Correlation of hercynian units of the Iberian massif and southeastern France

Correlación de unidades hercínicas del Macizo Iberico con el Sudeste de Francia

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ABSTRACT

The Ollo de sapo antiform in the northwest Iberian Massif is made up of superposed allochthonous units of Paleozoic metasediments and Ordovician orthogneisses, similar to gneissic domes in the eastern Pyrenees and in the Montagne Noire of southern France. Their association with Hercynian fold-nappes of comparable lithologies and structure points to a formerly continuous structure later sheared apart in the late Hercynian dextral megashear (North Pyrenean fault) which affected the Pyrenees and southern France and was also responsible for the formation of the domes.

Key words: *Ollo de sapo, Hercynian, Iberian Massif, Pyrenees, Montagne Noire, Ibero-Armorican arc*

RESUMEN

La antiforma del Ollo de sapo en el noroeste del Macizo Ibérico está constituida por unidades alóctonas superpuestas con metasedimentos paleozoicos y ortogneises ordovícicos, similares a las existentes en los domos gneisicos de los Pirineos orientales y en la Montaña Negra del sur de Francia. Están asociadas en ambos casos a grandes mantos de pliegues tumbados de litología y estructura comparables, lo que indica que se trata de estructuras hercínicas originariamente contínuas y posteriormente separadas por una megacizalla hercínica paralela a la cordillera pirenaica (falla Norpirenaica), cuya actividad contribuyó a la formación de los domos.

Palabras clave: *Ollo de sapo, Hercínico, Macizo Ibérico, Pirineos, Montagne Noire, arco Ibero-Armoricano*

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Introdution

Most reconstructions of the European Variscan orogen accept for the Iberian peninsula an arcuate connection with the Armorican Massif, which is known as the Ibero-Armorican arc (see Ries, 1978 for review of arguments). Nevertheless, although there are striking stratigraphic and palaeontologic similarities between different zones on the NW Iberian Peninsula and the Armorican Massif, there are also units clearly missing on either side. On the other hand, recent studies of late Hercynian deposits suggest that the Iberian Peninsula could have been located in a much more easterly position than today (Martínez-García, 1983, 1991), undergoing a westward drift in late Hercynian times and suggesting that perhaps the extension of the structures truncated by the Cantabrian coast should be looked for more to the east. One of these structures, the Ollo de sapo antiform is very distinctive of the northwestern Iberian Massif and can be used for correlation purposes. In this paper we will try to trace this structure to the east and find geological arguments to defend their former connection.

Northwest Iberian Massif: The Ollo de sapo antiform and the Mondoñedo nappe

Probably the most conspicuous structure of the Galician Castillian zone (Lotze, 1945) of the NW Iberian Massif, besides the ultramafic complexes to which it is closely associated, is the Ollo de sapo antiform (Fig. 1) in whose core, the Ollo de sapo augen gneisses crop out extensively. Their origin and age have been contro-versial, being considered from Pre-cambrian clastics and volcanics (Parga Pondal *et al.*, 1964) to Ordovician granites (Martínez-García & Quiroga 1993).

According to the last authors, the structure of the Ollo de sapo antiform observed at the Sanabria window, is a tectonic empilement of four allochthonous units . The upper one (Peña Trevinca unit) is made up of a Cambro-Silurian succession quite similar to the ones described from the West Asturian Leonese zone (Walter, 1968). The unit inmediately below (Ribadelago unit) comprises fine-grained and augen gneisses of the Ollo de sapo formation. Mylonitic rocks several tens of meters thick are found at the base and top of this tectonic unit. The radiometric age of the augen gneisses has been established as lower Ordovician (Gebauer *et al.*, 1993, 489 Ma U/Pb SHRIMP) in the Sanabria area. The underlying Viana unit is composed of the Porto Group (Martínez-García & Corretgé 1970) with metasediments (schists, quartzites, limestones and calc-silicate rocks) of probable Cambro-Ordovician age, and orthogneisses dated as Ordovician (460 Ma, Priem *et al.*, 1972; 465±10 Ma, Allegret, 1989). Metamorphic grade in this unit reaches garnet amphibolite zone and kyanite relics of an older episode have been cited. The lowermost unit, or Villanueva unit has been now separated as a less metamorphic Cambrian to Silurian succession with abundant andalucite- and tourmaline-rich schists and quartzites.

