



Magnetism in Iberia: results and new frontiers

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This special volume of *Journal of Iberian Geology* brings together a set of articles selected from the presentations given at the XIII MAGIBER congress, a meeting held at the Faculty of Sciences of the University of Porto from the 25th to the 28th of July 2023. The organization of the meeting was led by colleagues of this university and of the neighbouring Institute of Earth Sciences in close collaboration with the Paleomagnetic Commission of the Geological Society of Spain, and was dedicated to the general theme of “Magnetism in Iberia: Results and New Frontiers”. The meeting brought together more than 50 researchers and students from Portugal and Spain, allowing everyone who works in the field of paleo- and geomagnetism to share their results and research activities (Fig. 1). The laid-back atmosphere of the meeting favoured the strengthening of existing collaborations and the development of new partnerships between scientists of the two countries, reaffirming that Geosciences have no borders. The topics addressed during the meeting included the anisotropy of magnetic susceptibility, geomagnetism, rock and environmental magnetism, archaeomagnetism, paleomagnetism, magnetostratigraphy and magnetotectonics, in what is a clear presentation

of the multidisciplinary character of the discipline and of the scientific community involved in the meeting. The congress included two days of oral and poster presentations, a hands-on workshop on the applications and limitations of remanent magnetization curves unmixing led by recognized experts R. Egli and E. Font, and a field trip to the Praia de Lavadores in Porto (see <https://magiber2023.wixsite.com/xiii-magiber>). The full book of abstracts (Sant'Ovaia et al., 2023) can be downloaded from the website of the Paleomagnetic Commission of the Geological Society of Spain (<https://sociedadgeologica.org/magiber-xiii/>).

The ten articles gathered for this special volume of *Journal of Iberian Geology* cover most of the topics addressed at the XIII MAGIBER and offer the readers an updated view of the research that is being conducted in Portugal and Spain in the broad field of paleo and geomagnetism. Yet, among the published contributions, it is noticeable the predominance of papers devoted to the application of magnetic fabrics to a wide range of geological contexts and types of rocks, ranging from granitic plutons, gneisses and subvolcanic dykes to continental red-beds and marine marls.

Two of the articles published in this special issue deal with the study of the Anisotropy of Magnetic Susceptibility (AMS) of granites and their bearings on the mode and context of their emplacement. In the first of these papers, Portela et al. (2025) present a magnetic fabric, petrographic and geochronological study of the Lusinde granite in central-northern Portugal. This is a late- to post-Variscan pluton with a NE-SW orientation, related to the large Viséu batholith, and was studied in order to unravel its emplacement mechanisms. The authors provide new U-Pb zircon ages that indicate that the pluton was emplaced at 295 ± 1 Ma, and propose a model based on AMS data in which the magnetic lineations show variable directions and steep plunges, suggesting that the entire massif likely corresponded to a feeder zone. Furthermore, the authors interpret the Lusinde granite as an en échelon arrangement of tension gashes associated with the sinistral strike-slip Juzbado-Penalva do Castelo Shear Zone.

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Fig. 1 Participants of the XIII MAGIBER congress on Magnetism in Iberia: Results and New Frontiers, held in July 25th to 28th, 2023 in Porto (Portugal). Leading organizers from the University of Porto and the Institute of Earth Sciences are sitting in the front row

In the second of these papers, Gonçalves et al. (2025) introduce a review of AMS, petrological, SEM data from some granitic bodies from NE Portugal (Variscan orogeny): Valpaços, Freixo de Mumao, Caria, Vila da Ponte, Esmolfe-Matança and Capinha. The studied granites are ilmenite-type and range from biotite- to muscovite-rich compositions. Magnetic fabrics reveal distinct intrusion shapes and feeder zones, often aligned with regional structures. Three main K3 trajectory patterns suggest different emplacement geometries. Most granites ascended passively under low tectonic stress (Group A), while Valpaços shows active tectonic influence (Group B). Microstructural analysis indicates varied deformation histories from magmatic to solid-state, and indicate that the granites were emplaced during an extensional regime, with subhorizontal magnetic lineations aligned with σ_3 .

