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Deformation of Fold-and-Thrust Belts above a Viscous Detachment: New Insights from Analogue Modelling Experiments

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Theoretical and experimental studies on 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 and taper angle being directly influenced by the basal strength (increase in basal strength leading to narrower 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, two configurations were used: 1) a horizontal sand pack with a dry frictional basal contact; and 2) a horizontal sand pack above a horizontal PDMS layer, acting as a basal weak viscous contact.

Results of the experiments show that: the model with a dry frictional basal detachment support the predictions for the Coulomb wedges, showing a narrow wedge with dominant frontward vergence of thrusting, close spacing between FTs and high taper angle. The model with a weak viscous frictional basal detachment 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; 3) intermittent reactivation of FTs also occurs despite the steepening of the FT plane and existence of new FT ahead, creating a high critical taper angle; 4) injection of PDMS from the basal weak layer into the FTs planes also favours to the long living of FTs and to the high critical taper angle; 5) vertical sand thickening in the hanging block also added to the taper angle.