Mass-Transport Complexes as Deformation Markers: Insights from the Magdalena Fan, Offshore Colombia

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Abstract

Structural traps in submarine fold belts are often exploration targets. In active tectonic margins, structural growth is commonly associated with mass-wasting, which can remove large volumes of sediment from anticlines. Therefore, understanding the relationship and relative timing of deformation and mass-wasting is important when assessing the presence and risk of the elements of the petroleum system. This detailed study is based on mapping of a 3D seismic volume in the Magdalena Fan, offshore Colombia and it investigates how ongoing tectonic deformation affects the source and scale of mass-transport complexes (MTCs).

The study area is located at the northern tip of the Southern Sinuacute Fold Belt where two anticlines form the updip and downdip limits of a syncline. The younger downdip anticline is cored by the southern fault zone (SFZ) to the SW and to the NE is not faulted. Basinward of these folds several MTCs associated with at least three separate updip-headwalls coalesce into a 200 m thick package.

The source areas of individual MTCs, inferred from kinematic indicators, show that the oldest MTCs were sourced from anticlines to the south of the study area and are displaced by the SFZ. Later MTCs sourced from the tip of the SFZ, remain undeformed. A younger c. 400 km^2 erosional surface trends along the syncline and traverses the downdip anticline eroding c. 200 m of stratigraphy. Evidence of earlier syn-tectonic mass-wasting in both anticlines suggests that this surface resulted from several mass-flows: early degradation of the frontal limb of the downdip anticline resulted in MTCs that ran out into the basin, while MTCs derived from the updip anticline were ponded in the intervening syncline. Eventually the retrogressive erosion of the downdip anticline connected the syncline with the outboard basin-low enabling larger MTCs sourced from shelf to traverse the structural high.

MTC source areas shifted north as the deformation front propagated and while older MTCs were deformed, new sites of instability developed where the growing folds became steeper. This shows that the characteristics and distribution of MTCs can change in response to structural uplift and can be used to constrain the tectono-stratigraphic evolution. Given the significant erosion, fold degradation can affect reservoir and seal presence, and influence the thermal history. This study serves as an analogue for exploration prospects at greater depths in tectonically-active basin margins.