The contribution by Sousa et al. (2025) reports on the application of AMS and geochemical tools to investigate the magmatic origin and deformation history of the orthogneisses of the Foz do Douro Metamorphic Complex. Biotite orthogneisses derived from magnetite-type granitoids, formed from deep magmas (upper mantle/lower crust)

under oxidizing conditions. In contrast, garnet leucocratic orthogneisses formed from shallower, more evolved magmas under reducing conditions, and likely originated from a biotite orthogneiss precursor via fractional crystallization or partial melting. AMS data reveal that the magnetic anisotropy in both rock types is primarily strain-controlled, not compositional. Magnetic foliations are parallel to the XY-plane of the finite strain ellipsoid, and magnetic lineations correspond to the stretching direction. Both orthogneisses exhibit oblate strain and magnetic ellipsoids, consistent with intense flattening and S-tectonite fabrics. The observed variability in the orientation of lineation reflects deformation within a regional dextral transpressional regime. Altogether, the results attest to the activity of the NNE–SSW Porto-Tomar-Ferreira do Alentejo shear zone during the Variscan orogeny.

Moving on to a volcanic context, the paper by Oliveira et al. (2025) presents the study of several subvolcanic dykes (felsic, intermediate, and mafic) from northern Portugal using petrography, geochemistry, and magnetic analyses. Felsic rocks contain mainly diamagnetic minerals with scarce ferromagnetic components, while intermediate and

mafic rocks show higher magnetic mineral content, particularly magnetite. IRM tests reveal variable grain sizes and oxidation states of magnetite, mostly showing multidomain structures. Most dykes exhibit type-I AMS fabrics, suggesting passive magma flow along subvertical fractures formed in late Variscan tectonic phases. Magnetic fabrics support a lack of genetic relation between the dykes and host granites. Some dykes show altered or undefined fabrics due to mineralogical changes. Primary magnetite dominates mafic dykes, while in felsic rocks, it is likely secondary, although magma mixing may have introduced primary magnetite in some cases. Further magnetic studies are recommended to better constrain magnetite domain states.

Three additional contributions are devoted to the application of AMS data to gain insights into the influence of tectonic and climatic process on the formation of sedimentary rocks of different origins. In the first of these papers, Simón-Muzas et al. (2025) present a magnetic fabric study carried out in Permo-Triassic continental sedimentary red beds from the Cadi Basin (Eastern Pyrenees). These rocks were deposited on the top of a volcanic sequence when the regional tectonic regime changed from transtension to extension, and were later affected by the Pyrenean compression. The study has been performed following the “fragment methodology”, using oriented irregular fragments of claystones, and has proven to yield successful and replicable results that reveal a primary magnetic fabric that is recording a syn-sedimentary stretching in two nearly perpendicular directions, WNW-ESE and N-S, linked to development of the Permo-Triassic basin. No clear link has been observed between the orientation of the magnetic fabrics and sedimentary or tectonic markers of paleocurrents or deformation derived from the Pyrenean compression, respectively. The tectonic origin of the studied fabrics indicates that the geodynamic scenario of the Iberian plate during Late Permian to Triassic times can be explained according to regional trajectories of extensional stress due to the activity of the North-Pyrenean fault zone.

In the second paper, Oliva-Urcia et al. (2025) analyse iron-carbonate concretions from Middle Eocene marine marls of the Southern Pyrenees. Inverse magnetic fabrics were found in the concretions, revealing the presence of ferroan carbonates like iron-rich dolomite. Magnetite is the main carrier in surrounding marls, which show normal magnetic fabrics. Low-temperature magnetic measurements indicate a dominant paramagnetic contribution in all samples. AARM data suggest that ferromagnetic grains retain a normal orientation in both marls and concretions. Isotopic results show minor differences, supporting a marine pore water origin. The concretions likely formed during the Middle Eocene Climate Optimum due to increased bacterial activity. Magnetic fabrics are confirmed as a useful non-destructive tool

for identifying early diagenetic processes associated with transient climatic events recorded in sedimentary rocks.

