Ordovician between Pilzno and Busko in the Carpathian Foreland
(Southern Poland)

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The Ordovician carbonates encountered in the Pilzno 40 borehole at depth of 3593–3733 m have yielded index conodonts and ostracods which enabled to determine the age of the rocks as Llandeilo and Caradoc. Comparison with columns of other 6 boreholes in the area has shown a significant facies differentiation: Lower Ordovician sandstones of the western part pass eastwards into shales. Middle Ordovician shales in the northern sector are replaced by carbonates to the south. Ordovician is preserved in narrow synclines formed during the Caledonian and Early Variscan stages. Earlier, it covered greater areas and was removed by post-Variscan erosion. Ordovician transgression has proceeded from north to south.

INTRODUCTION

The Ordovician rocks are known in the Carpathian Foreland from several boreholes. In the central part of this area these sediments were first found in the Mędrzechów 1 borehole (H. Tomczyk, 1959–1960, 1963; P. Karnkowski, E. Glowacki, 1961; Z. Obuchowicz, 1963) — Fig. 1. Several years later they were pierced in the Zalesie 1 borehole near Szczucin (S. Kwiatkowski et al., 1966), in the Niwki 3 (W. Moryc, 1974) and in the Lubasz 2. Recently they were found in the Pilzno 40 borehole and most probably in the Zgórsko 2 one. The Pilzno 40 column has served as a starting point to correlate the Ordovician sequences in the whole region.

THE PILZNO 40 PROFILE

The Pilzno 40 borehole pierced by the Polish Oil and Gas Company is located in the so-called Miocene "bay" of Pilzno within the border zone of the overthrust Flysch Carpathians (the Skole nappe) with the parautochthonous sediments of the Miocene "bay".

The following sediments were pierced there (Fig. 2): Under the Quaternary there is a parautochthonous sandy-clayey Miocene series (Upper Badenian) resting on flysch of the Skole Unit. The flysch deposits are shale and sandstone with fucoid marly interbeds which represent the Inoceramus Beds of the Upper Cretaceous. The dips are up to 50°. The flysch deposits are thrust over the sandy-clayey Miocene series (Upper Badenian) of the Zglobice Unit. The latter rests according to borehole geophysics on similar sediments of probable autochthonous Miocene (there is no core material). The Miocene basement consists of epicontinental Upper Cretaceous marls resting on Upper Jurassic marls and limestones. Below the Jurassic there are clastic sandy-clayey reddish and greenish beds of the Buntsandstein (middle part) which in turn rest on Silurian graptolitic shales and Ordovician limestones, the latter not pierced down to depth of 3733 m.
Fig. 1. A. Situation sketch-map of the Pilzno 40 borehole
1 — boreholes, 2 — Carpathian overthrust

B. Geological sketch-map of the Ordovician deposits found in the Pilzno–Busko–Mielec area
1 — older rocks (Precambrian), 2 — Tremadoc(?)-Lower Arenig, 3 — Arenig, 4 — Llanwir–Llandeilo, 5 — Cardoc, 6 — Ashgill, 7 — presumed Ordovician, 8 — Silurian extent, 9 — faults, 10 — Carpathian overthrust, 11 — boreholes in which the Ordovician or older deposits were pierced: Brz. 1 — Brzozowa 1, Cz. P. 3 — Czarna Pilzno 3, D. 2 — Dębica 2, G. W. 1 — Gliny Wielkie 1, Ko. 1 — Kobylniki 1, K. M. 2 — Kostki Małe 2, L. 2 — Lubasz 2, M. 1 — Mędrczechów 1, N. D. 3 — Nieczajna Dolna 3, N. 3 — Niwki 3, P. 40 — Pilzno 40, P. 10 — Podborze 10, P. 16 — Podborze 16, P. U. 3 — Porębka Uszewska 3, P. U. 4 — Porębka Uszewska 4, Pu. 1 — Pustków 1, Ra. 2 — Radlina 2, R. 5 — Radłów 5, R. 2 — Radzanów 2, R. 4 — Radzanów 4, St. 1 — Stawiska 1, Str. 5 — Stróżyska 5, Su. 1 — Suflczyn 1, W. 5 — Waryń 5, W. 1 — Wola Ociecka 1, Za. 2 — Zagórze 2, Zak. 1 — Zakliczyn 1, Zal. 1 — Zalasowa 1, Zal. 2 — Zalasowa 2, Z. 1 — Zalesie 1, Zg. 2 — Zagórsko 2

