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Biostratigraphy of the Carboniferous sediments from the Wierzchowo area (Western Pomerania)

ABSTRACT: The stratigraphy and correlation is here given of Lower Carboniferous sediments encountered in 12 borehole profiles in the Wierzchowo area (Western Pomerania). The presence of the Tournaisian (*Tn1a—Tn3*) and of the Lower Viséan (*V1*) has been observed on faunal evidence.

INTRODUCTION

Between 1960 and 1974 the Oil Research Enterprise of Piła has drilled in the Koszalin—Chojnice zone some tens deep boreholes in which various Carboniferous or older deposits have been encountered underlying the Zechstein. No complete Dinantian or Silesian profile has, so far, been obtained from any of these boreholes. This is connected with the complicated block tectonics characterizing the zone under consideration both during the Carboniferous and probably also in the Lower Permian.

The lithology and biostratigraphy of the Carboniferous sediments from the Chojnice area — in the SE part of the zone — have been worked out in detail (Korejwo 1975, 1976; Matyja 1976). In the present paper the writer has turned her attention to the Carboniferous deposits obtained from 12 boreholes situated in the Wierzchowo area of the SW part of the Koszalin—Chojnice zone (Fig. 1). These sediments directly underlie the Zechstein — the Wierzchowo *4* borehole excepted where they are unconformably overlain by probably Saxonian conglomerates — and nowhere have they been pierced.

The lithological characters and the paleotectonic development of the Carboniferous in the Wierzchowo area have been described by Korejwo (1977).

In the present paper the stratigraphy of the Carboniferous deposits is based on macrofaunal remains found in the cores.

The core profiling was done currently as the work progressed either in the boreholes or in the core storage place at Piła. The samples have been worked out in

the Stratigraphic Laboratory of the Institute of Geological Sciences, Polish Academy of Sciences under the scientific co-operation understanding concluded between the above institution and the Oil Research Survey of Poland. The documentary materials are kept in the Laboratory here mentioned.

Special thanks are due from the writer to the Management of the Oil Research Survey in Warsaw and to the Oil Research Enterprise of Piła for their friendly co-operation in the accession to their materials. and archival data.

Dr. H. Matyja must be thanked for the identification of brachiopods.

The present paper has been prepared as a part of the problem "The Geodynamics of the Polish area".

GENERAL CHARACTERS OF THE CARBONIFEROUS FROM THE WIERZCHOWO AREA

The Carboniferous deposits in the Wierzchowo area are characterized by strong variability in lithology and thickness, this being due to the complex structure of the sedimentary basin resulting from tectonic processes connected with the Variscan diastrophism. These deposits are represented by carbonate and clastic rocks occurring in varying proportions. As a rule they have been subjected to strong diagenesis, occasionally to dolomitization obliterating their original character.

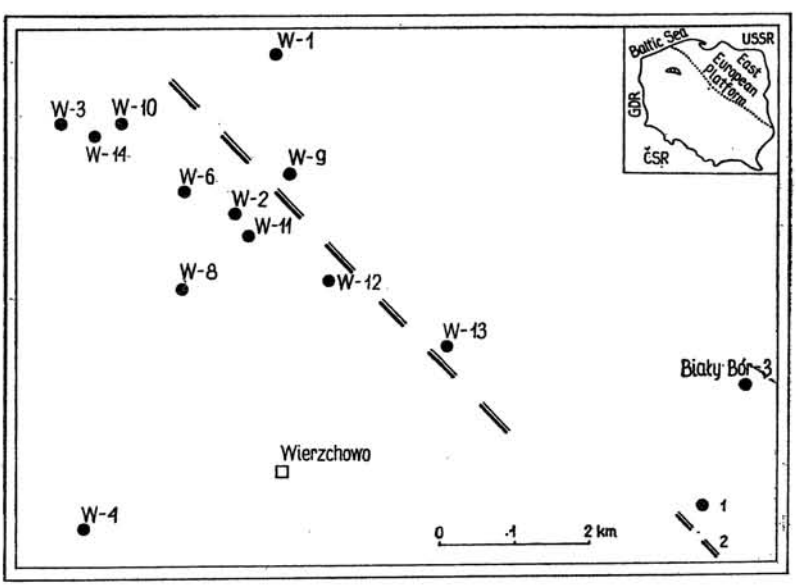

Fig. 1. Sketch showing the locality of the boreholes in the Wierzchowo area

1 — boreholes, *2* — hypothetical dislocation showing dip direction

The descriptions of profiles, the coring (as a rule incomplete) and the character of the deposits have been previously given in detail (Korejwo 1977).

In view of the limited area being investigated (ca. 34 sq. km.) no formal lithostratigraphic units have been determined before a complete description of the whole

Carboniferous from the Koszalin—Chojnice zone is achieved. On the basis of macro- and microscopic observations of the cored fragments and the interpretation of electric logging, complexes of analoguous or similar development have been tentatively differentiated in the several borehole profiles. They are indicated by lettering while their stratigraphic position is shown by Arabic numbers. The correlation is based mainly on the *W.4* and *W.9* profiles. In the former borehole ca. 1000 m of the Tournaisian (including the Strunian) have been drilled while in the latter still younger Dinantian members (Lower Viséan) have been encountered.

In order to show the spatial arrangement and the thickness of the several complexes some diagrammatic geologic sections and structural sketch maps have been presented (Korejwo 1977, Figs 1—7). An analysis of these sections has confirmed the supposition of the existence of a dislocation, probably with a NNW-SSE direction cutting the Wierzchowo structure into two blocks. The eastern limb comprising boreholes *W.1*, *W.9* and *W.13* (Fig. 1) is downthrown in relation to the western one. On borehole profiles *W.9* and *W.11* it may be reasonably supposed that the amplitude of the downthrow is something like 350 m. In the eastern limb some slightly younger Dinantian members (lower parts of the Viséan) have been preserved, too, while in the western limb there occur only the various Tournaisian members including a rather thick Strunian member (*Tn1a*). This has been observed in the southernmost and at the same time the most downthrown part where borehole *W.4* is situated.

In both of these two limbs the Carboniferous deposits occur horizontally or sub-horizontally. The correlation of the Carboniferous deposits from the Wierzchowo region is shown in Fig. 2. It differs somewhat from that accepted in the paper by Dadlez (1978).

STRATIGRAPHY

The stratigraphy of the Carboniferous deposits from the Wierzchowo area is based on the rather few macrofaunal fossil remains encountered in some of the cored intervals.

In most cases their state of preservation is very fragmentary, so much so that it prevents accurate specific or even sometimes generic identification. This as well as important discontinuity in coring account for the fact that it is hardly possible accurately to determine the age of the deposits, in the first place reliably to draw the boundary lines between the several stratigraphic members of the Dinantian. These boundaries may be but tentatively accepted on the few faunistic data, the analysis of the geophysical measurements and the lithological resemblance of the complexes differentiated by the writer (Korejwo 1977).

Most of the faunal remains here considered have been figured, except the brachiopods from the Strunian (*Tn1a*) observed in the sediments of the lower part of the *W.4* profile. These will be separately worked out by H. Matyja.

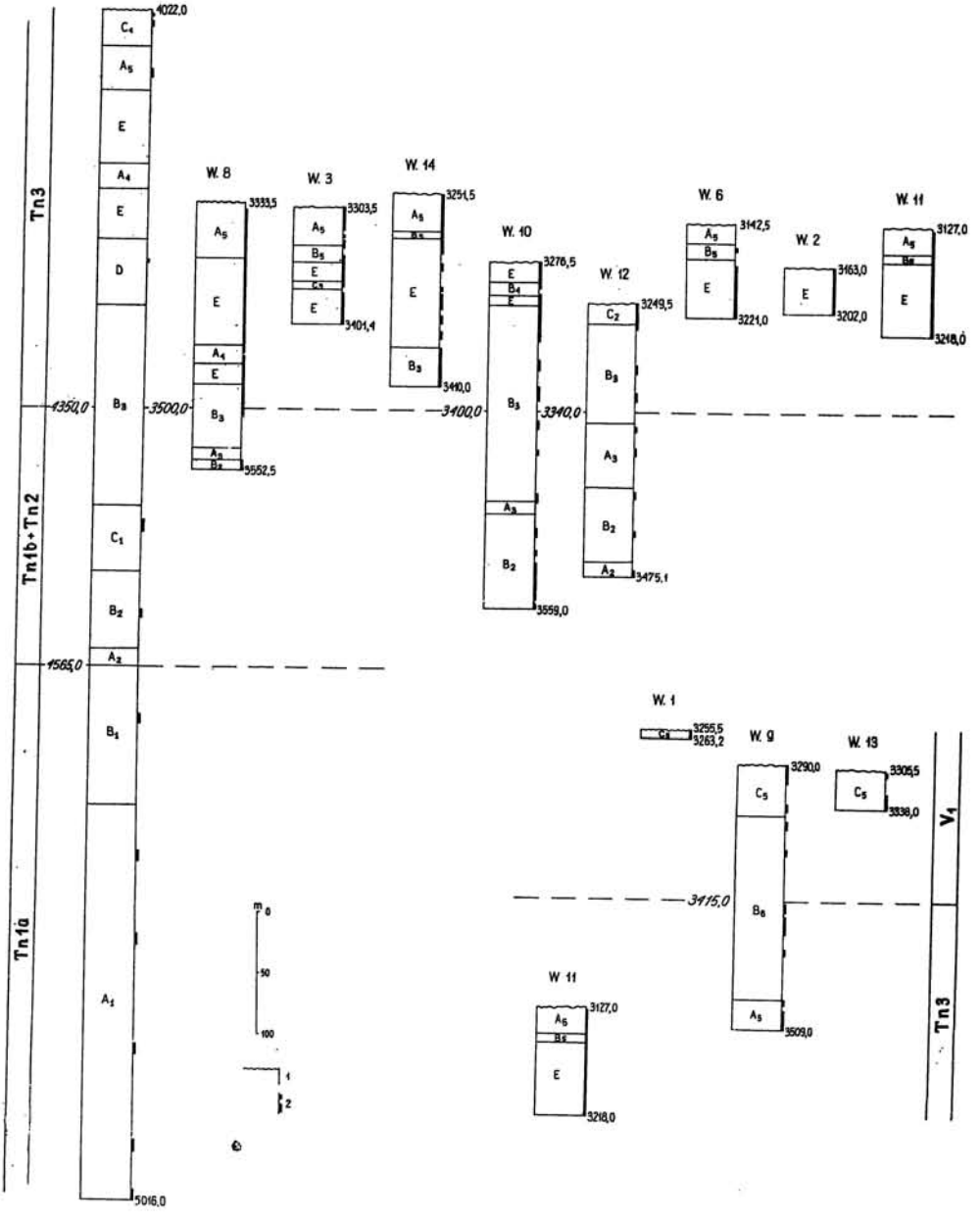

Fig. 2. Correlation of the Dinantian sequences in the Wierzchowo area
Lithological complexes differentiated in the Dinantian (Korejwo 1977): A_{1-5} — limestones, B_{1-6} — claystones or siltstones with limestone intercalations, C_{1-5} — claystones with siltstone intercalations, D — quartz sandstones with siltstone intercalations, E — greywacke and arkosic sandstones
1 — erosional boundary between Permian and Lower Carboniferous, 2 — cored intervals

In result of palynological investigations of the Carboniferous deposits from Western Pomerania, those of the Wierzchowo region included, several characteristic miospore horizons and subhorizons have been differentiated by Turnau (1978). Owing, however, to the absence of spores in some intervals as well as to incomplete coring, the above author was not able to fix the boundaries of the particular Carboniferous members.

In the Wierzchowo region the Carboniferous deposits are represented by the Tournaisian and the Lower Viséan.

Tn1a

The oldest deposits, corresponding to the Etroeungt (*Tn1a*) beds in the coral-brachiopod facies and to the Wocklumeria zone in the cephalopod facies, have been observed only in the *W.4* profile. Their top occurrence has been arbitrarily fixed at a depth of 4565.0 m, the thickness of the Strunian drilled through in this borehole being 451 m. Their actual thickness is, however, probably greater since they have not been pierced down to a depth of 5016.0 m (Fig. 2).

A limestone complex (A_1) occurs in the 5016.0—4682.0 m interval, brown-grey in colour, partly marly, beginning with 4827.0 m passing into grey organo-detrital limestones with thin intergrowths and streaks of limy mudstone.

Some sediments with a fairly satisfactory paleontological documentation have been encountered in several cores from a depth between 5016.0 and 4883.0 m. The following faunal remains have been observed besides crinoidal and ostracod (moulds) ones:

Lingula sp.
Orbiculoidea sp.
Kitakamithyris microgemma (Phill.)
Mesoplica cf. *praelonga* (Sow.)
Toryniferella cf. *echinulata* Brice
Tylothyris laminosa (McCoy)
Cyrtospirifer verneuili (Murch.)
Palaeoneilo cf. *sinuosa* (Ryckh.)
Parallelodon semicostatus (McCoy), Pl. 5, Fig. 6
Aviculopecten cf. *pungens* Muromz & Turb., Pl. 7, Fig. 2
Pterinopectinella cf. *polytricha* (Phill.), Pl. 7, Fig. 5
Pterinopecten sp., Pl. 7, Fig. 4
Modiomorpha sp., Pl. 6, Fig. 1
Scaldia cf. *lambotteana* Ryckh., Pl. 6, Figs 5, 6, 9
Straparollus (Euomphalus) pugilis (Phill.), Pl. 8, Fig. 4
Straparollus sp.
Lepetopsis umbrella de Kon., Pl. 10, Fig. 5
Phacops accipitrinus (Phill.), Pl. 13, Fig. 2

A similar faunal assemblage has been encountered in several borehole profiles of the Chojnice region within sediments referred to the Strunian (*Tn1a*) (Korejwo 1975, 1976; Matyja 1976). The Strunian age is reasonably suggested by the presence of such forms as *Kitakamithyris microgemma* (Phill.), *Toryniferella* cf. *echinulata* Brice, *Tylothyris laminosa* (McCoy), *Cyrtospirifer verneuili* (Murch.) (Matyja 1977) and *Phacops accipitrinus* (Phill.).