The four units shown at the Sanabria window have been strongly deformed by three Hercynian episodes of northeastern vergence.

The Ollo de sapo antiform itself was formed during the third phase of deformation, probably in middle Carbo-niferous times, since the crenulation cleavage associated to these folds affects 310 Ma old granites (Capdevila & Vialette 1965).

East of the Ollo de sapo antiform, and separated from it by an important tectonic accident (Vivero fault) lies a large Hercynian structure known as the Mondoñedo nappe (Fig. 1) which constitutes the western part of the West Asturian Leonese zone. The stratigraphy of the Mondoñedo nappe was essentially established by Walter (1968) and starts with a Precambrian schistose unit (Villalba schists) followed by sandstones, microconglomerates and shales (lower Cándana sandstones), of Vendian age. Above them are schists with interbedded sandstones and carbonates (Cándana schists), overlain by an alternance of quartzites, sandstones and schists. On top of this unit there are alternating green schists and pink sandstones (Transition beds) with lower Cambrian fossils. The unit above is formed by massive carbonates (Vegadeo limestone) where dolomites predominate in the lower part. The age of the upper member of this formation is middle Cambrian. Overlying this unit is a succession of green shales with some sandstone and mudstone intercalations (Riotorto formation). On top lies an alternance of gray slates and sandstones (Villamea formation) of upper Cambrian, Tremadoc and Arenig age, and overlying shales and sandstones (Eo River formation) of lower Ordovician age. These increase in thickness towards the east and forms the Cabos group of Lotze (1958). On top of the basal Ordovician slates and sandstones, there is a dark schist unit called Luarca slates with graptolites of Llanvirn-Llandeilo age. The stratigraphic succession in the Mondoñedo nappe ends up with some 50 m of ampelitic shales and sandstone intercalations where graptolites of Wenlock age were found. These Silurian rocks lie unconformably on older rocks. The Mondoñedo nappe has been emplaced in the Hercynian orogeny (Matte, 1968; Bastida & Pulgar 1978) as a recumbent fold-nappe with eastern vergence.

