Ophiolites in the Variscan suture of NW Iberia I: Distribution and types

Ofiolitas en la sutura Varisca del NW de Iberia I: Distribución y tipos

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Abstract: In the NW Iberian Massif, in the Galicia region, several allochthonous complexes (Cabo Ortegal, Órdenes and Malpica-Tui) contain a rootless Variscan suture that can be followed along the belt. The allochthonous complexes include two different continental terranes and several ophiolitic units sandwiched in between them. Two different ophiolitic belts exist, with different structural position and chronology. The lower ophiolitic units consist of the Bazar and Vila de Cruces ophiolites and are characterized by c. 500 Ma protolith ages. The upper ophiolitic units are composed of the Careón, Purrido and Moeche ophiolites, and contain mafic-ultramafic sequences dated at c. 395 Ma. This younger group represents the most common ophiolites in the Variscan Orogen. Moreover, a thick serpentinite mélange (Somozas Mélange) can also be included among the ophiolitic sequences of the Variscan suture.

Key words: Ophiolites, Distribution and types, Variscan suture, NW Iberian Massif.

Resumen: *En el NW del Macizo Ibérico, en Galicia, diferentes complejos alóctonos (Cabo Ortegal, Órdenes y Malpica-Tui) contienen una sutura Varisca desenraizada que puede seguirse a lo largo del orógeno. Los complejos alóctonos incluyen dos terrenos distintos de origen continental y diferentes unidades ofiolíticas que ocupan en general una posición intermedia entre ambos. Existen dos cinturones ofiolíticos distintos, con diferentes posiciones estructurales y cronología. Las unidades ofiolíticas inferiores están constituidas por las ofiolitas de Bazar y Vila de Cruces, y se caracterizan por unos protolitos datados en c. 500 Ma. Las unidades ofiolíticas superiores están constituidas por las ofiolitas de Careón, Purrido y Moeche, y contienen secuencias máficas-ultramáficas datadas en c. 395 Ma. Este grupo más joven representa las ofiolitas más comunes en el Orógeno Varisco. Además, entre las secuencias ofiolíticas incluidas en la sutura Varisca del NW de Iberia también puede incluirse una potente mélange de serpentinitas (Somozas Mélange).*

Palabras clave: *Ofiolitas, Distribución y tipos, Sutura Varisca, NW del Macizo Ibérico.*

INTRODUCTION

In the Variscan Belt, a long suture zone is outlined by thick sequences of mafic and ultramafic rocks, interpreted as ophiolites generated during the closure of at least one oceanic domain during the main stage of the Pangea assembly. They are included in allochthonous complexes formed by several exotic terranes, in some cases affected by high pressure metamorphic events (Fig. 1). It is accepted that the Rheic Ocean was the main oceanic domain closed during the collision of Gondwana and Laurussia in Late Devonian and Carboniferous times (Stampfli and Borel, 2002), but other minor oceanic domains also participated in the amalgamation of Pangea (Arenas et al., 2014a; Díez Fernández and Arenas, 2015).

The long Variscan-Appalachian-Alleghenian Orogen, which extends from Europe to eastern North America, contains key information for reconstructing the amalgamation history of the Pangea supercontinent. In the Variscan Belt, the oldest tectonothermal events are preserved in the complex suture zone that can be traced from the Iberian Peninsula to the Bohemian Massif. Two different events of high pressure metamorphism appear to have occurred relatively close in time, but were separated by the development of oceanic basins (Arenas et al., 2014a). This evolution is unusual in large collisional belts, whose tectonothermal evolution is commonly interpreted as reflecting a single high-P (HP) or ultra-high-P (UHP) metamorphic event associated with subduction of one of the colliding continental margins. In the Variscan Belt, both HP events and the development of some of the oceanic domains occurred after the earliest Devonian and are thus broadly coeval with the initial stages of the assembly of Pangea.