In the successive cores of the *W.4* profile at depths between 4801.0—4791.8 m and again between 4730.3—4721.0 m, trochites have been found, ostracod moulds and

Rugosochonetes hardrensis (Phill.)
Avonia nigra (Goss.)
Tylothyris laminosa (McCoy)
Aviculopecten cf. *peculiaris* Muromz. & Turb., Pl. 7, Fig. 6
Palaeolima cf. *turberculata* Muromz., Pl. 7, Fig. 3
Straparollus sp.

Avonia nigra (Goss.) is a form characteristic of the Etroeungt beds and of their age correspondents (*Tn1a*) as well as of the upper members of the Lower Tournaisian of Belgium, France and Germany. In Western Pomerania this species has been encountered in the Babilon *1* and Biały Bór *1* profiles (Matyja 1976). *Tylothyris laminosa* (McCoy) is with a similar vertical extent. In the Lublin basin and in Western Pomerania this species has been observed in Strunian deposits (Kaliś 1969, Matyja 1976, 1977).

Out of the pelecypods encountered in the lower part of the *W.4* profile, *Aviculopecten pungens* Muromz. & Turb., *Aviculopecten peculiaris* Muromz. & Turb. and *Palaeolima tuberculata* Muromz. have already been described from the lowermost Tournaisian of Siberia and Kazakhstan (Muromzeva 1974).

The limestones above to a depth of 4565.0 m are overlaid by a complex (B_1) of black limy mudstones with injections of pyrite and intercalations of grey crystalline limestones.

The core from a depth between 4615.0—4606.0 m has yielded a rich and diversified faunal assemblage, comprising i.a.:

Lingula sp.
Avonia sp.
Crurithyris urei (Flem.)
Aulacella cf. *interlineata* (Sow.)
Quadratia hirsutiformis (Walc.)
?Nuculopsis sp., Pl. 4, Figs 7—8
Palaeoneilo cf. *sinuosa* (Ryckh.), Pl. 4, Fig. 10; Pl. 5, Fig. 2
Parallelodon semicostatus (McCoy), Pl. 5, Figs 7—8
Scaldia cf. *lambotteana* Ryckh., Pl. 6, Fig. 8
Streblopteria sp. Pl. 5, Fig. 9
Pernopecten cf. *tenuis* (de Kon), Pl. 6 Fig. 4
Edmondia cf. *accipiens* Sow., Pl. 6, Fig. 10
Straparollus (Straparollus) planorbiformis de Kon., Pl. 9, Figs 1, 2
Straparollus sp., Pl. 8, Fig. 6
Trepospira sp.
Platyschisma sp., Pl. 9, Fig. 6
Rhaphischisma planorbiformis (de Kon.), Pl. 8, Fig. 7
?Tropidodiscus sp., Pl. 9, Fig. 8; Pl. 10, Figs 1—3
Dolorthoceras sp., Pl. 10, Figs 6—7
?Dolorthoceras sp., Pl. 10, Fig. 9
Reticycloceras cf. *sulcatum* (Flem.), Pl. 10, Fig. 8
?Parawocklumeria sp., Pl. 11, Fig. 2
?Imitoceras sp., Pl. 11, Fig. 1
Phacops accipitrinus (Phill.), Pl. 13, Fig. 1
Fish scale Pl. 14, Fig. 9
Incertae sedis Pl. 14, Figs 10, 11

The range of time and the occurrence of the brachiopod and pelycypod species here considered have been discussed in papers by Matyja (1976, 1977) and Korejwo (1975, 1976). All that assemblage, in the first place the presence of the trilobite *Phacops accipitrinus* (Phill.) reliably suggest the assignment to the Strunian (*Tn1a*) of the deposits from the depth of 4615.0 to 4606.0 meters.

Tn1b—Tn2

Sediments representing the upper part of the Lower Tournaisian (*Tn1b*) and the Middle Tournaisian (*Tn2*) have been encountered in borehole profiles *W.4*, *W.8*, *W.10* and *W.12* (Fig. 2).

In borehole *W.4* the thickness of these deposits overlying the Strunian and underlying the Upper Tournaisian (*Tn3*) is 215 m, while in the remaining boreholes they have not been pierced. In boreholes *W.10*, *W.12* and *W.8* the thickness is 159.0, 135.0 and 52.5 m respectively.

The deposits referred to *Tn1b* and *Tn2* are represented by limestones, grey coloured, compact, slightly sandy (complex A_2) (*W.4*, *W.12*), black mudstones intercalated by grey limestones (complex B_2) (*W.4*, *W.8*, *W.10* and *W.12*), by mudstones and limy siltstones (complex C_1 — only in borehole *W.4*) and by grey-brown dolomitic limestones (complex A_3) (boreholes *W.8.2.10*, *W.12*). In a part

of complex B_3 (*W.4*, *W.8*, *W.10*, *W.12*) the limestones are replaced by black and dark-grey mudstones intercalated by marly limestones, locally with a few ooids.

Relatively the best paleontological documentation is available for the upper part of the Lower Tournaisian (*Tn1b*) in *W.10* profile, from a depth between 3559.0 and 3545.0 m, based on the presence of the goniatite *Pseudarietites dorsoplanus dorsoplanus* H. Schmidt, Pl. 12, Fig. 2. This is an index species for the upper part of the Lower Tournaisian Gattendorfia subinvoluta zone in the Rhenisch Schiefergebirge (Vöhringer 1960). This is its first occurrence noted in Poland.

The following fossil remains have been, moreover, encountered in the profile here considered between the depth of 3559.0 and 3495.7 meters:

Schuchertella planiuscula (Semen & Moell.), Pl. 2, Fig. 5
Rugosochonetes cf. *laguessianus* (de Kon.), Pl. 1, Figs 9, 12
Brachythyris sp.
Athyris sp.
Cupularostrum sp., Pl. 3, Fig. 7
Parallelodon semicostatus (McCoy), Pl. 5, Fig. 5
Polidevcia cf. *attenuata* (Flem.), Pl. 5, Fig. 4
Scaldia cf. *lambotteana* de Ryckh., Pl. 6, Fig. 7
Straparollus (Straparollus) cf. *mammula* de Kon., Pl. 8, Fig. 8
Goniatitida gen. et sp. ind., Pl. 11, Fig. 7
Bispathodus stabilis (Branson & Mehl)

The brachiopod *Schuchertella planiuscula* (Semen & Moell.) belongs undoubtedly to the Tournaisian. This species has been observed in the Moscow basin within Lower Tournaisian sediments (Malevka horizon). In Western Pomerania it has been encountered in the Babilon *1* and Biały Bór *1* profiles (Matyja 1976).

At a depth from 3502.0 to 3495.7 m there occurs an accumulation of *Rugosochonetes* cf. *laguessianus* (Semen & Moell.). A thin layer packed with shells of this species in *W.12* profile (between 3407.7 and 3404.9 m) may be reasonably supposed to be the age correspondent of sediments mentioned above.

Among pelycypods the species *Parallelodon semicostatus* (McCoy) and *Polidevcia attenuata* (Flem.) are long-lived forms; *Scaldia* cf. *lambotteana* de Ryckh is known from the Tournaisian of Belgium; from Poland it is reported from the Lower Tournaisian of Western Pomerania in profiles Babilon *1*, Rzecznica *1* and Brda *1* (Korejwo 1975, 1976). The conodont *Bispathodus stabilis* (Branson & Mehl) — identified by H. Matyja — is a long-lived species known from the Famennian to the upper part of the Siphonodella Zone.

The faunal assemblage just described resonably suggests the assignment of sediments from the interval between 3559.0 and 3495.7 m in *W.10* profile to the Lower Tournaisian. Higher up, at a depth from 3474.3 and 3467.3 m the occurrence has been noted in a black limy mudstone, passing downwards into a grey limestone, of rare fragments of carbonized flora, impressions of indeterminate pelecypods, abundant Productus spines and *Crurithyris* cf. *unionensis* (Weller), Pl. 3, Fig. 6a, b. This species has been observed in the Lower Tournaisian of the Chojnice area (Matyja 1976). It is also known from deposits of analogous age in the South Urals, Kazakhstan and Western Altai Mts.

In black limy mudstones intercalated by marly limestones at a depth between 3434.0 and 3429.0, also between 3413.0 and 3406.0 m the presence has been observed of trochites, gastropod fragments, *Orbiculoidea* sp. and *Rugosochonetes* sp.

It seems rather possible that deposits from the two just mentioned intervals may already belong to the Middle Tournaisian.

To the Lower and Middle Tournaisian (*Tn1b—Tn2*) have also been referred the deposits from a depth between 3475.0 and 3340.0 m in *W.12* profile, chiefly on the basis of correlations with the neighbouring profiles since faunistic documentation here is extremely poor.

Few fragmentary remains have been encountered in the bottom series (3475.0—3470.3 m), i.a:.

Straparollus (Straparollus) laevigatus (Lev.), Pl. 8, Fig. 10
Trepospira sp., Pl. 9, Fig. 4
Phillibole sp., Pl. 13, Figs 4—5

Higher up, two cores from a depth between 3442.0 and 3404.9 m have yielded:

Lingula sp.
Rugosochonetes cf. *laguessianus* (de Kon.), in great abundance, Pl. 1, Figs 10, 11
Schuchertella sp.
Anthraconeilo sp., Pl. 4, Fig. 9
Polidevcia cf. *sharmani* (Ether.), Pl. 5, Fig. 3
Edmondia sp., Pl. 8, Fig. 2
Euomphalus sp., Pl. 8, Fig. 5
Goniatitida gen. et sp. ind., Pl. 11, Fig. 5; Pl. 12, Fig. 3

Because of the fragmentary state of preservation of a trilobite from the genus *Phillibole* its specific identification is hardly possible, the genus being reported both from the Tournaisian and the Viséan.

Rugosochonetes cf. *languessianus* occurs in great abundance at a depth from 3407.7 to 3404.9 m, similarly as in borehole *W.10* (between 3502.0 and 3495.7 m). Hence it may be reasonably supposed that deposits from these intervals are of analogous age.

Accurately indeterminate goniatite fragments have been encountered between 3439.0 and 3442.0 m. Similarly ornamented fragments have been observed in borehole *W.4* (4518.0—4525.0 m) and borehole *W.10* (between 3513.0 and 3517.0 m), moreover also in the Chojnice area (Rzeczenica *1* and Brda *1* profiles) within sediments referred to the Lower Tournaisian (*Tn1b*).

In the *W.8* profile the faunal remains are very scarce. Between 3552.5 and 3546.0 m the presence has been observed of brachiopod fragments from the genera *Schelwienella*, *Schuchertella*, and *Athyris*, also

Palaeoneilo cf. *sinuosa* (de Ryckh.), Pl. 5, Fig. 1
Streblopteria cf. *subelliptica* de Kon., Pl. 5, Fig. 11
Imitoceras sp., Pl. 12, Fig. 6

The only goniatite from the genus *Imitoceras*, which could be a reliable age-marker can hardly be more closely identified in spite of its partly preserved lobe line, but the genus has been reported throughout the Dinantian.

Because of the very scarce fauna it is particularly difficult to determine the stratigraphy in the *W.8* profile. On comparing the lithological and electric logging data of the neighbouring profiles (Korejwo 1977) it has been reasonably supposed that the bottom part of the Carboniferous from a depth between 3552.0 and 3500.0 m belongs to the Middle Tournaisian (*Tn2*).

Similar difficulties due to the lack of adequate fossil remains have been encountered in the division of Carboniferous substages in the *W.4* profile. It has been tentatively accepted that the deposits overlying here the Strunian in the 4565.0—4550.0 m interval represent the upper part of the Lower Tournaisian and the Middle Tournaisian. Only one core (4525.2—4518.0 m) has yielded faunal remains. These are indeterminate pelycypod and *Chonetes* fragments, also

Cririthyris urei (Flem.)
Trepospira sp., Pl. 8, Fig. 9
Goniatitida gen. et sp. ind., Pl. 11, Fig. 6; Pl. 12, Figs 1, 4—5.

Crurithyris urei (Flem.) is known from the Lower Carboniferous of England (Viséan), Belgium (Tournaisian), from the Tournaisian of the Moscow Basin and the Urals. It has also been reported from the Chojnice area (Matyja 1976) of Western Pomerania. The fossil goniatite remains encountered in the interval here considered resemble fragments also observed in the *W.10* and *W.12* profiles as well as in the Chojnice region, the sediments of their occurrence being referred, to the Lower Tournaisian (*Tn1b*) (Korejwo 1976).

In a cored part higher up in the *W.4* profile between the depth of 4445.0 and 4446.0 m no fossil remains have been found floral detritus and calamite imprints excepted. The Middle Tournaisian age is, however, suggested by the spore analysis (Turnau 1978).

Tn3

In the Wierzchowo area Upper Tournaisian sediments occur in 10 profiles being absent only from *W.1* and *W.13* boreholes. They have been observed overlying the Middle Tournaisian in profiles *W.4*, *W.8*, *W.10* and *W.12*. In the remaining profiles (*W.3*, *W.14*, *W.6*, *W.11* and *W.9*) the various members of that age have not been pierced (Fig. 2). The observed thickness ranges from 39 to 370 meters.

Lithologically the Upper Tournaisian deposits are represented in the bottom parts by black and dark-grey mudstones with marly limestone intercalations (higher part of complex B_3). Only in the profile *W.4* do calcareous sandstones intercalated by siltstones overlie these deposits (complex D_1). Higher up there occurs a most characteristic and interesting complex (*E*) of greywacke-arkosic sandstones, chiefly tufaceous in character (Korejwo 1977, Muszyński 1976), fine to coarse-grained, occasionally conglomeratic, rich in carbonates, iron oxides and clastic material. Relict iron or calcite ooids are present here and there. Bands and balls of apple-green mudstones or variegated mudstone laminae are rather frequent, coaly streaks occur less often. Organic remains are rare (plant detritus, spicules, trochites). The greywacke complex is sometimes divided by a thin intercalation of dolomitized oolitic sandy limestones (complex A_4) (*W.4*, *W.8*) or of mudstones intercalated by siltstones (complex C_3 in the *W.3* profile) or of mudstones intercalated by chiefly oolitic limestones (complex B_4) in the *W.10* profile.

