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SUMMARY

For over thirty years after the Busówno IG 1 borehole was completed, the drill core material has been subject to a wide range of research which included direct observations of the core and rock samples. These were sedimentological, ichnological, stratigraphical, paleontological and tectonic studies. The other research group included analytical investigations, mainly geochemical, petrographical and petrophysical. A full set of hydrogeological tests and geophysical logs were also run in the borehole.

The drilling was stopped at the depth of 4154.5 m in the Neoproterozoic Polesie Formation (not drilled). The age of continental and marginal-marine sandstones of this formation is unknown. Lithology of the Polesie Formation made it impossible to perform isotopic dating due to lack of stratigraphic indicators. It is most probable that the formation is of ?Lower or Middle Neoproterozoic age.

Deposition of the Polesie Formation may have been associated with the first stage of rifting in the Baltica continent during the breakdown of the Rodinia/Pannotia supercontinent around 800–700 Ma ago.

The Polesie Formation is overlain by the full sequence of Ediacaran rocks (depth 3580.0–4082.0 m) whose lithologies are typical of the East European Craton. A wide range of modern sedimentological, biostratigraphical and tectonic investigations of clastic rocks, and geochemical studies of volcanic rocks, performed in the Busówno IG 1 borehole and some other boreholes, provided detailed data on the evolution of the Lublin Basin during the Late Ediacaran.

The lower part of the Ediacaran succession is composed of volcanic rocks. These are mostly melaphyre and aphanitic basalts. Volcaniclastic rocks are dominated by agglomerates. Tuffs are rare. The volcanic complex is overlain by the Ediacaran siliciclastic, continental, coarse-grained sediments of braid rivers representing the Siemiatycze Formation, as well as by brackish deposits of the Lublin and Włodawa formations. The last-mentioned sediments were deposited in an environment of transgressing tidal flats.

The Ediacaran deposits of the Busówno IG 1 section are associated with a successively developing depocentres of a rifting phase of the Lublin–Podlasie Basin, during the final stage of the Rodinia/Pannotia breakdown.

As a result of biostratigraphic investigations conducted on the Busówno IG 1 section over the last 15 years, one biostratigraphic zone of *Sabellidites–Vendotaenia* was identified within the upper part of the Ediacaran sequence, and a new position of the Ediacaran/Cambrian boundary was established.

This position is in line with the standard approved by the International Commission on Stratigraphy. The Ediacaran deposits represent the lower part of the 2nd order depositional sequence developed mainly during a rapid relative sea-level rise stimulated by tectonic factors.

The Cambrian deposits (611.8 m thick) were encountered at the depth of 2968.2–3580.3 m. They are represented largely by alternating sandstones and mudstones deposited in a shallow, open-marine basin within the shoreface and offshore zones. This environment was dominated by strong waves with minimum influence of tides. The Cambrian deposits of the Busówno IG 1 borehole are represented by quartz arenite sandstones which underwent moderate diagenetic alterations. The rocks are texturally and mineralogically mature. The Cambrian succession evolved during the development of the 2nd order depositional sequence in the post-rift phase of the Lublin–Podlasie Basin due to relative sea-level fluctuations. The Busówno IG 1 Cambrian succession is represented (from bottom to top) by the highstand system tract and the transgressive system tract in the Lower Cambrian, and by the highstand system tract in the Middle Cambrian.

The Ordovician deposits (79.0 m thick) were encountered at the depth of 2890.0–2969.0 m. The Ordovician succession is represented by a mixed, clastic-carbonate sedimentation. The most common lithologies of the section are organodetrital and marly limestones, siliceous rocks of a chalcedonite type and clastics represented by quartz sandstones, mudstones, claystones and conglomerates. Most of the sandstones are grain-supported quartz arenites.

The Ordovician chronostratigraphic units (Tremadoc, Arenig, Llanvirn, Caradoc and Ashgill) have been correlated to the stages distinguished in the Ordovician succession of the Baltic Depression.

The depth interval trepresenting the Silurian occurs from 2008.0 to 2890.0 m. Most of the succession is dominated by clastics, largely claystones and mudstones rich in graptolite fossils. Silty and marly limestones occur in minor proportions. Revision of the Silurian stratigraphy in the Busówno IG 1 borehole according to the current international standards allowed for applying a classical British scheme recommended by the Subcommission on Silurian Stratigraphy, with the Silurian System divided into the Llandovery, Wenlock, Ludlow and Pridoli.

