IMAGING THE LITHOSPHERE IN THE CENTRAL ANDES

Susan Beck[1], Kevin Ward[1], Jamie Ryan[1], Hernando Tavera[2], Estela Minaya[3],
George Zandt[1], Lara Wagner[4], Abhash Kumar[4], Cristobal Condori[2], Maureen Long[5]

[1]Department of Geosciences, University of Arizona, Tucson, AZ, USA
[2]Instituto Geofisico del Peru, Lima, Peru
[3]San Calixto Observatorio, La Paz, Bolivia
[4]Department of Geological Sciences, University of North Carolina, Chapel Hill, NC, USA
[5]Department of Geology and Geophysics, Yale University, New Haven, CT, USA

INTRODUCTION

The central Andes of South America are part of a convergent margin where the Nazca plate is subducting beneath the continental edge of the South American plate and are considered the archetypical modern analogue for other ocean-continent subduction related (Cordilleran style) orogenic belts worldwide. The Andean Plateau of the central Andes is one of the world's largest orogenic plateaus with an average elevation of 3.5-4.5 km and is supported, in part, by thick continental crust (up to 70 km thick). One of the long-standing tectonic questions is whether the surface uplift in the central Andes is the product of slow, continuous isostatic uplift or rapid lithospheric removal? A gradual surface uplift history that coincides with isostatic compensation from crustal shortening would suggest the continuous removal of mantle lithosphere, while episodic surface uplift following significant lithospheric thickening would suggest pulses of rapid removal of dense lower lithosphere. Subsurface structure is a key constraint in understanding the uplift process.

In order to improve out understanding of the interplay between crustal shortening, lithospheric removal, and the slab geometry we have deployed a total of 90 broadband seismic stations in northwestern Bolivia and southwestern Peru. Fifty of theses stations, broadly distributed across the northern terminus of the Altiplano, are part of the interdisciplinary Central Andean Uplift and Geodynamics of High Topography (CAUGHT) project (Figure 1). In addition, we have deployed 40 broadband stations in south-central Peru as part of the PULSE project, which is focused on the flat slab region. We are using a variety of seismological techniques to image the crust and upper mantle including receiver functions, ambient noise tomography, earthquake surface wave tomography, travel-time tomography, and anisotropy measurements. Our initial work is focused on the crust.

SEISMIC IMAGING

In northwest Bolivia, perpendicular to the strike of the Andes there is a total of 275 km of documented upper crustal shortening (15° to 17°S) (McQuarrie et al, 2008). Associated with the shortening is crustal thickening and presumably lithospheric removal as the thick root becomes unstable. In order to compare crustal shortening estimates with present day crustal thickness estimates we have calculated receiver functions using an iterative deconvolution method and common conversion point stacking along the same profile as the surface structural shortening estimates. Our preliminary common conversion point stacks of receiver functions show a strong P to S conversion corresponding to the continental Moho at approximately 60-65 km depth underneath the Altiplano and portions of the Eastern Cordillera, decreasing to 35 km under the Beni basin.