A. Szkie sytuacyjny otworu wiertniczego Pilzno 40
1 — otwory wiertnicze, 2 — linia nasunięcia Karpat płaszczowych

B. Szkie geologiczny otworu wiertniczego z obszaru Pilzne–Busko–Mielec
1 — skaly starsze (prekambr), 2 — tremadoc(?)-dolny arenig, 3 — arenig, 4 — llanwir–landeilo, 5 — karadok, 6 — ashgill, 7 — przypuszczalny ordowic, 8 — zasięg syluru, 9 — uskoki, 10 — linia nasunięcia Karpat płaszczowych, 11 — otwory wiertnicze, w których stwierdzono otwory ordowiku lub starsze, objaśnienia symboli otworów — patrz tekst angielski
The Ordovician sediments have been found at depth of 3593–3733 m (Fig. 3). These are mostly carbonates in which the following rock complexes can be distinguished on the basis of cores and geophysical logs. The upper part consists of carbonate deposits (3593–3642 m) of similar geophysical characteristics. In a core from the uppermost part of this interval (3598–3607 m) there are vari-coloured, reddish, greenish dolomites showing character of altered rocks (metasomatosis). They are cavernous and interbedded with red-greenish shale in places. They contain veins of white calcite. Next rock interval down (3642–3692 m) these are pinkish-gray, crystalline, mainly nodular limestones. Matrix is composed of dark clay of euxinic character. The rocks are tectonised and small veins of white or pink calcite are common. These rocks have been recognized in two cores (3645–3654 and 3673–3676 m).

Below (3692–3718 m) there is a limestone bed characterized by positive gamma anomaly (Fig. 3). One core has been obtained there (3695–3703 m). These are compact, detrital limestones greenish-gray with pinkish spots. They contain fine white calcite concentrations. Wavy texture is present in some parts of the column. Moulds and destroyed Orthid shells are to be found. Some parts of the limestone are clayey and sandy. In one of such samples (3697 m) the petrographic study revealed a strongly arenaceous marl with abundant quartz and glauconite grains. The quartz grains up to 0.08 mm in diameter (seldom 0.16–0.18 mm) are subangular as a rule. Flakes of biotite, muscovite and feldspar grains are to be found sporadically. Numerous brownish spots point to enrichment of the rock in phosphatic compounds which is supported by positive gamma anomaly. Similar record is known from the phosphorite occurrence chemically documented in the Lower Ordovician sediments of the Lubasz 2 borehole (Fig. 4).
Clayey-carbonate sediments have been stated in the lowermost part of the column (3718–3733 m). Only one core has been obtained from this interval (3720–3728 m). These are greenish-gray somewhat brownish claystones with cherry red spots and numerous nest-like or nodular, less frequently bedded inliers of brownish-gray limestone. The claystones are limeless or only slightly carbonate, dolomitic in places or arenaceous of siltstone character. Petrographic analysis reveals in silty inliers (depth of ca. 3726 m) a clayey or clayey-carbonate matrix with fine needles of mica minerals (mainly muscovite), detrital quartz, fine semisharp-edged glauconite grains and ore minerals. There are circular and oval postorganic pseudomorphoses infilled with chalcedony or with chalcedony rims. The rock is in places almost completely silicified (sponge spiculae).

