Centrifuge Modelling Study of Contrasting Structural Styles in Salt Range and Potwar Plateau, Northern Pakistan

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The ENE-trending Himalayan fold-thrust belt in Pakistan depicts contrasting deformation styles along strike. The central Salt Range and Potwar Plateau (SR/PP) are gently deformed above a low-strength decollement in the Salt Range Formation; however, deformation is more complex in the eastern SR/PP. The emergent Salt Range Thrust transforms into a blind thrust in the east. It has been suggested that this drastic change in the deformation style in two adjacent areas was caused by the presence of a north-dipping frontal ramp in the central region, connected to an east-dipping lateral ramp in the east. The geometry of these structures has been presumed to reflect underlying basement faults.

The centrifuge modelling technique has been used to replicate the variations in structural style. For the purpose of modelling, the SR/PP stratigraphy has been grouped into four mechanical units. From bottom to top these are the Salt Range Formation, carapace unit (Cambrian-Eocene platform sequences), Rawalpindi Group, and Siwalik Group. These stratigraphic units of alternating competence, composed of thin layers of plasticine modelling clay and silicone putty, rest on a rigid base plate that represents the crystalline basement of the Indian plate. The models are built at a linear scale ratio of ~10^{-6} (1mm=1km) and deformed in a centrifuge at 4000g. To examine the effects of frontal/lateral ramp systems of various geometries, the ramp systems are pre-cut in the model stratigraphic package before each experiment. The models are subjected to horizontal shortening by collapse and lateral spreading of a "hinterland wedge" which simulates overriding by the Himalayan orogen (above the Main Boundary Thrust). The models are deformed in stages so that the kinematic evolution of structures can be monitored. Matched models are serially sectioned transversely and longitudinally to constrain the structure in 3-D.

The models show that the accretionary wedge develops a prominent culmination structure with fault-bend fold geometry over the frontal ramp. The main ramp, localized by a basement normal fault, is responsible for the deflection of the hanging-wall package to the surface and repetition of the whole stratigraphic sequence. As a result the fault-bend fold over the ramp will form out-of-sequence. Although the main decollement remained within in the ductile Salt Range Formation the eastern SR/PP is more internally deformed by detachment folds, fault-propagation folds and pop-up and pop-down structures. The transition from fault-bend fold to detachment-fold and fault-propagation-fold geometry takes place in a transfer zone marked by an S-bend structure (Chambal Ridge and Jogi Tilla) at the surface and the lateral ramp in the subsurface.

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