Geometry and Kinematics of Thrust Belts above a Viscous Detachment: Implications to Hydrocarbon Exploration from New Modeling Experiments

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Abstract

Theoretical and experimental studies on thrusts belts, or fold-and-thrusts belts (FTB), have shown that, under Coulomb conditions, deformation of brittle thrust wedges above a dry frictional basal contact is characterized by dominant frontward vergent thrusts (forethrusts) with thrust spacing being directly influenced by the basal strength, an increase in basal strength leads to tighter thrust spacing and higher taper angles; whereas thrust wedges deformed above a weak viscous detachment, such as salt, show a more symmetric thrust style (no prevailing vergence of thrusting) with wider thrust spacing and shallower wedges. However, different deformation patterns can be found on this last group of thrust wedges both in nature and experimentally. Therefore, we focused on the strength (friction) of the wedge basal contact, the basal detachment. We used a parallelepiped box with four fixed walls and one mobile that worked as a vertical piston drove by a computer controlled stepping motor. Fine dry sand was used as the analogue of brittle rocks and silicone putty (PDMS) with Newtonian behaviour as analogue of the weak viscous detachment. To investigate the strength of basal contact on thrust wedge deformation, the following configuration was used: a horizontal sand pack above a horizontal PDMS basal layer, acting as a basal weak viscous contact.

The experimental results for the weak viscous frictional basal detachment model show that: (1) forethrusts (FT) are dominant showing clearly an imbricate asymmetric geometry, with wider spaced thrusts than the dry frictional basal model; (2) after FT initiation, the movement on the thrust can last up to 15% model shortening, leading to great amount of displacement along the FT and model uplift; (3) intermittent reactivation of FTs occurs despite the steepening of the FT plane and existence of new FT ahead; and (4) injection of PDMS from the basal weak layer into the FTs planes favours to the long living of FTs.

These experimental results have relevance for Petroleum System evaluation by showing that: (1) fluid migration may be promoted through episodic pathways established along the reactivated FTs planes; (2) timing, seal integrity and HC charge of structural (tectonic) traps may also be affected; (3) enhanced seal capacity of tectonic traps by salt injection into FTs planes; and (4) the long FTs activity may lead to different uplift values between reactivated vs. non-reactivated thrusted slices.