Carbonate inliers are irregular of various size usually several centimetres in diameter. They make about 30% of the rock volume. These are grayish-brown compact, crystalline silicified limestones or dolomitic limestones and dolostones frequently making nodular-like nests. These limestones are interwoven by calcite and sporadically pyrite veins 1–3 mm in width. Poorly preserved remnants of Orthid brachiopods were found in the lowermost part of the column. Seldom are inliers of gray quartzitic sandstone, 5–10 cm thick, of slightly dolomitic matrix. Petrographic analysis (3721 m) shows that the rock is silicified limestone (micrite infiltrated by silica mainly chalcedony). Round forms of organic origin are to be seen in thin sections (sponge spiculae).

The conodont studies have been done on 18 samples taken from 5 cores of the Pilzno 40 borehole (3598–3728 m). Positive results were obtained from 13 samples (down to depth of 3699.5 m).

Dissolution of the rock samples in order to separate conodonts have been done using (CH₃CICOOH).

The palaeontological material includes 660 specimens the majority of which was good for identification. Natural taxonomy was used in identification of the conodonts. The specific names of specimens determined according to the rules of parataxonomy are marked with abbreviation s.f. (sensu formae). Aside of conodonts also presence of inarticulate brachiopods, bryozoans, ostracods and gastropods was stated.

The conodonts are well preserved as a rule. The assemblage consists predominantly of forms of single cone and the branching ones. The platform conodonts occur but sporadically and are preserved in fragments.

The carbonate sediments found in the Pilzno 40 borehole at depth of 3598.0–3699.5 m should be determined as Middle Ordovician on the basis of conodonts (Tab. 1). The correlation can be done due to identification of such species as Baltoniodus variabilis (Bergström), Amorphognathus tvaerensis.
### Conodonts in the Ordovician of the Pilzno 40 borehole

<table>
<thead>
<tr>
<th>Core interval [m]</th>
<th>Number of box</th>
<th>Interval in box [cm]</th>
<th>Depth calculated [m]</th>
<th>Number of specimens in sample</th>
<th>Identified conodonts</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>II</td>
<td>45–48</td>
<td>3599.45</td>
<td>0</td>
<td>–</td>
</tr>
<tr>
<td></td>
<td>III</td>
<td>15–20</td>
<td>3600.2</td>
<td>0</td>
<td>–</td>
</tr>
<tr>
<td>3645–3654</td>
<td>I</td>
<td>40–45</td>
<td>3645.4</td>
<td>12</td>
<td><em>Amorphognathus</em> sp., <em>Baltioniodus variabilis</em> (Bergström), <em>Cornuodus longibasis</em> (Lindström), <em>Panderodus gracilis</em> (Branson et Mehl)</td>
</tr>
<tr>
<td></td>
<td>II</td>
<td>30–35</td>
<td>3646.3</td>
<td>15</td>
<td><em>Amorphognathus</em> sp., <em>Baltioniodus variabilis</em> (Bergström), <em>Cornuodus longibasis</em> (Lindström), <em>Drepanoistodus venustus</em> (Stauffer)</td>
</tr>
<tr>
<td></td>
<td>III</td>
<td>–</td>
<td>3647.5</td>
<td>7</td>
<td><em>Baltioniodus variabilis</em> (Bergström), <em>Panderodus gracilis</em> (Branson et Mehl), <em>Roundya</em> sp.</td>
</tr>
<tr>
<td></td>
<td>V</td>
<td>75–80</td>
<td>3649.8</td>
<td>182</td>
<td>–</td>
</tr>
<tr>
<td>3673–3676</td>
<td>I</td>
<td>60–65</td>
<td>3673.6</td>
<td>65</td>
<td><em>Baltioniodus variabilis</em> (Bergström), <em>Scabbariella antiper</em> (Henningsmoen), <em>Panderodus gracilis</em> (Branson et Mehl), <em>Cornuodus longibasis</em> (Lindström)</td>
</tr>
<tr>
<td></td>
<td>II</td>
<td>60–65</td>
<td>3674.6</td>
<td>55</td>
<td>–</td>
</tr>
<tr>
<td>3695–3703</td>
<td>I</td>
<td>30–35</td>
<td>3695.3</td>
<td>57</td>
<td><em>Baltioniodus variabilis</em> (Bergström), <em>Drepanoistodus venustus</em> (Stauffer), <em>Panderodus gracilis</em> (Branson et Mehl)</td>
</tr>
<tr>
<td></td>
<td>II</td>
<td>–</td>
<td>3696.5</td>
<td>25</td>
<td><em>Baltioniodus variabilis</em> (Bergström), <em>Oistodus parvidens</em> Sergeeva s.f., <em>Acodus</em> sp.</td>
</tr>
<tr>
<td></td>
<td>III</td>
<td>55–60</td>
<td>3697.6</td>
<td>160</td>
<td><em>Baltioniodus variabilis</em> (Bergström), <em>Drepanoistodus venustus</em> (Stauffer), <em>Panderodus gracilis</em> (Branson et Mehl), <em>Drepanodus homocurvarus</em> Lindström s.f.</td>
</tr>
<tr>
<td></td>
<td>IV</td>
<td>–</td>
<td>3698.5</td>
<td>10</td>
<td><em>Drepanoistodus venustus</em> (Stauffer), <em>Panderodus gracilis</em> (Branson et Mehl), <em>Acodus</em> sp.</td>
</tr>
<tr>
<td></td>
<td>V</td>
<td>45–50</td>
<td>3699.5</td>
<td>20</td>
<td><em>Oistodus parvidens</em> Sergeeva s.f., <em>Drepanoistodus venustus</em> (Stauffer), <em>Cornuodus longibasis</em> (Lindström)</td>
</tr>
<tr>
<td>3720–3728</td>
<td>I</td>
<td>–</td>
<td>3721.0</td>
<td>0</td>
<td>–</td>
</tr>
<tr>
<td></td>
<td>II</td>
<td>–</td>
<td>3723.0</td>
<td>0</td>
<td>–</td>
</tr>
<tr>
<td></td>
<td>III</td>
<td>–</td>
<td>3725.0</td>
<td>0</td>
<td>–</td>
</tr>
</tbody>
</table>

