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Reducing sub-salt exploration uncertainties with insights from analogue modelling: Eastern Carpathian Bend Zone, Romania

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Fold and thrust belts affected by salt tectonics are an exploration challenge anywhere worldwide. It is the same case in the most prolific onshore area of Romania, the foreland of the Eastern Carpathian Bend Zone (ECBZ). The ECBZ is a thin-skinned fold and thrust belt, part of the Romanian Carpathians. Recent work in the area based on seismic interpretation and forward modelled regional cross sections and scaled analogue modelling, present a structural style characterised by supra-salt detachments folds and sub-salt duplexes. Due to the poor quality of the seismic in the sub-salt and the reduced number of deep wells, these areas present a high degree of uncertainty. The high structural complexity of the reservoirs in the ECBZ is given not only by the presence of multiple detachment levels but also by the superposed tectonic events (from Miocene to Recent).
Scaled sandbox models with layered brittle and ductile materials were used to gain critical insights in the structural evolution of this fold and thrust belt (ECBZ) and on the complexity of the sub-salt duplex structures. The models have been geometrically, kinematically and dynamically scaled in order to be quantitatively and qualitatively representative. Coloured dry quartz sand was used for modelling the brittle behaviour, while silicone was used for the ductile behaviour of the salt. For the other detachment levels, we used multiple types of materials, from 200-300 μm glass beads to silicone or a mixture of silicone and granular materials, in order to test the effects of these changes on the evolution of the sub-salt duplexes.
The experimental setup consists of a fixed horizontal box with one glass sidewall, below which a mobile base plate is pulled against at a constant rate. Deformation monitoring has been achieved with the use of side- and top-view 2D digital image correlation techniques (DPIV- Digital Particle Image Velocimetry). 3D digital elevation models (DEM) of the experiments were gathered with an IR projector and camera. After post-experiment treatment (wetting and consolidation), the models were serially sectioned and photographed. These vertical sections were used to build and interpret 3D digital models of the experiments.
Experimental results reduce exploration uncertainties both by bringing more insights into the overall fold-belt geometry and illustrating the possible geometries of sub-salt deformation which ranges from sub-salt duplexes to sub-salt buckle folding, depending on the efficiency of the detachment layers. The results of the analogue modelling experiments can also be used to improve seismic interpretation and better predict subsurface geometries in the poorly constrained areas, aiding in both development and further exploration potential of this mature hydrocarbon area.