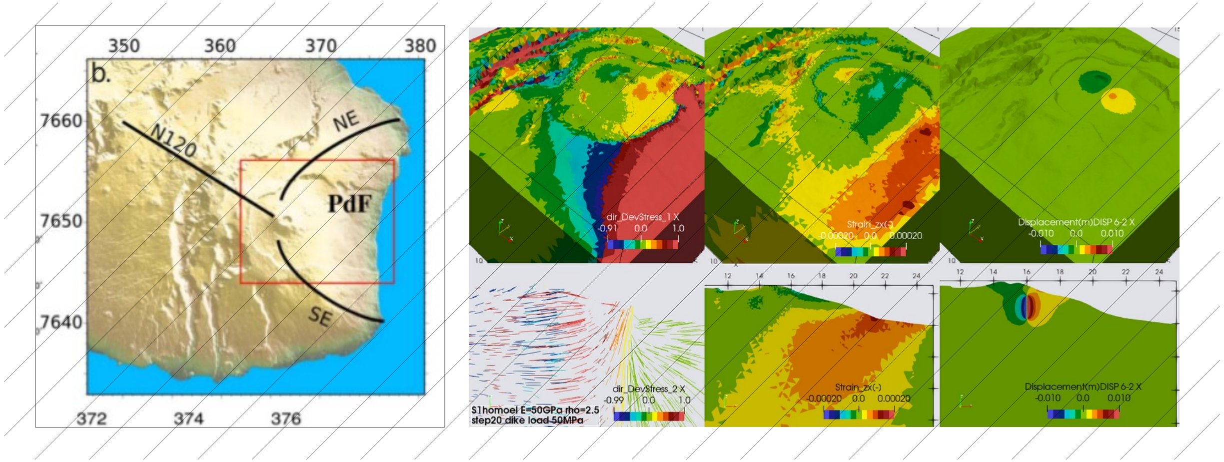
EGU2020-11571: Piton de la Fournaise...



- Sorry, we haven’t been able to achieve the planned work for this presentation : meet in 2021 !
- The following slides summarize another study, published in 2019, have a look !

Viscoelastic relaxation explains the decennial surface displacements at Laguna del Maule, Chile

Camila Novoa*, Dominique Remy, Muriel Gerbault,
J.C. Baez, A. Tassara, L. Cordoba, C. Cardona, M. Granger, S. Bonvalot, F. Delgado

Novoa et al., 2019.
DOI: 10.1016/j.epsl.2019.06.005

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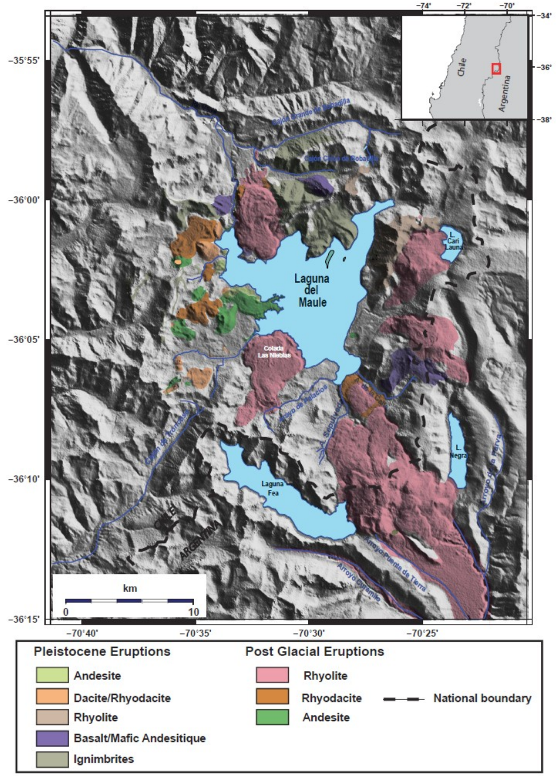
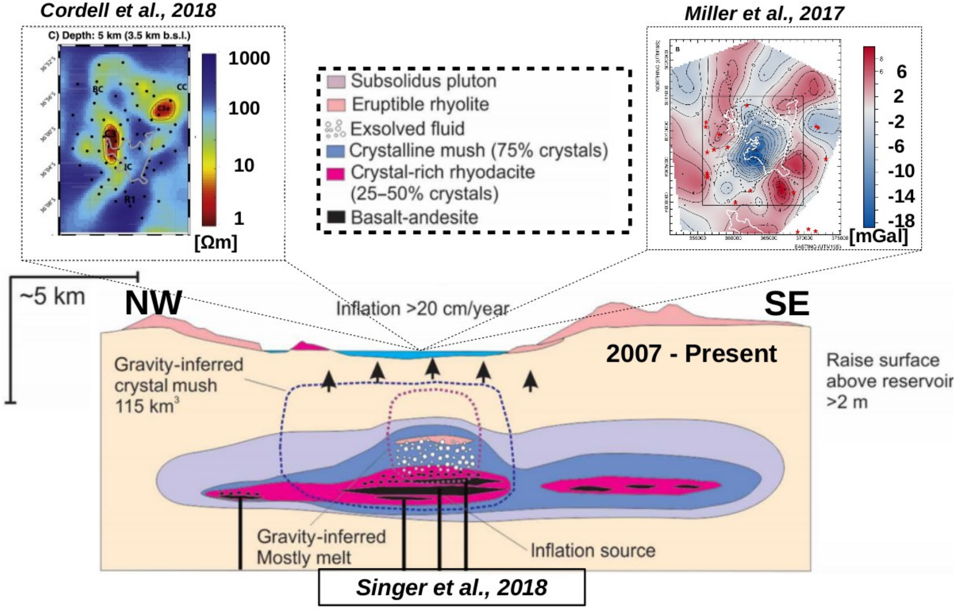
1. Introduction

