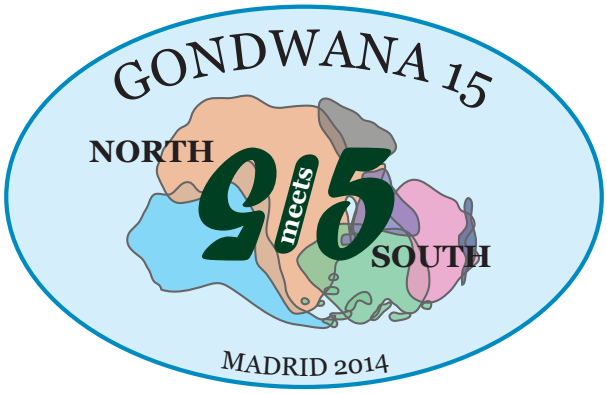
A scent of the Ollo de Sapo Formation at the Hiendelaencina section

GONDWANA 15

Mid-conference field trip



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1. Introduction

An iconic basement formation of the Iberian Massif and one of the most controversial metaigneous units in the Iberian Massif, the "Ollo de Sapo" gneisses have captured the attention of geologists since the beginning of the last century (Hernández Sampelayo, 1922).

BOX 1: What's in a name?

But not only geologists were mesmerized by these gneisses, the geologically uneducated people from the Galician villages where this rock crops out gave it the nickname "Ollo de Sapo", literally toad's eye, in reference to one of its most characteristic features, the big rounded feldspar porphyroclasts (Hernández Sampelayo, 1935). Differential erosion between the fine grained matrix and those huge porphyroclasts provided the rock the aspect of the toad's bulging eyes (if the outcrop were extent, it would be a knot of toads). Having into account the superstitious beliefs in this part of Spain, it's not a bad name.

In the mid 60's of the past century, Isidro Parga Pondal and coworkers included the blue quartz porphyroclasts as cause for the name (Parga Pondal et al., 1964).

2. Regional setting

The area we are visiting is located at the northeastern edge of the Spanish Central System in the so-called Somosierra-Ayllón Domain (Fig. 1). As a whole, the Spanish Central System is a pop-up structure generated by the Alpine orogeny during Tertiary times (de Vicente et al., 2007). This thick-skinned structure permits the exposure of the pre-Variscan basement in Central Spain. In the Somosierra-Ayllón Domain, this basement is composed of low-grade Ordovician metasediments, metamorphosed igneous rocks (both volcanic and plutonic) and a lower metasedimentary series of unknown age. According to Martínez Catalán et al. (2004) this "local" domain belongs to the broader Ollo de Sapo Domain (Fig. 2), which is in turn included in the Central-Iberian Zone.

MARGIN 1: Definition

Ollo de Sapo Formation:

Ensemble of metamorphic rocks of volcanic origin (with minor interbedded metasediments) characterized by the presence of Kfs, plagioclase and blue quartz porphyroclasts included in a recrystallized matrix, probably vitreous in origin. There are two different facies of this gneiss, coarse and fine grained. In the first case, the porphyroclasts can be up to 15 cm in diameter. The idiomorphic Kfs megacrysts are frequently surrounded by a plagioclase mantle, resembling a rapakivi texture. Additionally, in medium- to high-grade areas, the blue color of the quartz is lost.

MARGIN 2: Definition

Ollo de Sapo Domain:

Subdivision of the Central Iberian Zone, which extends 570 km, from the Lugo coast (in northern Spain) through Hiendelaencina (Guadalajara, central Spain). It is characterized by the nature of the lithologies underlying Ordovician series, the Ollo de Sapo Formation (and other pre-Ordovician series below it), in contrast the Schist-greywacke Domain, where the Schist-greywacke Complex can be found beneath the Ordovician materials.

3. Ollo de Sapo Domain

3.1 Lithostratigraphy and age

Hiendelaencina is one of the two places where you can find metamorphosed sedimentary and igneous rocks below the Ollo de Sapo Formation (Fig. 3), the other one being Viana do Bolo, between the Spanish provinces of Ourense and Zamora, close to the Portugal border. These materials are categorized in three formations, from bottom to top: Angón, Antoñita and Cardeñosa (González Lodeiro, 1981a, b).

The Angón Formation is composed of schist, quartzite, microconglomerate, marble and amphibolite. The Antoñita

Formation corresponds to a granitic orthogneiss (we will visit it at **Stop 5**) of probable Early Ordovician age. Finally, the Cardeñosa Formation is constituted by feldspathic quartzite, schist, calc silicate rocks and marble.

