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Massive generation of atypical ferrosilicic magmas along the Gondwana active margin: Implications for cold plumes and back-arc magma generation

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Abstract

One of the most intriguing characteristics of the northern (Iberia) and southern (Puna) Gondwana margins is the presence of large volumes of Late Cambrian–Early Ordovician magmatic rocks with *ferrosilicic* composition, i.e., rocks with high iron and silica contents (FeO>4.0 wt.%, SiO>63 wt.%) for very low contents in calcium (CaO<1.5 wt.%). Geological and geochemical features, as well as experimental results, show that ferrosilicic magmas resulted from near-total melting (80–90%) of crustal sources of metagreywacke and charnockite affinities, possibly derived from Neoproterozoic volcanoclastic sediments and/or their granulite facies equivalents, under very high temperatures (1000 °C–1200 °C) and at pressures of 1.0 to 2.0 GPa. A plausible tectonic setting for this peculiar magmatism is a back-arc region subjected to extension, with the ferrosilicic magmas ascending from a deep cold diapir or mantle wedge plume. Rifting in the back-arc progressed until the aperture of an ocean basin (the Rheic ocean) in the northern margin of Gondwana, but became aborted in Argentina.

Keywords: Gondwana; Ferrosilicic magmatism; Late Cambrian–Early Ordovician; Iberia; Puna

1. Introduction

It is broadly documented that an active margin at the Gondwana supercontinent resulted in large-scale crustal reworking and net addition of continental crust during Late Cambrian to Early Ordovician times (510–460 Ma) (Bock et al., 2000; Lucassen et al., 2000; Ramos and Aleman, 2000; Zimmerman and Bahlburg, 2003; Hongn and Riller, 2007). Geochemical features and radiometric age determinations of magmatic rocks, together with detailed structural studies, are used in combination to identify new terrains as derived from magmatic activity associated with a complex active margin along a large part of Gondwana. In the Variscan belt, these terranes represent in part ancient intraoceanic arcs and microcontinents that were separated from Gondwana during Late Cambrian to Early Ordovician times and attached again to its margin during Late Palaeozoic times (Martínez Catalán et al., 1997; Matte, 2001; Pin et al., 2006). Among the most important igneous formations related to magmatic activity at the Gondwana margin during Late Cambrian to Early Ordovician times, is a thick sequence of silicic magmatic rocks, widely represented in the Iberian peninsula by the so-called "Ollo de Sapo" sequence (Hernández Sampelayo, 1922; Parga Pondal et al., 1964; Martínez Catalán et al., 2004), and in the South American continent by the Famatinian–Eastern Puna magmatic eruptive belts (Pankhurst et al 1998; Saavedra et al., 1998; Coira et al., 1999; Hongn and Riller, 2007; Viramonte et al., 2007). In both cases the magmatic sequence is a several km thick association of silicic rock of igneous origin in which plutonic, subvolcanic and eruptive facies can be identified. A magmatic provenance is strike forward in the Puna eruptive belt, where no orogenic event has substantially modified the original relations of the magmatic rocks. In Iberia, these rocks were severely affected by deformation and metamorphism during the Variscan orogeny and the textural relations were largely obliterated. The identity in geochemical features and age of these igneous sequences, the

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Eastern Puna eruptive belt in South America and the Ollo de Sapo unit in Iberia, as well as the position of both zones at the Gondwana continental margin indicate that they formed part of the same magmatic event. In South America, the Famatina belt, a magmatic lineament of more than 2000 km (Chew et al., 2007), represents a typical arc with calc-alkaline magmas and the development of large batholiths (Pankhurst et al., 1998; Saavedra et al., 1998; Dahlquist et al., 2005). In Iberia, evidences of arc magmatism for Early Ordovician times are found in the Ordenes complex (Abati et al., 1999). Therefore, it has been proposed that these magmatic rocks were formed in relation to back-arc spreading associated with an active subduction (Coira et al., 1999) identified by arc magmatism. In both cases, Iberia and South America, the magmatic rocks of arc affinities and calc-alkaline batholiths related to the active margin of Gondwana during Cambrian to Ordovician times, occupied positions more external than the silicic magmatic belts (Ollo de Sapo and Eastern Puna eruptive belt). Consequently, the formation in a back-arc tectonic context seems to be the more plausible scenario for this silicic magmatism.

