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ORAL PRESENTATION

Forward Modeling and Mechanical Behaviors of a Carbonate Platform Involved in Fold-and-Thrust Belt. The Case of Antelope Field and Surrounding Prospectivity

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The Elk-Antelope multi-Tcf gas field (operated by Total 40.13% and partners: Exxon 37.04%, OilSearch 22.84%) located within PRL15 in western Papua New Guinea represents a singular example of a Tertiary isolated carbonate build-up located within the foothills at the junction of two major Fold Belt (FB) systems, the Papuan and the Aure Fold Belts.

The reservoirs of Antelope are associated with the Early-Mid Miocene Darai Formation, dominated by shallow-water carbonate deposits passing laterally to the Puri mud-prone deep-water carbonates and resedimented shallow water carbonates, then overlapped by Orbulina Marls. A thick overburden is composed of the shale-rich Orubadi and sand-rich Era foreland mega sequence. In that sense, the influence of mechanical stratigraphy plays an overwhelming role in the location of thrusts and final thrust sheet geometries driven by subsequent decollement levels both in the Mesozoic underlying sediments (Ieru and potentially Barikewa Fm.) and in the Orubadi Fm. The contrasted rheology of the implied series led to a strong decoupling between surface deformation and carbonate sub-thrust at depth, ie. large syncline development on top of carbonate thrust sheets.

In this way, the prospectivity of peri-Antelope and potential shallow or deep carbonates relies directly on the understanding of the structural model and the reconstruction of the pre-deformed framework to understand the palaeo-environnement and target more accurately areas of high reservoir quality as seismic imagery is very poor in this FB environment and does not allow direct de-risking.

For that purpose, a multiple approach integration is proposed using:

1. 3D constrained model and 2D forward modelling approach (Move™ software),
2. mechanical approach (Op+Um G2 software) based on final element, and
3. uplift quantification based on river profile analysis.

Two major structural hypotheses have been tested with forward modelling:

- Pure thin-skinned deformation with low angle thrusts using a shallow decollement level below the carbonate: the well-known Cretaceous Ieru detachment. This model implies large displacement (cumulated shortening up to 15km) along thrusts and a stacking of flat thrust sheets.
- Deeper decollement activation within the Barikewa Fm (cumulated shortening up to 7km) and / or involving pre-existing normal faults.

These two models can fit the surface and sub-surface observations. Consequently, in order to discriminate between alternative hypotheses a mechanical approach has been used integrating the influence of a stiff carbonate platform in between two incompetent layers (Orubadi and Ieru) on the onset and location of thrusts.

Finally, our multiple data integration approach refined:

- The timing of the deformation and the location of recent uplift.
- The most likely activation of deeper decollement levels.
- The location of thrusts in relation to the presence of carbonate lateral thickness variations in case of mechanical stratigraphy architecture dominated by two incompetent layers encompassing a stiffer layer.