OPHIOLITIC UNITS

Several recent papers have described the lithologies, chemical compositions and isotopic geochronology of the ophiolites of NW Iberia (see Arenas and Sánchez Martínez, 2015 and references therein). It is presently well-known that their igneous protoliths correspond to two age groups, which prevents linking their generation with a single stage in

the evolution of a single oceanic domain. These ophiolites provide information about the oceanic domains located along the periphery of Gondwana in pre-Ordovician times, and about the oceanic domains involved in the final assembly of Pangea. The ophiolites of NW Iberia consist of a varied group of mafic-ultramafic sequences. Five different ophiolites and a serpentinite mélange have been described in Galicia, in the northwesternmost part of the Iberian Massif (Figs. 1 and 2). Two groups of ophiolitic units have been distinguished (Figs. 1 and 2): an older group (lower ophiolitic units) containing metaigneous rocks of Late Cambrian age (c. 497-495 Ma; Arenas et al., 2007; Sánchez Martínez et al., 2012), and a younger group (upper ophiolitic units) including gabbroic rocks of Devonian age (Emsian-Eifelian; c. 395 Ma; Díaz García et al., 1999; Sánchez Martínez et al., 2011; Arenas et al., 2014b). The lower ophiolitic units are interpreted to represent a series of mafic complexes linked to the dynamics affecting the most external margin of Gondwana in Cambrian-Early Ordovician times. The Middle Devonian ophiolites are the most abundant group found in the Variscan suture. The origin and meaning of this group of ophiolites has been the object of different interpretations.

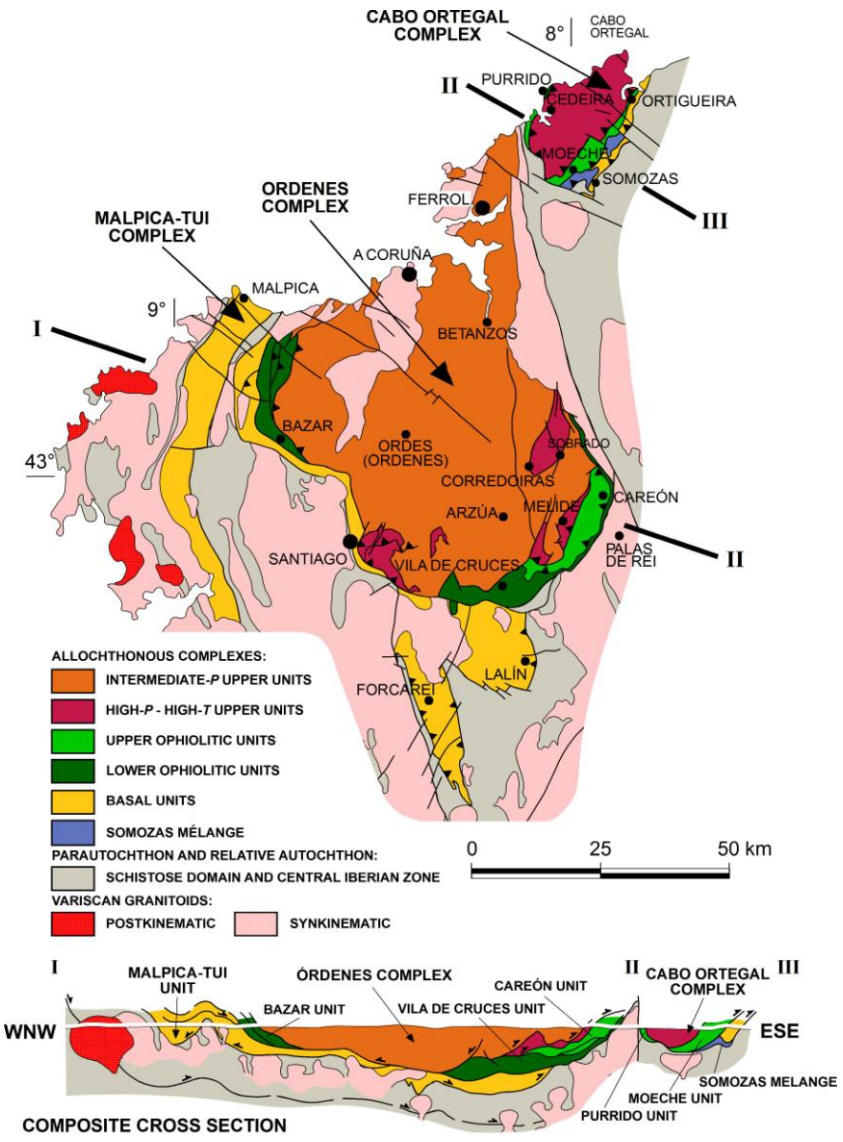

FIGURE 1. *Geological map and cross section of the allochthonous complexes of the NW Iberian Massif (Galicia region). They show the distribution and general structure of the terranes involved in the Variscan suture and the location and names of the ophiolitic units.*

