Chemical Geology 386 (2014) 165–183

Contents lists available at ScienceDirect

Chemical Geology

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

Subduction-related enrichment of the Neapolitan volcanoes (Southern Italy) mantle source: New constraints on the characteristics of the slab-derived components

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ARTICLE INFO

Article history:
Received 5 July 2013
Received in revised form 8 August 2014
Accepted 8 August 2014
Available online 20 August 2014

Editor: L. Reisberg

Keywords:
Neapolitan volcanic area
Phlegrean Volcanic District
Somma–Vesuvius complex
Basilicata ophiolites
Pre-enrichment mantle wedge
Subducted slab-derived melts and fluids

ABSTRACT

The Neapolitan volcanic area (Southern Italy), which includes the Phlegrean Volcanic District and the Somma–Vesuvius complex, has been the site of intense Plio-Quaternary magmatic activity and has produced volcanic rocks with a subduction-related geochemical and isotopic signature. High-Mg, K-basaltic lithic lava fragments dispersed within hydromagmatic tuff of the Solchiaro eruption (Procida Island) provide constraints on the nature and role of both the mantle source prior to enrichment and the subduction-related components. The geochemical data (Nb/Yb, Nb/Y, Zr/Hf) indicate a pre-enrichment source similar to that of enriched MORB mantle. In order to constrain the characteristics of subducted slab-derived components added to this mantle sector, new geochemical and Sr–Nd-isotopic data have been acquired on meta-sediments and pillow lavas from Timpa delle Murge ophiolites. These represent fragments of Tethyan oceanic crust (basalts and sediments) obducted during the Apennine orogeny, and may be similar to sediments subducted during the closure of the Tethys Ocean. Based on trace element compositions (e.g., Th/Nd, Nb/Th, Yb/Th and Ba/Th) and Nd-isotopic ratio, we hypothesize the addition of several distinct subducted slab-derived components to the mantle wedge: partial melts from shales and limestones, and aqueous fluids from shales, but the most important contribution is provided by melts from pelitic sediments. Also, trace elements and Sr–Nd-isotopic ratios seem to rule out a significant role for altered oceanic crust. Modeling based on variations of trace elements and isotopic ratios indicates that the pre-subduction mantle source of the Phlegrean Volcanic District and Somma–Vesuvius was enriched by 2–4% of subducted slab-derived components. This enrichment event might have stabilized amphibole and/or phlogopite in the mantle source. 6% degree of partial melting of a phlogopite-bearing enriched source, occurring initially in the garnet stability field and then in the spinel stability field can generate a melt with trace elements and Sr–Nd-isotopic features matching those of high-Mg, K-basalts of Procida Island. Furthermore, 2% partial melting of the same enriched source can reproduce the trace elements and isotopic features of the most primitive magmas of Somma–Vesuvius, subsequently modified by assimilation of continental crust during fractional crystallization processes at mid-lower depth. Combined trace element and Sr–Nd isotope modeling constrains the age of the enrichment event to 45 Ma ago, suggesting that the Plio-Quaternary magmatism of the Neapolitan area is post-orogenic, and related to the subduction of oceanic crust belonging to the Tethys Ocean.

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1. Introduction

The Mediterranean area is one of the most complex geodynamic settings in the world (e.g., Carminati et al., 2012, and references therein) as clearly illustrated by the huge variety of igneous rocks. On the basis of trace element concentrations, and isotopic compositions, the latter ranging from typical mantle to typical crustal values, sectors characterized by either anorogenic (Lustrino and Wilson, 2007) or orogenic magmatism (Harangi et al., 2006; Lustrino et al., 2011) are usually distinguished in the Central–Western Mediterranean area, including Italy (Fig. 1a). Since the Cenozoic, the Central–Western Mediterranean area has been the site of intense but discrete magmatic activity. The products show a wide compositional range, from sub-alkaline (tholeiitic and calc-alkaline) to alkaline (sodic, potassic, and ultrapotassic) and from mafic/ultramafic to felsic (Peccerillo, 2005, and references therein). There are many hypotheses concerning the magmagenesis and geodynamic significance of these rocks (e.g., Peccerillo and Lustrino, 2005), but most of the Mediterranean orogenic magmatism might reasonably be the result of partial melting of mantle sources

