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The Role of Isostasy in the Evolution of Thin-Skinned Fold and Thrust Belt

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The stacking of thrust sheets and mass transfer of sediment during fold and thrust belt accretion imposes a load on the basement and underlying mantle. This load induces an isostatic adjustment through a flexural response, which may also contribute to the overall architecture of the fold and thrust belt. Whereas plate kinematics imposes its tempo to evolving fold and thrust belts, the rheology of the mantle controls the tempo of the isostatic flexure. Using two-dimensional high-resolution numerical experiments, we explore how the interplay between the tectonic compressional rate and the isostatic flexural rate influences the structural evolution and final architecture of fold and thrust belts.

We run a suite of numerical experiments using the well-tested code Underworld. Our geological model is mapped over a 42 km by 16 km numerical grid, with a cell resolution of 80 m. The geological model consists from top to bottom of 'sticky air', 4 km of sediment that alternates in competence at 500 m intervals, a 3 km thick basement, and a basal layer which - in combination with a basal kinematic boundary condition - controls the amount of isostatic flexure. Materials have a mechanical behavior that results from elasto-visco-plastic rheology. The pressure at the base of the model is held constant, and the vertical velocity is updated at each timestep. The amount of material entering or exiting the model at each point along the base scales with the density of the basal layer, which is used to control the isostatic rate. Sedimentation and erosion are self-consistent through mechanical erosion and a hillslope diffusion law. Our models show that as the ratio between tectonic and flexural rates decreases (i.e. flexure gets faster), fold and thrust belts become narrower, lower in elevation, and structurally more complex. We compare these results with natural analogs including the Cordilleran and Jura fold and thrust belts.