*Bergström, Eoplacognathus elongatus* (Bergström) and *Panderodus gracilis* (Branson et Mehl) (Pl. I).

The last mentioned species belongs to the most common conodonts in the Old Palaeozoic sediments. Nevertheless, as it appears for the first time above the lower boundary of the Middle Ordovician its presence excludes Lower Ordovician age of the deposits in question.

Majority of the conodonts in this assemblage belong to the conodont elements (= formal species) included to the multi-element species *Baltioniodus variabilis* (Bergström). These
are: Prioniodus variabilis Bergström s.f., P. alatus Hadding s.f., Oistodus robustus Bergström s.f., Paracordylodus lindstroemi Bergström s.f. and Tetraprioniodus asymmetricus Bergström s.f.

Baltoniodus variabilis (Bergström) is a characteristic species in the Llanvirn and Lower Caradoc (S. M. Bergström, 1971; S. M. Bergström et al., 1985). Using the conodont zonation established for the Middle and Upper Ordovician (S. M. Bergström, 1971) the occurrence of Baltoniodus variabilis (Bergström) is associated with the upper part of the anserinus Zone (inaequalis Subzone) and the lower part of the vaeensis Zone (variabilis Subzone — Table 2). This species is particularly common in the Lundibundus Limestone (lowest Caradoc) of Sweden (Tvarnen area) (S. M. Bergström, 1962). It has been described also from the Llanvirn and Lower Caradoc sediments of the British Isles, from the Baltic-Scandinavian region, from Poland and from North America.

In samples from the cores at 3598–3607 and 3645.4–3647.5 m depths (Tab. 1) there were found usually damaged specimens of Amorphognathus Branson et Mehl. This genus is known from the Upper Llanvirn up to Ashgill. Several short-living species have been distinguished within it which are cosmopolitan. They are very useful in precise stratigraphy.

