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Storage conditions and eruptive dynamics of central versus flank eruptions in volcanic islands: The case of Tenerife (Canary Islands, Spain)

Joan Andújar [a,b,c,]*, Fidel Costa [d], Bruno Scaillet [a,b,c]

[a] Université d'Orléans, ISTO, UMR 7327, 45071 Orléans, France
[b] CNRS/INSU, ISTO, UMR 7327, 45071 Orléans, France
[c] BRGM, ISTO, UMR 7327, BP 36009, 45060 Orléans, France
[d] Earth Observatory of Singapore, Nanyang Technological University, Singapore 639798, Singapore

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ABSTRACT

We report the results of phase equilibrium experiments on a phonolite produced during one of the most voluminous flank eruptions (ca. 1 km^3) of the Teide–Pico Viejo complex (Tenerife Island). Combined with previous experimental and volcanological data we address the factors that control the structure of the phonolitic plumbing system of Teide–Pico Viejo stratovolcanoes. The Roques Blancos phonolite erupted ca 1800 BP and contains ~14 wt.% phenocrysts, mainly anorthoclase, biotite, magnetite, diopside and lesser amounts of ilmenite. Crystallization experiments were performed at temperatures of 900 °C, 850 °C and 800 °C, in the pressure range 200 MPa to 50 MPa. The oxygen fugacity (fO_2) was varied between NNO + 0.3 (0.3 log units above to the Ni–NiO solid buffer) to NNO-2, whilst dissolved water contents varied from 7 wt.% to 1.5 wt.%. The comparison between natural and experimental phase proportions and compositions, including glass, indicates that the phonolite magma was stored prior to eruption at 900 ± 15 °C, 50 ± 15 MPa, with about 2.2 wt.% H_2O dissolved in the melt, at an oxygen fugacity of NNO-0.5 (±0.5). The difference in composition between the rim and the cores of the natural anorthoclase phenocrysts suggests that the phonolite was heated by about 50 °C before the eruption, upon intrusion of a hotter tephriphonolitic magma. The comparison between the storage conditions of Roques Blancos and those inferred for other phonolites of the Teide–Pico Viejo volcanic complex shows that flank eruptions are fed by reservoirs located at relatively shallow depths (1–2 km) compared to those feeding Teide central eruptions (5 km).

1. Introduction

Understanding the plumbing system beneath volcanic edifices is crucial to constrain the parameters that control the evolution of ascending magmas and for anticipating the future eruptive behaviour of the volcano. The use of dense geophysical and geochemical monitoring networks deployed on highly active volcanoes (i.e., Etna volcano; Bonaccorso et al., 2004) allows to gain information concerning the movement and likely levels of magma storage. Monitoring data combined with petrological studies (e.g., Kahl et al., 2011) enables to better reconstruct the geometry of the plumbing system beneath the volcanic edifice of an on-going eruption, and thus construct more robust eruptive scenarios in the short time frame.

However, real time monitoring techniques do not easily allow to understand the mid (e.g., hundred years) to long-term (thousands of year or more) evolution of the volcanic system, or the variation of eruptive dynamics (i.e.; variation in eruptive style during a single event or between eruptions) with time. This is particularly true for volcanoes with low eruption frequency, which are characterised by long periods of dormancy during which little, if any, geophysical or geochemical signals can be recorded, making their interpretations difficult whenever the system awakes. The volcanological record often bears witness of significant variations in the eruptive styles (alternation between sustained explosive Plinian eruptions, transient explosive and purely effusive activity), and in vent location (central and flank eruptions; i.e., Ablay and Martí, 2000; Corsaro et al., 2007), which may in part reflect the complexity of the plumbing system. In such cases, only the study of past eruptions and the distribution of eruptive centres can provide insights on both the long-term evolution of the volcanic edifices and on the factors that control the eruptive dynamic.

This is the case of Tenerife in the Canary Islands, a volcanic island that has slowly evolved from a primitive to highly differentiated edifice. The spatial and temporal distribution of its recent volcanism demonstrates that the island is highly active (Martí et al., 2008), yet

* Corresponding author at: CNRS/INSU, ISTO, UMR 7327, 45071 Orléans, France. Tel.: +33 2 38 25 53 87; fax: +33 2 38 63 64 88.
E-mail addresses: Juan.Andujar@cnrs-orleans.fr (J. Andújar), fcosta@ntu.edu.sg (F. Costa), bscaille@cnrs-orleans.fr (B. Scaillet).

