Available online at www.sciencedirect.com
ScienceDirect
Earth and Planetary Science Letters 259 (2007) 227–238
EPSL
www.elsevier.com/locate/epsl

A unique lower mantle source for Southern Italy volcanics

Anita Cadoux [a,b,*], Janne Blichert-Toft [c], Daniele L. Pinti [d], Francis Albarède [c]

[a] *UMR IDES 8148, Interactions et Dynamique des Environnements de Surface, Université Paris Sud XI, Bât. 504, 91405 Orsay Cedex, France*
[b] *Instituto de Geofisica, Universidad Nacional Autonoma de Mexico, Circuitos Instituto s/n, Ciudad Universitaria, 04510 Mexico D.F., Mexico*
[c] *Laboratoire de Sciences de la Terre, CNRS UMR 5570, Ecole Normale Supérieure de Lyon, 46 Allée d'Italie, 69364 Lyon Cedex 7, France*
[d] *Département des Sciences de la Terre et de l'Atmosphère and GEOTOP-UQAM-McGILL, Université du Québec à Montréal, P.O. Box 8888, Succ. Centre Ville, Montréal, Qc, Canada H3C 3P8*

Received 21 July 2006; received in revised form 28 March 2007; accepted 2 April 2007
Available online 11 April 2007
Editor: H. Elderfield

Abstract

The Southern Italy volcanism is characterized by the unusual occurrence of volcanic rocks with ocean-island basalt (OIB)-like characteristics, in particular at Etna and Iblean Mts in Sicily. The geochemical properties of the source of the Italian magmatism are usually explained by a north–south binary mixing between a mantle- and a crustally-derived end-members. The nature of the mantle end-member is, however, not agreed upon. One type of interpretation invokes a mixture of depleted mantle (DMM) and high U/Pb (HIMU) end-members [Gasperini, D., Blichert-Toft, J., Bosch, D., Del Moro, A., Macera, P., Albarède, F., 2002. Upwelling of deep mantle material through a plate window: Evidence from the geochemistry of Italian basaltic volcanics, J. Geophys. Res. 107, 2367–2386], whereas an alternative view holds that the mantle end-member is unique and homogeneous, and similar to the FOZO- or C-type end-member identified in oceanic basalts [Bell, K., Castorina, F., Lavecchia, G., Rosatelli, G., Stoppa, F., 2004. Is there a mantle plume below Italy? EOS 85, 541–547]. Because mixing does not produce linear relationships between the isotopic compositions of different elements, we applied Principal Component Analysis (PCA) to the Pb isotope compositions of the Italian volcanics inclusive 36 of Sicily volcanoes. We demonstrate that HIMU cannot be an end-member of the Italian volcanics, but rather that the common component C (~FOZO), which we interpret as reflecting the lower mantle, best represents the mantle source of the Italian magmatism. Our PCA calculation shows that the first principal component alone, which we take to be a mixture of two geochemical end-members, C and a crustally-derived component, explains 99.4% of the whole data variability. In contrast, the DMM end-member (the second principal component) is only present in the volcanics from the Tyrrhenian Sea floor. The C-like end-member, well represented by the Etna and Iblean Mts (Sicily), has relatively low $^{3}He/^{4}He$ ratios suggesting upwellings of lower mantle material from the 670 km transition zone. A slab detachment beneath the central-Southern Italy and probably the Sicily could account for the particular character of Italian magmatism.

Keywords: Italian magmatism; OIB; lead isotopes; principal component analysis; common component; slab detachment

1. Introduction

The presence in oceanic basalts of a common mantle component that is not the ubiquitous depleted upper mantle (asthenosphere) of mid-ocean ridge basalts

* Corresponding author. Instituto de Geofisica, Universidad Nacional Autonoma de Mexico, Circuito Institutos s/n, Ciudad Universitaria, 04510 Mexico D.F., Mexico. Tel.: +52 55 5622 4028; fax: +52 55 5550 2486.
E-mail address: cadoux@geofisica.unam.mx (A. Cadoux).

