New Plays Revealed by Structural & Basin Modelling: A case study workflow from the Romanian Eastern Carpathians

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The Romanian Eastern Carpathians are part of the Alpine system, formed in response to the Cenozoic Himalayan-Alpine orogen. The Carpathian orogenic wedge verges eastward, overriding the previously extended Eastern European foreland block. A 4km deep foreland basin developed in response to tectonic compression, structural and sediment loading during the Miocene. Exploration and production efforts until the present day have focused on Miocene plays in the foreland basin and shallow, largely Palaeogene thrust anticlines in the fold belt.

The Eastern Carpathians hydrocarbon province is mature and structurally complex; Petrom operates the Moinesti Production Block, where oil was first discovered and produced in 1886. The block has since recovered over 2.5 BBOE from 41 fields exploiting Eocene, Oligocene and Miocene reservoirs. Little exploration potential remains in the shallow fold belt; of more than 5,000 wells drilled only 132 extend below 1500m depth, the majority of which exploit shallow targets. Consequently over the past 30 years a lack of major new discoveries has resulted in a flattening of the creaming curve. The challenge is to identify new plays in an area covered only by sparse seismic data where the harsh terrain and complex geology conspire to reduce the quality of what little reflection data there is available. We present a workflow comprising quantitative section construction in combination with structural and basin modelling that elucidates a previously unrecognized, large prospective closure at depth.

The few deep well data on hand revealed thrust imbricates and stacked ramp anticlines in the upper section. These typically detach within Eocene and Oligocene shales or lower Miocene evaporites. This intense shallow deformation degrades the seismic image of the deeper section. Structural modelling techniques were applied to provide more geologically robust interpretations in the poor data zone at depth. Seven seismic lines were depth converted, imported into structural modelling software and integrated with the deep wells. Dip line interpretations, generated using quantified section construction were tied to well picks, projected up to 2km along strike. The interpretations were balanced to assess area misfit and validity prior to palinspastic restoration. Dip domain analysis of seismic reflectors coupled with the reconstructions revealed a large closure at depth that developed in the Early Burdigalian (approximately 22Ma), which was subsequently modified by continued (in-sequence) deformation on yet deeper detachments. To avoid contamination by artefacts produced during the sequential restoration procedure, a series of forward models were generated for export to basin modelling software. Analysis indicated that sizeable volumes of hydrocarbons were expelled from the Eocene and Oligocene source rocks between 16 and 06Ma - after the onset of trapping - and proved a viable petroleum system for liquid hydrocarbons in the deep play. The balanced sections and strike line were integrated with a Digital Elevation Model (DEM) rendered with a 1:200,000 scale geological map. A three dimensional (3D) geological model was constructed in an effort to assess the lateral fault linkage and overall model integrity. Faults and horizons were exported to a seismic application, converted to time then re-depth converted based on the modified interpretation. The new lines were imported into a mapping package for volumetric analysis which suggested a sizeable prospect. If exploration of the prospect proves to be successful it could open a new play type along the entire Eastern Carpathians fold belt.