The Silurian deposits are overlain by a complex of Lower Devonian clastic-carbonate rocks. It is 567.0 m thick and rests at the depth of 1441.0–2008.0 m. The clastics are represented

chiefly by quartz sandstones, mudstones, claystones and sandstone/mudstone heteroliths. The carbonates are represented mainly by organodetrital limestones and rare coquinas. The succession was deposited in brackish environments. Stratigraphy of the Lower Devonian succession is based on palynological (miospores), microfaunal (ostracods) and macrofaunal (trilobites and brachiopods) investigations. Revision of the Lower Devonian stratigraphy in the Busówno IG 1 borehole enabled more accurate location of the Silurian/Devonian boundary.

The Carboniferous section of the Busówno IG 1 borehole is represented by clastic-calcareous deposits. These are mostly limestones, marls, mudstones, sandstones, stigmarian soils, carbonaceous claystones and coals. The chronostratigraphic boundaries have been determined based on a correlation of depositional sequences to neighbouring marker boreholes and to the global and West European Carboniferous stratigraphic scheme. It enabled a more detailed subdivision of the succession and resulted in a revision of the boundaries. During the low stand of relative sea level, the deposition occurred in river beds and flood plains. Incised valleys of large river systems were infilled with alluvial sediments in the Westphalian A. During a sea-level rise and subsequent highstand, the sedimentation took place in shallow-water deltas and on a shallow carbonate-clay shelf.

The Jurassic succession (95.0 m) of the Busówno IG 1 borehole was encountered at the depth of 555.0–650.0 m. It is wholly represented by carbonates: organodetrital, pelitic, oolitic and marly limestones and dolomites. Due to poor coring within this interval, its stratigraphy is based on well logs correlation to neighbouring boreholes.

The Cretaceous rocks occur at the depth of 17.0–555.0 m. The Lower Cretaceous section is represented by quartz-glauconite sandstones with phosphatic concretions, grading upwards into sandy marls. The Upper Cretaceous succession is composed of limestones, marly limestones, chalk-like marls and marly chalk. These rocks were deposited on an open shelf of an epicontinental basin with relatively calm sedimentary conditions. The Cretaceous succession includes the Albian, Cenomanian, Turonian and undivided Coniacian–Maastrichtian. It is overlain by a thin Holocene series (17.0 m) represented by fine- and medium-grained sands.

The principle objective of the Busówno IG 1 borehole was to determine prospects for hydrocarbon occurrence in the Cambrian deposits of the south-eastern part of the Włodawa Depression. Its purpose was also to provide new geological data and to more clearly define the geological structure of the central area of the Lublin region.

Petrographical investigations of organic matter carried out on the Ediacaran, Cambrian, Ordovician, Silurian, Devonian and Carboniferous rocks from the Busówno IG 1 borehole showed that vitrinite is the main component of Carboniferous organic matter. In the Devonian and Silurian sections, vitrinite-like material of a bitumen type is dominant. The Cambrian and Ediacaran deposits commonly show bitumen impregnation. Geochemical analyses of organic matter indicate that the Carboniferous and Silurian rocks do not contain much organic carbon. During Carboniferous time, organic matter was formed either as a result of bacterial decomposition with insignificant contribution of algal and humic material, or due to decay of vascular plants. Organic matter found at the bottom parts of the Silurian section originated from bacterial decomposition. Organic matter from the upper portions of the section is an algal decomposition product.

There were no hydrocarbon shows during drilling. The only events were higher methane contents (up to 2.5%) in the Middle Cambrian and lowermost Ordovician deposits. Hydrogeological tests revealed the presence of natural gas in the drilling mud in several depth intervals. There was also one interval in which brine flow with natural gas was observed. All these shows occurred in the Lower and Middle Cambrian rocks and in the uppermost Ediacaran. Detailed investigations indicate very poor reservoir properties of the Cambrian rocks, so they show little potential for hydrocarbon accumulations.

Translated by Krzysztof Leszczyński