Accelerating unrest within a large rhyolitic magma system during 2007-2013 at Laguna del Maule volcanic field, Chile

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The Laguna del Maule (LdM) volcanic field is remarkable for its unusual concentration of post-glacial rhyolitic lava coulées and domes that were erupted between 20 to less than 2 thousand years ago. Covering more than 100 square kilometers, they erupted from 24 vents encircling a ∼20 km diameter lake basin on the range crest of the Andes. This recent concentration of crystal-poor rhyolite is unparalleled both in the Andes and globally. Geodetic measurements at the LdM volcanic field show rapid uplift since 2007 over a ∼20km diameter area centered on the western portion of the young rhyolite domes. By quantifying this active deformation and its evolution with time, we aim to investigate the storage conditions and dynamic processes in the underlying rhyolitic reservoir that drive the ongoing inflation. Analyzing interferometric synthetic aperture radar (InSAR) data, we infer the following evolution of the deformation: the rate of vertical displacement is negligible from 2003 to 2004, and then accelerates from at least 200 mm/yr in 2007 to more than 300 mm/yr in 2012 (Feigl et al., 2013, in review). The deformation signal is modeled as inflation of a 7.5 km by 5.5 km sill at a depth of 5 km, assuming a rectangular dislocation in a half space with uniform elastic properties. The sill's maximum rate of inflation is 51 $\pm$ 8$\times$10^6 m^3/yr in 2012. In total, the volume increase of the source is about 160 million cubic meters since inflation began, no later than March 2007. Three continuous GPS stations installed in April 2012 around the lake confirm this extraordinarily high vertical uplift rate of more than 280 mm/yr and a significant radial expansion. As of January 2013, the rapid deformation persists in the InSAR and GPS data. During this interval, the rate of deformation at Laguna del Maule is higher than at any other volcano that is not actively erupting. For example, the remarkable recent inflation episodes at the Yellowstone (Chang et al., 2010) and Santorini calderas (Newman et al., 2012;Parks et al., 2012) exhibit rates two to five times slower than at LdM. Using the dynamic models, we can calculate changes in the local stress field. In particular, a large increase in stress in the magma chamber roof might lead to initiation and/or reactivation of ring faults. A finite element model is being developed to describe the configuration of the magmatic system and overpressure responsible for the observed uplift. Several hypotheses are considered for driving the deformation, including: (1) an intrusion of basalt into the base of a melt-rich layer of rhyolite leading to heating, bubble growth and subsequent increase pressure in the reservoir, and/or (2) the possibility of inflation of a hydrothermal system above the rhyolite melt layer.