Alternative Workflow for 3D Basin Modeling in Areas of Structural Complexity - Case Study from the Middle Magdalena Valley, Colombia

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ABSTRACT

In recent years there have been many developments concerning basin modeling in structurally complex areas. However the full application of these improvements in 3D modeling is not widespread because it requires the use of 3D structural restoration (or restoration on many cross sections), which is a time-demanding process that is not always available at the basin scale. Although a standard basin model could give a faster overview of the petroleum system elements in this kind of basin, it is an option that has to be carefully considered in structured settings because it may lead to pitfalls that could create a misunderstanding of the basin potential. Although there is not an available regional 3D structural restoration in the Middle Magdalena Valley Basin (MMVB) of Colombia, we present the main challenges and key alternative procedures that were used to get a reliable model in an area of 11.000 km2 in the central portion of the basin with a grid spacing of 100m. This model integrates previous basin models (E.g. Stifano et al., 2012), revised seismic interpretation, regional stratigraphy and calibration data from wells. The MMVB is located between the Central and Eastern Cordillera of Colombia, in the NW portion of the Andean range (Figure 1) which account for more than 2 billion barrels of production over the last century. Most oil production from this basin comes from structural plays on Tertiary fluvial reservoirs that range in age between Paleocene to Miocene. While it is evident that it is a mature basin in terms of production on Tertiary structural traps, there is still uncertainty in the geological and thermal evolution that become constraints to understand other play concepts.

The MMVB is an intramontane basin that has undergone a complex evolution from a divergent to convergent regime, where the present day geometry is characterized by dipping and repeated faulted beds that represent an inherent problem for paleo-geometric reconstruction by mean of the back-stripping method used in conventional modelling. Edition of paleothickness and particularly, correction of original thickness is a procedure commonly used for solving this issue, however taking into account that modelling softwares use linear interpolation thought time, a wrong time selection for the thickness correction could deal to minor corrections or even worst results. In our model, we have focused the thickness corrections on the most sensible control points that could produce more realistic results, which are those related to the main deformation events. A comparison between maturity maps derived from models without correction, with original thickness correction and with paleothickness correction related to deformation timing shows the importance of this fact.

On a similar way, the high variability in the present day heat flow in the MMVB reflects the impact of its complex evolution. Although there are some studies regarding the thermal model during the Cretaceous rift and post-rift phases, the thermal history interpretation during the compressive Tertiary phase is not as simple as an interpolation between the heat flow at the end of the Cretaceous and the present day heat flow. It is important to notice that since Eocene the strong structural deformation changed the geometric setting of the basin and subsequently,

it changed the thermal regime that continue evolving through the Tertiary. We used an alternative method to calculate the Tertiary heat flow maps that contribute to have a good calibration with the paleothermometers in the MMVB.

In addition to the geometrical and thermal improvements that are presented in our approach, there is further work that is in progress in order to reduce uncertainty in other petroleum system elements. Considering that in the study area there is a limitation related to the structural restoration, we are not suggesting that this model could be better than a future one based on a regional 3D-structural model, but it is good enough to increase our confidence in supporting new exploratory opportunities in the MMVB.