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eruptions are spaced in time, events being separated by about 100–1000 years (Carracedo et al., 2007; Martí et al., 2008). Tenerife island hosts the active Teide–Pico Viejo volcano, which is characterised by emission of magmas from either central (Teide main vent) or flank vents. Despite a diversity of eruptive styles during the last 35 kyrs, erupted magmas have similar phonolitic compositions (Ablay et al., 1995, 1998; Carracedo and Rodríguez-Badiola, 2006; Rodríguez Badiola et al., 2006; Carracedo et al., 2007; Martí et al., 2008;

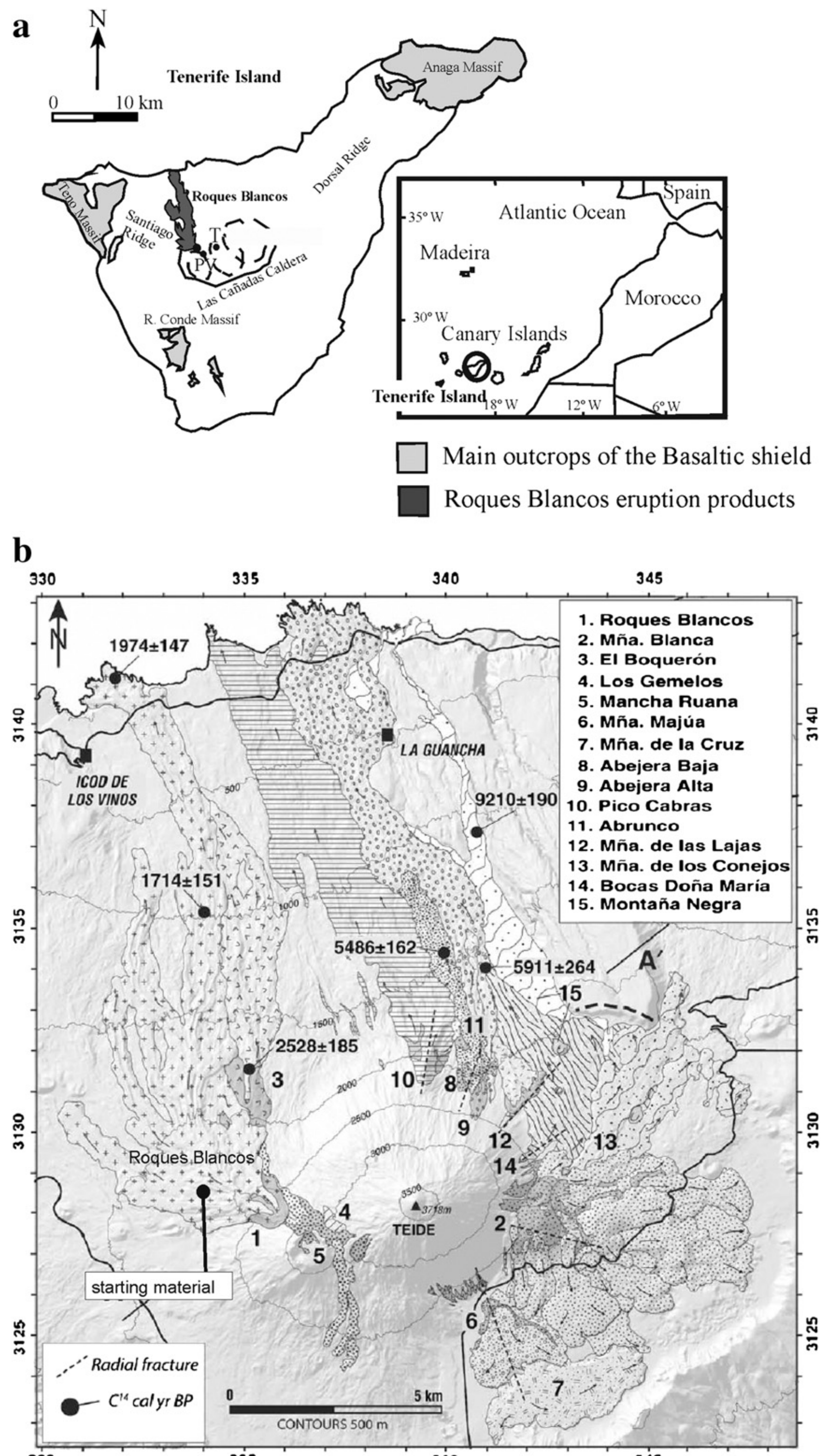

Fig. 1. a) Geographic location of the Canary Islands and simplified geological map of Tenerife showing the products of the ancient basaltic shield, the las Cañadas Caldera depression and the actual volcanic complex of Teide (T), Pico Viejo (PV), the vent and distribution of the Roques Blancos eruption products (modified from Ablay and Martí, 2000). b) Geological map of the flank dome eruptions of the Teide–Pico Viejo volcano and calibrated ages (modified from Carracedo et al., 2007); c) W view picture of the Roques Blancos flank dome and location of the corresponding vents (modified from Carracedo and Rodríguez-Badiola, 2006); d) Summary of the last 17.000 yr stratigraphy of the Teide–Pico Viejo volcanic complex (modified from Ablay and Martí, 2000; Geochronology from Carracedo et al., 2007). Note the difference in the number of phonolitic events from Pico Teide central eruptions compared to those from flank vents.