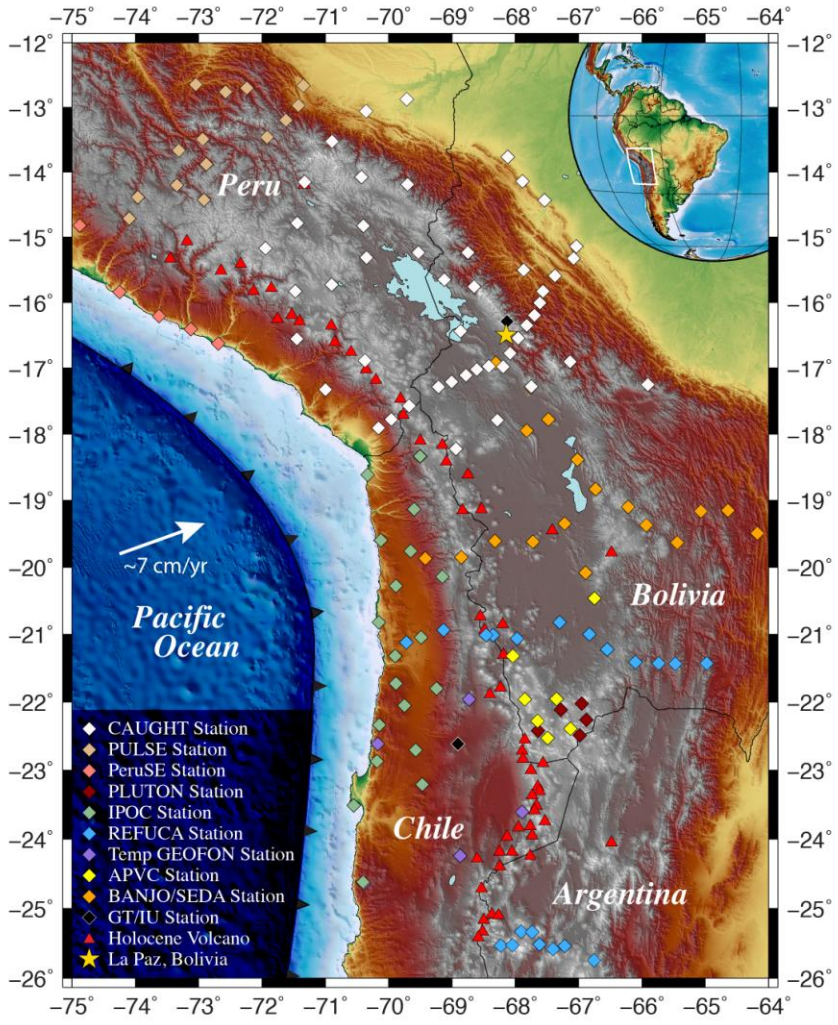

Figure 1. Map of the central Andes showing broadband seismic stations from temporary and permanent networks from 1994 to present.

The CAUGHT and PULSE station coverage combined with other IRIS PASSCAL and international stations deployed in the region are ideally distributed for ambient noise tomography (ANT). We determine the lateral variations in phase velocities from ambient noise for periods between 8 and 40 sec based on the method of Barmin et al., (2001) and Bensen et al. (2007) and then invert the phase velocities for the shear velocities at each grid point as a function of depth. We have good resolution of the S-wave velocities in the crust to a depth of ~50 km from approximately 13°S to 25°S. Figures 2 and 3 show map views of absolute S-wave velocities contoured at an interval of 0.25 km/s at depth slices of 7, 15, 20 and 30 km. At 7 km, we observe low S-wave velocities (<3.25 km/s) within the Altiplano basin, and slower velocities within the deeper subbasins, such as the Carmargo syncline. We also observe low S-wave velocities associated with the Subandean thin-skinned fold and thrust belt. A narrow corridor of high velocities within the Eastern Cordillera correlates with the high peaks of the Cordillera Real where

Triassic and Cenozoic plutons are exhumed. At 15 km and 20 km depth, the forearc region appears as a high velocity (>3.5 km/s) zone and the active volcanic arc parallels a zone of low velocities (<3.25 km/s) that may demark the modern batholith. Also at these depths, there are more localized low velocity anomalies near the major active volcanoes that may represent anomalously high temperatures or the presence of small amounts of partial melt. Between 21° and 23°S a region of very low S-wave velocities (<2.5 km/s) defines the Altiplano-Puna magma body that underlies the Altiplano-Puna volcanic center (APVC) (Zandt et al., 2003). A smaller satellite low-velocity body is located to the west of the active arc beneath the Precordillera in Chile. Although its location with respect to the modern arc is anomalous, the presence of this low-velocity zone was first recognized in the early seismic refraction surveys in this region (Wigger et al., 1994). We note that although it is on the edge of our resolution, the western edge of the Los Frailes volcanic field is also imaged at 20 km depth. At 30 km depth, velocities exceeding 4 km/s, consistent with lower crust, characterize much of the forearc. Most of the crust beneath the high Andean Plateau still has relatively low velocities (<3.5 km/s), and a belt of lower velocities (<3.25 km/s) parallels but lies to the east of the active arc. At 30 km depth, both the APVC and Los Frailes VF are still underlain by velocities less than 3.0 km/s. Between 13 and 17°S, the Eastern Cordillera and Subandes are underlain by higher velocities (>3.5 km/s) probably indicating the presence of underthrusting Brazilian Shield crust.

