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SUMMARY

The Sława IG 1 borehole was drilled in the Wschowa District (currently Lubusz Voivodeship) to a depth of 2273.0 m and stopped in Rotliegend deposits of the Lower Permian. The main objectives of the borehole were as follows:

- Explaining the possibility of extension of the Lubin-Głogów copper ore deposit towards the NW;
- Determining the depth to the Zechstein ore series;
- Determining the economic value of copper-bearing deposits;
- Acquiring data on water-bearing zones in the borehole section;
- Explaining the possibility of hydrocarbon accumulation within the Zechstein carbonates and Rotliegend sand-conglomerate deposits;
- Examining the prospect for rock salt and potassium salt accumulation.

Down to a depth of 494.7 m there was only one cored interval at 415.0–427.7 m. Below this depth, the borehole section was almost fully cored. A number of well logs were also run in the interval of 57.0–2255.0 m, which enabled establishing the stratigraphy of non-cored intervals in the Triassic and Cenozoic.

Since this borehole is important in terms of economic geology issues, geological investigations were focused primarily on the Permian deposits, in which the drilling was stopped after reaching Lower Rotliegend volcanites. These are overlain by Upper Rotliegend and Weissliegend sedimentary rocks (over 280 m thick) followed by the Zechstein series of predominant evaporites. Detailed sedimentological analysis of the Rotliegend succession enabled interpretation of sedimentary environments and identification of sedimentary cycles and depositional sequences (marked with the letters from A to T) controlled by climatic fluctuations in the Permian. The Rotliegend section in the Sława IG 1 borehole has provided evidence for offering a hypothesis about the existence of an extensive alluvial system prograding into aeolian deposits. Based on the sedimentological study, curves of palaeoclimate change have been constructed, which reflect long-term climatic fluctuations that can be arranged in a series of cycles referred to as climatic-sedimentary megacycles. The Rotliegend section can function as a marker borehole section for further analyses concerning the development of the Upper Rotliegend sedimentary cover in the Silesian Basin.

In the Sława IG 1 borehole, the Zechstein succession is relatively thick (549.5 m) and represented by almost all stratigraphic subdivisions; reduced only at the top, down through the PZ4a cyclothem. The deposits are undisturbed tectonically and consist of three carbonate-evaporite cyclothems: PZ1, PZ2 and PZ3, and one terrigenous cyclothem PZ4 subdivided in this region into PZ4a and the Top Terrigenous Series PZt. The Zechstein deposits overlie directly the Upper Rotliegend rocks. The fully cored interval between the Zechstein and the Upper Rotliegend has revealed the presence of transgressive lowermost Zechstein deposits represented by 4-metre thick homogeneous quartz sandstones, which are the product of erosion of Upper Rotliegend aeolianites by the transgressing sea. This is an equivalent to the basal conglomerate, but composed of sandy facies. Above, there is the widespread, distinctive Copper Shale (Kupferschiefer) (T1) with an average thickness of 29 cm, overlain with thin carbonate rocks of the Zechstein Limestone (Ca1). Full coring of the Zechstein section allowed conducting sedimentological investigations and reconstructing environments in the sedimentary basin of the region.

The Zechstein succession is overlain by Triassic deposits, 1101.0 m in thickness, represented by the Lower, Middle and Upper subdivisions. The uppermost Triassic deposits are Middle Keuper claystones. The informal carbonate-clastic formation in the lower part of the Middle Buntsandstein is represented, at depths of 950.0–971.8 m, by claystones, organodetrital limestones with glauconite, and subordinate sandstones. The presence of remarkable excursions on the natural gamma ray curve indicates that these deposits are enriched with uranium. The seismic section presented in this volume reveals clinoforms within the Lower Buntsandstein succession. They are inclined from the south to the north, which is consistent with the general transport direction of terrigenous material towards a shallow-marine basin. It suggests the possibility of the occurrence of cyclothems, within the Baltic Formation of the Sława IG 1 borehole, corresponding to a progradation

of shallow-marine environment into deeper basinal facies (?deltas). A preliminary analysis of geological data (from well logs and drill-core descriptions) has allowed the identification of three rock complexes representing individual cyclothems within the Baltic Formation. The order of magnitude of these cyclothems correlates with the scale of thickness of the succession of the identified clinoforms that can attain a great height of about 200 m on the seismic section.

Interpretation of depositional environment of the Baltic Formation in the Sława IG 1 borehole, as well as of the origin of the forms identified on the seismic section requires further detailed investigations. Nevertheless, the palaeogeographic position of the borehole in the marginal zone of shallow-marine basin suggests the possibility of delta system progradation.

In the Sława IG 1 borehole, like throughout the whole area of SW part of the Fore-Sudetic Monocline, Jurassic and Cretaceous deposits are absent because they were removed due to tectonic inversion of the epicontinental sedimentary basin in the latest Cretaceous and early Palaeogene. As the result, the Middle Keuper deposits are directly overlain by the Palaeogene series represented by the Upper Oligocene Leszno Formation, 66.0 m thick. The Neogene succession is 249.0 m thick and is represented by the Miocene formations of Rawicz, Ścinawa, Pawłowice and Poznań. The Ścinawa Formation includes lignite seams, including the thick 2nd Lusatian Lignite Seam. Next lignite seams are found in the Pawłowice Formation (relatively thin 2ndA Lubin Seam) and in the lower part of the Poznań Formation (1st Middle-Polish Lignite Seam).

