



Age of anatexis in the crustal footwall of the Ronda peridotites, S Spain



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ABSTRACT

This study investigates the age of anatexis of a crustal sequence constituting the footwall of the Ronda peridotite slab, in the hinterland of the Betic Cordillera (S Spain, region of Istán). These rocks represent a polymetamorphic basement involved in the Alpine orogeny and show an increase in the proportion of melt towards the peridotites. Metamorphic conditions in the migmatites vary between $T \approx 675\text{--}750\text{ }^{\circ}\text{C}$ at $P \approx 0.30\text{--}0.35\text{ GPa}$. The timing of metamorphism and deformation of the migmatites around the Ronda peridotites is controversial and has been previously ascribed to either the Alpine or Variscan orogenies. We present U–Pb SHRIMP dating of zircons from six samples collected across the migmatitic sequence that provide a tighter age constraint on the metamorphism. Zircon ages are related to conditions of metamorphism on the basis of the relationships between zircon microstructures and degree of melting recorded by the host rocks. Anatexis occurred during the late stages of the Variscan orogeny ($\approx 280\text{--}290\text{ Ma}$), as indicated by ages of euhedral, oscillatory-zoned domains or new crystals in metatexites and diatexites. Thin, U-rich zircon rims that are affected by radiation damage yield discordant scattered dates between ≈ 260 and 30 Ma , which are interpreted as reflecting a thermal and fluid overprint during the Alpine orogeny that produced recrystallization and Pb loss in Permian zircons. This study identifies a previously unknown Variscan domain within the Betic Cordillera, and indicates, in accordance with previous studies, that Variscan basements recycled during the Alpine orogeny that formed the Betic Cordillera preserve pre-Alpine mineral associations and tectonic fabrics.

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1. Introduction

Determining the ages and rates of high-grade metamorphism and anatexis in poly-metamorphic terrains is hampered by a series of factors. First, minerals and/or single mineral domains that crystallized and equilibrated during tectonometamorphic events belonging to different orogenic cycles can coexist within a sample (e.g. Fernández-Suárez et al., 2002). Second, the geochronometers that are suitable at upper amphibolite- and granulite-facies conditions are mostly accessory minerals such as zircon and monazite, whose growth is difficult to relate to major mineral assemblages that provide P–T conditions. Confusion or lack of information on the relationships between radiometric ages and major mineral growth produces a great uncertainty in the P–T–time path and, hence, in the tectonic interpretation of poly-metamorphic terrains. In the case of accessory minerals, the link between ages and metamorphic mineral assemblages can be achieved by different approaches, such as: (i) combined ages of accessory mineral

and P–T data from garnet, through the study of mineral inclusions in the garnet and the partitioning of REE between garnet and the accessory minerals (Harley and Kelly, 2007; Hermann and Rubatto, 2003; Rubatto, 2002; Whitehouse and Platt, 2003); (ii) in situ dating of accessory minerals that show well-defined microstructural relationships with major mineral assemblages (Williams and Jercinovic, 2012); (iii) dating of accessory minerals that can be linked to particular metamorphic reactions (Janots et al., 2009); and (iv) relating microstructures and ages of accessory minerals with variation in metamorphic grade in the host rock (Rubatto et al., 2001; Williams, 2001) or directly with melt inclusions (Cesare et al., 2003, 2009).

The Ronda peridotites outcrop in the hinterland of the Alpine Betic Cordillera of south Spain (Fig. 1), and represent the largest known exposure of subcontinental lithospheric mantle (Obata, 1980). They constitute a tectonic slab up to $\approx 5\text{ km}$ thick, sandwiched in between crustal units that show increasing metamorphic grade towards the contact with the mantle rocks, reaching conditions of anatexis at several hundred meters from the contact (Acosta-Vigil et al., 2001; Argles et al., 1999; Balanyá et al., 1997; Esteban et al., 2008; Lundeen, 1978; Platt et al., 2003a; Tubía et al., 1997). Partial melting in the crustal footwall

