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Age constraints on the Late Cretaceous alkaline magmatism on the West Iberian Margin

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ABSTRACT

The onshore sector of the West Iberian Margin (WIM) was the locus of several cycles of magmatic activity during the Mesozoic, the most voluminous of which was of alkaline nature and occurred between 70 and 100 Ma. This cycle took place in a post-rift environment, during the 35° counter-clockwise rotation of Iberia and initiation of the alpine compression. It includes the subvolcanic complexes of Sintra, Sines, and Monchique, the volcanic complex of Lisbon and several other minor intrusions, covering an area of approximately 325 km^2. Previous cycles were tholeiitic and transitional in nature, occuring around 200 Ma and 130–135 Ma, respectively.

New LA-ICP-MS U-Pb, ^{40}Ar/^{39}Ar, K-Ar and Rb-Sr ages on several intrusions distributed along the onshore WIM are presented, which combined with previously published data allows us to constrain the duration of the Late Cretaceous alkaline cycle to circa 22 Ma (94–72 Ma) and define two pulses of magmatic activity. The first one (94–88 Ma) occurred during the opening of the Bay of Biscay and consequent rotation of Iberia and clusters above N38°20′. The second pulse (75–72 Ma) has a wider geographical distribution, from N37° to N39°. This final pulse occurred during the initial stages of the Alpine orogeny in Iberia that led to the formation of the Pyrenees and Betics and to tectonic inversion of the Mesozoic basins.

Isotope and trace element geochemistry point to a sublithospheric source for the alkaline magmatism that clearly distinguishes it from the previous cycles which had an important lithospheric mantle component. Also, it allows the discrimination between the two different alkaline pulses in terms of trace element abundance and residual mantle minerology. It is speculated that these differences might be the result of distinct magma ascent rates due to either more or less favourable tectonic settings that avoided or allowed the interaction with metasomatized lithosphere and equilibration with K rich minerals like amphibole and/or phlogopite.

1. Introduction

The onshore sector of the West Iberian Margin (WIM) was the locus of several cycles of magmatic activity during the Mesozoic. Occurrences related to the first two cycles display tholeiitic and transitional affinities (Martins, 1991; Martins et al., 2008) and ages around 200 Ma (e.g. Dunn et al., 1998; Verati et al., 2007) and 130–135 Ma (Ferreira and Macedo, 1979), respectively. The last cycle was the most voluminous, shows an alkaline nature, and took place between 70 and 100 Ma (Ferreira and Macedo, 1979).

This cycle includes the NNW-SSE aligned subvolcanic complexes of Sintra, Sines, and Monchique, the volcanic complex of Lisbon and several other minor intrusions (Fig. 1). These rocks are discontinuously exposed from parallels 39° N to 37° N and cover an area of approximately 325 km^2 (Fig. 1). With the exception of the Monchique alkaline complex, all the alkaline rocks were emplaced within the Mesozoic Lusitanian and Algarve rift basins, developed in relation to the opening of the Atlantic.