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http://dx.doi.org/10.1016/j.chemgeo.2014.08.014
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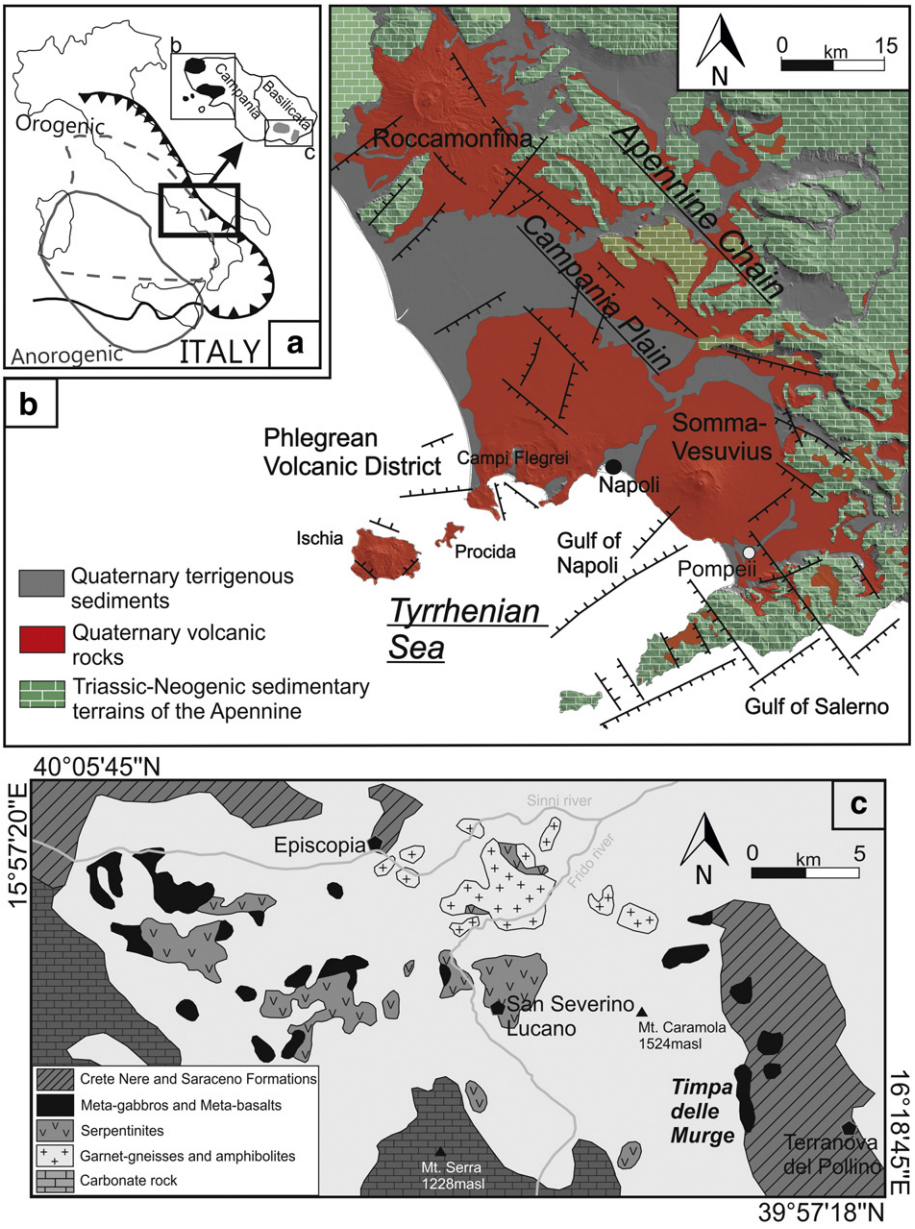

Fig. 1. a: Cenozoic anorogenic and orogenic magmatism in the Central–Western Mediterranean area, and the position of the Apennine thrust front. The boxes b and c show the approximate position of the Campania Volcanic Zone (CVZ) and Mt. Pollino Chain in the outline map of Italy. The upper right corner of Fig. 1a shows an expanded view of the bold box. b: Schematic geological and structural map of the Tyrrhenian margin of the Campania region (modified after Bonardi et al., 1988a). c: Geological map of the Liguride Units of the Mt. Pollino Massif in Basilicata (modified after Bonardi et al., 1988a).

modified by slab materials during and/or after subduction event(s). For Italian magmatism in particular, this hypothesis is supported by a considerable number of studies that highlight its post-orogenic character (e.g., Beccaluva et al., 1991; D'Antonio et al., 1996, 1999; Peccerillo, 1999; Conticelli et al., 2002, 2004; Francalanci et al., 2004; Tonarini et al., 2004; Duggen et al., 2005; Harangi et al., 2006; Conticelli et al., 2007; D'Antonio et al., 2007; Francalanci et al., 2007; Avanzinelli et al., 2008; Bianchini et al., 2008; Avanzinelli et al., 2009; Conticelli et al., 2009; Nikogosian and van Bergen, 2010; Lustrino et al., 2011; Prelević et al., 2012; D'Antonio et al., 2013). Furthermore, Italian magmatism has been related to the subduction of the Ionian oceanic lithosphere, which was part of the wider Tethys Ocean (Gvirtzman and Nur, 1999; Faccenna et al., 2007).

In the framework of the complex magmatism of the Western Mediterranean, the volcanic area of Campania (Southern Italy) is one of the most interesting. This area has been the site of intense volcanism during Plio-Quaternary times. Over the past ~40 ka, volcanism has been localized mainly in the Mt. Somma–Vesuvius complex (SV) and the Phlegrean Volcanic District (PVD), that includes the Campi Flegrei caldera as well as the Ischia and Procida islands in the Gulf of Napoli (Orsi et al., 1996; Fig. 1b). The products of all these volcanoes show geochemical and isotopic features typical of subduction-related volcanic rocks. The aim of this study is twofold. The first aim is to better identify the composition of the pre-enrichment mantle underlying the Neapolitan volcanic area, still poorly known due to the scarcity of suitable primitive mafic rocks; the second aim is to characterize the nature of the subduction-related components (fluids and/or melts from sediments and/or altered oceanic crust) that modified this pre-existing mantle composition.

In order to shed light on the nature of the pre-enrichment mantle, we selected the most mafic rocks of the Neapolitan volcanic area: the

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