PLUTONS: Imaging Deep Active Magma Intrusions in the Central Andes

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Abstract. PLUTONS (Probing Lazufre and Uturuncu TOgether: Nsf, Nerc, Nerc, SERGEOTECMIN, SERNAGEOMIN, observatorio San calixto, universidad nacional de San andres, universidad de poto Si, Sernap, chilean Seimological service, universidad de San Juan) is a multinational project that uses a variety of geophysical and geochemical techniques to investigate two actively deforming volcanic regions: Uturuncu volcano in southwest Bolivia and Lazufre volcanic region in central Chile. Data from seismic, geodetic, gravity, magnetotelluric, geochemical, and petrological studies are being integrated to constrain models of mid-crustal magma accumulation beneath these two uplifting regions.

Keywords: PLUTONS, Uturuncu, Lazufre, Lastarria

1 Introduction

Uturuncu (22.27 S, 67.22 W, 6008m) is a dacitic stratovolcano located in the Altiplano-Puna Volcanic Complex (APVC), an area of volcanism that is associated with a late Miocene ignimbrite flare-up (de Silva, 1989), and underlain by the Altiplano-Puna Magma Body, a zone of partial melt characterized by low seismic velocities and high electrical conductivities (Zandt et al., 2003; Schilling et al., 1997). The youngest lava flows are dated to ~270 ka using 39Ar/40Ar dating (Sparks et al., 2008).

Lazufre (25.25 S, 68.49 W) is a broad region of uplift ~50 km in diameter located between the volcanoes Lastarria and Cordón del Azufre. While observed uplift is similar in both form and magnitude to Uturuncu, it is located approximately 350 km south, well outside of the APVC. No eruptions have occurred near the center of the region of uplift, although Holocene eruptions have occurred at Lastarria Volcano (Naranjo, 2010).

2 Method and Results

2.1 Uturuncu Volcano

An InSAR (Interferometric Synthetic Aperture Radar) time series inversion shows that Uturuncu has been uplifting at a constant rate of about 1 cm/yr in the radar line of sight (LOS) since at least 1992 (when SAR data became available) until 2011 (Figure 1). The region of uplift is about 70 km in diameter and is centered on the summit of the volcano. Surrounding the uplifting region is a broad ring of subsidence that could have several possible causes including magma withdrawal feeding the inflating source, visco-elastic deformation, or something else. The uplift has been modeled with a simple source embedded in a homogeneous elastic half-space at a depth of ~17 km below the surface (Pritchard and Simons, 2004).

Figure 1. InSAR time series velocity maps from two different satellite tracks showing uplift rates in cm/yr at Uturuncu Volcano in SW Bolivia and Lazufre on the border between Chile and Argentina. Data is from ERS and Envisat.

Seismic results from a 15-seismometer network that was deployed from April 2009 to April 2010 show an average
seismicity rate of about 3 volcano-tectonic earthquakes per day, with many earthquakes occurring in swarms (Jay et al., 2012). Local magnitudes range from −1.2 to 3.7 and depths are near sea level, more than 10 km above the geodetically inferred inflation source and the APMB. The Mw 8.8 Maule earthquake on 27 February 2010 triggered hundreds of earthquakes at Uturuncu. Ambient noise tomography results reveal a low-velocity zone at 1.9 to 3.9 km depth below the surface, perhaps related to the hydrothermal system.

Geomorphology surveys show no discernible tilting of late Pleistocene and lake shorelines, suggesting that the surface deformation is probably recent or cyclic. A 2-D inversion of magnetotelluric data show a region of high resistivity from about 2 to 4 km below the surface and centered slightly south of the summit. A 3-D inversion of gravimetric data shows a partially molten body with a negative density contrast of 150 kg/m³ that encompasses the modeled deformation source.

2.2 Lazufre

As Lazufre is the secondary target of the PLUTONS project, fewer geophysical instruments have been deployed there. However, we have been able to monitor the deformation of Lazufre using InSAR since 1995 (Figures 1 and 2). InSAR time series show that the uplift began after about 1997-1999, and has since accelerated to a maximum rate of 3.5 cm/yr LOS (e.g., Ruch et al., 2009).

![Figure 2. InSAR time series plot showing cumulative displacement versus time at Lazufre. A quadratic fit to the uplift signal fits the data much better than a linear fit.](image)

3 Conclusions

To date, the data collected at Uturuncu are consistent with a recent intrusion of magma in the mid-crust at the depth of the APMB (15-20 km) and the existence of a shallow hydrothermal system. Seismic tomography and receiver function analysis will be performed using broadband data from 29 stations to further our understanding of the subsurface magmatic system. Future geochemical work will establish the extent to which Uturuncu represents a manifestation of APVC magmatism.

We currently have a network of seismometers and GPS stations deployed at Lazufre. The seismic and GPS data will be used to characterize the seismic activity of the region and verify InSAR measurements to ultimately compare and contrast Lazufre with Uturuncu.

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References


