

## SUMMARY

The Stadniki IG 1 borehole, like the Tłuszcz IG 1, Wrotnów IG 1, Wyszków IG 1, Łochów IG 1 and Łochów IG 2 boreholes drilled in the 1960s and early 1970s, is situated 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 of the Podlasie region, provide data on the geological structure, stratigraphy and lithology, reach the crystalline basement, and to acquire information to assess reservoir properties of lower Paleozoic rocks. An essential task of the drilling was to provide data on the facies development and the extent of lowermost Ordovician (Tremadoc) and lowermost Cambrian deposits and to get a marker section for interpretation of geophysical surveys. The final depth of the drilling was 1560.5 m (Proterozoic crystalline rocks – gneisses); borehole geophysical measurements were made to the same depth. The total of 266.5 m of drill core was acquired, that accounts for 17.0% of the total borehole section.

The core material obtained from the Stadniki IG 1 borehole provided many geological data, which became the basis of numerous studies. The present publication provides information and research results from the well's report (*"Dokumentacja wyników otworu badawczego (strukturalno-parametrycznego) Stadniki IG 1"* 1973), and, first of all, presents results of new lithological, lithofacies, stratigraphical, petrographical, sedimentological, and structural investigations conducted based on modern research methods.

A full set of hydrological and geophysical tests was made in the borehole, being the basis for developing a comprehensive and substantive report. Subsidence and sedimentation rate analyses were also made for the Paleozoic and Mesozoic succession. Data from the Stadniki IG 1 borehole were used in the analysis of sedimentary basin at different stages of geological evolution in the Podlasie region.

Proterozoic rocks represent a structurally diverse orthogneisses and rare thin interlayers (?schlieren) of biotitic schists. The formation of orthogneisses was associated with the development of heterogeneous ductile shear zones under the conditions of non-coaxial rotational deformation. Development of penetrative ductile shear zones, leading to the development of various types of mylonitic rocks, probably took place during the Svekofennian or Polish-Danish orogenesis in Mesoproterozoic (?Calymmian) times. Different

thrust to transpressional displacements along heterogeneous shear zones led to the creation of complex structures with the characteristics of tectonic slices.

The sedimentary cover in the Stadniki IG 1 borehole starts by Lower Cambrian deposits. According to the new studies, the sandstones that were previously considered Ediacaran, represent Lower Cambrian marine deposits.

In Cambrian times, the area under investigation was located in the central part of the Podlasie zone of the Lublin-Podlasie sedimentary basin, included in a system of late Neoproterozoic-early Paleozoic sedimentary basins stretching along the western edge of Baltica. Cambrian deposits occur at a depth of 1182.5–1532.0 m (logger's depth), attaining a thickness of 349.5 m. The top of the Cambrian section lies at a depth of 1193.4 m (driller's depth). The range of the Lower Cambrian deposits interpreted from geophysical measurements in the correlation with the Wrotnów IG 1, IG Łochów 1 and Łochów 2 sections is not confident. In the new chronostratigraphic scheme of the Cambrian, the Lower Cambrian roughly corresponds to the Terreneuvian and Series 2.

The Middle Cambrian (~Series 3) deposits have not been proved by biostratigraphic evidence. No trilobites were found in the Lower and Middle Cambrian. The likely presence of the lowest biostratigraphic zone of the Middle Cambrian in this section may be suggested by a correlation with the Tłuszcz IG1, Łochów IG 1 and Łochów IG 2 boreholes.

Recent petrographic investigations showed that the Middle Cambrian sandstones are more texturally and mineralogically mature than the Lower Cambrian arenites.

Ordovician deposits, separated from the underlying and overlying formations by erosional surfaces, were pierced with continuous coring. There is a significant difference here in the logger's depth relative to the driller's depth – approximately 11 m. The Ordovician section was found at a depth of 1126.3–1193.4 m (driller's depth) reaching a thickness of 67.1 m. The Stadniki IG 1 borehole is situated in the western part of the Lithuanian facies zone, corresponding to a shallow-neritic zone of the Baltic paleobasin in the Ordovician, and is distinguished by the presence of limestone-marl deposits.

The global stages from Tremadocian to Katian have been established in the investigated section. The traditional British scheme (from lower Tremadoc through lower Ashgill) was

used also in establishing the stratigraphy. Ordovician deposits contain abundant trilobite and nautiloid fauna. Llanvirn and lower Caradoc deposits contain cystoids. Rare graptolites were found in the uppermost Caradoc. Petrographic studies of the Ordovician deposits indicate the occurrence of sandstone, glauconitic, clay and carbonate-marly, and pyroclastic lithofacies.

Frequent scour surfaces and intraformational clasts and pebbles at the top of the glauconitic series and overlying carbonate deposits suggest discontinuous sedimentation and denudation events in the Ordovician in this part of the Podlasie Depression.

Silurian deposits occur at a depth of 845.5–1126.3 m (driller's depth), reaching 280.8 m in thickness. Few drill cores have been acquired from this section: 58.6 m, i.e. 21% of the total thickness. Stratigraphical reinterpretation of the section indicates that its lowest part can be represented by ?Llandovery or ?Wenlock deposits. Llandovery age of these deposits has not been proved by paleontological evidence, and the stratigraphic position of the deposits may be established based on lithological correlation with the sections from the Brest region of the Podlasie depression (Belarus).

The Silurian section is typical of the marginal part of the Precambrian Platform. The predominant lithology is horizontally lying claystones and, to a lesser extent, siltstones with infrequent carbonate interbeds. The orthostratigraphy is based on graptolites that are the dominant fauna. In addition to the standard global stratigraphic scheme of the Silurian, used in the present study, the regional, informal division presented in the final borehole report also given.

