, 1968)

1 calcareous deposits of the shallow-neritic zone; 2 mudstone-limestone or siltstone-limestone deposits of the shallow-neritic zone; 3 mudstone-sandstone deposits with intercalations of gravel, limestone-mudstone and limestone in the shallow-neritic zone; 4 mudstone-siltstone-sandstone deposits of the shallow-neritic zone; 5 mudstone-siltstone-limestone deposits intercalated by sandstones in the shallow-neritic, littoral and intermittently continental zones; 6 mudstone-siltstone-sandstone deposits in the deeper neritic zone; 7 predominantly denuded areas; 8 coal seams; 9 range of marine facies

thin coal seams whose number in the Lublin basin is decidedly greater than in the eastern part (within the Precambrian platform). It is not excluded that a similar type of sedimentation may have also occurred in the eastern part of the Carpathians.

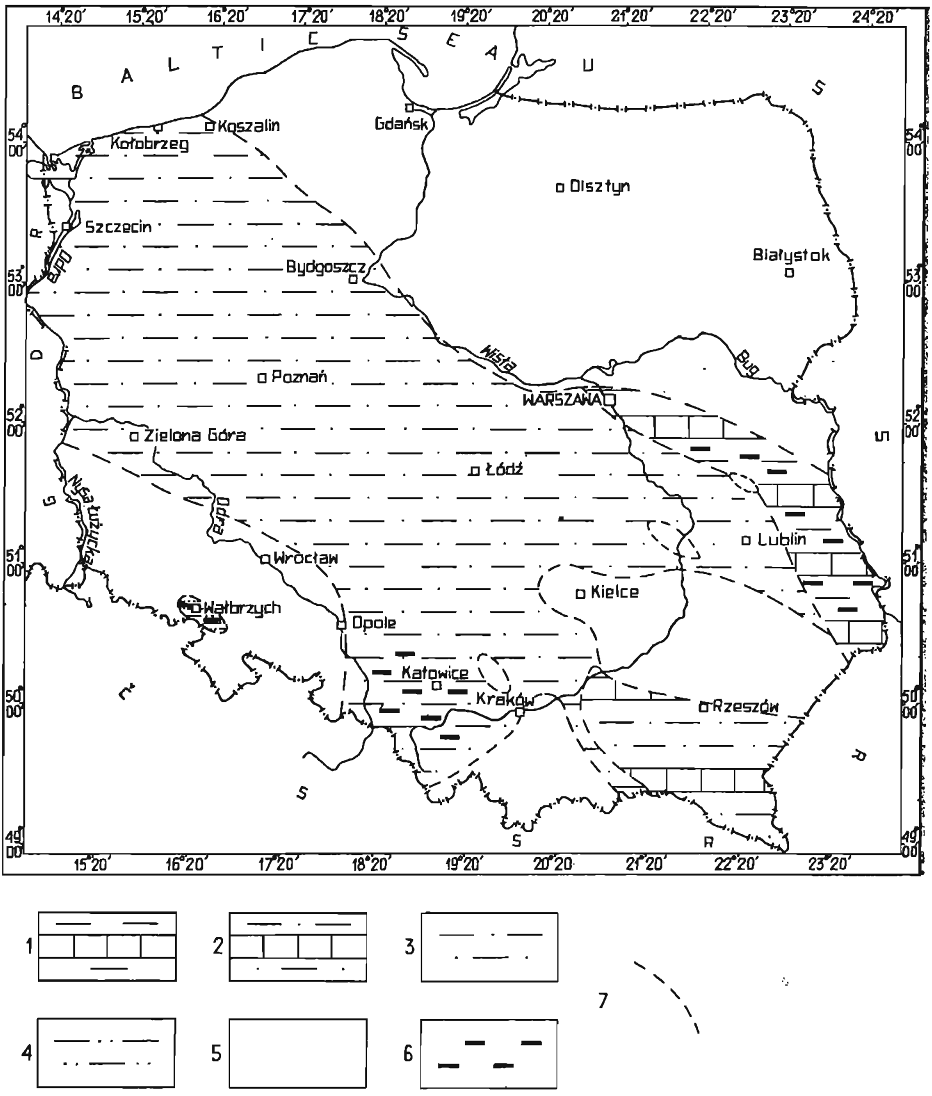


Fig. 4

Palaeogeographic sketch map of the Lower Namurian

1 mudstone-limestone deposits intercalated by sandstones in the shallow-neritic, littoral and intermittently continental zones; 2 limestone-sandstone deposits in the shallow-neritic zone; 3 mudstone-sandstone deposits of the deeper neritic zone, only intermittently continental; 4 limnic sandy-muddy deposits; 5 predominantly denuded areas; 6 coal seams; 7 facial range

The Namurian basin was an extensive one stretching far to the north-west of the Lublin basin, as deposits of this age have been encountered in boreholes of Western Pomerania. Central Poland as well as the distant forefield of the Sudetes were most likely also overflooded by the sea, since Lower Namurian deposits have been found below the Permo-Mesozoic in the Fore-Sudetic monocline.

Still more marked paleogeographic changes in Poland followed the Lower Namurian in result of the setting in of the Erzgebirgian phase. The sea regressed completely from the Upper Silesia basin which was altered into a limnic intramountainous depression delimited from the north and the east by mountain chains, the so called Cracovian Variscan Arch (Bukowy 1964b, Znosko 1965b). All throughout the Upper Namurian and the Westphalian clastic sediments continued to accumulate owing to the denudation of the uplifted massifs around the intramountainous depression. Huge series of sandy and silty deposits were laid down, containing conglomerate intercalations and coal seams (Namurian and Westphalian beds of the anticlinal and synclinal series). In relation to the Lower Namurian the already limnic Upper Silesia basin grows narrower in the west as well as in the north-east and the south-east. A local foredeep may also have formed in the forefield of the new Variscan Arch where coal-bearing deposits might have been laid down.

In the Miechów depression, separated from the Upper Silesia basin by an orogenic arch, the presence has been observed of the Lower Carboniferous and the lower part of Namurian A (without coals). In some boreholes, however (Słomniki, Łobzów), Westphalian coal pebbles have been encountered in Jurassic and Triassic conglomerates. According to Bukowy and Jachowicz (1964) these coals may have been brought from a basin situated somewhere perhaps even in the Miechów depression, possibly in its eastern part.

The Upper Namurian period is characterized by a further enlargement of the area subject to denudation (vide fig. 5). The Sudetic land stretches farther out to the east, that of the Pra-Carpatians to the north-west, communication is stopped between the Upper Silesia basin and the paralic sedimentation areas i.e. the Lublin basin and its north-western extension. In the Intra-Sudetic depression, where the sedimentary area expands to the south, only certain stratigraphic gaps reflect the Erzgebirgian phase. Limnic clastic-muddy deposits with coal (the Biały-Kamień beds) are laid down here.

The limnic sedimentation probably continues within an area situated between the present Upper Silesia basin and the Holy Cross Mts. The enlarged area of the Holy Cross Mts. massif, together with the Carpathian forefield, persisted as land undergoing erosion and denudation. To the east of the Pra-Carpathian land, in the Lublin basin and its western extension in central Poland and Western Pomerania, paralic sedimentation still continues. This has been reliably established in boreholes only in the Lublin basin and in Western Pomerania. Undoubtedly, both during the Lower and the Upper Carboniferous, there existed a sea basin in Western Pomerania stretching W to the German Lowland (Mecklenburg and Rügen) and SE to the Lublin basin.

Fig. 5

Palaeogeographic sketch map of the Upper Namurian

1 mudstone-siltstone-sandstone deposits of the shallow neritic-intermittently continental-zone; *2* mudstone-siltstone deposits intercalated by sandstones in the deeper neritic zone; *3* limnic sandy-muddy deposits; *4* limnic clastic mudstone deposits; *5* predominantly denuded areas; *6* coal seams; *7* facial range

It is now currently accepted that during the Upper Namurian, the southern margin of the East European Precambrian platform was the boundary of the sea basin in N and NE Poland. No Carboniferous deposits have so far been found in that platform, except its south-eastern region which included the Lublin basin. It is not quite excluded, however, that north-eastern Poland may have been intermittently encroached by the sea and that the sediments laid down there were subsequently eroded. When discussing the role played by the Caledonian and Variscan movement in the tectonic evolution of the Baltic regions, P. Suveizdis (1968) postulates that the uplifting movements during the late Carboniferous are responsible for the changes in the structural pattern of the Peri-Baltic syneclise and the adjacent areas. In result of the Variscan orogeny, the present White-Russia-Mazury anteclise was strongly elevated during the late Carboniferous, dividing the Peri-Baltic syneclise into two separate parts: Polish-Lithuanian in the N and the Podlasie--Brest area in the South.

According to P. Suveizdis (1968), during the Variscan phase, the Peri-Baltic syneclise was again submerged to a depth of over 1,200 m. This further development of the above syneclise is reliably indicated by Lower Carboniferous (and Devonian) deposits that have persisted in north-western Lithuania and south-western Latvia (Lijeldina 1967, Zeiba 1967). The strongest uplifting movements occurred during the Upper Carboniferous and they may have also been responsible for the erosion of pre-Permian (Devonian and Carboniferous) deposits of northern--eastern Poland.

Owing to the Variscan orogeny, the range of the Carboniferous basin in Poland was gradually reduced. The Erzgebirgian phase persisting during the Upper Namurian resulted in an expansion of the areas affected by denudation, also in sedimentary gaps within the Intra-Sudetic depression and the Silesia-Cracow basin. The latter area was altered into an intramountainous limnic depression. Towards the close of the Namurian, paralic sedimentation still continues in the Lublin basin and its north-western extension in Western Pomerania, probably also in central Poland.

During the Lower Westphalian, no essential changes were introduced into the general outlines of the areas affected by denudation (vide fig. 6). After the Lower Westphalian A, the sea basin retreats from the Polish territory while the younger deposits of that stage are developed only in the limnic facies.

The correlation of the main Namurian paralic basins of Europe is shown in chart 7.

In characterizing the Namurian period it may be stated that, in western Europe, sedimentation took place under conditions associated with the formation of a foredeep north of the emerging Variscan massifs.

In this foredeep the transition from the Dinantian to the Namurian was on the whole continuous (only here and there with minor gaps), the carbonate sediments passing into the terrigenous. This change depended on the transport of clastic material from the alimentary areas which consisted of previously emerged massifs then subject to denuda-

Fig. 6

Palaeogeographic sketch map of the Lower Westphalian A

1 sandstone-siltstone deposits, intercalated by mudstones, here and there by limestones in the shallow-neritic, littoral or intermittently zone; 2 mudstone-sandstone deposits intercalated by siltstones in the deeper neritic zone; 3 limnic, sandy-muddy deposits; 4 limnic gravel--sand deposits; 5 predominantly denuded areas; 6 coal seams; 7 facial range

tion. Not everywhere, however, was the sedimentary series between the Lower and the Upper Carboniferous continuous in character. In Great Britain and in the northern margin of the Welsh-Brabant massif the Namurian deposits occasionally lie transgressively on various Viséan members or even on older deposits. A similar situation exists in some regions of the Continent.

In its westernmost part, the Welsh-Brabant massif did not play such an important role in the Namurian sedimentation, and this is reflected in the lithologic-stratigraphic profiles to the south of this massif, in northern France and southern Belgium, as well as north of the massif, in Campine, Dutch Limburg and the Aachen area.

In the Namurian basin stretching from Great Britain in the west as far as south-eastern Poland and the adjacent parts of the Ukraine (Lvov-Volhynia basin) the sedimentation was cyclic, so characteristic of the paralic type of basins. The deposits then formed are generally productive measures. In most of the Namurian areas in western Europe, conditions favouring coal formation generally set in towards the close of Namurian A, or during Namurian B or even C (Westphalia). In the Upper Silesia basin, coals occur as early as in the Lower Namurian, while in the basins of Lublin and of Lvov-Volhynia, similarly as in those of the Pripyat and the Donetz, thin coal seams are known as early as in the Viséan. This early appearance of coals is characteristic of Scotland, too. The passage from the Namurian to the Westphalian within the extensive paralic basin here considered is gradual.

On faunal correlations, particularly those with goniatites, it is seen that, during the Namurian, the paralic basin of Poland had a convenient communication route with the basins of western Europe, (though in the Upper Silesia basin this route existed only during Namurian A — vide charts 6 and 7). The basin of north-western Poland (Western Pomerania), undoubtedly, communicated both, during the Dinantian and the Silesian, with Rügen and north-eastern Mecklenburg, while to the south-east there must have been a communication route with the basins of Lublin and of Lvov-Volhynia.

The communication route with the Donetz basin is obviously less distinct. While in the Lower Carboniferous the basins of Lublin and Lvov-Volhynia were connected with the Donetz basin (Carboniferous outcrops) via the Pripyat basin and its south-western extension, i.e. the Dniepr-Donetz depression (Carboniferous deposits observed in boreholes), these connections were most probably broken off during the Namurian.

In the Pripyat basin, situated in the northern margin of the Ukraine massif, the presence of the Lower and Upper Carboniferous has been established in numerous boreholes (Stefanenko 1958, Kozlov 1958, Akimets et al. 1960, Golubtsov & Makhnach 1961, Lukashev & Makhnach

1966). The occurrence of the Carboniferous in this area was, however, first suggested by Sujkowski (1946). The total thickness of the Carboniferous deposits there ranges from 1,000 m in the north (the Szatiłowsk depression), to 1,300 m farther south (the Elsk depression). As regards the Namurian in the Pripyat basin, only its lower deposits have so far been observed within a narrow belt of the Elsk depression, where they are developed as limestones, often silicified and interbedded by strongly fossiliferous mudstones, or by sandstones, less often by coals.

The Namurian sediments occur here on various Viséan members at a depth between 266.0 and 1,437.0 m; only the lowermost members are, however represented in the western part of their occurrence area. The thickness of the still persisting Namurian members ranges from a few to a. 40 metres. According to Golubtsov & Makhnach (1961) the decrease in thickness from the east to the west and north may suggest the blocking up of the direct communication route with the sea of the Lvov and Moscow basins via the Pripyat and the Donetz basins. Short-lasting connections may, however, have still existed in the Bashkirian stage. The Lower Bashkirian deposits (partly corresponding to Namurian C and the Lower Westphalian of the west European subdivision) lie transgressively on strongly weathered Lower Namurian sediments. These are represented by variegated mudstones with plant remains and sandstone interbeddings, also with thin intercalations of limestones and fossiliferous mudstones. They are covered by sediments Upper Bashkirian or Moscovian in age.

From the Paleogeographic Atlas of the Ukraine and Moldavia (1960) and the Paleogeographic Atlas of the USSR (1965) it may be inferred that the Soviet explorers accept the existence of connections, may be short--lasting, between the Donetz and the Lvov-Volhynia basins via the Dniepr-Donetz and the Prypyat basins.

The paralic sedimentation in the Lvov-Volhynia basin ends in the lowermost Westphalian, in the Lublin basin somewhat later, most likely after the Lower Westphalian A, farther west — already outside the Polish territory — in the Ruhr basin, about the Middle Westphalian C, similarly as in Holland (Limburg), Belgium and northern France. It continues longest, i.e. to the close of the Westphalian C, in Great Britain (Nottinghamshire — Derbyshire and South Wales) (vide Patteisky 1965).

The above data indicate the westward extinction of the foredeep where the paralic sedimentation gradually changes into a typically limnic one not affected by sea ingressions.

Sedimentation in the Donetz basin differed in character from that in western Europe. Beginning with the Tournaisian (the Strunian included) until the end of the Gzhelian (corresponding to the Stephanian of western Europe), the sedimentation in the Donetz basin is cyclic; the marine and paralic deposits that are laid down have a total thickness between 10,000 and 12,000 m. Out of this, the Namurian sediments (in the west-European sense) take up a. 2,300 metres.

The Donetz basin was the northernmost and independent arm of the Mediterranean geosyncline stretching along the southern border of the Russian platform (Aïzenverg et al. 1960; Ejnor et al. 1960, 1965). It formed one whole with the Dniepr-Donetz basin, farther on with the Pripyat basin. The Pripyat basin was intermittently connected on one side with the Moscow depression, on the other, to the SW — at least up to the beginning of the Namurian — with the Lvov-Volhynia and Lublin basins.

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K. KOREJWO

STRATYGRAFIA I PALEOGEOGRAFIA NAMURU NA NIŻU POLSKIM

(Streszczenie)

Omówiono charakterystykę osadów karbońskich na Niżu Polskim ze szczególnym uwzględnieniem namuru, który najpełniej wykształcony jest w lubelskim basenie karbońskim. Stratygrafia namuru z tego obszaru ustalona została w oparciu o makrofaunę — głównie goniatyty. Większość ich gatunków, szczególnie z namuru górnego, stwierdzona została w Polsce po raz pierwszy. Umożliwiło to rozgraniczenie namuru B i C oraz wydzielenie podpięter i zon goniatytowych, znanych z klasycznych obszarów występowania namuru w Europie Zachodniej. Przedstawiono również litologię i przebieg sedymentacji w lubelskim basenie w epoce namurskiej. Scharakteryzowano karbon z obszaru śląsko-krakowskiego i niecki miechowskiej. Uwzględniono również niektóre obszary leżące poza granicami kraju — na północnym zachodzie Rugię i Meklenburgię, a na południowym wschodzie obszar lwowsko-wołyński. Paleogeografię obszaru Polski w epoce namurskiej przedstawiono na tle rozwoju paralicznych basenów górnokarbońskich w subwaryscyjskim rowie przedgórskim zachodniej Europy. Przedyskutowano ponadto możliwość połączeń namurskiego basenu Polski z zachodnią i wschodnią Europą.

Pracownia Stratygrafii
Zakładu Nauk Geologicznych PAN
Warszawa 22, Al. Żwirki i Wigury 93
Warszawa, w grudniu 1968 r.

DESCRIPTION OF PLATES I—XLVII

PL. I

1—4 — *Campylites carbonarius* (Mc Coy), fig. 1 — borehole Goździk 1, depth 2041.0—2043.8 m × 10; fig. 2 — Dęblin 2, 2222.8—2223.0 m × 8; fig. 3 — Ursynów 1, 1975.0—1976.0 m — × 2; fig. 4 — Ursynów 1, 1910.0—1916.6 m — × 2.

5 — *Beloraphe kochi* (Ludwig), Dęblin 2, 1967.3—1967.5 m × 2

6—8 — *Orbiculoidea* cf. *missouriensis* (Shum.), fig. 6 — Ursynów 1, 1910.0—1916.6 m — × 10; figs. 7—8 — Dęblin 7, 2418.0—2419.0 m — × 6.

PL. II

1 — *Orbiculoidea missouriensis* (Shum.), Bystrzyca IG-1, 1243.5—1243.7 m × 10

2a, b — *Orbiculoidea ingens* Dem., Bystrzyca IG-1, 1407.7—1407.8 m × 2

3—6 — *Lingula mytilloides* Sow., fig. 3 — Bystrzyca IG-1, 1243.5—1243.7 m — × 7; fig. 4 — Kołbiel 1, 2191.9—2193.2 m — × 7; figs. 5—6 — Dęblin 7, 2418.0—2419.0 m, fig. 5 — × 8, fig. 6 — × 6.

7 — *Lingula squamiformis* Phill., Opole Lub. 5, 1720.0—1723.0 m × 6

8 — *Lingula* cf. *parallela* Phill., Opole Lub. 5, 1974.0—1978.0 m × 10

PL. III

1—4 — *Chonetes (Rugosochonetes) aureolus* Schwarzb., fig. 1 — Chełm IG-1, 990.0—990.7 m — × 5; fig. 2 — Strzyżów, 528.5 m — × 5; fig. 3 — Bystrzyca IG-1, 1745.6—1747.6 m — × 5; fig. 4 — Chełm IG-1, 1098.5—1098.7 m — × 4.

5—6 — *Chonetes (Rugosochonetes) brinkmanni* Schwarzb., fig. 5 — Chełm IG-1, 1094.4—1094.5 m — × 4; fig. 6 — Chełm IG-1, 1098.5—1098.7 m — × 4.

7—12 — *Plicochonetes waldschmidti* Paeck., figs. 7—8 — Bystrzyca IG-1, 1752.5—1753.1 m, fig. 7 — × 6, fig. 8 — × 10; figs. 9, 11 — Strzyżów, 594.8—595.0 m, fig. 9 — × 8, fig. 11 — × 10; figs. 10, 12 — Chełm IG-1, 1071.2—1071.5 m — × 8.

PL. IV

1—10 — *Tornquistia polita* (Mc Coy), fig. 1 — Bystrzyca IG-1, 1727.3—1728.7 m — × 7; fig. 2 — Strzyżów, 594.8—595.0 m — × 8; figs. 3a, b, 4 — Chełm IG-1, 1072.0—1072.3 m — × 4; fig. 5 — Chełm IG-1, 1071.4—1071.5 m — × 12; fig. 6 — Strzyżów, 594.8—595.0 m — × 10; fig. 7 — Chełm IG-1, 1072.0—1072.3 m — × 9; figs. 8, 10 — Strzyżów, 594.8—595.0 m, fig. 8 — × 9, fig. 10 — × 12; fig. 9 — Chełm IG-1, 1072.0—1072.3 m — × 4.

11 — *Linoproductus* sp., Dęblin 7, 2437.3—2443.0 m × 5

PL. V

1a, b, c; 2a, b, c, d — *Productus concinnus* Sow., Bystrzyca IG-1, 1381.9—1382.9 m — × 2; fig. 2d — with visible diaphragma.

3—4 — *Camarotoechia pleurodon raricosta* (Phill.), fig. 3 — Strzyżów, 587.4 m — × 1.5; fig. 4 — Chełm IG-1, 978.6—978.8 m — × 4.

PL. VI

1 — *Pugnax* sp., Bystrzyca IG-1, 1727.3—1728.7 m × 3

2—5 — *Spirifer bisulcatus oystermouthensis* Vaugh., figs. 2—4 — Chełm IG-1, 939.4—939.6 m, fig. 2 — × 2, figs. 3 and 4 — × 2.5; fig. 5 — Chełm IG-1, 1031.8—1032.0 m — × 2.

6—7 — *Anthraconeilo oblonga* (Mc Coy), fig. 6 — Chełm IG-1, 990.6—990.7 m — × 4; fig. 7 — Chełm IG-1. 938.0—938.2 m — × 5.

8—12 — *Anthraconeilo laevirostrum* (Portl.), fig. 8 — Chełm IG-1, 1023.0—1023.2 m — × 4; fig. 9 — Chełm IG-1, 1094.0—1094.4 m — × 7; figs. 10, 11 — Chełm IG-1, 1069.7—1070.5 m, fig. 10 — × 6; fig. 11 — × 5; fig. 12 — Dęblin 7, 2341.5—2347.6 m — × 5.

PL. VII

1—2 — *Anthraconeilo undulata* (Phill.), Niedrzwica 3, 1693.0—1699.0 m × 6

3—5 — *Anthraconeilo transversalis* (Kleb.), fig. 3 — Strzyżów, 537.7—537.9 — × 4; figs. 4, 5 — Bystrzyca IG-1, 1749.6—1750.6 m — × 4.

6—8 — *Nuculopsis gibbosa* (Flem.), figs. 6, 7 — Chełm IG-1, 1093.4—1094.9 m — × 3; fig. 8 — Strzyżów, 536.5—536.9 m — × 6.

9—12 — *Nuculavus luciniformis* (Phill.), figs. 9, 10 — Strzyżów, 536.9—537.7 m — × 8; fig. 11 — Strzyżów, 594.8—595.0 m — × 4; fig. 12 — Strzyżów, 590.6—590.9 m — × 4.

13—16 — *Nuculavus ostraviensis* (Kleb.), figs. 13, 15 — Bystrzyca IG-1, 1752.5—1753.1 m — × 4; fig. 14 — Kazimierz 1, 1826.0—1830.6 m — × 4; fig. 16 — Niedrzwica 2, 1956.8—1962.8 m — × 4.

PL. VIII

1 — *Polidevcia vasiceki* Kump., Prantl. & Ruż., Chełm IG-1, 990.8—991.0 m × 3

2—3a, b — *Polidevcia attenuata* (Flem.), Chełm IG-1, 938.0—938.4 m, fig. 2 — × 5; figs. 3a, b — × 7.

4—6 — *Polidevcia sharmani* (Ether.), fig. 4 — Chełm IG-1, 1069.6—1069.7 m — × 2; fig. 5 — Bystrzyca IG-1, 1752.5—1753.1 m — × 4; fig. 6 — Chełm IG-1, 990.1—990.6 m — × 8.

