WIDESPREAD GRAVITY CHANGES ACCOMPANYING RAPID UPLIFT AT LAGUNA DEL MAULE, CHILE

Craig Miller, Glyn Williams-Jones, Hélène Le Mélédic, Basil Tikoff

e. Simon Fraser University 8. University of Wisconsin-Madison
cam32@sfu.ca

INTRODUCTION

Laguna Del Maule Volcanic Field

- Will this be the world’s next caldera forming eruption?
- Active since 1.5 Ma producing at least 130 distinct vents.
- 36 eruptions post glaciation from 24 vents, high silica rhyolite (Hildreth et al., 2010).
- Most recent rhyolite dated at 2.2 ka.
- Currently the world’s fastest inflating volcano that is not actually in-eruption.
- Deformation first detected in 2007 from InSAR at rates of up to 250 mm/year.
- Our hypothesis is that uplift is due to intrusion of basaltic magma into the base of a rhyolitic magma chamber.
- In 2013 we began a microgravity and deformation study to test this hypothesis.

SURVEY METHOD

- A 35 benchmark microgravity network established in March 2013 and resurveyed in January 2014 (Figure 2).
- Benchmarks precisely positioned with static GNSS, connected with network of 5 CGPS stations around LdM.
- 3 gravity meters employed to minimise errors from an individual site.
- Data corrected for Earth tides, ocean loading and up to 294 mm of uplift (µcorrection, llc). Maximum llc = 11 μgals.

METHOD

- Reduced gravity changes accompanying rapid uplift at Laguna del Maule, Chile.
- Data corrected for Earth tides, ocean loading and up to 294 mm of uplift (µcorrection, llc). Maximum llc = 11 μgals.

HEIGHT CHANGE

- Benchmark height changes between 2013 and 2014 show a maximum uplift of 281±13 mm, centered in the south of the lake (Figure 3).
- Height errors range from 2 mm to 25 mm to a maximum 79 mm.
- Uplift pattern is roughly circular around the maximum with a slight NW-SE elongation.

Figure 4: Height change (Ldh) between 2013 and 2014 surveys. Black dots are survey stations, blue line is lake outline, contour interval 602 m.

- Residual gravity change between surveys has a maximum Δg of 134±30 μgals (Figure 3).
- Two samples, bootstrap-t-test, on all the data, shows 2013 and 2014 gravity surveys are different at p < 0.01.
- The Δg anomaly is oriented east-west and covers an area of 5 km x 10 km in the southern half of the lake.
- 1.2 x 10^13 kg estimated minimum mass increase from Gaussian integration of the residual gravity anomaly.
- Source depth range of 2-4 km from half amplitude / half width relationships for spherical source.
- Localised, small positive and negative anomalies may relate to mass changes caused by roadworks near the benchmarks.

Future work

- Resurvey the network in 2015 and 2016 to assess the continuation of temporal changes.
- Quantitatively model the gravity changes to determine the shape, density and depth of the intrusion.
- Jointly invert the gravity and height data to determine the spatial relationships between the volumetric and mass sources. How to reconcile the differences in source depths?
- Undertake Bouguer gravity survey to model internal structure.
- Undertake CO₂ soil gas survey to help constrain magma input into system.

CONCLUSIONS

- Widespread mass and density increase beneath southern part of Laguna del Maule accompanies uplift.
- Volumetric source and mass volumes broadly agree but sources may be spatially distinct.
- If rate of volume change has been constant then up to 0.3 km³ of magma has been intruded since 2007.
- Gravity anomaly coincident with most recent rhyolite flow: possible long lived area of melt.

ACKNOWLEDGEMENTS

- Field work was funded by NSF RAPID grant EAR-1322595.
- Thanks to Nathan Andersen (UW) for field assistance, and the dates in Introduction.
- H.L.M. has been partially supported by NASA grant (NASA-NNX12AO02C), the G.P. Woolard fund, and NSF-1411779.
- C.A.M. is supported by GNS Science, EQC and Mitasco, with acknowledgements to Mira Geoscience.

REFERENCES