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Westward migration of San Andreas plate boundary: consequences to the anisotropy in the upper mantle

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Analysis of SKS splitting beneath Northern California evidenced (i) a shallow anisotropic layer with fast polarization directions parallel to the San Andreas fault in the vicinity of the transform boundary and (ii) a deeper, probably asthenospheric anisotropic layer characterized by a smooth rotation of the direction of polarization of the fast split waves from NW/SE in the west to NE/SW in the east. We proposed that this pattern records the westward migration through time of the Pacific/North America plate boundary that results in progressive reorientation of the olivine crystallographic fabric in the asthenosphere from directions close to the absolute plate motion (APM) of the Pacific lithosphere (NW/SE) to directions close to parallel to the APM of the North America plate (NE/SW).
We tested this hypothesis by coupling thermo-mechanical models of a moving transform plate boundary and underlying asthenosphere using the 3D finite-element program Adeli and a viscoplastic self-consistent approach (VPSC) in order to predict the evolution of olivine and pyroxene crystal preferred orientations and hence constrain the anisotropic elastic properties of the deformed medium. The model is composed by four blocks: a 8km thick Pacific mafic crust, a 20km thick North America acid crust, a 20km thick strain-weakened acid crust in the fault zone, and wet peridotic mantle. The crustal blocks follow an elasto-viscoplastic rheology while the mantle has a viscoplastic power law rheology, which depends on both temperature and pressure. A 50 Myr old oceanic geotherm is applied west of the fault zone. Beneath the transform and up to 60 km east of it, a hot geotherm, corresponding to the one expected in an asthenospheric window, has been imposed. The remaining of the model has a 100 km thick continental lithosphere geotherm. Absolute plate motions velocities derived from HS3-NUVEL-1A are applied at the lateral edges of the "Pacific" and "North American" lithospheres (yz plane) in order to induce right lateral strike-slip together with a westward displacement of the fault zone. All models display strain localization, with development of horizontal shear zone in the asthenosphere due to drag by the moving plates. The strike-slip dynamics of the plate boundary is not entirely accommodated within the lithosphere and also produces strain at asthenospheric depths. This suggests that the San Andreas transform influence is probably not limited to the lithosphere in disagreement with the initial interpretation of SKS splitting data. Both transform and plate-drag related strains are observed to progressively migrate westward and extend slightly towards larger depths. Estimation of the resulting anisotropic elastic constants based on the CPO calculated using the VPSC approach allows us to compare the model results to SKS data from Northern California.