Magmatic processes and time scales below a yet-to-be silicic caldera eruption

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Large explosive eruptions from silicic calderas are among the most catastrophic events on earth. Identification of previously unknown but possible sites of caldera eruptions is thus among the most pressing and challenging problems in volcanology. Here we combine petrological and InSAR observations from Cordón Caulle volcano in Southern Chile that suggest the existence of a large interconnected system of silicic melt at shallow depth and sheds light into the processes that might occur in a yet-to-be caldera system.

Cordón Caulle has produced explosive to effusive rhyodacitic eruptions in 1920-21, 1960, and 2011-12, all of similar size (0.5-0.8 km^3), nearly identical petrochemical features, and pre-eruptive conditions: 900° C, ca. 4 wt% H_2O, and a storage depth of 6-7 km. Analysis of InSAR data from 2007 to 2011 has identified 4 large scale deformation episodes of areas between 20 and 400 km^2, and maximum uplifts of 19 cm. The deformation sources are far (2-10 km) from the 2011-12 eruptive vent, and coincide with the vents from the 1921-22 and 1960 eruptions, and with the neighboring Puyehue volcano. Modeling of the 2008-2009 deformation episode suggests source depths of 5-9 km. Modeling of exsolution lamellae in clinopyroxene found in the three historical rhyodacites, shows that the magmas below Caulle have been slowly cooling for a few thousand years in a reservoir of up to tens of km^3. Thus, our geological, petrochemical, and deformation data suggest that below Cordon Caulle there is an interconnected silicic magma plumbing system that allows for pressure and perhaps magma transfer over an area of at least 20 km^2, and resembles that of a large silicic caldera system. If the pre-eruptive deformation was caused by magma replenishment the new magma was silicic and similar to the pre-existing magma, and/or did not erupt. Pre-eruptive deformation can occur in pulses and reach its peak years before eruption, and a lack of deformation does not necessarily imply that eruption is not imminent.