The Cauca-Patia Basin of Colombia: Applying Multidisciplinary Methods to Improve the Exploration Evaluation of a Frontier inter-montane Basin

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Successful exploration of onshore frontier basins will increasingly depend on a multidisciplinary blend of different data sources and expertise. Basins with simple structuring and clear seismic images have become mature, and onshore basins with complex structural histories and difficult velocity structures are typical of the few remaining unexplored areas. An iterative approach, in which different data sources contribute to an increasingly accurate subsurface picture, is an effective exploration strategy in these basins.

The SW-NE trending onshore Cauca Patia Basin in south western Colombia is bounded to the west by the Western Cordillera and to the east by the Central Cordillera. The Patia Basin (southern sector of the Cauca Patia) is about 80 km long and up to 25 km wide in the central part. The structural configuration has been a matter of debate over the last decades. Previous models represent the basin as dominated by thin-skin tectonics with significant over-thrusting distances. We present new structural interpretations, based on newly reprocessed 2D seismic data and newly acquired 2D seismic data, which independently confirm that the structural style of the basin is dominated by thick-skin tectonics. Based on our observations and due to the geologic context (plate-tectonics, present-day stress etc.), we propose that the structural configuration of the basin is dominated by dextral-transpressional strike-slip tectonics. The roots of the main structures cannot be directly observed due to the noisy data in the deep section. There are indications for localized thin-skin tectonics, which cannot be correlated across seismic lines, mainly due to seismic spacing. Possible thin-skinned detachments could be hosted in shales of the lower Esmita Fm. or, alternatively, at the top of the “Diabasico” economic basement (Cretaceous oceanic crust).

Two general tectonic phases can be distinguished in the basin: an earlier phase which caused the formation of several trends of transpressional structures in the core of the basin (and related localized thin-skin structures) and a later inversion phase which caused the kilometer-scale uplift of both basin-shoulders, juxtaposing Cretaceous economic basement (oceanic crust and crystalline rocks) against the mostly Tertiary basin-fill. Structural timing analysis reveals that the majority of the structural relief was most likely built in post-Miocene times.

Two to three continuous trends of large, basin-parallel anticlines are observed in the basin. These anticlines have no marked vergence, are constrained by surface and seismic data and can be correlated across several seismic lines over distances of up to ten kilometers in strike-direction illustrating significant structural trap potential.

Hydrocarbon seeps are observed in the southernmost part of the basin, which could be due to the fact that the basin floor rises towards the south (as seen on new seismic data) and this could direct migration or remigration from the centre of the basin outwards and towards the south.

Information in the basin includes a scattering of stratigraphic wells, vintage and newer seismic, as well as good surface geology maps and recently acquired aero gravity and magnetic data. Interpretation and processing of the seismic data is hampered by the structural complexity of the basin and unknown velocity field. This has resulted in abrupt lateral changes in the seismic data quality and a high level of uncertainty as to the validity of the structures.

The authors' approach to solving these issues is multi-fold:

1) Use surface geology and potential field data to delimit the edges of the sedimentary basin and identify areas with inherently chaotic data, such as the metamorphic zones and intrusives. These zones can be ignored as exploration targets and seismic imaging of these areas can be considered as less important.
2) Use surface geology and potential field data to map areas where high velocity material, such as basalts or metamorphic rocks, has been thrusted over the lower velocity sediments. At the same time, this data can be used to suggest where lower velocity material is at the surface and that imaging issues are the result of structural complexity and not velocity inversions.
3) Re-process and re-interpret the seismic data, using the new boundaries and velocities suggested by the surface and potential field data, to refine structural models. These can be used to iteratively update the interpretation of the potential field data and overall structural geologic model.

A new gravity and magnetic survey was acquired over the area in by Gran Tierra Energy Colombia. Results are excellent, as can be seen by the close correlation of the derivative maps with the basin boundaries and other structural features. An example is shown in Figure 2.

The resulting updated structural model was fed back into the processing of the seismic data, resulting in various improvements and the generation of a suite of prospects, as detailed in the complete paper.

