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## SUMMARY

The Szwejki IG 3 borehole was performed in the southern part of the Płock Trough; in the Paleozoic plan, it is located in the NW part of the Radom–Kraśnik High, close to the joint point of four tectonic units and separating them Grójec and Nowe Miasto faults. The primary objective of the drilling was to investigate the base of the Permian: its lithology and stratigraphy, as well as reservoir properties and perspectives for hydrocarbon generation.

According to the plan, the borehole reached a depth of 5501 m. It drilled through Cenozoic, Cretaceous, Jurassic, Triassic, Upper Permian, and ended within the Devonian rocks. The drilling allowed to determine that the Radom–Kraśnik High extends towards NW, beyond the Nowe Miasto Fault.

The borehole was cored unevenly – no core was collected from the Cenozoic and Upper Cretaceous rocks, control cores representing up to few % of a given system come from the Lower Cretaceous, Jurassic and Triassic; formations beneath the Mesozoic were cored to a larger extent, between ca. 30 to above 90%. Lithostratigraphic sections were developed based on both drilled core investigations and geophysical measurements.

The Devonian (not drilled-through) occurs at depths of 4226.0–5501.0 m, which translates into the total thickness of 1275.0 m of the ?Emsian, Eifelian, Givetian, and ?Frasnian. Most of them were cored, which allowed for better stratigraphic understanding of individual lithostratigraphic units. Within the Devonian there were recognized: Marly Carbonates Unit (not drilled-through; >197.0 m), Marls and Calcareous Shales Unit (258.5 m; 255.7 m according to the core), sandstones and mudstones of the Ostałów Formation (9.5 m; 11.5 m according to the core), shaly carbonates and mudstones of the Bąkowa Formation (486.0 m; 486.6 m according to the core), limestones and dolomites of the Szwejki Formation (198.0 m; 198.2 m according to the core), shales and marls of the Iżanka Formation (51.5 m; 51.6 m according to the core), as well as Dolomites and Limestones Unit (74.5; 75.0 m according to the core). Few transgressive-regressive system tracts has been recognized within the Devonian sec-

tion: Ł-2 (open-marine carbonate-shaly shelf), Ł-3 and Ł-4 (shaly-carbonate subtidal shelf with periodic skeletal accumulations, and shallow-water shelf clastics of the Ostałów Formation corresponding with regressive part of the Ł-4 cycle), Ł-5 (transgressive part of the cycle was identified as an open-marine shelf or carbonate-shaly ramp; during regression periods shallow-water shales and muds of the Łaziska Member were deposited), Ł-6 (an extensive shallow-marine carbonate platform, with dominant component of inner platform facies – Szwejki Formation), Ł-7 (transgressive tract of shaly-carbonate shelf – Iżanka Formation, and regressive deposits of Dolomites and Limestones Unit).

The conodont stratigraphy approach allowed to identify the lower part of the Marls and Calcareous Shales Unit as the Upper Emsian, and the middle part of the unit as Eifelian (Costatus Zone). The basal part of the Szwejki Formation was dated as the middle/upper Givetian, while the upper Givetian falls in the lowermost part of the Iżanka Formation. Data on Devonian biostratigraphy also come from ostracods and corals. Based on ostracods, it was possible to establish the age of the upper part of the Marls and Calcareous Shales Unit as the upper Eifelian, corresponding to *Kockelianus* conodont Zone, while the topmost part of the unit was correlated with the lower Givetian. Ostracod assemblage typical for the middle Givetian was found in the middle part of the Bąkowa Formation, while in its upper part it was typical for the upper Givetian. In this context, Iżanka Formation may correspond to Frasnian. Investigations focused on corals provided coherent stratigraphic results, except for the lowermost part, where only mid-Devonian (instead of Lower Devonian) forms were observed.

