Deformation of Cordon Caulle Volcano (Chile) measured by InSAR from 2007 to 2011

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We combine petrological and ground deformation data to constrain the subsurface magmatic and hydrothermal processes related to the 2011-2012 rhyodacite eruption of Cordon Caulle volcano in southern Chile. The geochemical data indicate that the phenocryst-poor rhyodacite erupted in 2011-2012 is very similar to that of the 1960 and 1921-1922 eruptions. The calculated pre-eruptive conditions for the 3 erupted magmas are also indistinguishable: 900 +/- 20 deg C, 4 +/- 0.5 wt percent H2O, and 150 +/- 20 MPa. This implies that either (1) there has been no significant intrusion of magma in about 100 years while still erupting about 2 km3 (DRE) in the 3 eruptive periods, or (2) that all new additions are rhyodacitic melt that are indistinguishable from that in the shallow reservoir and is probably generated much deeper, in the lower crust. Using InSAR, we have found a complex history of ground deformation preceding the eruption at Cordon Caulle, and the nature of the several distinct inflation events are informed by this petrological data. This is one of the few large rhyodacite eruptions with detailed images of ground deformation in the years before the eruption.

InSAR studies show that Cordon Caulle has undergone episodes of deformation since at least 1996 and has varied between subsidence and uplift in different locations of the volcanic complex. Between 2007 and 2009 we observe two distinct uplift episodes, both with a maximum uplift signal of 18.5 cm at the center of deformation. We also find an episode of deformation occurring sometime between Feb-Mar 2010 located in the Cordillera Nevada caldera with 10 cm uplift within the caldera and 10 cm subsidence on the eastern rim of the caldera. This deformation episode is likely related to the nearby Trahuilco hot springs, which is fed by a shallow steam-heated aquifer and is the main outflow of the Cordon Caulle geothermal system. We do not observe any deformation from late 2010 to early 2011, when the ALOS satellite ceased operation. Petrological studies of the clinopyroxene exsolution lamellae in the 2011 eruptive products indicate the existence of a large (10 km3) long-lived (5 ka) shallow magma reservoir. We hypothesize that the 2007-2009 uplift episodes could have resulted from an injection of magma into the base of a pre-existing rhyodacite magma reservoir with minimal interaction between the 2 magma sources. Initial modeling of the 2008-2009 deformation pattern using one inflating point source puts the deformation source at about 7 km depth with a volume change of 0.03 km3. Assuming an appropriate value for magma compressibility, the combined modeled reservoir volume change from 2007-2009 could account for the volume of the 2011-2012 DRE erupted material of 0.8 km3. However, this simple model does not provide an accurate fit to all available ascending and descending interferograms, suggesting that a more complicated source may be involved, such as a prolate spheroid or faulting.