7—10 — *Phestia bellicostata* (Schwarzb.), figs. 7a, b, 9, 10 — Chełm IG-1, 938.0—938.9 m, figs. 7a, b — × 7, figs. 9 and 10 — × 10; fig. 8 — Bystrzyca IG-1, 1752.5—1753.1 m — × 3.

11 — *Parallelodon tenuistriatus* (Meek & Worth.), Chełm IG-1, 1094.8—1094.9 m × 7

12—13 — *Leiopteria thomsoni* Portl., Opole Lub. 5, 1592.0—1597.0 m, fig. 12 — × 4; fig. 13 — × 6.

PL. IX

1—3 — *Myalina sublamellosa* Ether., figs. 1, 2 — Bystrzyca IG-1, 1373.8—1378.1 m, fig. 1 — × 2; fig. 2 — × 3; fig. 3 — Chełm IG-1, 923.9—924.1 m — × 7.
4 — *Myalina* cf. *dorlodoti* Dem., Bystrzyca IG-1, 1374.2—1374.3 m × 6
5 — *Myalina* cf. *pernoides* (Portl.), Bystrzyca IG-1, 1381.2—1381.3 m × 2
6—8 — *Posidoniella* cf. *minor* (Brown), Bystrzyca IG-1, 1407.8—1410.7 m, figs. 6 and 7 — × 3, fig. 8 — × 7.

9—10 — *Posidoniella elongata* Hind, fig. 9 — Chełm IG-1, 923.3—923.4 m × 3; fig. 10 — Bystrzyca IG-1, 1379.8—1380.4 m — × 1.5.

PL. X

1—2 — *Posidoniella elongata* Hind, fig. 1 — Bystrzyca IG-1, 1378.0—1378.1 m — × 3; fig. 2 — Chełm IG-1, 923.9—924.1 m — × 3.

3 — *Aviculopinna carbonaria* Dem., Bystrzyca IG-1, 1619.0—1620.0 m × 2

4—7 — *Posidonia corrugata* (Ether.), figs. 4, 5 — Chełm IG-1, 923.3—924.6 m, fig. 4 — × 6, fig. 5 — × 4; fig. 6 — Niedrzwica 3, 1693.0—1699.0 m — × 6; fig. 7 — Bystrzyca IG-1, 1378.0—1378.1 m — × 3.

PL. XI

1 — *Posidonia corrugata* (Ether.), Kazimierz 1, 2014.0—2020.0 m × 5

2 — *Posidonia* cf. *radiata* Hind, Bystrzyca IG-1, 1410.6—1410.7 m × 3

3 — *Aviculopecten* cf. *gentilis* Sow., Dęblin 7, 2470.2—2471.2 m × 5

4—6 — *Streblopteria ornata* (Ether.), figs. 4, 6 — Chełm IG-1, 1067.0—1069.8 m — × 3; fig. 5 — Strzyżów, 587.8—588.0 m — × 3.

PL. XII

1—6 — *Obliquipecten costatus* Yates, figs. 1, 2 — Bystrzyca IG-1, 1574.7—1574.9 m — × 5; figs. 3—6 — Dęblin 7, 2593.8—2594.8 m — × 4.

PL. XIII

1—2 — *Streblochondria condrustinse* (Dem.), Chełm IG-1, 925.7—925.9 m, fig. 1 — × 4, fig. 2 — × 3.

3 — *Pernopecten* cf. *carboniferous* (Hind), Chełm IG-1, 1094.0—1094.4 m × 4

4—6 — *Curvirimula belgica* (Hind), figs. 4, 5 — Bystrzyca IG-1, 1261.0—1261.3 m — × 3; fig. 6 — Bystrzyca IG-1, 1252.5—1254.0 m — × 5.

7—8 — *Anthracomya lenisulcata* Trueman, Chełm IG-1, 784.2—785.7 m × 2

9—10 — *Anthracomya* cf. *lenisulcata* Trueman, Bystrzyca IG-1, 1261.0—1261.3 m, fig. 9 — × 3, fig. 10 — × 4.

PL. XIV

1 — *Anthraconaia perlongata* Pastiels, Chełm IG-1, 784.7—785.7 m × 2

2—3 — *Anthraconaia williamsoni* (Brown), Chełm IG-1, 738.9—784.5 m × 1

4 — *Anthraconaia tchernyshevi* Korejwo, Chełm IG-1, 784.7—785.7 m × 4

5—6 — *Carbonicola lenicurvata* Trueman, Chełm IG-1, 704.0—705.0 m, fig. 5 — × 1, fig. 6 — × 1.5.

7 — *Carbonicola pseudacuta* Trueman, Chełm IG-1, 704.4—705.0 m × 1

PL. XV

1 — *Curvirimula samsonowiczi* (Korejwo), Chełm IG-1, 786.2—786.4 m × 3

2—3 — *Curvirimula* cf. *truemani* (Korejwo), fig. 2 — Opole Lub. 5, 1592.0—1597.0 m — × 8; fig. 3 — Niedrzwica 2, 1559.5—1563.5 m — × 7.

4—7 — *Janeia primaeva* (Phill.), figs. 4, 5 — Kazimierz 1, 1487.0—1493.0 m — × 4; fig. 6 — Niedrzwica 3, 1693.0—1699.0 m — × 3; fig. 7 — Bystrzyca IG-1, 1407.8—1408.5 m — × 2.

8 — *Janeia* cf. *primaeva* (Phill.), Bystrzyca IG-1, 1407.8—1408.5 m × 4

PL. XVI

1 — *Grammysiopsis variabilis* (Mc Coy), Bystrzyca IG-1, 1649.1—1650.8 m × 2

2—4 — *Edmondia josepha* de Kon., figs. 2, 3 — Chełm IG-1, 1044.0—1044.2 m — × × 1.5; fig. 4 — Chełm IG-1, 1094.0—1094.4 m — × 5.

5—6 — *Edmondia* cf. *jacksoni* Dem., Kazimierz 1, 1478.1—1493.0 m × 3

7—9 — *Solenomorpha minor rotundata* Schwarzb., Chełm IG-1, 1022.6—1023.0 m × 4

PL. XVII

1—2 — *Solenomorpha parallela* (Hind), Niedrzwica 2, 1900.7—1905.7 m, fig. 1 — × × 7, fig. 2 — × 5.

3—4 — *Solenomorpha lanceolata* Shulga, Bystrzyca IG-1, 1621.0—1622.0 m × 2

5—6 — *Sanguinolites* cf. *tricostatus* Portl., fig. 5 — Bystrzyca IG-1, 1402.0—1407.0 m — × 3; fig. 6 — Chełm IG-1, 938.0—938.2 m — × 5.

7—8 — *Sanguinolites interruptus* Hind, fig. 7 — Bystrzyca IG-1, 1382.5—1388.0 m — × 6; fig. 8 — Bystrzyca IG-1, 1359.4—1359.6 m — × 5.

9 — *Sanguinolites clavatus* (Ether.), Chełm IG-1, 924.6—924.7 m × 4

10 — *Sanguinolites* cf. *angustatus* (Phill.), Goździk 1, 2125.8—2127.9 m × 8

11 — *Prothyris scotica* Wilson, Chełm IG-1, 1044.2—1044.3 m × 4

PL. XVIII

1—3 — *Euphemites urii* (Flem.), figs. 1a, b, c — Chełm IG-1, 1066.7—1072.7 m — × × 2.5; figs. 2, 3a, b — Bystrzyca IG-1, 1575.6—1576.2 m, fig. 2 — × 7, figs. 3a, b — × 1.5.

4—5 — *Euphemites spiralis* (Phill.), fig. 4 — Niedrzwica 3, 1892.0—1898.0 m — × × 3; fig. 5 — Opole Lub. 5, 1820.0—1824.0 m — × 4.

6 — *Knightites (Retispira) hibernicus* (Weir), Chełm IG-1, 1044.2—1044.3 m × 4

7—8 — *Knightites (Retispira) silesiacus* Schwarzb., fig. 7 — Opole Lub. 5, 1929.0—1935.0 m — × 15; fig. 8 — Chełm IG-1, 938.0—938.2 m — × 10.

9 — *Agnesia* sp., Goździk 1, 2125.8—2127.9 m × 7

PL. XIX

1 — *Knightites (Retispira) decussatus* (Flem.), Niedrzwica 3, 1892.0—1898.0 × 3

2 — *Knightites (Cymatospira) moravicus* (Kleb.), Chełm IG-1, 817.4—821.3 m × 3

3—7 — *Straparollus (Euomphalus) straparolliformis* (Kleb.), figs. 3, 4 — Bystrzyca IG-1, 1753.1—1766.0 m — × 5; fig. 5 — Chełm IG-1, 990.1—990.6 m — × 6; fig. 6 — Chełm IG-1, 1071.4—1071.5 m — × 5; fig. 7 — Ursynów IG-1, 1910.0—1916.6 m — × 5.

8 — *Soleniscus (Macrochilina) primogenius* (Conrad), Bystrzyca IG-1, 1727.3—1728.7 m × 8

9 — *Soleniscus* sp., Bystrzyca IG-1, 1745.6—1747.6 m × 7

10 — *Naticopsis* sp., Chełm IG-1, 938.8—939.6 m × 15

11 — *Donaldina* sp., Chełm IG-1, 938.0—938.4 m × 12

PL. XX

1—7 — *Plagioglypta* sp., figs. 1, 2 — Chełm IG-1, 1044.0—1044.2 m, fig. 1 — × 3, fig. 2 — × 8; fig. 3 — Chełm IG-1, 786.5—786.6 m — × 8; figs. 4—7 — Chełm IG-1, 938.2—939.1 m, figs. 4 and 5 — × 8, fig. 6 — × 6, fig. 7 — × 12.

8—9 — *„Orthoceras” martinianum* de Kon., fig. 8 — Dęblin 7, 2593.8—2594.8 m — × 2; fig. 9 — Niedrzwica 3, 1693.0—1699.0 m — × 5.

10 — *„Orthoceras' calamus* de Kon., Chełm IG-1, 923.0—923.5 m × 3

11 — *Cycloceras kionoforme* Dem., Chełm IG-1, 1069.3—1069.4 m × 3

PL. XXI

1 — *Cycloceras kionoforme* Dem., Niedrzwica 3, 2218.2—2220.7 m × 5

2 — *„Orthoceras” steinhaueri* Sow., Niedrzwica 3, 1693.0—1699.0 m × 3

3—4 — *Perigrammoceras sulcatum* (Flem.), fig. 3 — Niedrzwica 3, 1892.0—1898.0 m — × 3; fig. 4 — Niedrzwica 2, 1927.3—1932.0 m — × 4.

5 — *Brachycycloceras* cf. *scalare* Goldf., Niedrzwica 3, 1693.0—1699.0 m × 4

PL. XXII

1 — *Tylonautilus* cf. *nodosocarinatus* Roem., Dęblin 7, 2470.2—2471.2 m × 2

2—3 — *Stroboceras bisulcatum* (de Kon.), Niedrzwica 2, 1900.7—1905.7 m × 6

PL. XXIII

1—2 — *Stroboceras* cf. *stygiale* (de Kon.), fig. 1 — Dęblin 7, 2592.8—2596.5 m — × 2; fig. 2 — Niedrzwica 3, 1892.0—1898.0 m — × 3.

3—4 — *Coelonautilus* sp., fig. 3 — Niedrzwica 3, 1693.0—1699.0 m — × 6; fig. 4 — Opole Lub. 5, 1929.0—1935.0 m — × 7.

5 — *Metacoceras* cf. *perelegans* Girty, Kołbiel 1, 2191.9—2193.2 m × 1.5

PL. XXIV

1—4 — *Eumorphoceras* cf. *pseudobilingue* Bisat, Dęblin 7, 2593.8—2594.8 m, fig. 1 — × 7, fig. 2 — × 5, fig. 3 — × 6, fig. 4 — × 4.

5—6 — *Cravenoceras* cf. *malhamense* Bisat, Dęblin 7, 2593.8—2594.8 m, fig. 5 — × 5, fig. 6 — × 6.

PL. XXV

1 — *Eumorphoceras* ex gr. *bisulcatum* Girty, Bystrzyca IG-1, 1700.9—1701.5 m × 4

2—8 — *Cravenoceratoides nitidus* (Phill.), figs. 2—5 — Chełm IG-1, 938.0—939.1 m, figs. 2—4 — × 10, fig. 5 — × 15; figs. 6—8 — Dęblin 7, 2507.7—2513.7 m, figs. 6 and 7 — × 3, fig. 8 — × 2.

PL. XXVI

1—4 — *Cravenoceratoides* cf. *edalensis* (Bisat), Dęblin 7, 2507.7—2513.7 m, fig. 1 — × 8, figs. 2 and 3 — × 4, fig. 4 — × 6.

5—6 — *Cravenoceratoides nititoides* (Bisat), Chełm IG-1, 925.6—926.5 m, fig. 5 — × 3, fig. 6 — × 2.

PL. XXVII

1 — *Cravenoceratoides* sp., Bystrzyca IG-1, 1574.7—1574.9 m × 6

2—4 — *Homoceras* cf. *subglobosum* (Dolle), fig. 2 — Dęblin 7, 2501.7—2507.7 m —

× 3; figs. 3 and 4 — Niedrzwica 3, 1999.0—2002.0 m, fig. 3 — × 6, fig. 4 — × 7.

5 — *Homoceras* ex gr. *beyrichianum* (de Kon.), Dęblin 7, 2470.2—2471.2 m × 5

PL. XXVIII

1 — *Homoceras* cf. *henkei* Schmidt, Bystrzyca IG-1, 1381.2—1381.3 m × 12

2—5 — *Homoceras* cf. *beyrichianum* (de Kon.), fig. 2 — Kazimierz 1, 2060.0—2062.4 m — × 7; figs. 3, 4 — Dęblin 7, 2498.4—2501.7 m, fig. 3 — × 4, fig. 4 — × 6; fig. 5 —Bystrzyca IG-1, 1410.7—1410.8 m — × 4.

6 — *Homoceras* cf. *moorei* Bouck., Kazimierz 1, 1753.1—1758.6 m × 6

PL. XXIX

1 — *Homoceratoides varicatus* Schmidt, Bystrzyca IG-1, 1373.8—1373.9 m × 12

2 — *Homoceratoides* sp., Bystrzyca IG-1, 1359.4—1359.6 m × 10

3 — *Homoceratoides* sp., Bystrzyca IG-1, 1373.1—1373.3 m × 4

4—6 — *Homoceratoides* cf. *mutabile* Bis. & Huds., Dęblin 7, 2437.3—2438.2 m, fig. 4 — × 10, figs. 5 and 6 — × 8.

PL. XXX

1 — *Homoceratoides* sp., Bystrzyca IG-1, 1373.1—1373.3 m × 6

2 — *Homoceratoides* sp., Chełm IG-1, 680.5—682.5 m × 4

3—6 — *Reticuloceras* cf. *umbilicatum* Bis. & Huds., Bystrzyca IG-1, 1371.4—1373.4 m, figs. 3 and 4 — × 6, figs. 5 and 6 — × 10.

PL. XXXI

1 — *Reticuloceras adpressum* Bis & Huds., Bystrzyca IG-1, 1373.0—1373.3 m × 4

2—4 — *Reticuloceras* cf. *adpressum* Bis. & Huds., figs. 2 and 3 — Bystrzyca IG-1, 1371.6—1373.0 m — × 4; fig. 4 — Bystrzyca IG-1, 1381.2—1381.3 m — × 6

PL. XXXII

1—3 — *Reticuloceras* cf. *adpressum* Bis. & Huds., fig. 1 — Bystrzyca IG-1, 1372.9—1373.0 m — × 5; fig. 2 — Bystrzyca IG-1, 1378.1—1378.3 m — × 4; fig. 3 — Bystrzyca IG-1, 1381.2—1381.3 m — × 6.

4 — *Reticuloceras* sp., Bystrzyca IG-1, 1371.6—1372.0 m × 6

PL. XXXIII

1 — *Reticuloceras todmordenense* Bis. & Huds., Bystrzyca IG-1, 1373.0—1373.3 m × 3

2—3 — *Reticuloceras* cf. *todmordenense* Bis. & Huds., fig. 2 — Bystrzyca IG-1, 1378.6—1378.8 m — × 2.5; fig. 3 — Bystrzyca IG-1, 1373.0—1373.3 m — × 4.

4—5 — *Reticuloceras* sp., Bystrzyca IG-1, 1371.6—1372.9 m, fig. 4 — × 4, fig. 5 — × 6.

PL. XXXIV

1 — *Reticuloceras* cf. *todmordenense* Bis. & Huds., Bystrzyca IG-1, 1372.9—1373.0 m × 4

2 — *Reticuloceras* sp., Niedrzwica 2, 1505.5—1511.5 m × 4

3—4 — *Reticuloceras bilingue* (Salter), Niedrzwica 2, 1505.5—1511.5 m, fig. 3 — × × 5, fig. 4 — × 8.

PL. XXXV

1 — *Reticuloceras bilingue* (Salter), Niedrzwica 2, 1505.5—1511.5 m × 8

2 — *Reticuloceras* cf. *bilingue* (Salter), Niedrzwica 3, 1693.0—1699.0 m × 4

3 — *Reticuloceras superbilingue* Bisat, Niedrzwica 3, 1554.0—1554.7 m × 4

PL. XXXVI

1—5 — *Reticuloceras superbilingue* Bisat, Niedrzwica 2, 1409.8—1410.0 m, fig. 1 — × 5, fig. 2 — × 4, fig. 3 — × 10, figs. 4 and 5 — × 8.

6 — *Gastrioceras* cf. *cumbriense* Bisat, Chełm IG-1, 680.5—682.5 m × 6

PL. XXXVII

1 — *Agastrioceras* cf, *carinatum* (Frech), Opole Lub. 5, 1357.0—1357.2 m × 4

2 — *Gastrioceras* cf. *cumbriense* Bisat, Niedrzwica 3, 1553.2—1553.7 m × 3

3—4 — *Gastrioceras* cf. *cumbriense* Bisat, Chełm IG-1, 680.5—682.5 m × 4

PL. XXXVIII

1—2 — *Gastrioceras* ex gr. *cancellatum* Bisat, Opole Lub. 5, 1357.0—1357.2 m, fig. 1 — × 8, fig. 2 — × 6.

3—5 — *Anthracoceras paucilobum* (Phill.), fig. 3 — Chełm IG-1, 926.4—926.5 m —

× 2; fig. 4 — Dęblin 7, 2498.4—2501.7 m — × 6; fig. 5 — Chełm IG-1, 923.1—923.4 m — × 2.

6—7 — *Anthracoceras* sp., Chełm IG-1, 938.0—939.1 m, fig. 6 — × 12, fig. 7 — × 10.

PL. XXXIX

1—3 — *Anthracoceras paucilobum* (Phill.), fig. 1 — Chełm IG-1, 923.1—923.4 m — × × 4; fig. 2 — Dęblin 7, 2507.7—2513.7 m — × 4; fig. 3 — Tarchały 1, 1849.5—1850.2 m — × 8.

4—5 — *Anthracoceras* cf. *paucilobum* (Phill.), Bystrzyca IG-1, 1550.1—1554.2 m, fig. 4 — × 2, fig. 5 — × 6.

PL. XL

1—5 — *Anthracoceras arcuatilobum* (Ludwig), figs. 1 and 2 — Bystrzyca IG-1, 1372.2—1373.0 m, fig. 1 — × 10, fig. 2 — × 6; fig. 3 — Bystrzyca IG-1, 1380.8—1380.9 m — × 8; figs. 4 and 5 — Niedrzwica 2, 1409.8—1410.0 m — × 10.

6 — *Dimorphoceras (Paradimorphoceras)* cf. *looneyi* (Phill.), Bystrzyca IG-1, 1372.6—1372.7 m × 4

PL. XLI

1—5 — *Dimorphoceras (Paradimorphoceras)* cf. *looneyi* (Phill.), figs. 1—4 — Bystrzyca IG-1, 1372.8—1373.9 m, figs. 1, 2, 4 — × 4, fig. 3 — × 3; fig. 5 — Dęblin 7, 2498.4—2501.7 m — × 4.

PL. XLII

1 — *Dimorphoceras* sp. (suture line), Dęblin 7, 2498.4—2501.7 m × 6

2—5 — *Dimorphoceras* sp., figs. 2 and 3 — Goździk 1, 2129.0—2130.8 m — × 6; figs. 4 and 5 — Chełm IG-1, 938.0—938.4 m — × 10.

6—7 — *Particeps scoticus* Reed (determined by H. Osmólska), Chełm IG-1, 961.7—962.3 m × 8

PL. XLIII

1—2 — *Paladin* cf. *eichwaldi* (Fischer) (determined by H. Osmólska), Chełm IG-1, 1044.0—1044.2 m, fig. 1 — × 10, fig. 2 — × 20.

3 — *Paladin mucronatus* (Mc Coy), Bystrzyca IG-1, 1749.6—1750.6 m × 6

4—10 — *Isaura (Lioestheria)* cf. *striata* (Münster), Chełm IG-1, 787.6—787.7 m × 10.

PL. XLIV

1 — *Carbonita* sp., Niedrzwica 3, 2218,2—2220,7 m × 15

2—5 — *Carbonita* cf. *fabulina* (Jones & Kirkby), Chełm IG-1, 938.0—938.8 m × 10

6 — *Richterina* sp., Opole Lub. 5, 1929.0—1935.0 m × 15

7 — *Jonesina* sp., Chełm IG-1, 938.8—939.6 m × 12

8—9 — *Hindeodella* sp., Niedrzwica 2, 1559.5—1563.5 m × 10

10—13 — *Hyolithes* sp., figs. 10—12 — Opole Lub. 5, 1929.0—1935.0 m — × 6; fig. 13 — Chełm IG-1, 1040.0—1040.5 m — × 8.

PL. XLV

1—3 — *Coleolus* cf. *carbonarius* Dem., Chełm IG-1, 923.9—924.6 m × 2

4—5 — *Cladodus* sp., fig. 4 — Bystrzyca IG-1, 1751.6—1752.5 m — × 5; fig. 5 — Goździk 1, 2127.9—2128.5 m × 4.

6 — *Megalichthys* cf. *hibberti* Agass., Niedrzwica 2, 1456.0—1460.0 m × 6

7 — *Megalichthys* sp., Dęblin 7, 2049.0—2055.0 m × 8

PL. XLVI

1 — *Strepsodus* cf. *sauroides* Binney, Chełm IG-1, 787.6—787.7 m × 2

2 — *Strepsodus* sp., Goździk 1, 2129.0—2130.8 m × 5

3 — *Rhabdoderma elegans* (Newb.), Goździk 1, 2129.0—2130.8 m × 8

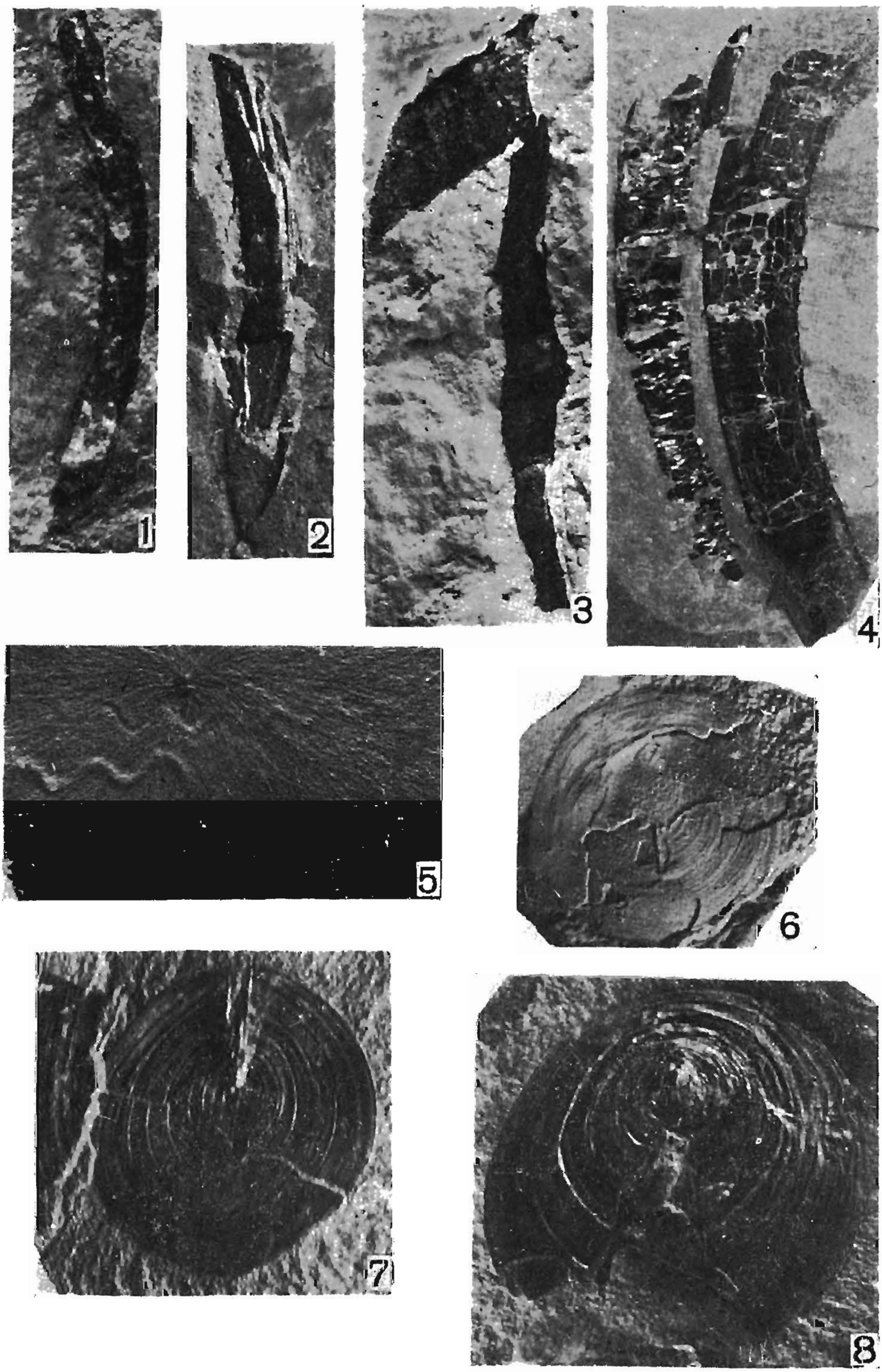
4—5 — *Rhabdoderma* sp., fig. 4 — Niedrzwica 2, 1559.5—1563.5 m — × 10; fig. 5 — Kołbiel 1, 2190.7—2191.9 m — × 7.