The Quaternary series in the Sława IG 1 borehole is 57.0 m thick and is represented by sands, gravels and tills.

The copper-bearing series was analysed (microscopic observations) for the presence of mineralisation. The analysis was performed on the Weissliegend, Copper Shale and Zechstein Limestone deposits. Microscopic observations in reflected light show that the copper-bearing series of the Sława IG 1 borehole contains following ore minerals: chalcopyrite ($CuFeS_2$), bornite (Cu_5FeS_4), chalcocite (Cu_2S), sphalerite (ZnS), galena (PbS) and pyrite (FeS_2). The results of chemical analysis of samples from the Sława IG 1 borehole prove that the copper mineralisation is concentrated in the upper part of the Weissliegend and the bottom part of the Copper Shale, in an ore-bearing interval occurring at a depth of 1960.89–1961.34 m (0.45 m thick) with a minimum Cu content of 0.5%. In this interval, the copper content varies from 0.60 to 7.27%, and the silver content from 43 to 652 ppm. The ore interval is characterised by the average content of 1.92% Cu and 161 ppm Ag, and the equivalent copper content is 37.46 kg/m^2 Cue. Other deposits of the ore-bearing series show low concentrations of copper and silver. Only some samples of sandstones from below the ore interval exhibit elevated contents of these metals, up to 0.46% Cu and 163 ppm Ag.

Besides copper and silver, the deposits studied also contain significant quantities of lead and zinc. The contents of gold and platinum family elements in the Weissliegend and Copper Shale are negligible. In the Rotliegend, beneath the Weissliegend base, the contents of metals, including silver, gold, platinum and palladium, are generally low.

Petrographic analysis of organic matter dispersed in Copper Shale sediments from a depth of 1960.9 m was also performed. It is characterised by a rich sulphide mineralisation represented mostly by clusters of framboidal pyrite and other ore minerals. The relation between organic matter and mineralisation is also indicated by co-occurrence (paragenesis) of alginite and mineral grains, and the presence of bituminite surrounding ore minerals.

Thermal maturity of organic matter, determined by measuring vitrinite reflectance values, corresponds to the main phase of liquid hydrocarbon generation (oil window). The average value is 0.64% R_o, ranging within an individual sample from 0.54 to 0.75% R_o. These data indicate that the maximum palaeotemperatures of diagenetic processes were about 70–80°C.

Rocks samples of copper shale from the Sława IG 1 borehole show both high content of organic matter (TOC 3.82–16.09 wt.%) and very high to excellent hydrocarbon potential. The organic matter is within the phase of oil window (T_{max} 437–441; 0.7–0.78% VR_o cal.). Worth noting is the considerable vertical variability in total organic matter content (TOC) within the interpreted interval. The TOC variation displays a downward increasing trend and may prove a considerable variability in physicochemical conditions of the copper shale sedimentary environment. The samples analysed are definitely dominated by sapropelic, oil-generating type-II kerogen consisting of liptinite group macerals.

Petrographic studies of Rotliegend rocks indicate the predominance of sandstones with less frequent conglomerates, siltstones and claystones. The conglomerates are polymictic. The psephitic fraction is of volcanic and sedimentary origin, rarely of metamorphic or plutonic. Lithoclasts in the sandstones are dominated by sedimentary rocks. Analysis of the observed effects of postsedimentary processes suggests that they represent mesodiagenetic and eodiagenetic processes. The earliest alterations included the formation of clay and clay-ferruginous rims on detrital grains, and the beginning of mechanical compaction and early cementation. The mesodiagenetic processes included deepening of the effects of mechanical compaction; there was a main phase of alteration and dissolution of feldspar grains and lithoclasts. Various stages of carbonate, sulphate and quartz cementation also developed.

The tested reservoir horizons in the Rotliegend, Main Dolomite and Zechstein indicate the lack of reservoir properties of rocks in the immediate vicinity of the Sława IG 1 borehole.

Hydrogeological investigations of the Buntsandstein and Muschelkalk aquifers show disadvantageous conditions for the use of mineral waters for medicine purposes. Water from the Buntsandstein aquifer is characterised by mineralisation exceeding 180 g/dm^3, which does not allow for using it for therapeutic purposes. The Muschelkalk deposits yielded no water inflow, or the inflows were very low.

The analysis of hydrogeological conditions, based also on the results of well logs, indicates a negative assessment of the possibility of obtaining mineral or thermal water from a utilitarian point of view.

A set of borehole geophysical measurements was performed in the Sława IG 1 borehole. However, due to their limited range and, first of all, low measurement standard because of the use of very poor-quality well-logging methods in the 1970s, the results and parameters are only approximate. In general studies related to, *e.g.*, geothermal energy recovery, hydrogeology, analyses of CO_2 sequestration, or near-surface geophysical modelling, including seismic and gravity surveying, they should be used to a limited extent and with a great caution.