The Ollo de Sapo Formation (see Margin 1) appears overlying these formations. The contact between them is always very deformed and metamorphosed, making difficult to determine their mutual relationships. It is mainly composed of porphyroids (see Box 2) with some thin layers of quartzite, slate and felsic rocks interbedded. In general terms, the fine grained facies predominate in the upper part of the formation, whereas the coarse grained facies is more abundant in the lower part.

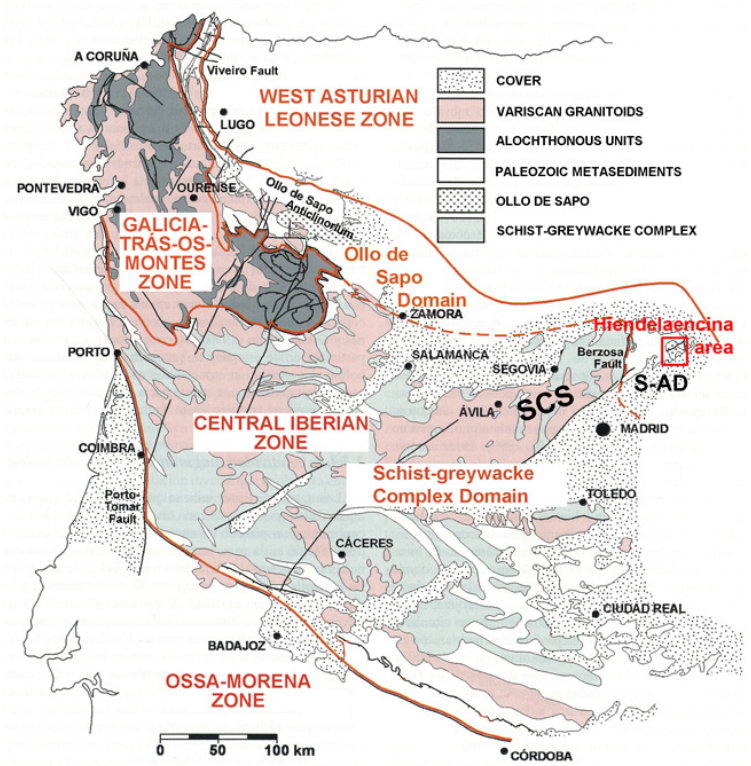


Figure 1. Geological sketch of the Central Iberian Zone showing the division in domains based on stratigraphic criteria (see text for further explanation). SCS, Spanish Central System; S-AD, Somosierra-Ayllón Domain. Modified from Martínez Catalán et al. (2004).

In areas with lower metamorphic grade (Sanabria and Hiendelaencina), the igneous textures have been preserved, permitting the recognition of different lithologies and deposits: augengneiss, welded ignimbrite, coarse grained tuff, metarhyolite and volcanosedimentary rocks.

At Hiendelaencina, the so-called Bustares granite by Schäfer (1969), which is actually an orthogneiss, crops out between the coarse grained Ollo de Sapo facies (see more details at **Stop 2**). It is interpreted as a conduit of the tuffs.

Overlying the Ollo de Sapo Formation, there are several metasedimentary formations from the Ordovician through

