Hanna MATYJA

SUMMARY

The Bydgoszcz IG 1 borehole is located in the south-eastern part of Pomerania about 18 km to the west of the city of Bydgoszcz, near the seismic profile 12.III.81.

The following systems are represented in the section: Silurian?, Devonian (Givetian and part of the Frasnian), Permian (Upper Rotliegend and Zechstein), almost complete Triassic and Jurassic (lack of almost all the Upper Jurassic except for the lower Oxfordian), Neogene? and Quaternary (see detailed lithostratigraphic-stratigraphic section). The characteristic feature of this section is the presence of large gaps not only between individual systems (lack of Carboniferous, Cretaceous and Paleogene deposits), but also within the systems (e.g. lack of the entire Lower Devonian and part of the Middle Devonian, and lack of a significant part of the Upper Devonian). Some of these gaps are typical of the entire Western Pomerania area, e.g. lack of Lower Devonian deposits, but most of them are local gaps, like the absence of a substantial part of the Frasnian, and the complete lack of Famennian, Carboniferous and Cretaceous deposits.

Analysis of seismic data (P. Krzywiec) indicates that the Devonian section in a zone located relatively close to the Szubin IG1 borehole is thicker and more complete than in the region of the Bydgoszcz IG1 borehole, and there is the Carboniferous present in that area. It may suggests, according to P. Krzywiec, that a reverse fault occurring to the SW of the Szubin IG1 borehole, associated with the inversion of this segment of the Mid-Polish Trough, was active as a normal fault in late Palaeozoic times. The final stage of tectonic evolution of the area, which is part of the Mid-Polish Trough, was the Late Cretaceous-Palaeogene inversion, which led to an uplift of the axial zone of the basin and the formation of the Mid-Polish Swell. Post-inversion erosion removed all the Cretaceous sedimentary cover, and therefore it is not possible to analyze the process of inversion in this area based on seismic data.

The Pomeranian area was very specific, in its both tectonic-structural development and facies architecture. It was characterized by an Early Palaeozoic active tectonic stage (Caledonian) followed by a platformal stage that started from the Early Devonian. The Devonian and Carboniferous sedimentary successions of the Pomeranian basin are typical of shelf environments. Structural instability of the basement in the Pomeranian sedimentary basin during the Devonian and Early Carboniferous (associated with synsedimentary activity of some fault zones) and periodic mobility of the nearby land (East European Craton) caused thickness variability and relative (on a regional scale) sea-level changes, and thus facies variability. During the Late Carboniferous, the marine basin of the Variscan foreland became first paralic, and then it was only a continental marginal foreland basin of the uplifting Variscan orogen. However, the Permian and Mesozoic basins were typical intracratonic basins extending between the Variscan orogen and the elevated part of the East European Craton.

The oldest deposits drilled are strongly faulted claystones with few marly mudstone and claystone interbeds, probably representing the Silurian (T. Podhalańska). The fauna of inarticulate brachiopods, poorly preserved bivalves, nautiloids and acritarchs (Szczepanik, 1989) found in the sediments did not allow an unambiguous determination of their stratigraphic affiliation. According to E. and H. Tomczyk (1990), these sediments resemble the Rzepin Beds of the Holy Cross Mts, hence their suggestion that the analyzed sediments may also represent the (?Upper) Silurian.

The Silurian is directly overlain by Middle Devonian siliciclastics and carbonates that probably belong to the Givetian and lower Frasnian (H. Matyja, J. Pacześna, E. Turnau). Three lithostratigraphic units were distinguished within this succession, from oldest to youngest: (1) the Tuchola Formation represented by marly claystones, marls and stromatoporoid-coral limestones, (2) the Silno Formation represented mainly by non-calcareous siliciclastic sediments (sandstones and mudstones) with subordinate claystones and occasional thin limestone beds, (3) the Chojnice Formation composed mainly of non-calcareous siliciclastic sediments (mudstones and subordinate sandstones and claystones), with relatively frequent and thick interbeds of stromatoporoid-coral limestones. The overlying Koczała Formation, composed mainly of carbonate-marly rocks with interbeds of calcareous quartz sandstones, probably represents the uppermost Givetian and part of the Frasnian. The Devonian clastic deposits and their depositional environments locate themselves between the lagoon, tidal flat and barrier. The trace fossil assemblage from these deposits was described by J. Pacześna. Carbonate depositional environments are represented almost exclusively by small organic build-ups and their immediate surroundings (H. Matyja). A thin beige interlayer of a massive effusive rock, identified as dacite, occurring within the Givetian marly limestones with stromatoporoids and corals of the Chojnice Formation, was thoroughly analysed for petrographic composition (E. Jackowicz). The dacite layer is a fragment of lava flow or an in situ intrusive body. Devonian deposits were analysed for miospors and conodonts (H. Matyja, E. Turnau). However, the Devonian rocks occur at significant depths in this borehole, hence organic matter here has been strongly modified by thermal factors. That means that spores from test samples are black, opaque,

