Hanna MATYJA

SUMMARY

This report contains the results of both early analyses and recent stratigraphic, sedimentological, petrographical and geochemical investigations based on modern research methods and within the chronostratigraphic units recommended by the International Commission on Stratigraphy.

Ordovician, Devonian, Permian, Triassic, Jurassic, Cretaceous and Neogene and/or Quaternary deposits were encountered in the Jamno IG 1, Jamno IG 2 and Jamno IG 3 boreholes.

The oldest rocks drilled in the boreholes are Ordovician deposits represented by strongly tectonically deformed fine-grained siliciclastics (mostly claystones and mudstones) characterized by the presence of thin clayey siderite interbeds, lenses and concretions as well as small crystalline pyrite concretions and aggregates. Graptolite fauna found in claystones indicates the *gracilis* Zone (Jamno IG 2) and the *multidens* Zone (Jamno IG 1 and Jamno IG 2), corresponding to the lower portion of the Caradoc stage in Britain.

No uppermost Ordovician, Silurian and almost entire Lower Devonian sections were encountered in all of the analysed boreholes.

Upper Ordovician (Caradoc) rocks are directly overlain by Devonian deposits: ?Lower, Middle and Upper (only part of Frasnian) Devonian in Jamno IG 1, ?Lower and part of Middle Devonian in Jamno IG 2 and Jamno IG 3. Four lithostratigraphic units have been distinguished within this stratigraphic range. These are (from oldest to youngest): the Jamno Formation represented by conglomerates, sandstones and mudstones (Jamno IG 1, Jamno IG 2 and Jamno IG 3), the Sianów Formation represented mainly by carbonates and mixed siliciclastic-carbonate series (Jamno IG 1), the Wyszebórz Formation characterized by dominant conglomerates, sandstones and mudstones (Jamno IG 1) and the Koczała Formation composed of carbonates and mixed siliciclastic-carbonate series (Jamno IG 1). The Devonian deposits were analysed for biostratigraphic, microfacies, petrographical and diagenetic investigations. Biostratigraphic research based on miospores and conodonts. Palynological analysis shows that basal parts of the Devonian succession cannot be older than the uppermost Emsian and younger than the middle Eifelian. The topmost Devonian strata were dated by conodonts and miospores as lower and middle Frasnian. No Upper Devonian was encountered in the boreholes. The gap also comprises the Carboniferous and Lower Permian. Middle (Givetian) or Upper (lower and middle Frasnian) Devonian is overlain directly by the Upper Rotliegend deposits belonging to the Darłowo Formation (Jamno IG 2) or Miastko Formation (Jamno IG 3) or to the Zechstein strata (Jamno IG 1). The Zechstein deposits were analysed for petrographical microfacies and diagenetic investigations. Some informations were also presented on the Zechstein salt deposits in the Jamno IG 1 section.

The Mesozoic succession is represented by the Triassic, Jurassic and Cretaceous.

Triassic deposits of all the boreholes seem to be represented by the almost complete stratigraphic range of the system. Thirteen lithostratigraphic units of group, formation and beds rank have been identified within the succession. These are (from oldest to youngest): Lower Buntsandstein (Baltic Formation), Middle Buntsandstein (Pomorze and Połczyn formations), Upper Buntsandstein (Barwice Formation), Lower, Middle and Upper Muschelkalk, Lower Keuper (Sulechów Beds) and ?Upper Keuper (?Red Sandstein), and Drawno, Jarkowo, Zbąszynek and Wielichowo beds. The Jamno IG 2 section seems to be stratigraphically complete although there are signs of tectonic activity. Within the Jamno IG 1 and Jamno IG 3 sections, only Carnian deposits are missing.

Jurassic deposits were identified in all the boreholes, although none is complete. The Lower Jurassic was encountered in Jamno IG 1, Jamno IG 2 and Jamno IG 3. It is represented by the Hettangian, Sinemurian and Pliensbachian (Jamno IG 1, Jamno IG 2, Jamno IG 3) and Toarcian (Jamno IG 2 and Jamno IG 3). The Middle Jurassic was also encountered in all the boreholes, however the presumed Aalenian deposits are suggested only in the Jamno IG 3 borehole, upper Bajocian is observed in Jamno IG 2, and variably complete Bathonian and Callovian deposits are represented in all the boreholes. Upper Jurassic rocks, represented by the Oxfordian and Kimmeridgian, occur in the Jamno IG 3 section. The Lower Jurassic succession consists of 7 lithostratigraphic formations. These are: the Zagaje, Skłoby, Ostrowiec, Łobez, Komorów, Ciechocinek and Borucice formations. No lithostratigraphic units have been identified within the Middle Jurassic succession represented by the presumed Aalenian (Limnic series), upper Bajocian, Bathonian and lower Callovian. The middle and upper Callovian deposits are included in the Łyna Formation. Its uppermost part belongs partly to the Oxfordian. The Upper Jurassic is represented by 4 lithostratigraphic units: the Łyna, Chociwle, Brda and Pałuki formations.

