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The Central Iberian arc: implications for the Iberian Massif

El arco Centroibérico: implicaciones para el Macizo Ibérico

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ABSTRACT

Variscan folds and magnetic anomalies of the Central Iberian Zone (Iberian Massif) delineate an orocline similar in size to the Ibero-Armorican arc but of opposite sense of curvature. Its core is occupied by the Galicia-Trás-os-Montes Zone, formed by allochthonous terranes which include the suture of the Rheic Ocean. The West-Asturian-Leonese Zone is also bent by the arc but neither the Ossa-Morena, nor the the South Portuguese zones are involved. The orocline, for which the name of Central Iberian arc is propossed, explains the width of the Central Iberian Zone by duplication of a strip half its present width. It also explains the structural position of the allochthonous terranes, and opens new insights for correlations with the rest of the Variscan belt, specially with the Armorican Massif, whose central domain may represent the continuation of the southern branch of the Central Iberian arc, detached by late Variscan strike-slip tectonics. The relative age of the two arcs of the Iberian Massif and the possible origin of the Central Iberian arc are discussed.

Key-words: *Oroclines, Central Iberian arc, Iberian Massif, Variscan belt.*

RESUMEN

Los pliegues variscos y las anomalías magnéticas del Macizo Ibérico dibujan en la Zona Centroibérica un oroclinal de tamaño similar al del arco Ibero-Armoricano, aunque con un sentido de curvatura opuesto. Su núcleo está ocupado por la Zona de Galicia-Trás-os-Montes, formada por terrenos alóctonos que incluyen la sutura del océano Réico. La Zona Asturoccidental-leonesa está también doblada por el arco, pero ni la de Ossa-Morena ni la Sudportuguesa parecen involucradas en él. El oroclinal, para el que se propone el nombre de arco Centroibérico, explica la anchura de la Zona Centroibérica por duplicación de una banda de la mitad de anchura. También hace más comprensible la posición estructural de los terrenos alóctonos, y abre nuevas perspectivas de correlación con el resto del cinturón Varisco, en particular con el Macizo Armoricano, cuyo dominio central puede ser la continuación de la rama sur del arco Centroibérico desgajada por la tectónica transcurrente tardi-varisca. Se discuten la edad relativa de los dos arcos mayores del Macizo Ibérico y las posibles causas de formación del arco Centroibérico.

Palabras clave: *Oroclinal, Arco Centroibérico, Macizo Ibérico, Cinturón Varisco.*

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Introducción

In spite of the advances made in the knowledge of the Variscan belt in the last decades, important issues including terrane correlation and the number of oceans involved remain unsolved. This is partly due to lack of recognition or awareness of large structures, such as thrusts, strike-slip shear zones and oroclines.

The Variscan belt delineates several oroclinal arcs, such as those in the Bohemian and Massif Central massifs (Perroud, 1986; Tait *et al.*, 1996; Matte, 2001; Franke and Zelazniewicz, 2002), and the Ibero-Armorican arc (Bard *et al.*, 1971; Ribeiro *et al.*, 1995).

The latter does not represent, however, the last orocline of the Variscan belt to the SW, as another arc of similar magnitude and opposite curvature exists, and was drawn by Du Toit (1937) and described by Aerden (2004). This contribution deals with this arc, and discusses its relationship with the Ibero-Armorican arc and its meaning in the context of the Iberian Massif and the Variscan belt.

Geological setting

The zones, domains, and units of the Variscan belt can be divided into autochthonous and allochthonous terranes. The Iberian autochthon, the central and northern Armorican Massif, and several autochthonous zones of the Bohemian Massif can be compared on the basis of stratigraphic and paleotectonic similarities, such as the presence of a Cadomian event, a Cambro-Ordovician rift sequence, and the associated felsic magmatic activity (Cogné, 1974; Chantraine *et al.*, 1994; Franke, 2000; Robardet *et al.*, 1990; Young, 1990; Linnemann *et al.*, 2003). All of them share a peri-Gondwanan origin.

