Available online at www.sciencedirect.com
ScienceDirect
Lithos 101 (2008) 379–396
LITHOS
www.elsevier.com/locate/lithos

Partial crustal melting beneath the Betic Cordillera (SE Spain): The case study of Mar Menor volcanic suite

A.M. Álvarez-Valero [a,*], L.M. Kriegsman [b]

[a] Department of Geology, Faculty of Experimental Sciences, University of Huelva, Campus El Carmen, Avda. Fuerzas Armadas, s/n, 21071, Huelva, Spain
[b] National Museum of Natural History, Naturalis, Darwinweg 2, 2333 CR Leiden, The Netherlands

Received 27 April 2007; accepted 15 August 2007
Available online 29 August 2007

Abstract

The Neogene Volcanic Province (NVP) within the Betic Cordillera (SE Spain) consists of three main metapelitic enclave suites (from SW to NE: El Hoyazo, Mazarrón and Mar Menor). Since the NVP represents a singular place in the world where crustal enclaves were immediately quenched after melting, their microstructures provide a "photograph" of the conditions at depth just after the moment of the melting.

The thermobarometric information provided by the different microstructural assemblages has been integrated with the geophysical and geodynamical published data into a model of the petrologic evolution of the Mar Menor enclaves. They were equilibrated at 2–3 kbar, 850–900 °C, and followed a sequence of heating melt producing reactions. A local cooling event evidenced by minor melt crystallization preceded the eruption.

The lower crustal studies presented in this work contribute to the knowledge of: (i) the partial melting event beneath the Mar Menor volcanic suite through a petrologic detailed study of the enclaves; (ii) how the microstructures of fast cooled anatectic rocks play an important role in tracing the magma evolution in a chamber up to the eruption, and how they can be used as pseudothermobarometers; (iii) the past and current evolution of the Alborán Domain (Betic Cordillera) and Mediterranean Sea, and how the base of a metapelitic crust has melted within an active geodynamic setting.

Keywords: Betic Cordillera; Crustal partial melting; Enclaves; Microstructures; Mar Menor

1. Introduction and geological setting

Partial melting is a decisive process-link between metamorphism and magmatism, playing a key role in the development of migmatites, granulites and S-type granites during crustal evolution (e.g. Ashworth and Brown, 1990; Clemens and Droop, 1998). The interactions and equilibria between melt, fluid, and solid phases are critical parameters for understanding the processes operating in the lower crust and upper mantle during partial melting (e.g. Waters, 1988; Cesare et al., 1997; Kriegsman, 2001a; Buick et al., 2004). Thus, to characterize the assorted features of partial melting, as a function of the protolith type and geodynamic setting, it is important to study the chemistry, amount of melt produced and mode of segregation, and the ascent and emplacement mechanisms of melt at crustal depths (e.g., Brown, 1994; Brown et al., 1995; Cesare et al., 1997; Kriegsman, 2001b).

* Corresponding author. Tel.: +34 959219826; fax: +34 959219810.
E-mail address: antoniomiguel.alvarez@dgeo.uhu.es (A.M. Álvarez-Valero).

0024-4937/$ - see front matter © 2007 Elsevier B.V. All rights reserved.
doi:10.1016/j.lithos.2007.08.016