and only few specimens have retained the characteristic features that enable identification to the genus and sometimes to the species. Better preserved are acritarchs and Prasinophytes, however, the taxa show long stratigraphic ranges and are therefore less useful for stratigraphy. The Givetian and lower Frasnian lithology indicates the dominance of shallow-marine environments in the area, which is a problem in the conodont analysis. Therefore, the proposals for biostratigraphic subdivision of the Devonian, despite abundant sampling, are vague and poorly documented. The biostratigraphic analysis revealed that basal layers of the Devonian deposits cannot be older than Givetian, and their top layers represent the Frasnian. No upper Devonian (upper Frasnian and the whole Famennian), Carboniferous and lower Permian deposits have been found.

The lower Frasnian is overlain by Permian fine-grained clastic deposits of the Upper Rotliegend molasse subassociation, included in the Warta Group and representing the transition between the fluvial and playa depositional systems in its lower part, and only the playa depositional system in the middle and top parts (J. Pokorski). Detailed petrographic analysis included identification of diagenetic processes and was made for the sandstone and mudstone-claystone lithofacies (M. Kuberska).

The Zechstein is characterized by a complete lithostratigraphic section represented by saline facies typical of the central part of the sedimentary basin in the Mid-Polish Trough (R. Wagner). Three carbonate-evaporitic cyclothems of TP1, TP2 and TP3, and a very large terrigenous-evaporotic cyclothem PZ4 are present. Detailed analysis of microfacies and diagenetic processes was performed for the Zechstein Limestone (M. Wichrowska). Evaporitic sediments represented by anhydrite (T. Peryt) and salts (G. Czapowski) were also examined.

The Mesozoic succession is represented by Triassic and Jurassic deposits.

The Triassic stratigraphic scheme in the Bydgoszcz IG 1 borehole is based on lithostratigraphic units identified primarily from well logging (A. Becker and A. Szyperko-Teller). The approximate position of chronostratigraphic units is given based on the correlation with data from other parts of the basin. Triassic deposits seem to represent a significant stratigraphic interval of the system, from the Lower Triassic represented probably by the Buntsandstein facies of the Induan and Olenekian, through the Middle Triassic represented by the Muschelkalk facies, to the Upper Triassic probably represented by the Rhaetian facies of the Keuper. In total, 15 lithostratigraphic units in the rank of groups, formations and beds have been distinguished.

Little core has been acquired from Jurassic deposits in the Bydgoszcz IG 1 borehole. The section probably includes the whole of the Lower and Middle Jurassic and the lowest part of the Upper Jurassic, Oxfordian (A. Feldman-Olszewska). It seems that the Jurassic continuously overlies the uppermost Triassic (Rhaetian). Kimmeridgian, Tithonian, and presumably uppermost Oxfordian rocks were removed by erosion during the uplift of the Mid-Polish Swell at the turn of the Cretaceous and Palaeogene. The Lower Jurassic succession is represented by six lithostratigraphic units at the formation rank. In this region, no lithostratigraphic units have been distinguished so far in the Middle Jurassic represented by Aalenian, Bajocian, Bathonian and Callovian deposits. The Upper Jurassic is represented by one lithostratigraphic unit at the rank formation.

The Mesozoic succession is capped probably by Neogene and Quaternary deposits (Z. Fert).

The Palaeozoic and Mesozoic complex of the Bydgoszcz IG 1 borehole is generally characterized by a low content of organic matter represented mainly by humic material (vitrinite, inertinite, liptinite) in the Permian and Mesozoic deposits and vitrinite-like material (solid bitumens and zooclasts) in the Silurian and Devonian rocks (I. Grotek). The greatest amounts of organic matter are found in mudstones of the top portion of the Middle Triassic and in Upper Triassic sandstones, however, they contain mainly redeposited material. Increased concentration of organic matter is observed in basal and uppermost parts of the Middle Devonian. Some enrichment (0.70–0.90%) is also observed in the Silurian, topmost Upper Devonian and lower Permian. Thermal maturity of the deposits changes with the depth of burial within a very wide range, from the main phase of oil generation in the Jurassic and Triassic section at vitrinite reflectance values of 0.57–1.00% R_o, through the main phase of gas generation in the Permian and Upper Devonian at the reflectivity of 1.67–2.00% R_o,r, to the overmature phase and R_o,r values of 2.05–2.73% in the Middle Devonian and Silurian. The data suggests changing thermal conditions during diagenesis from 70°C in the Lower Jurassic deposits to more than 200°C in the Middle Devonian and Silurian section.