6 — *Rhadinichthys* sp., Dęblin 7, 2238.5—2238.9 m × 20

7—8 — *Elonichthys* sp., fig. 7 — Dęblin 7, 2238.5—2238.9 m — × 20; fig. 8 — Dęblin 7, 2437.3—2438.2 m — × 6.

9 — *Acrolepis* sp., Niedrzwica 2, 1680.3—1684.3 m × 15

Fotografie wykonał R. Adamik
Photographs by R. Adamik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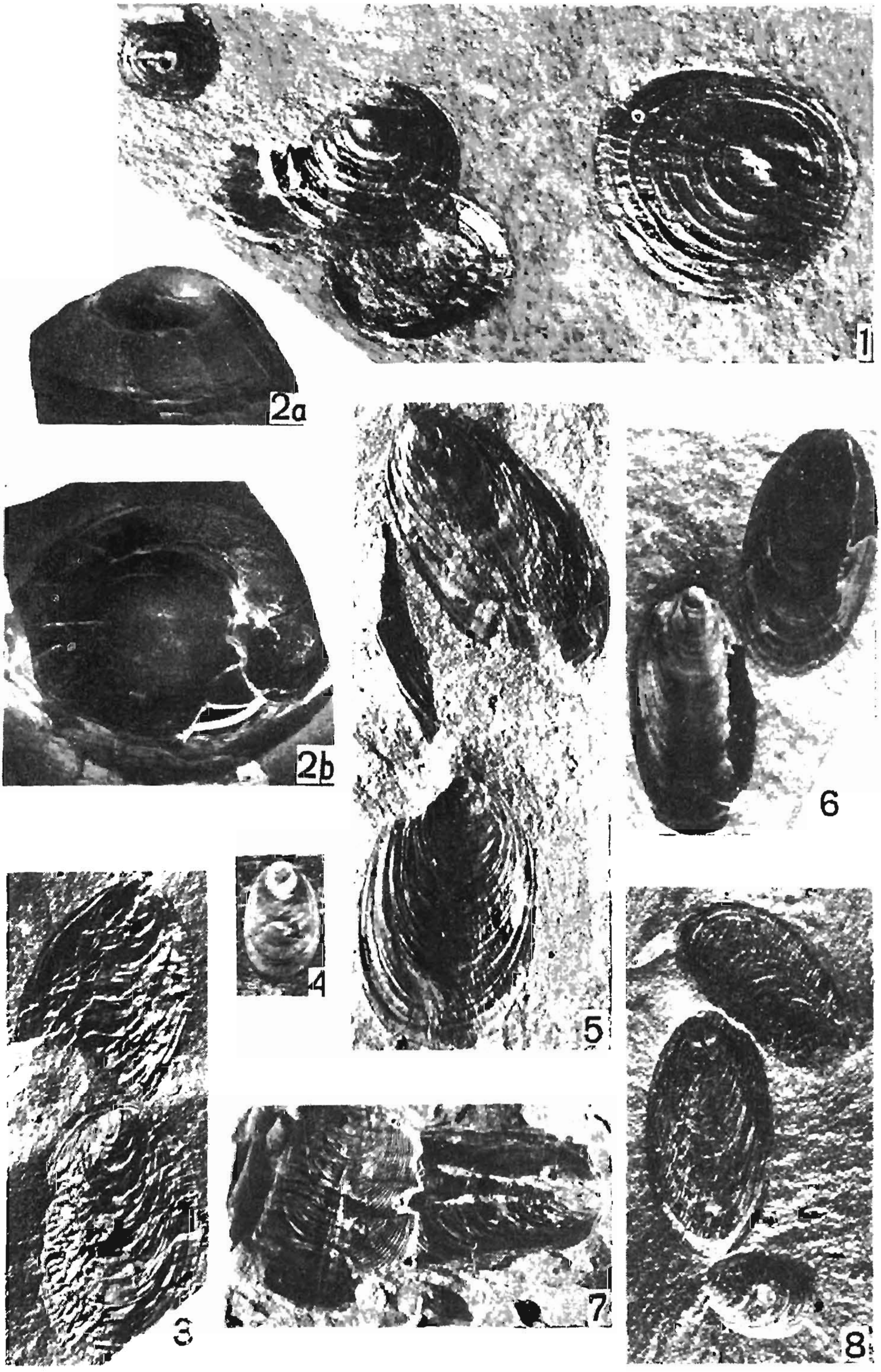
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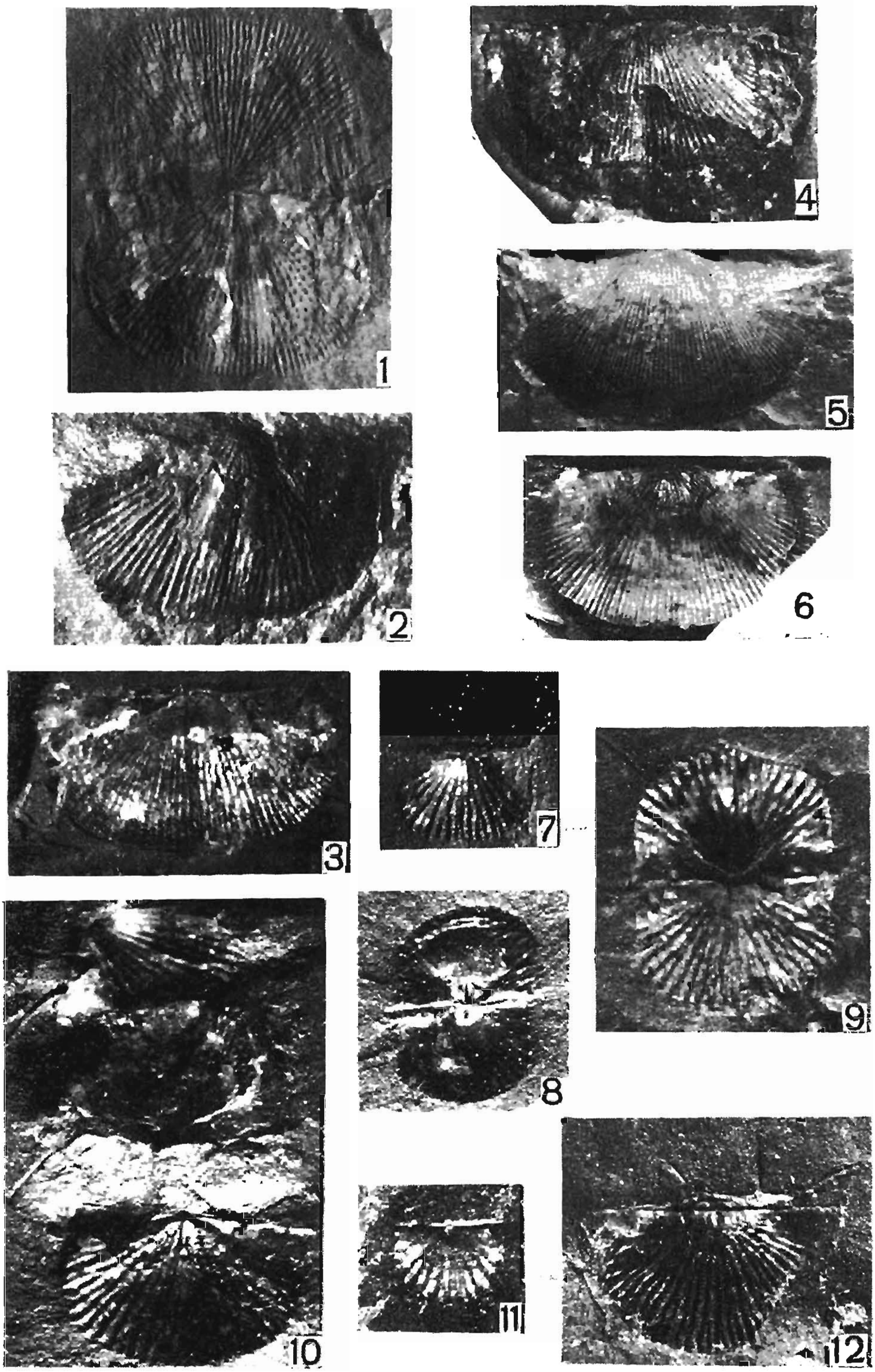
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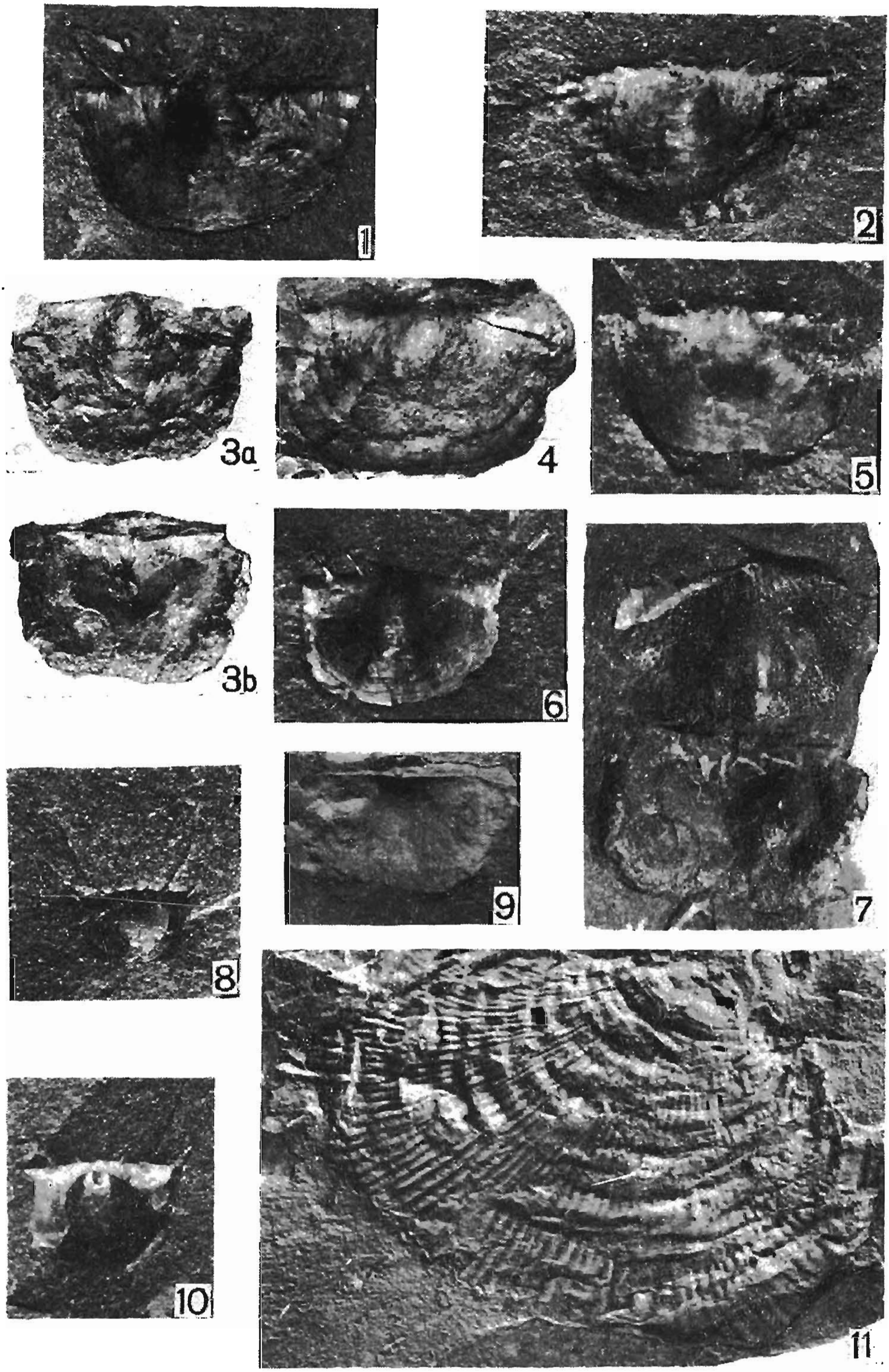
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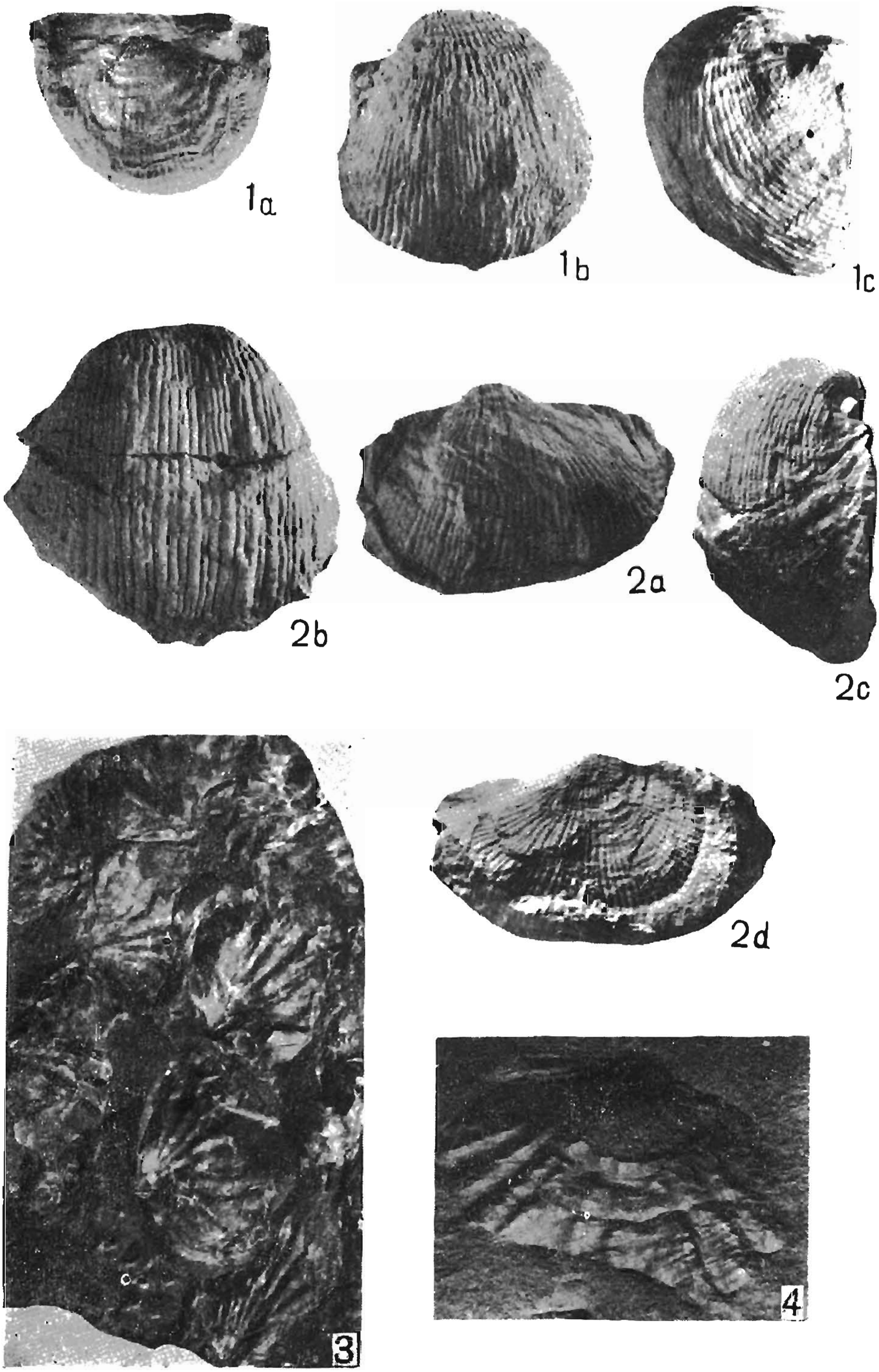
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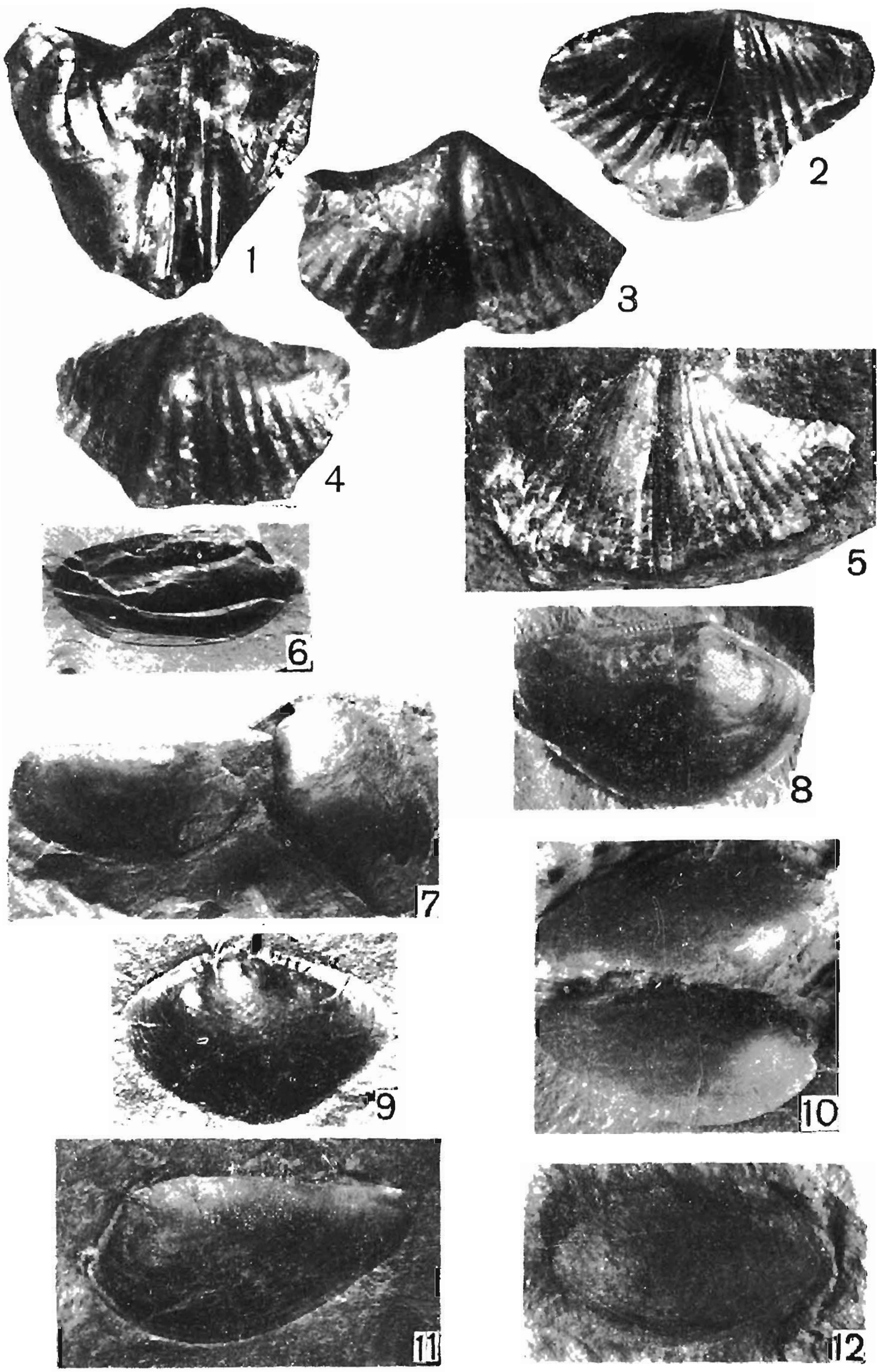