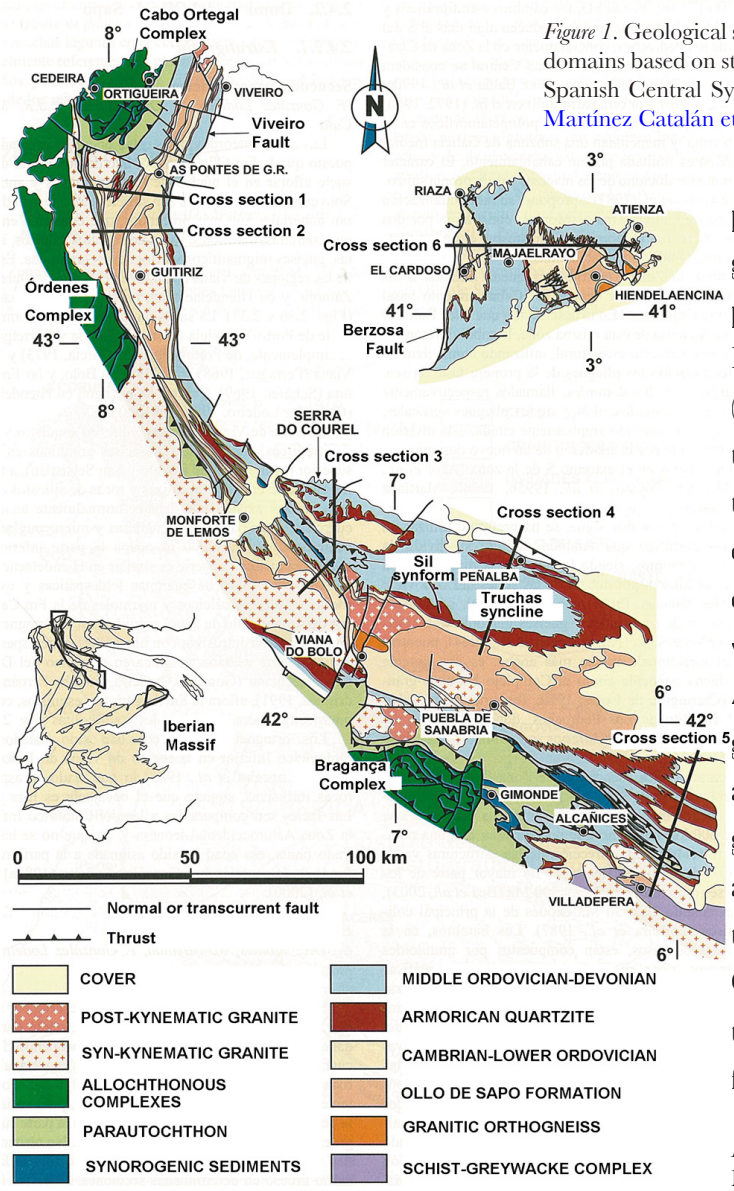


Figure 2. Geological map of the Ollo de Sapo Domain. Modified from Martínez Catalán et al. (2004).

BOX 2: What's a porphyroid?

If you skim through the Ollo de Sapo literature, you'll probably bump into this word. According to the glossary of terms included in Fettes and Desmonds (2007) a porphyroid is an "ambiguous term originally proposed for igneous rocks allied to porphyries. Later used for metamorphosed acid volcanic rocks or their tuffs". Among Spanish geologists, porphyroid refers to the latter meaning.

the Devonian. They receive local names depending on the sector they are defined, but can be correlated all along the Ollo de Sapo Domain. In Hiendelaencina, we will visit two of these formations at **Stop 1**, from bottom to top: Constante and Alto Rey.

The Constante Formation it is constituted by an alternation between quartzite and phyllite deposited at the intertidal/subtidal zone in a shallow platform during the earliest Ordovician (Tremadocian). The contact with the underlying Ollo de Sapo Formation has been interpreted in two ways (see discussion in Capote, 1983 and Díez Montes et al., 2004), (i) a transition without an evident discontinuity, and (ii) presence of an important discontinuity (Fig. 4), firstly attributed to the Sardic phase but recently related to the Toledanian phase (see Gutiérrez-Marco et al., 2002). The latter was the prevailing idea until isotopic dating revealed the real age of the Ollo de Sapo Formation (Early Ordovician, Valverde Vaquero and Dunning, 2000; Montero et al., 2007, 2009).

The Alto Rey Formation is the local name of the Armorican Quartzite, which includes sandstones deposited in a shallow stable shelf during the Early Ordovician (Floian).

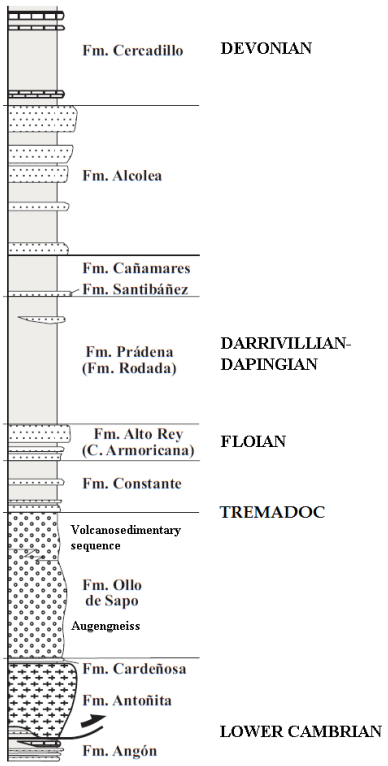


Figure 3. Schematic stratigraphic column of the Hiendelaencina sector. Modified from Martínez Catalán et al. (2004).

