

Geometry and Structural Evolution of a Productive Structure: La Cira Anticline, Middle Magdalena Valley, Colombia

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Abstract

La Cira Anticline is located in a sedimentary basin called Middle Magdalena Valley, Colombia. This structure, that contains hydrocarbons, has been studied mainly at a reservoir scale, but its structural style and kinematic evolution have not been analyzed in detail yet. It is a region in which ductile deformation (folding) coexists with brittle deformation (normal and reverse faults). A 3D seismic data reprocessing carried out in 2018 has allowed us to perform an accurate structural interpretation of the anticline. For this study, a 3D seismic volume, several 2D seismic lines and well logs are available. Fourteen horizons (including an unconformity) and several faults have been interpreted. The anticline involves a sedimentary sequence formed by Cretaceous marine rocks and Cenozoic continental rocks. An Eocene angular unconformity separates an Eocene-Quaternary succession from a Cretaceous-Paleocene succession. La Cira anticline is kilometer-scale, N-S asymmetric fold. Its western limb is shorter and dips steeply than the eastern one. Two main N-S reverse faults, as well as some E-W normal faults, occur within the anticline. The Eocene unconformity is folded and the horizons above and below the unconformity exhibit a different geometry. Thus, the reflectors below the unconformity are truncated and tightly folded. The horizons above the unconformity are parallel to it and exhibit an open anticline. Two thrusts with opposite dips, involving the post-unconformity succession, form a triangular zone in the anticline core. The anticline axial surface in the post-unconformity reflectors is displaced to the west with respect to the anticline axial surface in the pre-unconformity reflectors. The main geometric characteristics of La Cira anticline are simulated in simple kinematic models of asymmetric anticlines including unconformities, in which the anticline amplification mechanisms involve limb rotation, and the strain distribution in the layers below the unconformity is flexural slip. According to our structural interpretation, La Cira Anticline resulted from two main contractional events: a pre-unconformity event related to the “Cordillera Central” uplift, which took place by the end of the Cretaceous, and a post-unconformity event related to the “Cordillera Oriental” uplift and folding in the Late Miocene-Pliocene. As a result of this new structural interpretation, the oil field blocks and the area compartmentalization could be better understood, using also pressure data. Thus, the water-oil contact has been determined and an OOIP has been calculated for each block, allowing us to improve the location of the new injection and producer wells to be drilled in the field.