In summarizing the results of geochemical studies of organic matter in the Palaeozoic and Mesozoic succession, it should be noted that they are in general characterized by a low content of organic carbon and labile components (E. Klimuszko). It was found that the Upper Permian deposits contain epigenetic bitumens. A large amount of organic carbon, which specifies the deposits as “good” source rocks for hydrocarbon generation, occurs only at the base of the Middle Devonian and in the Lower Jurassic. Organic matter observed in the Middle Devonian generally originates from decomposition of bacteria and algae, so it is good “oil-forming” material. The poorly examined Lower Jurassic deposits contain two coexisting genetic types of organic matter.

One-dimensional analysis of tectonic subsidence (backstripping) and sediment deposition rate analysis were performed for the Bydgoszcz IG 1 borehole (P. Poprawa). The Permian–Mesozoic tectonic subsidence curve illustrates the tectonic evolution partly typical of the Polish Basin. It begins with a tectonic event expressed by rapid subsidence in the Late Permian–Early Triassic, followed by a long period of gradual deceleration of subsidence through the remainder of the Mesozoic. This part of the tectonic subsidence curve has a shape typical of rift basins. The main phase of synrift extension can be identified with the phase of rapid subsidence in the Late Permian–Early Triassic, while the subsequent deceleration of subsidence can be interpreted as an expression of post-rift thermal subsidence. The Cretaceous/Cenozoic transition was a period of tectonic uplift and associated erosion that removed Cretaceous and part of Upper Jurassic deposits. A feature specific to the Bydgoszcz IG 1 section, unusual for the Polish Basin, is the weak Late Jurassic tectonic subsidence event. This is due to the location of the borehole in the northern part of the Polish Basin, where the event is weak or negligible. Another specific feature is the presence of a tectonic uplift event in the Late Triassic. The sediment deposition rate in the Polish Basin was the highest in Late Permian and Early Triassic times, when it was about 110–275 m/million years. In the Middle–Late Triassic and Jurassic, the deposition rate was 12–50 m/million years, except during the Callovian, when it dropped to about 3 m/million years.

The reconstructed burial history is characterized by the presence of several phases of rapid burial, separated by periods of stagnation or tectonic uplift (P. Poprawa). The Upper Silurian sediments were deposited during rapid subsidence and burial, which continued until the end of Silurian. The Early Devonian tectonic uplift occurred probably as a result of post-collisional isostatic effect, which led to the removal of the top part of the Upper Silurian succession. The original thickness of the Upper Palaeozoic cover could be about 2200 m due to continued subsidence and burial in the Devonian and Early Carboniferous. In the Late Carboniferous and/or Early Permian, the area underwent another uplift and erosion event, leading to the removal of Lower Carboniferous and upper part of Upper Devonian rocks.

Starting from the Late Permian, a rapid burial took place in the Permian-Mesozoic Polish Basin. Its main phase occurred during the Late Permian-Early Triassic. Rapid increase in the thickness of sedimentary cover also continued in the Jurassic. The period of maximum burial occurred in the Late Cretaceous.

Geophysical surveys were performed in the Bydgoszcz IG 1 borehole successively in 13 depth intervals (J. Szewczyk). Radiometric measurements were the basic type of geophysical surveys that enabled assessing the lithology and reservoir properties of rocks.

Formation tests were performed for nine reservoir horizons: one was made during drilling and eight were carried out after the drilling was completed (L. Bojarski, A. Sokołowski and J. Sokołowski). The hydrodynamic conditions and characteristics of the chemical composition of groundwater analysed in terms of preservation of hydrocarbons in the Devonian deposits indicate a total loss of reservoir properties of rocks. The Devonian deposits are in a zone of elevated reservoir pressure gradients. Rotliegend deposits show very poor reservoir properties at abnormally high reservoir pressure gradients $G = 1.89\times10^3$ hPa/10m.

These results point to a wider zone of anomalously high reservoir pressure in the sub-Zechstein Palaeozoic in this part of Pomerania, identified so far in the Szubin–Unisław region. Potentially, it is a prospective area for discovering new hydrocarbon deposits in Permian and Devonian deposits of Pomerania. It should be noted, however, that the Devonian and Permian deposits are unfortunately lacking of reservoir properties in the Bydgoszcz IG 1 section due to low permeability. The Mesozoic deposits show much better reservoir properties, except for strata from the Lower/Middle Buntsandstein transition. The Upper Middle Buntsandstein deposits are characterized by moderate reservoir properties, as evidenced by brine inflow of 2.5 m^3/h. The Rhaetian and Lower Jurassic deposits have very good reservoir properties, as evidenced by high brine artesian inflow of 96–100 m^3/h. The Rhaetian section revealed the presence of gas dissolved in brine, containing increased content of heavy hydrocarbons (11% vol.), whose presence may indicate bitumen accumulations in this region. The Mesozoic brine contains mainly NaCl (95%), which may be attributed to the leaching of rock salt.