The presence of the greywacke complex (*E*) has been ascertained in 8 profiles (*W.4*, *W.8*, *W.3*, *W.14*, *W.10*, *W.6*, *W.2* and *W.11*), its thickness ranging up to 100 metres. Overlying it in profiles *W.3*, *W.14*, *W.6* and *W.11* there occur mudstones, chiefly variegated in colour with thin siltstone interbeddings and intercalations of dolomitized marly limestones (complex B_5).

Overlying the greywackes or the mudstones there occurs a characteristic complex (A_5) of oolitic limestones with an admixture of clastic material and anhydrite, occasionally pyrite. In places there are laminae of variegated mudstone, less often coaly streaks. This complex has been observed in profiles of boreholes *W.4*, *W.8*, *W.3*, *W.14*, *W.6*, *W.11* and *W.9*, its thickness ranging from 17.5 to 45.0 metres.

The oolitic limestone is overlaid, mostly transgressively, by the Zechstein. Only in profile of borehole *W.4* there still occurs a 31 m thick complex (C_4) of variegated mudstones and siltstones, partly calcareous, with indeterminate brachiopod impressions and thin intercalations of greyish-pink, fine-grained sandstone, while in the *W.9* profile a complex of darkgrey and black mudstones intercalated by marly limestone (complex B_6). Its bottom part has been referred still to the Upper Tournaisian and the top one to the Lower Viséan.

A fairly abundant but poorly preserved fauna has been found in sediments reached by drilling in borehole *W.3*, between the depth of 3401.4 and 3303.6 m which have been referred to the Upper Tournaisian. The bottom part of the drilled series between 3401.4 and 3370.0 m is represented by greywacke sandstones, with a thin intercalation of black slightly calcareous mudstones and siltstones in its lowermost part. The mudstones have yielded only fragments of *Lingula* sp. and *Hindeodella* sp.

Higher up in the 3370.0—3365.0 m interval there occurs a complex of black mudstones intercalated by siltstones. Scales of fishes, fragmentary conodonts from the genera *Lygonodina*, *Hindeodella*, *Lonchodina*, also *Orbiculoidea tornacensis* Dem. and *Tornquistia* cf. *polita* (McCoy), Pl. 1, Fig. 13, have been observed there.

The interval between 3365.0 and 3348.0 m is represented by greywacke sandstone, found to be unfossiliferous. But, in siltstones and mudstones with thin intercalations of grey limestones occurring between 3348.0 and 3335.0 m the presence has been observed of:

Orbiculoidea tornacensis Dem., Pl. 1, Figs 6—7
Lingula mytilloides Sow.

Schelwienella sp.
Rugosochonetes sp.
Pustula cf. *pyxidiformis* de Kon., Pl. 2, Fig. 7
Pustula sp., Pl. 2, Fig. 6
Leiorhynchus sp., Pl. 4, Fig. 2
Prospira sp., Pl. 4, Fig. 1
Archegonus (Phillibole) sp., Pl. 13, Fig. 6
a scolecodont, Pl. 13, Fig. 9

In addition some few ostracods (moulds) and conodonts from the genera *Hindeodella* and *Bryantodus* have been found.

In the top part of the profile here considered, at a depth from 3335.0 to 3303.5 m occurs a complex of dolomitized oolitic limestones bearing some meagre detritus of carbonized plants, trochites and fragmentary brachiopod from the genus *Athyris*.

The faunal remains in the *W.3* profile are scarce but the presence of such forms as *Orbiculoidea tornacensis* Dem. and *Pustula* cf. *pyxidiformis* de Kon. reliably suggests the Tournaisian age of the deposits. The former species has been determined in the Upper Tournaisian of Belgium. In Poland it is known from the Upper Tournaisian members of the Holy Cross Mts, while in Western Pomerania it has been encountered in the Chojnice area (Matyja 1976). *Pustula pyxidiformis* (de Kon.) is a form common in the Upper Tournaisian and Lower Viséan of western and eastern Europe (Paeckelmann 1931, Sarycheva & al. 1963). In the upper part of the *W.3* profile a trilobite pygidium from the genus *Archegonus* (*Phillibole*) has been found, characteristic of the Culm facies, mainly that of Central Europe (Hahn 1975). The morphology of the cephalon is of primary importance in specific determination since in several *Phillibole* species, known both from the Tournaisian and the Viséan, the pygidia are much alike. In H. Osmólska's opinion (oral information) our form comes closest to *Archegonus* (*Phillibole*) *aprathensis* (R. & E. Richter).

In the *W.10* profile the Upper Tournaisian age has been assigned to sediments from the depth of 3400.0 up to the top of the reached Carboniferous i.e. to 3276.5 m. In several cores from the 3390.0—3310.0 m interval, represented by a black limy mudstone intercalated thinly by marly limestones, besides plant fragments, trochites, ostracods (moulds) and bryozoans, the presence has been observed of the following:

Schuchertella sp., Pl. 2, Fig. 8
Schizophoria sp.
Pustula sp.
Dictyoclostus sp., Pl. 3, Fig. 1
Leiorhynchus cf. *carboniferous* (Girty), Pl. 3, Fig. 9
Athyris sp.
Phillibole sp., Pl. 13, Fig. 3

In the greywacke sandstones in the *W.10* profile, from a depth between 3310.0 and 3303.0 m no traces of faunal remains have been encountered.

The next part of the profile lying higher up between 3303.0 and 3292.4 m, represented by dark-grey mudstones with intercalations of dolomitized oolitic sandy limestones or marly limestones, contains detritus of carbonized plants, fossil remains of trochites, bryozoans, scales of fishes, indeterminate trilobite fragments and

Anthraconello laevirostrum (Portl.)
Mytilarca sp., Pl. 5, Fig. 12
Sanguinolites cf. *tricostatus* (Portl.), Pl. 8, Fig. 3
Pernopecten cf. *concentricum* (Hind), Pl. 6, Fig. 2
Knightites (Retispira) cf. *elegans* (d'Orb.)
Hyolithes sp., Pl. 13, Fig. 7

Pernopecten cf. *concentricum* and *Knightites(Retispira)* cf. *elegans* have been encountered in the Tournaisian deposits of the Chojnice area (Korejwo 1976).

The top part of the Carboniferous reached in the *W.10* profile is represented by greywacke sandstone with a thin intercalation of variegated mudstone at the bottom. The mudstone contains plant detritus and *Orbiculoidea tornacensis* Dem., Pl. 1, Fig. 4.

In the remaining profiles of the Wierzchowo area deposits referred to the Upper Tournaisian are but sporadically fossiliferous.

In the *W.6* profile faunal remains have been encountered only in one core at a depth between 3165.0 and 3162.1 m where, besides trochites and fish scales the presence has been noted of:

Orbiculoidea tornacensis Dem.
Brachythyris cf. *peculiaris* (Shum.), Pl. 4, Fig. 6
Edmondia sp.

The presence of the 2 first forms suggests the Tournaisian age of the deposits. *Brachythyris peculiaris* (Shum) is a form reported from the Tournaisian of North America, the Urals and Kazakhstan. In Western Pomerania this species has thus far been observed in profiles Brda *1* and *2* (Matyja 1976).

Similarly in profile *W.11* in a 91 m thick series of the Upper Tournaisian faunal remains have been found only between 3160.0 and 3147.7 m. They are represented by fragmentary crinoids, gastropods, lingulae and

Composita sp.
Edmondia sp., Pl. 8, Fig. 1
Pernopecten cf. *concentricum* (Hind), Pl. 6, Fig. 3

The last species has also been observed in Tournaisian deposits of the Chojnice area (Korejwo 1976).

In profile *W.12* scarce faunal remains have been encountered only in the top parts of the pierced Carboniferous between the depth of 3266.8 and 3249.5 metres. These are:

Schizophoria sp.
Streblochondria sp., Pl. 5, Fig. 10
Edmondia unioniformis (Phill.), Pl. 7, Fig. 1
Straparollus sp.

The Carboniferous deposits in the *W.14* profile (at a depth between 3410 and 3251.5 m) have been referred to the Upper Tournaisian on correlations with the neighbouring profiles. In the bottom series between 3410.0 and 3379.5 m in black mudstones intercalated by marly limestones the following have been found:

Schelwienella sp.
Ovatia cf. *laevicosta* (White), Pl. 2, Fig. 9
?Ovatia sp., Pl. 3, Fig. 4
Dictyoclostidae gen. et sp. ind., Pl. 3, Fig. 2
Trepospira sp., Pl. 9, Fig. 3
?Imitoceras sp., Pl. 11, Fig. 3

Ovatia laevicosta (White) is a form in the first place known from the Tournaisian of North America and the USSR. In Western Pomerania this species has been observed in Tournaisian sediments in profiles Brda *1* and Babilon *1* (Matyja 1976).

In the top of the pierced Carboniferous — interval 3283.5—3251.5 m — the oolitic limestone has yielded only fragmentary brachiopods of the genus *Athyris*, also *Polygnathus communis carina* Hass. This species, characteristic of the Upper Tournaisian, has been found in Poland in neptunian dykes on the Dalnia Hill of the Holy Cross Mts, also additionally in Western Pomerania in the Brda *1* profile (fide Matyja 1976).

It has been accepted that sediments from profile *W.9* between the depth of 3509.0 and 3415.0 m represent the Upper Tournaisian.

The bottom part of the pierced Carboniferous (depth 3509.0—3485.0 m) is represented by grey-brown oolitic limestones, partly dolomitized, partly sandy containing plant detritus, crinoids and fragments of indeterminate brachiopods.

Owing to lack of paleontological data the age of these limestones may be but indirectly determined. On macroscopic observations and thin sections these limestones seem analogous with those

encountered in profiles of the western limb of the Wierzchowo structure (*W.3*, *W.8*, *W.14*, and *W.11*), which have been referred to the Upper Tournaisian.

Black limy mudstones intercalated by darkgrey marly limestone occur in several cores in the 3485.0—3424.0 m interval. Besides trochites, and fragmentary lamellibranches and ostracods they contain

Ovatia cf. *laevicosta* (White), Pl. 3, Fig. 3
Mourlonia cf. *placida* de Kon., Pl. 9, Fig. 5

The former species is known mostly from the Tournaisian. In Pomerania it has been observed in the Chojnice area (Matyja 1976), the latter form being likewise characteristic of the Tournaisian (Batten 1966).

Deposits lying higher up between the depth of 3424.0 and 3421.0 m are represented by fine-grained sandstones with streaks or carbonized plant detritus and siltstones with mica.

In black mudstones with thin intercalations of marly limestone between 3421.0 and 3415.7 m have been encountered trochites, indeterminate lamellibranch impressions, ostracod moulds, fish scales and

Lingula sp.
Orbiculoidea tornacensis Dem., Pl. 1, Fig. 5
Mourlonia sp., Pl. 9, Fig. 7

The Upper Tournaisian age has likewise been assigned to sediments from profiles *W.4* (depth 4350.0—4022.0 m), *W.8* (depth 3500.0—3333.5 m) and *W.2* (depth 3202.0—3163.0 m), though they did not provide any conclusive faunal evidence with the exception of very few brachiopod fragments from the genera *Schuchertella*, *Athyris*, *Cancrinella* (Pl. 3, Fig. 5) and "*Spirifer*" (Pl. 4, Fig. 3).

The Upper Tournaisian age for the here considered parts of profiles has been accepted on the basis of electrical logging, and lithological similarities suggesting correlations with the neighbouring profiles.

Lower Viséan (V_1)

The somewhat higher Dinantian members, representing the Lower Viséan have been reached directly underlying the Zechstein in the eastern (subsided) limb of the Wierzchowo structure in profiles *W.9* (depth 3415.0—3290.0 m), *W.1* (3263.2—3255.5 m) and *W.13* (3338.0—3303.0 m) (Fig. 2).

These sediments, in profile *W.9* overlying the Upper Tournaisian, are 125.0 m thick. In the two other profiles only the Lower Viséan has been reached, its thickness being 32.5 m in the *W.13* profile and hardly 7.7 m in profile *W.1*.

In the profile *W.9* from the 3415.0—3332.0 m interval the deposits are developed as black calcareous mudstones, silky in places and intercalated by marly limestone (upper part of complex B_6). The occurrence is also noted of thin siltstone-with-mica intercalations, of pyrite injections and plant detritus.

At a depth of 3412.0—3405.0 m, along with trochites, ostracod moulds and fragmentary Chonetes the presence has also been observed of *Chonetipustula* cf. *concentrica* (Sarr.) (Pl. 2, Fig. 1). This species is mentioned from the Middle and Upper Viséan of the Rhine Schiefergebirge (Paeckelmann 1931, Nicolaus 1963) as well as from the Uppermost Tournaisian and Lower Viséan of Spain (Winkler Prins 1969).

Fragmentary lamellibranchs and *Lingula mytilloides* Sow. (Pl. 1, Figs 2—3) and *Orbiculoidea* sp. have been found in two cores in the 3364.5—3337.6 m interval.

Higher up in the *W.9* profile (3332.0—3290.0 m) also in the *W.13* profile (3338.0—3305.5 m) and the *W.1* profile (3263.3—3255.0 m) black mudstones occur. In the top these are variegated and with intercalations of dark-grey siltstones occasionally laminated by quartz sandstone. The sandstone contains carbonized plant detritus and calamite impressions, also abundant mica, pyrite nodules, here and there with slickensides (complex C_5).

