Constraining the lithosphere-asthenosphere coupling from geodynamical modeling based on tomography models over the North American continent

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Understanding the interaction between the lithosphere and asthenosphere is one of the most fundamental problems in geodynamics, and coupling is especially complex in the continental context. We take advantage of major imaging improvements brought through the set up of the mobile EarthScope/USArray, to quantify this interaction. We couple the DNA13 tomography model with thermodynamic calculations to derive realistic density and temperature anomalies. We then compute instantaneous mantle flow in a 3D spherical geometry with realistic temperature and pressure dependent rheology, and derive the lithospheric stresses and the induced tectonic regimes. Our model can account for several complex seismicity patterns.

For example, the San Andreas Fault systems divide into three segments, each with different characteristics. Along the southernmost segment the deformation is transtensional, while the central and northern parts are in transpression. Our model reproduces this transition. We find radial extension between latitudes 30 and 35^{o}S, and compression between latitudes 35 and 39^{o}N, which may be related to a downwelling flow created by lithospheric drip. Our modeled stresses also reproduce the main characteristics of the surface deformation observed along the Yellowstone–Snake River Plain volcanic region. We predict extension over the tectonic parabola of deformation, as observed in focal mechanism and strain-rate tensors derived from GPS measurements. We also predict an extensional regime parallel to the volcanic track. Such a regime will develop faults perpendicular to the track direction, i.e. along the NW-SE direction, consistent with the direction of the Pleistocene-Quaternary major faults. In the New Madrid seismic zone, we retrieve the thrust regimes with a P-axis orientation along the NE-SW direction. This suggests that at least a part of the active seismicity is generated by the present-day state of the mantle, not to older re-adjustment processes.