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Relative timing of transcurrent displacements in northern Gondwana: U–Pb laser ablation ICP-MS zircon and monazite geochronology of gneisses and sheared granites from the western Iberian Massif (Portugal)

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ABSTRACT

The Variscan belt of Western and Central Europe was formed by the oblique subduction of the Rheic Ocean and the collision of Laurussia with Gondwana during the Late Palaeozoic. We present field relationships and new U–Pb LA-ICP-MS zircon and monazite ages for Variscan gneisses and granites from a key section of the western Iberian Massif. The Martinchel section records the interplay of two kilometre-scale Variscan transcurrent shear zones active in the Gondwana basement of Pangaea: the Porto–Tomar fault zone (PTFZ) and the Coimbra–Córdoba shear zone (CCSZ). Different kinematic models have been invoked to explain the formation and evolution of these major Variscan structures mainly based on assumptions made in the absence of reliable radiometric ages. We show that: (1) ductile deformation and metamorphism were active in the CCSZ during the Visean–Serpukhovian (c.335–318 Ma) and created conditions for amphibolite facies metamorphism and coeval emplacement of granites; and (2) later ductile–brittle deformation related to dextral movements along the PTFZ overprinted the earlier foliation and folds derived from the CCSZ deformation, and deformed the previously intruded granites. U–Pb dating of zircon and monazites yield c.335 Ma ages for the ductile deformation developed under amphibolite facies metamorphic conditions in the Martinchel gneisses of the CCSZ. The gneisses were intruded by granites at c.335–318 Ma, and both were later deformed under ductile–brittle conditions by dextral motion on the PTFZ. The geometry of the Martinchel gneisses (typical of the CCSZ) changed from one of thrusting to one of normal faulting by refolding of the early foliation, stretching lineation and asymmetric structures related to the later PTFZ dextral shear episode. This pattern of interference is not fully considered in previous models and may lead to incorrect tectonic interpretations. According to our data and recently published ages, we suggest that the PTFZ was active after the Serpukhovian–Kasimovian since the c.318–308 Ma granites are deformed by north–south (170°) dextral shear planes. These data are critical to the interpretation of large-scale Carboniferous transcurrent displacements in northern Gondwana (Iberian Massif), and bear upon global models of crustal deformation that emphasize the importance of long-lived dextral movements during the collision between northern Gondwana and Laurussia following the closure of the Rheic Ocean.

1. Introduction

The Variscan belt of Western and Central Europe is a part of a large-scale orogenic system, with continuations into North America (Ouachitas and southern Appalachians) and West Africa (Mauritanides) (Matte, 1991; Shelley and Bossiere, 2000; Simancas et al., 2004; Martinez-Catalan et al., 2007; Melleton et al., 2010; Murphy et al., 2009). In the 1970s and early 1980s, a number of structural schemes were proposed to clarify the complex architecture of the Variscan belt of Western Europe with respect to the subduction of the Rheic Ocean and the collision of Laurentia–Baltica with Gondwana (Arthaud and Matte, 1977; Bard et al., 1980; Matte, 1986). Based on analogies with Alpine and Himalayan belts, these authors attempted to explain the time and space constraints of deformation, metamorphism and magmatism linked to the evolution of this Palaeozoic belt.

Some of the most prominent structures in the Variscan belt of Western and Central Europe are major fracture zones in the Precambrian

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and Palaeozoic regions of the Iberian (Coimbra–Córdoba shear zone and Porto–Tomar fault zone), Armorican (South Armorican shear zone) and Bohemian (Elbe fault zone) massifs, which may extend for as much as 3000 km. This belt additionally includes the Ibero–Armorican Arc, which represents a prominent orocline centered in the Bay of Biscay. The development of this arc has been attributed to syn-Variscan indentation of a rigid block by analogy with the Himalayas (Matte and Ribeiro, 1975; Matte, 1986, 1991; Dias and Ribeiro, 1995; Ribeiro et al., 2007). However, other authors have argued that the arc is a late to post-Variscan feature and formed as the result of oroclinal bending of an originally linear belt (Weil et al., 2001; García-Navarro and Férnandez, 2004; Gutiérrez-Alonso et al., 2004).

