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Sedimentary loading-unloading cycles and faulting in intermontane basins: insights from numerical modeling and field observations from the broken foreland basin of NW Argentine Andes

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The removal, redistribution, and transient storage of sediments in tectonically active mountain belts is thought to exert a first-order control on shallow crustal stresses, fault activity, and hence on the spatiotemporal pattern of regional deformation processes. Accordingly, sediment loading and unloading cycles in intermontane sedimentary basins may inhibit or promote intrabasinal faulting, respectively, but unambiguous evidence for this potential link has been elusive so far.

Here we combine 2D numerical experiments that simulate contractional deformation in a broken-foreland setting (i.e., a foreland where shortening is diachronously absorbed by spatially disparate, reverse faults uplifting basement blocks) with field data from intermontane basins in the NW Argentine Andes. Our modelling results suggest that thicker sedimentary fills (> 0.7-1.0 km) may suppress basinal faulting processes, while thinner fills (< 0.7 km) tend to delay faulting. Conversely, the removal of sedimentary loads via fluvial incision and basin excavation promotes renewed intrabasinal faulting.

These results help to better understand the tectono-sedimentary history of intermontane basins that straddle the eastern border of the Andean Plateau in northwestern Argentina. For example, the Santa María and the Humahuaca basins record intrabasinal deformation during or after sediment unloading, while the Quebrada del Toro Basin reflects the suppression of intrabasinal faulting due to loading by coarse conglomerates. We conclude that sedimentary loading and unloading cycles may exert a fundamental control on spatiotemporal deformation patterns in intermontane basins of tectonically active broken forelands.

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