The Devonian is directly overlaid by the Upper Permian (3960.0–4226.0 m), starting with basal breccia made of Devonian rocks bonded by dark-gray muddy dolomite. The occurrence of breccia suggests sedimentary (instead of tectonic) contact between the two systems, even though the geologic record lacks the Carboniferous. The upper Permian, which is 265.5 m thick, is cut by two faults and reduced to two twice-repeated cyclothems PZ1 and PZ2. Besides, the Main Do-

lomite and Basal Anhydrite of the PZ2 cyclothem were also found to be repeated; however, the occurrence of PZ3 cyclothem above the fault cannot be excluded. The PZ1 cyclothem accounts for the basal breccia, Zechstein Limestone, Lower Anhydrite, Oldest Halite, and Upper Anhydrite; the PZ2 cyclothem consists of the Main Dolomite and Basal Anhydrite. Development of the Zechstein deposits in the Szwejki IG 3 well, in particular the occurrence of Zechstein Limestone, Main Dolomite, and anhydrites point to deposition within the marginal part of the carbonate platform. In the initial phases, an important role was also played by syndepositional slumps and a very shallow subaqueous sabkha-type deposition system, which implies close distance to the coastline.

Sedimentological studies of Zechstein anhydrites allowed to distinction of several anhydrite types within cyclothem PZ1 and PZ2: massive with traces of flow, brecciated, banded, massive recrystallized, recrystallized with relict banding, layered recrystallized, recrystallized with selenite crystals, veined, porous, and nodular. The anhydrites from the basal part, which show traces of flow, were interpreted as syndepositional landslide deposits, while those occurring above were interpreted as formed under shallow subaquatic conditions. The anhydrites from the uppermost part of the section exhibit typical characteristics of the Upper Anhydrite in the peripheral part of the sedimentary basin.

Petrographic studies of thin sections from the Zechstein Limestone (Ca1) documented equigranular dolomicrosparites with a high anhydrite content. Originally, these were packstones/grainstones/oncoid rudstones or microbial deposits or highly transformed madstones formed in a very shallow-water environment. Identified diagenetic processes include complete dolomitization, pressure dissolution, fracturing, and strong anhydritization. Petrographic studies of the Main Dolomite (Ca2) have shown that these were primarily formed as dolomicrites and, less frequently, dolomicrosparites. Initially, these were mudstone deposits with sparse interbedding of granular (oncoid) sediments, which were completely dolomitized as a result of diagenetic processes. Numerous fractures filled with coarsely crystalline dolomite and anhydrite were found in the middle part of the unit.

The Triassic in the Szwejki IG 3 well was found at a depth of 2520.0–3960.5 m (1440.5 m in thickness). It is represented by a Upper and Middle Triassic, as well as tectonically reduced (at its base) Lower Triassic. The boundary between the Triassic and the underlying Permian rocks is tectonic (Żelichowski *et al.*, 1990). The lowest part of the succession is composed of the Middle Buntsandstein (Samsonów Formation – claystones and mudstones with sparse sandstone interbeddings, with sandstones dominating in the upper part) and the Upper Buntsandstein (sandy mudstones and heteroliths). The sediments of the Lower Buntsandstein and the lower part of the Middle Buntsandstein were tectonically reduced (Żelichowski *et al.*, 1990). The Muschelkalk and Keuper are fully developed; however, a significant thickness (727.5 m) of the Middle Keuper results from tectonic repetitions within the Upper Gypsum Beds and the Studzianna Beds. The Muschelkalk (3482.5–3586.5 m; 104.0 m

in thickness) is tripartite, with the Lower Muschelkalk being dominated by limestones, the Middle Muschelkalk primarily consisting of dolomitic claystones, marls, and dolomites with anhydrite interbeds, and the Upper Muschelkalk dominated by limestone-claystone deposits. All lithostratigraphic units have been identified within the Keuper: the Sulechów Beds (variegated sandstones and claystones), the Lower Gypsum Beds (dolomites, marls, and dolomitic claystones), the Schilfsandstein (sandstones and claystones), the Upper Gypsum Beds (sandstones, calcareous mudstones, and grey claystones), the Studzianna Beds (variegated claystones and mudstones), and the Trileites Beds (grey claystones and mudstones, interbedded with sandstones). The Buntsandstein deposits account for the fluvial and coastal environment, proximal to the carbonate shelf. The Muschelkalk represents the typical for this unit shallow carbonate shelf environment. Marine regression, recorded at the Muschelkalk/Keuper transition, brought back the terrestrial environments – primarily the fluvial floodplain. Due to the very low percentage of core yield within the Triassic interval (~6%), no biostratigraphic data were obtained for this interval.