The large-scale horizontal intra-continental displacements along the fracture zones of the Variscan belt of Western and Central Europe as the result of progressive convergence. These continental fracture zones were probably formed as steeply dipping strike-slip zones, but their origin is not clear and their interpretation has been hindered by the lack of absolute ages and by an incomplete understanding of the exact tectonic configuration in which these faults operated during the assembly of Pangaea. Field evidence in the western Iberian Massif

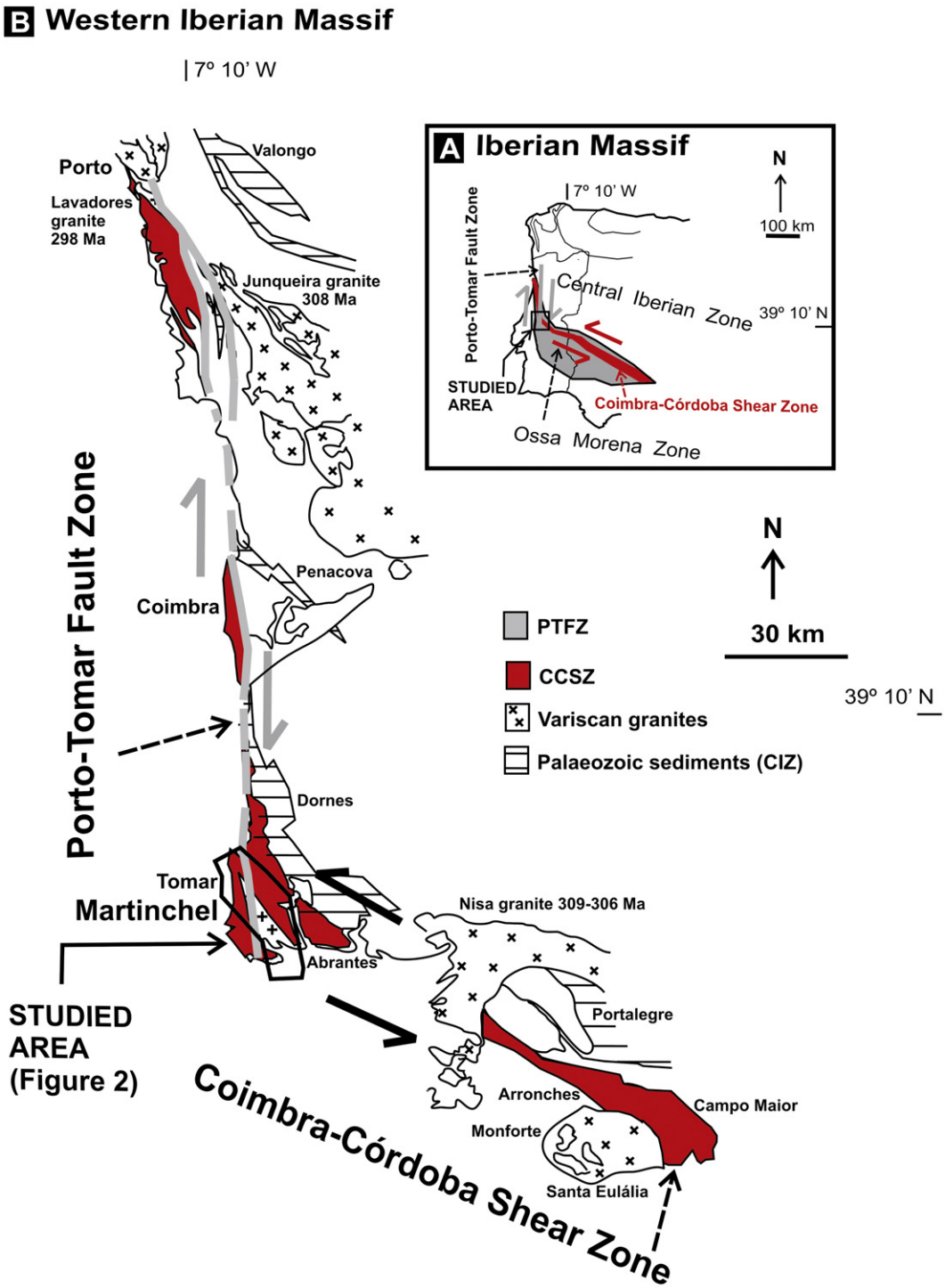

Fig. 1. Schematic map of the Western Iberian Massif showing the location of the Porto–Tomar fault zone (PTFZ) and the Coimbra–Córdoba shear zone (CCSZ) in Portugal with the location of the study area. Inset indicates the geographic location of the study area relative to the Ossa-Morena Zone (OMZ) and the Central-Iberian Zone (CIZ).