More closely indeterminate fossil remains of ostracods, bryozoans, corals, also scolecodonts and fish scales have been noted in the *W.9* profile (at a depth between 3306.0—3296.0 m), moreover:

Lingula mytilloides Sow., Pl. 1, Fig. 1
Chonetipustula concentrica (Sarr.), Pl. 2, Fig. 3
Chonetes sp., Pl. 1, Fig. 8
Athyris sp.
Torynifer sp., Pl. 3, Fig. 8
Prospira sp., Pl. 4, Figs 4, 5
Lepetopsis cf. *phillipsi* de Kon., Pl. 10, Fig. 4
?Imitoceras sp., Pl. 11, Fig. 4

In the profile *W.13* faunal remains occur only between the depth of 3310.5 and 3308.0 m. They belong to crinoids, ostracod moulds and

Schuchertella portlockiana (Sem.), Pl. 2, Fig. 10
Chonetipustula cf. *concentrica* (Sarr.), Pl. 2, Figs 2, 4

The former of these two is a long-lived species and occurs from the Lowermost Tournaisian to the Viséan. In Pomerania its presence has been observed in several profiles of the Chojnice area (Matyja 1976).

The Carboniferous deposits pierced in profile *W.1* are developed as a pale medium-grained sandstone with abundant mica and carbonized plant detritus, towards the top passing into variegated mudstones and siltstones with coaly streaks. The mudstones have yielded indeterminate ostracod moulds, lamellibranchian shell detritus from the genus *Sanguinolites* and

Euphemites sp.
scolecodonts, Pl. 13, Fig. 8
fish scales, Pl. 14, Figs 1—8

The here considered complex (C_5) is 42.0 m thick in profile *W.9*, while in the profiles *W.13* and *W.1* it is 32.5 and 7.7 m respectively.

It has been accepted that deposits of this complex in the boreholes here considered are of analogous age. However, it is not out of the question that a slightly younger Lower Viséan member is represented in profile *W.1*.

FINAL REMARKS

The Subpermian deposits of the Wierzchowo area are represented solely by the Lower Carboniferous. The Tournaisian occurs in the western limb including the Strunian (*Tn1a*) of great thickness observed in the *W.4* profile, while in the eastern limb, depressed in relation to the western one, Lower Viséan deposits have also been preserved.

The thickness of the unpierced Strunian is 451 m, that of the higher Tournaisian members ca. 580 m, while the pierced Lower Viséan deposits are 125 m thick. The total thickness of the Dinantian in this region is ca. 1160 meters. Taking into account the Prepermian erosion of its upper members it may be reasonably supposed that the actual thickness of the Lower Carboniferous may have ranged up to 1500 metres

The Wierzchowo structure is situated in an elevated, so far but poorly inyestigated Gościno—Wierzchowo zone. In the vicinity of Gościno Devonian deposits directly underlie the Zechstein while in the area of Wierzchowo lying farther SE there occur Lower Carboniferous and perhaps Lower Permian sediments (*W.4*).

In spite of considerable subsequent block dislocations to which the Carboniferous deposits had been subjected it is possible to reconstruct the subsidence direction of the bottom of the sedimentary basin comprising present Western Pomerania. This process took place gradually to the SW from the tectonic-erosional boundary with the Precambrian platform, the Wierzchowo area being during the Carboniferous in the lowermost part of this basin so far differentiated. It seems that the sedimentation here, like in the Chojnice region too, continued uninterruptedly from the Upper Devonian at least through the Middle Viséan, maybe even slightly longer.

An analysis of the lithological complexes together with the distribution of bentonic fauna in the deposits of the profiles here considerd reasonably suggest that this was a shallow-water well aerated basin. Its bottom was extremely labile and subject to continuous subsidence, particularly so in the lowermost Carboniferous, as is indicated by the great thickness of the Lower Tournaisian. This labile character of the bottom together with the intense denudation of rather nearby alimentary area is also reflected in the strong lithological variability of the deposits.

The Carboniferous of the Wierzchowo area should be studied against the background of the whole Koszalin—Chojnice zone structure (Dadlez 1974) where the Post-Caledonian cover, i.e. the Devonian and Carboniferous sediments had experienced the Variscan syndiastrophism. Its early — Bretonian and Sudetic — phases were marked by stronger epeirogenic movements which caused the passage of the carbonate lithofacies into the terrigenous one, often even coarse-clastic and were responsible for the sedimentary-erosional gaps, occasionally even the formation of local dislocations.

In the Wierzchowo area, owing to vertical movements along with an increased supply of clastic material after the Middle Tournaisian there occurs a change in the sedimentation from a carbonate-mudstone one to coarse clastic. A thick (up to 100 m) complex of greywacke-arkose sandstones was formed, the sandstones being probably the synorogenic deposit of the off-shore zone of the basin. On the other hand, the presence of pyroclastic material in the Carboniferous deposits indicates that the sedimentation was accompanied by increased volcanic activity.

The passage of this facies into a carbonate one (oolitic limestones) indicates further shallowing of the basin until its complete emersion, possibly earlier than or during the Upper Viséan. The elevated area was subsequently dislocated owing to the Variscan syndiastrophism — chiefly during the Sudetic phase. The eastern limb was by some hundreds of meters depressed in relation to the western one and the lower Viséan parts have been there preserved. On the other hand, in the western limb the presence is noted of only the various Tournaisian members, the Strunian included. In both limbs the Carboniferous deposits lie horizontally or sub-horizontally.

The dislocating movements are followed by a period of tectonic calm accompanied by strong erosion affecting the Carboniferous deposits.

The area comprising the Wierzchowo region had been uplifted en bloc after the Westphalian owing to the action of the Asturian phase when the whole Ko-

szalin—Chojnice zone was strongly dislocated because of block-like deformations (Dadlez 1974). In the upthrusted zones have been preserved the Devonian sediments and the lower Dinantian members while in the subsided zones so far mostly the Dinantian with slightly higher members and occasionally Silesian fragments (Westphalian) have been encountered. The latter have been preserved in the NW of the Koszalin—Chojnice zone.

The Zechstein sea transgression encroaches the degraded sediments of the various Carboniferous, locally it overfloods older deposits.

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K. KOREJWO

BIOSTRATYGRAFIA OSADÓW KARBOŃSKICH Z REJONU WIERZCHOWA (POMORZE ZACHODNIE)

(Streszczenie)

W czasie intensywnych poszukiwań bituminów w strefie Koszalin—Chojnice, uzyskano cenne i nowe materiały z profilów, w których napotkano osady karbonu reprezentowane przez różne ogniwa stratygraficzne. W żadnym z otworów nie otrzymano dotychczas pełnego profilu dinantu i silezu. Związane to jest ze skomplikowanymi procesami tektonicznymi, jakim podlegała ta strefa zarówno w karbonie jak i zapewne w dolnym permie.

Dotychczas opracowano szczegółowo zarówno pod względem litologicznym jak i biostratygraficznym osady karbonu z rejonu Chojnic (Korejwo 1975, 1976, 1979; Matyja 1976). W dalszej kolejności autorka zajęła się osadami karbonu uzyskanymi z 12 wierceń, usytuowanych w południowo-zachodniej części strefy Koszalin—Chojnice — w rejonie Wierzchowa (fig. 1). Osady te występują bezpośrednio pod permem i nigdzie nie zostały przebite.

Szczegółową charakterystykę litologiczną i rozwój paleotektoniczny karbonu rejonu Wierzchowa zamieszczono w pracy Korejwo (1977).

Opracowanie niniejsze obejmuje stratygrafię osadów karbońskich opartą na szczątkach makrofauny, napotkanych w niektórych rdzeniowanych interwałach.

Stan zachowania fauny jest przeważnie tak fragmentaryczny, że uniemożliwia ścisłe oznaczenia gatunkowe, a niekiedy nawet rodzajowe. Powyższe, jak i znaczne luki w rdzeniowaniu są przyczyną, że ustalenie dokładnego wieku osadów, a przede wszystkim wyznaczenie ścisłych granic pomiędzy poszczególnymi ogniwami stratygraficznymi nie jest możliwe. Można je tylko wyznaczyć umownie na podstawie skąpych danych faunistycznych i analizy pomiarów geofizycznych, wreszcie przez porównanie poszczególnych kompleksów litologicznych wyróżnionych uprzednio przez autorkę (Korejwo 1977).

Większość napotkanej fauny jest ilustrowana (pl. 1—14). Wyjątkiem są brachiopody, stwierdzone w osadach dolnej części profilu *W.4*, a należących do *Tn1a*. Będą one w przyszłości opracowane przez H. Matyję.

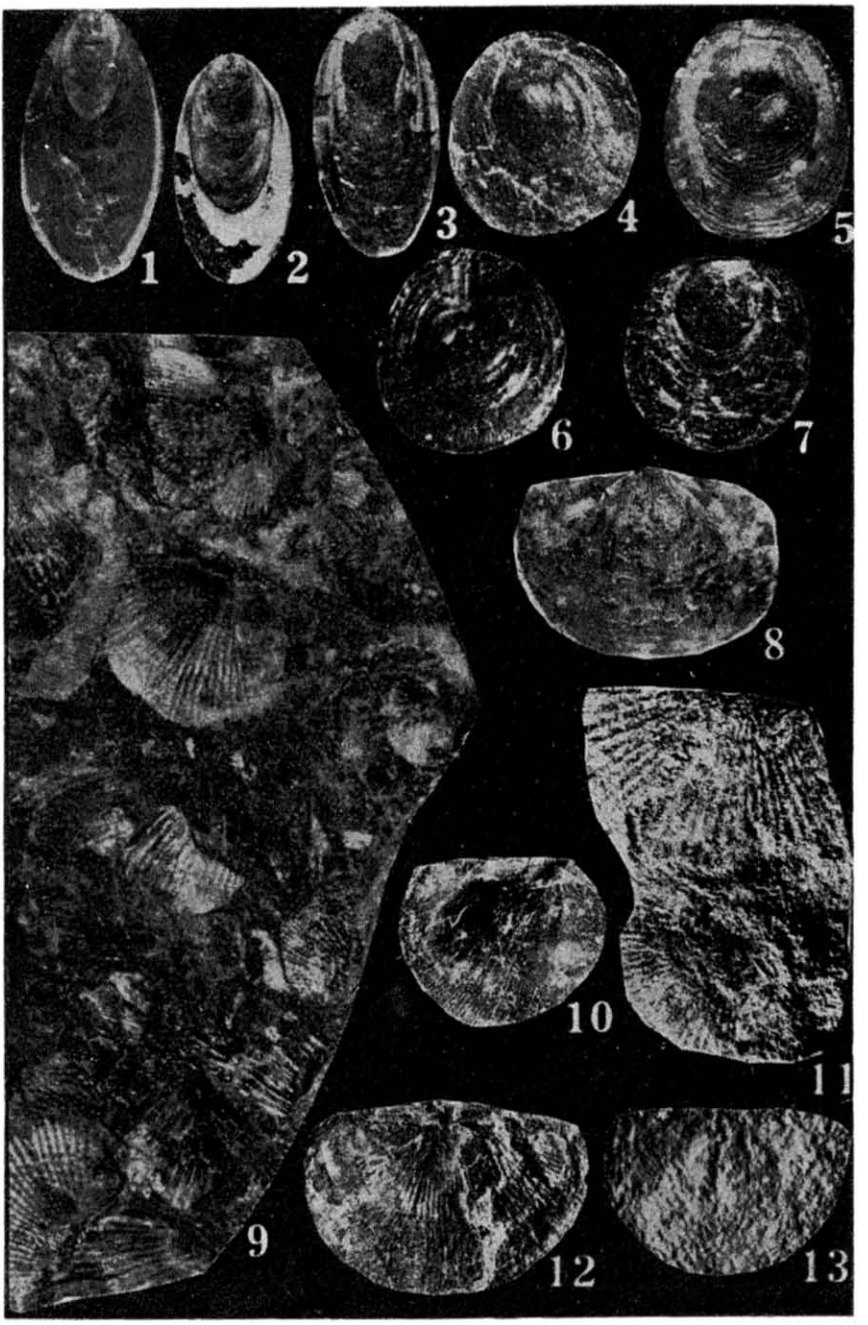
Podpermskie osady rejonu Wierzchowa reprezentowane są tylko przez karbon dolny.

Dla zobrazowania układu przestrzennego i miąższości poszczególnych kompleksów dinantu przedstawiono kilka schematycznych przekrojów oraz mapek strukturalnych (Korejwo 1977, fig. 1—7). Analiza tych przekrojów potwierdziła przypuszczenie o istnieniu dyslokacji prawdopodobnie o kierunku NNW—SSE, rozcinającej strukturę Wierzchowa na dwa bloki. Skrzydło wschodnie