Silicic systems generate the most explosive eruptions on Earth; they can accumulate large volumes of magma without systematically erupting, or maybe later on … ?



Laguna del Maule (LdM) in the Southern Volcanic Zone (SVZ) of Chile, is one of the most active Holocene silicic complexes in the world; it has been inflating since 2007, accumulating 2 m of uplift without erupting !

Geophysical and geochemical studies conclude that a large crystal rich reservoir reside beneath LdM, consistent with the concept of crystal-rich reservoirs ("mush zones"), maintained over long times beneath silicic volcanoes.



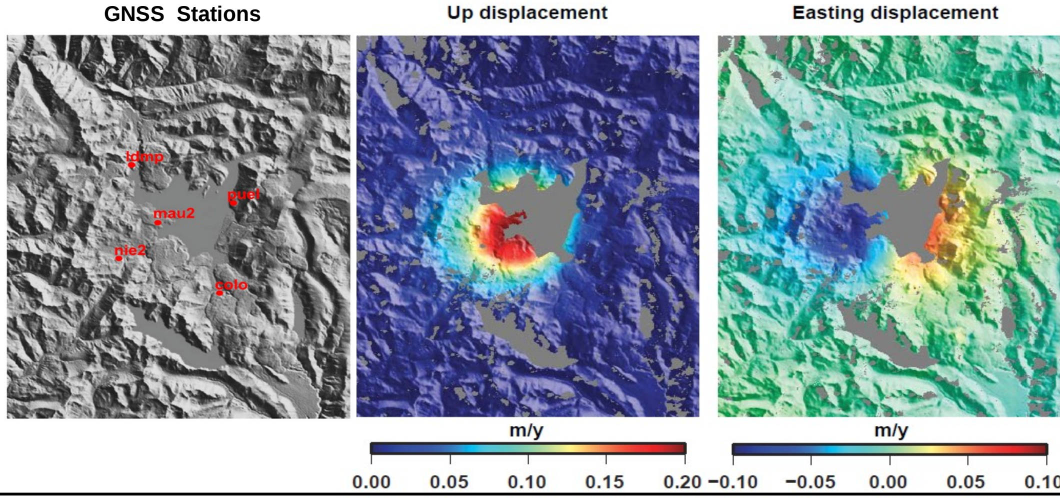
→ Here, we characterize the mechanical properties of such a mush reservoir, able to promote large surface displacements at LdM.