The allochthonous terranes occur in nappe stacks. In NW Iberia (Fig. 1A), they include from top to bottom the remnants of Cambro-Ordovician, peri-Gondwanan volcanic arcs, Paleozoic, supra-subduction zone ophiolites, pieces of thinned continental crust with evidences of Ordovician rifting, and a parautochthon, derived from the N Gondwana passive continental shelf. Similar terranes occur in the southern Armorican Massif, the French Massif Central, the Vosges and Black Forest, the Bohemian Massif, the Polish Sudetes, the External massifs of the Alps, the Maures, Corsica and Sardinia (references in Martínez Catalán *et al.*, 2007).

The Central Iberian arc (CIA)

The axial traces of the first Variscan folds (D1) run subparallel in most of the Iberian Massif, delineating the Ibero-Ar-

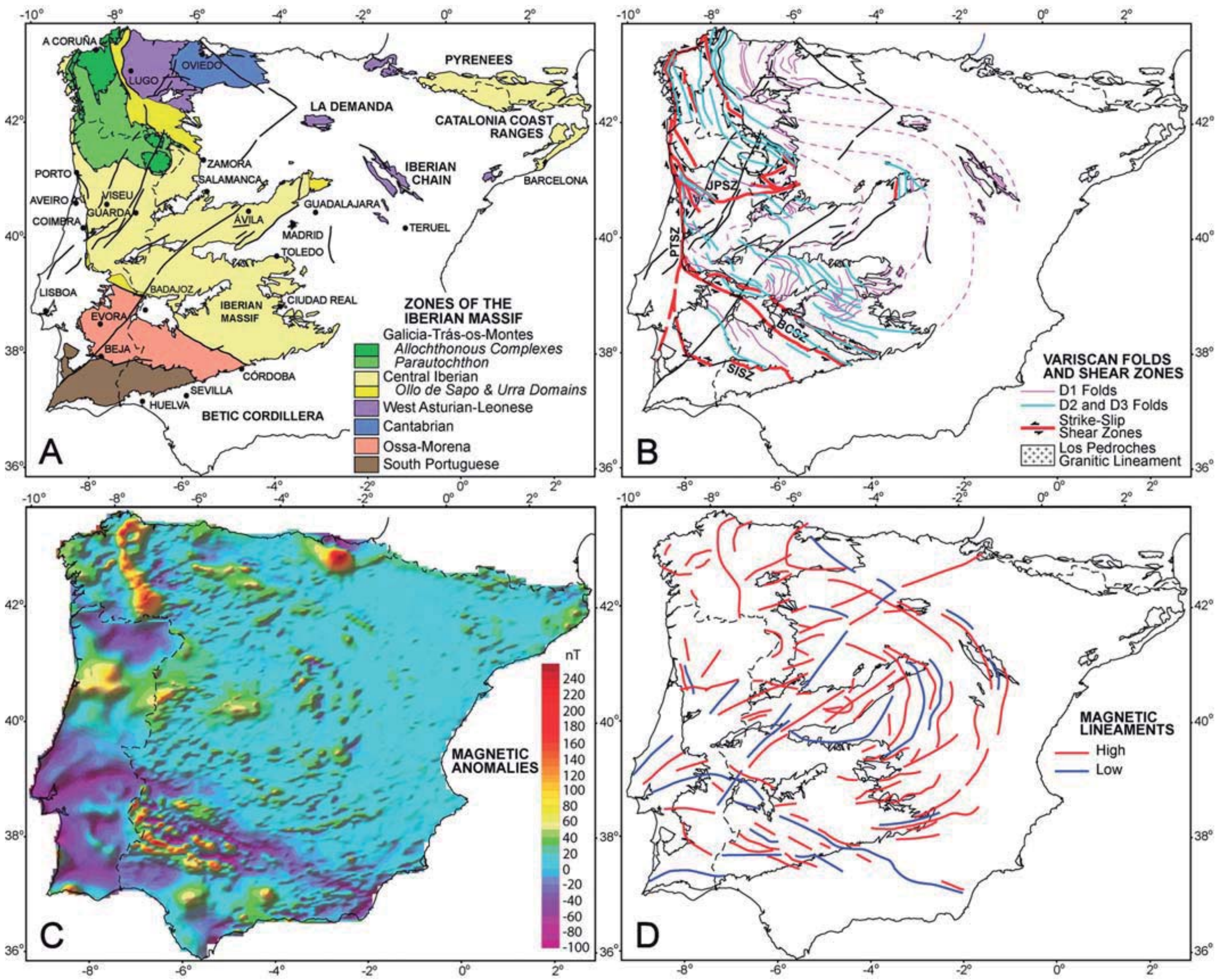

Fig. 1.- Variscan Basement of the Iberian Peninsula. A. Zones. B. Folds and shear zones: BCSZ- Badajoz-Córdoba; JPSZ- Juzbado-Penalva; LPSZ- Los Pedroches; PTSZ- Porto-Tomar; SISZ- Southern Iberian. C. Magnetic anomalies. D. Magnetic lineaments.

Fig. 1.- Basamento varisco de la Península Ibérica. A. Zonas. B. Pliegues y zonas de cizalla: BCSZ- Badajoz-Córdoba; JPSZ- Juzbado-Penalva; LPSZ- Los Pedroches; PTSZ- Porto-Tomar; SISZ- Sudibérica. C. Anomalías magnéticas. D. Alineaciones magnéticas.

morican arc (IAA). But to the E of the massif, D1 folds rotate toward mutual convergence at the eastern limit of the Central Iberian Zone (CIZ; Fig. 1B), delineating an arc whose hinge zone is covered by Meso- and Cenozoic deposits (Aerden, 2004).

The curved structure described by the Variscan folds can also be seen in the aeromagnetic data (Ardizone *et al.*, 1989; WDMAM project, Maus *et al.*, 2007). The magnetic map (Fig.1C) shows an arc in the central part of the Iberian Peninsula. Many magnetic lineaments (Fig. 1D) roughly correlate with the axial traces of the Variscan folds (Aerden, 2004; Martínez Catalán, 2010). Others are linked to ultrabasic and basic rocks in the allochthonous complexes of NW Iberia and in the Ossa-Morena Zone (OMZ), and many are related to Variscan faults.