The fragmentarily preserved specimens of Amorphognathus found in samples from depth of 3648.4–3649.8 m belong most probably to the multielement species Amorphognathus vaeensis Bergström. This species is characteristic of conodont assemblages in the Lower Caradoc and is an index taxon for the conodont Zone vaeensis (Tab. 2). It is known from the Caradoc sediments in the Baltic-Scandinavian region, in Poland, in Scotland and in the North America.

Concurrence in the column of the Pilzno 40 borehole at depth of 3645.0–3649.8 m of the species Baltoniodus variabilis (Bergström) and Amorphognathus vaeensis Bergström shows that the sediments containing them should be correlated with the uppermost Llanvirn and Lower Caradoc (S. M. Bergström et al., 1985). At depth of 3649.8 m (Tab. 1) there was found damaged specimens of a platform conodonts. There are most probably Eoplacognathus telongatus (Bergström), the occurrence of which is associated with the Caradoc. In the conodont zonation the stratigraphic range of this taxon (Tab. 2) is confined to the upper part of the inaequalis Subzone as well as Subzones variabilis and in part gerdae (S. M. Bergström et al., 1985). This determination, however, due to bad preservation state is problematic.

Aside of the above mentioned species of conodonts occurring in the carbonate sediments in the Pilzno 40 borehole in the core taken from depth of 3598.0–3699.5 m Cornudodus longibasis (Lindström), Drepanoistodus venustus (Stauffer), Dapsilodus mutatus (Branson et Mehl), Scabbdardella antipes (Henningsmoen), Strachanognathus parvus Rhodes and Oistodus parvidentatus Sergeeva s.f. (Tab. 1) were found. The last mentioned species is known in the Baltic-Scandinavian region from the Upper Arenig (Upper Volkhov) up to the Lower Caradoc (Idavere Stage). The species Cornudodus longibasis (Lindström), Drepanoistodus venustus (Stauffer) and Strachanognathus parvus Rhodes are known from the Arenig up to Ashgill, whereas the occurrence of Dapsilodus mutatus (Branson et Mehl) is associated with Middle and Upper Ordovician.

Ostracods were also found in the column studied. Aside of abundant but indeterminable smoothshelled forms there are representatives of genera Sigmobolbitina Henningsmoen, Ctenonotella Opik and Klimphores Schallreuter. The occurrence of Sigmobolbitina is associated with deposition of the Middle and Upper Ordovician. Specimens of those ostracods were found at depth of 3696.5 m. They are strongly damaged, nevertheless, similar to Sigmobolbitina camerata Janusson, described from the Caradoc Chasmops Limestone of Norway. In Lithuania they occur in sediments of Upper Caradoc and Ashgill (Rakvere-Vormsi Stages). Also in Latvia their presence is associated with the Upper Caradoc and Ashgill. They appear there slightly earlier in sediments correlated with the Estonian Keila Stage.

The Ctenonotella Opik genus is known so far from the Middle Ordovician only. It was found here in the core from depth of 3695–3703 m. The specimen is slightly damaged but it is possible to classify it to the Ctenonotella superba Sarv a species common in the Upper Caradoc in Estonia and Lithuania. The Middle Ordovician age of sediments seems to be supported by a find of ostracods of the species Klimphores holdreensis Gailite (3645–3654 m). This species has been described from the uppermost Caradoc and Lower Ashgill (Wormsi—lower part of Pirgu Stages) of Lithuania (N. Sidda-
COMPARISON OF THE ORDOVICIAN DEPOSITS FROM BOREHOLES IN THE CENTRAL PART OF THE CARPATHIAN FORELAND

In the central part of the Carpathian Foreland the Ordovician strata have been encountered so far in 7 boreholes (Figs. 1B and 4).

The oldest deposits of this system are known from the Lubasz 2 borehole. In the lower part (1900–1931 m) (Fig. 4) there are sandstones with glauconite, greenish-gray and conglomerates containing pebbles of quartzite, sandstone and claystone with phosphorite concretions. Remnants of fossils determined as *Linguilla* sp., *Acroreta* sp. and "*Obolus*" sp. were found there. On the basis of lithology and the above mentioned fossil remains one may suppose that these sediments belong to Early Ordovician. In the opinion of H. Tomczyk (oral communication) they may represent the Upper Tremadoc *Thysanotos silicarius* Zone. Even in the case they would be younger than Tremadoc, in the light of geophysical logs they should be older than the Upper Arenig sandstone found in the Mędzchów 1 and Niwiki 3 boreholes (Fig. 4).

