

SUMMARY

The Wrotnów IG 1 borehole, like the Tłuszcz IG 1 marker borehole and the Wyszaków IG 1, Łochów IG 1 and Łochów IG 2 boreholes, was drilled in the 1960s and early 1970s in the Podlasie Depression of the marginal zone of the East European craton within a contact zone with the Mazury Elevation.

The goal of the drilling was to explore the geological structure in the north-central part of the Podlasie Depression and to provide data on the geological structure of the south Mazury–Suwałki Elevation, especially the Lower Palaeozoic (Ordovician and Cambrian), in terms of prospecting for bitumen. Another goal was to explore the top of the crystalline basement and to provide comparative geological material for interpretation of geophysical investigations.

This publication contains both early results of investigations performed in the borehole and the newest lithological, stratigraphical, petrographical, structural and geochemical studies conducted based on modern research methods. The stratigraphy was established according to the Polish stratigraphic standards and current recommendations of the International Commission on Stratigraphy.

The oldest rock formation drilled in the Wrotnów IG 1 borehole (depth 2026.1 to 2063.0 m) is the Proterozoic metamorphic series. Detailed chemical and microscopic investigations show that the rocks represent a monotonous series of oriented amphibole gneisses. Originally, they probably represented a set of distinctly layered mudstones or sandstones interbedded with claystones.

The inferred metasomatic origin due to alteration of sedimentary rocks into hornblende gneisses and amphibolites is in a discrepancy with structural and microstructural data documenting the very varied ductile shear processes. The processes led to, among others, mylonitic foliation described as lamination of metamorphic rocks, inherited after the sedimentary protolith.

Due to the lack of reliable radiometric datings, it is difficult to determine an accurate age of deformation of the crystalline rocks. It can be conventionally accepted that the deformation took place during the Gothian epoch. The crystalline rocks drilled in the Wrotnów IG 1 borehole may be a fragment of a tectonically dismembered ophiolitic sequence formed under conditions of transpressional regime with a sinistral component and dominant thrusting towards the SW.

Cambrian deposits were encountered at a depth of 1608.7 to 2026.1 m (according to the drill core) (thickness 417.4 m). This interval was poorly cored. Lower Cambrian deposits are represented mostly by fine-grained sandstones. The lowermost part of the section contains coarse-grained and vari-grained sandstone interbeds. Claystones and mudstones

are subsidiary rocks in the Lower Cambrian lithological spectrum. Trace fossils are common in the claystone-mudstone-sandstone series. Middle Cambrian deposits are represented in cored intervals mainly by poorly compact fine-grained sandstones.

The Cambrian deposits are poorly biostratigraphically documented. Trilobite and brachiopod fossils are rare and observed only at the top of the Lower Cambrian succession. In this part of the section, trilobites indicate the presence of the undivided *Holmia* + *Protolenus* zones according to K. Lenzion, or they correspond to the *Holmia kjerulfi* and *Protolenus* Zone distinguished by M. Moczyłowska. The last biostratigraphic unit mentioned results from correlation of stratigraphic ranges of acritarch associations which occur in the last-mentioned trilobite zones, with their equivalents from South Sweden. The lowermost Lower Cambrian contains fairly frequent *Yanishvskyites* annelids and *Platysolenites* individuals. The latter may belong to annelids or foraminifers, and indicate the presence of the *Platysolenites* Zone according to K. Lenzion or of the *Platysolenites antiquissimus* Zone according to M. Moczyłowska.

The Middle Cambrian deposits of the Wrotnów IG 1 borehole have not been dated biostratigraphically. A correlation with the closest wells of Tłuszcz IG 1, Łochów IG 1 and Łochów IG 2 can indicate the probable presence of the lowermost biostratigraphic zone of the Middle Cambrian – *Acadaparadoxides oelandicus*.

Ordovician deposits of the Wrotnów IG 1 borehole were fully cored at a depth of 1579.5–1608.7 m (1577.0–1605.5 m wireline log depth). The section falls within the western part of the so-called Lithuanian confacies corresponding to the outer parts of the Ordovician basin. The confacies is conspicuous by the presence of carbonate-marly deposits. However, the section is characterized by a specific development and differs from other Ordovician sections of the Podlasie region.

A strong reduction in thickness and predominance of carbonates over marly-clay facies (carbonate index is approximately 50) are observed here. Such lithologies are due to the location of the section within a positive palaeotectonic element – the so-called Sokołów Podlaski Elevation, separating two negative tectonic elements in the Ordovician structural pattern: the Brest Depression and Warsaw Depression.

The characterization of the Ordovician system shows a correlation of standard chronostratigraphic units, local (British and Baltic) stages with graptolite and conodont zonation.

Petrographical investigations of Ordovician rocks revealed the presence of sandstone, glauconitic, carbonate and

carbonate-clayey lithofacies characterized by K. Lendzion. Petrographical studies show that the Cambrian rocks are represented by a siliciclastic association typical of epicontinental marine deposits in the Polish part of the East European craton.