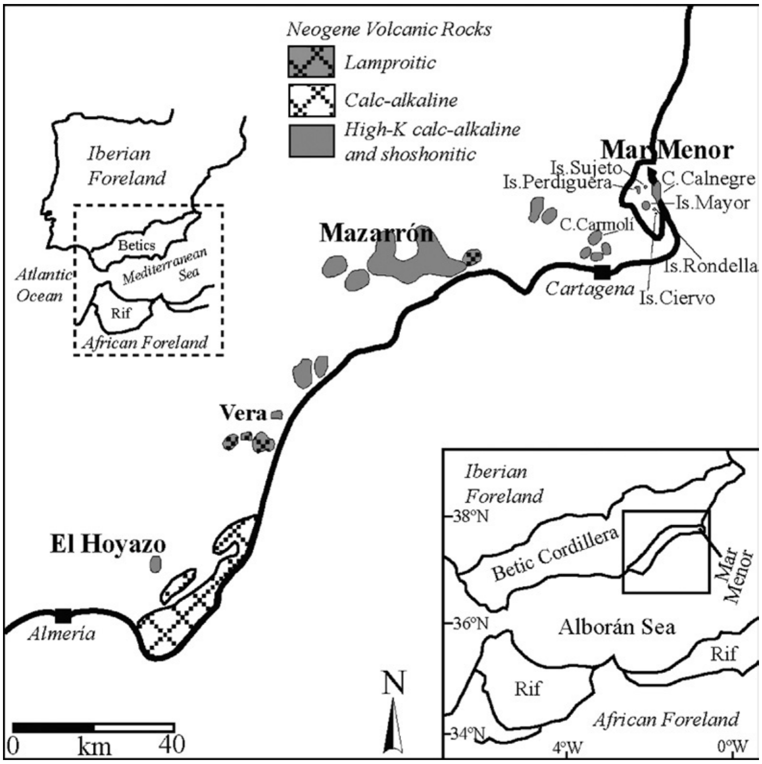

Fig. 1. Geographic location and schematic tectonic elements of the main edifices of the Miocene volcanic rocks of the Neogene Volcanic Province within the Alborán Domain.

Regional migmatites are crustal domains affected by partial melting, where melt extraction has been inefficient, leaving behind a high melt fraction. As regional migmatite domains are large and generally situated at depths of 15 km or more, melt crystallization is slow enough to allow back reaction with residual solids. Hence, prograde migmatite textures are generally overprinted by retrograde textures (Kriegsman and Hensen, 1998; Kriegsman, 2001a). The alternative approach of experimental simulation (e.g. Patiño-Douce and Johnston, 1991; Holtz and Johannes, 1994; Vielzeuf and Montel, 1994; Stevens et al., 1997) also has the limitations of producing grain-sizes which are several orders of magnitude finer, and of using rates which are several orders of magnitude faster, than in nature. On the other hand, crustal enclaves are residual solids brought to the (near-) surface through volcanic vents, where melt crystallization is fast and prograde textures are frozen in. Therefore, this work is important because it allows studying the process of crustal anatexis in enclaves where all phases that were present during anatexis, including the melt phase, are now recognizable, analyzable, and melt–restite back reactions are likely absent or reduced to a minimum. That's why the importance of studying systems (i.e. exceptional natural enclaves which can confidently be considered as true examples of the behaviour of lower to mid-crustal rocks during partial melting), where peritectic phases and quenched glass compositions are preserved.

The most important volcanism associated to the Betic Cordillera is the Neogene eastern area, lying along approximately 250 km of scattered outcrops. At this volcanic fringe three main metapelitic enclave suites originated by partial melting at different crustal depths, decreasing from 20–25 km in the SW (El Hoyazo) to 9–12 km in the NE (Mar Menor) (Cesare et al., 1997; Álvarez-Valero and Kriegsman, 2007). The Mar Menor volcanic zone is made up of numerous calc-alkaline dacitic to andesitic islands and some upland outcrops, e.g. Isla Perdiguera, Isla Mayor, Isla del Sujeto, Isla del Ciervo, Isla Rondella, Cerro Carmolí, Cerro Calnegre, with c. 20 km^2 of erupted volcanic rocks (Fig. 1). The lava is porphyritic, with >50 vol.% of rhyolitic glassy matrix, and phenocrysts of plagioclase, biotite, cordierite. It also contains abundant xenocrysts, encompassing the whole mineral assemblage of restites. From a chemical point of view these rocks are peraluminous and mainly composed of calc-alkaline andesites with plagioclase and orthopyroxene crystals (Zeck, 1968, 1970; Cesare et al., 1997; Benito et al., 1999).