In the third paper dealing with AMS of sedimentary rocks, Sierra-Campos et al. (2025) introduce AMS data from weakly deformed Eocene marine mudrocks from the Jaca-Pamplona basin. AMS fabrics mainly reflect layer-parallel shortening (LPS) related to both near and far-field tectonic structures. In the Izaga section, magnetic fabrics shift from triaxial to oblate ellipsoids upwards, indicating a decline in tectonic activity. In the Berdún section, ellipsoids change from oblate to prolate and back, with early prolate ellipsoids revealing a previously undetected thrust. The uppermost Berdún levels show prolate fabrics linked to intensified deformation and basin continentalization. AMS thus proves sensitive enough to capture both subtle and localized tectonic changes. This supports its value as a proxy for reconstructing tectonic evolution in fold-and-thrust belts.

Although rock magnetic data are often produced in order to support paleomagnetic results of different kinds, sometimes rock magnetic properties constitute the central topic of the study. This is the case of a set of papers published by Santamaría Barragán et al. (2025) and Dias et al. (2025). In the first case, Santamaría Barragán et al. (2025) present a multiproxy dataset from two sediment cores drilled at the Guadix-Baza intramontane basin in the Betic Cordillera, well known for recording some of the earliest evidence for hominin presence in western Europe. Of special relevance has been the application of magnetic susceptibility data to characterize the sedimentary facies and to assist in the correlation between both cores to build a composite section. The results, performed using a multi-sensor core logger and discrete samples, have demonstrated the excellent congruence between both types of measurements. In addition, they offer the possibility for correlating the studied cores with field sections, with the implications for future magnetostratigraphic constraints on the important fossil localities of the basin.

The article by Dias et al. (2025) deals with the rock magnetic properties of the iron ores of Vila Nova do Marão Mining Field (VCMF) and Moncorvo Iron Complex (MIC) in northern Portugal. As it often happens in rock magnetic studies, the magnetic properties provide a rapid and non-expensive tool not only to precisely characterize the different ores but also to provide a rapid assessment of the concentration of different magnetic minerals they host, a key issue dealing with an iron ore. In this particular case, both ores are characterized by an enrichment in mainly magnetite (VCMF) and hematite (MIC) with respect to their host rocks. Given the lower specific magnetization of hematite with respect to magnetite, the MIC ore is characterized by distinctively lower magnetic susceptibility and isothermal remanent magnetization values, which can be very useful

for future exploration of both types of ores by means of magnetic prospecting tools.

The closing article of this special issue is that of Larrasoña et al. (2025), and presents new findings from the Bardenas Reales de Navarra in the western Ebro Basin, providing a well-dated and expanded continental record from the lower to middle Miocene. Through updated small mammal fossil data and refined magnetostratigraphy, the authors establish a revised chronology for Iberian Mammal Neogene zones. This work significantly enhances our understanding of the biostratigraphy and paleoenvironments during the Miocene Climate Optimum, a key interval for studying ancient global warming. The fossil record indicates a gradual rise in temperature and humidity in southwestern Europe between 20 and 15.5 million years ago, correlating with global climatic trends and likely driven by changes in oceanic circulation. Sedimentological and rock magnetic data suggest a threshold hydrological response in the Ebro Basin and periods of heightened climate variability. These findings underscore the importance of integrating multiple paleoenvironmental proxies to reconstruct ecosystem responses to global climate change.

We hope that this collection of articles results stimulating and inspires new research in the broad field of paleomagnetism in the Iberian Peninsula and its surrounding areas, a region of special interest given its particular geodynamic and geographic context halfway between the Atlantic and Mediterranean realms and the African and European plates.

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