Buntsandstein and Keuper formations were subjected to petrographic studies and diagenetic investigations. Based on the obtained results, the Buntsandstein rocks were found to consist of wackes and arenites, in which the detrital material is represented primarily by monocrySTALLINE quartz. Feldspars, micas, and lithoclasts – primarily fragments of crystalline and metamorphic rocks – are also present. Fragments of sandstone, siltstone, and claystone also occur. Monazite, zircon, and tourmaline were observed as accessory minerals. The sandstone cement is primarily contact and/or porous. Among the cement components, carbonate minerals, authigenic quartz, anhydrite, kaolinite, chlorite, and iron hydroxides were distinguished. The effects of diagenetic dissolution and replacement processes were commonly observed, as were the effects of chloritization, kaolinitization, and, to a lesser extent, illitization, which affected the detrital grains and cement components. The Keuper rocks include fine-grained lithic and sublithic sandstones and limestones. The sandstones are represented by quartz or lithic (sublithic) arenites and wackes. The main components of the detrital material in the sandstones are mono- and polycrystalline quartz, with smaller amounts of feldspars (mainly anhedral plagioclase grains, less frequently potassium feldspars). Lithoclasts (fragments of quartz crystalline rocks, quartz-mica schists, quartz schists, and claystones) have also been observed, along with micas (muscovite, biotite), zircon, and staurolite, as well as single glauconite grains and a few pseudoooids. Iron oxides and hydroxides, as well as leucoxene, are also present. The main cementing components include allo- and authigenic clay minerals (chlorites, kaolinite, illite), carbonates (calcite, dolomite), anhydrite, and quartz.

A complete Jurassic (Tithonian–Hettangian) succession was found in the Szwejki IG 3 well at depths of 562.5–2520.0 m (1957.5 m in thickness) and drilled largely without core collection. The Lower Jurassic, 592.5 m thick, occurs at depths of 1927.5–2520.0 m. It is composed exclusively of si-

liciclastic rocks of (from the bottom to the top) the Zagaje, Skłoby, and Przysucha ore-bearing formations (Hettangian), Ostrowiec Formation (Sinemurian), Gielniów and Drzewica formations (Pliensbachian), as well as Ciechocinek and Borucice (Toarcian). The Lower Jurassic is dominated by gray and dark gray siliciclastic rocks deposited in a terrestrial environment. The percentage of sandstones and claystone-mudstone formations varies depending on the formation – mudstones and claystones dominate the Zagaje and Ostrowiec formations, while sandstones predominate in the Drzewica and Borucice formations. Only sandstones of the Skłoby Formation (part of the Hettangian) and the mudstone-claystone deposits of the Gielniów Formation (early Pliensbachian) are of marine origin. Furthermore, the greenish-gray claystone-mudstone rocks of the Ciechocinek Formation (early Toarcian) manifest a distinctly brackish character.

The Middle Jurassic was defined at depths of 1355.0–1927.5 m, which translates into the total thickness of 572.5 m. The Aalenian, Bajocian, and Bathonian intervals are dominated by dark gray claystones and mudstones, and light gray sandstones; subordinately, the Middle and Upper Bathonian sections contain sandy limestones and calcareous-dolomitic sandstones, while the Callovian is composed of sandy dolomitic limestones. The Middle Jurassic begins with the 85 m thick Lower Aalenian sandstone complex of estuarine origin. Above, an epicontinental marine facies, forming transgressive-regressive cycles, occurs. The lower parts of those cycles are dominated by dark gray claystones and mudstones (Upper Aalenian–lowermost Bajocian, Upper Bajocian, Lower Bathonian) formed in the disoxic offshore zones. The upper parts of the cycles are composed of sandstones and mudstones (upper Lower Bajocian, uppermost Bajocian) deposited in the foreshore zone. Very poor coring and the predominantly sandstone-carbonate lithology of the Middle and Upper Bathonian and Callovian have prevented the determination of cycle boundaries in this interval.