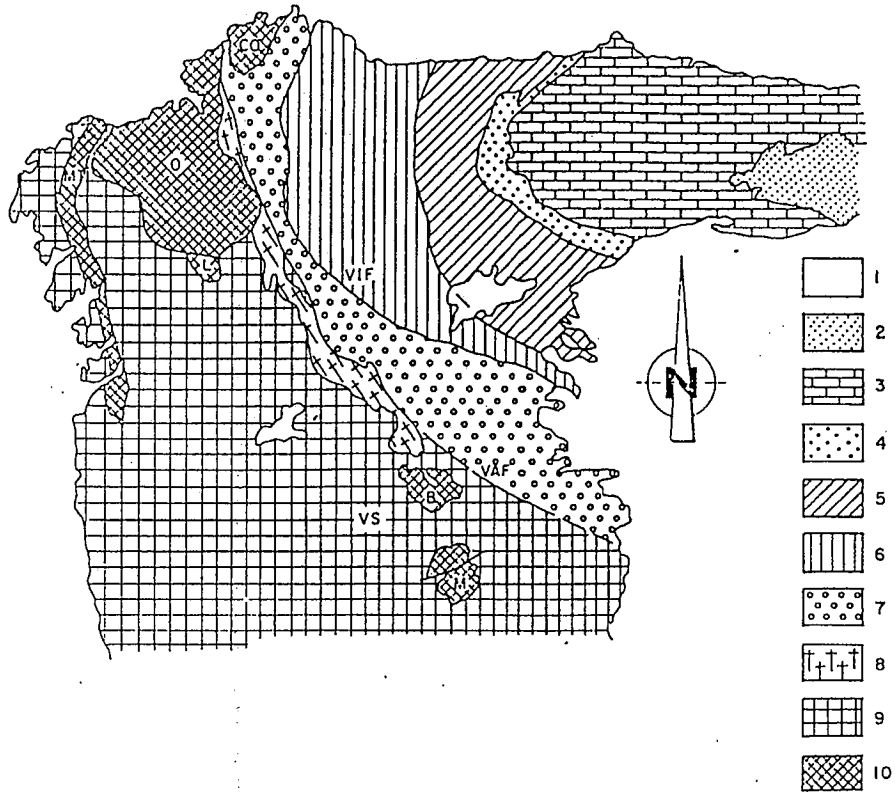

Fig. 1.- Geological sketch-map of the NW Iberian Massif: 1. Post-Hercynian cover, 2. Palentian zone, 3.Cantabrian zone, 4. Narcea antiform (Precambrian), 5. West Asturian Leonese zone (Navia Domain), 6. West Asturian Leonese zone (Mondoñedo nappe and other), 7. Ollo de sapo antiform, 8. Early Carboniferous granodiorites, 9. Western Galician Castillian zone, 10. Ophiolitic complexes.

Fig. 1.- Mapa geológico esquemático del NW del Macizo Ibérico: 1.Cobertera posthercínica, 2. Zona Palentina, 3. Zona Cantábrica, 4. Antiforma del Narcea(Precámbrico), 5. Zona Astur Occidental Leonesa (dominio del Navia), 6. Zonz Astur Occidental Leonesa (manto de Mondoñedo y otros), 7. Antiforma del Ollo de sapo, 8. Granodioritas del Carbonífero Inferior, 9. Zona Galáico Castellana occidental, 10. Complejos ofiolíticos.

Eastern Pyrenees: gneissic domes

In the eastern Axial zone of the Pyrenean range, several gneissic domes are known long time ago (Zwart, 1979) (Fig. 3). Some of these are cored by augen-gneiss, as the Trois Seigneurs, Saint Barthelemy, Aston, Hospitalet, Canigou, Agly, and Roc de France. In other, migmatic, granitic, mafic, granulitic or composite cores are found (Soula *et al.*, 1986). Some authors conclude that the domes are due to diapirism contem-poraneous with the main regional defor-mation, being emplaced between 350 and 250 Ma,, while other have considered some of the augen-gneiss-cored massifs as formed by nappe emplacement. In the Canigou massif, Guitard (1970) interpreted the augen gneisses in the core as a Precambrian basement, and the structure itself as a recumbent fold, the supposedly Palaeozoic sediments of the Balatg window cropping out in the reverse limb. Later, Soliva *et al.*, (1989) analyzed the kinematics of the lower contact of the gneissic unit and concluded that this was formed by a mylonitic zone at the base of a thrust unit, the shear sense being towards the SW. The sedimentary cover of the Canigou dome is essentially Cambrian and Ordovician.

On the other side, the late Precambrian age obtained for the Canigou gneiss by (Vitrac Michard *et al.*, 1975), has been questioned by Delaperriere (1990), who found an age of 440 Ma for the same. Also Delaperriere & Solira (1992) established an Ordovician-Silurian age for the Casemi ferrohastingsite-bearing gneiss, intrusive in the sediments below the Canigou gneiss nappe cropping out in the Balatg window.

Montagne Noire: Axial zone and southern nappes

The Montagne Noire, which stands as the southernmost unit of the french Massif Central shows also a gneissic dome in its Axial zone, comparable to that of the Canigou, in which, the augen-gneisses are forming the core of the structure. There is no outcrop of the deeper units, although several imbrications seem to be represented within the gneiss unit, as evidenced by interbedded sheets with paragneisses, mafic and ultramafic boulders and eclogites. The Axial zone cover is formed by the "Schistes X", a metamorphic succession of schists with sandstone, chert and carbonate intercalations which have been considered Precambrian or Palaeozoic. On either side of the Axial zone, there are equivalent low-metamorphic fossiliferous successions allochthonous to the Axial zone. This structure has been recently interpreted by Echtler *et al.*,(1988) as a Variscan metamorphic core-complex composed of an uplifted core of gneissic and migmatitic rocks and an upper plate of low grade to non metamorphic folded Palaeozoic sediments.

