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Cambrian ensialic rift-related magmatism in the Ossa-Morena Zone (Évora–Aracena metamorphic belt, SW Iberian Massif): Sm–Nd isotopes and SHRIMP zircon U–Th–Pb geochronology

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Abstract

The Late Ediacaran (c. 560–550 Ma) Série Negra sediments of the Évora–Aracena metamorphic belt, Ossa-Morena Zone, SW Iberian Massif, preserve a record of the erosion of an Avalonian–Cadomian magmatic arc and subsequent related turbiditic sedimentation. Detrital zircon from the Série Negra is characterized by predominantly Ediacaran and Cryogenian ages, with few Paleoproterozoic and Archean cores, and a marked lack of Grenvillian ages. These features, when combined with the metasediments' enrichment in LREE (La/Yb=14), negative Eu-anomalies, low $^{147}Sm/^{144}Nd$ values (0.121) and negative $\varepsilon Nd_{550}=-5.5$, indicate that the protolith Série Negra sediments were derived from a continental magmatic arc.

A period of Late Cadomian (ca. 560–540 Ma) tectonism was followed by an extended episode of widespread bimodal magmatism related to Cambrian (ca. 540–500 Ma) rifting. This tectonic inversion is expressed in the geological record by a regional Early Cambrian unconformity.

SHRIMP zircon U–Th–Pb ages from four felsic orthogneisses from the Évora Massif record Cambrian (527±10 Ma, 522±5 Ma, 517±6 Ma and 505±5 Ma) crystallization ages for their igneous protoliths. This confirms the existence of widespread Lower Paleozoic igneous activity in the Ossa-Morena Zone: (i) a Lower Cambrian (ca. 535–515 Ma) igneous–felsic dominated–sedimentary complex (with calc-alkaline signature and associated carbonate and siliciclastic deposition), and (ii) a Middle Cambrian–?Ordovician (ca. 515–490 Ma) igneous–bimodal–sedimentary complex (with calc-alkaline and tholeiitic signatures and associated dominant siliciclastic deposition, but also carbonate sediments).

The Cambrian felsic magmatism was characterized by negative Eu-anomalies, $(La/Lu)_N=0.8–11$, $^{147}Sm/^{144}Nd=0.1289–0.1447$ and εNd_{500} ranging from −1.5 to −0.8. A tendency towards peraluminous compositions suggests late fractionation, low degrees of partial melting, or the mixing of crustal and mantle-derived material in the magma source region. Some felsic rocks possibly represent the last residual melts of high-temperature, zircon-undersaturated mafic magmas later affected by crustal contamination, while others indicate partial melting of crustal metasediments variably contaminated by basaltic liquids.

The transition from early felsic dominated to later more mafic magmatism suggests the gradual opening of the system to tholeiitic N–E-MORB products ($Th_N/Ta_N<1.0$). The as yet undated (Cambrian–?Ordovician) E-MORB amphibolites have $^{147}Sm/^{144}Nd=0.1478–0.1797$ and εNd_{500} values ranging from +6.4 to +7.3, while the N-MORB amphibolites have $^{147}Sm/^{144}Nd=0.1818–0.1979$ and εNd_{500} values of +5.8 and +7.0, reaching a maximum of +9.1. In contrast, other amphibolites have a negative Ta-anomaly ($1.35<Th_N/Ta_N<2.41$) reminiscent of lavas from "orogenic" settings or alternatively, typical of crustally-contaminated within-plate magmas. These "VAB-like" amphibolites have $^{147}Sm/^{144}Nd$ values ranging from 0.1639 to 0.1946 and εNd_{500} values of +3.5 to +5.2, suggesting derivation by crustal assimilation processes. The sub-alkaline igneous precursors of the amphibolites were most likely generated in a rift setting by asthenospheric upwelling.

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