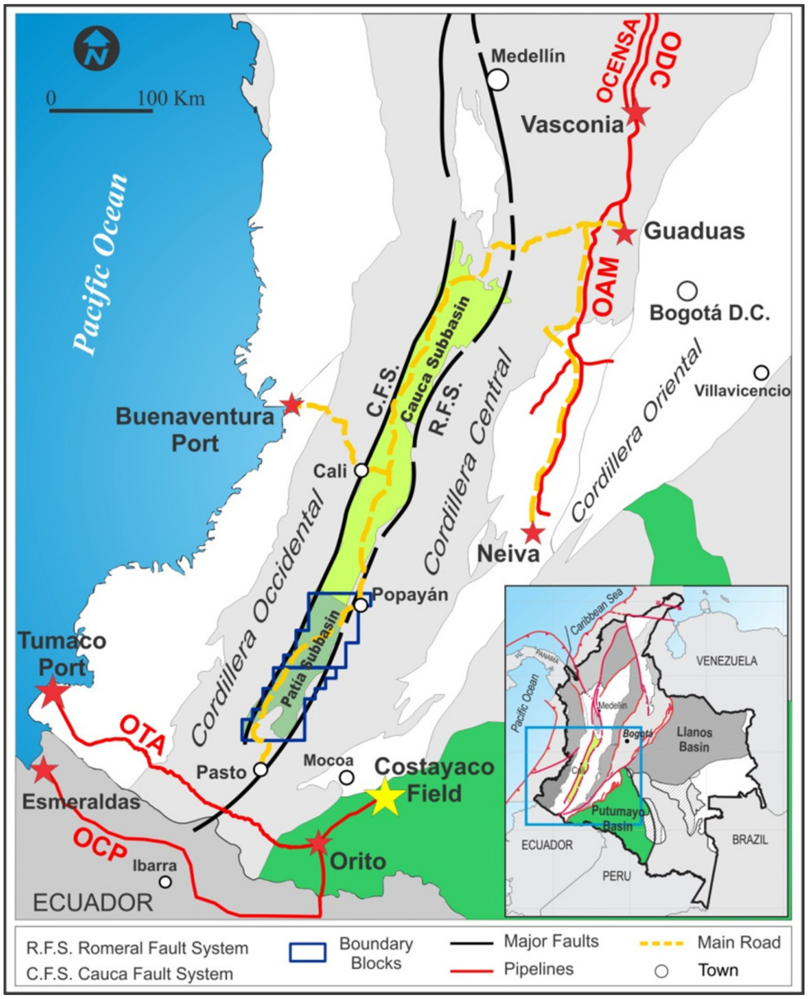

Figure 1 Regional setting

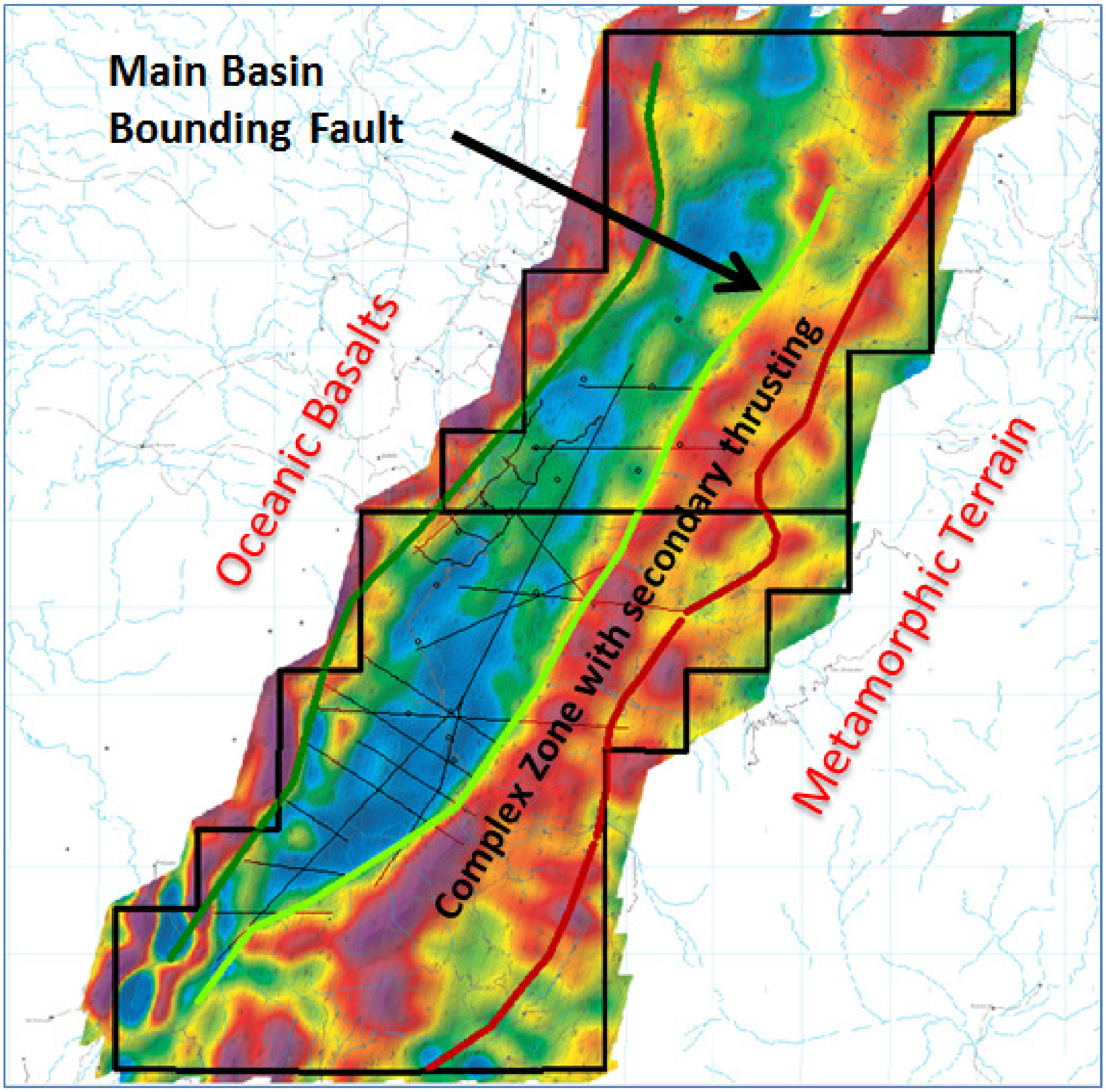

Figure 2 – First Derivative Gravity with Structural Features

