Chemical Geology 334 (2012) 324–344

Contents lists available at SciVerse ScienceDirect

Chemical Geology

journal homepage: www.elsevier.com/locate/chemgeo

Crustal versus source processes recorded in dykes from the Northeast volcanic rift zone of Tenerife, Canary Islands

F.M. Deegan [a,b,*], V.R. Troll [a,c], A.K. Barker [a], C. Harris [d], J.P. Chadwick [e], J.C. Carracedo [c], A. Delcamp [f]

[a] Department of Earth Sciences (CEMPEG), Uppsala University, 75236 Uppsala, Sweden
[b] Laboratory for Isotope Geology, Swedish Museum of Natural History, SE-104 05 Stockholm, Sweden
[c] Departamento de Física (GEOVOL), Universidad de Las Palmas de Gran Canaria, Las Palmas de Gran Canaria, Canary Islands, Spain
[d] Department of Geological Sciences, University of Cape Town, Rondebosch 7701, South Africa
[e] Science Gallery, Trinity College Dublin, Dublin 2, Ireland
[f] Department of Geography, Vrije Universiteit Brussels, Belgium

ARTICLE INFO

Article history:
Received 24 February 2012
Received in revised form 17 September 2012
Accepted 3 October 2012
Available online 12 October 2012

Editor: L. Reisberg

Keywords:
Tenerife
Ocean islands
Volcanic rift zones
O–Sr–Nd–Pb isotopes
Crustal contamination
Mantle sources

ABSTRACT

The Miocene–Pliocene Northeast Rift Zone (NERZ) on Tenerife is a well exposed example of a feeder system to a major ocean island volcanic rift. We present elemental and O–Sr–Nd–Pb isotope data for dykes of the NERZ with the aim of unravelling the petrological evolution of the rift and ultimately defining the mantle source contributions. Fractional crystallisation is found to be the principal control on major and trace element variability in the dykes. Differing degrees of low temperature alteration and assimilation of hydrothermally altered island edifice and pre-island siliciclastic sediment elevated the $\delta^{18}O$ and the $^{87}Sr/^{86}Sr$ ratio of many of the dykes, but had little to no discernible effect on Nd and Pb isotopes. Once the data are screened for alteration and shallow level contamination, the underlying source variations of the NERZ essentially reflect derivation from a young High-μ (HIMU, where $\mu = ^{238}U/^{204}Pb$)-type mantle component mixed with depleted mid-ocean ridge-type mantle (DMM). The Pb isotope data of the NERZ rocks ($^{206}Pb/^{204}Pb$ and $^{207}Pb/^{204}Pb$ range from 19.591 to 19.838 and 15.603 to 15.635, respectively) support a model of initiation and growth of the rift from the Central Shield volcano (Roque del Conde), consistent with latest geochronology results. The similar isotope signature of the NERZ to both the Miocene Central Shield and the Pliocene Las Cañadas central volcano suggests that the central part of Tenerife Island was supplied from a mantle source that remained of similar composition through the Miocene to the Pliocene. This can be explained by the presence of a discrete column of young HIMU-like plume material, ≤100 km in vertical extent, occupying the melting zone beneath central Tenerife throughout this period. The most recent central magmatism on Tenerife appears to reflect greater entrainment of DMM material, perhaps due to waning of the HIMU-like "blob" with time.

1. Introduction

Ocean island rift zones are volcanic and intrusive alignments that play an important role in controlling island growth. They have been well studied in the Canary Islands, particularly with respect to their structural development (e.g. Carracedo, 1994, 1999; Walter and Schmincke, 2002; Walter and Troll, 2003; Walter et al., 2005; Carracedo et al., 2007, 2011; Delcamp et al., 2010, 2012). Canary Island rift zones are generally long-lived, dynamic structures, whose life spans are punctuated by giant collapse events (e.g. Carracedo, 1994; Watts and Masson, 1995; Carracedo et al., 2011). Flank collapses may, in turn, influence the petrologic evolution of rift zone magmas by disrupting the underlying plumbing system and promoting initially increased mafic volcanism that is later followed by magma differentiation at higher crustal levels (cf. Longpré et al., 2009; Manconi et al., 2009; Carracedo et al., 2011). Rift zones may therefore demonstrate a large degree of petrological variability, and the magma feeding them may undergo a variety of differentiation processes, including fractional crystallisation, magma-mixing, and crustal assimilation during storage within the island edifice (Clague et al., 1995; Klügel et al., 2000; Stroncik et al., 2009; Troll et al., 2012). When looking at the elemental and isotope chemistry of ocean island rift zone magmas, it is vital to first decipher and quantify these processes before evaluating the primary mantle signatures.

The isotopic compositions of ocean island magmas are frequently employed as probes of the mantle, and exhibit variations consistent with mixing of several isotopically extreme end-member components (Zindler and Hart, 1986). Included in these are: 1) depleted MORB mantle (DMM), characterised by high $^{143}Nd/^{144}Nd$ and the lowest Sr–

* Corresponding author at: Laboratory for Isotope Geology, Swedish Museum of Natural History, Box 50 007, SE-104 05 Stockholm, Sweden. Tel.: +46 18 51954074.
E-mail addresses: Frances.Deegan@geo.uu.se, Frances.Deegan@nrm.se (F.M. Deegan), Valentin.Troll@geo.uu.se (V.R. Troll), Abigail.Barker@geo.uu.se (A.K. Barker), Chris.Harris@uct.ac.za (C. Harris), jane.chadwick@sciencegallery.com (J.P. Chadwick), jcarracedo@proyinves.ulpgc.es (J.C. Carracedo), delcampa@tcd.ie (A. Delcamp).