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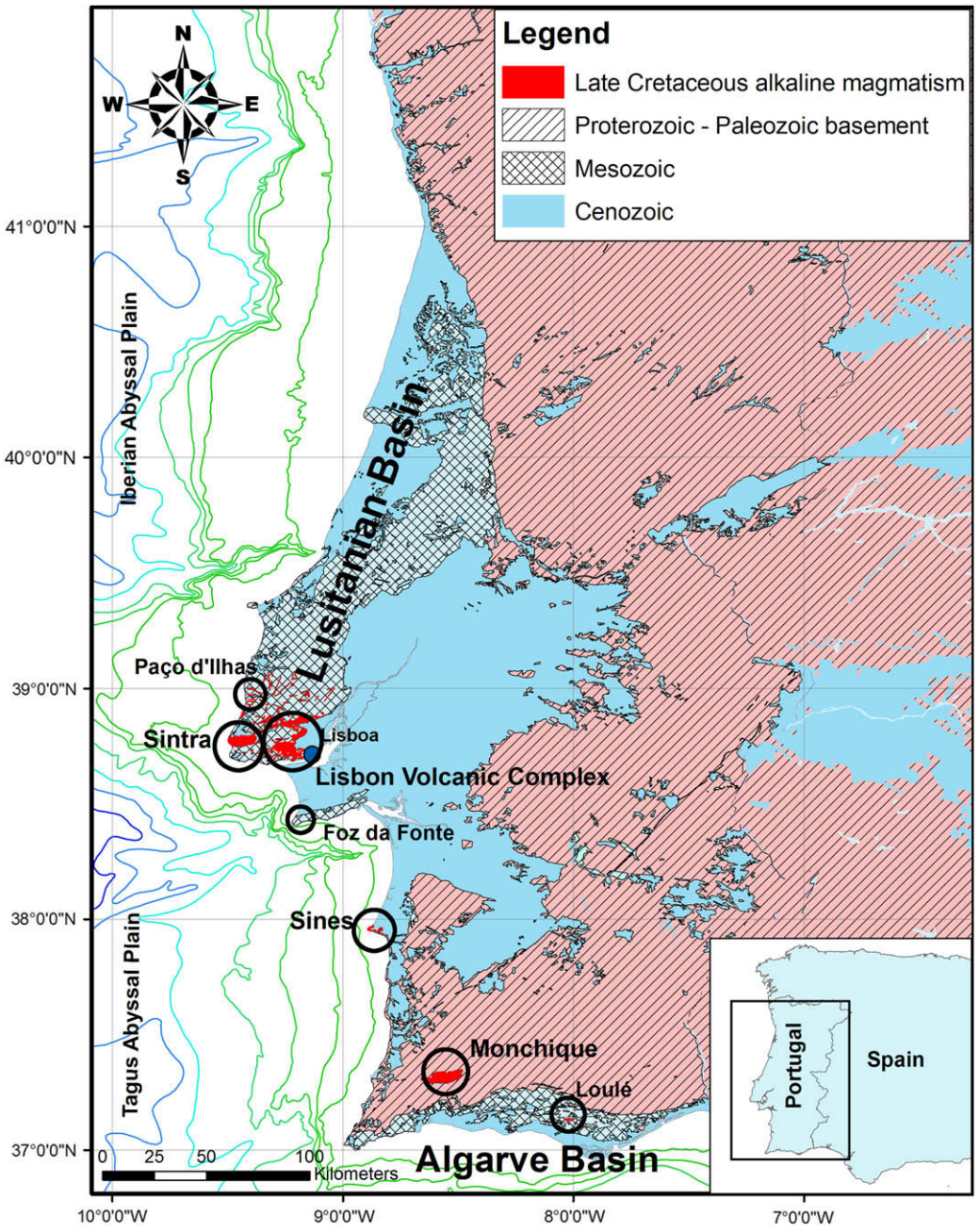

Fig. 1. The Late Cretaceous alkaline magmatism in the onshore sector of the West Iberian Margin. Circles indicate all of the sampled intrusions. Portuguese Geology and batimetry adapted from data available at http://www.iambiente.pt/atlas/est/index.jsp. Spanish geology adapted from the 1:1000000 geological map of the Iberian peninsula (Alvaro et al., 1994). Batimetry contours every 100 m. Geographic coordinates, WGS 84.

The Cretaceous alkaline rocks were grouped along with other smaller intrusions from the Pyrenees in the Late Cretaceous Alkaline Igneous Province of Iberia (Rock, 1982). Despite their older age, Lustrino and Wilson (2007) included these occurrences in the Circum-Mediterranean Cenozoic Anorogenic Igneous Province.

During the Late Cretaceous, the offshore sector of the WIM and adjacent oceanic crust were also the site of important alkaline magmatic activity that produced a series of seamounts like the Ormonde peak of the Gorringe Bank (Auzende et al., 1978; Cornen, 1982; Féraud et al., 1982; Bernard-Griffiths et al., 1997) and the Northern section of the Madeira-Tore rise (Geldmacher et al., 2006; Merle et al., 2006).

The alignment of the Sintra, Sines, and Monchique Late Cretaceous alkaline massifs has been a matter of debate in the past. Ribeiro et al. (1979) suggested the massifs were emplaced along a dextral strike-slip fault during the rotation of Iberia and Mougenot (1980) proposed that the massifs intruded along crustal pull-apart strain domains between en echelon faults during tectonic inversion of the WIM. Terrinha (1998) and Kullberg (2000) showed the existence of Early-Middle Jurassic age syn-rift faults along the lineament and proposed that these faults controlled the magma ascent in the Late Cretaceous.

The main goal of this work is to better constrain the chronology of emplacement of the onshore Late Cretaceous intrusions of the WIM by presenting new LA-ICP-MS U-Pb, $^{40}Ar/^{39}Ar$, K-Ar, and Rb-Sr ages. These data, combined with new geochemical analyses and other geological information, bring new insights on the tectono-magmatic processes of the WIM during the Late Cretaceous.