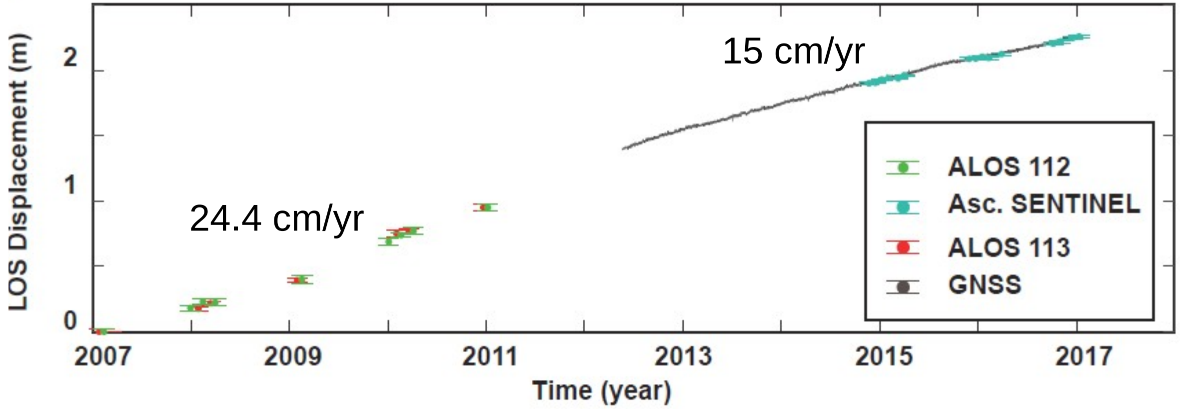
2. Observations Analysis

We use GNSS data and create ascending and descending INSAR time series between 2007 and 2017: they reveal a linear trend and an elliptical displacement pattern.

1. Elliptical displacement pattern

GNSS stations, vertical and easting surface displacement observed from Nov. 2014 to Feb. 2017 obtained from Sentinel InSAR data.





2. Linear trend

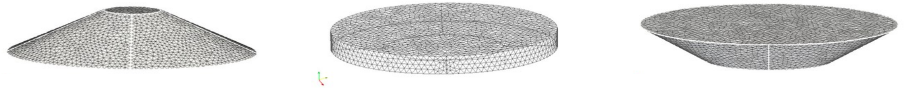
Time series of LOS displacements and their uncertainties for ascending ALOS1 InSAR and Ascending Sentinel data at the location of the GNSS station MAU2.

3. Mechanical models

1) Ground deformation modeled with an elastic rheology

We use MC3 for linear elastic media (Cayol and Cornet, 1998) in order to search for the geometries that best explain the data. The inversion is performed using a neighborhood search algorithm (Sambridge, 1999)

→ Several massive sources between 2 – 6 km depth explain the ground surface displacements



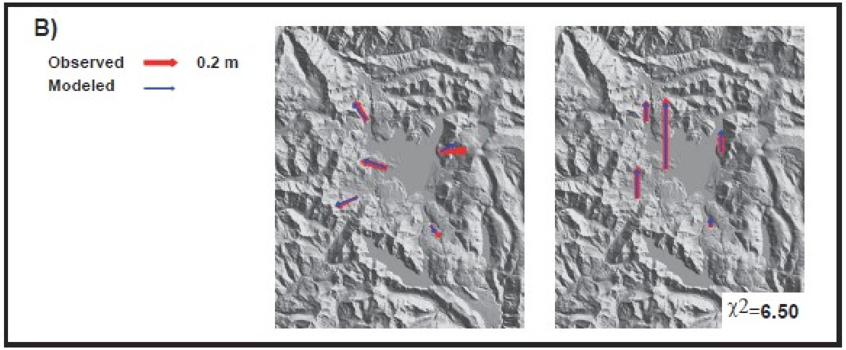
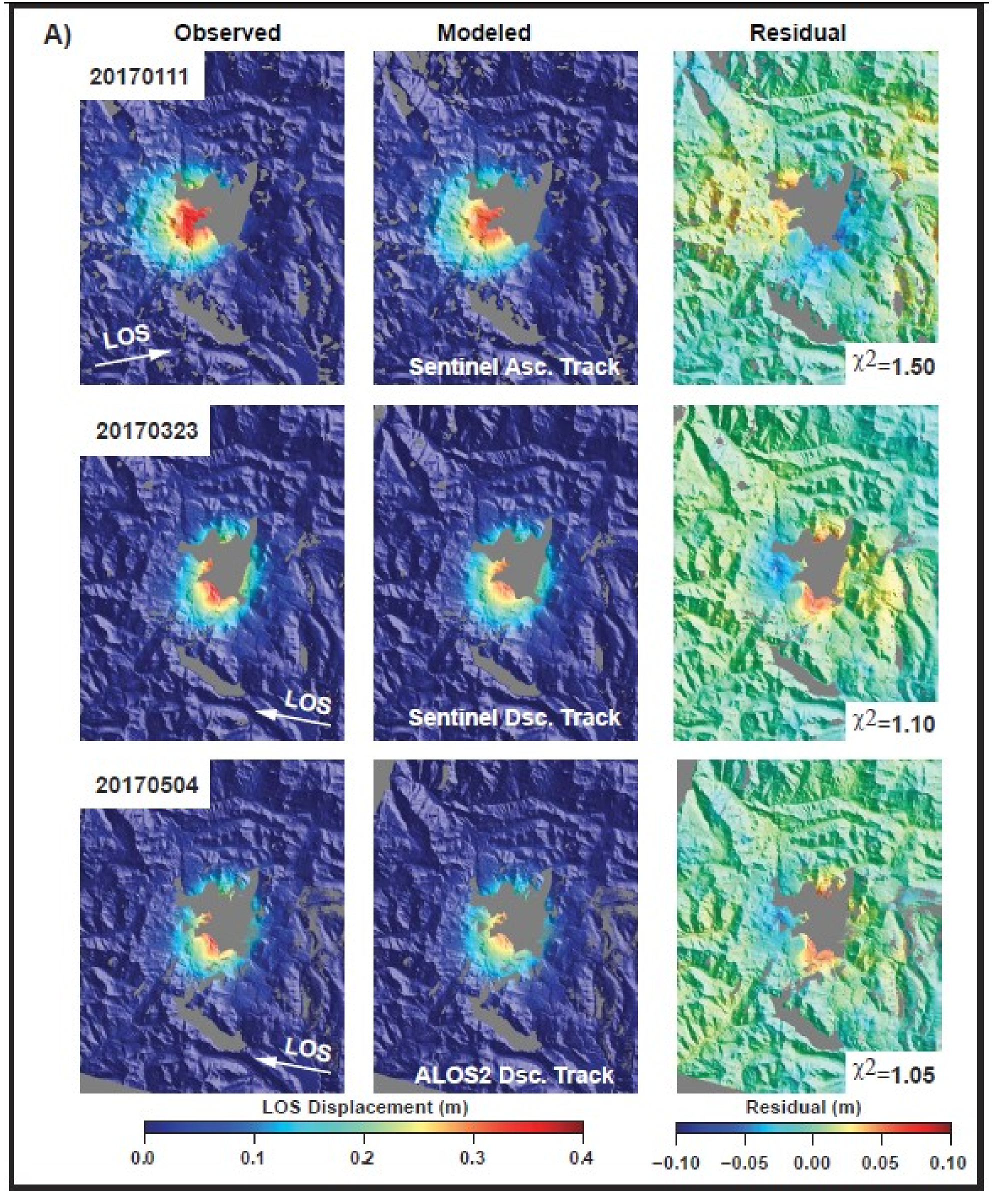


