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Exhumation of a migmatite complex along a transpressive shear zone: inferences from the Variscan Juzbado–Penalva do Castelo Shear Zone (Central Iberian Zone)

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Abstract: High-grade metamorphic rocks associated with S-type granites are recorded in the Central Iberian Zone, Iberian Variscides. Though most of these occur as inferred metamorphic core complexes affiliated with detachment faults, others, such as the Figueira de Castelo Rodrigo–Lumbrales Anatectic Complex, crop out between low-grade metamorphic rocks separated by steeply-dipping strike-slip shear zones, such as the Juzbado–Penalva do Castelo Shear Zone. Our structural analysis has been able to constrain two major deformation stages during the Variscan D_3: (a) D_{3a} ductile deformation event, with clear sinistral kinematic criteria; and (b) D_{3b} thrusting ductile–brittle deformation event. The petrological investigation confirmed the jump in metamorphic grade between the host rocks and the anatectic complex. *P–T* estimates on calc-silicate rocks interlayered with the metapelites of the anatectic complex provided minimum metamorphic peak conditions of $T = 761 \pm 50$°C and $P = 5.0 \pm 1.0$ kbar. However, petrological modelling results show that *P–T* conditions must have exceeded $T > 800$°C. Both structural and geothermobarometric data support a two-step model for the exhumation of the Anatectic Complex, including a 5 – 8 km vertical exhumation along a 65 – 100 km horizontal displacement due to a simple shear-dominated transpression mechanism during the Variscan D_3 events.

Supplementary material: The petrology data, mineral chemistry analyses of the calc-silicate units and EPMA analytical conditions, and the *P–T* modelling methodology can be found at https://doi.org/10.6084/m9.figshare.c.3785648

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Migmatites are a product of partial melting of deep to mid-crustal rocks under conditions of ultrametamorphism. Upon migmatization the crust suffers a significant strength reduction and their melt-weakened domains tend to flow along crustal discontinuities constrained by pressure gradients associated with the dominant tectonic stresses (e.g. Jamieson *et al.* 2011). Upward migmatitic flow is an efficient way of crustal heat and mass transfer, ultimately leading to its emplacement at shallower crustal levels, locally generating very high metamorphic gradients.

The occurrence of high-grade metamorphic belts (i.e. metamorphic core complexes and/or gneiss domes) along low-dipping faults or shear zones in between low-grade metamorphic units is well established in the literature. Several models have been proposed for the exhumation of such high-grade complexes, namely channel flow (e.g. Hodges *et al.* 2001; Harris 2007; Searle 2013), extensional tectonics (e.g. Rey *et al.* 2009; Horton & Leech 2013), buoyancy-driven flow (e.g. Teyssier & Whitney 2002; Whitney *et al.* 2004) and late-orogenic gravitational/orogenic collapse (e.g. Martínez Catalán *et al.* 2007; Bento dos Santos *et al.* 2010, 2015; Gradim *et al.* 2014).

In the Variscan Central Iberian Zone (CIZ), high-grade metamorphic rocks and the associated S-type granites are known to be in contact with low-grade metamorphic units (e.g. Tormes Dome, Escuder Viruete *et al.* 1994; Escuder Viruete 1999; South Salamanca detachment, Díez Balda *et al.* 1995; Porto-Viseu Metamorphic Belt, Valle Aguado *et al.* 2005, 2007; Mindelo Migmatite Complex, Silva 2014). The exhumation of these high-grade metamorphic belts, associated with gently-dipping shear zones, has been explained by different mechanisms, such as extensional collapse of the Iberian Variscan Massif (Valle Aguado *et al.* 2010; Azevedo & Valle Aguado 2013), channel flow followed by extrusion tectonics (Rodrigues *et al.* 2013) and crustal thinning, as the result of normal faulting (Ribeiro *et al.* 1990).

In the CIZ, high-grade metamorphic complexes also occur in the vicinity of subvertical shear zones with predominant transcurrent kinematics. This is the case of the Figueira de Castelo Rodrigo–Lumbrales Anatectic Complex (FCR–LAC; including both migmatites and anatectic granites) bounded by the Juzbado–Penalva do Castelo Shear Zone (JPCsz; Carvalhosa 1960; Figuerola & Parga 1968; Iglesias & Ribeiro 1981). The exhumation mechanism of this complex is highly debated and has been considered either as the result of the sinistral transpression induced by the D_3 Variscan regional event (Pereira 2014) or the product of the extensional orogenic collapse along a low-dipping major shear zone during the regional D_2 deformation event (Fernández & Pereira 2016).

Here, a petrological, mineral chemistry and structural analysis study is presented and discussed in order to characterize the JPCsz and associated migmatites. The *P–T* metamorphic evolution is modelled and combined with the structural data in order to propose an evolution model for the exhumation of the FCR–LAC in the geodynamic context of the Iberian Variscides.

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