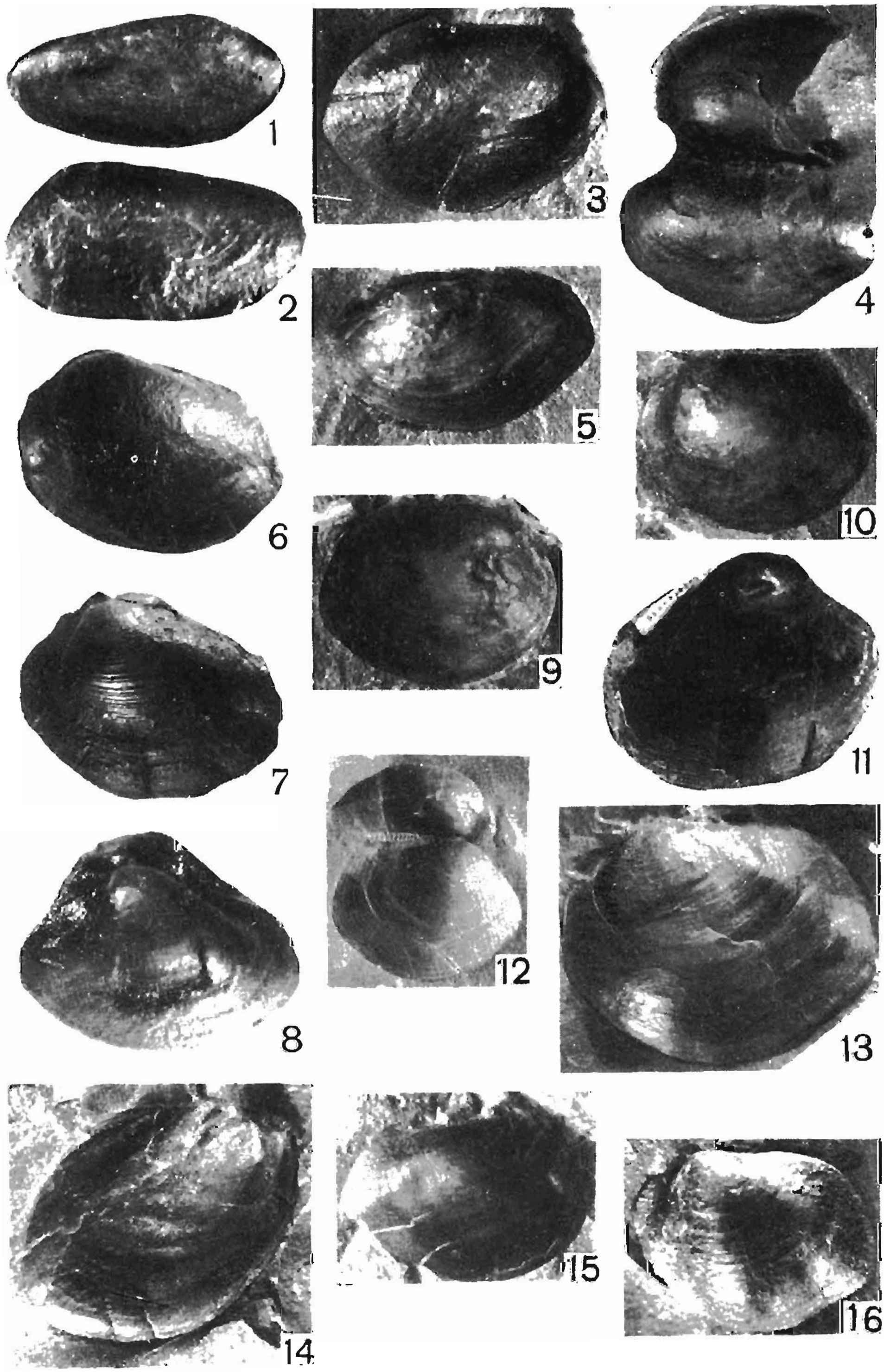
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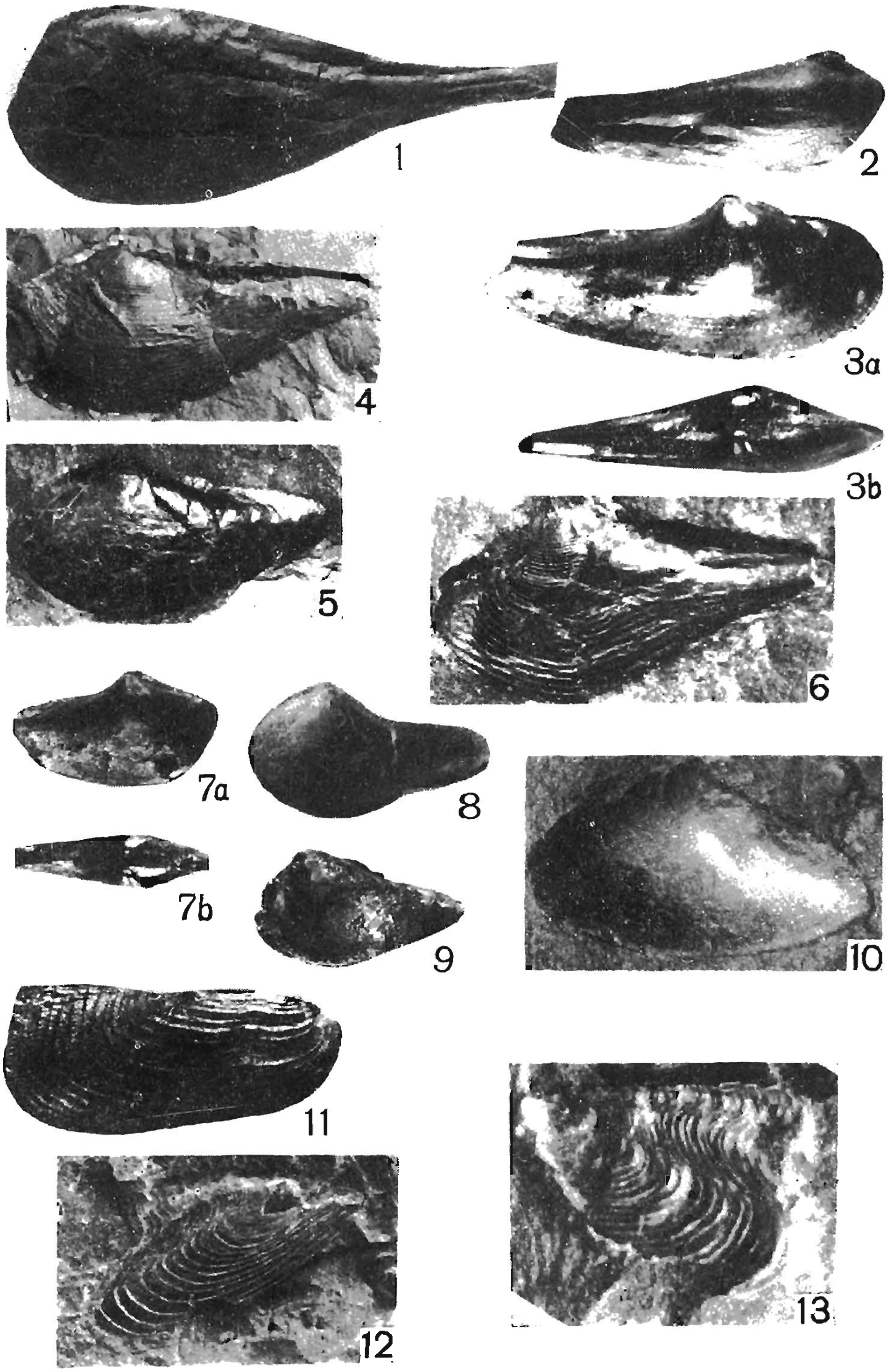
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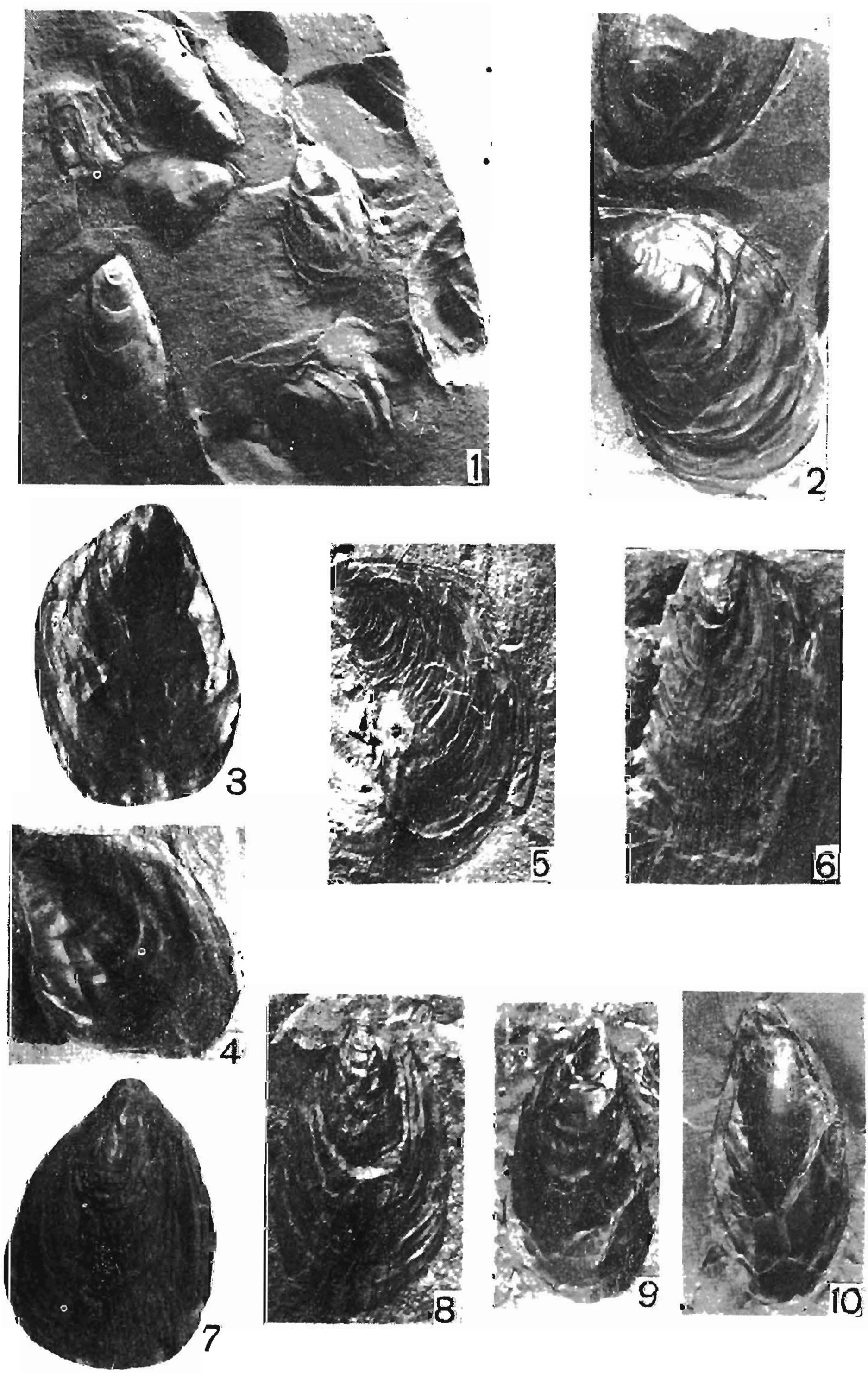
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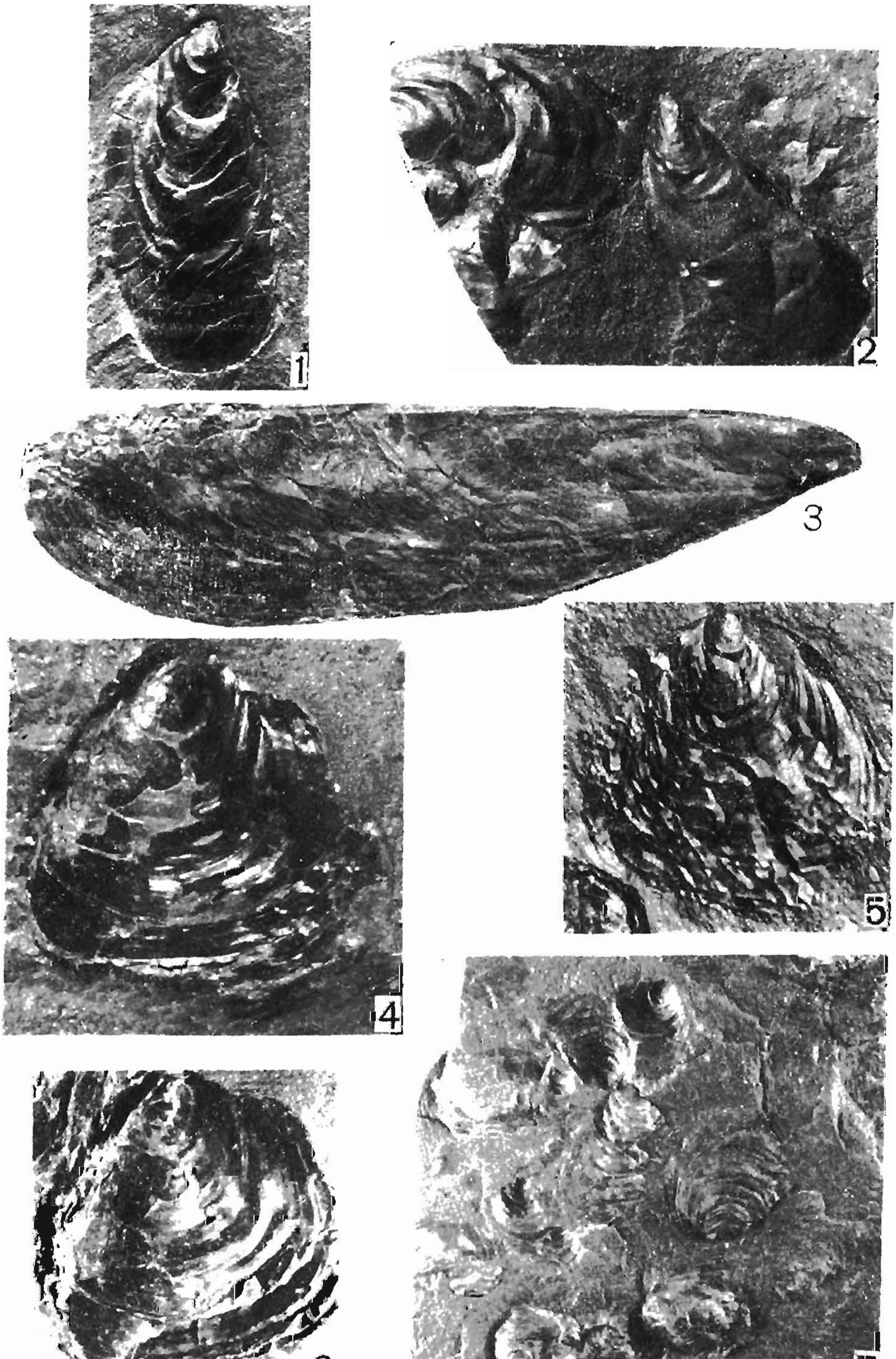
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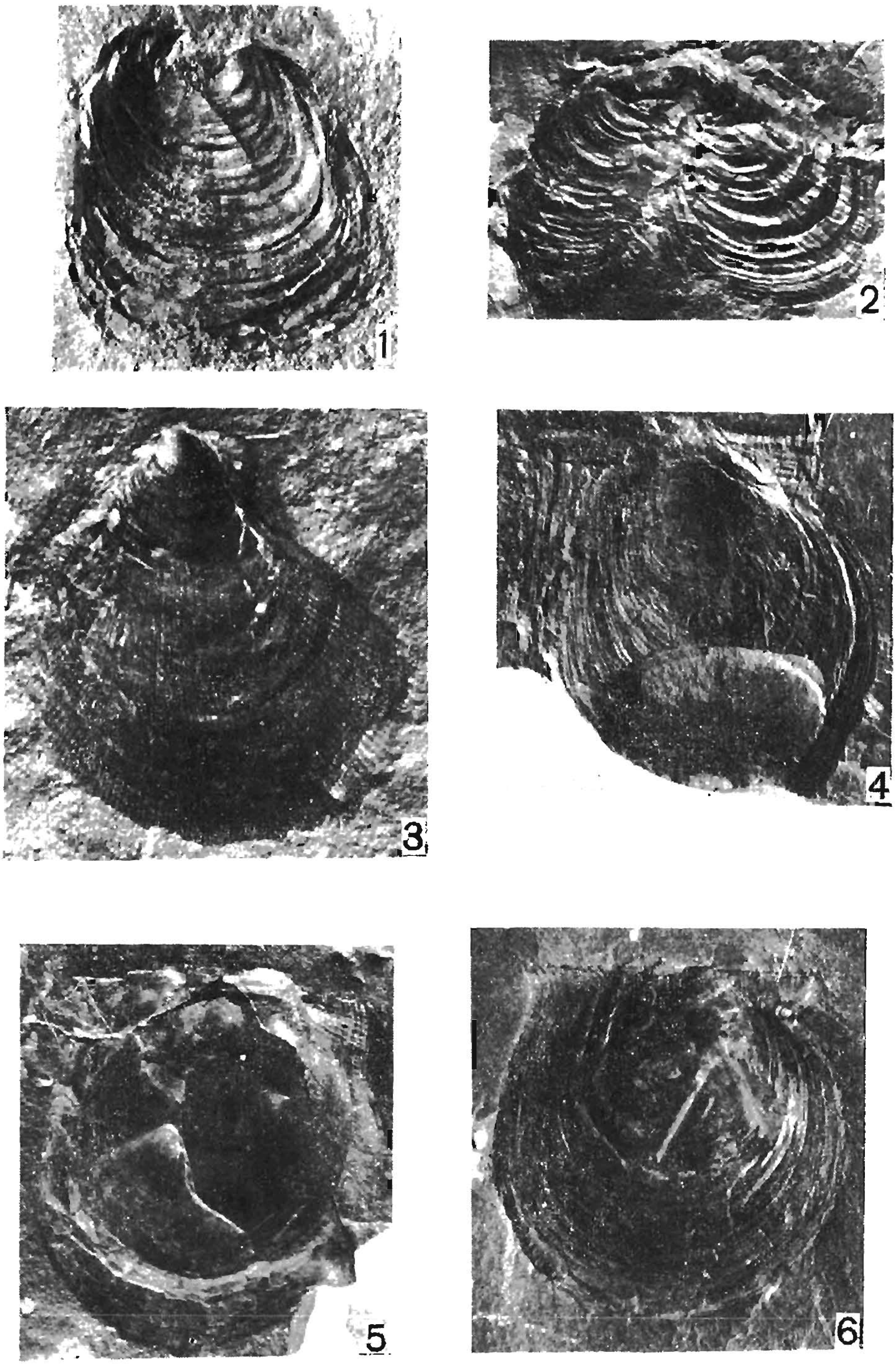

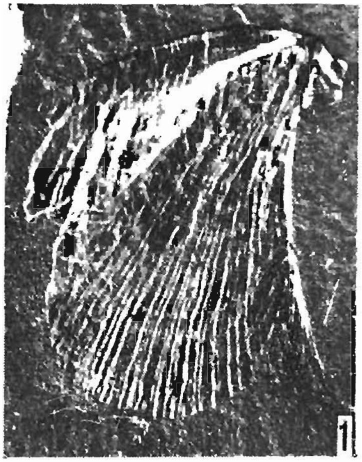
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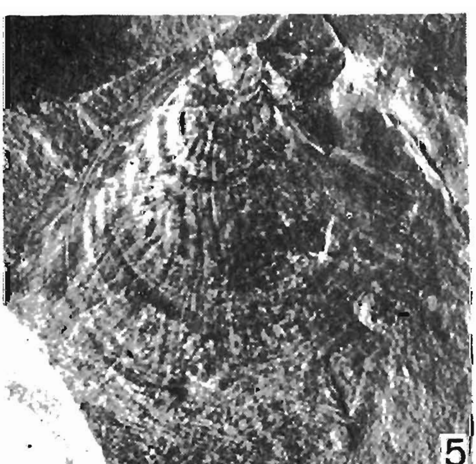
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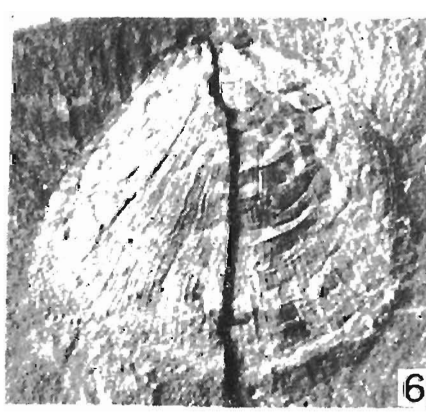
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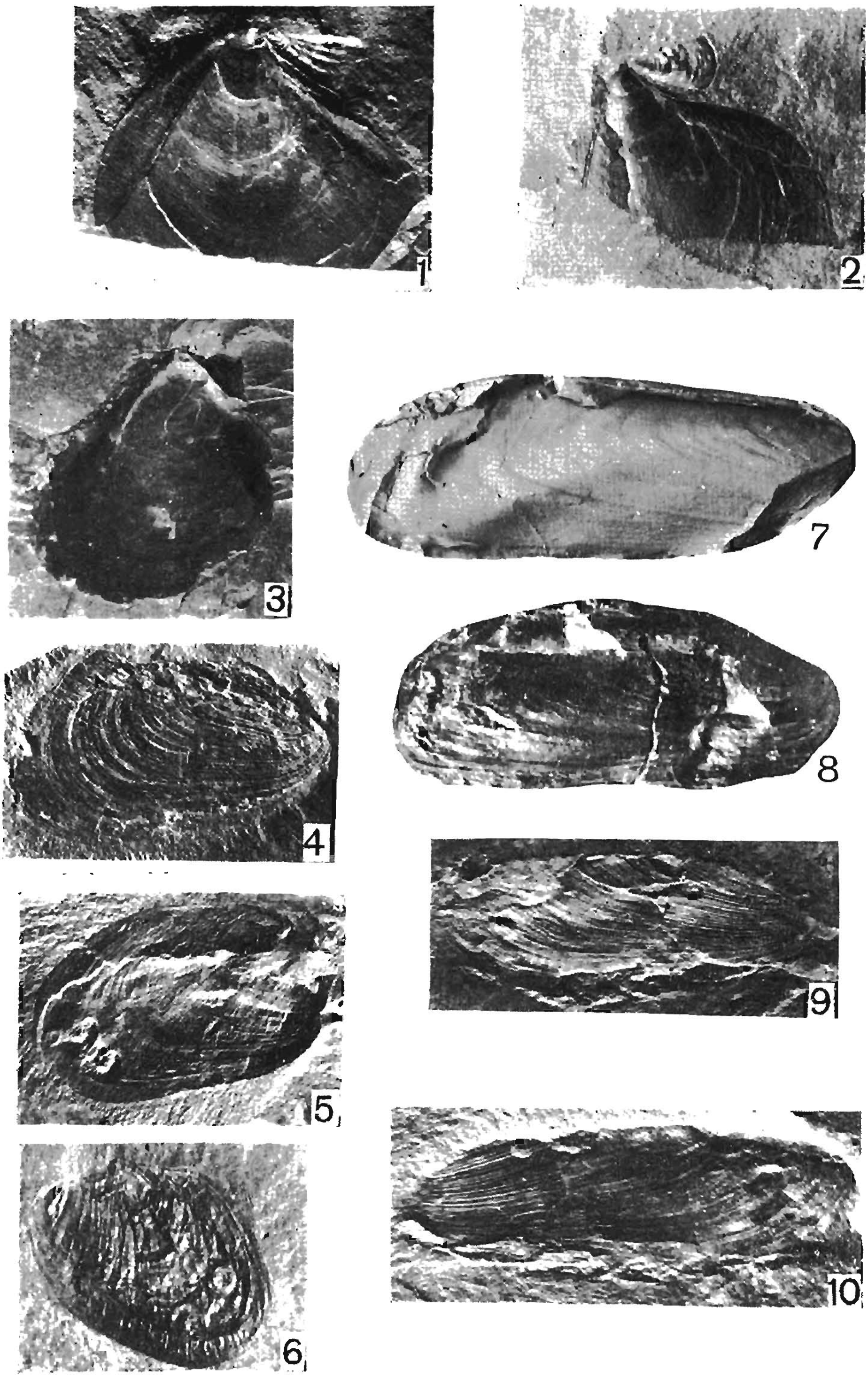
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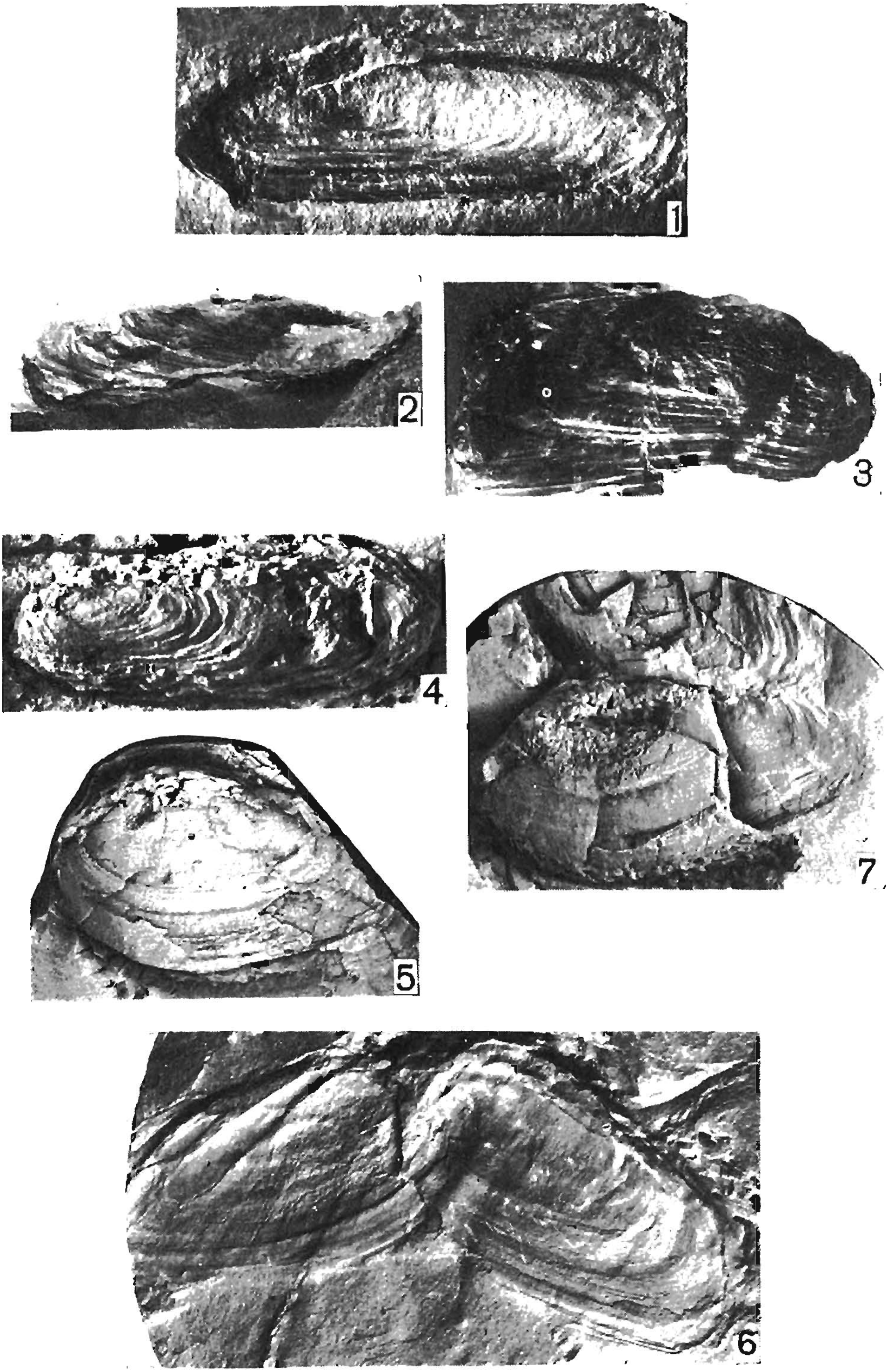
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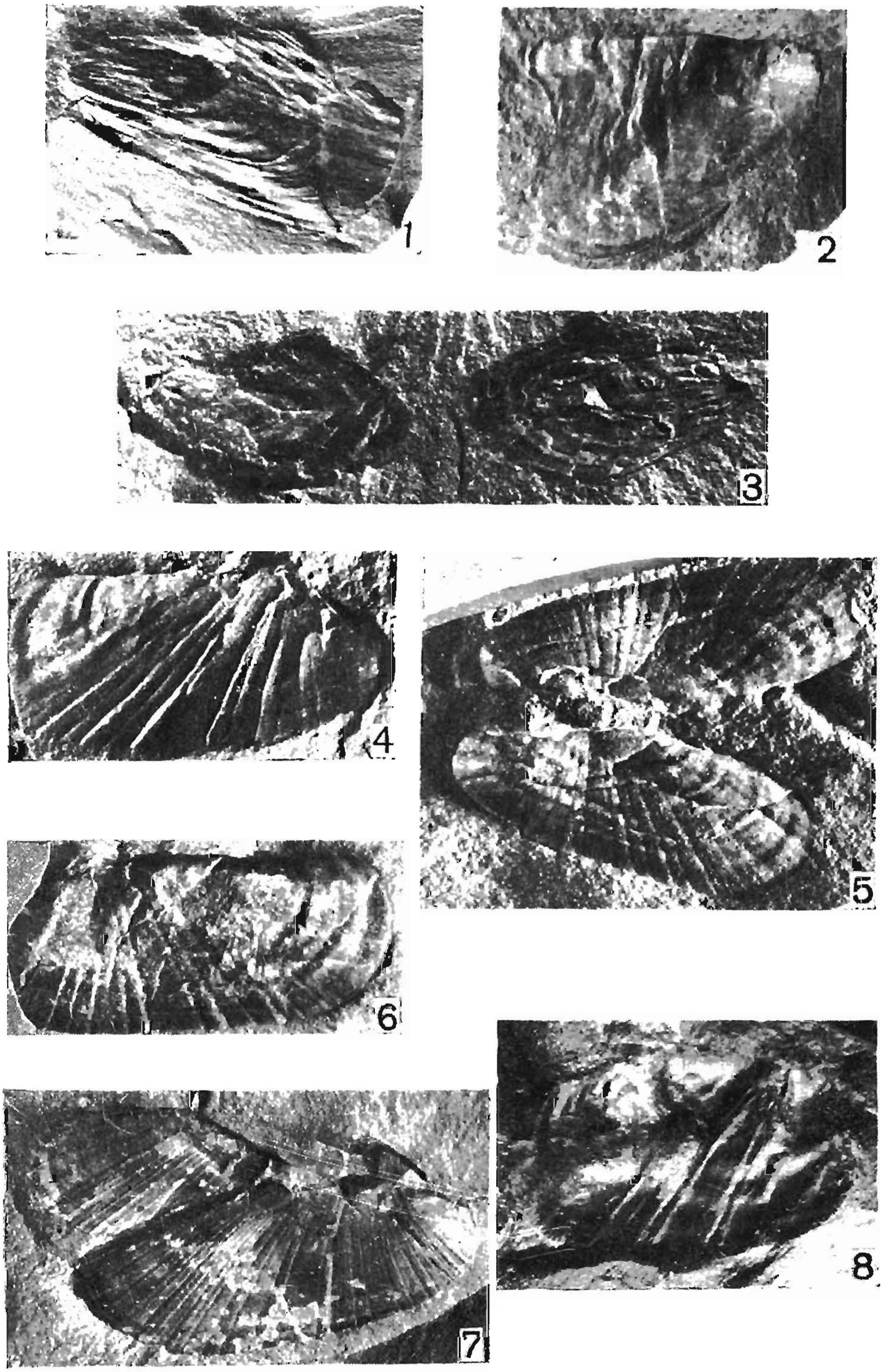