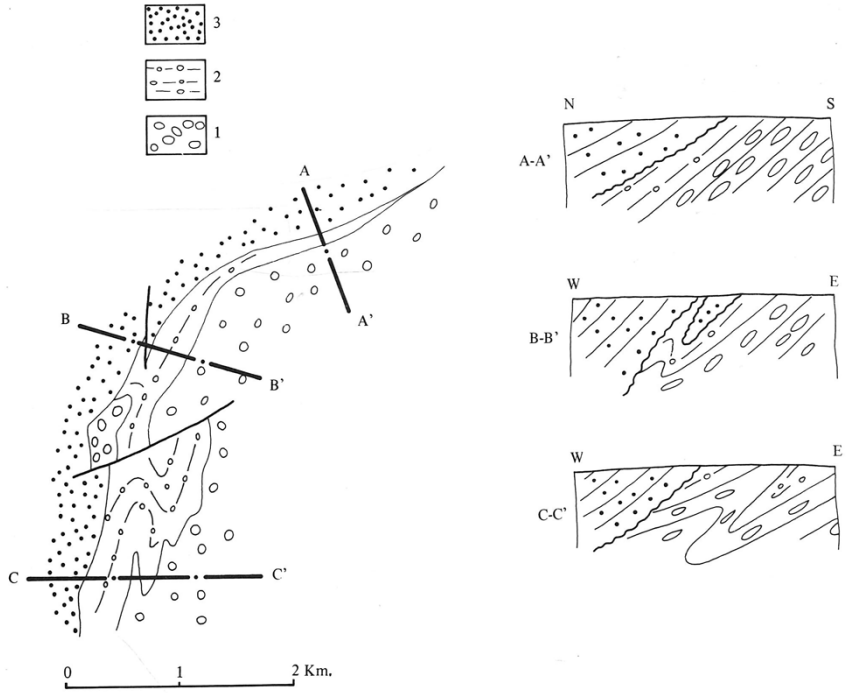


Figure 4. Geological sketch and cross sections to the NW of the Hiendelaencina sector showing the alleged discordance between the Ollo de Sapo and the Ordovician. (1) Coarse grained Ollo de Sapo; (2) fine grained Ollo de Sapo; (3) Lower Ordovician. After González Lodeiro (1980).

3.2 Structure

As we already stated (see Margin 2), the Ollo de Sapo Domain is defined on the basis of stratigraphic criteria. However, other authors individualized the northern sector of the Central Iberian Zone (including the Ollo de Sapo anticlinorium) using structural parameters (e.g., Matte 1968) and named it "recumbent and refolded folds domain". The structure in the Ollo de Sapo Domain (Fig. 5) is the result of a succession of three main deformation events (e.g., Macaya et al., 1991): (i) recumbent folds accompanied by a penetrative planar fabric (S1), (ii) ductile thrusting with a new foliation (S2) associated to shear zones, and (iii) backfolding which gave rise to the crenulation of the existent structures (S3).