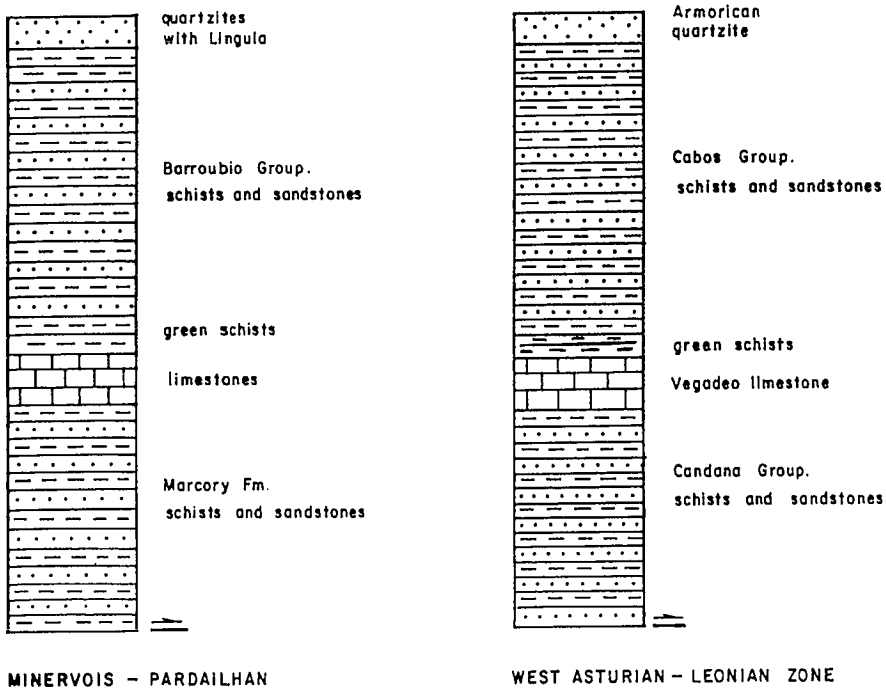

Fig. 2.- Comparative stratigraphy of the Minervois-Pardailhan (southern France) and Mondoñedo (NW Spain) nappes.

Fig. 2.- Estratigrafía comparada de los mantos de Minervois-Pardailhan (sur de Francia) y Mondoñedo (NW de España).

The radiometric age of the core augengneiss has been dated as Ordovician (447±16 Ma, Gebauer *et al.*, 1988).

South of the Axial zone of the Montagne Noire, there are several allo-chthonous units made up of Palaeozoic rocks, named from top to bottom, the Minervois, Pardailhan, Mont Peyroux, and Faugéres nappes. The stratigraphic column of the first two is made up of a mainly Cambrian to lower Devonian succession, while in the Mont Peyroux nappe, there is an almost complete Ordovician to lower Carboniferous succession and in the Faugéres, almost only Carboniferous rocks are found with included older Palaeozoic exotic blocks.