A string of magnetic highs surrounds the Galicia-Trás-os-Montes Zone (GTMZ; Fig. 1A, C), from the N-S band following the Lugo and Sanabria domes, to the W of Zamora, perhaps the S of Ávila, the E of Guarda, and the Viseu-Coimbra area. The latter magnetic highs probably represent the constructive interference of lineaments related to the bent continuation to the S of the Lugo-Sanabria anomaly with late Variscan-Mesozoic faults.

The sources of the Lugo-Sanabria anomaly seem to be magnetite-bearing migmatites and inhomogeneous granites (Ayarza and Martínez Catalán, 2007), but they possibly reflect a structural feature in the pre-Variscan basement. In fact, many of the magnetic lineaments delineating the arc do not fit exactly the Variscan structures, and probably occur in the basement or are inherited from it, so that the structures in its metasedimentary cover or in the Variscan granites reflect the basement lineaments only in a loose way.

Zones, shear zones, and relative age

The CIA explains the large width (up to 400 km) of the Central Iberian Zone (CIZ) by duplication of a narrower strip, and clarifies the position of the allochthonous GTMZ, which occupy the core of the arc and includes the Rheic suture. The West Asturian-Leonese Zone (WALZ) is also involved (Fig. 1B), and the Cantabrian Zone (CZ) probably too.

However, a continuous, negative magnetic anomaly marks the boundary between the CIZ and the OMZ. It continues to the east of Córdoba with a NW-SE direction (Fig. 1C, D), delineating a rather straight feature of the Variscan basement preserved even beneath the Betic cordillera. This lineament suggests that the OMZ and the South Portuguese Zone (SPZ) were not involved in the arc.

The CIA is comparable in size to the IAA, and their curvatures are opposite. The continuity of both arcs may suggest a common and coeval origin, but a close view reveals a more complex history.

The CIA post-dates D1 folds and probably also the emplacement of the GTMZ. Several upright D3 folds nucleated in domes and basins developed during D2 extensional collapse, and many others are associated with crustal-scale strike-slip ductile shear zones.

