Evolution of a large, hot, restless rhyolitic magma system at Laguna del Maule, Chile

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The Laguna del Maule Volcanic Field (LdM) is the foremost example of post glacial rhyolitic volcanism in the Southern Andes. New 40Ar/39Ar age determinations indicate that silicic eruptions began with deglaciation at about 19 to 20 ka and persisted until less than about 2 ka. These rhyolitic and rhyodacitic domes and coulees total 6.5 km3 and encircle the 23 by 16 km lake basin. This is not only the greatest concentration of post-glacial rhyolite in the Andes, but to our knowledge there has been no comparable rhyolite flare up this recently anywhere else on Earth. Colinear major and trace element variation suggests these lavas share a common evolutionary history (Hildreth et al., 2010). Moreover, geodetic observations (InSAR and GPS) indicate that LdM is inflating at a rate of 30 cm per year since 2007. Modeling predicts that an expanding magma body located at 5 km depth is driving this inflation (Fournier et al., 2010; LeMevel et al., 2013). The distribution of high-silica rhyolite lavas erupted 12 km apart on opposite sides of the lake within a few kyr of each other, magnetotelluric data showing an extensive zone of low resistivity at 5 km depth, and numerous local volcano-tectonic and long period earthquakes shallower than 5 km, suggest that the magma intrusion may represent only a portion of a much larger rhyolitic body, potentially of caldera-forming dimensions. Significant andesitic and dacitic volcanism is absent from the central basin of LdM since the early post-glacial silicic flare up began suggesting that a large body of low density rhyolite has blocked mafic magmas from reaching the surface. Temporal trends in the major element compositions of the phenocryst-poor and glassy rhyolite domes show the most evolved was erupted early in the post-glacial period followed by slightly lower-silica rhyolites. Two oxide thermometry reveals that the rhyolites tapped highly oxidized and hot melt stored at 760 to 850 oC and fO2 at Ni-NiO plus 1.25 log unit. Fractional crystallization modeling using the rhyolite calibration of the MELTS algorithm (Gualda et al., 2012) reproduces the high-silica compositions from a basaltic parental magma. The preferred model predicts 86 percent crystallization while cooling from 1290 to 800 deg. C at a depth of 5 to 8 km resulting in a water content of 4-6 wt. percent in the residual high-silica magma. The suite of recent LdM lavas lies on a single evolutionary pathway supporting a cogenetic origin. Our observations and modeling are are consistent with a large active, hot, crystal-poor, rhyolitic body of melt underlying much of the LdM lake basin. This body has the potential to fuel either a modest explosive eruption, or perhaps a caldera-forming eruption.