The stratigraphic column of the Pardailhan nappe is made up of (Arthaud *et al.*, 1982) a schist-sandstone succesion (Marcory sandstones) at the base with schist intercalations. On top of them there are sandstones (Pardailhan sandstones) and dolomitic intercalations with Cambrian trilobites, followed by limestones and dolomites in the Malviés unit, as well as by limestones and marbles at the top with Archaeocyatha. The carbonate unit is followed by pseudonodular marly limestones (pseudogriottes) and purple schists with carbonate nodules. On top of these are green slates with rich trilobite (*Paradoxides*) faunas. The upper part of the Cambrian succession is made up of an alternance of chlorite rich schists and sandstones (série de Barroubio) with rare upper Acadian faunas. The Ordovician is formed by a thick (up to 1500 m) succession of alternating schists and sandstones with Tremadoc faunas. There are massive quartzites at the top, ending up with black schists with Arenig graptolites. There is an apparent gradual transition between Cambrian and Ordovician strata. Follow some pyroclstic rocks of rhyolitic composition and massive andesites. The Caradoc is represented by quartzitic sandstones with microconglomerates followed by a volcano-sedimentary succession with alternating quartzites and microconglomerates. These units have not been dated palaeontologically. The Silurian rocks are black ampelitic slates with some nodular marls with Orthoceras, Pelecipods and Graptolites. Their age is Llandovery-lower Wenlock. The lower Devonian (Gedinnian) is represented by micro-conglomerates at the base, accompanied by carbonates and thin oolitic ironstones followed by quartzites.

Correlations between the different structures

From this schematic description of some structures with augengneiss cores of Spain and France, we can draw the following conclusions: The units described at the Sanabria window in the Ollo de sapo antiform of northwest Spain are quite comparable to those in the Canigou and Montagne Noire nappe empilements. The upper thrust unit is made up of Palaeozoic metasediments, and the second one of mylonitic augengneisses. The third one of Precambrian to lower Palaeozoic meta-sediments with intruded alkaline to peralkaline granites of Ordovician age is seen at Sanabria and Canigou. The existence of a pre-Hercynian metamorphism at Sanabria, and the Ordovician intrusives point to a similarity of this unit with other present in the polymetamorphic complexes of NW Iberia and the leptyno-amphibolitic complexes of the french Massif Central (Malpica Tuy unit, Santiago unit, Levezou complex, Lower Gneissic unit, etc.).

With regard to the Mondoñedo and Parhaildan nappes of the West Asturian Leonese zone of Iberia and southern Montagne Noire of France, it seems evident the great facies and faunal similarities of the Cambrian and Ordovician successions (Fig. 2). The occurrence of large recumbent folds on both cases and the identical structural vergence, point to a former connection of both structures, which would have been separated in late Hercynian times. As for the Pyrenees, it seems problematic to describe a similar structure, due to the strong late Hercynian strike-slip activity which would have dispersed it in many fragments. The dome structures found there can be explained as the result of transpression on earlier Hercynian antiforms during development of a dextral late Hercynian megashear (Fig.3) already mentined by Matte (1968) and Herranz (1984).

We can summarize the common stratigraphic, igneous and tectonic features, of the various structures in northwest Spain, Pyrenees and southeastern France as follows:

1.- All of them are broad antiforms or domes cored by megacrystal-bearing augen-gneisses of Ordovician age

2.- The contact of these augen-gneisses with the metasedimentary cover is tectonic in most cases and there is an intervening unit of mylonitic fine-grained gneisses due to overthrusting.

3.- The cover succession is composed in all cases by metamorphosed sedimentary and volcanic rocks of late Precambrian to Silurian age and comparable lithological development.

4.- When exposed, the base of the augen-gneiss unit shows also extensive mylo-nitisation and a tectonic contact with the underlying metasedimentary unit (or units).

5.- In cases of exposure of an underlying unit, it shows the existence of intrusive rocks (orthogneisses) of Ordovician age.

6.- There are Hercynian nappe structures with similar stratigraphic and tectonic characteristic on the same side of the augen-gneiss structures.