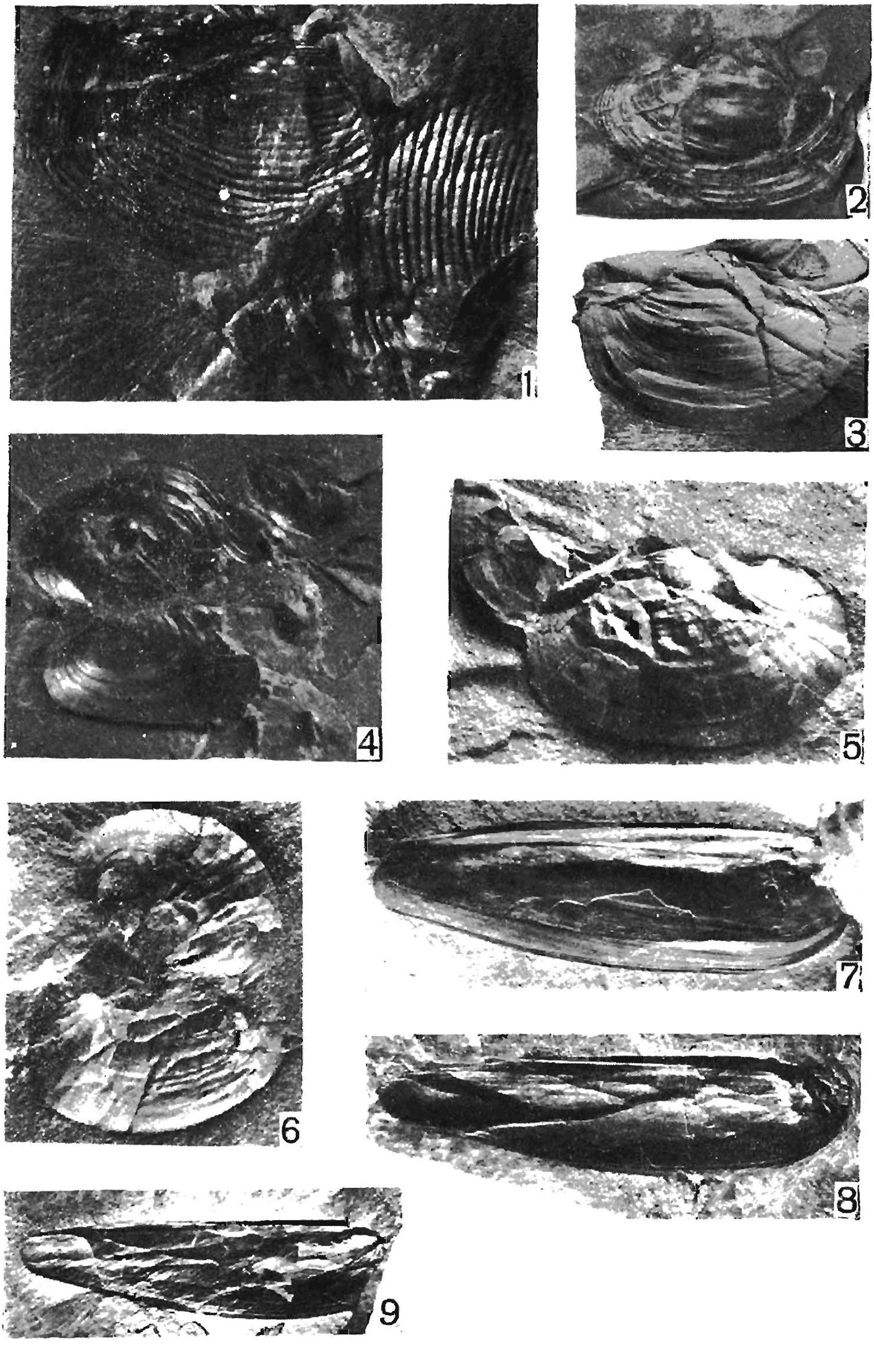
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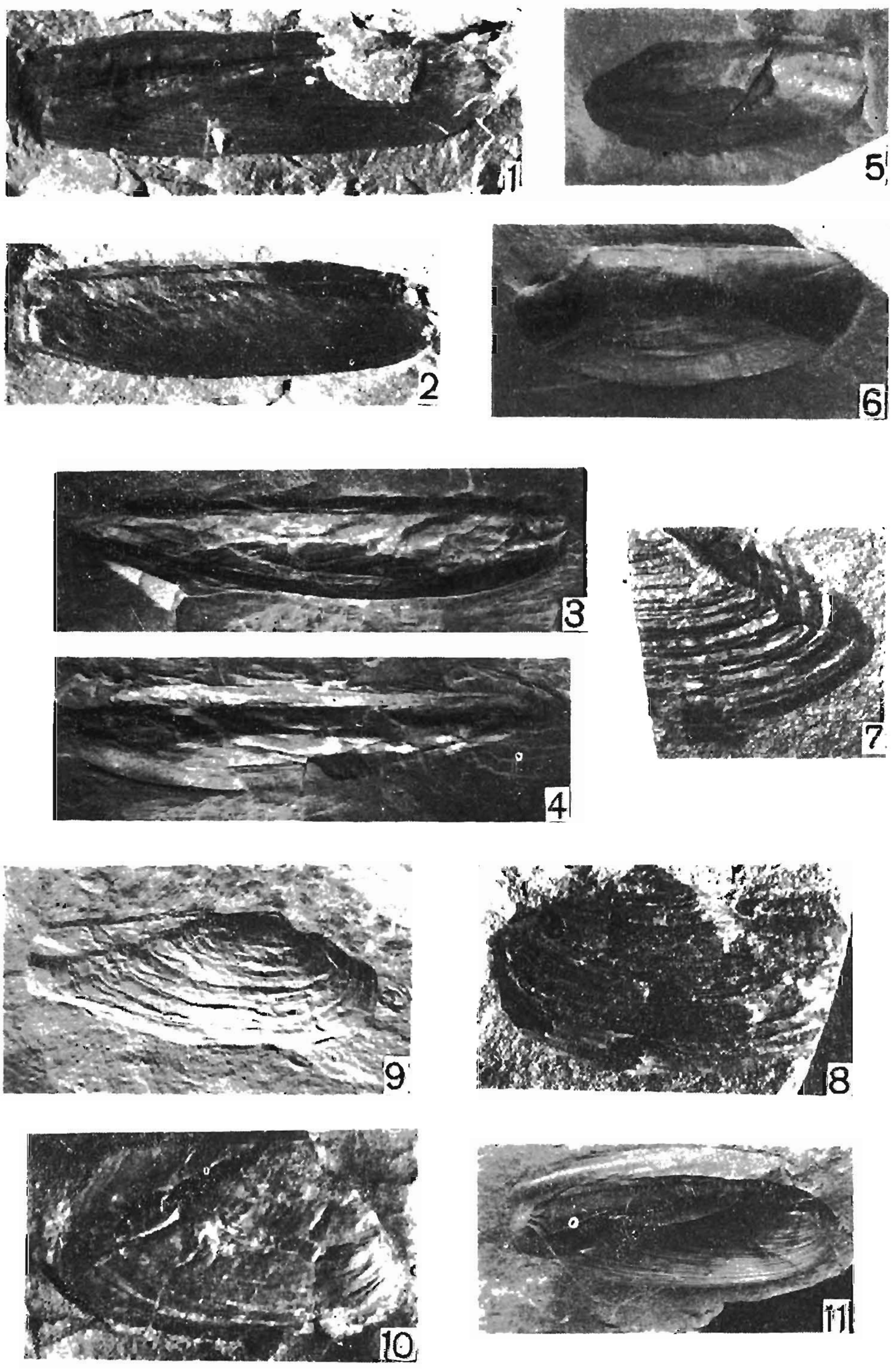

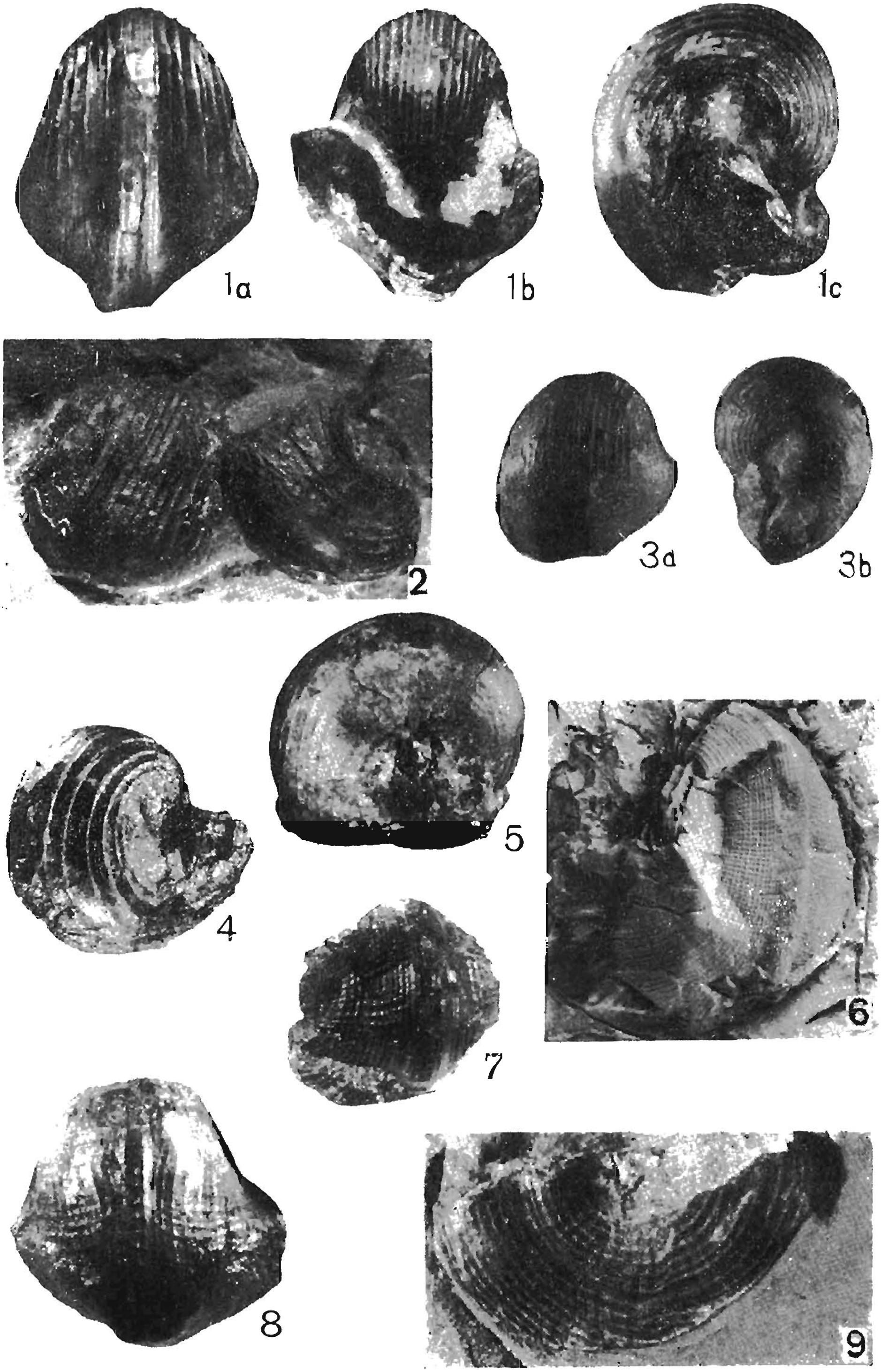
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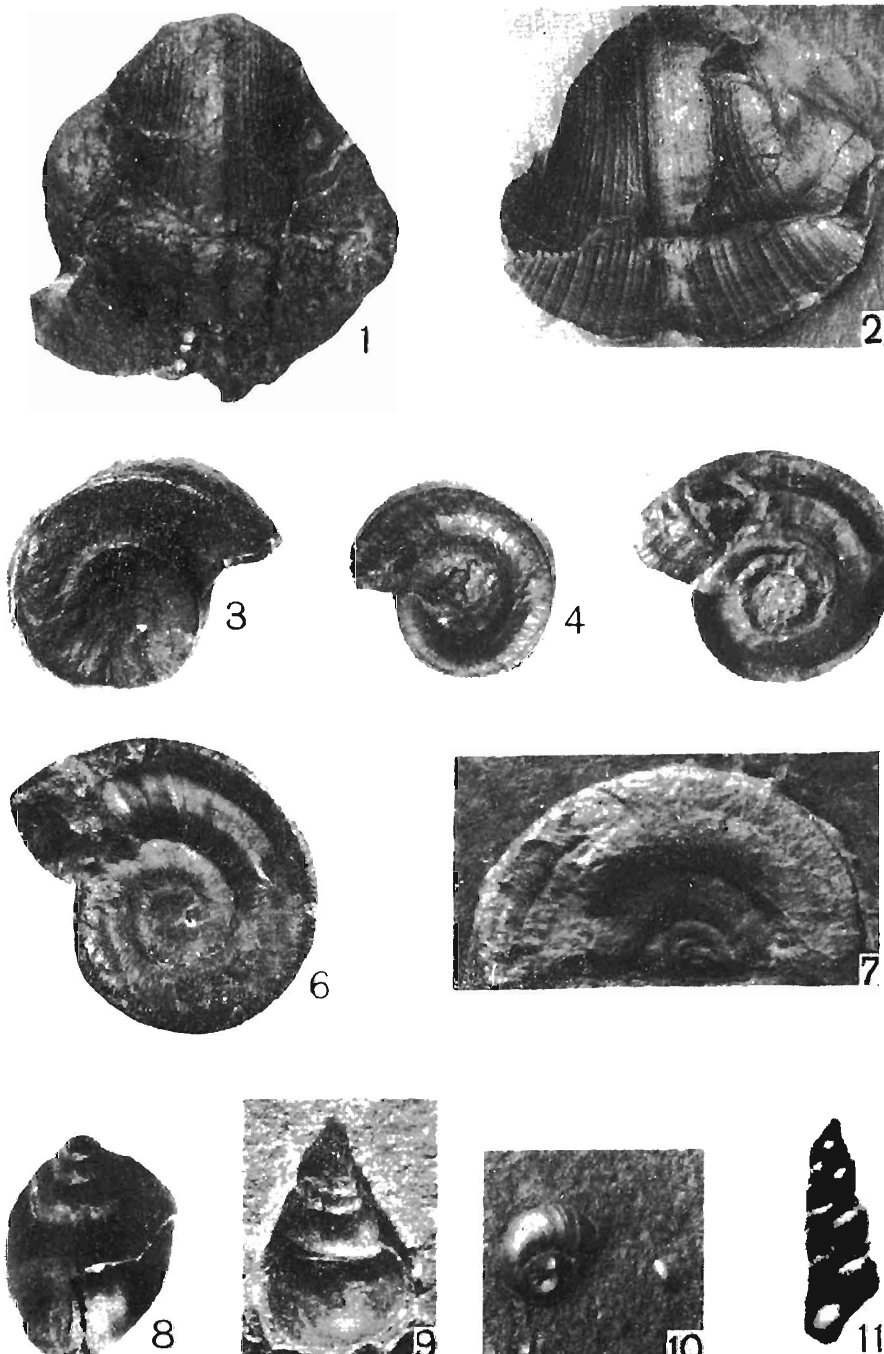
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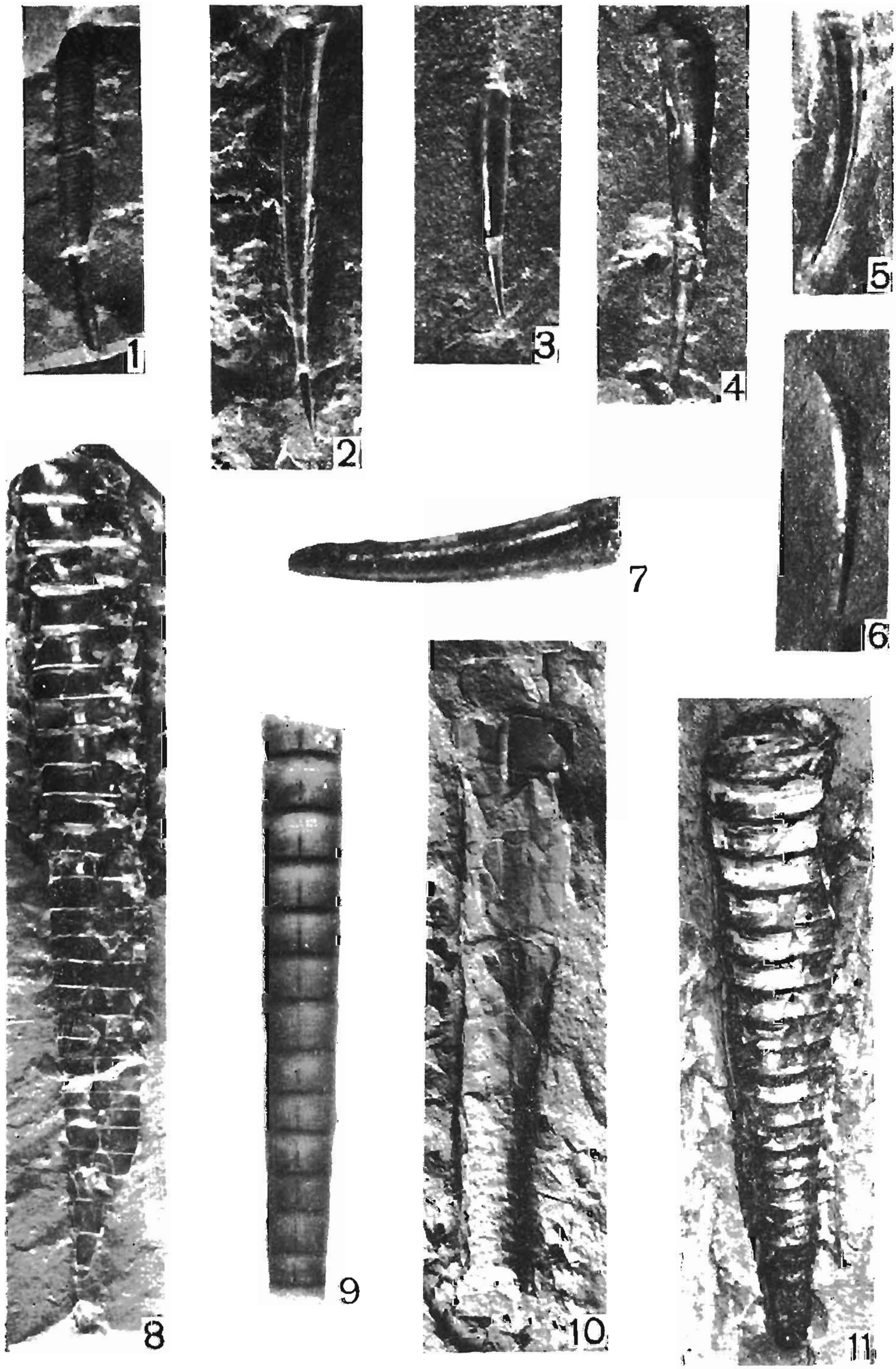
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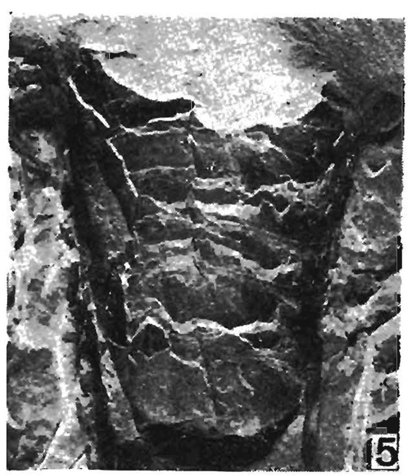

