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SUMMARY

The research objective of the Piotrków Trybunalski IG 1 drilling was to provide information on the Zechstein and Mesozoic succession and its immediate basement within a zone located between the Precambrian and Variscan platforms along the so-called Trans European Suture Zone (TESZ).

The borehole was drilled in 1976–1982 in the eastern flank of the Bełchatów Anticline extending in the southern part of the Uniejów (Łódź) Trough (west of the town of Piotrków Trybunalski, central Poland) within the Gniezno–Łask tectonic unit. The drilling has not fully achieved its original geological objectives as it has not reached the planned depth of 5500.0 m. The drilling was stopped at 4849.0 m (in Zechstein deposits) due to technical hole-drilling problems. So the borehole has not penetrated the basement of Zechstein deposits. Therefore, high-confidence data refers only to the Zechstein 4 and part of the Zechstein 3 deposits. Beneath, there is much doubt about the stratigraphy of the section.

As the borehole has not reached the base of Zechstein, the problem of geological interpretation of the refraction horizon showing boundary velocities of approximately 6000 m/s has not been resolved. It is still an open question whether the horizon may be related to the consolidated Variscan basement in the area of the Gniezno–Łask tectonic block.

The Zechstein section has remained unpierced in this borehole. Its lower portion is here composed of a salt series of unknown stratigraphic position, and contains a dolomitic-halite breccia. It may be supposed that the Main Dolomite was brecciated in this zone and then incorporated into the deforming salt and jointly uplifted. It proves the occurrence of intense tectonic movements in this region. The Top Terrigenous Series shows in this borehole one of the greatest thicknesses (106.0 m) recorded in the Polish Basin. It has been almost entirely cored enabling detailed investigations and providing excellent results concerning sedimentary environments and age of the series, based on palynological analysis. The miospore assemblages, which usually have not been preserved in such environments, are in very good conditions in this section. Therefore, the Piotrków Trybunalski borehole is a marker one for the Zechstein/Buntsandstein and Permian/Triassic boundary in the Central European Basin, representing the Permian/Triasssic transition sequence typical of more central part of the basin. No salts younger than Lower Youngest Halite ($Na4a_1$) are observed, and their equivalents may occur in the lower part of playa-type basin deposits. The playa was subsequently subjected to gradual shallowing and emergence resulting in the appearance of distal fluvial deposition. Geochemical investigations indicate an increasing contribution of meteoric waters and maybe slight humidification accompanied by cooling of the climate in the latest Permian. The area around Piotrków Trybunalski was inundated by the Griesbachian transgression (earliest Triassic). After a period of Griesbachian brackish-marine sedimentation the conditions turned to continental.

The results of geological investigations indicate that the Triassic section is a typical one for this region. During the Early Triassic the area was situated in the southern, palaeotectonically inhomogenous part of the sedimentary basin. In the earliest Triassic it was the southern sector of the Mid-Polish Trough with maximum subsidence rate. Later, the trough became narrower and the area around Piotrków Trybunalski IG 1 was a slope of the much more slowly subsiding Sieradz Trough separated from the Mid-Polish Trough by a positive structure called the Kalisz Elevation.

The subsidence rate in this area during sedimentation of the Middle Buntsandstein deposits was almost three times lower than that in the southern flank of the Mid-Polish Trough. At the Early/Middle Triassic transition the subsidence became equalized. This trend persisted until the latest Middle Triassic. The results of stratigraphic-lithological investigations confirmed the lack of at least the uppermost Upper Gypsum Beds. Thus, it may be inferred that the region was subjected to an uplift and erosion at the end of Keuper sedimentation.

During the late 1990s, there was a research project in which sedimentological and seismic stratigraphic investigations were performed in the Piotrków Trybunalski IG 1 borehole. They resulted not only in determination of sedimentary environments but also in modification of the Triassic stratigraphy scheme in the borehole. That scheme is also referred to in this volume, however is not used as the basic one.