In the Mędzchów 1 borehole the Ordovician sediments have been long recognized (P. Karnkowski, E. Glowacki, 1961; H. Tomczyk, 1963). These are mainly sandstones, with glauconite, in the upper part also limestones. H. Tomczyk (op. cit.) has determined their age as Upper Arenig. Analogous rocks pierced in the Niwiki 3 borehole (W. Moryc, 1974) are most probably of similar age. Thus it seems reasonable to correlate the Ordovician deposits from the Mędzchów 1 and Niwiki 3 boreholes with the sandstone of the Lubasz 2 borehole marked on geophysical logs, the upper boundary of which i.e. the top of the Arenig lies at depth of 1832 m.

This boundary according to geophysical logs should correspond to sandstone (Fig. 4) the top of which has been pierced in the Zalesie 1 borehole at depth of 1865 m. Above that boundary in both boreholes there occur clayey-arenaceous sediments at bottom and higher up — argillaceous ones. Graptolites were found in the upper part of this complex pointing to Lower Arenig and in the lower part — of the Arenig-Llanvirn boundary (most probable Llanvirn) (S. Kwiatkowski et al., 1966).

A strong positive anomaly in the gamma logs is to be observed in both boreholes Zalesie 1 and Lubasz 2 in the lower part of the clayey complex. It may point to rocks rich in phosphatic compounds similar to those ones described above from older members of Middle Ordovician in the Pilzno 40 borehole (Fig. 3). These facts suggest that also in the boreholes Lubasz 2 and Zalesie 1 the clayey complex maybe of Middle Ordovician age as well (Lower Caradoc-Llandeilo or possibly Llanvirn).

Similar profile of probable Ordovician age is recognized in the Zgórsko 2 borehole (Fig. 4). No core was obtained there (traces of shale in the upper part) but similarity of geophysical logs to the Zalesie 1 and Lubasz 2 boreholes allows to put a boundary at depth about 1890 m between sandstone of probable Lower Ordovician age and the clayey complex of presumably Middle Ordovician age.

Clayey sediments of probable Lower Caradoc age are younger members in the area in question. Those are, however, not the youngest ones of the Ordovician as in the Strozyska 5 borehole (Figs. 1B and 4) where under the Ludlow graptolite shales, crystalline and marly limestones were stated the age of which is probably Upper Ashgill (W. Bednarczyk et al., 1968). These sediments were not pierced to the bottom thus their relation to the older Upper Ordovician members is unknown. Carbonate sediments of Upper and Middle Caradoc age are known from the Pilzno 40 borehole. Clayey facies of that age is known from the Lubasz 2 and Zalesie 1 boreholes and from the drillings located further east in the area of Sędziszów–Rzeszów (W. Moryc, 1992, 1996).

In the light of the so far known data a distinct facies differentiation is to be observed in this area.

In the Lower Ordovician in the Lubasz–Mędzchów–Niwiki zone an arenaceous facies prevails which further east in the Nosówka area — according to geophysical logs — passes to more clayey facies. This is proved by the results of the Dobromil Strzelbice 33 borehole in the Ukraine (D. M. Drygant, L. T. Boychevskaia, 1984) in which clayey facies of the Arenig documented by graptolites and conodonts occurs.

Greater facies differentiation is marked in the Middle Ordovician. In the northern part of the area within the zone Lubasz–Zalesie and Będżienyśl 3–Podgórze 1–Nosówka–Kielanówka the Middle Ordovician (Caradoc-Llandeilo-Llanvirn) is developed in clayey facies with graptolites (very rare marly limestone inliers). In the south almost entirely carbonates occur as it is shown by Pilzno 40 borehole. The limestones of Upper Ashgill in the Strozyska 5 borehole can be possibly a continuation of that facies as it is the case farther north-west in the area of the Malopolska Massif near Zawiercie, Mrzygłód and Myszków. The carbonate Ordovician sequence there embraces also deposits of Early Ordovician (K. 

