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The interaction of two indenters in an analogue experiment – a way to explain the formation of the Tajik fold-and-thrust belt?

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Curved fold-and-thrust belts mirror the deformation history of an orogenic belt and its foreland. In this study we investigate indentation of crustal blocks in a sedimentary basin in order to explain structural features of fold-and-thrust belts by means of scaled analogue experiments. A new experimental set-up is explored, with two flat indenters moving parallel to each other, but with different velocities. The slower indenter moves with a velocity of 40% up to 80% with respect to the fast indenter. Sand and low friction glass beads model the sedimentary stack and the detachment in a first experimental series, whereas silicone oil represents a viscous detachment in a second experimental series. All experiments were continuously recorded with 3D particle image velocimetry (3D-PIV), in order to permit computation of the model topography during the experiment as well as the spatiotemporal velocity and strain fields.

During the experiments, a wedge evolves in front of the indenters by fore-thrusting according to the critical taper theory. The thrust wedge in front of both indenters decouples at a relative velocity below 55% and two independent wedges in front of both indenters are created. A curved thrust wedge develops, if indenter velocities are more similar to each other. Depending on the relative velocity, the thrust front is smooth at low velocity differences (70 - 80%) and intensely curved at higher velocity differences (55 - 60%). At the curved thrust wedge, which is also termed transfer zone, particle rotation und lateral material transport directed to the slow indenter front occur. Thrusts nucleate in front of the fast indenter wedge and propagate laterally to the slow indenter front. Growth of the slow indenter thrust wedge is influenced by lateral thrust propagation.

The rheology of the detachment affects wedge dip and thrust orientation. In the experiments with the silicone oil detachment, a low-angle wedge is generated, which is less curved and features fore and back thrusts in the wedge front.

Comparisons of the experimental results with nature show that this experimental set-up is able to explain some features of the curved fold-and-thrust belt of the Tajik basin. Based on observed seismicity, the fast indenter would be equivalent to the Pamir whereas the slow indenter would represent the Hindu Kush/Afghan block movement. The experiment with 60% relative velocity generates a curved thrust wedge, which is similarly curved as the Tajik fold-and-thrust belt. Rotation observed in the basin especially close to the Pamir is in agreement with rotation taking place in the transfer zone in the experiments. Thrusting and folding within the Tajik basin exhibits a vergence to the centre of the basin above the detaching Jurassic rock salt. Such a variation of thrust vergence can be only generated in experiments with a viscous detachment.