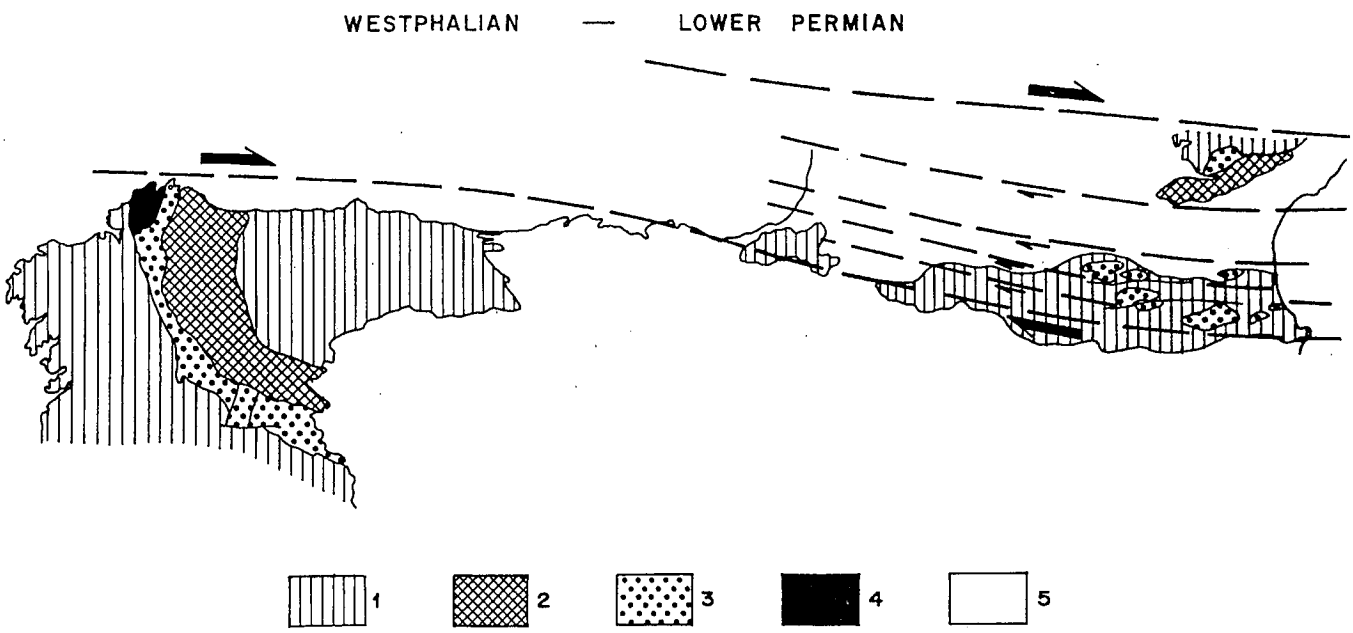

Fig. 3.- Late Hercynian megashear along the North Pyrenean fault. Geological units: 1.- Iberian Massif and Paeleozoic of Pyrenees and Montagne Noire, 2.- Mondoñedo and Pardailhan nappes, 3.- Ollo de sapo augengneiss, 4.- Ophiolitic complexes, 5.- Post-Hercynian cover.

Fig. 3.- Megacizalla tardihercínica según la falla Norpirenáica. Unidades geológicas: 1.- Macizo Ibérico y Paleozoico de los Pirineos y Montagne Noire, 2.- Mantos de Mondoñedo y Pardailhan, 3.- Gneis con megacristales Ollo de sapo, 4.- Complejos ofiolíticos, 5.- Cobertera posthercínica.

Conclusions

All these facts seem to indicate that the augengneiss cored structures found in northwest Iberia, eastern Pyrenees, and Montagne Noire, belong to a comparable tectonic empilement which has been modified and disrupted by the late Hercynian dextral strike - slip activity causing the westward movement of the Iberian peninsula. This fault activity (Fig. 3) was mainly concentrated between the northern margin of the Iberian peninsula and an E-W trending line north of the Montagne Noire. The effect of the dextral shear on the N-S trending Hercynian structures was probably the cause of the formation of E-W to NW-SE oriented gneissic domes wthin the individual fractures. As a consequence, the existence of a direct connection between NW Iberia and the Armorican massif, through the Ibero-Armorican arc, must be questioned and a connection proposed of the Iberian and European structures through the eastern Pyrenees.

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