Extending a Continent: Magmatism and Dynamics of the Lithosphere across the Basin and Range, US

Terry Plank, Esteban Gazel, Claire Bendersky: LDEO, Palisades, NY
Don Forsyth, Christina Rau: Brown University, Providence, RI
Erik Hauri, DTM, Carnegie Institution of Washington
Cin-Ty Lee, Rice University

On-going extension across the Basin and Range has generated topography, faults and volcanoes, and yet the relationship between these features is yet not clear. Moreover, recent work points to a driving role for small-scale convective phenomena in the mantle, such as lithospheric drips, edge-driven convection, or flow around subducting slabs. Here we use the Earthscope platform to constrain the dynamics of melting and evolution of the continental lithosphere, by integrating the shear wave velocity structure derived from inversion of Rayleigh waves, with petrological information in volcanic rocks that record the conditions of their formation in the mantle.

We contrast here the western boundary of the Basin and Range, in Owens Valley California (the Big Pine Volcanic Field), with the eastern boundary within the Transition Zone to the Colorado Plateau (Snow Canyon Volcanic Field). Big Pine basaltic melt inclusions, trapped in primitive olivines, record in their low FeO and moderate H2O contents low mantle equilibration temperatures, that mark a shift over the last 500 ka from melting of 1300°C potential temperature asthenosphere at 50-75 km depth, to melting or melt percolation and equilibration at 1200-1250°C within a thin lithospheric layer at 40-50 km, just below the Moho. Correlations between trace element ratios, and melting temperatures and pressures support this shift to shallower, lithospheric melting with time. The shallow melt equilibration beneath Big Pine is consistent with the lack of a high velocity seismic lid here, and supports the notion that mantle lithosphere has been severely thinned or lost, possibly due to its foundering in the last several Ma. In contrast, Snow Canyon basaltic melt inclusions record in their high FeO and low H2O contents high mantle equilibration temperatures (1375-1425°C, at 65-75 km), very near the seismically inferred lithosphere-asthenosphere boundary, and at the top of a very low velocity zone (Vs < 4.1 km/s) that extends to > 100 km. Such high melt temperatures and low seismic velocities might require active upwelling of hot mantle, in support of recent proposals for the thermal erosion of Colorado Plateau lithosphere along its margins. The large variation in the temperature of the shallow mantle, and the evolution of mantle lithosphere across the Basin and Range point to the potential importance of lithospheric downwellings and asthenospheric upwellings as drivers of magmatism and consequences of continental extension.