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Origin of some types of several-million-years tectonic fluctuations at convergent and transform plate boundaries

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I present examples of several-m.y. tectonic fluctuations in the late Cenozoic time at convergent plate boundary in the central Andes and at transform plate boundary in the San Andreas Fault system in California. I use finite element thermomechanical modeling technique employing realistic elasto-visco-plastic rheology to study origin of these tectonic fluctuations.

The intensive orogeny in the central Andes occurred during the last 30 m.y. due to the tectonic shortening of leading edge of the South American plate overriding the subducting Nazca plate. Geological data suggest that the shortening rate has generally increased during the last 30 m.y., but also experienced a few pulsations with duration of several m.y. I use a 2D model of thermomechanical interaction of the subducting and overriding plates with realistic composition and rheology and implemented gabbro-eclogite transformation in mafic rocks. The modeling shows that the general tendency of overriding-plate shortening rate to rise is likely due to reported acceleration of the westward drift of the South American plate during the last 30 m.y. The tectonic shortening in the model results in thickening of the continental crust and causes gabbro-eclogite mineral reactions in the thickened, continental lower crust followed by lithospheric delamination. The model replicates fluctuations in the shortening rate and suggests that their reason may be increased viscous coupling between the plates caused when the asthenospheric wedge is blocked by the cool, delaminating, mantle material that is moving to the tip of the asthenospheric wedge by subduction corner flow. The duration of the shortening-rate pulsations is controlled by the volume of the delaminating material and velocity of the corner-flow.

It has been argued that many aspects of the present day San Andreas Fault system

in California, including regular 30-50 km spacing between the major faults, have resulted from few landward “jumps” of the San Andreas Fault, following the northward passage of the Mendocino triple junction during the last 20-30 m.y. Using extended 2D thermomechanical model I show that two key conditions are required to generate landward “jumping” of the San Andreas Fault with appropriate spacing between the major faults: (1) heating and then cooling (and strengthening) of the lithosphere following passage of the triple junction which causes ductile deformation at depth to migrate landward with time and (2) the dramatic drop of frictional strength at high strain in the upper crust which results in friction coefficient at major faults of less than 0.1.