Geometry of a Fold-And-Thrust Belt Generated by Multiple Décollements (Kuqa Basin, NW China): Insights from Analogue and Numerical Models

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Abstract

The Kuqa Basin (NW China) is a deformed, oil-bearing basin in the southern foreland of the Tian Shan Range. Its structure is strongly controlled by weak décollements interlayered in the stratigraphic sequence: thin Triassic and Jurassic coal layers and Cenozoic syn-orogenic evaporites (salt and gypsum). Of these, the Paleocene-Eocene Kumugeliemu Salt is critical because it gave rise to an important decoupling between structures deforming Mesozoic and Cenozoic units respectively. The thickness and nature of this unit prevents straightforward seismic interpretation of presalt layers and influenced the development of suprasalt structures whose evolution, timing, and geometry are not yet fully understood. To address these uncertainties, we undertook an integrated analogue and numerical modelling approach that sheds some light on the geometry and kinematics of both presalt and suprasalt structures.

The analogue experiments were built with dry silica sand and two décollements simulated by polymer with different mechanical properties: a deeper and thinner one analogous to the Triassic-Jurassic coal layers, and a shallower and thicker one analogous to the Kumugeliemu Salt. The experiments included syntectonic sedimentation and analyzed parameters such as changes in sedimentation rate and the thickness and distribution of the décollements. The upper décollement generates migration of deformation to the pinch-out of the polymer whereas the thinner lower décollements trigger development of foreland directed horses.

The numerical experiments used a 3D discrete element (DE) model in which the DE assemblage is defined with cohesion and also has frictional behavior. Like the analogue models, they can study the effect of syntectonic sedimentation and undergo compression by the movement of one boundary wall. The initial numerical models considered only one intermediate weak décollement, which was defined as frictionless and with low cohesion. These experiments analyzed different décollement geometries as well as basement tilts with regard to the initial undeformed stratigraphy. Further experiments will introduce a second décollement at the base of the model to simulate the double decoupling observed in the Kuqa Basin.