Above the Triassic sequence there is a gap spanning the Lower Jurassic and part of the Middle Jurassic succession due to a general tectonic restructuring of the area at the Triassic/Jurassic transition. Lower Jurassic rocks of the Gniezno–Łask block were variably eroded and the Middle Jurassic transgression was late in the region, as proved by deep boreholes drilled throughout the area. The gap can also be a result of a rising salt pillow of the Bełchatów Anticline. Stratigraphical investigations show that the uppermost Upper Jurassic and Neocomian deposits are also lacking.

The Lower Cretaceous succession commences with the Mogilno Formation sandstones (probably its upper part represented by the Lower–Middle Albian Kruszwica Member). The Upper Albian–Upper Cretaceous succession does not

exhibit any differences from the regional pattern. It is represented mostly by carbonate and carbonate-siliceous rocks deposited in general in an open marine environment.

Borehole geophysical logging performed in Piotrków Trybunalski IG 1 enabled detailed recognition of both the lithologies and petrophysical features of the rocks. Due to a wide range of petrophysical investigations this is one of the key calibration boreholes in central Poland, being complexly examined in terms of petrophysical properties of rocks. Worth noting is the very high value of the temperature gradient exceeding 30°C/km. The heat flow value for the Piotrków Trybunalski IG 1 borehole is 77.6 mW/m^2. This corresponds to the amount of heat flow typical of a transitional zone from the Palaeozoic Platform to the East European Craton. The high mean bulk density values of 2.59–2.83 cm^3 measured in the Jurassic (excluding Upper Kimmeridgian), Triassic and Top Terrigenous Series (Zechstein) rocks suggest relatively strong diagenetic processes related to large burial depths.

Open porosity measurements were carried out only on Kimmeridgian and Lower Cretaceous (Mogilno Formation) rock samples. Effective porosity of these deposits is below 6 and 21% (average), respectively. Porosity of older rocks has not been measured due to discovering that it is commonly below 5%.

Complex seismic velocities show much variability within the same rock types. Analyzing the research results, it is possible to predict that more prominent seismic reflection boundaries in this area can be expected at the top of Jurassic and the top of Lower Triassic (Upper Buntsandstein). The Oxfordian limestones and topmost Muschelkalk layers may also be considered good reflectors in this region.

Organic matter studies indicate that the contents of organic carbon and labile components in the rocks are low. Slightly higher amounts of organic carbon were recorded in the topmost portion of Lower Triassic deposits. Due to variable sedimentation, "good" source rocks for hydrocarbon generation occur only locally, also in this formation. High content of bitumens in the Upper Triassic deposits is of epigenetic nature.

The rocks sampled show in general the co-occurrence of sapropel and humic types of organic matter along the borehole section, but in variable proportions. The degree of organic matter alteration is high, but there is a coexistence of organic matter being at different stages of maturity.

Sedimentary environment conditions interpreted for Jurassic, Triassic and Zechstein deposits were in general oxidizing, locally poorly oxidizing, and only sporadically reducing.

Vitrinite reflectance studies in the Triassic deposits indicate that the degree of organic matter alteration is high. Their thermal maturity corresponds to the main phase of gas generation at the maximum palaeotemperatures increasing up to 150 and 250°C.

Thermal maturity of the Zechstein deposits also corresponds to the phase of gas generation. Diagenesis of these deposits occurred at the maximum palaeotemperature below 150°C.

The tectonic subsidence curve drawn for the Piotrków Trybunalski IG 1 profile is typical of the Polish Basin. However, worth noting is the high subsidence rate during the Late Triassic, and the halt of subsidence during the Early Jurassic. These events may be explained by the effect of transtensional stresses.

Thermal history modelling indicates that the thermal maturity profile is a result mainly of Late Cretaceous burial under conditions of heat flow values similar to the recent ones.

Initially, it was planned to make drill stem tests using a wireline formation tester and a DS packer. However, due to drilling obstructions it was not possible to run the full test set, and only 13 formations were tested using wireline testers. Gas recovered from all the samples contained >90% of nitrogen and <1% of hydrocarbons. It indicates that the gas released due to a drill mud fermentation process and the test results are negative.

The Piotrków Trybunalski IG 1 borehole has provided a lot of important information for the geological knowledge about the region. However, technical drilling problems, which enabled reaching the planned depth of 5500.0 m, made it impossible to pierce the whole Zechstein succession and to reach its immediate basement.