

## SUMMARY

In the 1970–1980s, considerable intensification of geological and geophysical (mostly seismic) operations took place in the southern part of the Permian Basin, extending over the Kujawy and Gielniów Swell, and the Marginal and Uniejów troughs. The research results provided much information about the tectonic setting of the area. The basement, consolidated during the pre-Vendian epoch, was encountered in the Płock Trough, Łuków–Hrubieszów Block and Lublin Graben. A Caledonian and Carboniferous-Devonian cover occurs here upon the older Paleozoic formations. In the immediate southwestern proximity, in the Radom–Kraśnik Elevation, there is a folded series of lower Palaeozoic rocks overlain by the Permian and Mesozoic formations, locally also by the Devonian–Carboniferous succession. It seems that the area of the present-day Rawa-Gielniów Swell was a link between the folded Caledonides of Western Pomerania and the Lublin area, Holy Cross Mts. and Nida Trough, consolidated as well during the Caledonian epoch.

The Budziszewice IG 1 well is the first drilling hole located in the Rawa Block of the Kujawy Swell, which pierced the Permian and Mesozoic succession and penetrated its Carboniferous basement.

It should be noted that the borehole is situated in the southeastern part of the Zechstein-Mesozoic tectonic structure, the so-called Gałkówek structure, within a sub-salt elevation of Budziszewice, which continues southeastwards to the Tomaszów Mazowiecki structure.

The Budziszewice IG 1 borehole fulfilled the geological goal of penetrating the sub-Permian basement. Geological data acquired during drilling operations make it an important link in exploring the sub-Zechstein Paleozoic formations in terms of prospecting for hydrocarbons in the southern part of the Polish Permian Basin.

The sub-Permian basement is represented in this area by Carboniferous deposits encountered at depths beneath 5050 m down to the hole bottom at 5601.0 m. The succession is thus 551.0 m thick (apparent thickness, steeply inclined strata).

The Carboniferous deposits are composed of claystones, mudstones, silty sandstones, sandstones, carbonaceous claystones and tuffites. Sandy mudstones and mudstones are the dominant lithologies. Sandstones and claystones occur in minor proportions. Carbonaceous claystones and tuffites are sporadic.

The rocks are strongly tectonically deformed. Irregular fissility, disturbed sedimentary structures, crenulation, strong deformations of sandstone laminae and lenses, small-scale drag folds, slickensides, tectonic contacts between beds of

different lithologies and numerous fractures are commonly observed. The most common fracture dips are 60 and nearly 90°. Part of the fractures form complementary systems dipping at 60 and 30°, 20 and 60° and 50 and 60°. The fractures are commonly filled with mineral veins. Tectonic stratal dips vary from 0 to 90°, 30–60° are most frequent.

Żelichowski (1983) suggested that the lithology can be indicative of flysch type deposits accumulated in an outer zone of the so-called Variscan geosyncline. Their stratigraphic affiliation to the Carboniferous System was claimed based on the presence of coalified plant remains and rare goniatites indicating, however, that the rocks are Namurian in age (based on one goniatite specimen from a depth of 5383.5 m). It is impossible now to make a more detailed stratification for the succession.

Strong tectonic deformation of the Carboniferous rocks shows that the late Palaeozoic front of tectonic activity extends far to the N and NW into the Kujawy Swell and possibly to the Łódź Trough. As a result of an oblique arrangement of young Paleozoic tectonic structures (W–E and WNW–ESE) in relation to the edge of the East European Platform (stretching NW–SE), a tectonic superposition (at least partial) upon the Caledonian basement and its cover probably took place.

It cannot be precluded that there is a transition in this area between a Variscan foredeep and a platform of an offset tectonic block that likely developed at the suture zone between the pre-Vendian platform and Caledonian platform (the so-called Lublin Graben in SE Poland).

