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Seismic and Magmatic Evidence for Crustal and Mantle Lithospheric Delamination under the Puna Plateau of the Central Andes

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Crustal and mantle lithospheric delamination have become popular mechanisms for understanding processes in many orogenic belts. Such a model was proposed in the early 1990's for the southern Puna plateau of the Central Andes to explain low Sn mantle attenuation, a gap in intermediate depth slab seismicity, low effective elastic thickness, a change in fault kinematics and the distribution and chemistry of mafic lava flows, glassy andesites, and the giant Galan ignimbrite. Strong support for this proposal now comes from slab and crustal earthquake locations, tomographic and receiver function images and shear wave splitting images generated in the southern PUNA passive seismic experiment at 25-28S and 65-70W (Mulcahy et al. 2014; Calixto et al., 2013, 2014 ; Bianchi et al. 2013; Liang et al.; 2014; Heit et al. 2014). The most dramatic evidence comes from a Vs tomographic image under the Cerro Galan caldera region that shows an ~100 km wide high velocity anomaly sitting above a lower velocity region interpreted as the slab at a depth of 150-200 km. A virtual seismic gap in this slab along with weak arc geochemical signatures in the overlying young mafic volcanic rocks in the region (e.g., Kay and Coira, 2009; Risse et al. 2013) support a high temperature mantle wedge in the region as is consistent with sparse slab earthquakes with strong S wave attenuation. Other evidence for a delaminated block under the Cerro Galan region comes from a circular pattern of shear wave splitting vectors generally outlining the proposed detached block. A thin lithospheric mantle is supported by S-p and P-S receiver function images indicating a lithosphere-asthenosphere boundary at 70-90 km. Such a thickness is consistent with mantle magma equilibration depths of 60-80 km at temperatures of > 1350°C that have been calculated from magma compositions. Evidence for a hot shallow crust comes from high crustal Vp/Vs ratios, evidence for a shallow brittle-ductile transition region from magnitude earthquakes limited to depths of 10 km and a seismic swarm under the Galan caldera. Receiver functions indicate a 45-55 km thick crust under the high plateau with Vp/Vs ratios < 1.70 implying a relatively felsic crust.

Recently, Beck et al (2015) have used regional scale P-wave and shear wave velocity images to argue that the southern Puna seismic array sampled only the northern boundary of a larger high velocity block that they interpret as reflecting massive lithosphere delamination under the central plateau to the north. Their proposed block shows little correlation with magmatic activity at the surface nor does it explain the low velocity crust and lithosphere of the southernmost Puna. Others have proposed a mantle plume like uprising on the margin of the southern Puna. Resolution of the size and configuration of delaminated lithosphere under the Puna awaits higher resolution studies.

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