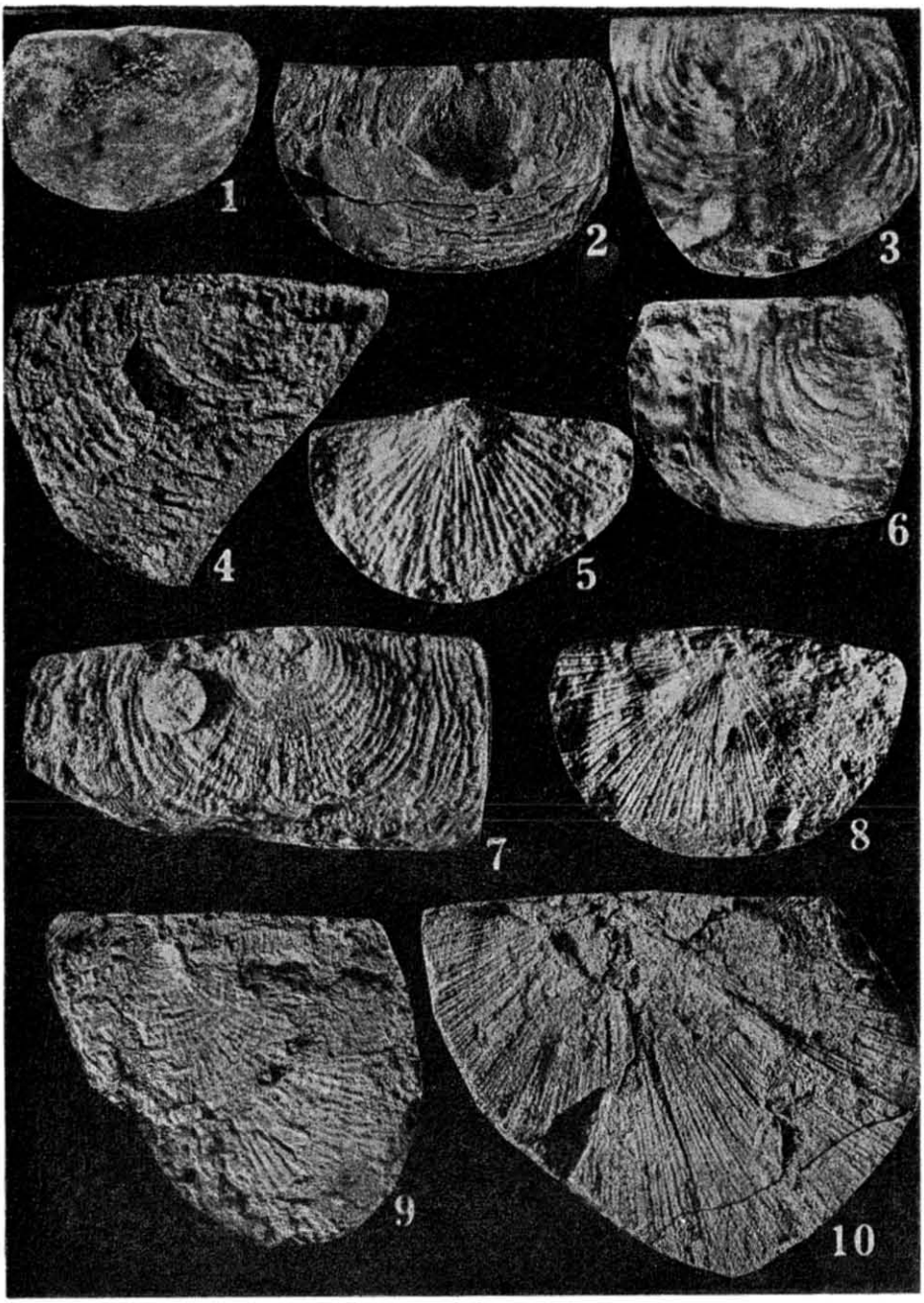
z otworami *W.1*, *W.9* i *W.13* (fig. 1) zrzucone jest w stosunku do zachodniego. Na podstawie profilów *W.9* i *W.11* można przyjąć, że amplituda zrzutu wynosi około 350 m. W skrzydle wschodnim zachowały się również nieco młodsze ogniwa dinantu (dolne partie wizenu), podczas gdy w zachodnim obecne są tylko różne ogniwa turneju, w tym dużej miąższości strunu (*Tn1a*), który stwierdzony został w najbardziej południowej i jednocześnie najbardziej obniżonej części, gdzie usytuowano wiercenie *W.4*.

W obu skrzydłach osady karbonu leżą poziomo lub prawie poziomo. Korelacja osadów karbońskich z rejonu Wierzchowa przedstawiona jest na fig. 2. Odbiega ona nieco od przyjętej przez Dadleza (1978).

Miąższość nieprzebitego strunu (*Tn1a*) wynosi 451 m, wyższych ogniw turneju około 580 m, natomiast nadwierconego wizenu dolnego 125 m. Łączna miąższość dinantu w tym rejonie wynosi około 1160 m. Jeśli uwzględnić przedpermską erozję wyższych jego ogniw, to można przyjąć, że rzeczywista miąższość dolnego karbonu mogła dochodzić do ponad 1500 m.



1—3 *Lingula mytilloides* Sow.; borehole Wierzchowo 9; *1* — depth 3302.0—3306.0 m, ×7; 2—*3* — 3359.3—3364.5 m, ×,
4—7 *Orbiculoidea tornacensis* Dem.; *4* — *W.10*, 3284.3—3290.1 m, ×6; *5* — *W.9*, 3415.7—3421.0 m, ×10; *6*, *7* — *W.38* 3335.9—3337.3 m, ×15
8 *Chonetes* sp.; *W.9*, 3296.0—3302.0 m, ×2
9—12 *Rugosochonetes* cf. *laguessianus* (de Kon.); *9*, *12* — *W.10*, 3495.7—3502.0 m; 9×4, *12*×2.5; *10*, *11* — *W.12*, 3404.9—3407.7 m; *10*×3, *11*×4
13 *Tornquistia* cf. *polita* (McCoy); *W.3*, 3367.0—3370.0 m, ×15



1, 2, 4, *Chonetipustula* cf. *concentrica* (Sarr.); *1* — *W.9*, 3405.0—3412.0 m. ×10; *2*, *4* — *W.13*, 3308.0—3310.5 m; *2*×2 *4*×4

3 *Chonetipustula concentrica* (Sarr.); *W.9*, 3302.0—3306.0 m, ×1.5

5 *Schuchertella planiuscula* (Sem. & Moell.); *W.10*, 3540.0—3545.0 m, ×10

6 *Pustula* sp.; *W.3*, 3343.3—3346.0 m, ×5

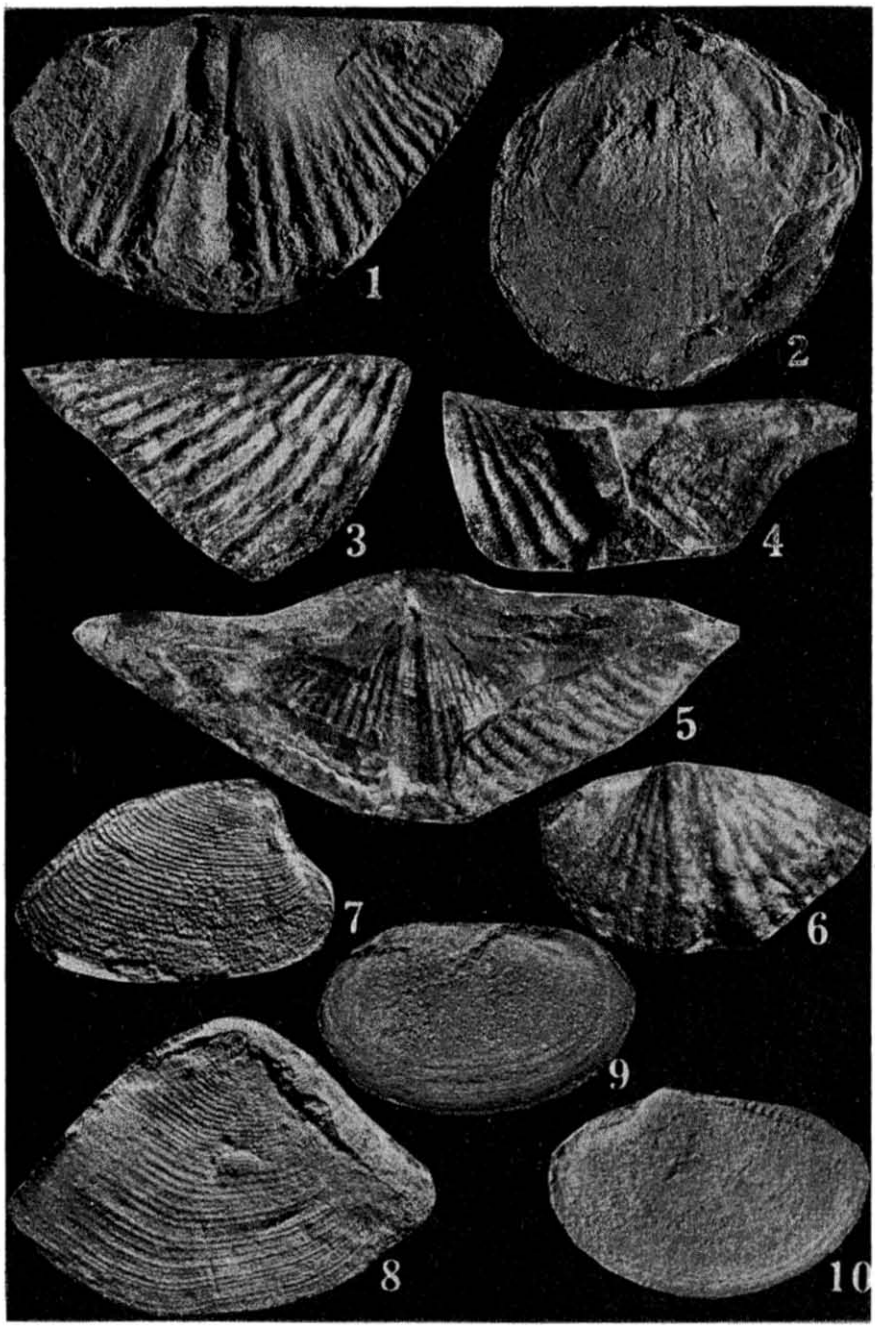
7 *Pustula* cf. *pyxidiformis* (de Kon.); *W.3*, 3343.3—3346.0 m, ×2.5

8 *Schuchertella* sp.; *W.10*, 3322.5—3329.0 m, ×4

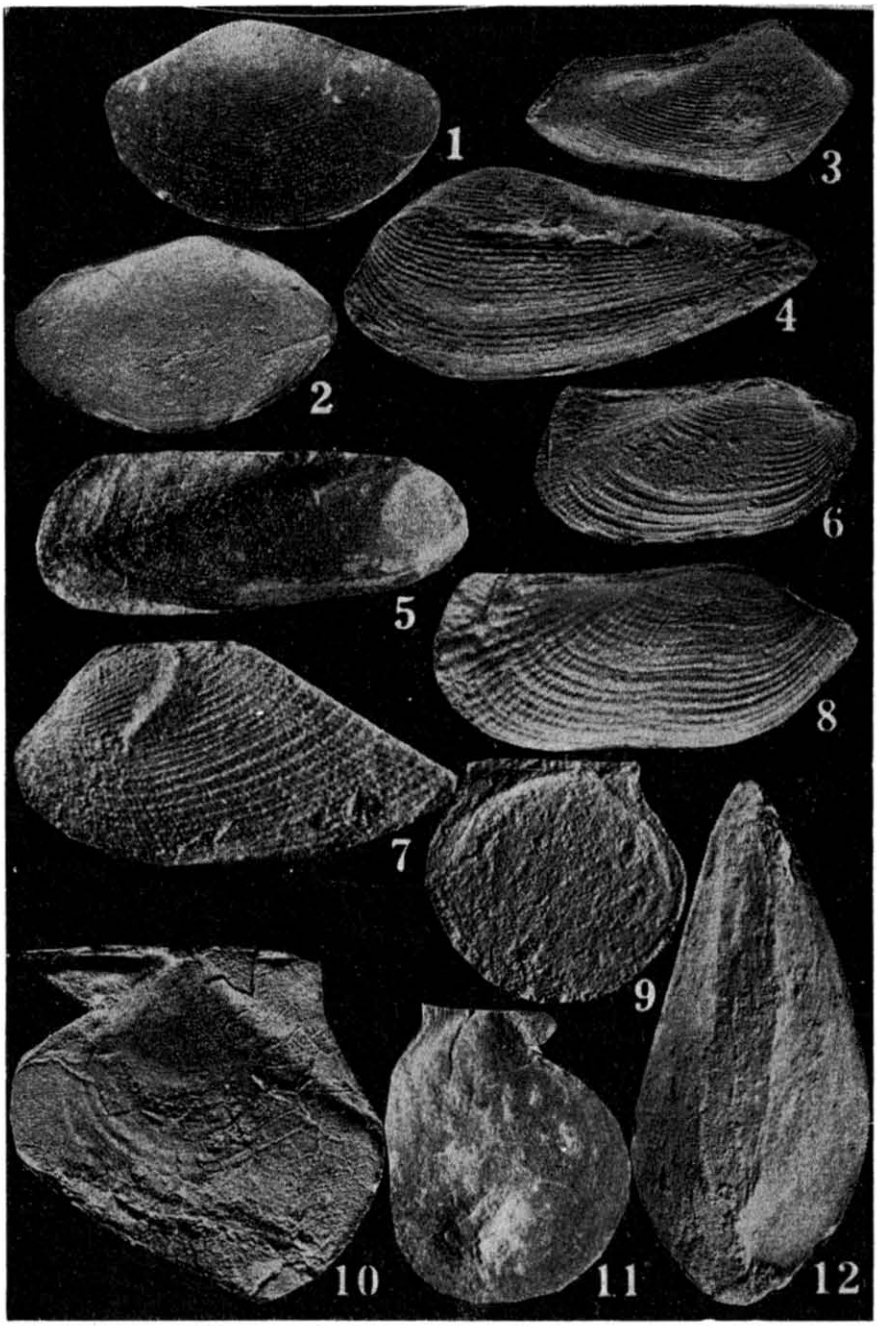
9 *Ovatia* cf. *laevicosta* (White); *W.14*, 3403.5—3410.0 m, ×3