Petrographical analyses of sandstones indicated that terrigenous material was supplied to the sedimentary basin from both volcanogenic areas and crystalline rocks (both igneous and metamorphic). Geochemical investigations show a close relationship of the Carboniferous sandstones to the Upper Viséan–Lower Namurian flysch association composing the fold-and-thrust belt of the Wielkopolska and Moravian-Silesian externides. Grains originating from older sedimentary rocks are also observed in the clastic material. The Carboniferous deposits could be deposited partly in a turbidite current environment, as evidenced by the presence of current marks. The rocks show low porosity and permeability due to regeneration of quartz grains and the presence of siliceous cement. Stratal dips locally reach 90°. Tectonic breccia beds were also encountered in the sequence. The occurrence of goniatites may indicate Early Silesian–Namurian age of the deposits.

The Carboniferous succession is overlain by a thick Rotliegend series represented by two formations: the Drawa and Noteć formations. The Rotliegend section is composed of al-

luvial fan and alluvial plain deposits, and fluvial sequences represented by channel fills of braided and meandering rivers.

The Rotliegend deposits lie in a horizontal position. Due to strong diagenetic processes and secondary postdepositional alterations, the sandstones show poor reservoir properties.

The Zechstein and Mesozoic succession is represented by the Zechstein, Triassic, Jurassic and Quaternary formations. The section is typical of the Kujawy Trough characterized by complete sequences and considerable thicknesses. The lack of formations younger than Bathonian is the result of removal of pre-existing uppermost Middle Jurassic, Upper Jurassic and Cretaceous deposits during the Late Cretaceous–Early Paleogene inversion and later.

A surprise is the strongly tectonically deformed Zechstein sequence, almost 900 m in thickness. Only the lowermost units: Copper Shale, Zechstein Limestone and Lower Anhydrite are in a normal position. Above, the sequence is strongly faulted. The faults found out in the Zechstein deposits reduce the section so that some stratigraphic units are absent here.

The considerable tectonic deformation of the Zechstein rocks indicates strong activity of the basement beneath the Budziszewice tectonic block that formed between the Galkówek and Zaosie salt pillows.

Analyses of seismic and geological sections in the Rogóżno–Galkówek–Zaosie zone show that the salt structures were especially strongly active during the Late Triassic, Middle and Late Jurassic and probably at the Cretaceous/Paleogene transition.

Geochemical investigations of bitumens from the Permian and Mesozoic rocks indicate that the Permian and Triassic deposits are characterized by low contents of organic matter and bitumens that additionally show low degree of metamorphism, and by scarcity of hydrocarbons of low migration coefficient.

Geochemical research of organic matter (bitumen) in the Permian and Mesozoic rocks proves that the Permian and Triassic deposits contain little amount of both very poorly al-

tered organic matter and bitumens. The only sample in which a higher content of organic matter was recorded comes from Middle Jurassic rocks.

Microscopic investigations of dispersed organic matter indicate that the degree of its metamorphism increases with depth. Authogenic-type vitrinite reflectance values (average  $R_o$  0.77–0.97%) from the Middle Jurassic–Upper Buntsandstein interval show that organic matter is within the solid to gas coal alteration zone. It points to the possibility of liquid oil generation in this area.

Vitrinite reflectance values in the Buntsandstein increase to an average of 1.25–1.30%, reaching the fat coal phase.

The analysis of palaeotemperature gradients and the recent thermal gradient, supported by investigations of organic matter alteration degree, indicates that the Paleozoic rocks of the Rawa Block passed through the phase of liquid hydrocarbon destruction, whereas the Mesozoic rocks entered the phase of liquid hydrocarbon generation.

Laboratory and geohydrochemical investigations revealed poor reservoir properties of the Carboniferous and Lower Permian (Rotliegend) rocks. Slightly better properties were observed for the Buntsandstein sandstones. Small inflow of brines of increased degree of metamorphism indicates that the deposits occur in a zone of possible hydrocarbon occurrence.

Astonishing results were obtained from the Lower Jurassic deposits. For the first time in the Polish Lowlands strong shows of combustible gas were detected. The natural gas contains 94.5% of methane. It suggests that especially uppermost Lower Jurassic sandstones are prospective for exploration for hydrocarbons.

The main objective of the Budziszewice IG 1 drilling was to investigate the sub-Zechstein basement within the Rawa Block of the Kujawian Swell, especially the Carboniferous and Rotliegend successions. The borehole fulfilled the geological task by drilling through the 551-m thick Carboniferous complex overlain by Permian and Mesozoic formations.