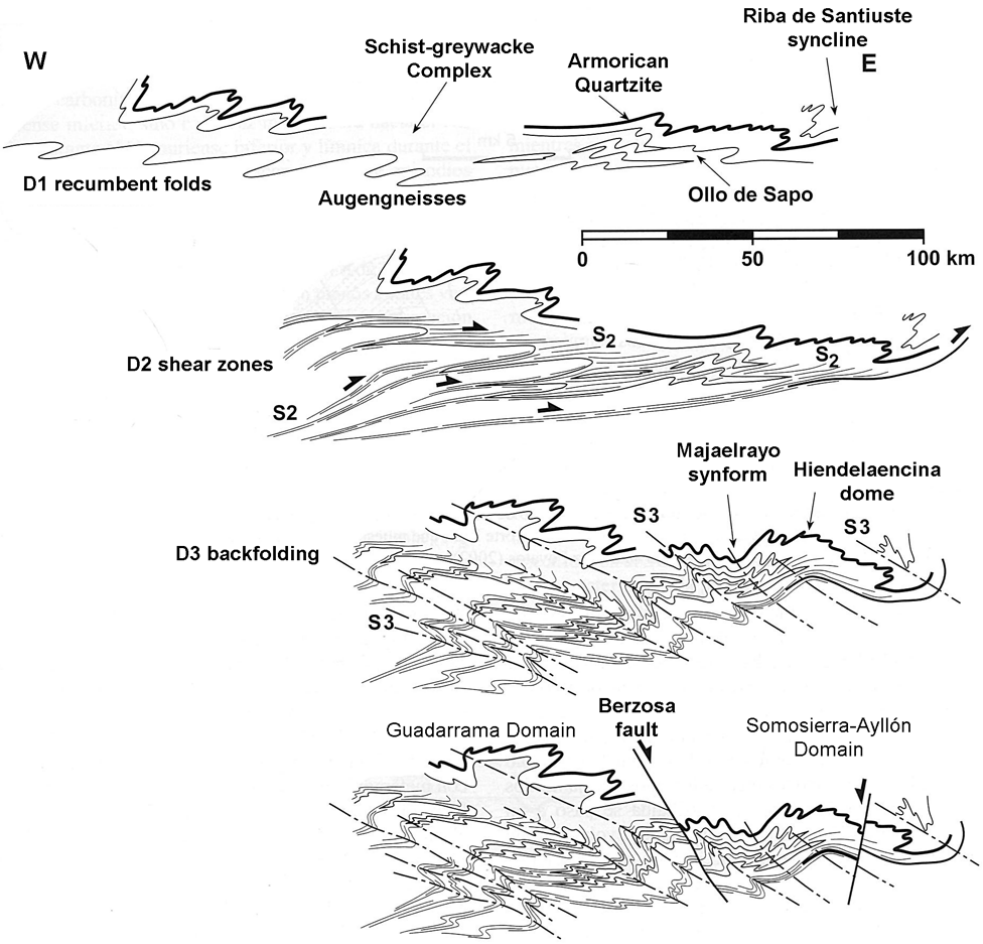


Figure 5. Structural evolution of the Sierra de Guadarrama. After Macaya et al. (1991).

3.3 Geochemistry

The Ollo de Sapo Formation is constituted by dacites and rhyolites with peraluminous and calc-alkaline character (with K_2O content between 3 and 5 wt%). Trace elements indicate a volcanic arc signature (Navidad and Bea, 2004). However, the absence of mafic and intermediate members and, more importantly, the coeval Early Ordovician sedimentation clearly linked to a passive continental margin are in conflict with the geochemical data (Díez Montes et al., 2010).

This arc signature could be explained in terms of crustal recycling of an older Cadomian basement with calc-alkaline affinity (Fig. 6). This interpretation is supported by the abundance of inherited zircon cores, most of which are Ediacaran (Díez Montes et al., 2010).