Upper Jurassic occurs at depths of 551.0–1355.0 m (804.0 m in thickness). It provides a complete record of the Oxfordian through the Tithonian. Within the Upper Jurassic interval, a number of formations have been distinguished (from the bottom): Spongy Limestone Fm. (I), Calcareous-Marly Fm. (II) or Coral Fm. (III), and above that, Oolitic Fm. (IV), Calcareous-Marly-Coquina Fm. (V), Pałuki Fm. (VI), and the lower part of the Kcynia Fm. – the *Corbulomima* Limestone Member. The 199 m thick Spongy Limestone (I) Formation is composed of organodetrital spongy limestones, largely dolomitized and silicified, and – in its upper part – pelitic limestones with sponge spicules, flints, and fragments of echinoderms. Based on petrographic studies, those were classified as floatstones and spongiolit packstones/wackestones. The following Calcareous-Marly/Coral (II/III) Formation was documented in a single core containing pelitic limestone (wackestone), while the Oolitic (IV) Formation was not cored. Their presence and boundaries were established based on regional correlations. The Calcareous-Marly-Coquina (V) Formation is developed as a complex of alternating thick series of limestones, marly limestones, and marls, which contain frag-

ments of bivalves, brachiopods, and echinoderms. Petrographic analysis of thin sections revealed significant variability in microfacies (rudstones, floatstones, packstones, mudstones) and the presence of numerous oncoids, intraclasts, and skeletal elements of echinoderms, bivalves, brachiopods, gastropods, and foraminifers. The Pałuki Formation is dominated by marls and clay-marly mudstones with marly limestone intercalations (designated as mudstones). The coreless Kcynia (VII) Formation covers the uppermost Tithonian *Corbulomima* Limestone Member. Microfaunal studies of the three topmost Upper Jurassic formations allowed only for a general age determination as the Kimmeridgian–Tithonian.

The Cretaceous of the Szwejki IG 3 borehole (101.5–551.0 m) was drilled almost coreless. Based on geophysical logs, a single core, drill cuttings, as well as correlation with adjacent boreholes, the Lower Cretaceous has been established as 197.0 m thick (354.0–551.0 m), while the Upper Cretaceous is 252.5 m thick (101.5–354.0 m). The basal part of the Lower Cretaceous is represented by the Białobrzegi Formation (Upper Valanginian–Hauterivian) and above the Mogilno Formation (Barremian–Middle Albian) have been distinguished. The Mogilno Formation is transgressively sealed by the Upper Albian deposits. The Białobrzegi Formation, developed as mudstones and claystones with heterolithic interbeds in its lower part, and transitioning to sandy mudstones, silty sandstones, and sandy limestones with glauconite, has been assigned to the Valanginian based on the foraminiferal microfauna and bivalve macrofauna. The upper part of the formation, developed as slightly calcareous mudstones, most likely represents the Hauterivian. The Białobrzegi Formation was deposited within a shallow siliciclastic-carbonate shelf. The sandstone deposits of the Mogilno Formation represent a shallow siliciclastic shelf zone. The Upper Albian formations (topmost Lower Cretaceous) are developed as gray sandy marls with glauconite, with gaize interbeddings and isolated phosphates at the top.

The Upper Cretaceous interval includes the Cenomanian, Turonian, and Coniacian. Drill cuttings investigations allowed for only approximate age determination of those rocks. The Cenomanian consists of sandy marls and marly limestones with glauconite and isolated cherts. The Turonian and Lower Coniacian account for marly limestones with intercalations of marls and opokas (carbonate-siliceous deposits), while the Upper Coniacian is developed as opokas and marls. The Upper Cretaceous was deposited on carbonate and carbonate-silica shelves of a vast marine basin.