LOWER OPHIOLITIC UNITS

The Bazar Ophiolite, located in the westernmost part of the Órdenes Complex (Fig. 1), consists of an imbricate of tectonic slices, c. 5000 m thick, containing metagabbroic rocks and a minor proportion of ultramafic rocks at the base of the ophiolite. The main tectonic slice (Carballo-Bazar, Fig. 2) is c. 4000 m thick and is composed of amphibolites and foliated

metagabbros with a HT foliation, which evolved from an initial granulite-facies tectonothermal event. Scarce metric-sized boudins of mafic granoblastic granulites are preserved within the metagabbros. They are wrapped by the HT foliation and their mineral association is transitional between low and intermediate-P conditions (plagioclase – clinopyroxene – orthopyroxene – hornblende – ilmenite ± garnet ± olivine). The lower part of the main slice consists of relatively well-preserved gabbros and ultramafic rocks, with minor leucogabbros and tonalites (Fig. 2). Located SE of the Órdenes Complex (Fig. 1), the Vila de Cruces Ophiolite has a complex structure characterized by the presence of at least two overlaid tectonic slices with a total thickness of c. 4000 m (Fig. 2). The main lithologies are greenschist rocks of possible metavolcanic origin, alternating with abundant layers of phyllites, micaschists and schists with albite and garnet porphyroblasts, and scarce metacherts bands. Lenticular intercalations of metagabbros and two bodies of tonalitic orthogneisses transitional to metagabbroic types can also be identified. Thin serpentinite bands occur along the contact between the main slices.

