Origin of measured surface displacements at the volcanic complex of Lastarria-Cordon Del Azufre between 1996 and 2010: Insights from numerical simulations

Alexis Hrysiewicz[*†1], Thierry Menand[1], Jean-Luc Froger[*1], Valérie Cayol[*2], and Dominique Remy[3]

[1]Laboratoire Magmas et Volcans (LMV) – Université Clermont Auvergne, Centre National de la Recherche Scientifique : UMR6524, Institut de recherche pour le développement [IRD] : UMR163 – Campus Universitaire des Cézeaux, 6 Avenue Blaise Pascal, 63178 Aubière Cedex, France

[2]Université de Lyon – Laboratoire Magmas et Volcans, Université Jean Monnet - Saint-Etienne, Université Clermont Auvergne, Centre National de la Recherche Scientifique - CNRS : UMR6524, Institut de recherche pour le développement [IRD] : UMR163 – 23 rue Dr. Paul Michelon, 42023 Saint Etienne, France

[3]Géosciences Environnement Toulouse (GET) – Université Paul Sabatier (UPS) - Toulouse III, CNRS : UMR5563, Institut de recherche pour le développement [IRD] : UR234 – Observatoire Midi-Pyrénées 14 Avenue Edouard Belin 31400 Toulouse, France

Résumé

Since the end of the 90s, an uplift of large spatial extension (_˜ 60 km by 50 km) is observed on the volcanic complex of Lastarria-Cordon del Azufre, North of Chile, from InSAR data. A remarkable and as yet unexplained fact is that the evolution of surface displacements over time is occurs at a constant rate (3 cm/year) since at least until 2010 and perhaps as far back as 2003, (Remy et al., 2014).

In this work, we test different models to try to explain this temporal evolution, assuming that the surface displacement is due to the presence of a pressurized magma body in the crust. We also assume that the displacement related to this magma body may have begun before and continued after the observation period with a possible different dynamics (i.e. not necessarily a linear function of time). We have investigated two different hypotheses where the evolutions of displacement would appear linear in time during the period of observation. The first tested hypothesis is whether a viscoelastic rheology of the crust could produce an apparent constant rate of displacement. The second tested hypothesis, already proposed by Remy et al. (2014), is whether the evolution of displacement could have its origin in a linear evolution of the reservoir overpressure.

The first hypothesis was tested using both analytical and numerical models. An exploration of several viscoelastic models shows that only a Maxwell rheology is able to reproduce the observed displacement. But this rheology seems unrealistic because it results in the crust

*Intervenant

†Auteur correspondant: a.hrysiewicz@opgc.univ-bpclermont.fr

creeping infinitely with time (as long as stress is maintained).

For the second hypothesis, we used the thermo-mechanical models of Tait et al. (1989) and Turcotte and Schubert (2002) to show that volatile exsolution induced by magma crystallisation can indeed lead to a increase in reservoir overpressure compatible with surface observations. For sill-like sources of small volumes, a pressure increase of a few MPa/yr could explain the observations. For more voluminous sources, an increase in overpressure with a constant rate of the order of 10ˆ-2 MPa/year is required (Remy et al., 2014), and such an increase could be induced by either the crystallisation of the entire reservoir or that of a new magma batch within a pre-existing mushy magmatic reservoir; both cases are equally possible and cannot be distinguished by the models.

Future investigations will include the recent Sentinel 1 SAR data (from 2014 to 2017) to compare the proposed models with the observations.

References:

Remy, D., J.-L. Froger, H. Perfettini, S. Bonvalot, G. Gabalda, F. Albino, V. Cayol, D. Legrand, and Michel de Saint-Blanquat. 2014. "Persistent Uplift of the Lazufre Volcanic Complex (Central Andes): New Insights from PCAIM Inversion of InSAR Time Series and GPS Data." *Geochemistry, Geophysics, Geosystems.* doi:10.1007/s13398-014-0173-7.2.

Tait, Stephen, Claude Jaupart, and Sylvie Vergniolle. 1989. "Pressure, Gas Content and Eruption Periodicity of a Shallow, Crystallising Magma Chamber." *Earth and Planetary Science Letters* 92: 107–23.

Turcotte, Donald L., and Schubert Gerald. 2002. *Geodynamics Second Edition.* Cambridge University Press.