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Timing and propagation rates of the thrust and fold belts of southern Bolivia and its implications for the evolution of the central Andes

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The 150 km wide Neogene Subandes fold and thrust belt of south-central Bolivia is an integral part of the Andean orogenic system that is related to the thin-skinned and basement-involved shortening, uplift, and thrust loading, and the subsequent eastward propagation of the Andean deformation. The kinematics and shortening magnitudes of the belt in particular and the central Andes in general are well documented. However, the timing and propagation rates of thrusts and its relationship to the Andean mountain building are poorly understood.

To unravel this puzzle on the timing and propagation history of Andes, we use well logs, industrial seismic lines, new zircon U-Pb age data from Mio-Pliocene sedimentary strata and balanced cross sections to evaluate the thrust front propagation rates and deposition pinch-out migration rates of the Neogene strata. We combine our results with published Neogene shortening and sediment accumulation rates to decipher the timing of deformation and history of orogenic evolution.

The results of the new Zircon U-Pb ages from volcanic ash samples intercalated in sedimentary rocks show that thrusting arrived in the Subandes at 12.4 Ma. In addition, the radiometric ages indicate that the Subandes witnessed an out-of-sequence deformation between 6 and 2.1 Ma. Furthermore, our results show about three-fold (10.03 mm/a; 22 mm/a) increase in the eastward migration rate of the depositional pinch-out and propagation rates between 8-6 Ma. In contrast, during the same period the shortening rate was at its lowest stand (ca. 6 mm/a).

Our observations suggest that the basin had already witnessed accommodation space creation between 12-8 Ma as a result of tectonic loading and coeval eastward advance of thrusting. The created space was filled with clastic sediments as a result of enhanced erosion that occurred during the 8-6 Ma period. The climate-induced high erosional unloading of the topography and the high sediment supply deduced from rapid increase in sedimentation rate led to the outward increase in deposition pinch-out migration rate during the same period with corresponding decrease in propagation and shortening rates. The coeval three-fold increase in deposition pinch-out migration- and thrust front propagation rates from the 12-8 Ma to the 8-6 Ma interval could reflect readjustment from an overcritical state of the thrust wedge that may have been caused by sediment loading, an increase in pore pressure and weakening the basal detachment.