Available online at www.sciencedirect.com
ScienceDirect
Earth and Planetary Science Letters 255 (2007) 148–163
EPSL
www.elsevier.com/locate/epsl

Two scales of inflation at Lastarria-Cordon del Azufre volcanic complex, central Andes, revealed from ASAR-ENVISAT interferometric data

J.-L. Froger [a,b,*], D. Remy [c,d], S. Bonvalot [c,d], D. Legrand [d]

[a] *Institut de Recherche pour le Développement (IRD)-UR163-UMR6524 (LMV)-UBP-CNRS-IRD, Obs. de Physique du Globe de Clermont-Ferrand, 5 rue Kessler, 63038 Clermont-Ferrand Cedex, France*
[b] *Departamento de Geología, Facultad de Ciencias Físicas y Matemáticas, Universidad de Chile- Plaza Ercilla 803, Santiago, Chile*
[c] *Institut de Recherche pour le Développement (IRD)-UR154-UMR5563 (LMTG)-UPS-CNRS-IRD, Obs. Midi-Pyrénées- 14, av. E. Belin, 31400 Toulouse, France*
[d] *Departamento de Geofísica, Facultad de Ciencias Físicas y Matemáticas, Universidad de Chile-Blanco Encalada 2002, Santiago, Chile*

Received 29 March 2006; received in revised form 4 December 2006; accepted 7 December 2006
Available online 2 February 2007
Editor: C.P. Jaupart

Abstract

ASAR-ENVISAT Interferometric Synthetic Aperture Radar (InSAR) data collected over the Lastarria-Cordon del Azufre complex (Chile–Argentina) between March 2003 and May 2005 show the persistence of the large wavelength ground inflation revealed by Pritchard and Simons in 2002 from the analysis of ERS InSAR data [Nature 418 (2002) 167–170]. After reducing the tropospheric contribution in the interferograms using a combination of data network adjustment and analysis of MODIS images, we produced an accurate interferometric time series showing a 2 yr long temporal evolution of the ground displacements patterns. Two distinct inflating signals are detected. The main signal covers an elliptical area with a 45 km NNE–SSW major axis and a 37 km minor axis. It is correlated with a regional topographic dome. We estimated its maximum inflation rate to $\sim$2.5 cm yr^{-1}. We inverted the InSAR data for a range of source geometries (spherical, prolate ellipsoids, penny-shaped cracks). The inferred source parameters for 2003–2005 period are consistent with an over-pressured reservoir at shallow to intermediate crustal depths (7–15 km), with an average volumetric rate of inflation of about 14×10^6 m^3 yr^{-1}. In addition to this main signal a new feature highlighted by the ASAR data is short wavelength inflation (6 km wide) at the location of Lastarria volcano on the northern margin of the large wavelength signal. We explain this short wavelength signal by a spherical over-pressured source lying 1000 m below the summit of Lastarria volcano. We estimate the average volumetric rate of inflation during the observation period to be $\sim35\times10^3$ m^3 yr^{-1}. It is remarkable that both volumetric variations for the large and small inflations exhibit the same evolution during the 2003–2005 period, suggesting that both processes could be related. On the basis of the inversion results and of arguments provided by field evidences and a morpho-structural analysis of the Digital Elevation Model of the area, we propose that the deep source have a magmatic origin while the shallow source is most likely related to hydrothermal fluids. In our interpretation, the on-going deformation processes observed at Lastarria-Cordon del Azufre volcanic complex could represent an evolving pre-

* Corresponding author. Present address: Institut de Recherche pour le Développement (IRD)-UR163-UMR6524 (LMV)-UBP-CNRS-IRD, Obs. de Physique du Globe de Clermont-Ferrand, 5 rue Kessler, 63038 Clermont-Ferrand Cedex, France. Tel.: +33 473 346 700; fax: +33 473 346 744.
E-mail addresses: froger@opgc.univ-bpclermont.fr (J.-L. Froger), remy@ird.fr (D. Remy), bonvalot@ird.fr (S. Bonvalot), denis@dgf.uchile.cl (D. Legrand).

0012-821X/$ - see front matter
doi:10.1016/j.epsl.2006.12.012

caldera silicic system. Further field geological and geophysical investigations will be required to confirm these hypotheses and refine the proposed model, mostly based on satellite observations.