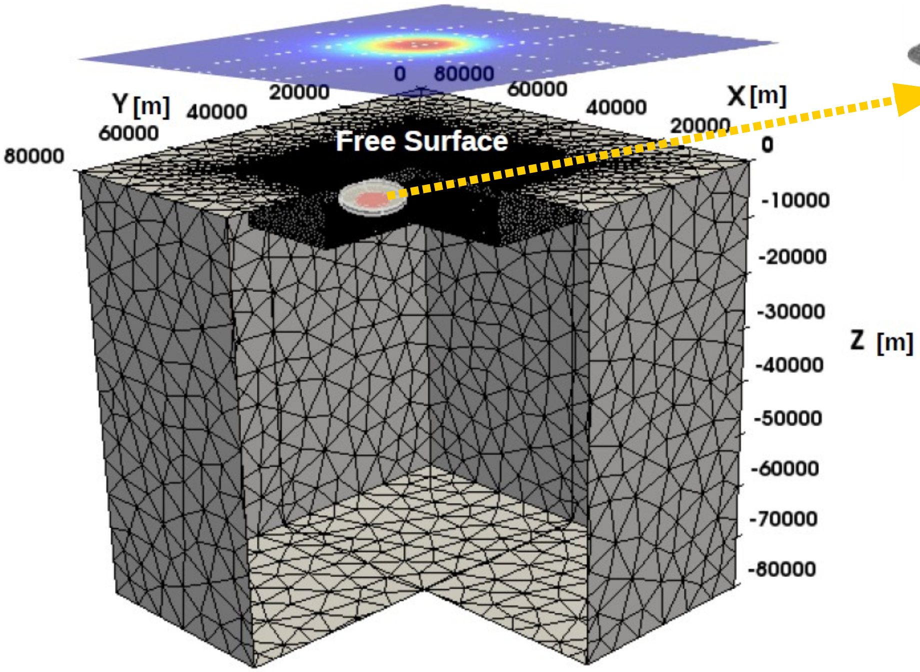
Fig. 4. Observed and modeled GNSS and InSAR data. A) Example of three LOS displacement maps, the model prediction and the residuals with observed data. B) Observed and modeled cumulated Horizontal and vertical GPS displacements from 2014 to 2017.

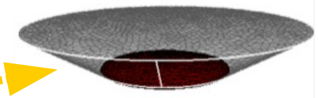


3. Mechanical models

2) Ground deformation modeled with a visco-elastic rheology :

The 3D code ADELI (Hassani et al., 1997) is used to model the temporal evolution of displacement caused by an intrusion of mafic magma located at the base of a viscoelastic mush reservoir.