The Coniacian (Upper Cretaceous) is directly overlaid by the Neogene (56.0–101.5 m; 55.5 m in thickness), and the Quaternary (0.0–101.5 m; 101.5 m in thickness). The Neogene is represented here by the Middle and Upper Miocene deposits: fine-grained sands of the Adamów Formation and variegated clays and silty sands of the Poznań Formation. The Quaternary accounts for the Middle Polish Glaciation deposits. These are gray clay, gravels, and variegated sands deposited during the Odra Glaciation, as well as, at the top of the section, till representing the Warta Glaciation.

Vitrinite reflectance investigations were applied to samples coming from the Devonian, Permian, Triassic, Lower, and Middle Jurassic. They are characterized by a low content of organic matter of humic origin. Most samples are dominated by an amorphous form of vitrinite – collinite; tellinite with preserved cellular structure and vitrinite in the form of thin laminae or larger fragments or lenses were rarely encountered. Macerals from the inertinite group are very rare and include thin-walled fusinite, massive semifusinite, as well as micrinite and inertodetrinite. Exinite (liptinite) was observed primarily as resinite impregnating tellinite cells, or occasionally forming lenses in the sediment. In one sample, the majority of the organic material was composed of spores. The degree of alteration of the analyzed organic matter is limited and increases with depth. Mean reflectance values vary from 0.65% (Middle Jurassic), through 0.72–0.73% for the Lower Jurassic, 0.75–0.91% for the Triassic, 0.85–0.88% for the Zechstein, to 0.61–1.18% for the Devonian. This corresponds to the transition from the bituminous coal to the coking coal stage, indicating that, during the diagenesis, the analyzed deposits were subjected to the main phase of liquid hydrocarbon generation.

Rock-Eval analysis of the Devonian–Upper Jurassic interval confirmed low total organic carbon (TOC) content, which rarely exceeded 0.5%. A  $T_{max} < 430^{\circ}\text{C}$  indicates that the Upper Jurassic samples, as well as most of those coming from the Lower Triassic and Permian/Upper Devonian interval, are thermally immature. The rest of the samples mostly fall within the kerogen II/III oil window ( $430^{\circ}\text{C} < T_{max} < 455/465^{\circ}\text{C}$ ). Besides, a single Upper Triassic sample and several Eifelian and Emsian samples exhibit  $T_{max}$  values within the gas window or are postmature. According to the S1 parameter values, no sample evidenced elevated hydrocarbon generation. The S2 parameter indicates that two samples (from depths of 1797 m and 4973 m) manifest at least good potential for hydrocarbon generation, but their thermal maturity exceeded the oil/gas window. Almost all of the investigated samples are characterized by HI values between 11 and 200 mgHC/gTOC, which indicates only the gas-prone type III and/or IV kerogen. The production index (PI) of most of the samples also indicates that the organic matter is immature ( $\text{PI} < 0.2$ ) or postmature ( $\text{PI} > 0.4$ ).

Bitumen and hydrocarbon content also reveal low organic matter content (mostly 0.1–0.2%  $\text{C}_{org}$ ); slightly higher values were observed only in the Jurassic and some of the Keuper and Devonian horizons. Bitumen is sparse, usually low-altered, and is characterized by a predominance of aromatic hydrocarbons over saturated hydrocarbons. Highly altered bitumens occur only within the Middle Devonian limestones. There, hydrocarbons occur in higher amounts (0.028–0.032%) and manifest a significantly lower degree of aromaticity. The calculated CPI indicates that the hydrocarbon migration is limited.

The burial history in the Szwejki IG 3 borehole spans the Eifelian–Pliocene interval, including two stratigraphic gaps.

In this time, the section was subjected to (1) a phase of rapid burial (Eifelian–Late Frasnian); (2) a phase of rapid uplift (Early Famennian–Early Zechstein); (3) a very long phase of subsidence, lasting from the Late Permian to the mid-Late Cretaceous, which is characterized by three stratigraphically shorter phases, each consisting of an initially slower and then rapid subsidence and burial phase (Late Permian–Middle Triassic, Late Triassic–Oxfordian, Kimmeridgian–Late Coniacian); (4) a phase of rapid uplift (Early Santonian–Early Paleogene); and (5) a phase of stagnation (Early Paleogene–present).

