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Summary of the doctoral dissertation

The influence of depositional architecture on the distribution of reservoir properties and natural gas accumulations in the "Przemyśl 3D" seismic cube (Miocene of the Carpathian Foredeep)

The Middle Miocene Machów Formation represents main sedimentary increment in the Carpathian Foredeep infill and hosts numerous gas fields. The formation was studied in the area of the "Przemyśl 3D" seismic survey that largely corresponds to the high-methane natural gas field "Przemyśl". The research was initiated in response to the intensification of exploratory works focused on the verification of hydrocarbon resources in the discovered oil and gas fields in Poland. The latest results show, among others, that a significant hydrocarbon potential may exist in thin-bedded sandstone-mudstone alternations (heterolithic facies), which were mostly underestimated in this respect. The poroperm properties of such heterolithic reservoir rocks depend predominantly on the sandstone content. However, this parameter can hardly be evaluated properly in such thin-bedded, binary lithology using standard geophysical methods.

The main goal of the work was to interpret the stratigraphic architecture of the Machów Formation in terms of lithofacies, facies associations and main depositional elements, as well as to elucidate on links between these sediment units and their reservoir properties. An important part of the research involved constructing a range of consistent structural and parametric 3D models of individual reservoir series based on the integration of the results of facies analysis, wireline log interpretation and seismic analysis. The sedimentological logs were augmented with the results of selective filtration of core images. This enabled the precise determination of the sand content within the distinguished facies associations. All results of petrophysical formation evaluation were integrated through the 3D numerical modelling on the Petrel platform, where the simulated parameters were bound to “shaliness” classes.

In the study area, 16 lithofacies and 8 facies associations were identified and interpreted based on the examination of well cores, 449 m in the total length. The facies spectrum reflects a variety of products laid down mainly from turbidity currents, accompanied by cohesive debris, slumps, and rarely storm deposits. Among the turbidites, the non-classical ones predominate and provide features suggestive for a hyperpycnal feeder system. Noteworthy, hybrid event beds were identified for the first time within the Machów Formation. Such beds document a down path flow transformation from turbulent to cohesive flow conditions. The facies associations and their successions reflect deposition within a structurally controlled, basinal turbidite setting, submarine fans and mud-rich slopes possibly

extending upwards slightly above the storm-wave base. The facies associations documents main depositional elements comprising: (1) extensive levees, (2) distal fans and interlobe areas, (3) depositional lobes dissected by shallow distributary channels, (4) channel-levee systems, (5) upper fan dissected by central channel, (6) sandy lobes associated with lower slope fans, (7) lower muddy slope containing depositional lobes and products of slope gravity collapse, and (8) upper muddy slope located between the fair-weather and storm-wave base. The resultant facies models reveal the presence of nine deep-water fans built of highly laterally connected sandstone bodies that form the main reservoir volume. Many sandstone bed types display petrophysical parameters typical of conventional reservoirs. Good petrophysical properties are also observed within thin-bedded heteroliths, which are characterized by relatively low net to gross and can be classified as subconventional reservoirs. In particular, such range of reservoir properties is observed within the extensive levee deposits, where the estimated average sandstone content is 23%. Linking the electrofacies model to reservoir properties has allowed determining a series of domains typified by specific distribution of reservoir properties, such as effective porosity, or net to gross ratio. The constructed static models calibrated to facies models enable to predict the abovementioned parameters for future drilling at any location across the Machów Formation.