

# Provenance Analysis of the Late Ediacaran Basins from Southwestern Iberia (Série Negra Succession and Beiras Group): Evidence for a Common Neoproterozoic Evolution

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**Abstract** This study makes a comparison of detrital-zircon age populations from upper Ediacaran greywackes of the Ossa–Morena Zone (OMZ) with those from the southern domains of the Central Iberian Zone (S-CIZ). The results reveal that the main difference between the age spectra of both populations of detrital zircon is the Neoproterozoic, in particular the Cryogenian grains. Our new data suggest that deposition in the CIZ and OMZ Ediacaran basins was coeval, indicating a long-lived magmatic event typical of the northern Gondwana margin (Avalonian–Cadomian belt and Pan-African belt). Overall, southwestern Iberia shows the following sequence of Cryogenian and Ediacaran zircon-forming events: (1) ca. 850–700 Ma, Pan-African suture (well represented in the Beiras Group and in the Mares Formation of the Série Negra succession); (2) ca. 700–635 Ma, early

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Cadomian arc (dominant in the Beiras Group and in the Mares Formation of the Série Negra succession); and (3) ca. 635–545 Ma, late Cadomian arc (predominant in the Mosteiros and Escoural formations of the Série Negra succession). The results emphasise that the late Ediacaran basins of southwestern Iberia evolved together in the active margin of North Gondwana in the same palaeogeographical scenario but were sufficiently separated to justify the differences identified in their Neoproterozoic detrital zircon contents. This finding shows that there is no basis for considering that the boundary between the OMZ and the S-CIZ marks a Cadomian suture.

**Keywords** Detrital zircon · Source areas · Central Iberian Zone · Ossa–Morena Zone · North Gondwana

## Introduction

The Ossa–Morena Zone (OMZ) and the southern domains of the Central Iberian Zone (S-CIZ) represent the two main divisions of southwestern Iberia. However, the nature of the boundary between is still a subject of debate (e.g., Robardet 2003 and references therein). The stratigraphy of the OMZ and the S-CIZ contains well-exposed Ediacaran sedimentary rocks (Cadomian basement) overlain by lower Palaeozoic sedimentary rocks (Cambrian–Ordovician) (Linnemann et al. 2008; Pereira et al. 2011, 2012a, b). The Ediacaran basement of the OMZ (the Série Negra succession; Gonçalves 1971 and references therein) can be distinguished from its stratigraphic equivalent in the S-CIZ (the Beiras Group, the lower unit of the Slate–Greywacke Complex; Sousa 1984); The Série Negra succession, which includes the Mosteiros, Mares, and Escoural formations, is characterized by a thick accumulation of greywackes and black shales with interbedded black cherts, mafic volcanics, and minor carbonate rocks variably deformed and metamorphosed. The Beiras Group comprises a thick and monotonous succession of siliciclastic rocks with a low grade of metamorphism, consisting mainly of slates, siltstone, and sporadic greywackes (Sousa 1984; Medina 1996).

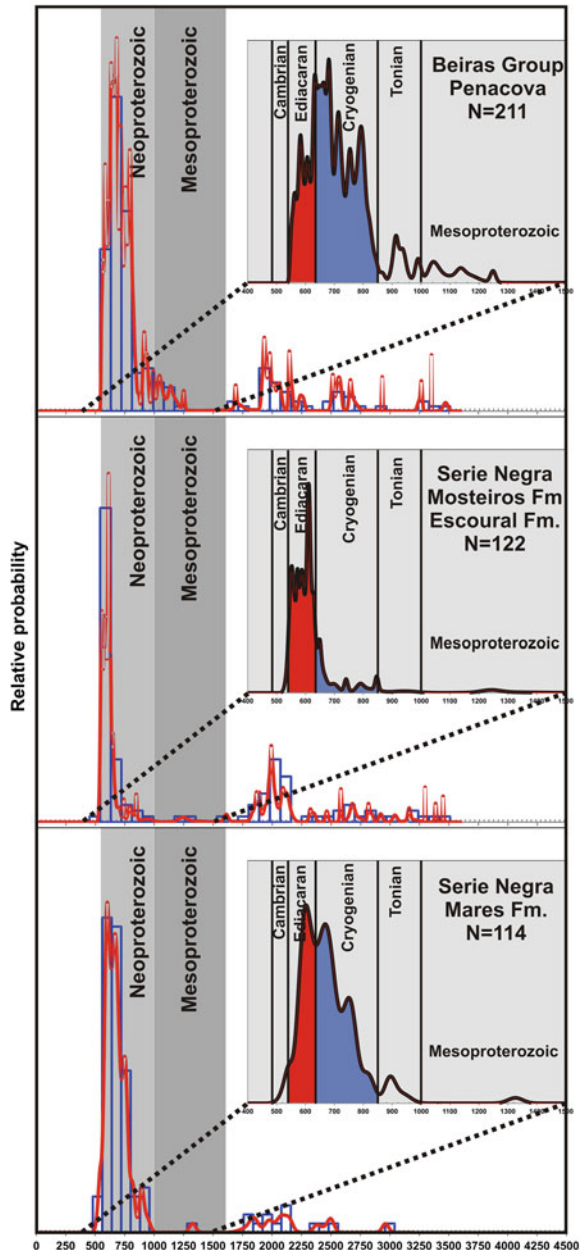
This study presents a comparison of the available U–Pb detrital zircon data from the Série Negra greywackes (sampled from the Oguela-Mosteiros Formation, Linnemann et al. 2008; from the Estremoz-Mares Formation, Pereira et al. 2012a; and from the Santiago do Escoural–Escoural Formation, Pereira et al. 2008) with the Beiras Group greywackes (sampled in the Penacova-Raiva section, Pereira et al. 2012b). The objectives of the study are to: (1) characterize potential source areas by examining zircon-forming older events; (2) better understand the relationship between the OMZ and S-CIZ Ediacaran basins; and (3) improve palaeogeographical reconstructions of the North Gondwana active margin during the Neoproterozoic.