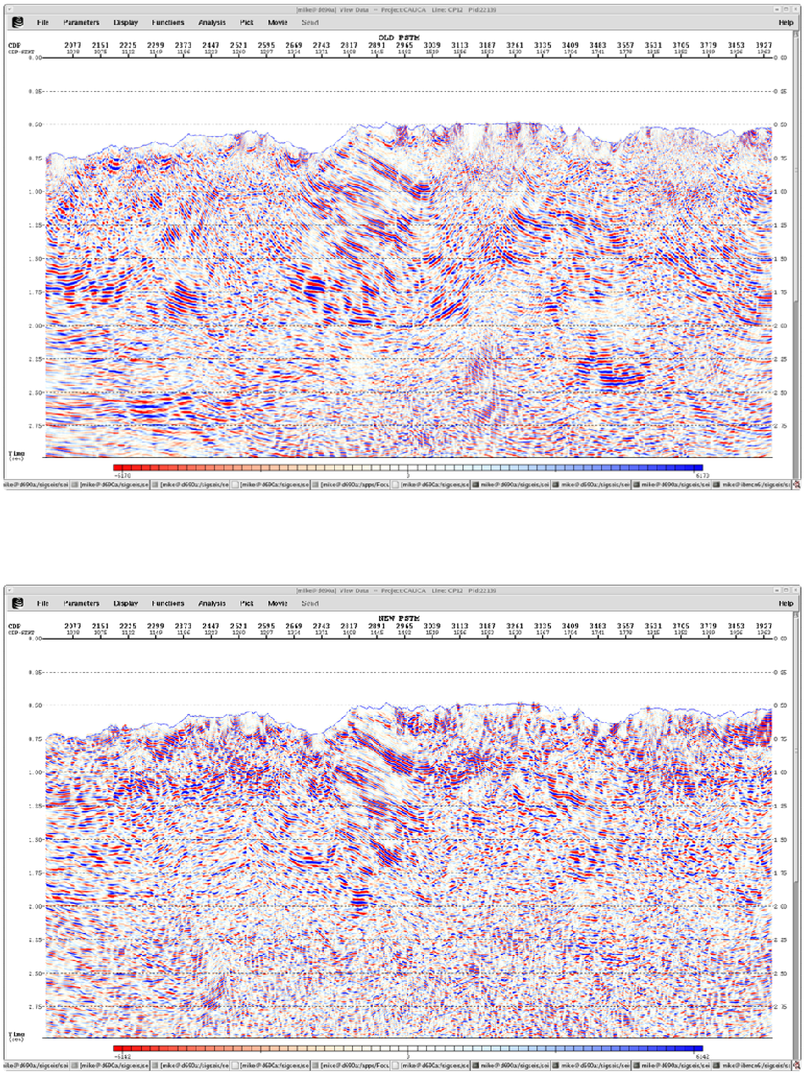

Figure 3 – Comparison of Seismic Images with Old and New Velocities based on Potential Field Data and Surface Mapping