The Significance of Changes of Source Areas During Carboniferous Turbiditic Deposition (Southwestern Iberia)

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Abstract U–Pb dating of detrital zircons from the Carboniferous turbidites of southwestern Iberia (the Cabrela, Mértola, Mira, and Brejeira formations) shows that synorogenic sedimentation during the Carboniferous was marked by significant variations in the source areas, involving the denudation of different crustal blocks and a break in synorogenic volcanism. The Visean is characterized by the accumulation of immature turbidites (the Cabrela and Mértola formations and the base of the Mira Formation). These turbidites were probably formed in relation to sources (magmatic arcs) of Mid–Late Devonian age poorly influenced by sedimentary recycling, as indicated by the near-absence of pre-Devonian zircons, ages that are typical of the Gondwana basement. The presence of Carboniferous grains in Visean turbidites indicates that volcanism was active at this time. Later, Serpukhovian to Moscovian turbiditic sedimentation (the Mira and Brejeira

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formations) included sedimentary detritus derived from mature felsic source rocks situated far from active magmatism. The abundance of Proterozoic and Palaeozoic zircons reveals strong recycling of the pre-Carboniferous basement. A peri-Gondwanan provenance is indicated by zircon populations with Neoproterozoic (the Cadomian–Avalonian and Pan-African zircon-forming events), Palaeoproterozoic, and Archean (the West African Craton zircon-forming events) ages. The presence of Late Ordovician and Silurian detrital zircons in the Brejeira turbidites, which do not correspond to the Gondwana basement of southwestern Iberia, indicates an external source (Laurussia?).

Keywords U–Pb zircon geochronology · South Portuguese Zone · Ossa–Morena Zone · Variscan orogeny · Pangaea

The Ossa–Morena Zone (OMZ) is a peri-Gondwanan terrane that records the development of a Neoproterozoic active margin (the Cadomian orogeny; Linnemann et al. 2008). The lower Palaeozoic stratigraphy is dominated by siliciclastic sedimentation related to the evolution of Cambrian–Early Ordovician intracontinental rifting with significant magmatic activity (Sanchez-Garcia et al. 2010). The Lower to Middle Devonian deposits represent a change to sedimentation in a passive margin setting without noteworthy magmatism (Robardet and Gutierrez-Marco 2004). Middle–Upper Devonian rocks are very rare in the OMZ, and the lower Carboniferous stratigraphy is similar to that of the South Portuguese Zone (SPZ) reflecting the deposition of turbidites coevally with volcanism (Pereira et al. 2012a and references therein). The upper Carboniferous sediments in the OMZ are essentially detrital and typically continental with the sandstones and slates containing numerous fossil remains of terrestrial plants (Quesada et al. 1990). In the SPZ, the Carboniferous stratigraphy (Tournaisian to Moscovian) is composed predominantly of turbidites, indicating marine deposition (Oliveira 1990) (Fig. 1).

U–Pb dating of detrital zircons confirms that there are marked variations in the sources of the Carboniferous turbidites in southwestern Iberia. The Cabrela and Mértola formations and the base of the Mira Formation are dominated by Mid–Late Devonian and early Carboniferous detrital zircons (Pereira et al. 2012a). The rest of the Mira Formation marks another drastic change in sedimentary source dominated by Precambrian zircon-forming events (Pereira et al. 2013). This variation marks a decrease in the importance of sources related to Middle Devonian to early Carboniferous zircon-forming events (Variscan magmatism) and the presence, instead, of a characteristic source associated with the Gondwana basement of southwestern Iberia: (1) West African Craton affinity including an absence or near-absence of Stenian ages; (2) Neoproterozoic ages (the Cadomian–Avalonian and Pan-African zircon-forming events); and (3) Cambrian and Early Ordovician ages (a zircon-forming event related to the rifting in the Gondwana margin that led to the opening of the Rheic Ocean). Close to the base of the Brejeira Formation, essentially the same sources from the Gondwana basement of southwestern Iberia already identified for the Mira greywackes are retained, except for the absence of the Devonian and Carboniferous sources.