Silurian deposits occur at a depth of 1316.0 to 1577.0 m (wireline log depth) reaching 261.0 m in thickness. The Silurian section is typical of the area along the Precambrian Platform slope. Fine-grained sediments are predominant: claystones and minor mudstones. The strata lie horizontally or dip at very low angles. The main fossils being the basis for the orthostratigraphic subdivision are graptolites. The global standard scheme was used for the stratigraphic subdivision of the Silurian deposits in the borehole. It differs from the previously applied stratigraphic scheme presented in the borehole documentation. The range of modifications includes rejection of the local stratigraphic units introduced by H. & E. Tomczyk, of undefined stratigraphic character, such as the Podlasie, Siedlce, Mielnik and Pasłek beds, as well as changes in the position of some stages.

Instead, international standard units have been introduced: Llandovery, Wenlock and Ludlow. The boundaries with Ordovician and Permian are erosional.

The Permian is represented by the Rotliegend and Zechstein. The Upper Rotliegend is 20.0 m thick. It is part of the topmost portion of the Parsęta Formation, as indicated by anhydritic impregnation and sulphide mineralization.

The Rotliegend is overlain by Zechstein deposits represented by all the Zechstein cyclothems. The section is typical of the Precambrian Platform. The carbonate-evaporitic cyclothems are reduced in terms of both stratigraphy and thickness. They are characterized by predominance of carbonates containing terrigenous series. The topmost Zechstein rocks are represented by sandstones and mudstones. These deposits may represent a continental series of the uppermost Zechstein. The Zechstein/Lower Buntsandstein boundary coincides with a new transgressive stage of the basin evolution.

The Triassic stratigraphy in the Wrotnów IG 1 borehole is based on archival data and correlation with the Wyszaków IG 1, Tuszcz IG 1, Łochów IG 1 and Łochów IG 2 boreholes. Only a 3.1 m long drill core was acquired from the Triassic section (281.5 m in thickness). The interpretation of the section is based on the wireline logs and drill cuttings analysis. The section was reconstructed from the lithostratigraphic units typical of the Triassic from the Central European basin. Their ages have not been determined in this borehole. The presumed age of the deposits was inferred based on data from other parts of the Polish Lowland basin and Central European basin.

The Jurassic section includes the Lower Jurassic, upper Middle Jurassic (Bathonian–Callovian) and lower Upper Jurassic (Oxfordian).

It is possible that no Rhaetian deposits are observed in this area, like elsewhere in the western Podlasie region. There are a number of stratigraphic gaps within the Jurassic succession. The major ones indicate the lack of much of Hettangian, Sinemurian and Pliensbachian, and the total lack of Aalenian through (?) Late Bajocian deposits. It is possible that stratigraphic gaps are present also within the Bathonian succession. The Oxfordian limestones are overlain by Albian glauconitic sandstones. In this case the gap spans the Kimmeridgian through late Early Cretaceous.

The Cretaceous succession is relatively thin (432.5 m, of which the Upper Cretaceous (Cenomanian–Maastrichtian) accounts for 427.5 m). The Lower Cretaceous overlies the Oxfordian succession and is represented by a very thin series of Middle–Upper Albian quartz-glauconitic sandstones deposited in a shallow siliciclastic shelf. The rocks mark the onset of the prominent Late Cretaceous transgressive cycle.

The Upper Cretaceous sequence is composed mostly of a relatively monotonous series of carbonates deposited in an open marine shelf with calm sedimentation in an epicontinental basin of low and relatively constant sedimentation rate. The original interpretation of the section assumed the presence of Lower Paleocene deposits at the top of the sequence. However, newer data from a number of boreholes drilled in this area and better recognition of the regional geology suggest that there are no rocks of this age in the Wrotnów IG 1 borehole.

Wireline logging was made down to a depth of 2055.0 m allowing for identification of lithologies, determination of thicknesses of individual stratigraphic units in non-cored intervals, verification of the stratigraphy, determination of thermal regime in the well, reservoir potential assessment and correlation of stratigraphic horizons to nearby boreholes.

The Mesozoic deposits strongly wedge out eastwards. Thickness variations between individual Mesozoic series are considerable. The variations in the Palaeozoic succession are smaller. Individual rock complexes are elevated by a few hundred metres while moving to the east. Interpretation of wireline logs shows no oil and gas occurrences.

Drill stem tests proved that the Cambrian reservoir horizons are characterized by “good” properties for hydrocarbon accumulation. No bitumen shows were observed during testing, however the occurrence conditions and hydrochemical parameters of brines indicate the possibility of bitumen occurrences in the Cambrian rocks. The highly metamorphosed Cambrian brines, capped by Ordovician and Silurian deposits, create favourable conditions for such occurrences. The values of the hydrochemical index $rNa:rCl$ vary from 0.50 to 0.65 indicating a total and long-term isolation from infiltration waters. The values of the hydrochemical indices $Cl:Br$ (107) and $(rSO_4 \times 100):rCl$ (0.45) measured for the Lower Cambrian brine from a depth of 2001.0–2043.7 m may additionally suggest close crude oil accumulations.