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Improved seismic imaging of the Szamotuły salt diapir (NW Poland) based on finite-difference full waveform modelling

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The Szamotuły salt diapir, located in NW Poland, was formed within the Mid-Polish Trough – Permo-Mesozoic sedimentary basin that was inverted during the Late Cretaceous to Paleogene. The Szamotuły diapir was sourced from the Upper Permian (Zechstein) evaporites. Tectonic evolution during extension and compression resulted in a very complex geometry of the salt body and surrounding Mesozoic sedimentary sequences. This, together with significant velocity contrasts between the Zechstein evaporites and the Mesozoic siliciclastic – carbonate sequences resulted in complicated seismic ray paths that hampered seismic imaging of the salt diapir and supra-salt and sub-salt sedimentary strata.

The aim of this work was to apply and test selected seismic imaging methods (pre- and post-stack time migrations) for improved imaging of the salt diapir, including its steep and overhang walls, salt wings etc. The study was carried out by using theoretical waveform which was calculated using finite-difference method. The synthetic data were based on the geological depth model which was constructed using results of interpretation of the regional 2-D seismic profile crossing Szamotuły diapir zone. Additional information was provided by well logs from several wells drilled in the study area. The seismic modelling was completed using Gedco's Omni software. Before performing the full waveform modelling, the offset modelling based on seismic ray theory (seismic ray tracing) was carried out. The results of the offset modelling were used to design the survey methodology of the synthetic seismic profile and to plan the most effective processing workflow. Then, synthetic common-shot gathers were generated using a finite-difference solution of the 2-D wave equation in acoustic variant. Finite-difference modelling results were subsequently used during the next processing stage of that study which was done using Gedco's Vista Seismic Processing software. Important part of this work was multiples attenuation using predictive deconvolution in tau-p domain and iterative seismic velocity analysis before the PreSTM. Tested time migration techniques included Kirchhoff pre- and post-stack migration and post-stack FD migration. Finally, the comparison of the migration results was carried out, especially the analysis of imaging quality of the steep salt diapir flanks, salt overhangs and wings, and Lower Permian (Rotliegendes) and older sub-salt sedimentary sequences. The final results proved that the quality of the time imaging in that area strongly depends on the acquisition parameters, particularly offsets distribution and migration aperture distance. The elimination of the selected multiple waves at the processing stage (especially attenuation of intra-bed multiples) may be a strong challenge for the further studies which may improve the quality of time imaging using real data, and then depth imaging and more advanced seismic interpretation of the Szamotuły salt diapir.