10 *Schuchertella portlockiana* (Sem.); *W.13*, 3308.0—3310.5 m, ×2.5

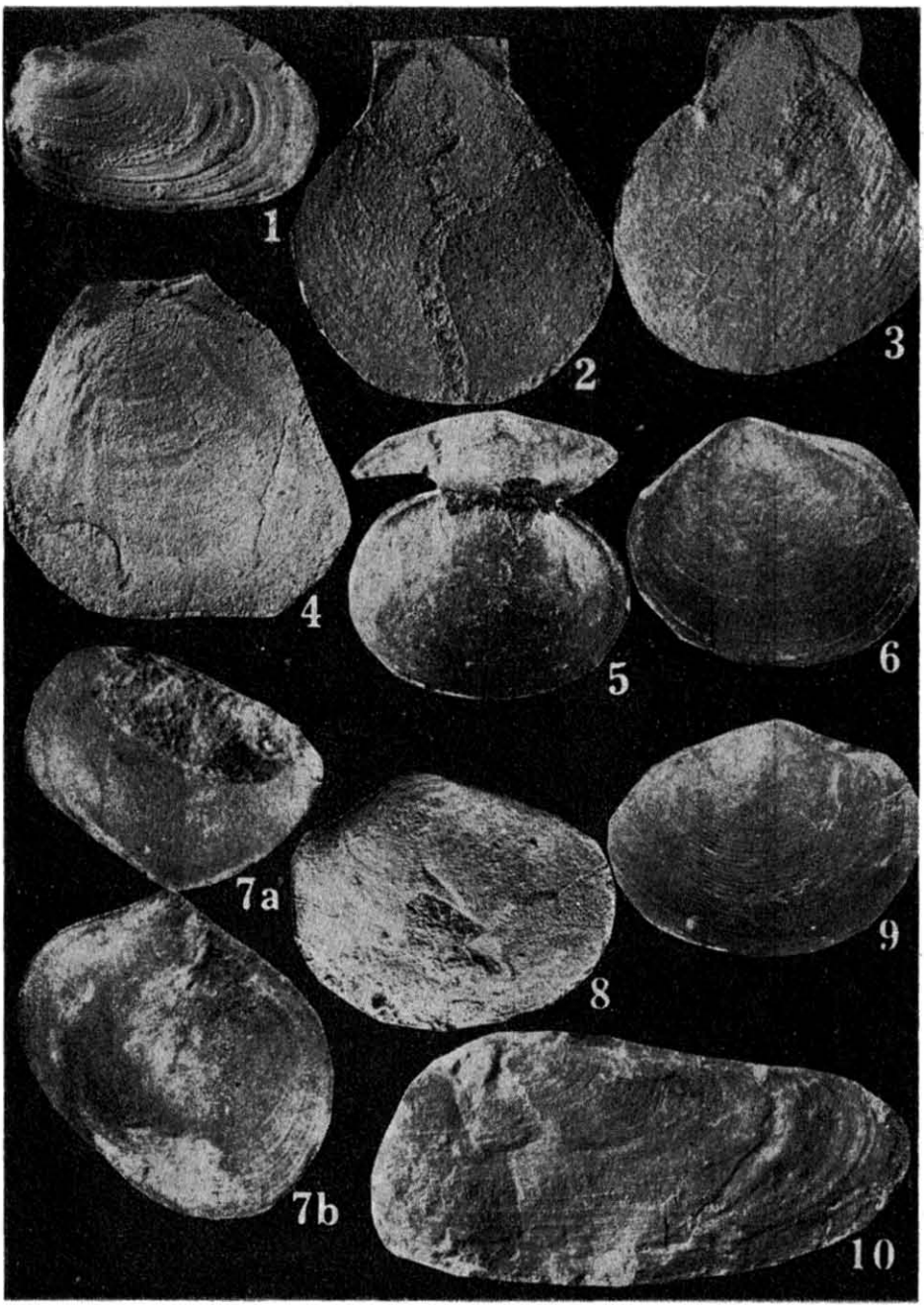
1 *Edmondia* sp.; *W.11*, 3150.5—3156.9 m, ×2
2 *Edmondia* sp.; *W.12*, 3439.0—3442.0 m, ×2
3 *Sanguinolites* cf. *tricostatus* (Portl.); *W.10*, 3293.0—3297.2 m, ×5
4 *Straparollus (Euomphalus) pugilis* (Phill.); *W.4*, 4883.5—4893.3 m, ×3
5 *Euomphalus* sp.; *W.12*, 3439.0—3442.0 m, ×8
6 *Straparollus* sp.; *W.4*, 4606.0—4615.0 m, ×8
7 *Rhaphischisma planorbiformis* (de Kon.); *W.4*, 4606.0—4615.0 m, ×8
8 *Straparollus (Straparollus)* cf. *mammula* de Kon.; *W.10*, 3552.0—3559.0 m, ×6
9 *Trepospira* sp.; *W.4*, 4518.0—4525.0 m, ×6
10 *Straparollus (Straparollus) laevigatus* (Lev.); *W.12*, 3470.3—3475.0 m, ×2



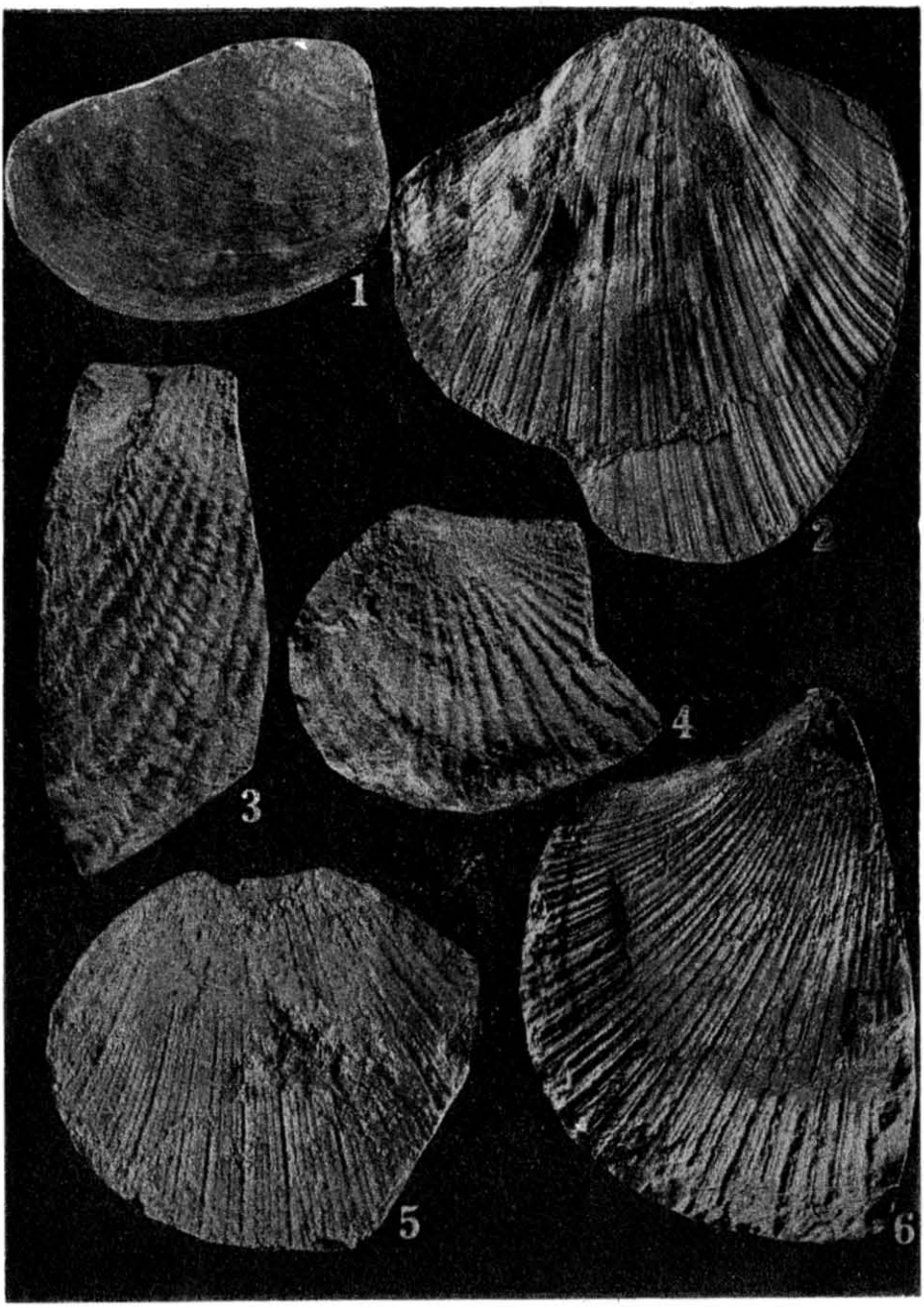
1 *Prospira* sp.; *W.3*, 3343.3—3346.0 m, ×4
2 *Leiorhynchus* sp.; *W.3*, 3335.0—3337.3 m, ×4
3 "*Spirifer*" sp.; *W.8*, 3459.0—3465.0 m, ×3
4—5 *Prospira* sp.; *W.9*, 3296.0—3302.0 m; *4*×4, *5*×2
6 *Brachythyris* cf. *peculiaris* (Shum.); *W.6*, 3162.1—3165.0 m, ×5
7—8 ?*Nuculopsis* sp.; *W.4*, 4606.0—4615.0 m; *7*×7, *8*×6
9 *Anthraconeilo* sp.; *W.12*, 3439.0—3442.0 m, ×7
10 *Palaeoneilo* cf. *sinuosa* (Ryckh.); *W.4*, 4606.0—4615.0 m, ×10



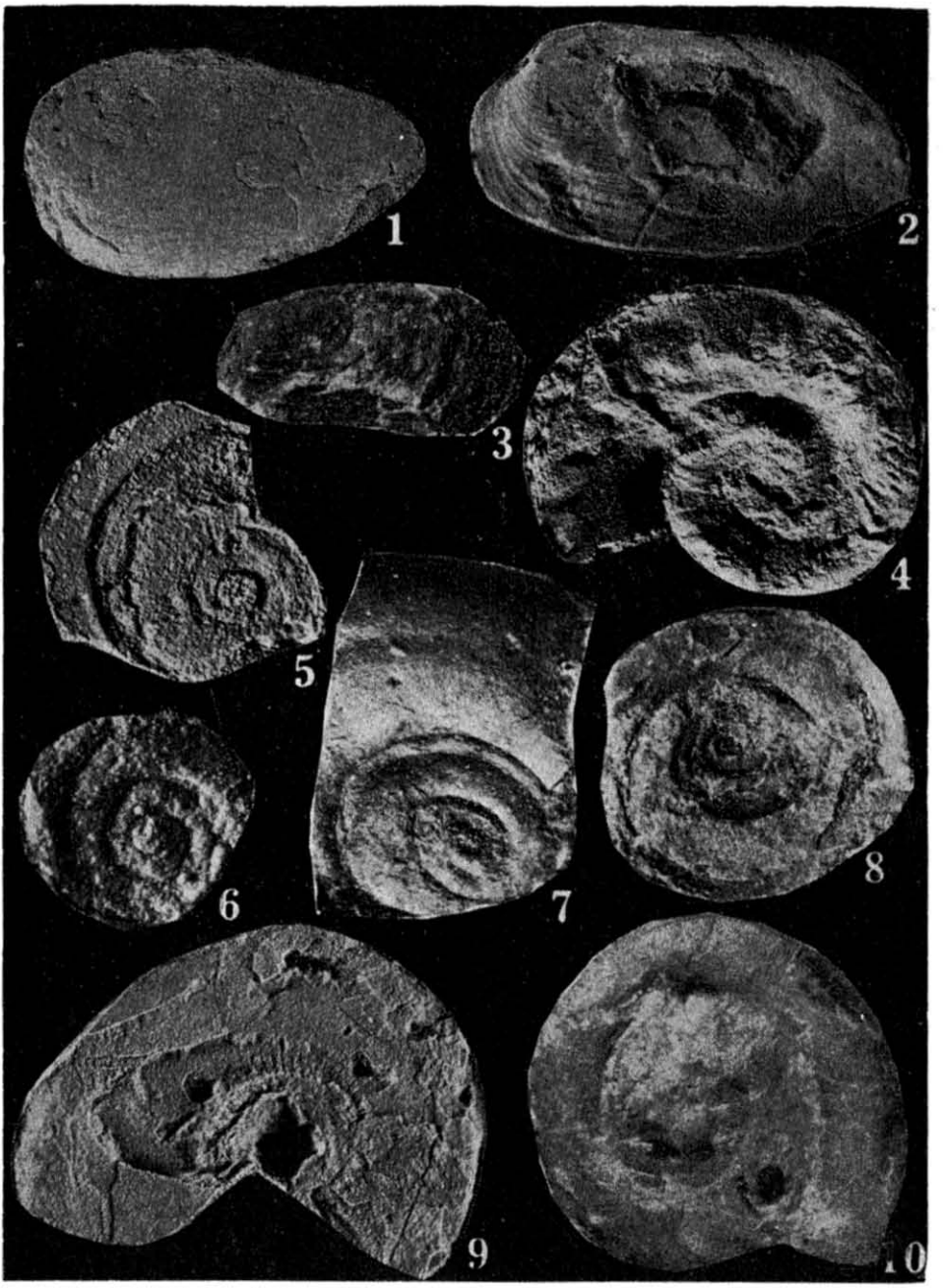
1—2 *Palaeoneilo* cf. *sinuosa* (Ryckh.); *1* — *W.8*, 3546.0—3552.5 m, ×5; *2* — *W.4*, 4606.0—4615.0 m, ×4
3 *Polidevcia* cf. *sharmani* (Ether.); *W.12*, 3439.0—3442.0 m, ×3
4 *Polidevcia attenuata* (Flem.); *W.10*, 3495.7—3502.0 m; ×4
5—8 *Parallelodon semicostatus* (McCoy); *5* — *W.10*, 3540.0—3545.0 m, ×4; *6* — *W.4*, 4965.2—4975.0 m, ×4; *7*, *8* — *W.4*, 4606.0—4615.0 m; *7*×6, *8*×8
9 *Streblopteria* sp.; *W.4*, 4606.0—4615.0 m, ×6
10 *Streblochondria* sp.; *W.12*, 3253.7—3258.0 m, ×2.5
11 *Streblopteria* cf. *subelliptica* de Kon.; *W.8*, 3546.0—3552.5 m, ×3
12 *Mytilarca* sp.; *W.10*, 3293.0—3297.2 m, ×3



