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Structural Evolution of the Situche Complex, Marañon Basin, Peru

Geoff Rait,* David Dolberg and Mark Hearn
Talisman Energy Inc., Calgary, Alberta, Canada
grait@talisman-energy.com

Summary

The Marañon Basin is one of the sub-Andean foreland basins of South America, lying at the south end of the Putumayo–Oriente–Marañon basin trend of southern Colombia, Ecuador and Peru. It contains up to 4000 m of Cenozoic continental deposits derived mostly from the Andes to the west, a gently westward-thickening (to > 1000 m) shallow marine and terrestrial Cretaceous succession derived from the Brazilian Shield to the east, and a restricted marine and terrestrial Triassic–Jurassic succession, including in the west Triassic salt, that unconformably overlies a block-faulted Paleozoic stratigraphy. The Cretaceous succession is very similar in the basins to the north and south, where it hosts most of the oil reserves of the sub-Andean province. In the Marañon, production comes from Upper and Lower Cretaceous sandstones of the Vivian, Chonta, Agua Caliente and Cushabatay formations in fields in the east of the basin that were formed by gentle Neogene inversion of Paleozoic normal faults. The Situche structural complex lies near the western edge of the basin, at the north end of a WNW- to NW-trending zone of en-echelon grabens and half-grabens in Late Cretaceous to Paleogene strata. Oil was tested from the Lower Vivian Formation in well 64-15-2X ("Situche Central-2X") in January 2006.

The Situche complex is a structural assemblage comprising three WNW-trending half-grabens (Situche Norte, Central, & Sur) and, at its south end, a broad, high dome (Situche Sureste) adjacent to a W-dipping reverse fault. The northern half-graben faces NNE and the southern two face SSW. Each has a set of minor antithetic faults that dip oppositely to a single master fault. Stratigraphic and structural relationships show the structures evolved in two main phases: extension during the Late Cretaceous to Paleogene and contraction, with inversion of parts of some of the earlier extensional faults, in the late Neogene. The extensional faults strike WNW and the contractional fault system strikes NNW (roughly perpendicular to the present Nazca–South America plate convergence and local maximum horizontal compression directions). The Cretaceous–Paleogene extension has influenced the thickness distributions of the strata of that age: on the downthrown, rotated side of the larger normal faults, the Chonta to post-Vivian interval shows thickening and wedging. This appears to be unique in the Marañon Basin. The Neogene contractional fault system is, at Vivian level, discontinuous and loses displacement southward. Situche Sureste, at the highest-displacement end of the contractional system, owes its origin entirely to reverse faulting and is the highest structure in the complex. As the contractional system is traced northward towards its termination, the Sur, Central and Norte structures along it become less inverted and less elevated. It is notable that this contraction is very young: even the shallowest reflectors are folded to the same degree as the Pozo horizon.

Although the late Neogene reverse faulting has acted to invert the earlier structures of the complex, at Vivian level most of the normal faults do not show reverse reactivation. Immediately south of where the normal and reverse faults bounding the Situche Central culmination intersect, the resulting single fault displays both early normal and late reverse movement: although at Pozo and higher levels there is structural elevation of the hangingwall, the Chonta to Pozo hangingwall interval is thickened and the Chonta and lower levels remain in net extension. As this compound fault is traced farther SE into the Situche Sur structure, however, this hangingwall thickening diminishes and the fault again displays only late Neogene reverse movement. Evidently, the eastern end of the Situche Central master normal fault has been used to make a hard link between two en-echelon, non-overlapping segments of the late Neogene reverse fault system; but in the rest of the complex, the Cretaceous–Paleogene normal faults are not reactivated and the Neogene contraction has been accomplished on steep reverse faults – probably reactivations of an underlying Paleozoic–early Mesozoic structure or structures – that are oblique to the Cretaceous–Paleogene ones. At Vivian (reservoir) level, the obliquity of the two fault sets combined with the discontinuity of the late contractional set has resulted in culminations that are four-way or three-way closures with triangular shapes.

Although the Situche culminations could broadly be classified as ‘inversion’ structures, the geometries and evolution outlined above make them interestingly untypical examples: the lack of reactivation of most of the normal faults during subsequent contraction is rare, the position of the contractional faults in the footwalls of the extensional faults has resulted in the culminations being in the footwalls rather than the hangingwalls, and the obliquity of the two fault sets combined with the low amount of contraction has resulted in the crest lines of the culminations being oblique to both. Such geometries would be difficult to unravel without 3D seismic or surface exposure.

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