Application of structural modeling workflows in sub-salt plays: case studies from Peru and Germany

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We present new structural interpretations from two pre-salt rift basins; one example from the Permian Basin in Germany and two examples from the Subandean Ucayali and Marañon Basins of Peru.

Newly interpreted old vintage 2D seismic along the northeastern margin of the Permian Basin in Germany reveals highly complex salt-cored extensional structures that we call incipient salt-rafts (***Fig. 1a***). These structures overlie a multiphase rift-basin, with horsts and grabens, in which prolific oil and gas reservoirs are actively being explored. The main reservoir targets here are the Permian Rotliegend clastics and Permian Zechstein carbonates. Although pre-salt and post-salt strata are mostly decoupled, there is strong evidence for localized mechanic interference of the underlying rift structures with the overlying salt-rafts. Static and kinematic structural modeling helped us to identify critical exploration risks, related mainly to salt windows that had been overlooked by explorers in the past.

Jurassic evaporates, locally forming salt-pillows, overlie Permo-Triassic (and older) rift sequences in the Peruvian Ucayali and Marañon Basins (***Fig 1b & 1c***). Traditional hydrocarbon exploration in these Subandean Basins so far was focused on the Mesozoic reservoirs, although locally enormous amounts of gas and condensate have been found in Paleozoic reservoirs (Camisea region). The Jurassic evaporates of the Sarayaquillo and Pucara stratigraphic units are only present in the westernmost Subandean domain. In this western area the pre-salt rift sequences are mostly unexplored, mainly due to poor and sparse seismic data, deep targets and poorly understood exploration risks. Regional structural correlations, static and kinematic structural modeling significantly improved the understanding of the pre-salt rift sequences, in terms of size and orientation of half-grabens, depocentres, polarity changes of master faults, transfer and accommodation zones and migration pathways.

In all three projects similar structural workflows were applied: (1) laterally consistent seismic correlations were carried out; (2) individual fault planes were correlated and mapped consistently, if possible in 3D or pseudo-3D; (3) the structural interpretation was conducted with a kinematic model in mind (tectonic history, present-day stress-field etc.); (4) kinematic restoration was conducted to validate the structural model. Common exploration risks found in pre-salt rift basins of Germany and Peru are the absence or presence of salt (may act as top seal or migration barrier), highly complex migration routes (charge), relative and absolute structural trap timing, the degree of coupling and interference between post- and pre-salt strata and the constructive or destructive effect of inversion tectonics.

In summary, static and kinematic structural modeling workflows presented here, based on modern concepts, may significantly contribute to understand complex basins with superimposed structural styles. Even in areas with old and poor 2D seismic, where mapping is difficult, pseudo-3D models help to build structurally robust interpretations and represent a powerful tool in reducing exploration risk.