## Results

The maximum age of deposition of the Beiras Group greywackes (S-CIZ) is late Ediacaran or younger. The age of the youngest zircon population has been estimated at ca. 578–560 Ma (Pereira et al. 2012a). This age range matches the interval of deposition for the Série Negra greywackes in the OMZ (ca. 590–545 Ma; Linnemann et al. 2008; Pereira et al. 2008, 2012a), suggesting that the basins formed coevally. The U–Pb detrital zircon data set for the Beiras Group greywackes (S-CIZ) indicates a predominance of Neoproterozoic ages (75–78 %) with the population of Cryogenian detrital zircons being more significant than the Ediacaran. There are also some Palaeoproterozoic and Archean ages, but the Tonian and Mesoproterozoic–Stenian zircons are uncommon (<8 %). The Série Negra greywackes (the Mosteiros and Escoural formations) show also a predominance of Neoproterozoic ages (~80 %), with the population of Ediacaran detrital zircons being more significant than the Cryogenian. There are also some Palaeoproterozoic and Archean ages, but the Tonian and Stenian grains are almost absent.

The results obtained indicate source areas with zircon-forming events with North Gondwanan affinity: (1) Palaeoproterozoic and Archean ages including a gap in or the almost absence of Mesoproterozoic–Stenian ages (West African Craton zircon-forming events); and (2) Neoproterozoic ages (Cadmian and Pan-African zircon-forming events). The predominance of Cryogenian ages (mainly at ca. 840–750 Ma and ca. 685–660 Ma) over Ediacaran ages distinguishes the Beiras Group greywackes (SW CIZ) from the age-equivalent Série Negra Mosteiros and Escoural formations (OMZ) where the main age clusters are concentrated in the Ediacaran (late Cadomian arc, ca. 640–550 Ma). Unexpectedly, the Mares Formation, also part of the Série Negra–OMZ, presents similarly to the Beiras Group, with a predominance of Cryogenian over Ediacaran ages (Fig. 1). The Cryogenian zircon-forming events that are dominant in the Beiras Group and also well represented in the Mares Formation are probably related to a source area of early Cadomian juvenile crust (ca. 700–635 Ma) and with a possible contribution by the Pan-African suture (ca. 850–700 Ma). The presence of Tonian and Mesoproterozoic–Stenian (<8 %) age clusters in both the Beiras Group and the Mares Formation imply either a distinct or an additional source area of detrital zircons probably derived from Ediacaran rocks in Northern Africa, which contain scarce Tonian–Stenian zircons (Meinhold et al. 2011), or in the Sinai desert (northern Arabian Nubian Shield) where they are significant (Be’eri-Shlevin et al. 2012).

**Fig. 1** Comparisons between probability plots of detrital zircon U–Pb age populations. *Top* Upper Ediacaran greywackes of the Ossa–Morena Zone and southwestern Central Iberian Zone (Penacova region); *Middle* Typical age spectra for the Ediacaran Série Negra formations; *Bottom* Typical age spectra for the Série Negra of Estremoz Anticline (Mares Formation)



## Conclusion

In conclusion, we consider four key points:

- (1) The Neoproterozoic zircon-forming events may reflect the existence of a long-lived magmatic arc in the North Gondwana margin (Cadomian Pan-African belt; Pereira et al. 2012a, b and references therein).
- (2) The early Cadomian arc was the main source for the Beiras Group and Mares Formation, with a probable contribution by the Pan-African suture, whereas the Mosteiros and Escoural formations had a greater input by the late Cadomian arc with an additional contribution by the fragmented early Cadomian arc.
- (3) The southwestern Iberia Ediacaran basins appear to represent back-arc basins that developed in the North Gondwana active margin, separated sufficiently to justify the differences in their detrital zircon contents. The S-CIZ Ediacaran basin was located close to the continent-ward passive margin with a major contribution by the fragmented early Cadomian arc and the Pan-African suture. The OMZ Ediacaran basin was located in the vicinity of the late Cadomian arc-ward margin, which was probably characterized by more strongly stretched continental crust (including the fragmented early Cadomian arc).
- (4) Given the common geodynamic setting, there is no reason to consider that a Cadomian suture existed separating the two Ediacaran basins (Pereira et al. 2012b).

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