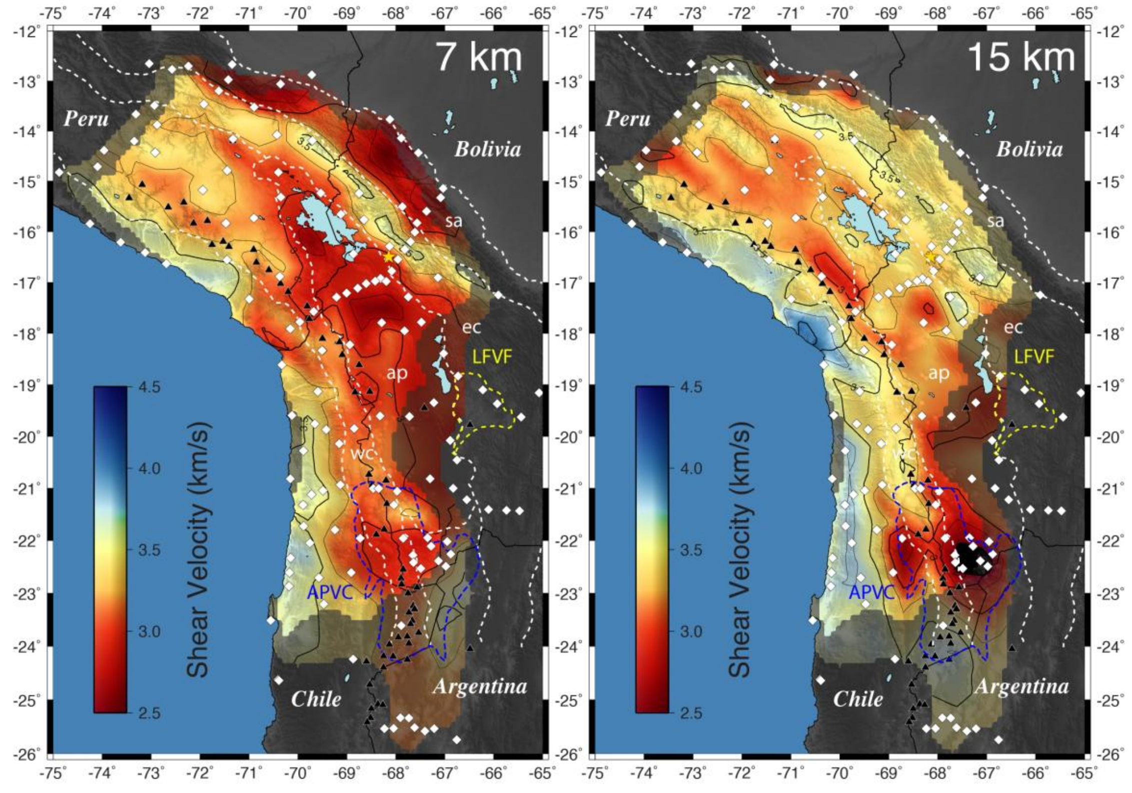

Figure 2. Map view shear wave velocities from ambient noise tomography (ANT) for depth slices at 7 and 15 km. Holocene volcanoes are shown as black triangles and seismic stations are shown as white diamonds.

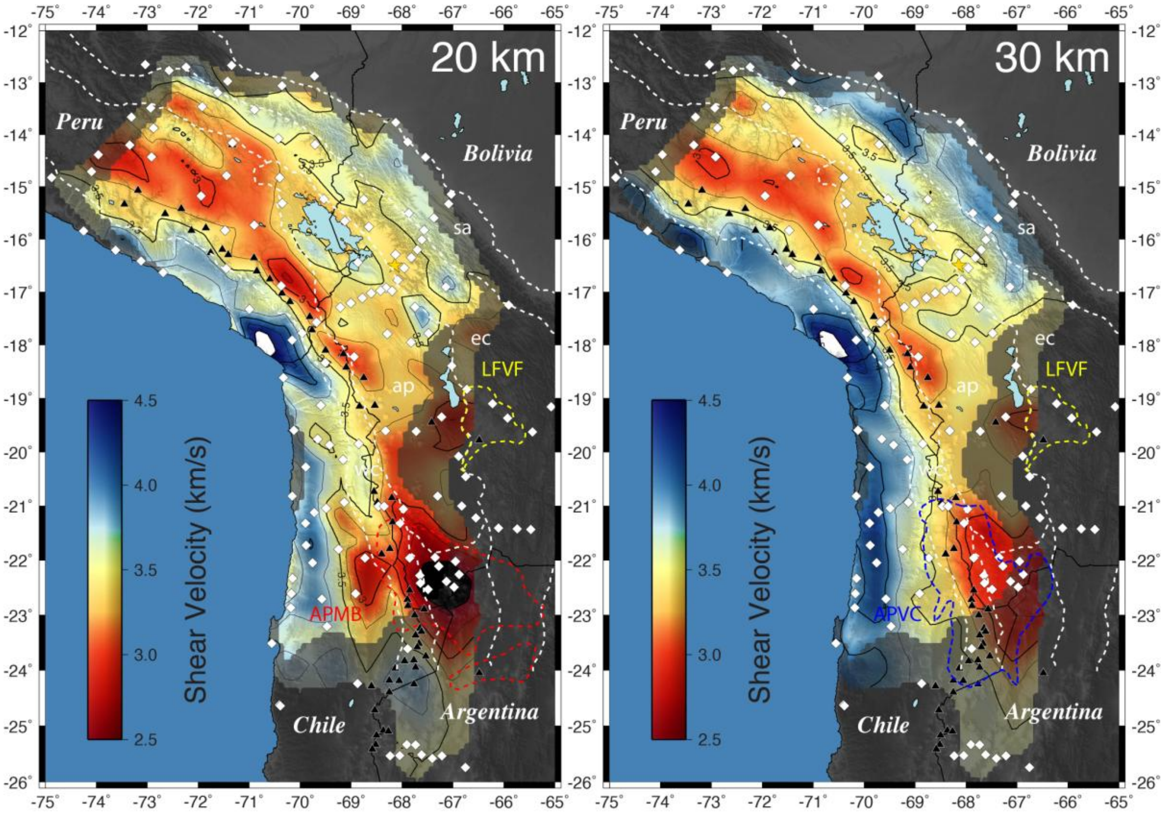

Figure 3. Map view shear wave velocities from ambient noise tomography (ANT) for depth slices at 20 and 30, km. Holocene volcanoes are shown as black triangles and seismic stations are shown as white diamonds.

SUMMARY

The ANT study is our first step in obtaining a comprehensive crustal velocity model for the region. Future work will focus on imaging the upper mantle and the down-going Nazca slab.

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