Some of the strike-slip structures separate zones of the Iberian Massif, such as the South Iberian (SISZ) and Badajoz-Córdoba (BCSZ) shear zones (Fig. 1B). Others do not, as the Juzbado-Penalva shear zone (JPSZ), but have also large displacements. The Porto-Tomar shear zone (PTSZ; Ribeiro *et al*., 1980), a N-S dextral wrench fault, dragged the D1 folds, the JPSZ, and the BCSZ, rotating them clockwise (Fig. 1B). It seems to continue in the southern branch of the South Armorican shear zone (SASZ-S; Martínez Catalán *et al*., 2007), cutting across the CIA but being folded by the IAA (Fig. 2). So, the CIA would be older than the IAA or, rather, would have reached full development before.

This conclusion is supported by the fact that most D3 folds affecting the allochthonous nappe stack (GTMZ) and the CIZ show an axial planar attitude in relation to the orocline (Fig. 1B), and seem coeval with its development. This implies that while D1 folds are bent by the CIA, D3 folds are not. In contrast, the IAA bends both D1 and D3 folds.

On the other hand, the N limit of the BCSZ coincides with a straight magnetic anomaly not folded by the CIA (Fig. 1). So, this boundary, a sinistral fault, should be younger than the arc.

Origin and implications

The CIA might have developed by indentation of the GTMZ, or at least of its upper allochthon, a peri-Gondwanan, Cambro-Ordovician island arc which, after separation from the continent, accreted to Baltica and was re-incorporated to Gondwana during the Variscan collision (Gómez Barreiro *et al*., 2007).

The indentation hypothesis has a precedent in the non-cylindrical model of a tongue-shaped extension of southern Baltica which would have impinged obliquely the northern margin of Gondwana (Martínez Catalán, 1990). However, the allochthonous terranes formed a roughly horizontal thin sheet, 15-20 km thick, difficult to envisage as a rigid indentor.

The same geometry could also be explained by an extruding wedge spreading laterally form the collision of two continents with curved, no-matching margins (Schellart and Lister, 2004). These models would imply a pre-D3 full development of the arc.