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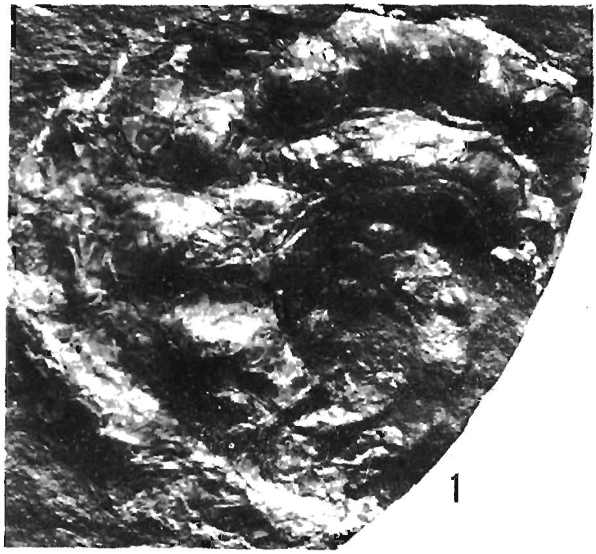

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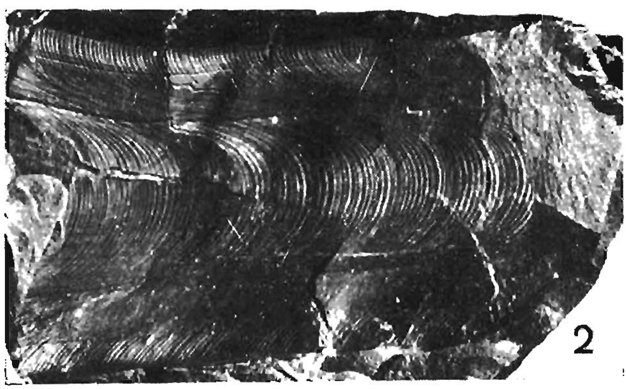

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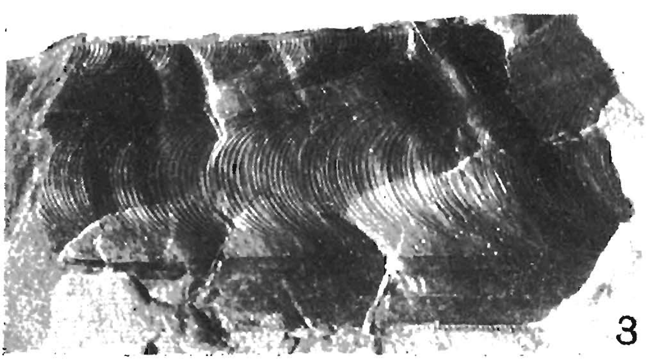

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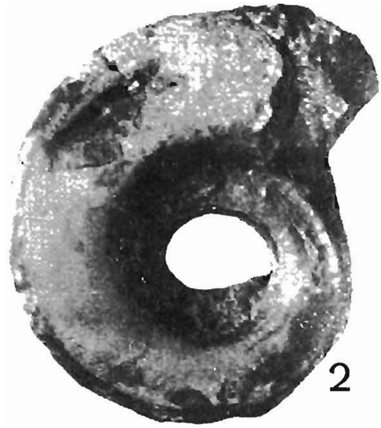

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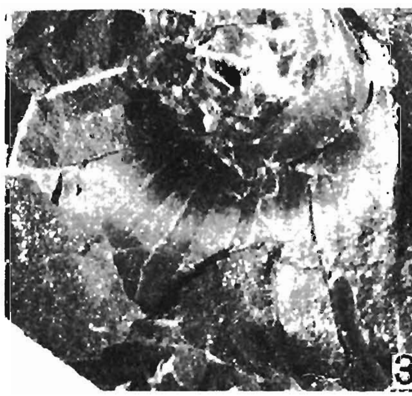

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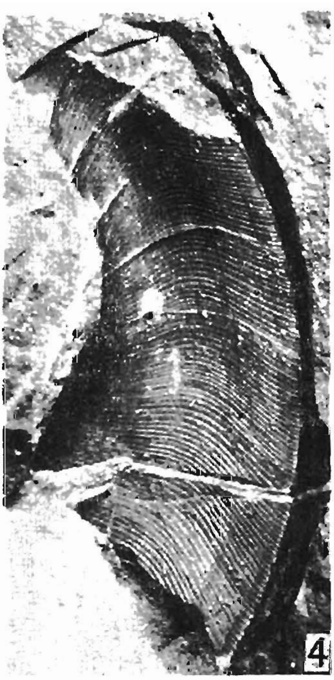

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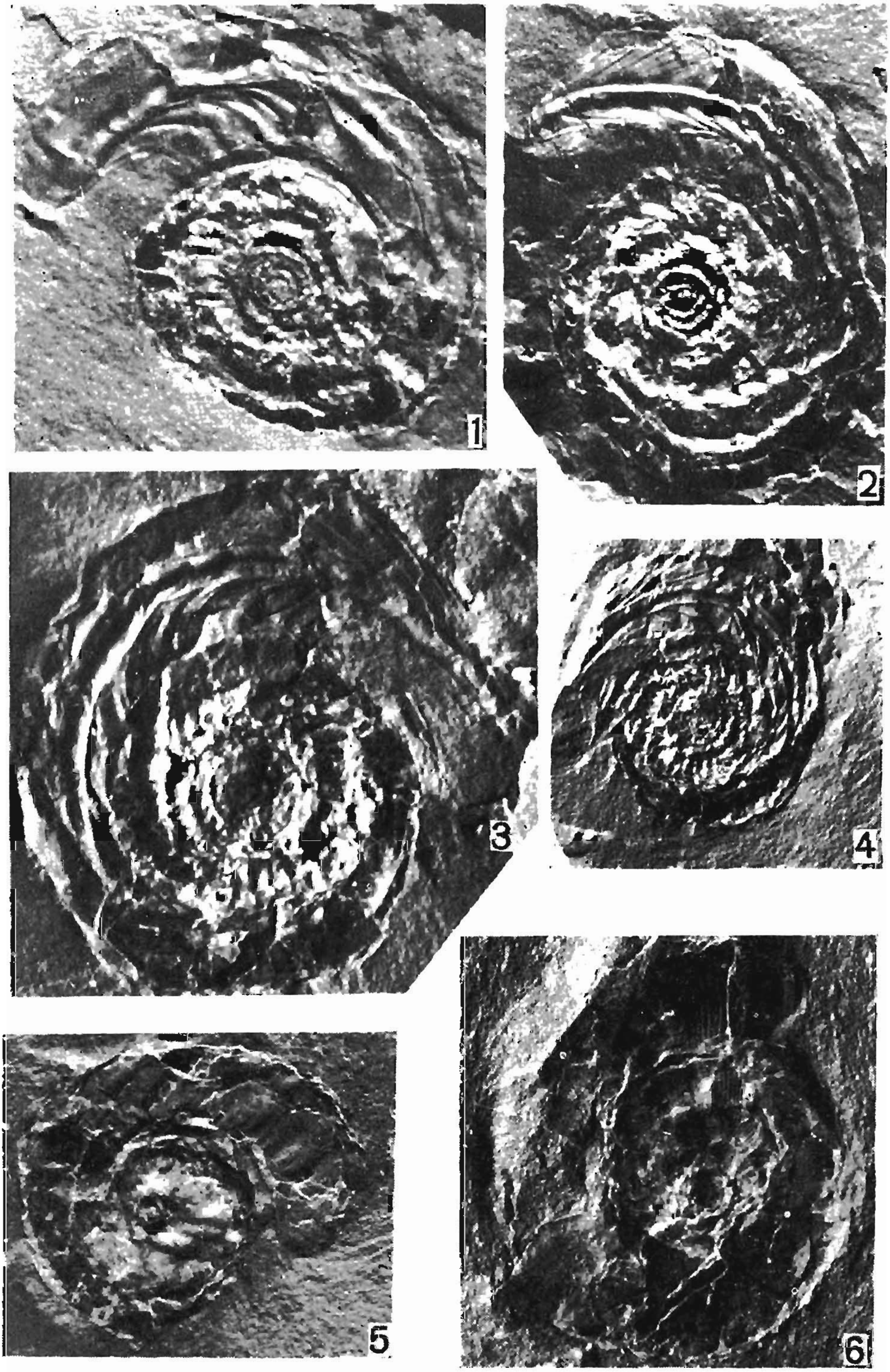
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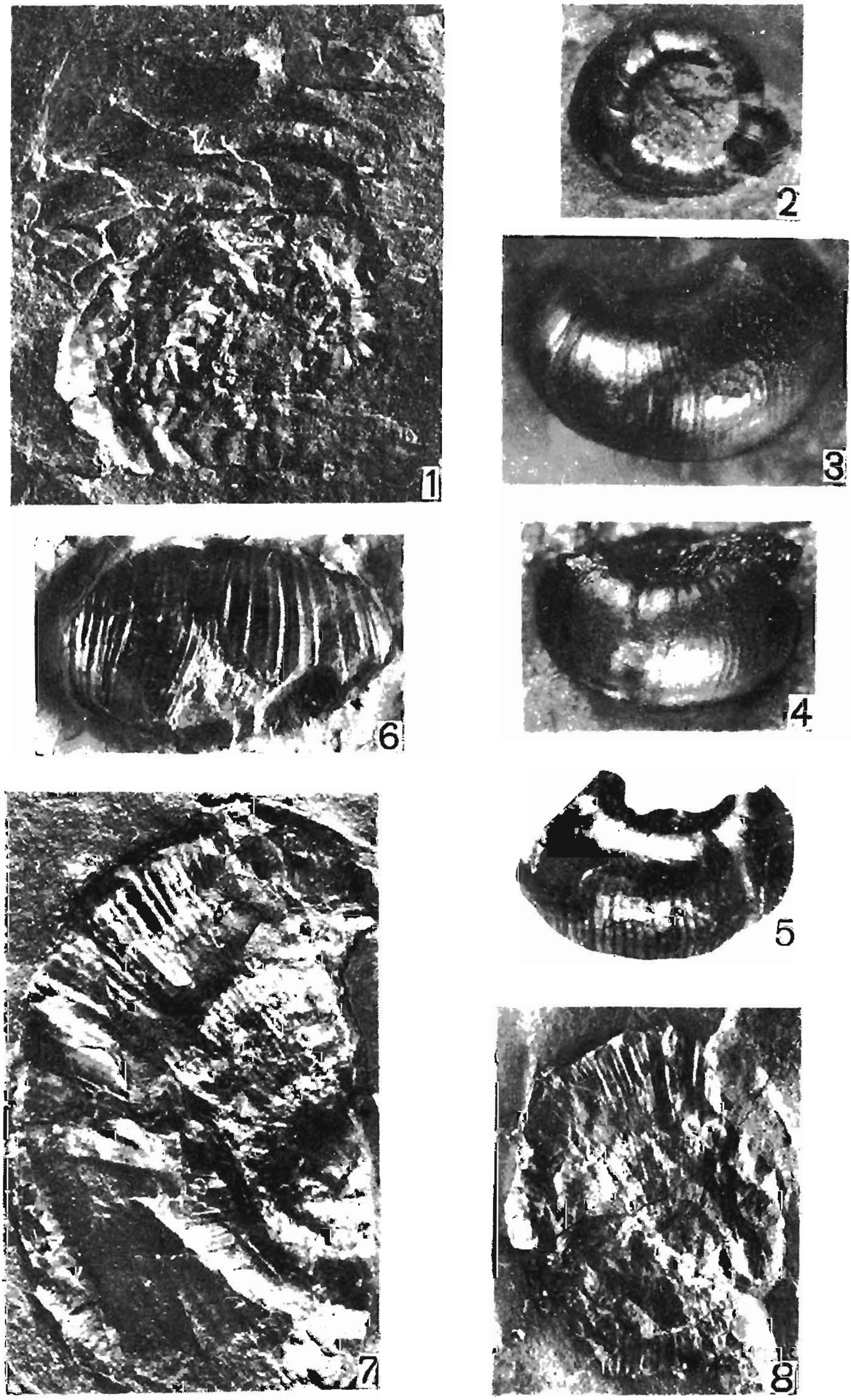
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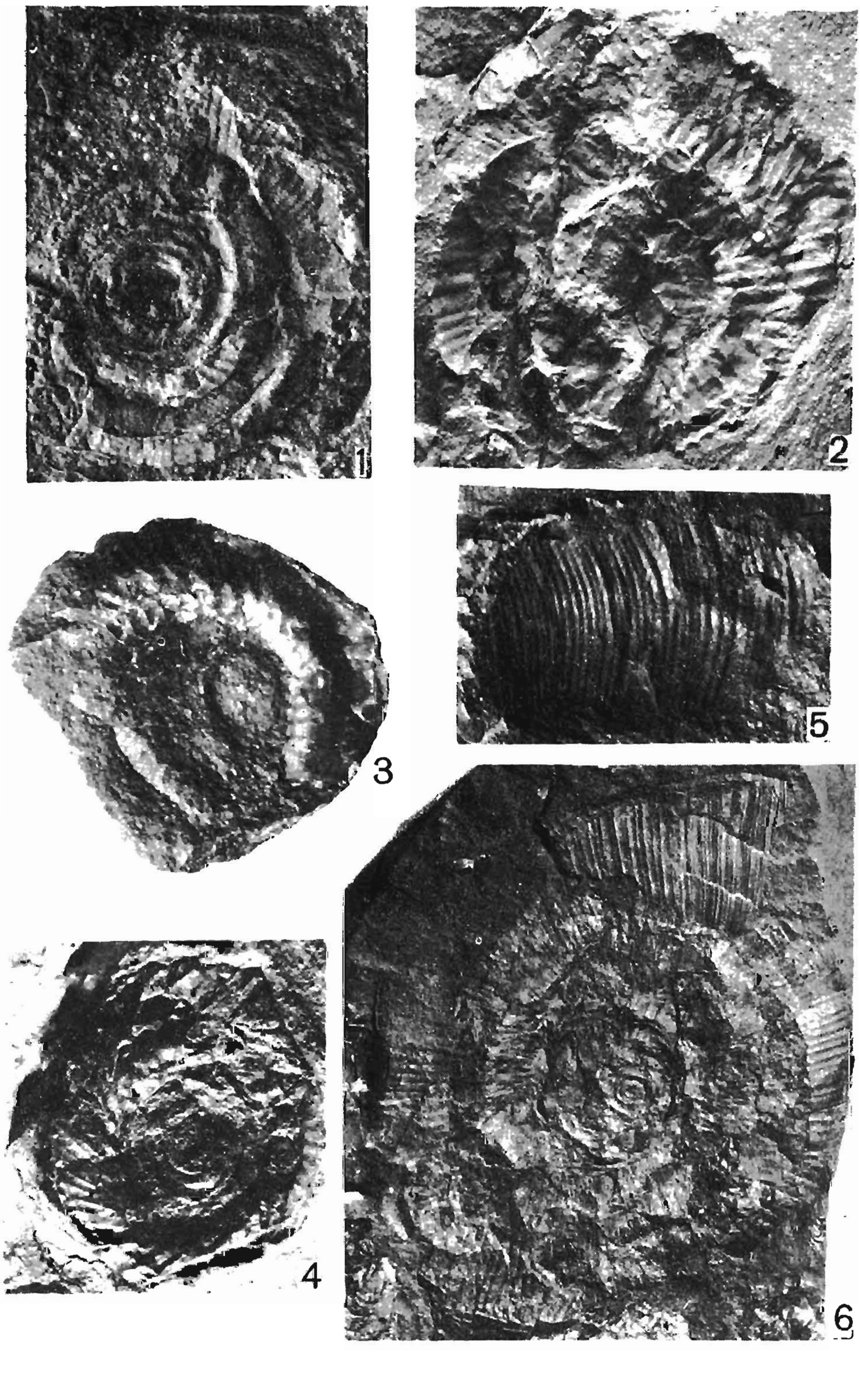
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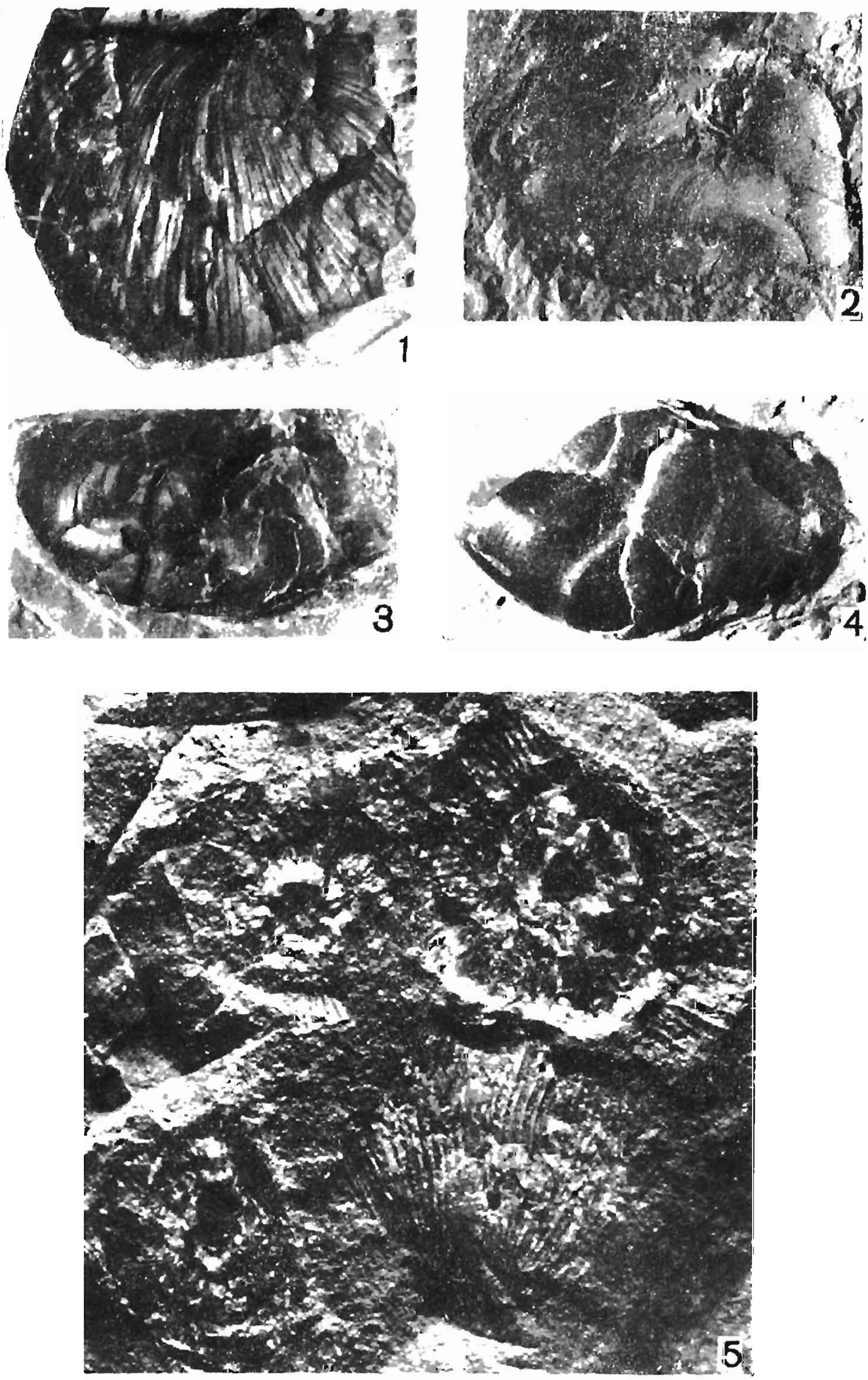
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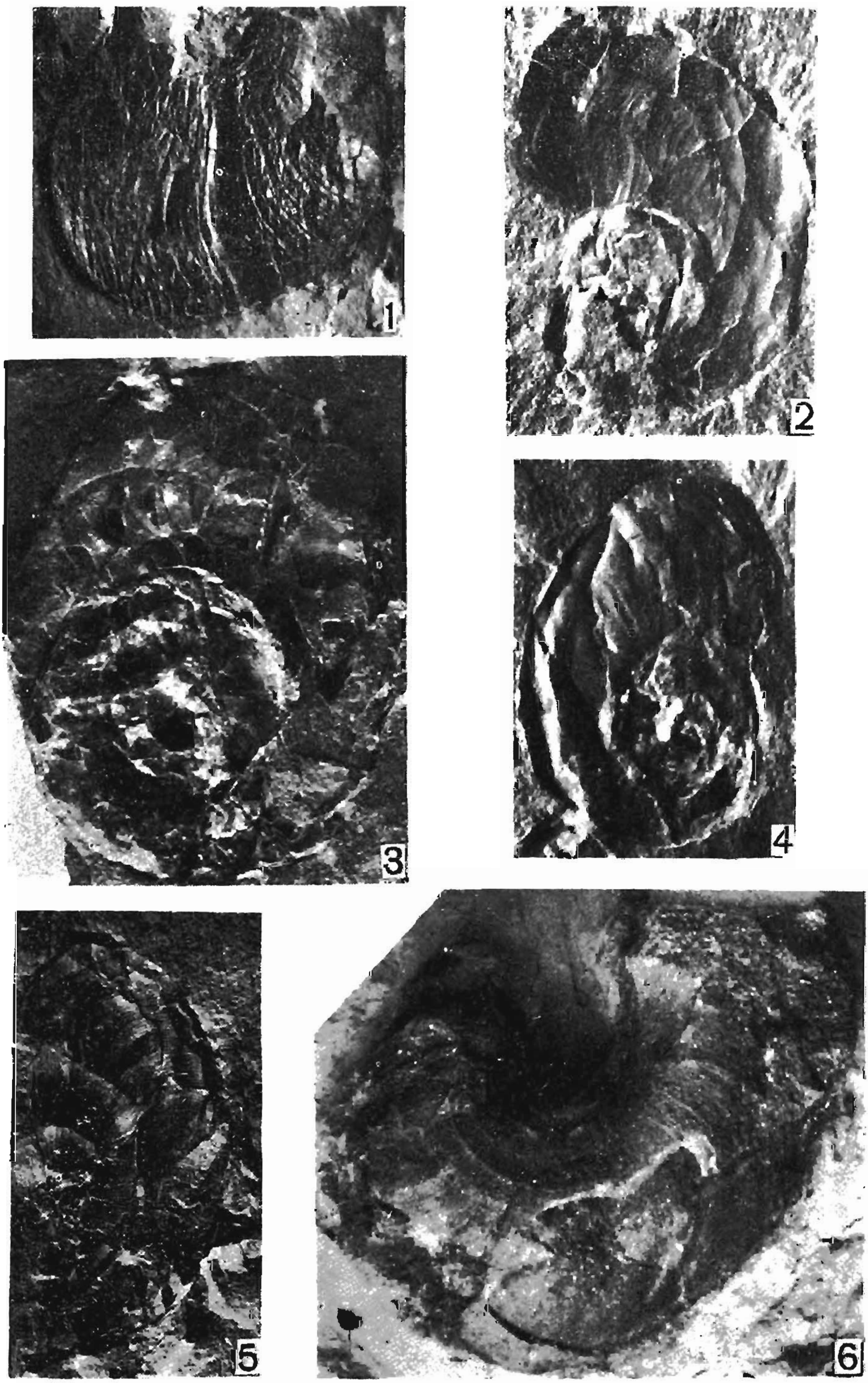
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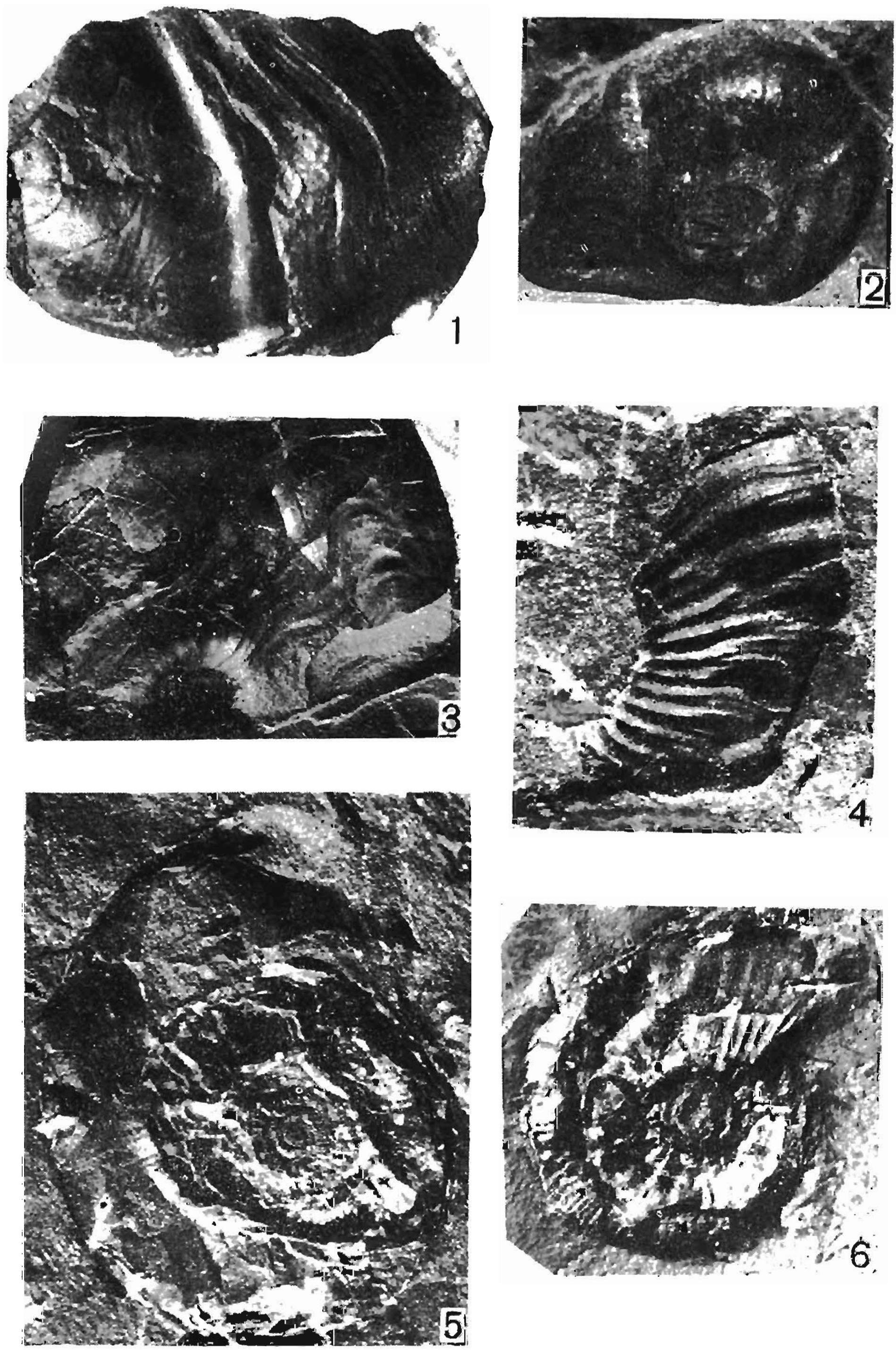
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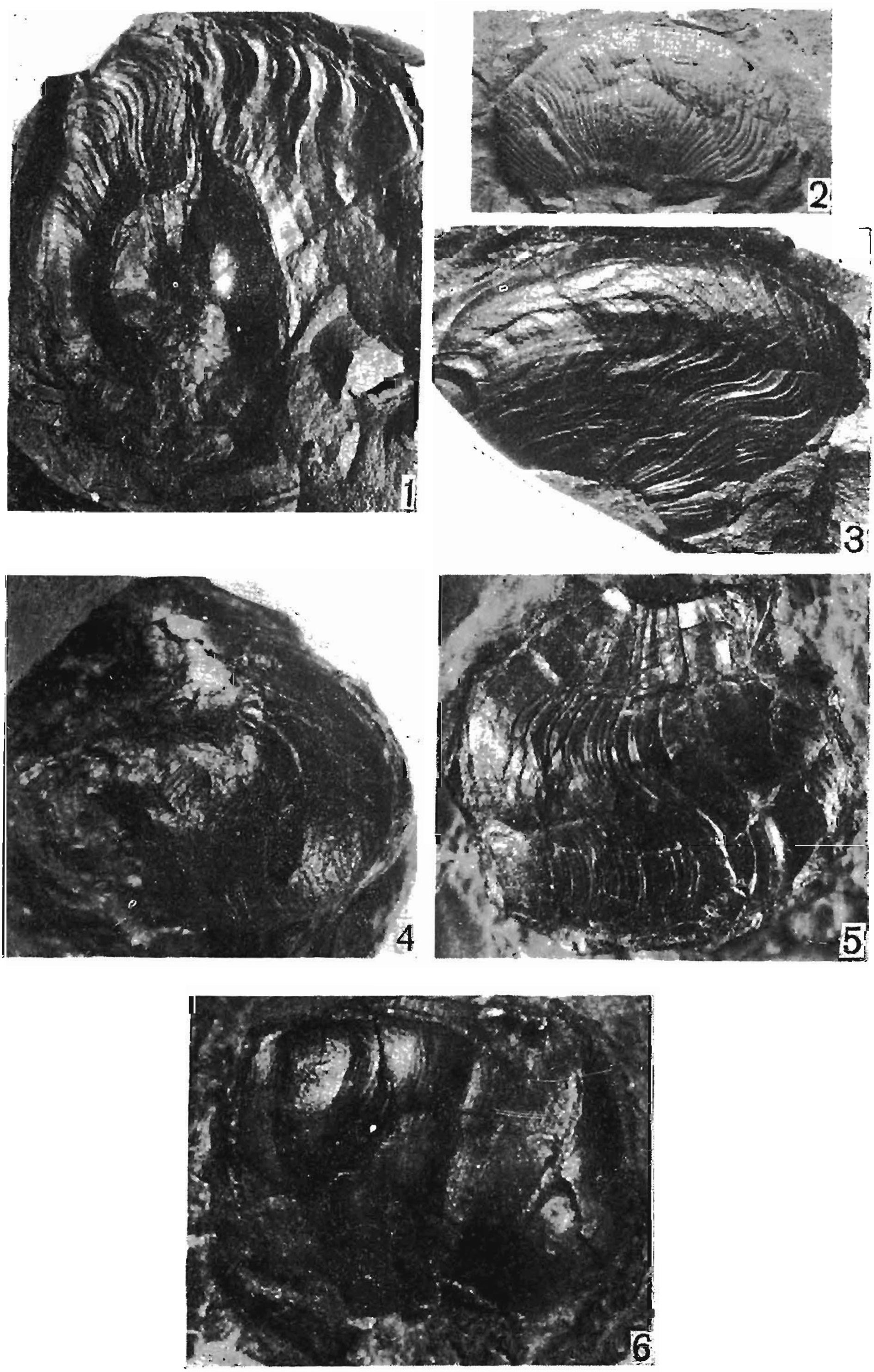
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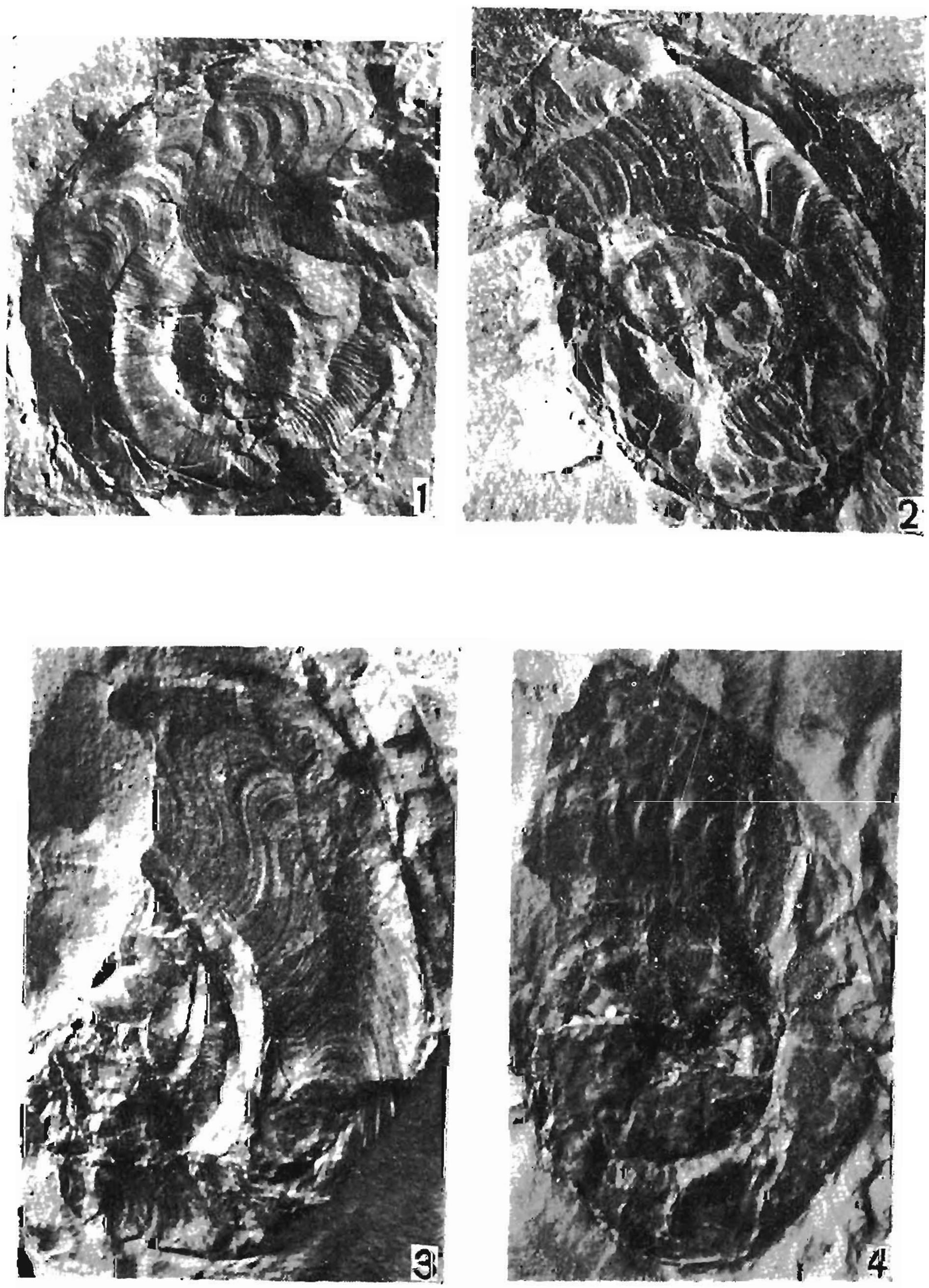


