How to make the Andes?

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The Andes, the worlds second highest orogenic belt after Tibet, were generated by the Cenozoic tectonic shortening of the South America (SA) plate margin overriding the subducting Nazca plate. Using a 2D coupled thermo-mechanical numerical modeling of dynamic interaction between subducting and overriding plates we search for factors controlling the intensity of the tectonic shortening.

We employ a parallel thermo-mechanical finite element/finite difference code LAPEX (LAgrangean Particle EXplicit) which combines the explicit lagrangian algorithm FLAC with the particle-in-cell technique. Particles track material properties and full stress tensor minimizing numerical diffusion related to remeshing. The method allows employing realistic temperature- and stress-dependent visco-elastic rheology combined with Mohr- Coulomb plasticity. A number of versions of the LAPEX code are developed and extensively used in geodynamic modeling in our Group in Potsdam: 2D version (Babeyko and Sobolev, 2005; Sobolev and Babeyko, 2005), extended 2D version (Sobolev et al., 2005) and 3D version (Petrunin and Sobolev, 2005).

¿From the numerical modeling constrained by geological and geophysical observations we infer that the most important factor for the tectonic shortening in the Andes was fast and accelerating westward drift of the SA plate, while large changes in the subduction rate were not as important. Other important factors are crustal structure of the overriding plate and shear coupling at the plates interface. The model with thick (40-45 km at 30 Ma) SA crust and relatively high friction coefficient (0.05) at the Nazca-SA interface generates more than 300 km of tectonic shortening during 30-35 Myr and replicates well crustal structure and evolution of the high Central Andes. The model with the initially thinner (less than 40 km) continental crust and lower friction coefficient (less than 0.015) results in less than 50 km of the SA shortening, replicating situation in the Southern Andes. Our model predicts that down-dip limit of the frictional coupling domain between Nazca and South America plates should be by ca 10-20 km deeper in the Southern Andes (south of 28S) than in the high Central Andes. This prediction is consistent with the GPS and seismological observations. Another model prediction is anti- correlation of the magmatic arc activity and rate of regional tectonic shortening, which also seems to be supported by observations.

References:

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