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Quantification of structural uncertainties in multi-scale models; case study of the Lublin Basin, Poland

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The multiscale static modeling of regional structure of the Lublin Basin is carried on in the Polish Geological Institute, in accordance with principles of integrated 3D geological modelling. The model is based on all available geospatial data from Polish digital databases and analogue archives. Mapped regional structure covers the area of 260x80 km located between Warsaw and Polish-Ukrainian border, along NW–SE-trending margin of the East European Craton. Within the basin, the Paleozoic beds with coalbearing Carboniferous and older formations containing hydrocarbons and unconventional prospects are covered unconformably by Permo-Mesozoic and younger rocks. Vertical extent of the regional model is set from topographic surface to 6000 m ssl and at the bottom includes some Proterozoic crystalline formations of the craton. The project focuses on internal consistency of the models built at different scales – from basin (small) scale to field-scale (large-scale). The models, nested in the common structural framework, are being constructed with regional geological knowledge, ensuring smooth transition in the 3D model resolution and amount of geological detail.
Major challenge of the multiscale approach to subsurface modelling is the assessment and consistent quantification of various types of geological uncertainties tied to those various scale sub-models. Decreasing amount of information with depth and, particularly, very limited data collected below exploration targets, as well as accuracy and quality of data, all have the most critical impact on the modelled structure. In deeper levels of the Lublin Basin model, seismic interpretation of 2D surveys is sparsely tied to well data. Therefore time-to-depth conversion carries one of the major uncertainties in the modeling of structures, especially below 3000 m ssl. Furthermore, as all models at different scales are based on the same dataset, we must deal with different levels of generalization of geological structures. The same degrees of generalization shall be applied to uncertainties. However, approach for uncertainty assessment and quantification may vary depending on the scale of the model. In small scale regional and sub-regional models deterministic modelling methods are used, while stochastic algorithms can be applied for uncertainty modelling at large scale multi-prospect and field models.
We believe that the 3D multiscale modelling describing geological architecture with quantified structure uncertainties, presented on standard deviation maps and grids, will allow us to outline exploration opportunities as well as to refine existing and build new conceptual models. As the tectonic setting of the area is the subject of long-term dispute, the model depicting at different resolutions both structures and gaps in geological knowledge shall allow to confirm some of the concepts related to geological history of the Lublin Basin and reject or modify the others.