Textural relations have been modified for the Ollo de Sapo rocks. However, in the Eastern Puna eruptive belt the original volcanic provenance and derivation from silicic melts are evident. Given their atypical composition, the fact that these silicic magmas are derived by crystallisation from a melt sets an important petrogenetic problem. Conditions for the generation of these atypical silicic magmas are discussed here. Their implications are considered in a plate-tectonic scenario relating Fe-rich, silicic magma production with active subduction and back-arc spreading. In the first part of the paper we show the

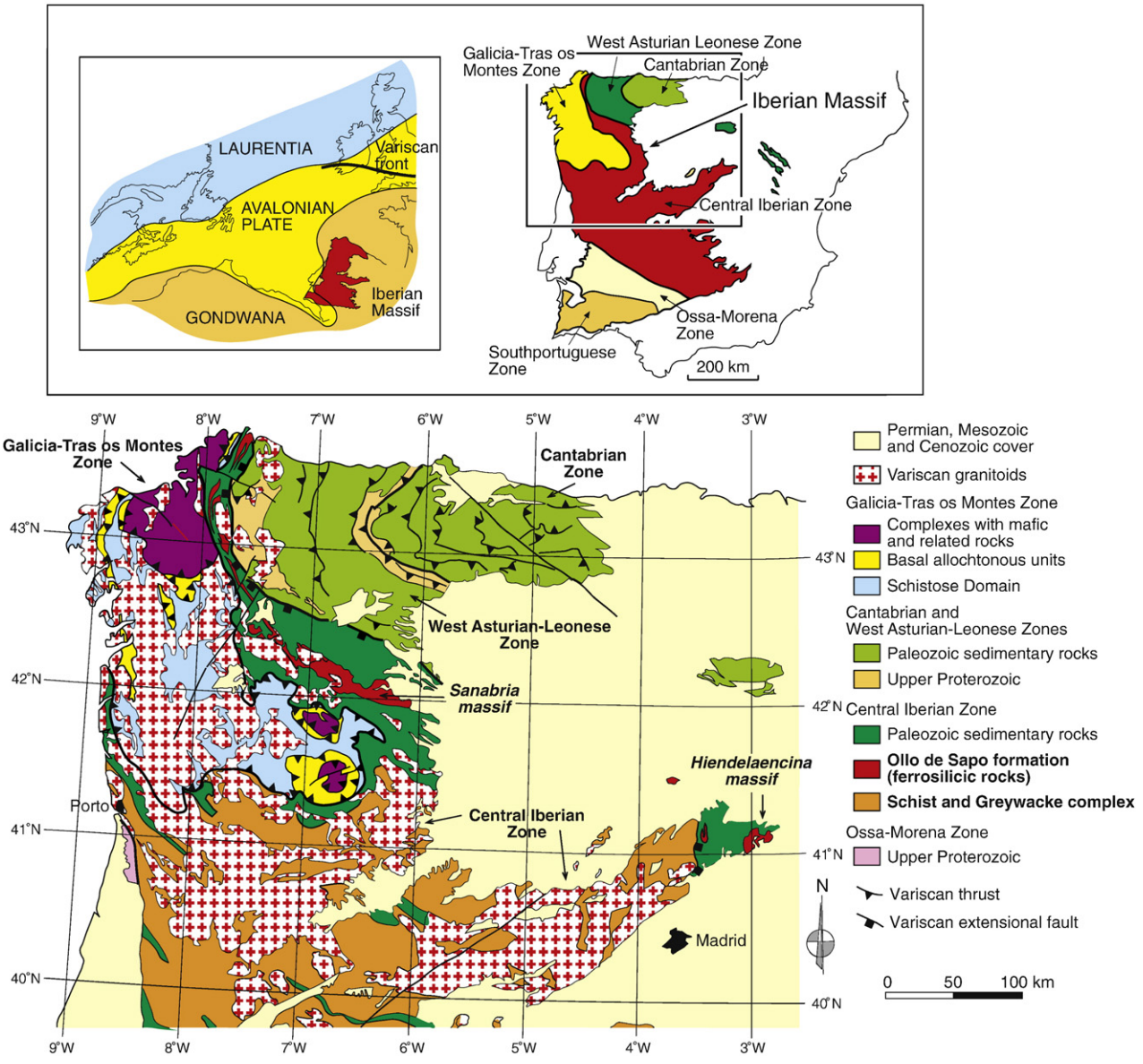

Fig. 1. Geological map of northwest Iberia (modified from Rodríguez-Fernández, 2004) showing the exposures of the main units studied in this work, the Ollo de Sapo formation and the Schist and Greywacke complex. Inset shows a simplified sketch of the Iberian Massif (right, based on Farias et al., 1987) and its location in the realm of the Variscan orogen during the Late Palaeozoic (left, modified from Martínez Catalán et al., 1997).