0012-821X/$ - see front matter © 2007 Published by Elsevier B.V.
doi:10.1016/j.epsl.2007.04.001

(MORB) is probably one of the major findings of igneous isotope geochemistry (Farley and Craig, 1992; Hart et al., 1992; Hanan and Graham, 1996). Although all these authors concur that this common mantle component, dubbed FOZO (FOcus ZOne) by Hart et al. (1992), PHEM (Primitive HElium Mantle) by Farley and Craig (1992), and C (Common component) by Hanan and Graham (1996), may represent the lower mantle, it has been recognized, probably most vividly by Hanan and Graham, that it is not unequivocally associated with high $^{3}He/^{4}He$ ratios and therefore does not carry the signature of primordial material. How ubiquitous the common component (which we will hereafter refer to as C in recognition of the criteria used by Hanan and Graham that were probably the strongest) and therefore how widespread upwellings of lower mantle may be, is still unknown. One of the places where such an upwelling was suggested is Southern Italy. Since the work of Hamelin et al. (1979), several authors have emphasized the presence of a strong ocean island basalt (OIB) 'flavor' in the lavas erupted in the area centred around Mt. Etna, Sicily. More specifically, D'Antonio et al. (1996) and Gasperini et al. (2002) suggested that this flavor was due to a mixture of two standard mantle end-members: DMM, for depleted MORB mantle, and HIMU, for a high U/Pb reservoir. Gasperini et al. (2002) observed very well-defined mixing hyperbolas between mantle-derived and crustally-derived (or EM II) components in a variety of isotopic systems, which they suggested reflect a thorough mixture between these two components in the lavas from Southern Italy. Gasperini et al. (2002) inferred that OIB-type mantle is injected through a slab window created under the Southern part of the peninsula by the rotation of the downgoing slab subsequent to the Apennine collision, but wondered how hot spot material

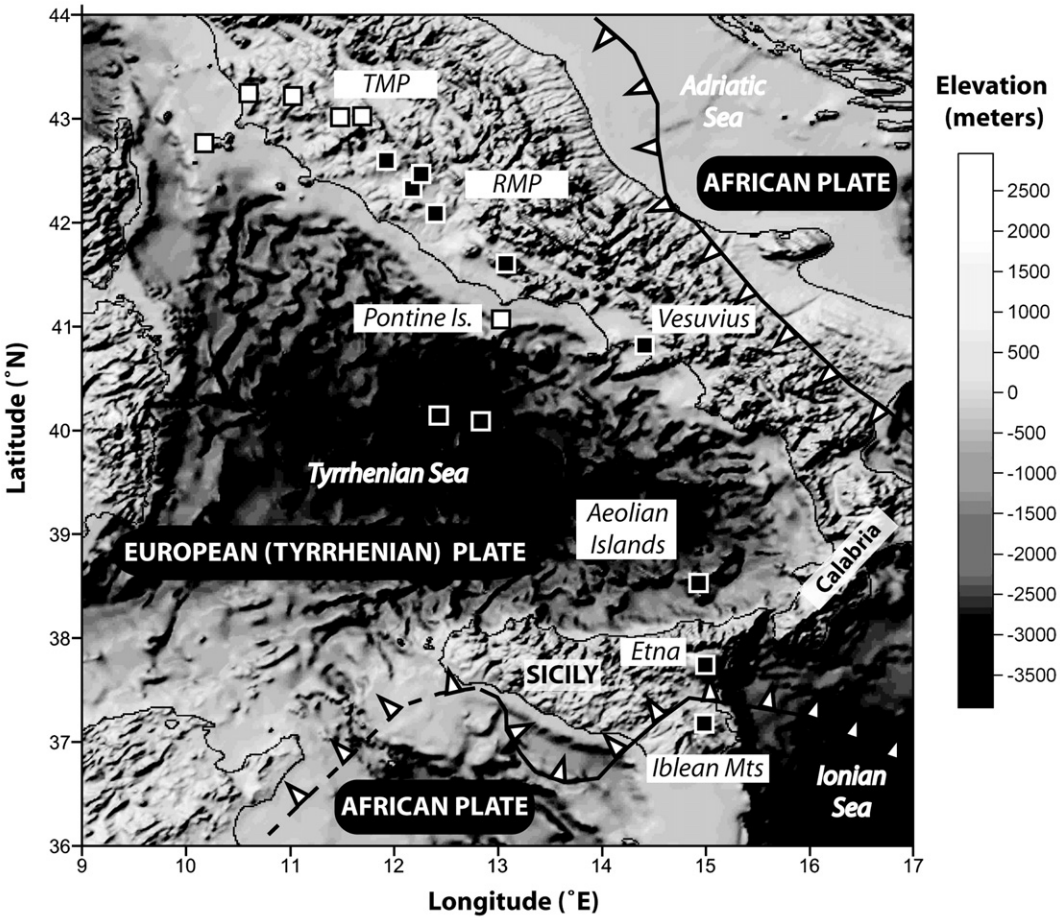

Fig. 1. Digital elevation model of Italy (built from 1 min gridded GEBCO data) with data location. White squares: this study (data reported in Table 1); black squares: Gasperini et al. (2002). TMP, Tuscan Magmatic Province; RMP, Roman Magmatic Province. The present location of the subduction front (D. Frizon de Lamotte, personal communication) and the European and African plates are indicated.