The Silurian section includes the ?Llandovery, Wenlock and Ludlow. The Wenlock/Ludlow boundary is drawn in the drill core at the first occurrence of the *Neodiversograptus nilsoni* (Lapworth) graptolite, an indicator of the oldest graptolite zone in the Ludlow. In the absence of drill core, the Ludlow and Wenlock remain undivided. The boundaries with the Ordovician and Permian (Rotliegend) are erosional.

Permian deposits are represented by the Rotliegend and Zechstein. The borehole was located in the north-eastern part of the Rotliegend basin known as the Podlasie Basin. The Rotliegend deposits are composed of conglomerate-sandstone cycles, typical of riverbed sediments, and lie with a large sedimentary and stratigraphic gap upon Ordovician, Silurian or Cambrian rocks. The upper boundary with the Triassic (Buntsandstein) is also erosional. The deposits were included in the uppermost Rotliegend, i.e. the Noteć diastrophic-sedimentary megacycle. In the East European Craton they are referred to as the Pasłęka Formation.

Zechstein deposits from the Stadniki IG1 borehole, which was paleogeographically located in the north-eastern area of the Podlasie Embayment, overlie Rotliegend rocks in its peripheral part. The section is highly reduced in terms of both stratigraphy and thickness. The Zechstein section is typical of a coastal part of the Zechstein basin in the Precambrian Platform and is represented by carbonates with terrigenous series (?PZ1, PZ2 and ?Zt). The topmost portion of the Zechstein is represented by sandstones and siltstones that can represent

continental deposits. The lower boundary with the Rotliegend was conventionally drawn at the base of the sandy complex containing in its lowest part coarse-grained arkosic conglomeratic sandstones, with quartz and feldspar pebbles.

Microfacies analysis of the Zechstein carbonates (Zechstein Limestone and Main Dolomite) shows that the Zechstein Limestone represents probably a regressive succession. Marly dolomites are overlain by grainy, porous ooid - oncoidal packstones /grainstones/ deposited in a near-shore marine environment in a high hydrodynamic regime and normal salinity sea water. The Main Dolomite carbonates may have been deposited in a quiet environment (?lagoon) with a substantial contribution of organic matter (algae and cyanobacteria). Shelly wackestone/packstone deposition occurred within a shallow lagoon or in a near-shore zone at the margin of clastic sedimentation areas.

The Lower and probable Middle Triassic was found at a depth of 631.5–778.5 m and attains a thickness of 147.0 m.

The total drill core length of 10.2 m was acquired from the Triassic section and the stratigraphy is established based on wireline logs in correlation with the Wyszaków IG 1, Tuszcz IG 1, Łochów IG 1 and Łochów IG 2 boreholes.

Buntsandstein sedimentation occurred in this region in the eastern, peripheral part of the Central European Basin (including the basin of the Polish Lowlands), within the so-called Podlasie Embayment. The presumed Muschelkalk deposits are represented by alternating carbonates and fine-grained clastic rocks. Due to lack of drill core, the age of the complex is uncertain.

The Jurassic section includes the Middle Jurassic (Bathonian–Callovian) and lower Upper Jurassic (Oxfordian) deposits, lying between two distinct discontinuity surfaces. A number of stratigraphic gaps are observed within the Jurassic section. The most important gaps are the absence of the Lower Jurassic and the lower part of the Middle Jurassic, and the complete absence of the uppermost Upper Jurassic. The Oxfordian limestones are overlain by ?Albian glauconitic sands, so in this case the stratigraphic gap spans the interval from the Kimmeridgian to the decline of the Early Cretaceous.

The Cretaceous section is typical of this region. The stratigraphy and lithology in this poorly cored succession were established from wireline logs and correlation with the other boreholes, so the boundaries between individual stages are uncertain. Lower Cretaceous quartz-glauconitic sandstones of a shallow siliciclastic shelf (?middle and upper Albian), 16.0 m thick, overlie the Upper Oxfordian with a significant stratigraphic gap. The Upper Cretaceous sequence is composed mainly of a monotonous series of open-marine epicontinental carbonates. The whole Cretaceous section indicates a calm sedimentation in a marine sedimentary basin of low and relatively constant subsidence rate.

Detailed regional studies suggest lack of lower Paleogene deposits. Maastrichtian rocks are overlain by a 113-m thick series of ?Oligocene–?Miocene clayey sands interbedded with clays. The Quaternary series is represented by 74.5 m-thick sediments.

Subsidence analysis shows that the main burial phases were during the Early and Middle Cambrian, late Silurian, late Permian-early Triassic, late Jurassic and late Cretaceous-Cenozoic. The most important phases of uplift and erosion occurred in this area in the Early Carboniferous and Late Carboniferous-early Permian. Tectonic subsidence curve for the Stadniki IG 1 borehole illustrates several stages in the evolution of the region.

Well logging was performed to a depth of 1560.5 m. The entire drillhole section is covered by a full set of wireline logs performed using a standard analogue equipment. After reaching the final depth, additional unifying radiometric measurements were made. Geophysical surveys have been completed measuring the temperature in near-stable conditions.

Formation tests were performed to examine the possibility of hydrocarbon accumulation. The Cambrian horizons have very good reservoir properties. The Cambrian sandstones are highly permeable. Despite very good reservoir properties of the horizons, the possibility of hydrocarbon accumulation has been considered negative. The existence of the Ordovician and Silurian seal does not prevent from water exchange from the basin margin towards its central part. The effect of low-mineralized water migration is better accentuated in the basal parts of the Cambrian deposits than in their upper parts. Hydrogeological tests of reservoir horizons showed no signs of bitumens.