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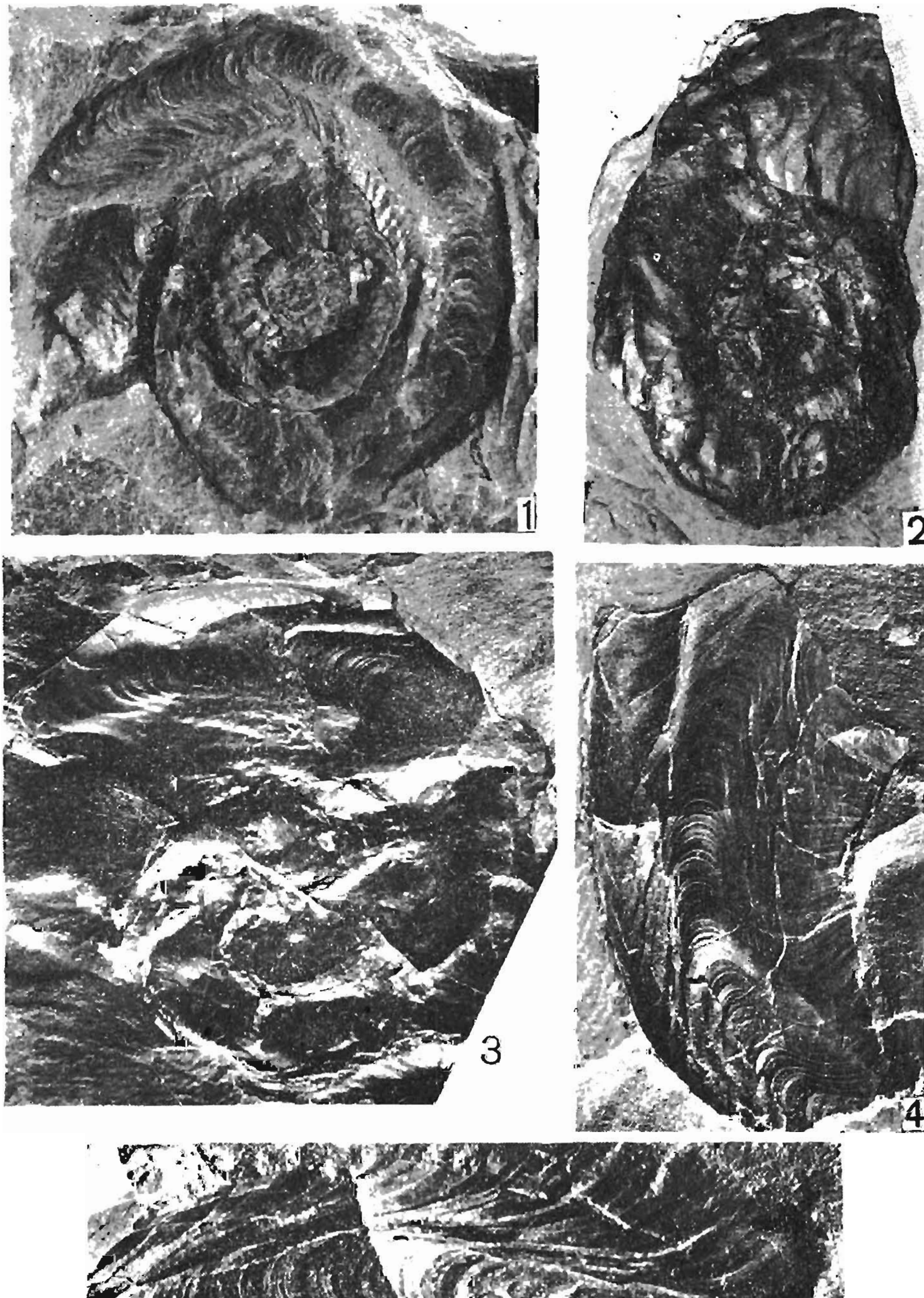
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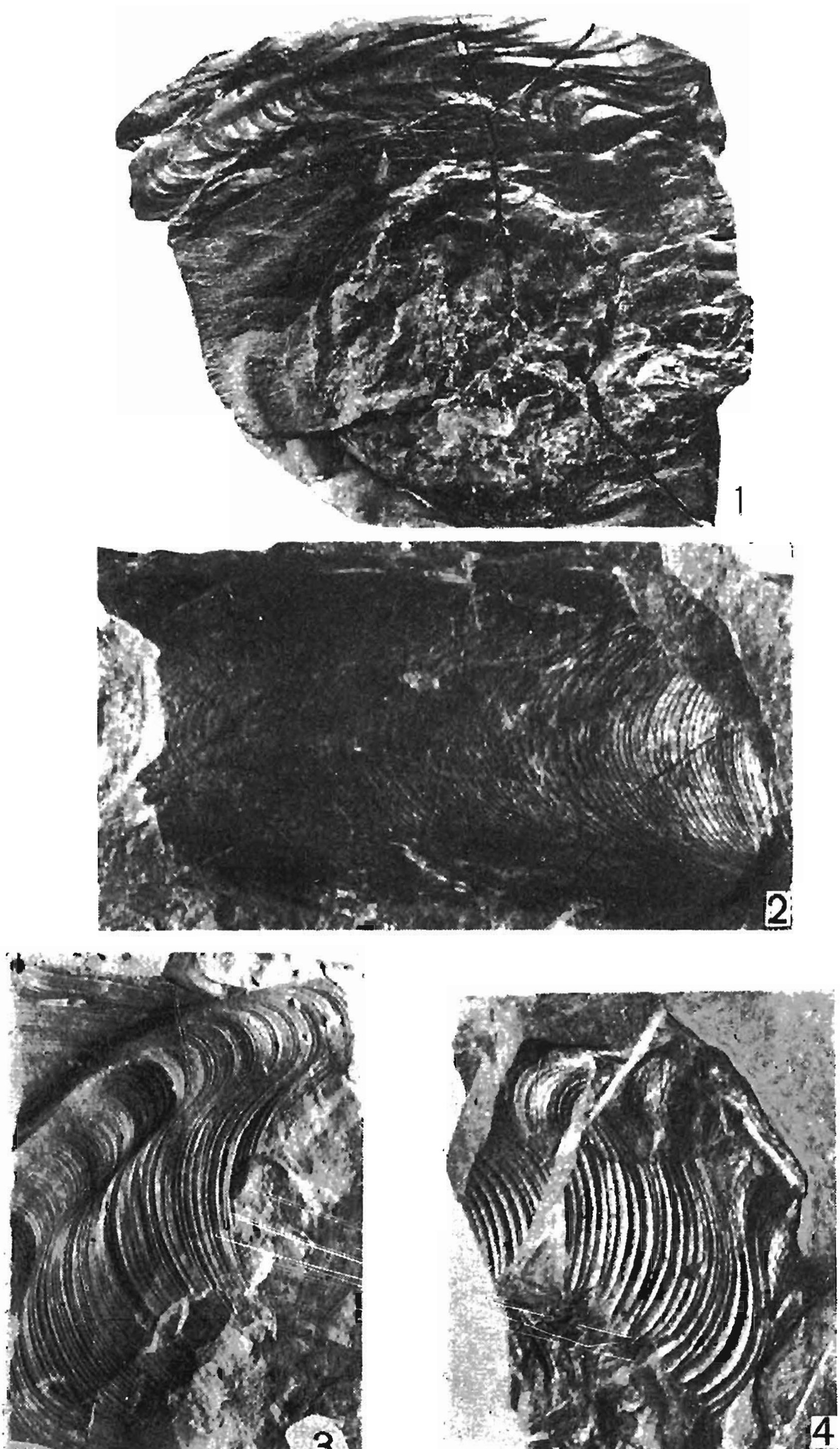


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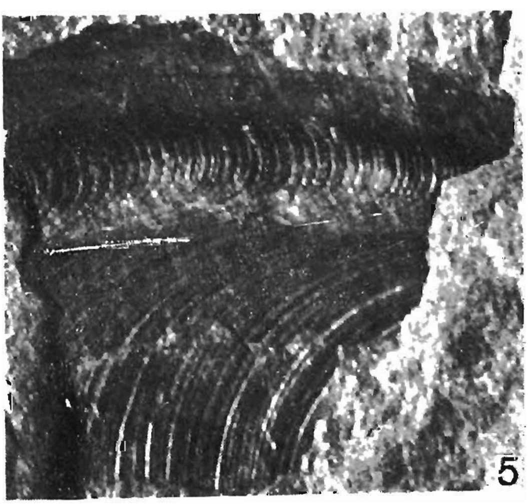
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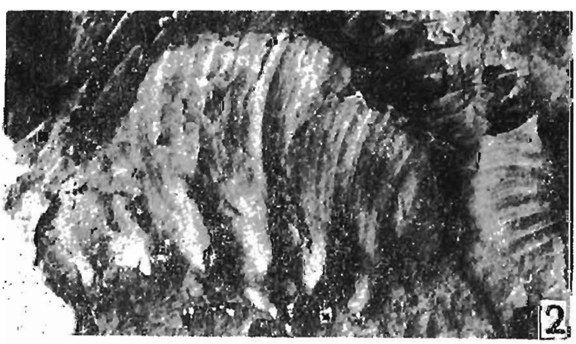

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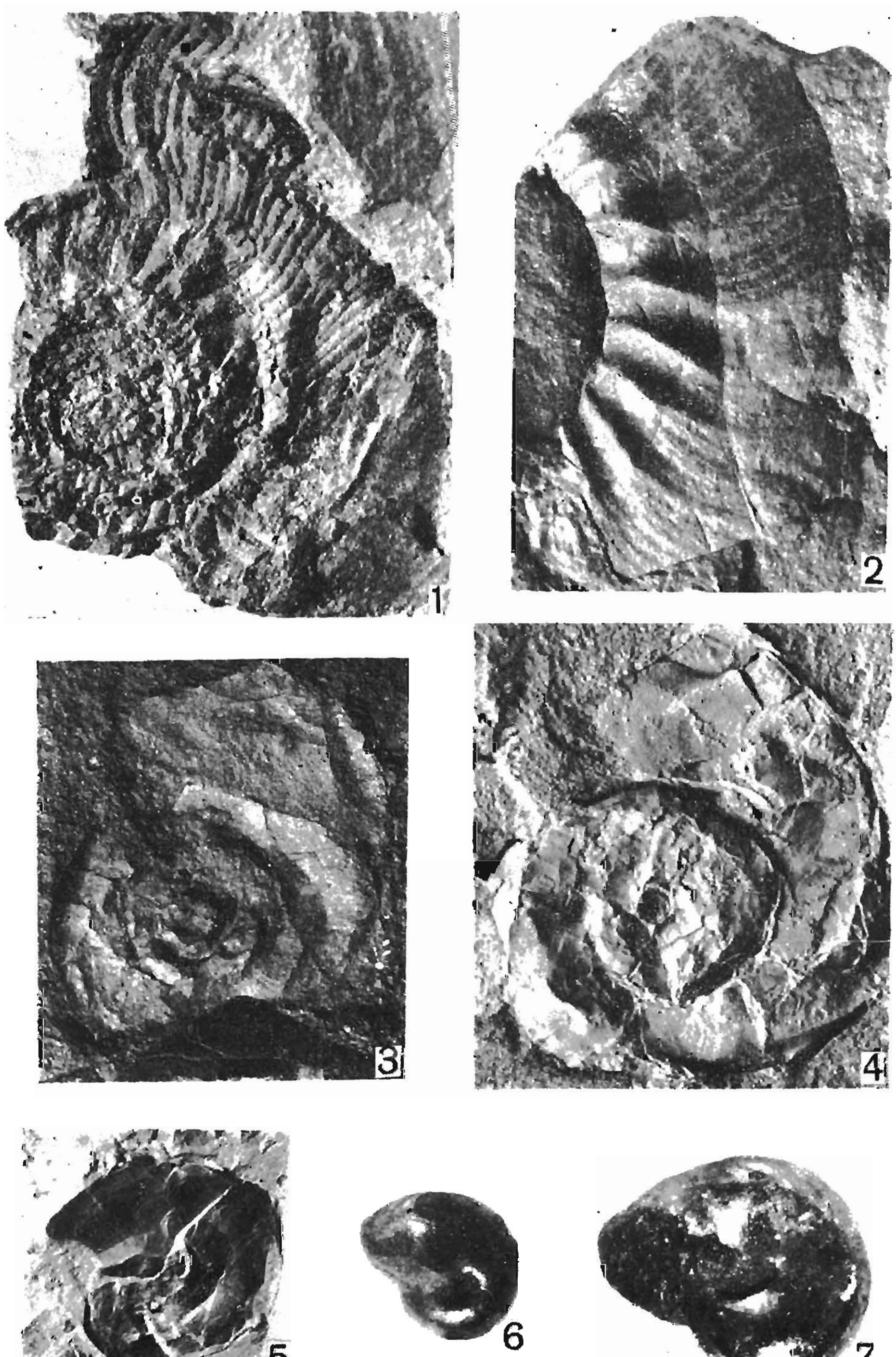
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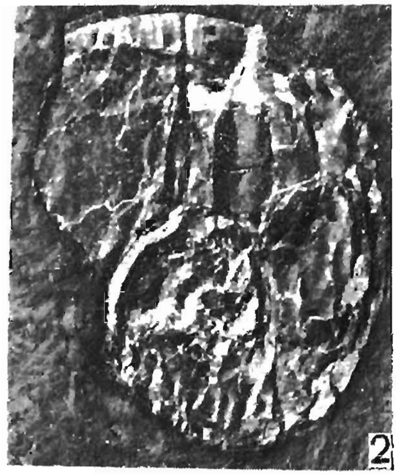

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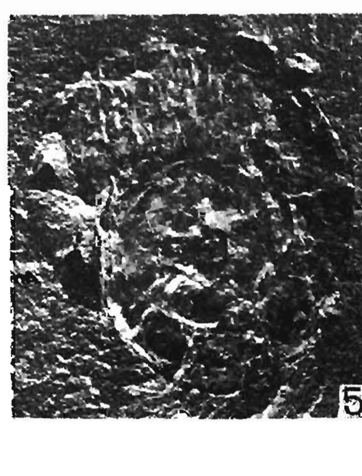