Keywords: Interferometry; volcanoes; displacements; Lastarria; Lazufre; Andes

1. Introduction

The Central Volcanic Zone of the Andes (CVZ) includes 50 active or potentially active volcanoes distributed along a 1500 km arc between South Peru and Chile (from 15°20′S, 72°30′W to 27°20′S, 69°W, Fig. 1a) [1–4]. Most of these volcanoes are located in remote areas difficult to access and, as a consequence, are poorly known and generally not monitored using ground geophysical networks. Synthetic Aperture Radar Interferometry (InSAR) is, therefore, an appealing and appropriate alternative to volcano monitoring in the CVZ. Moreover, due to its extreme aridity, the central part of the CVZ is an exceptionally favourable natural laboratory for InSAR studies of volcanic deformation.

Using ERS data acquired between 1992 and 2000, Pritchard and Simons [5,6] achieved a large scale InSAR survey of the CVZ. They gave the first evidence of broad scale inflation and subsidence during unrest periods over few volcanic centres which where not

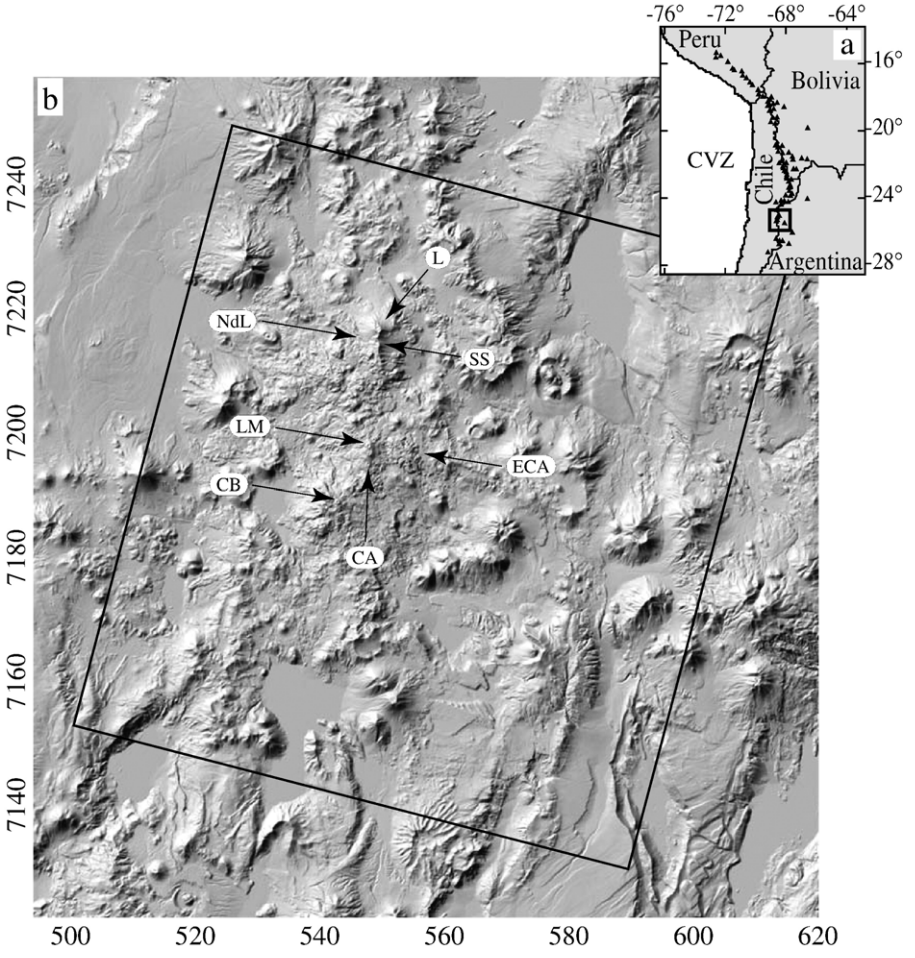

Fig. 1. (a). Location of the Lastarria-Cordon del Azufre area (black box) in the Central Volcanic Zone of the Andes. (b). Shaded DEM (SRTM) of the Lastarria-Cordon del Azufre area (CA Cordon del Azufre, CB Cerro Bayo, ECA East Cordon del Azufre, L Lastarria cone, LM La Moyra, NdL Negriales de Lastarria, SS South Spur). The black box outlines the area covered by the interferograms. Coordinates in km UTM-WGS84 (19 zone South).