0009-2541/$ – see front matter © 2012 Elsevier B.V. All rights reserved.
http://dx.doi.org/10.1016/j.chemgeo.2012.10.013

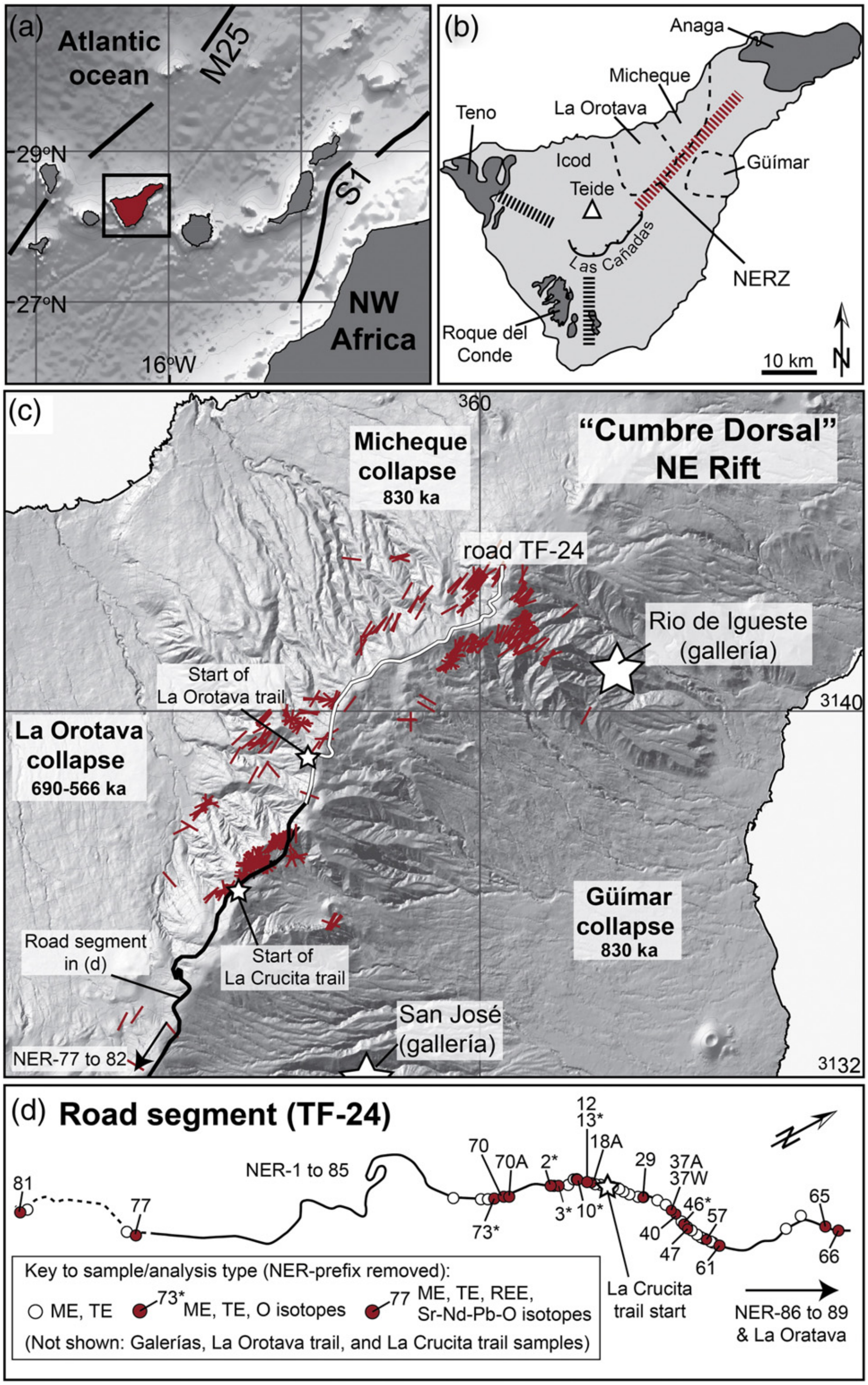

Fig. 1. a: Map of the Canary Archipelago, located off the coast of NW Africa between magnetic anomalies S1 (175 Ma) and M25 (156 Ma) (Roeser, 1982) with Tenerife highlighted. b: Simplified geological map of Tenerife showing i) the location of the shield basalt massifs Roque del Conde (the Central Shield), Teno, and Anaga, ii) the three rift zones (thick dashed black lines) and the collapse scars flanking the NERZ, iii) the Las Cañadas caldera wall, and iv) the location of the Teide volcanic complex at the junction of the rift zones and within the Icod landslide scar. c: Shaded relief map of the NERZ showing the distribution of dykes along the rift (short red lines) and the three collapse depressions flanking the ridge. The road TF-24 is shown, along which there is good exposure of the rift zone dykes. Most of the dykes analysed in this study were sampled along the segment of TF-24 highlighted in black and shown in detail in (d). The start of the trails "La Orotava" and "La Crucita" leading away from the main road, and the locations of the entrance to two gallerías are also shown. d: Detail of a segment of the road TF-24 along which most of the analysed dykes were sampled. Samples used for isotopic analysis from this road segment are highlighted in red and labelled.

Pb isotope ratios of all the mantle components, 2) enriched mantle (EM 1 and 2) with variable $^{87}Sr/^{86}Sr$, low $^{143}Nd/^{144}Nd$, and high $^{207}Pb/^{204}Pb$ and $^{208}Pb/^{204}Pb$ at a given $^{206}Pb/^{204}Pb$ and 3) high-μ (HIMU, where $\mu = ^{238}U/^{204}Pb$) which has low $^{87}Sr/^{86}Sr$, intermediate $^{143}Nd/^{144}Nd$, the highest Pb ratios of the mantle components, and is thought to involve subducted ocean crust with long mantle residence times (see Hoffman,