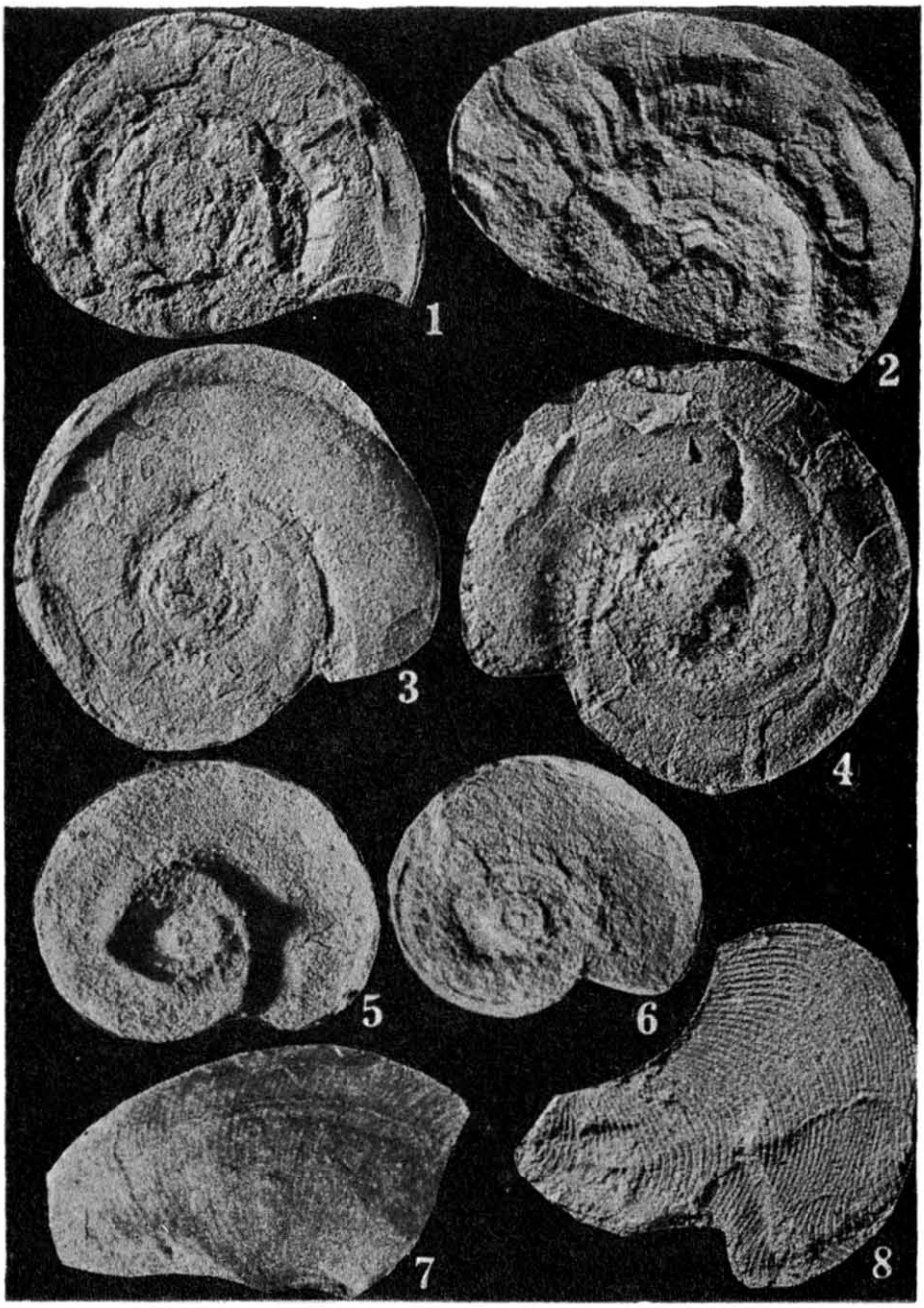
1 *Modiomorpha* sp.; *W.4*, 4965.2—4975.0 m, ×8
2—3 *Pernopecten* cf. *concentricum* (Hind); *2* — *W.10*, 3293.0—3297.2 m, ×3; *3* — *W.11*, 3147.7—3160.7 m, ×6
4 *Pernopecten* cf. *tenuis* (de Kon.); *W.4*, 4606.0—4615.0 m, ×6
5—9 *Scaldia* cf. *lambotteana* Ryckh.; *5, 6* — *W.4*, 4883.5—4893.3 m, ×3; *7* — *W.10*, 3524.0—3530.0 m, ×4; *8* — *W.4*, 4606.0—4615.0 m, ×6; *9* — *W.4*, 4965.2—4975.0 m, ×6
10 *Edmondia* cf. *accipiens* Sow.; *W.4*, 4606.0—4615.0 m, ×3



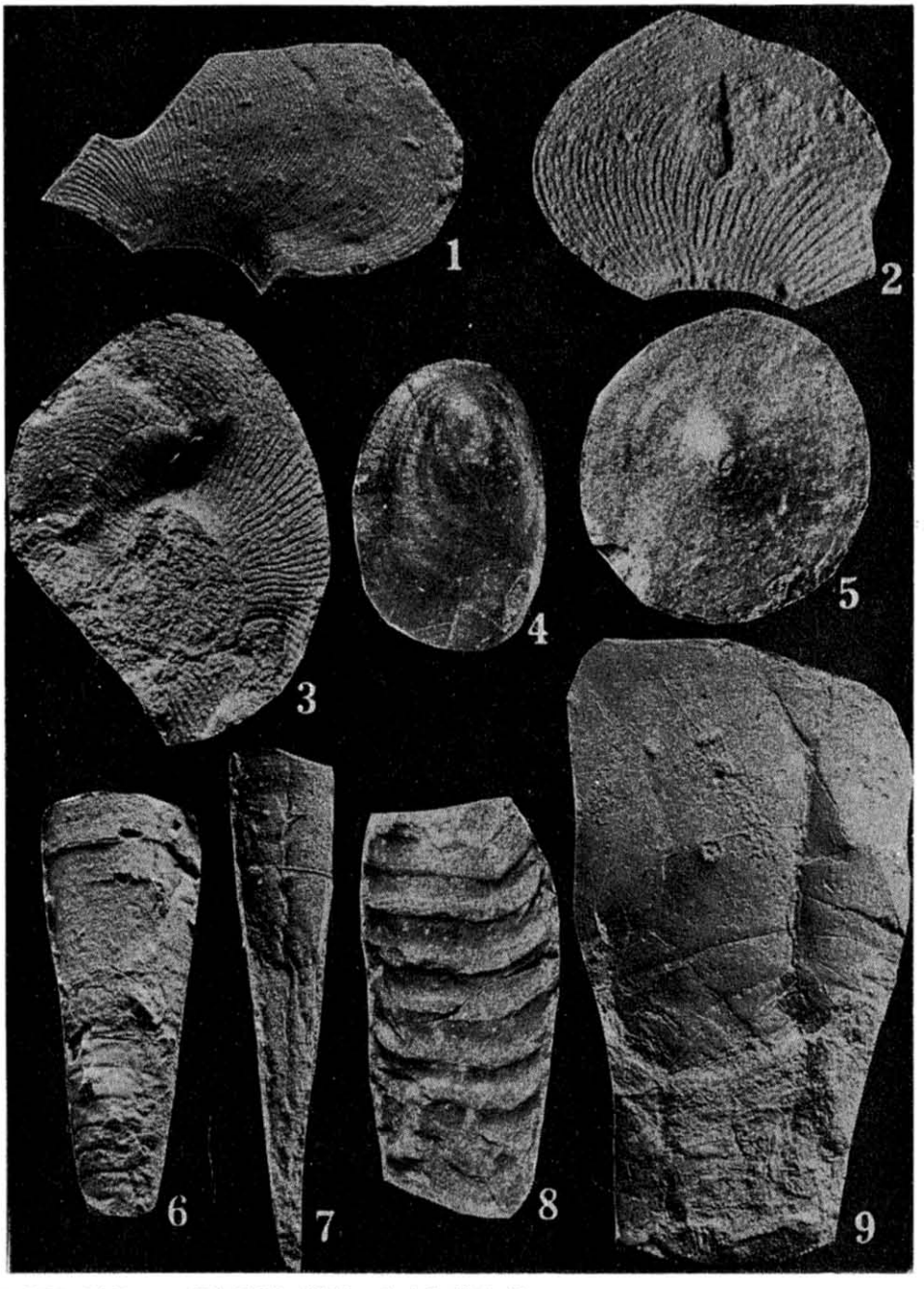
1 *Edmondia unioniformis* (Phill.); *W.12*, 3262.4—3266.8 m, ×3
2 *Aviculopecten* cf. *pungens* Muromz. & Turb.; *W.4*, 4883.5—4893.3 m, ×2
3 *Palaeolima* cf. *turberculata* Muromz.; *W.4*, 4721.0—4730.3 m, ×2
4 *Pterinopecten* sp.; *W.4*, 4883.5—4893.3 m, ×5
5 *Pterinopectinella* cf. *polytricha* (Phill.); *W.4*, 4883.5—4893.3 m, ×3
6 *Aviculopecten* cf. *peculiaris* Muromz. & Turb.; *W.4*, 4791.8—4801.0 m, ×3



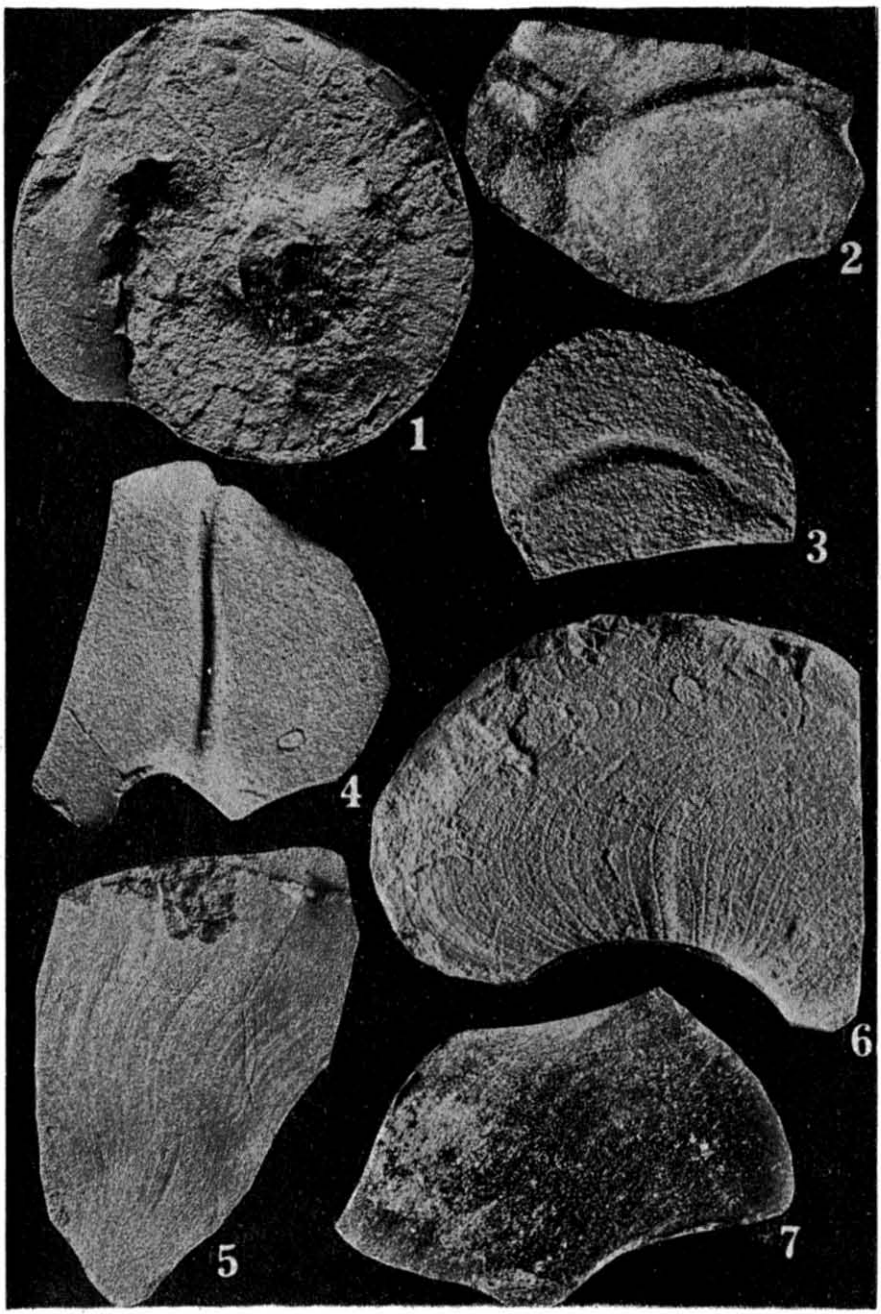
1 *Edmondia* sp.; *W.11*, 3150.5—3156.9 m, ×2
2 *Edmondia* sp.; *W.12*, 3439.0—3442.0 m, ×2
3 *Sanguinolites* cf. *tricostatus* (Portl.); *W.10*, 3293.0—3297.2 m, ×5
4 *Straparollus (Euomphalus) pugilis* (Phill.); *W.4*, 4883.5—4893.3 m, ×3
5 *Euomphalus* sp.; *W.12*, 3439.0—3442.0 m, ×8
6 *Straparollus* sp.; *W.4*, 4606.0—4615.0 m, ×8
7 *Rhaphischisma planorbiformis* (de Kon.); *W.4*, 4606.0—4615.0 m, ×8
8 *Straparollus (Straparollus)* cf. *mammula* de Kon.; *W.10*, 3552.0—3559.0 m, ×6
9 *Trepospira* sp.; *W.4*, 4518.0—4525.0 m, ×6
10 *Straparollus (Straparollus) laevigatus* (Lev.); *W.12*, 3470.3—3475.0 m, ×2