Cretaceous deposits were encountered only in the Jamno IG 1 borehole. The section falls within the Upper Cretaceous comprising the Cenomanian through upper Maastrichtian stages. No lithostratigraphic units are identified within the sequence.

The Mesozoic succession is capped in the Jamno IG 1, Jamno IG 2 and Jamno IG 3 boreholes by rocks of presumed Neogene and/or Quaternary age.

The most organic-rich Paleozoic deposits are the Upper Ordovician clay shales composed of a sapropel-type organic-mineral association, bitumen, infrequent zooclasts and inertinite represented mostly by algae and cyanobacteria. The other organic matter-rich horizon is the Upper Devonian carbonates composed mostly of vitrinite-like material, sapropel-type organic-mineral association accompanied by alginite and relatively frequent nituminous impregnations. The Upper Permian claystones contain increased amounts of organic matter in relation to the carbonates. The organic matter is composed chiefly of vitrinite macerals and rare liptinite. Humic organic matter observed in the Mesozoic deposits is represented by vitrinite, inertinite and liptinite (both *in situ* and redeposited) occurring in the greatest abundance in the Middle Jurassic rocks.

Thermal maturity of the Upper Ordovician through Middle Cretaceous rocks is low. The degree of authigenic organic matter alteration increases with the burial depth and age of deposits – from immature for hydrocarbon generation (Cretaceous–Jurassic) at the maximum reflectance of 0.42–0.48% R_O, to the main phase of oil generation in the Upper Permian–Upper Ordovician rocks (0.5–0.75% R_O). The maximum palaeotemperatures were <90°C.

Geochemical data indicate that the Paleozoic and Mesozoic rocks are poor in organic matter. The Ordovician and Devonian deposits show features of "poor" source rocks for hydrocarbon generation. They also contain small amount of labile components. The Permian and Triassic rocks also exhibit features of "poor" source rocks. The Middle and Lower Jurassic deposits contain abundant but unevenly distributed organic matter. They are considered "good" rocks for hydrocarbon generation. The Upper Jurassic deposits have been analyzed relatively poorly. The Cretaceous rocks from Jamno IG 1 contain low percentages of organic carbon, as they are represented mostly by carbonates. Thus they are considered "poor" source rocks for hydrocarbon generation. The degree of organic matter alteration in these rocks is very low.

Organic matter found in the Ordovician and Devonian deposits originated from algal and bacterial decomposition. Organic matter originating from decomposition of vascular plants was observed only in the Upper Devonian rocks of the Jamno IG 1 borehole. However, the degree of its alteration is low. A mixed-type of organic matter was found in the Triassic and Jurassic rocks. Upper Triassic and Lower Jurassic deposits contain organic matter derived mostly from decomposition of algae and bacteria, and a certain amount of humic material. More humic-type organic matter is observed in the Lower Jurassic rocks. The Lower Triassic rocks are conspicuous by a low humic material content. The Upper Triassic and Middle Jurassic series are more abundant in humic-type organic matter in relation to the amount of sapropel-type matter. The degree of organic matter alteration in the Mesozoic rocks is low in this region.

The suite of wireline logs included caliper, sontaneous potential, resistivity, radiometric and temperature logs. The basic goals of the borehole geophysical measurements comprised determination of lithology and depth to individual strata, determination of geothermal parameters (heat flow and geothermal degree), identification of formations showing reservoir properties as well as determination of depth-related changes in physical parameters of rocks. Wireline logs from the Jamno boreholes enabled construction of lithological logs and determination of petrophysical properties of rocks indicating formations of the best reservoir properties.

Drill stem tests performed in the boreholes aimed at examination of the Palaeozoic and Mesozoic reservoir horizons in terms of possibility for crude oil, natural gas and industrial groundwater occurrences. Test horizons were selected based on the results of wireline logging and bitumen shows detected during drilling operations. In the Jamno IG 1 borehole, 7 reservoir horizons were tested: the connected Ordovician– Devonian horizon (no flow), 5 Devonian horizons and 1 Lower Triassic horizon. In the Jamno IG 2 borehole, 4 reservoir horizons were tested: 1 Devonian horizon and 3 Permian horizons. In the Jamno IG 3 borehole, 7 reservoir horizons were tested: 1 Devonian horizon, the connected Zechstein–uppermost Devonian horizon, 2 Zechstein horizons, 2 Triassic horizons and 1 Jurassic horizon. The boreholes are situated within an area prospective for hydrocarbon accumulation. Although no hydrocarbon shows were observed during drilling, it is indicated by the properties of brines analysed from the boreholes.

The Devonian and Permian (Zechstein) rocks are of the greatest interest. They contain strongly metamorphosed brines separated from other water-bearing horizons. The hydrochemical indices indicate the possibility of bitumens accumulations. The hydrochemical indices of Permian groundwater show a proximity to hydrocarbon fields. Strongly isolated metamorphosed brines are also observed in the Triassic rocks. The hydrochemical parameters do not preclude the hydrocarbon accumulations.