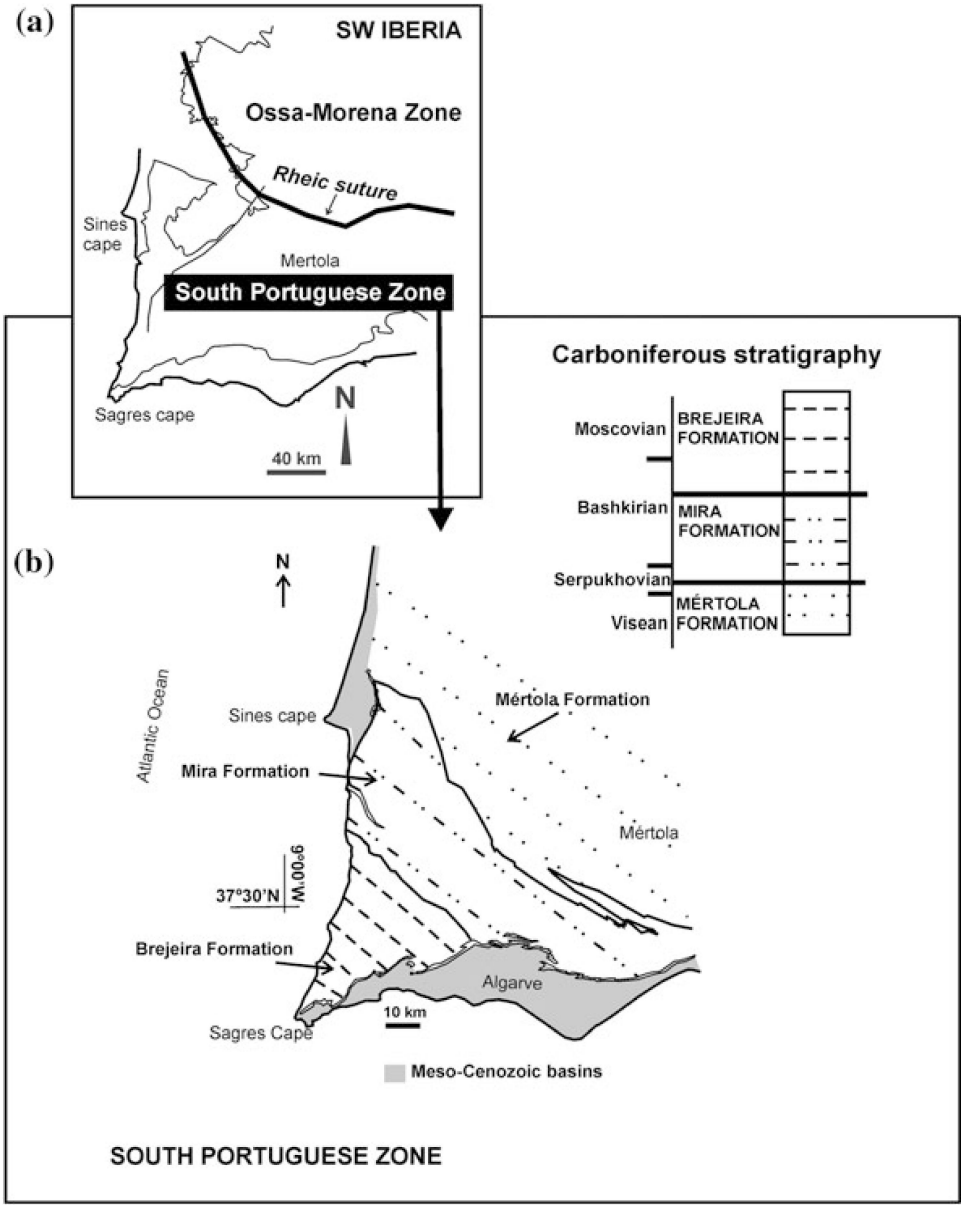

Fig. 1 Sketch geological map of SW Iberia showing the locations of the Ossa-Morena Zone (OMZ) and the South Portuguese Zone (SPZ). Carboniferous stratigraphy of the South-Portuguese Zone (Adapted from Oliveira 1990)

Stratigraphically higher, the Brejeira turbidites are characterized by the reappearance of detritus from sources related to the closure of the Rheic Ocean and the development of Devonian and Carboniferous zircon-forming events. The youngest of these Carboniferous ages is older than ca. 321 Ma, indicating that the turbidites of the SPZ were deposited in the absence of active volcanism both during and after the late Serpukhovian. The source of the Mid–Late Devonian zircons is not obvious. There is no record of igneous activity of Mid–Late Devonian age in the OMZ. In addition, the Famennian volcanic rocks that occur in the SPZ (Pyrite Belt) are not volumetrically significant. A possible source of the Late Devonian grains is the magmatic rocks formed during the accretion of the Meguma terrane to Avalonia in

the Laurentian margin (the Neo-Acadian orogeny, ca. 372–362 Ma; van Staal et al. 2009). However, these identifiable source areas are too young to be the source of many Middle Devonian detrital zircons found in our samples from the Brejeira greywackes, and thus it seems plausible that the source terrane no longer crops out either in southwestern Iberia or in nearby tracts of the Variscan orogen. The ideal source terrane was probably a Middle Devonian oceanic magmatic arc related to the closure of the Rheic Ocean, whose vestiges are preserved in the allochthonous oceanic terranes of northwestern Iberia (Pereira et al. 2012a and references therein).

A singular feature of Brejeira greywackes is the presence of zircons of Stenian age (ca. 1.1–1 Ga). These Mesoproterozoic ages are usually found in Laurentia, Ganderia, and Avalonia (Nance et al. 2008) and also, although less markedly, in North Africa (Meinhold et al. 2012). In Iberia, they occur in Ordovician to Carboniferous sedimentary rocks of the Cantabrian Zone (northwestern Iberia; Pastor-Galán et al. 2012), in the Rheic Ocean suture allochthonous units (northwestern Iberia; Diez-Fernandez et al. 2010), in the Pulo do Lobo Domain sedimentary rocks (the Alájar mélange, southwestern Iberia; Braid et al. 2011), in the Ordovician sedimentary rocks of the Central Iberian Zone (northwestern Iberia, Gutierrez-Alonso et al. 2003; southwestern Iberia, Pereira et al. 2012b), and in the Upper Devonian to lower Carboniferous sedimentary rocks of the SPZ (Pereira et al. 2012a). Also of interest is the discovery of Late Ordovician and Silurian grains in the Brejeira greywackes, which are unusual ages in southwestern Iberia. These results point to a provenance external to southwestern Iberia, with one possibility being Laurussia. The Late Ordovician zircon-forming event is not found in Iberia, Ganderia, or Avalonia, but is present in Laurentia (van Staal et al. 2009). The Silurian zircons found fit the intervals of: (1) significant magmatism in peri-Laurentian terranes (van Staal et al. 2009); (2) the Salinic (ca. 442–425 Ma) and Acadian (ca. 419–400 Ma) zircon-forming events associated with the protracted process of accretion of Laurussia and the collision between Ganderia and Avalonia (Murphy et al. 2011); and (3) early Silurian magmatism in Meguma (Keppie and Krogh 2000).

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