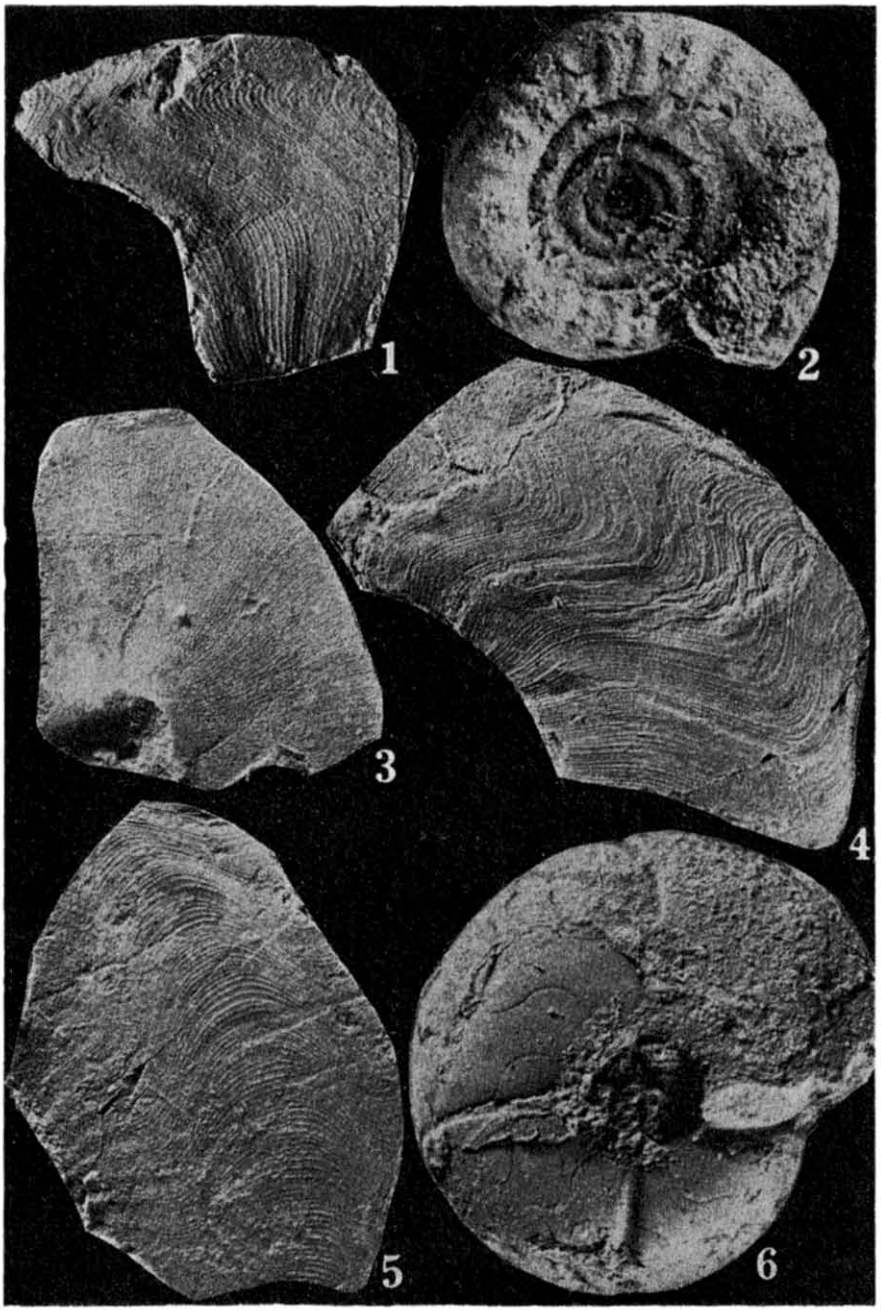
1—2 *Straparollus (Straparollus) planorbiformis* de Kon.; *W.4*, 4606.0—4615.0 m; *1*×6, *2*×7
3 *Trepospira* sp.; *W.14*, 3403.5—3410.0 m, ×5
4 *Trepospira* sp.; *W.12*, 3470.3—3475.0 m, ×7
5 *Mourlonia* cf. *placida* de Kon.; *W.9*, 3442.0—3446.8 m, ×8
6 *Platyschisma* sp.; *W.4*, 4606.0—4615.0 m, ×10
7 *Mourlonia* sp.; *W.9*, 3415.7—3421.0 m, ×6
8 ?*Tropidodiscus* sp.; *W.4*, 4606.0—4615.0 m, ×10



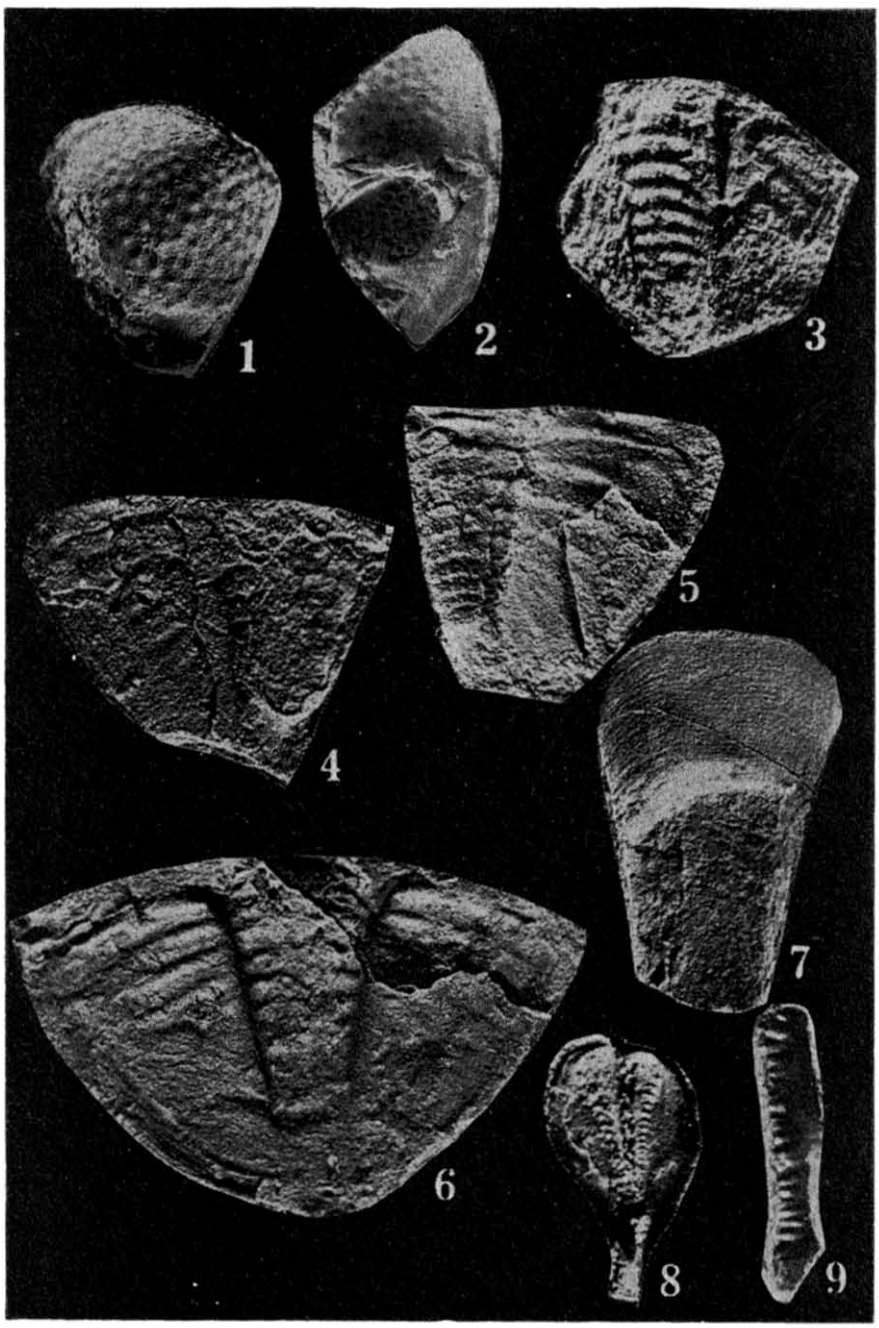
1—3 *?Tropidodiscus* sp.; *W.4*, 4606.0—4615.0 m; *1* ×4, *2*—10, *3* ×12
4 *Lepetopsis* cf. *phillipsi* de Kon.; *W.9*, 3302.0—3306.0 m, ×10
5 *Lepetopsis umbrella* de Kon.; *W.4*, 4883.5—4893.3 m, ×6
6—7 *Dolorthoceras* sp.; *W.4*, 4606.0—4615.0 m, ×3
8 *Reticycloceras* cf. *sulcatum* (Flem.); *W.4*, 4606.0—4615.0 m, ×3
9 *?Dolorthoceras* sp.; *W.4*, 4606.0—4615.0 m, ×2



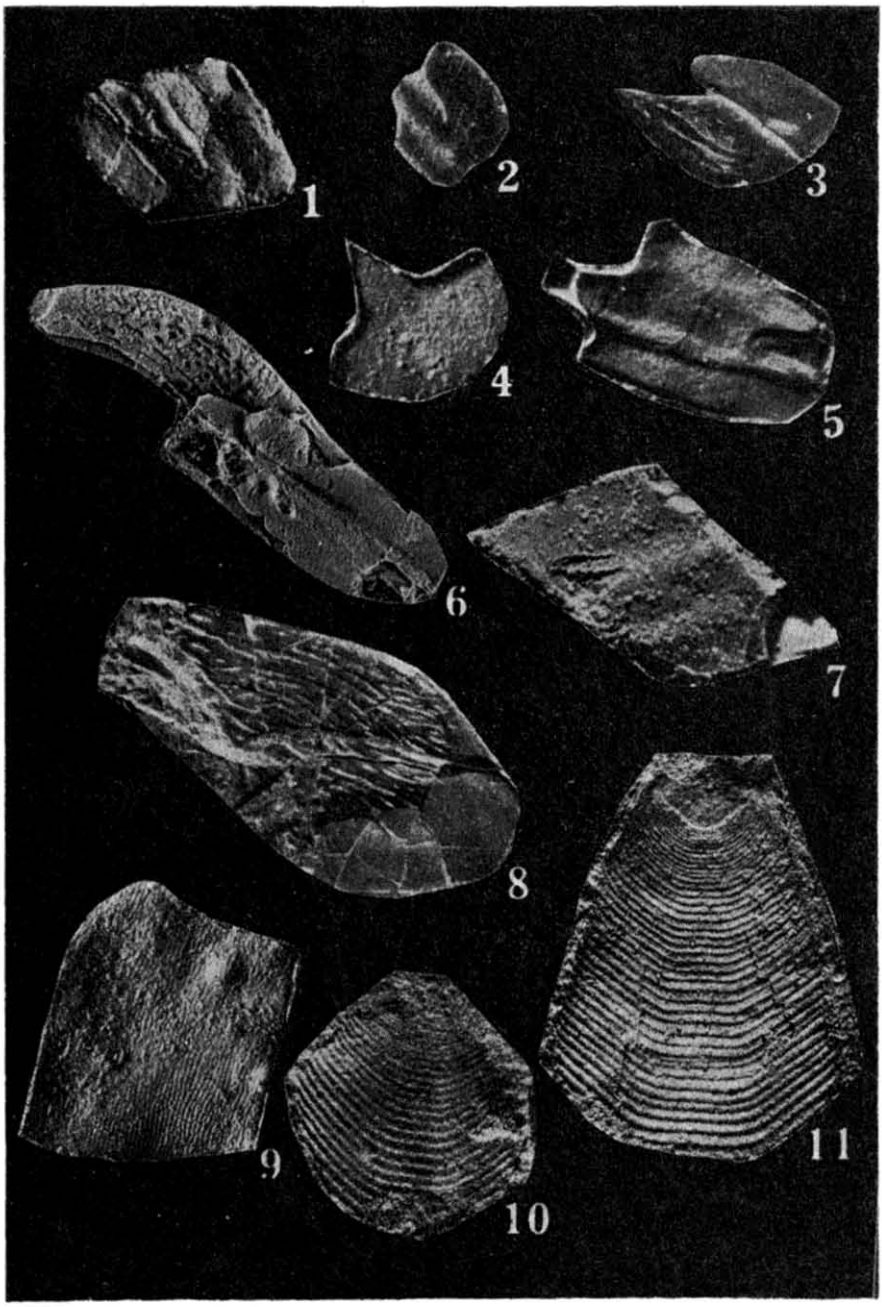
1 ?*Imitoceras* sp.; *W.4*, 4606.0—4615.0 m, ×7
2 ?*Parawocklumeria* sp.; *W.4*, 4606.0—4615.0 m, ×8
3 ?*Imitoceras* sp.; *W.14*, 3403.5—3410.0 m, ×7
4 ?*Imitoceras* sp.; *W.9*, 3302.0—3306.0 m, ×7
5—7 Goniatitida gen. et sp. indet.; *5* — *W.12*, 3439.0—3442.0 m, ×2; *6* — *W.4*, 4518.0—4525.2 m, ×7; *7* — *W.10*, 3513.0—3517.0 m, ×4



1 Goniatitida gen. et sp. indet.; *W.4*, 4518.0—4525.2 m, ×5
2 *Pseudarietites dorsoplanus dorsoplanus* H. Schmidt; *W.10*, 3545.0—3552.0 m, ×10
3 Goniatitida gen. et sp. indet.; *W.12*, 3439.0—3442.0 m, ×2
4—5 Goniatitida gen. et sp. indet.; *W.4*, 4518.0—4525.2 m; *4* ×4, *5* ×2.5
5 *Imitoceras* sp.; *W.8*, 3546.0—3552.5 m, ×7



1—2 *Phacops accipitrinus* (Phill.); *1* — *W.4*, 4606.0—4615.0 m, ×3; *2* — *W.4*, 4965.2—4975.0 m, ×3
3 *Phillibole* sp.; *W.10*, 3332.4—3339.4 m, ×10
4—5 *Phillibole* sp.; *W.12*, 3470.3—3475.0 m, ×8
6 *Archegonus (Phillibole)* sp.; *W.3*, 3335.9—3337.3 m. ×5
7 *Hyolithes* sp.; *W.10*, 3293.0—3297.2 m, ×4
8—9 scolecodonts; *8* — *W.1*, 3255.5—3263.2 m, ×15; *9* — *W.3*, 3335.9—3337.3 m, ×20



1—9 scales; *1—8 W.1*, 3255.5—3263.2 m; *1, 4, 5* ×15; *2, 3, 7* ×10; *6* ×5; *8* ×20; *9—W.4*, 4606.0—4615.0 m, ×6
10—11 incertae sedis; *W.4*, 4606.0—4615.0 m, ×6