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raviczene, 1992), Ashgill of Belarus and Upper Caradoc (Oandu-Rakvere Stages) of northeastern Poland. The so far known stratigraphic range of the genus *Klimphores* Schallreuter is restricted to the Middle and Upper Ordovician.

Summing up it should be said that the deposits pierced in the Pilzno 40 borehole (3598–3703 m) maybe classified on the basis of conodont and ostracod fauna to the Middle Ordovician: Lower Caradoc and Llandeilo. Exact boundaries of this interval determined on the basis of logs of geophysical measurements correspond to depth of 3593–3718 m (Fig. 3). The underlying clayey-carbonate sediments (3718–3733 m) do not contain fossils hence its age cannot be determined. Similar lithology and presence of substance of organic origin suggest their Ordovician age. On that basis these sediments have been classified to Llandeilo as well, although it is not out of question that they may represent Llanvirn, or they may be older.
The results obtained so far allow to present a preliminary geological sketch and presumable distribution of the Ordovician deposits in the Carpathian Foreland. The Ordovician strata are preserved in two zones (Fig. 1B) — in the northern part in a zone Strožyska 5, Zalesie 1 and probably Zgórsko 2 boreholes and in the central part from Niwki 3 up to Pilzno 40. Farther east they continue south of Dębica, Sędziszów and Rzeszów (W. Moryc, 1992, 1996). Those are relic occurrences that escaped pre-Silurian and later erosion. Primarily they made presumably more or less continuous cover — though not thick — in the whole area of the Małopolska Massif and the adjacent areas in the Miechów Basin as well as the neighbouring in the north and east areas of the Polish Lowlands.

The present-day distribution of the Ordovician deposits is limited to synclinal zones that were formed most probably during the Taconian phase and then established by later Late Caledonian and Bretonian phases. Lack of Ordovician deposits in the Czarna–Pilzno 3 borehole is remarkable. In the light of their presence at Pilzno 40 and Niwki 3 it should not be a result of primary absence but maybe caused by pre-Silurian erosion. The erosion of that time is well marked in the whole area as various Ordovician levels are present under the Silurian deposits. This is well illustrated by such boreholes as Miedzychów 1 and Niwki 3 in which Caradoc sediments are to be found under the Silurian. The erosion of that time is well marked in the whole area as various Ordovician levels are present under the Silurian deposits. This is well illustrated by such boreholes as Miedzychów 1 and Niwki 3 in which Caradoc sediments are to be found under the Silurian. At Strožyska 5 Upper Ashgill occurs under the Silurian.

The Ordovician fields shown on Figure 1B are limited by boreholes that have reached Precambrian rocks. Cambrian sediments do not occur in the area.

The synclinal fields of the Ordovician are limited by the Lower Ordovician arenaceous sediments (Tremadoc?–Arenig). The axial parts are infilled with Caradoc sediments and at Strožyska 5 — of the Upper Ashgill.

Similar overlapping character of the Ordovician deposits is marked near Lubaczów (H. Tomczyk, op. cit.) as well as in the Miechów Basin as it comes from analysis of the Jarono–Zalesie 1, Zgórsko 2 boreholes (H. Jurkiewicz, 1975). These facts point to greater uplift of the southern part of the Małopolska Massif prior to the Ordovician which retarded the Ordovician transgression.

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**REFERENCES**


Opisano rozwój litologiczny utworów środkowego ordowiku z otworu Pilzno 40 i określono ich wiek na podstawie kordonów. Osady te skorelowano z utworami ordowikowymi z innych otworów ze środkowo-południowej części przedgórza Karpat, a także omówiono stosunek tych utworów do ograniczających je osadów sylurskich i prefektyrzkich. Otwór Pilzno 40, odwiercony przez Polskie Górnictwo Naftowe i Gazownictwo - Poszukiwania Nafty i Gazu, Kraków, jest usytuowany w strefie granicznej między Między Pilznem a Buskiem na przedgórzu Karpat.

