

Palaeomagnetism in the Sines massif (SW Iberia) revisited: evidences for Late Cretaceous hydrothermal alteration and associated partial remagnetization

P. Ribeiro,^{1,2} P. F. Silva,^{3,4} P. Moita,⁵ Z. Kratinová,⁶ F. O. Marques⁷ and B. Henry⁸

¹Centro de Geofísica da Universidade de Coimbra (CGUC), Av. Dr. Dias da Silva, 3000-134 Coimbra, Portugal. E-mail: pribeiro@ci.uc.pt

²Observatório Geofísico e Astronómico da Universidade de Coimbra, Av. Dr. Dias da Silva, 3000-134 Coimbra, Portugal

³Instituto Superior de Engenharia de Lisboa (ISEL/ADF), Rua Conselheiro Emídio Navarro, 1, 1959-007 Lisboa, Portugal

⁴Instituto Dom Luiz, Universidade de Lisboa, Campo Grande, Edifício C8, Piso 3, 1749-016 Lisboa, Portugal

⁵Centro de Geofísica de Évora, Universidade de Évora, Rua Romão Ramalho, 59, 7000 Évora, Portugal

⁶Institute of Geophysics ASCR, v.v.i., Prague, Czech Republic

⁷Universidade de Lisboa, Alameda da Universidade, 1649-004 Lisboa, Portugal

⁸Paléomagnétisme, Institut de Physique du Globe de Paris, Sorbonne Paris Cité, Univ Paris Diderot, and UMR 7154 CNRS, France

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SUMMARY

This study revisits the palaeomagnetism of the Sines massif (~76 Ma) in the southwestern Iberian Margin (Portugal). The palaeomagnetic analysis was complemented by a comprehensive study of the magnetic mineralogy by means of rock magnetic measurements and petrographic observations. The overall dispersion of palaeomagnetic directions (declination ranging between ~N0° and ~N50°) and their migration observed during stepwise demagnetizations have revealed the superposition of remanence components. We interpret this complex palaeomagnetic behaviour as related to the regional hydrothermalism associated with the last stages of Late Cretaceous magmatic activity. This environment favoured mineralogical alteration and a partial chemical remagnetization, giving in most samples a composite magnetization, which has been erroneously interpreted as the primary one in a previous study, then leading to a questionable model for Cretaceous Iberia rotation. Nonetheless, for some samples a single component has been isolated. Interesting rock magnetic properties and microscopic observations point to a well-preserved magnetic mineralogy for these samples, with magnetite clearly of primary origin. The associated ChRM mean direction ($D/I = 3.9^\circ/46.5^\circ$, $\alpha_{95} = 1.7^\circ$, $N = 31$ samples) then represents the true primary magnetization of the Sines massif. This new palaeomagnetic direction and the corresponding palaeomagnetic pole (long = 332.0° , lat = -79.5° , $A_{95} = 1.7^\circ$) agrees with those from the other palaeomagnetic works for the same period and region (e.g. the Sintra and Monchique massifs), yielding a lack of significant rotation of Iberia relative to stable Europe since the uppermost Late Cretaceous (Campanian–Maastrichtian).

Key words: Magnetic fabrics and anisotropy; Magnetic mineralogy and petrology; Palaeomagnetism applied to tectonics; Remagnetization.

1 INTRODUCTION

The opening of Biscay Bay and consequent counter-clockwise rotation of Iberia with respect to Eurasia is a long-standing geodynamic problem (Argand 1924; Du Toit 1937; Carey 1958; Bullard *et al.* 1965). In the following years, numerous marine geological and geophysical studies confirmed the Argand's hypothesis by showing the oceanic nature with linear magnetic anomalies of the Biscay Bay (Williams 1975; and references therein). Several kinematic models have been then proposed for the opening of the Biscay Bay, the rotation of Iberia and its relation to the formation of Pyrenees (e.g.

Srivastava *et al.* 1990; Sibuet & Collette 1991; Olivet 1996; 2000; Sibuet *et al.* 2004; Vissers & Meijer 2012).

The Iberian rotation puzzle was also addressed by palaeomagnetists since the early 1960s (Schwarz 1963; Girdler 1965; Van der Voo 1967; Van Dongen 1967; Watkins & Richardson 1968). The comprehensive work of Van der Voo (1969) provided the strongest support for the Argand's hypothesis using the palaeomagnetic results obtained from rocks of different ages from Portugal and Spain. It concluded that Iberia rotated of approximately 35° anticlockwise between the Late Triassic and the Late Cretaceous. Later, the palaeomagnetic directions of the Iberian rocks have been investigated to