Orogen-transverse folding in the North Singhbhum Mobile Belt, India: Role of gravity-driven crustal flows

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Many convergent tectonic belts show large-scale transverse folding affecting the earlier fold structures and their associated rock fabrics. The origin of such cross folds is generally explained in terms of a different deformation episode, separated in time from the main orogenic events, considering a reorientation of the tectonic stress axes. This study reports cross folds from the North Singhbhum Mobile belt (NSMB), claiming their development in the course of a single unidirectional convergent movement. A southward convergence in the NSMB resulted in localized thrusting of the NSMB over the Singhbhum craton (SC), coupled with regional (distributed) ductile deformations producing orogen parallel folds (F_1) and fabrics (S_1) on a wide range of scales. The structural mapping reveals overprinting of NE-SW trending cross folds (F_2) in the eastern flank of NSMB, giving rise to a series of crustal scale culminations and depressions. Scaled laboratory experiments were conducted on a scaled representative NSMB model by temporally varying the tectonic convergence rate (V_c). The experimental runs had an initial period of fast-rate convergence (Stage I: V_c = 16 mm/yr), followed by an intermediate (Stage II: V_c = 8 mm/yr) and an extremely slow (Stage III: V_c = 0.8 mm/yr) rate. During Stages I and II, the arcuate SC geometry causes the NSMB to undergo heterogeneous shortening, forming elevated surface topography preferentially in the northern part of the SC. The maximum horizontal instantaneous stretching axes (ISA_{Hmax}) are oriented grossly E-W in these two stages. The differential horizontal crustal flows develop a distinct region of dextral shear in the eastern flank of NSMB that causes the finite strain axes (i.e., F_1 folds and S_1 schistosity) to reorient along NW-SE orientations in this part. With slowing down of the V_c in Stage III, the elevated topography in the northern part undergoes gravitational collapse, setting in a dominant SE-directed crustal flow around the SC. This flow generates NW-SE compression in the eastern flank of NSMB, which in turn produces cross folds on small to large scales. A time-series strain analysis from the model suggests tectonic deformations varying from flattening to plane strain and constriction type in space and time across NSMB.