Tectonic structures corresponding with several extensional and compressional phases were recorded in the Szwejki IG 3 well. Extension occurred before the Late Carboniferous, forming veins filled with pinkish-white calcite. This was followed by deformation in a thrust regime (before the Permian), leading to the formation of shallow slickensides and veins filled with white calcite. Abnormal pore pressure occurred during this phase, and slight folding of the complex may have occurred. Deformations observed within the Zechstein sulfates may be associated with slope flows, while dense and irregular fractures within the dolomites may result from limestone metasomatism and the loss of volume. It is possible that the exceptionally intense fracturing and extension within this interval are associated with the presence of a fault zone or flexure. The Triassic interval is characterized by the occurrence of numerous slickensides (on bedding surfaces) and irregular fractures, as well as significant deviations in bedding direction, which indicate increased tectonic deformation and suggest the proximity of a fault. Within short Jurassic core intervals, intensely fractured dolomites were found, which suggests their diagenetic origins.

In the seismic cross-section, in the vicinity of the borehole, two SW-dipping faults cutting the Devonian, Permian, and Lower Triassic, and terminating in the lower part of the Upper Triassic, were identified. The presence of one of these faults, passing through the borehole in Permian formations, is also confirmed by structures visible in the core at a depth of 4041.0 m. To the NE, a few kilometers from the Szwejki IG 3 borehole, runs the Nowe Miasto fault zone. It is bounded by two faults, of which the SW-most ‘main’ fault, rooted in sub-Permian formations, is located between the Szwejki IG 3 and Szwejki 1 boreholes, while the second (rooted in Permian formations) is located to the NE of the Szwejki 1 borehole. Initially, the SW fault was a reverse fault, and the NE fault was a normal fault. During the inversion of the Mid-Polish trough, the direction of the movement changed, what results – starting from the Middle Jurassic beds – in a normal character of the SW fault and a reverse character of the NE fault. Secondary normal faults are also observed within the fault zone.

The results of seismic velocity measurements in the Szwejki IG 3 well allowed for a determination of a number of velocity complexes, indicating lithological changes within the stratigraphic units. An increase in velocity was no-

ted between the Quaternary sands and clays, through Coniacian marls and opokas, to Turonian limestones. After a slight decrease at the Upper (including Albian)/Lower Cretaceous transition, a further decrease was observed between the Valanginian limestones and marls and the Kcynia Formation (limestones and anhydrites). A marked increase in velocity was observed at the boundary between the Kcynia and Pałuki formations. The greatest contrast throughout the entire well was observed within the Upper Jurassic, at the boundary between the Calcareous-Marly-Coquina (V) Formation and the Oolitic (IV) Formation. Beneath the base of the Oolitic Formation, towards the Bajocian, a gradual decrease in velocities, associated with a gradual lithological change from limestone to sandstone, is observed; it is followed by a reverse trend towards the Hettangian. The Hettangian and the Upper Triassic are manifest limited variability of seismic velocities. Distinct reflections, which should be visible on seismic cross-sections, were observed also within the Triassic, where Muschelkalk facies clearly distinguish from the underlying and overlying clastic deposits; a corresponding applies to the Permian and the boundaries between the basal anhydrite (A2) and the main dolomite (Ca2), as well as between the lower anhydrite (A1d) and the Zechstein Limestone (Ca1). In the basal part of the section, a strong decrease in velocities accounts for the boundary between the Frasnian Dolomites and Limestone Unit and the Ilzanka Formation (claystones and marls).