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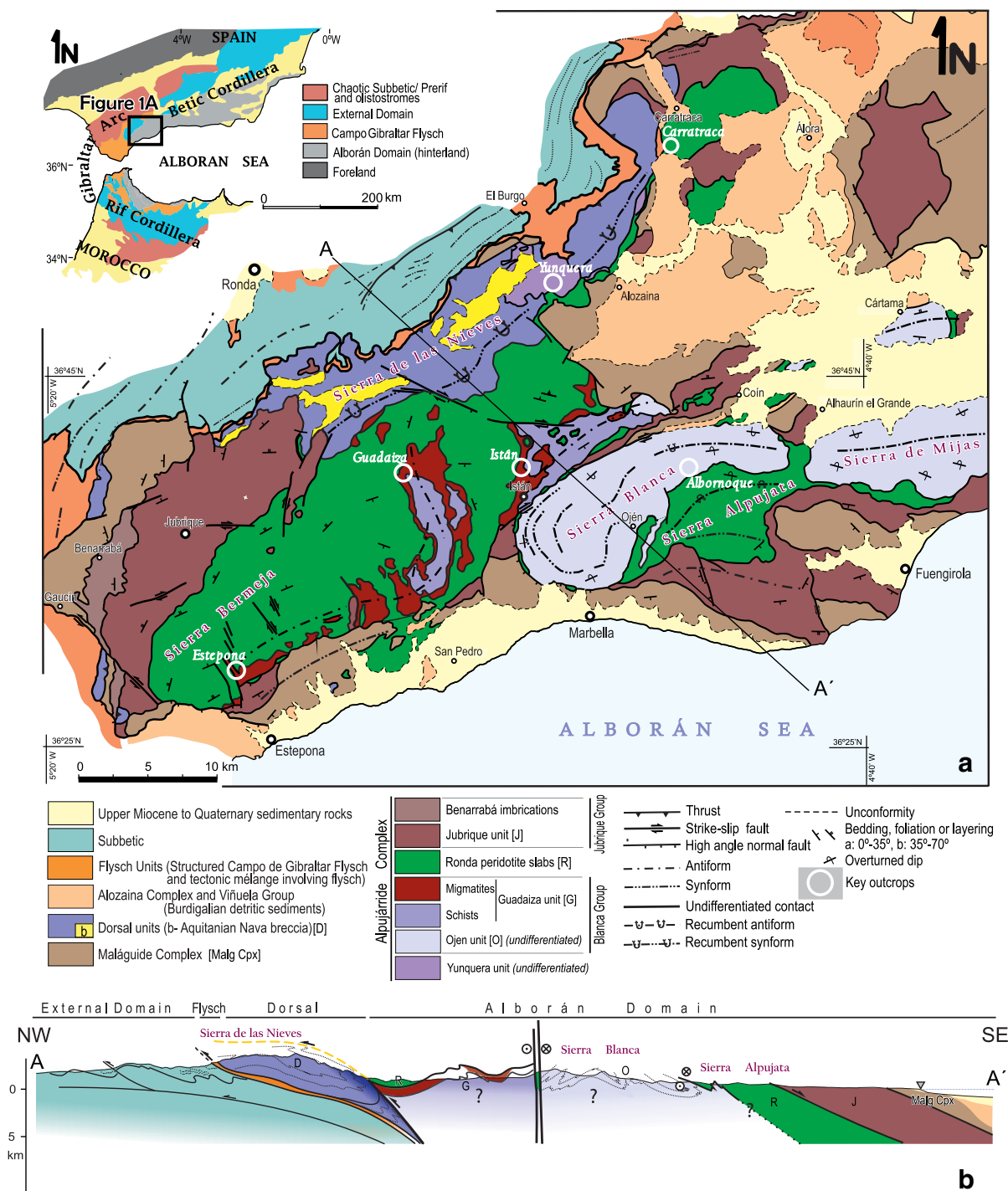


Fig. 1. (A) Geologic maps of the Betic-Rif orogen and the western Betic Cordillera (modified from Balanyá et al., 1997; including data from Martín-Algarra, 1987; Mazzoli and Martín-Algarra, 2011; Sanz de Galdeano and Andreo, 1995; Tubía et al., 2013), showing the several outcrops of the Guadaíza and Ojen units, the study area near the village of Istán, and the location of the cross-section shown in subpanel B. (B) Schematic cross-section of the western Betic Cordillera across the peridotite massifs of Sierra Bermeja and Sierra Alpujata.

has been associated with the hot crustal emplacement of the Ronda peridotites (Esteban et al., 2008; Torres-Roldán, 1983; Tubía et al., 1997, 2013), whereas anatexis of the crustal rocks above the peridotite has been related to decompression melting during crustal thinning (Argles et al., 1999; Platt et al., 2003a). Numerous studies conducted in the area (or in equivalent units from the Rif in northern Morocco) have attributed the high-grade metamorphism and partial melting in these rocks, and in general in the crystalline basements of the Betic-Rif orogen, either to the Variscan (Acosta, 1998; Bouybaouène et al., 1998; Gómez-Pugnaire et al., 2004; Michard et al., 1997; Montel et al.,

2000; Rossetti et al., 2010; Sánchez-Rodríguez, 1998) or the Alpine (Esteban et al., 2011a; Loomis, 1975; Rossetti et al., 2010; Sánchez-Rodríguez and Gebauer, 2000; Whitehouse and Platt, 2003) orogenies. This controversy obviously makes uncertain the P-T conditions reached during the Alpine orogeny, the geodynamic evolution of the entire Betic-Rif orogen, and even the age of the crustal emplacement of the Ronda peridotites. This study sheds light on this controversy by investigating the age of zircon in rocks across the anatexis sequence that underlies the Ronda peridotites. To relate ages from zircons to P-T conditions derived from the major mineral assemblages in the rocks, we

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