Osady ordowiku stwierdzono w tym otworze w grubości do 3733 m. W intervalu tych występują utwory węglanowe, wśród których wyróżniono następujące komponenty sk卡尔ne (ogólne):

- 3362-3642 m — osady węglanowe o zbliżonej charakterystyce geoizy-

- 3692-3718 m — wapienie zwięzłe, szorostkie, detrywityczne, szarzowane,
niektóre z tzw. rzątków ordowikowych.

Osady węglane napolitowe w otworze Pilzno 40 na głęb. 3598-3699.5 m na podstawie analizy biostratygraficznej kordonów zostały zaliczone do środkowego ordowiku (tab. 1). Do przeprowadzenia korelacji uprawomocnił zidentyfikowanie gatunków: Baltoniodus variabilis (Bergrstrem, Amorphognathus tvarrensi Bergrstrem, Eqpalacognathus Telen-gatur (Bergrstrem) i Panderodus gracilis (Brasson et Mehl). Współwystępujące w profilu tego otworu na głęb. 3645-3654 m Baltoniodus variabilis (Bergrstrem) i Amorphognathus tvarrensi Bergrstrem wskazuje, iż zawiera- 
jące osady węglane były skorelowane z najwyższym llandeilem-dolnym karadokiem.

W środkowej części przedgórza Karpat, między Pilznom a Buskiem utwory ordowickie stwierdzono dotychczas w 7 otworach wiertniczych (fig. 1, 4). W rejonie tym w ordowiku zarysowuje się dość wyraźne zróżnicowanie fasjalne. W dolnym ordowiku w strefie Lubusza-Młodziceńcza - Niwek do-

Dolne Karpaty


dominują piaskowce, które w Niz Polski najprawdopodobniej są płytki lodowej zrównane z wietrznańcem w wątro poprzez wiatrzyczną działalność. Osady węglane obejmujące cały Kwart- sza i jego zarysowanie w dolnym ordowiku w rejonie Nisz. Osady węglane obejmujące cały Kwart- sza i jego zarysowanie w dolnym ordowiku w rejonie Nisz. Osady węglane obejmujące cały Kwart- sza i jego zarysowanie w dolnym ordowiku w rejonie Nisz.

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EXPLANATIONS OF PLATES

PLATE I

Fig. 1. Baltaniadus variabilis (Bergström)
a, b — ambalodontiform elements, depth 3696.5—3697.6; c — amorphognathiform element, depth 3646.3 m; d — amorphognathiform element, depth 3649.8 m; e — paracordylodontiform element, depth 3696.5 m; f — tetrapriodontodontiform element, depth 3697.6 m; g — oistodontiform element, depth 3697.6 m.

Fig. 2. Scabbardella antipes (Henningsmoen)
Depth 3673.6 m

Fig. 3. Panderedus gracilis (Branson et Mehl)
Depth 3598.5 m

Fig. 4. Cornuodus longibasis (Lindström)
Depth 3699.5 m

Fig. 5. Dapsilodus mutatus (Branson et Mehl)
Depth 3598.5 m

Figs. 6, 7. Amorphognathus vaerensis Bergström
Amorphognathiform elements, damaged specimen; Fig. 6 — depth 3648.4 m, Fig. 7 — depth 3649.8 m

Fig. 8. Eoplacognathus sp.
The specimen damaged, depth 3649.8 m

Figs. 9, 10. Eoplacognathus Telongatus (Bergström)
Fig. 9 — depth 3649.8 m; Fig. 10: a — ambalodontiform element, b — amorphognathiform element, depth 3649.0 m

All the conodonts are of Middle Ordovician age and were found in the Pilzno 40 borehole; x 180
Władysław MORYC, Maria NEHRING-LEFELD — Ordovician between Pilzno and Busko in the Carpathian Foreland (Southern Poland)