A total of 770 samples were subjected to identification of their physical and chemical properties; in the case of drill cut samples, only carbonate (calcite and dolomite) content was evaluated. Specific weight, bulk density, effective porosity, and the total porosity were determined for 300 core samples, while in the case of 295 samples, horizontal and vertical permeability were also measured (for most samples, permeability was  $< 0.1$  mD, or analyses were not possible). For the Devonian and Permian formations, average effective porosity was 0.12–5.75% and the total porosity was 0.33–5.94%. These are mostly impermeable ( $< 0.1$  mD) or very poorly permeable (0.36–20 mD for the Devonian and 0.26–2.00 mD for the Permian). The Triassic is characterized by an average effective porosity of 2.89% (0.14–14.42%) and an average total porosity of 3.68% (0.36–15.35%), with the best parameters observed in the Upper Rhaetian sandstone (depth 2644.4 m). Permeability ranged between  $< 0.1$  mD (for half of the examined samples) and 182 mD (in the Upper Buntsandstein sandstone). The Lower Jurassic manifests an effective porosity of 1.48–25.81%, total porosity of 1.73–26.22%, and permeability of  $< 0.1$ –1240.0 mD. The highest permeability was observed in sandstones belonging to the Borucice Formation (375.0–1240.0 mD). Middle Jurassic samples display an average effective porosity of 11.83% (0.49–24.46%) and an average total porosity of 14.11% (0.69–25.00%). Permeability ranged from  $< 0.1$

2750.0 mD. The highest value was recorded in the Aalenian sandstone (1910.9 m), demonstrating the highest permeability throughout the entire drilling. Within the Upper Jurassic, effective porosity ranged between 3.31% and 21.53%, total porosity between 4.44% and 22.96%, while permeability ranged between  $< 0.1$  mD and 0.57 mD. Two Lower Cretaceous samples manifest effective porosity of 3.76–7.40%, total porosity of 4.04–8.08%, and no permeability.

Several reservoir horizons were sampled in the well: 3 levels in Devonian limestones (depths 4222.0–4250.0 m, 4270.0–4297.0 m and 4307.0–4550.0 m), 1 level in Permian (Main Dolomite, depth 3993.0–4023.0 m), 1 level in Lower Triassic sandstones and mudstones (depth 3675.0–3710.0 m) and 1 level in Middle Jurassic sandstones (depth 1620.0–1650.0 m). Sampling revealed poor reservoir properties of the Devonian formations, as evidenced by limited brine flows (0.09–0.88 m<sup>3</sup>/h) and relatively low reservoir pressure with pressure gradient  $G = 1.08$  at/10 m. The brines contained natural gas with approximately 60% volume of hydrocarbons, including 17% of heavy hydrocarbons, which is indicative of the presence of crude oil within the Devonian in the vicinity of the Szwejki IG 3 well. The Permian formations are characterized by a lack of reservoir properties. The reservoir properties of the Buntsandstein were determined as medium, as evidenced by a brine flow of 1.39 m<sup>3</sup>/h and the extrapolated reservoir pressure  $P_z = 365.9 \times 10^3$  hPa; this value corresponds to  $G = 0.99 \times 10^3$  hPa/10 m. The brines manifest a high degree of metamorphism and high mineralization. They also contain natural gas, constituting 31.1% of hydrocarbons by volume, indicative of favorable conditions for the hydrocarbon preservation. The brines occurring within the Lower Triassic can be classified as relic brines in a zone of hydrodynamic stagnation. This is indicated by the 'r' index value ( $\text{Na}^+/\text{Cl}^-$ ) significantly below 0.86, the chloride-to-bromide ratio significantly below 300, as well as the sulfate index value  $< 1$ . Very good reservoir properties, with an inflow of 1.96 m<sup>3</sup>/h and significant permeability, characterize the Middle Jurassic horizon. The low mineralization of the waters and their weak metamorphism indicate that they should be classified as relic/synsedimentary waters with a distinct admixture of paleoinfiltration waters, typical of the transitional zone between the hydrodynamic stagnation zone and the zone of active exchange. This is confirmed by the ratio of equivalent weights of sodium and chloride ions  $< 0.86$  and the sulfate index  $< 1$ , along with the  $\text{Cl}^-/\text{Br}^-$  index significantly exceeding 300. Consequently, conditions for the hydrocarbon preservation in this interval are unfavorable.

The Devonian interval brought only brines contaminated with drilling mud; those were not chemically tested. The Lower Triassic brines are of chloride-sodium-calcium iodine type, while chloride-sodium-potassium iodine type brines were obtained from the Middle Jurassic.

The Szwejki IG 3 borehole has fulfilled its geological purpose.