The indentation or the lateral extrusion hypotheses might account for the nucle-

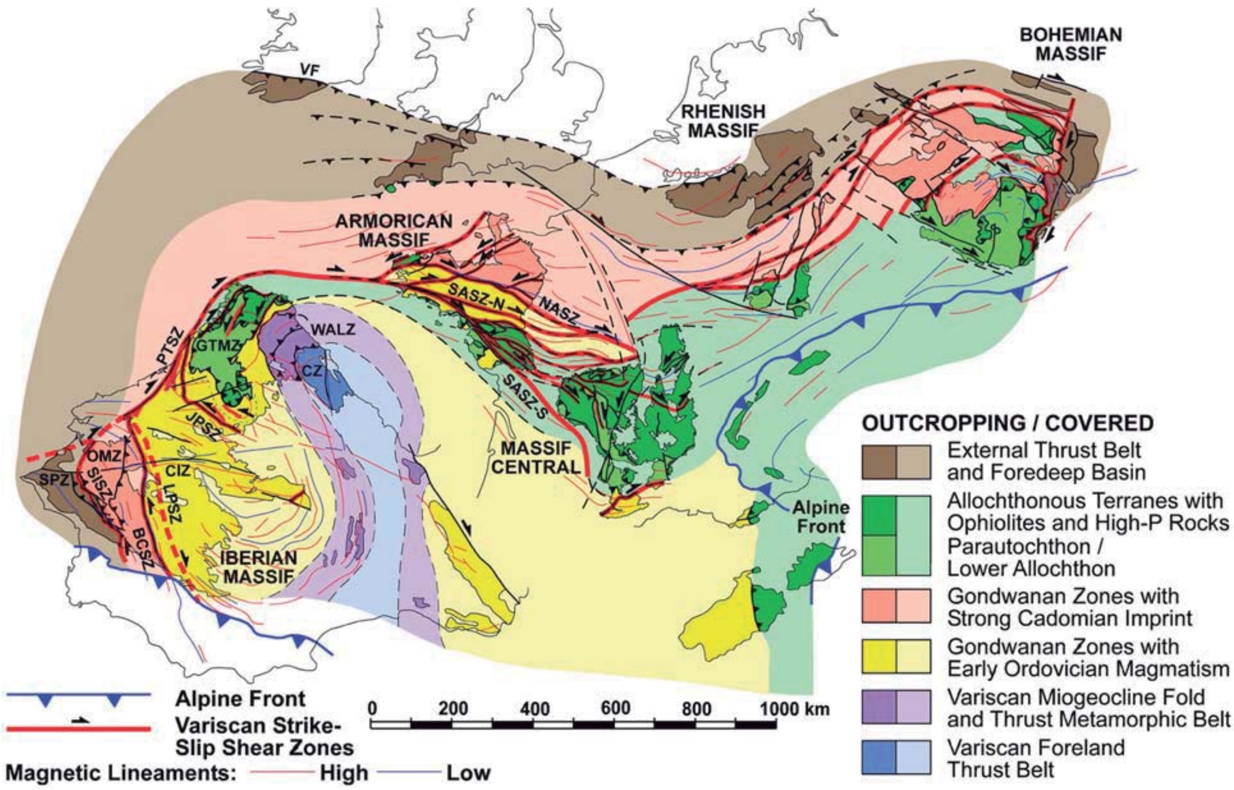

Fig. 2.- Sketch of the Variscan belt based on Martínez Catalán *et al.* (2007), showing also the main magnetic lineaments, based on Ardizone *et al.* (1989), Galdeano *et al.* (1990), Salansky (1995), and Maus *et al.* (2007). Shear zones: NASZ- North Armorican; SASZ- South Armorican (N and S-northern and southern branches). For other abbreviations, see text and figure 1.

Fig. 2.- Esquema del cinturón Varisco basado en Martínez Catalán* et al. *(2007), y mostrando además las principales alineaciones magnéticas, basadas en Ardizone* et al. *(1989), Galdeano* et al. *(1990), Salansky (1995), y Maus* et al. *(2007). Zonas de cizalla: NASZ- Nordarmoricana; SASZ- Sudarmoricana (N y S-ramas norte y sur). Para otras abreviaturas, ver texto y figura 1.

ation and part of the development of the CIA, but its tightness and apparent syn-D3 age is better explained by transcurrent shearing. The arc folds about a vertical axis the dominantly schistose CIZ, previously affected by upright D1 folds with low-plunging axes. Magnetic lineaments are also bent by the arc, whose core is occupied by the GTMZ with the remnants of the Rheic Ocean. All these features have a recent equivalent in the South Island orocline of New Zealand, which bends the Otago schists, the Permian Dun Mountain ophiolite belt, and the Junction magnetic anomaly, and is related to dextral strike-slip motion of the Alpine fault (Hall *et al*., 2004).

Accordingly, the CIA, which nearly doubles in size its younger counterpart, might be explained by bending or buckling associated with transcurrent shearing. As the dominant component of late Variscan wrench motion is dextral (references in Martínez Catalán *et al*., 2007), shearing of its present SW flank could explain the arc. A right-lateral shear zone hidden by Los Pedroches granitic lineament (Aranguren *et al*., 1997), may form the southern limit of the CIA (LPSZ, Fig.1B). Dextral transcurrence explains the stratigraphic similarities between the CIZ and the Central Armorican Zone (Robardet *et al*., 1990; Young, 1990), the latter being a contractional duplex displaced by the PTSZ-SASZ-S (Fig. 2).

Conclusions

Fold traces and magnetic anomalies define a large orocline of Variscan age in the Iberian Peninsula, for which the denomination of Central Iberian arc (CIA) is proposed. It is best seen in the CIZ, but the WALZ, and probably the CZ were also involved on it, whereas the OMZ and SPZ were not bent by the arc.

The GTMZ occupies the core of the CIA. This clarifies the structural position of the allochthonous terranes in the middle of the CIZ, poorly understood until now. Moreover, this suggests that before the Variscan collision, the only domains with continental crust existing between the CIZ and the Rheic Ocean lithosphere were the present parautochthon and the continental crust thinned during the Ordovician rifting and presently forming the basal allochthonous units.

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