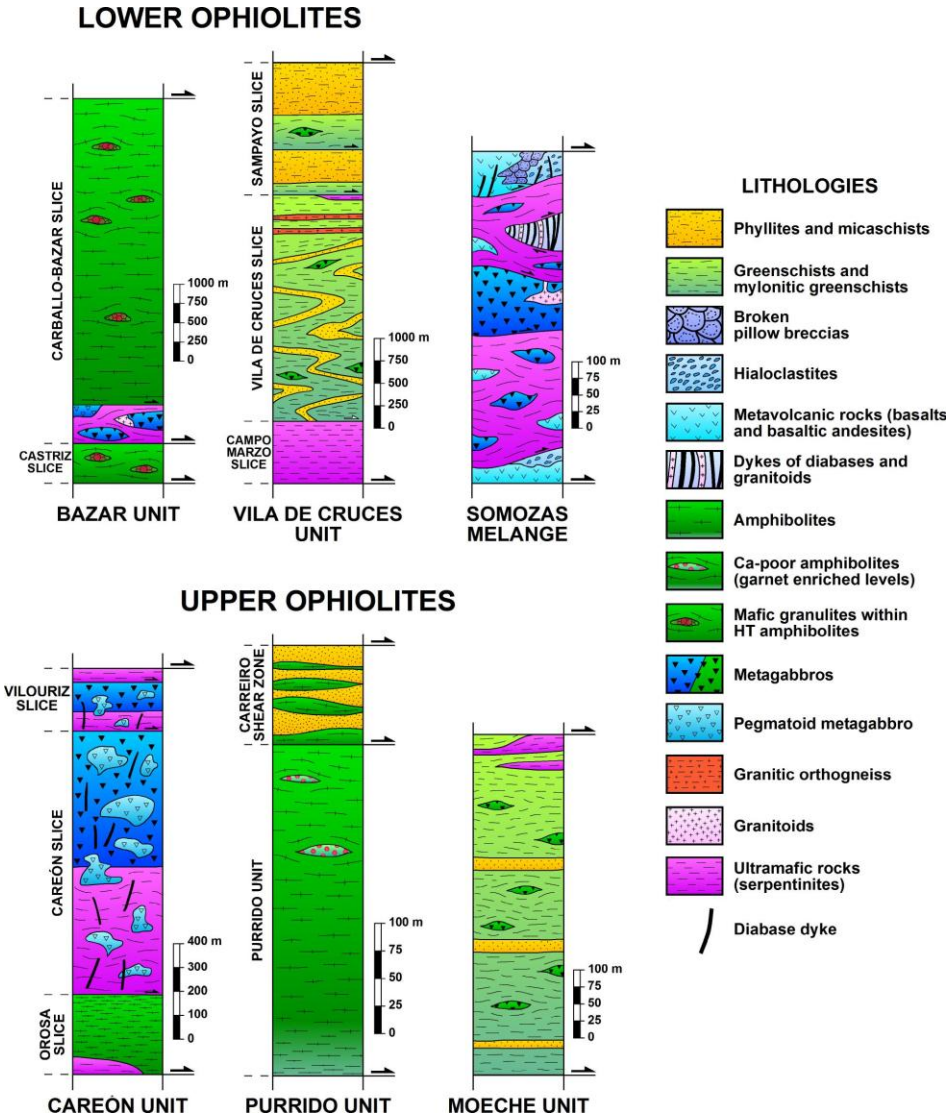

FIGURE 2. *Schematic columns showing the lithological constitution of the ophiolites from Galicia.*

UPPER OPHIOLITIC UNITS

The Careón Ophiolite contains the best preserved metaigneous succession in NW Iberian Massif (Figs. 1 and 2). It consists of three imbricated sheets that repeat the mantle-crust transition with a total thickness of c. 1500 m. The thickest slice is the c. 1000 m thick Careón Sheet, which consists mainly of serpentinized ultramafic rocks and isotropic metagabbros, with abundant stocks of pegmatoid metagabbros emplaced at all levels as well as scarce wehrlite sills. Diabase and late diabase dykes cut all exposed levels, from the deepest mantle section to the most superficial crustal sections. The lithological constitution of the Careón Ophiolite strongly differs from the classical MOR

ophiolitic types. Therefore, it was interpreted as an ophiolite generated in a supra-subduction zone setting by Díaz García et al. (1999). The intrusion of abundant diabase dikes at all levels of the Careón Sheet suggests the development of this ophiolite in a context of extension and thinning, above a subduction zone. Located at the westernmost limit of the Cabo Ortegal Complex (Fig. 1), the Purrido Ophiolite consists of c. 300 m of monotonous amphibolites and garnet-bearing amphibolites of metagabbroic origin (Fig. 2). Unlike the Careón Ophiolite, well preserved igneous features do not occur but the amphibolite types that appear on both units are very similar from a mineralogical and compositional point of view, so that both ophiolites have been traditionally correlated. The Moeche Ophiolite crops out widely in the eastern part of Cabo Ortegal Complex (Fig. 1). The Moeche and Purrido ophiolites are in contact in a small coastal section to the West of Cedeira village, where the Moeche Ophiolite occupies the lower structural position. This ophiolitic unit consists of c. 500 m of greenschists with abundant intercalations of phyllites and micaschist, and scarce metagabbros and serpentinites (Fig. 2).

The lowest part of Cabo Ortegal Complex includes a thick tectonic mélange, only represented in this place in the allochthonous complexes of NW Iberian Massif (Fig. 1). The Somozas Mélange comprises a c. 1800 m thick unit composed of two contrasting members (Arenas et al., 2009). The upper member is c. 500 m thick and consists of a typical serpentinite mélange. The sheared serpentinitic matrix surrounds tectonic blocks ranging from metric-hectometric to kilometric in size. The tectonic blocks consist of gabbro, diabase, granitoid, metabasalt, andesitic basalt, pillow breccia, pillow lava, hyaloclastite, marble, phyllite, sandstone and conglomerate, together with HT metamorphic rocks including orthogneisses, common amphibolite and zoisite-rutile rich metabasites. The lower member is c. 1000 m thick and it is composed of a mélange with a matrix of ocher-colored phyllites or blue-colored phyllonites surrounding tectonic blocks of the lithologies involved in the serpentinite mélange.

CONCLUSIONS

In the NW Iberian Massif, two main groups of ophiolites are preserved in the Variscan suture: Cambrian (c. 500 Ma; lower ophiolitic units) and Devonian (c. 395 Ma; upper ophiolitic units). A thick serpentinitic mélange of uncertain age and origin also occurs. These ophiolites are composed of mafic sequences and minor ultramafic rocks, deformed and metamorphosed from greenschist to low-P granulites facies. Although the primary mineralogy is not preserved, the plutonic, intrusive and volcanic textures and structures are frequently observed. Sedimentary rocks are rather scarce and it is unclear whether their presence in the ophiolite has tectonic significance.

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