Model 3

1) The increase in pressure **dP** inside the thin ellipsoidal source (red source) is applied in 2 steps, a first linear increase until **t1**, then it remains constant.

2) Then, an optimization grid search method determines the optimum loading duration of th injection (**t1**), the optimum overpressure (**dP**) inside the ellipsoidal source and the optimum viscosity (**η**) in the visco-elastic truncated cone (Levenberg,1944).

Tested range :

Shell Viscosities (η): [10^{15} – 10^{18}] Pa s
Pressure loading (t1) : [1 – 10] years
Pressure (P):[1 - 100] MPa

4. Predictions

Best fit :

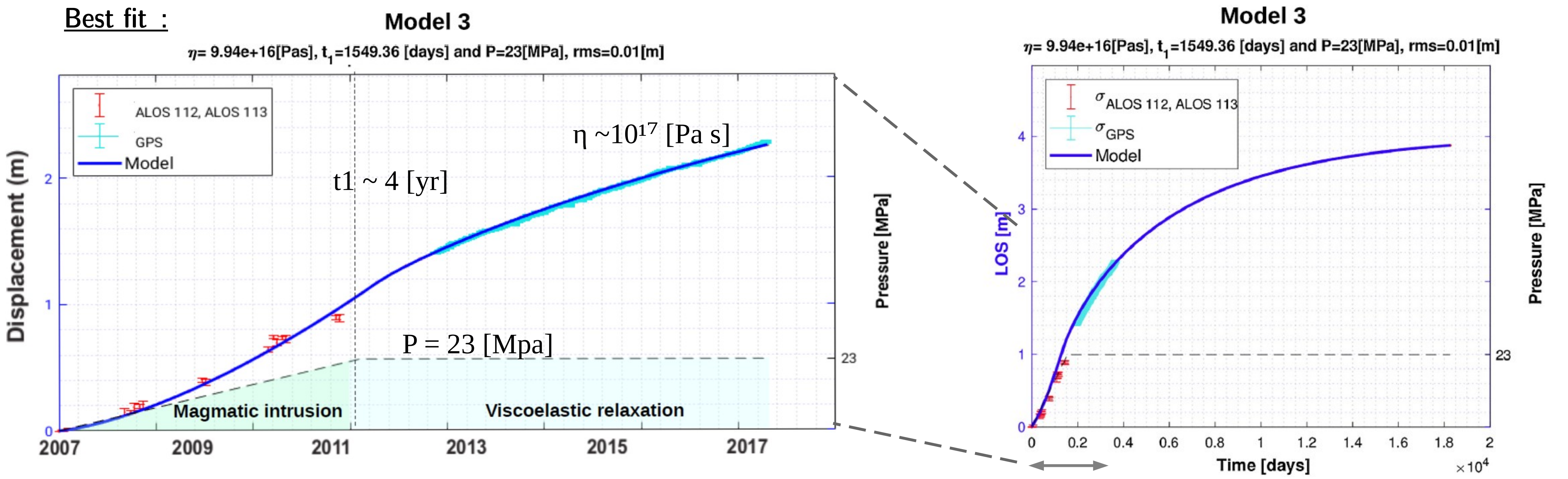


Fig. 6. Predicted temporal evolution of displacement at MAU2 for the next 50 years.

* Our model fits (thus predicts), the temporal and spatial evolution of ground displacements measured with InSAR and GNSS data between 2007 and 2017.
* We interpret the temporal behavior of displacements at LdM as resulting from two contributions: a magma recharge within the first 4 yr, followed by the viscous response of the surrounding viscoelastic shell, of equivalent viscosity 10^{17} Pa s.

* Compared to an elastic solution, our model suggests that up to 50% of the cumulated surface displacement within 10 yr can be explained by this viscous response, and predicts ongoing displacements for another 40 yr.

5. Conclusions

- Large mush reservoirs as LdM, Long Valley, Campi Flegrei, etc. may be associated to recurrent mafic recharges that do not mean imminent eruption.

- Our models support a scenario in which a basal mafic intrusion first inflates during a few yrs, then followed by continuous slow transfer of pressure through a viscoelastic reservoir (mush domain), promoting increasing ground surface displacements for up to 50 yr.

- Our best fitting dimensions, viscosity and overpressure of the visco-elastic mush reservoir are consistent with previous interpretations of a large long-lived, near-solidus magma body underneath LdM, and offers a simple explanation of the temporal evolution of surface displacements.

- We illustrated the mechanical behavior of large partially crystallized domains in the upper crust, in terms of transient stress transfer over large areas.