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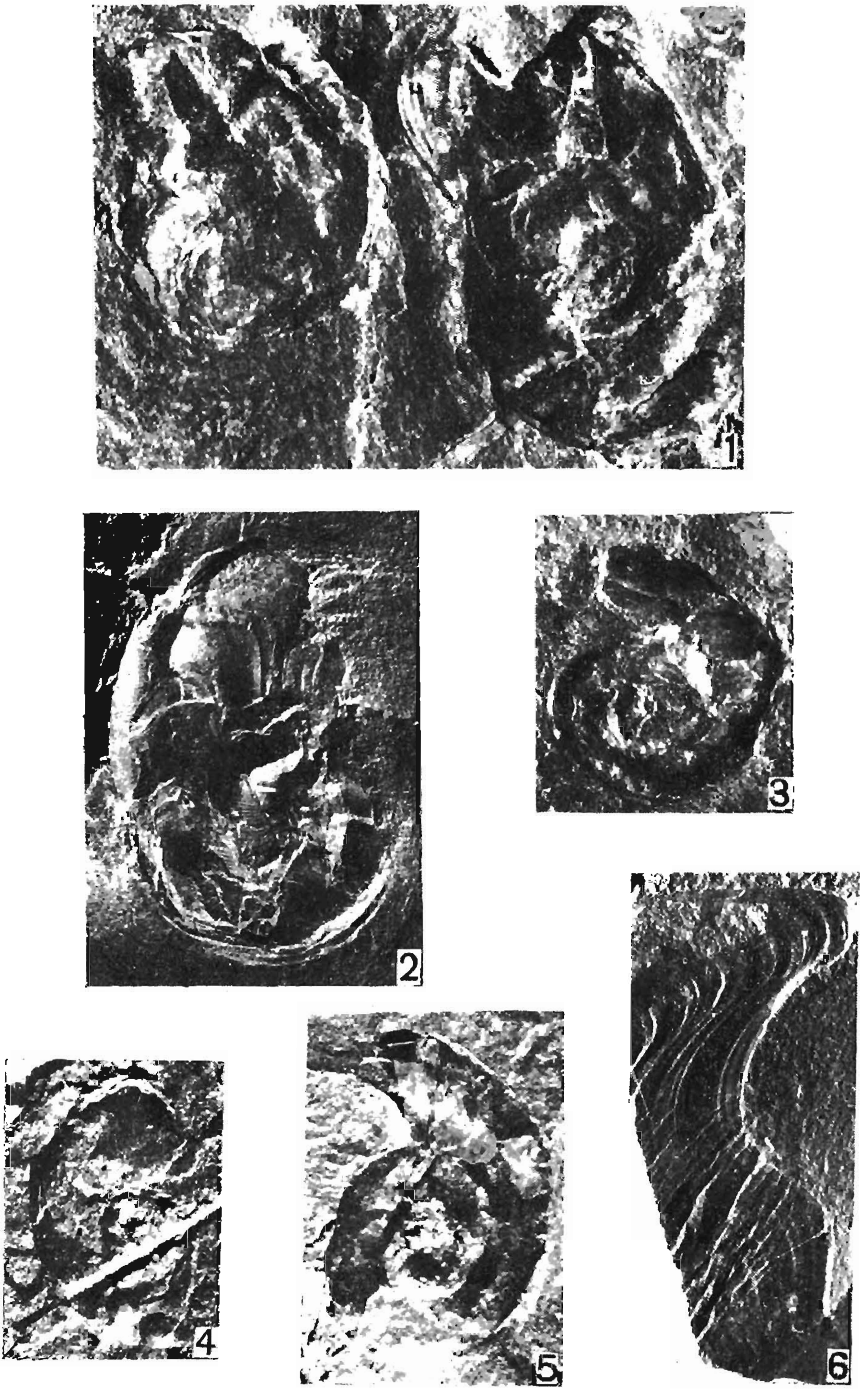
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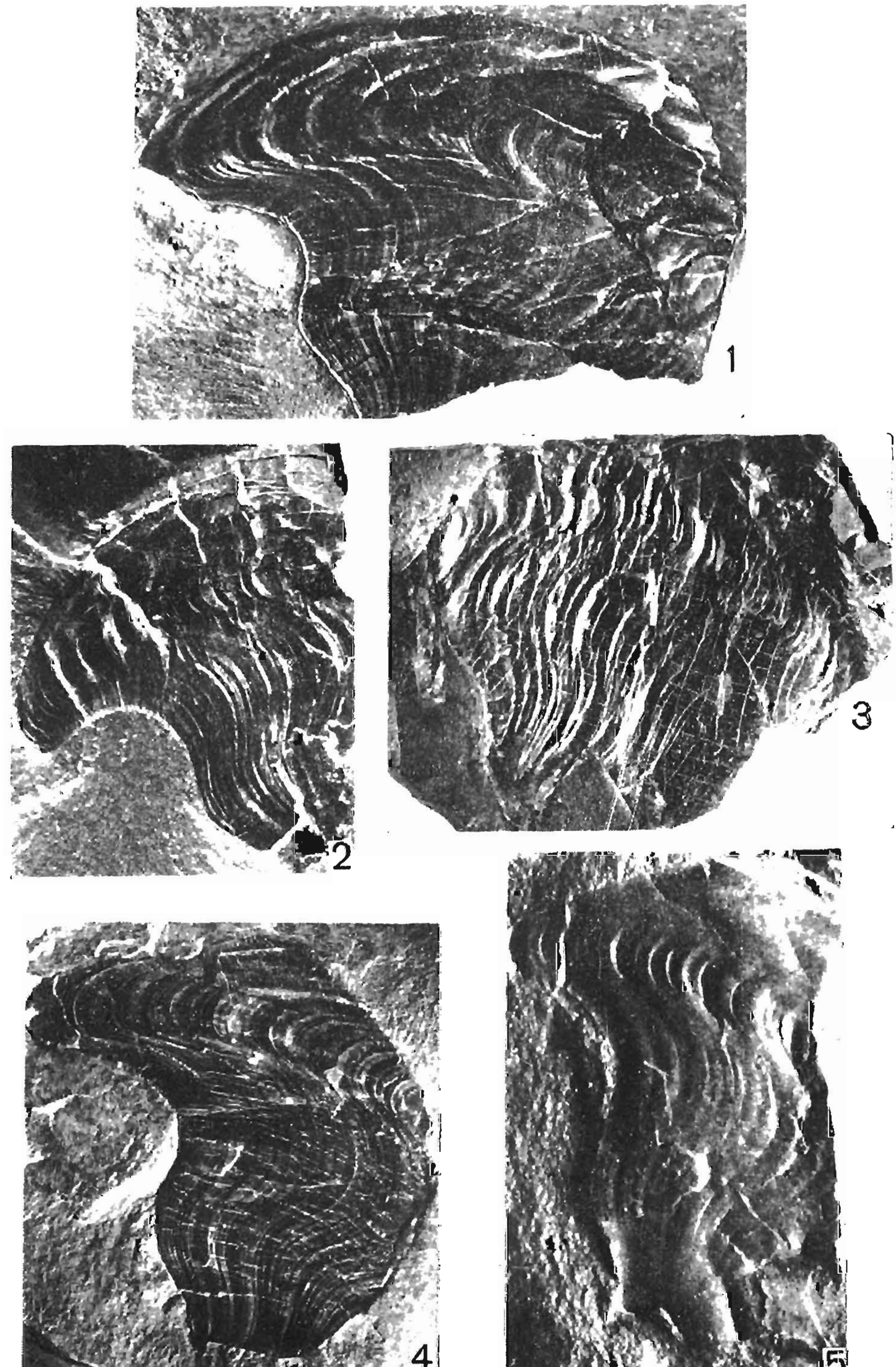
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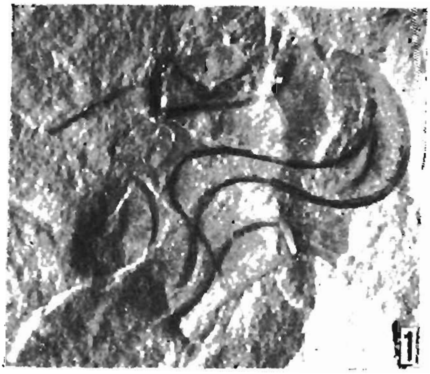
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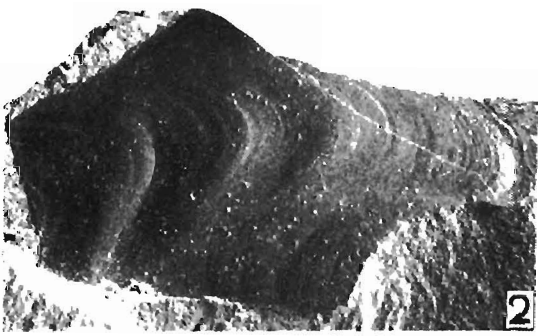
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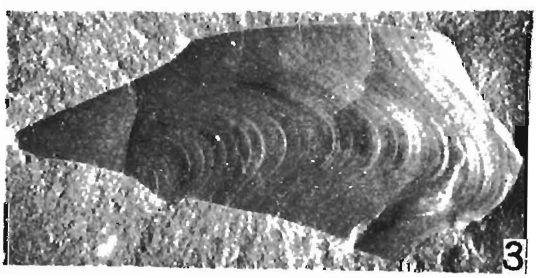
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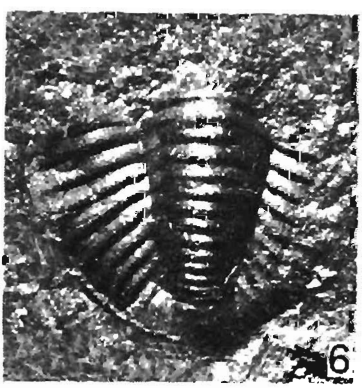
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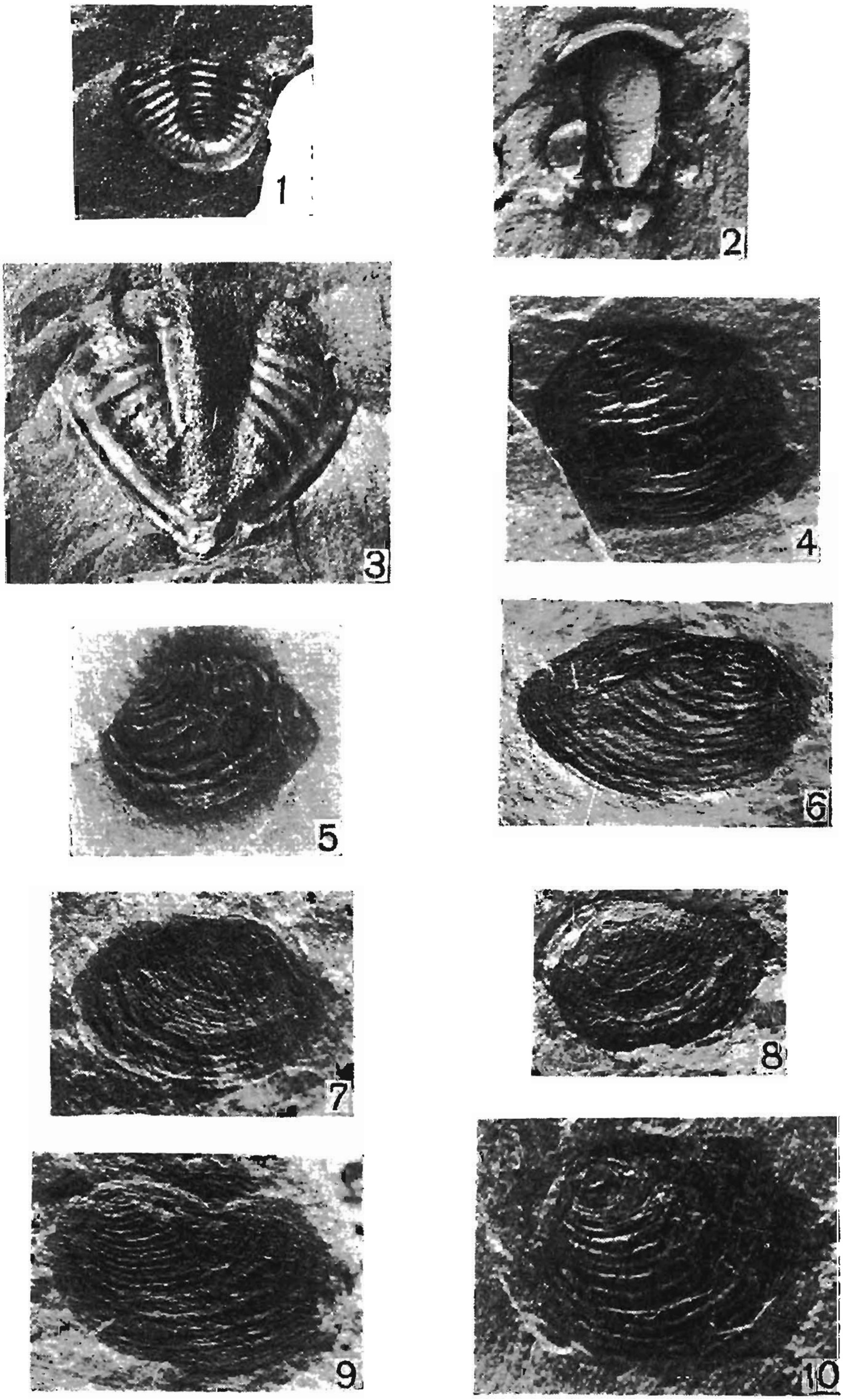

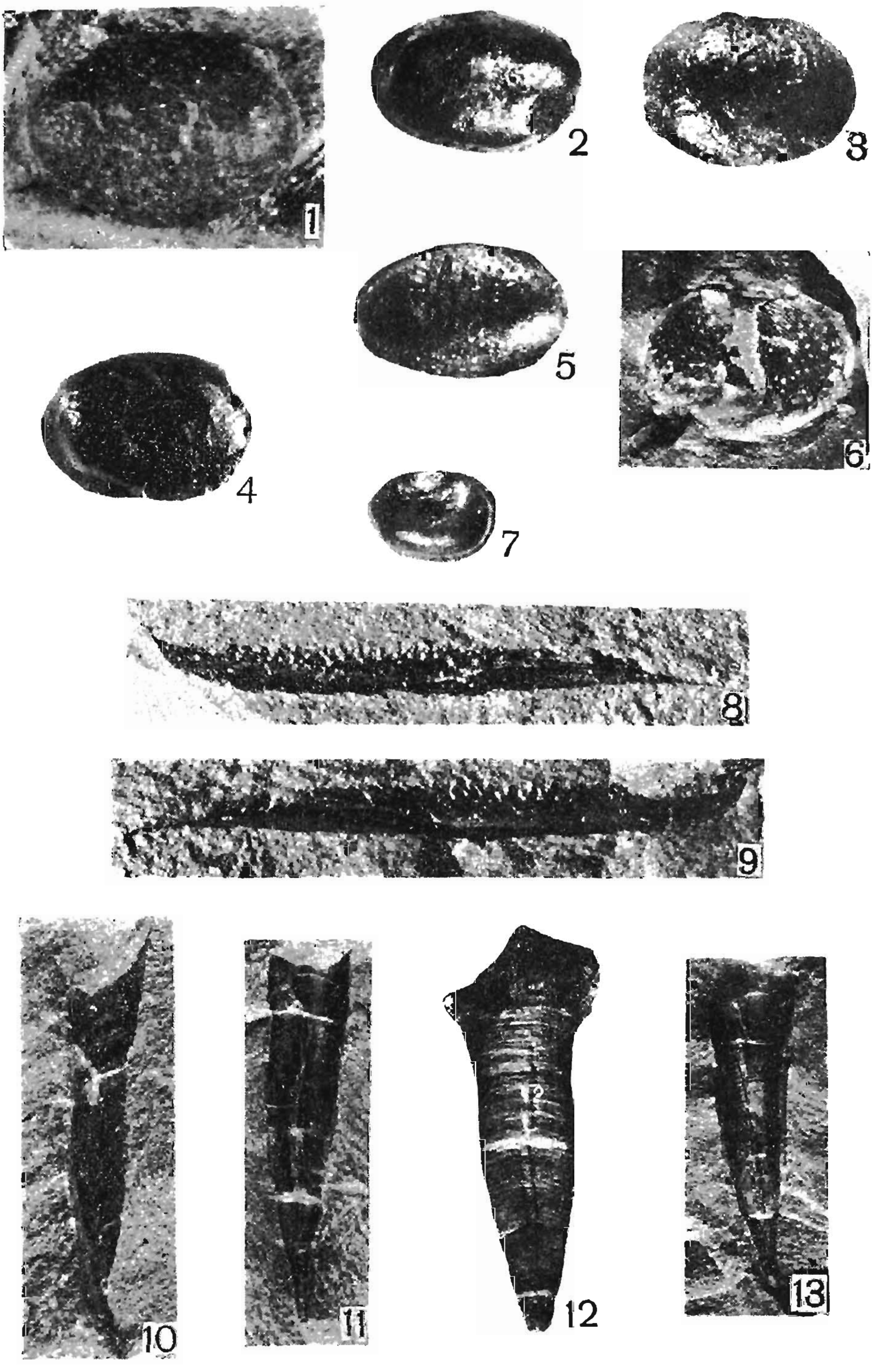

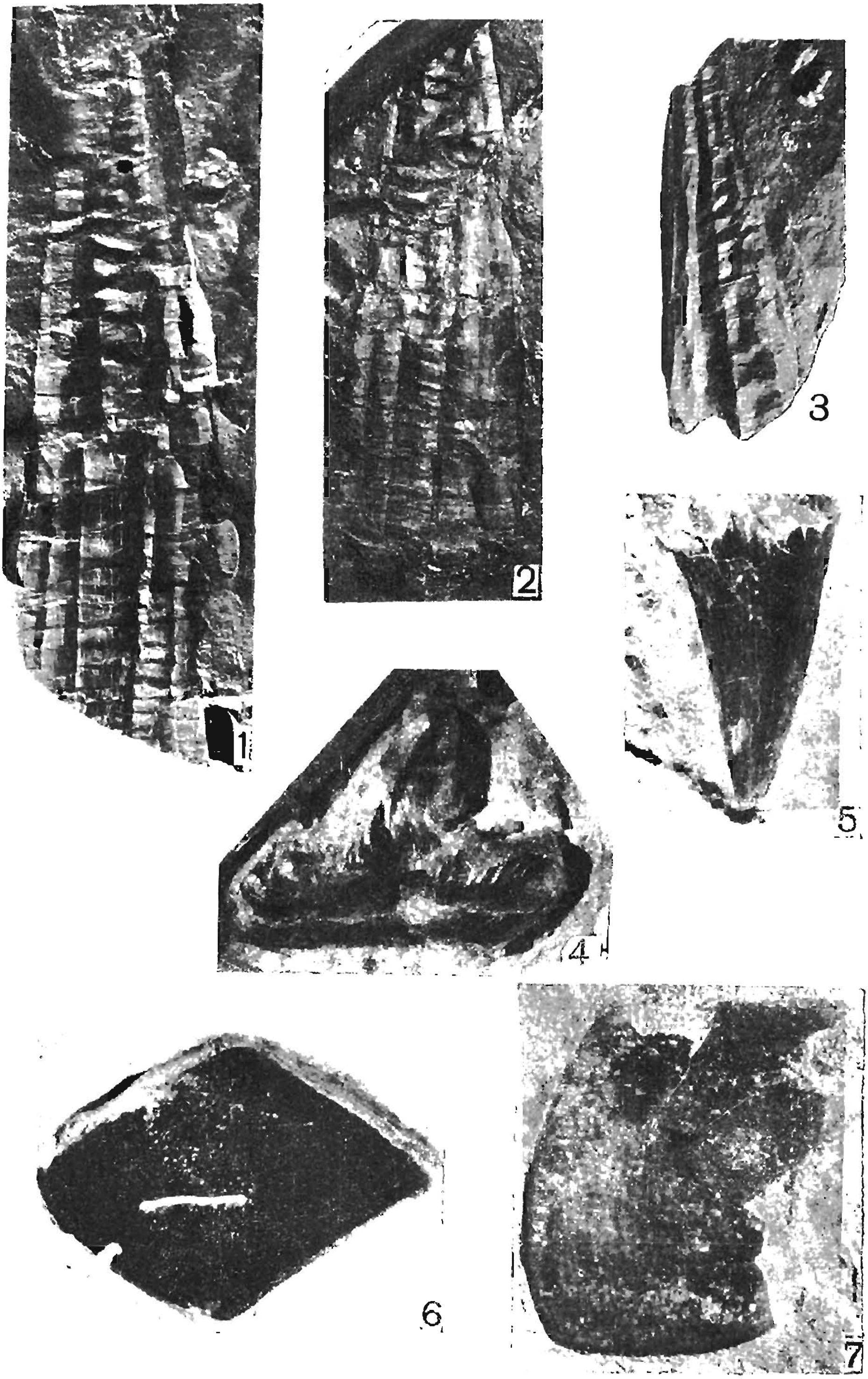
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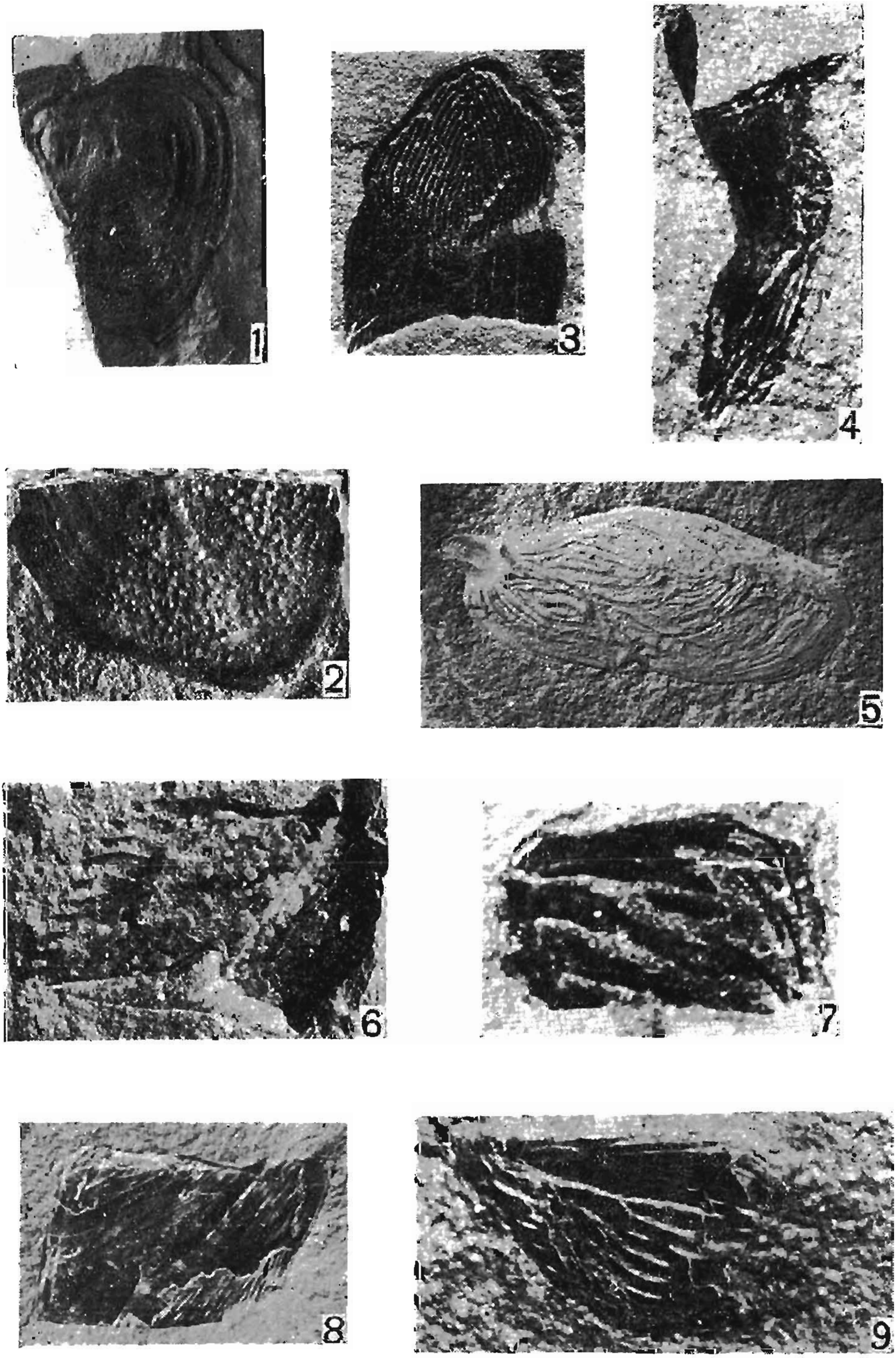
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