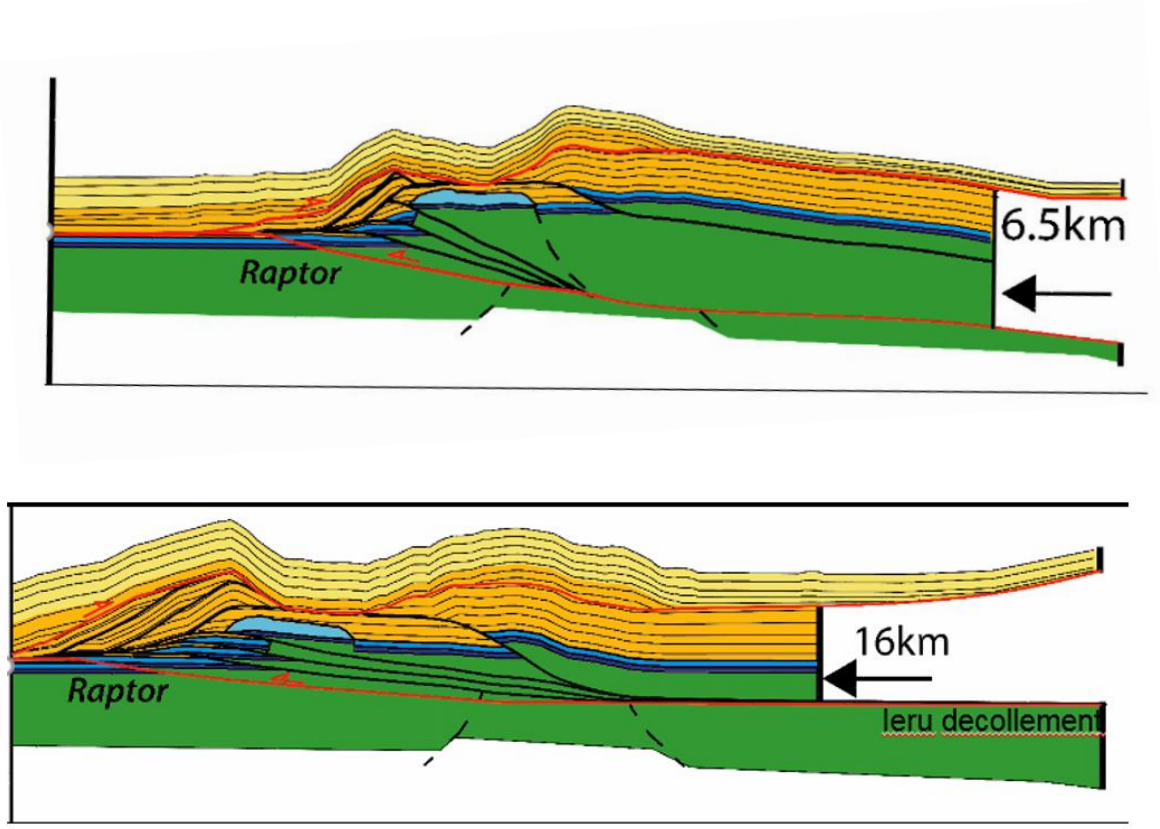

Figure 1. Two hypotheses of forward modelling testing the activation of a shallow versus deep decollement level on final geometry (amount of uplift, overburden erosion, …)

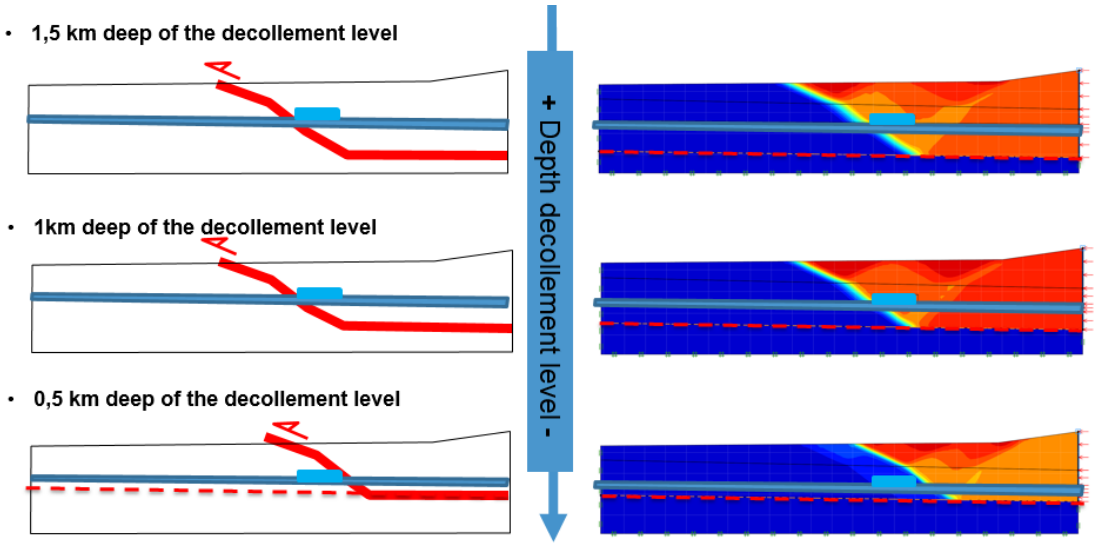

Figure 2. Mechanical modelling using Op+Um G2 software showing the influence of the depth of decollement level on the thrust onset at the front or at the back of a simulated rigid carbonate platform