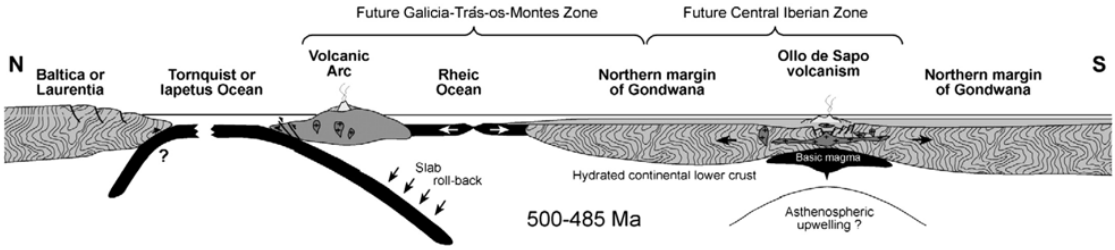


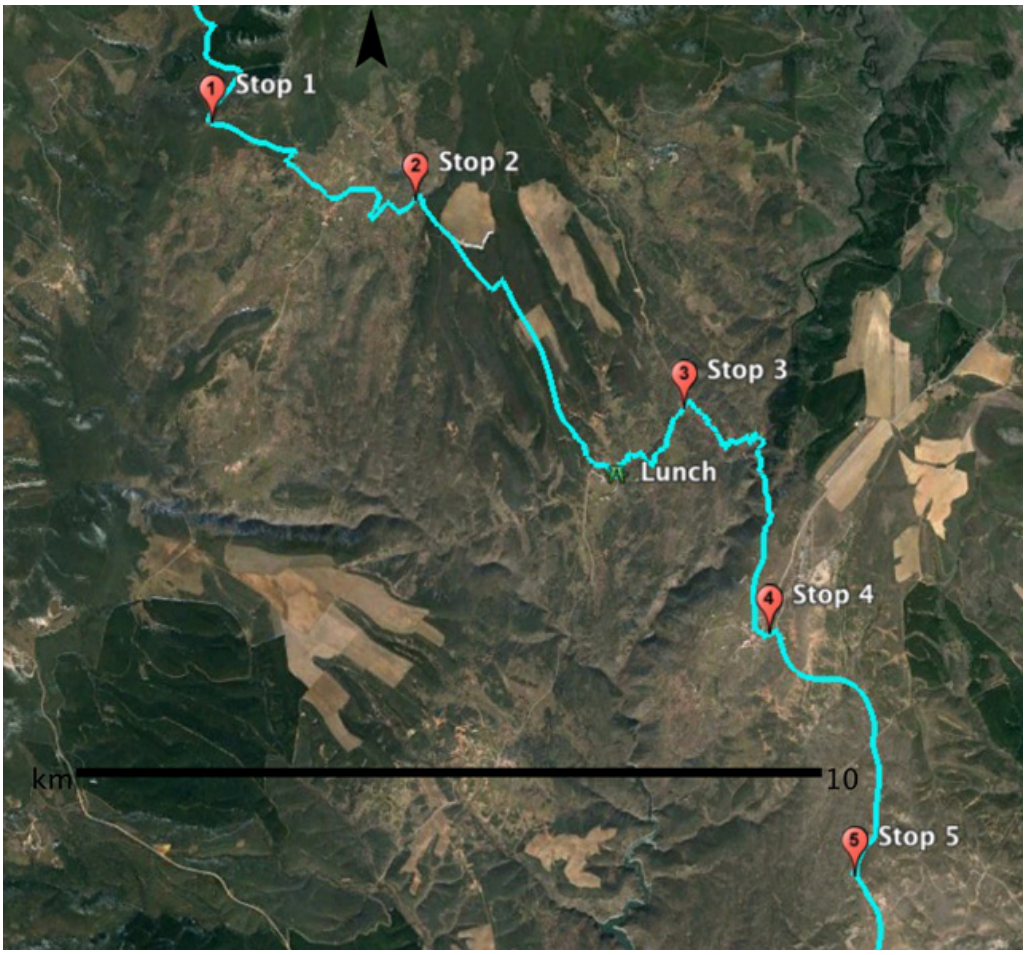
Figure 6. Sketch of the tectonic setting of the Ollo de Sapo Formation. After Díez Montes et al. (2010).

3.4 Mineralization

During the late stages of the dome formation (Late Carboniferous-Permian), when brittle conditions were already attained, the hydrothermal activity increased in the area, favored by the ascent of andesitic magmas, resulting in an epithermal silver-base metal district (Concha et al., 1992). In spite of the relative importance of this mining district, we will not visit feature related to it.

BOX 3: The Ollo de Sapo abroad

In addition to the more than 500 km of extension in the Iberian Peninsula, Ballevre et al. (2012) have recently correlated a porphyroid unit in the Armorican Massif with the Ollo de Sapo Formation, and suggested that other metavolcanic units in the Montaigne Noire Massif (southern France) could be also equivalent.



Stop 1. The Age

At this point, we will take a look at the Alto Rey Formation, named after a nearby range, which is equivalent to the Armorican Quartzite.

Below this metasandstone we can observe an outcrop of the Constante Formation shales.

Going further to the SE, we will find a controversial outcrop. The rocks present in it were formerly interpreted as a microconglomerate located at the base of the Ordovician succession, which was the result of the erosion of the older Ollo de Sapo rocks. Thus, the contact between the Lower Ordovician series and the Ollo de Sapo would be discordant and the age of the Ollo de Sapo Fm. would be pre-Ordovician.

Stop 2. The protolith

Until recent times, every geologist in Spain (and probably in Portugal too) had an opinion on different aspects of the Ollo de Sapo formation, whether he/she worked on them or not. One of those debatable questions was its protolith. In this case, most of us would agree in their volcanosedimentary origin (see for example, Parga Pondal et al., 1964; Navidad, 1978), where the most fine grained facies represents metamorphosed volcaniclastic material and the coarse grained facies could represent in some cases tuffaceous material.

However, some colleagues interpreted the coarse grained facies as metaplutonic rocks, whereas the fine grained facies were the results of shearing those coarser facies (Díaz García, 2002).

At this point, we will observe the **Ollo de Sapo coarse grained facies** in the road cut, with some centimetric metapelitic enclaves. Walking by the right margin of the Uncillas Creek we will find a different facies, unique in the whole formation, the so called **Bustares Granite** (which is actually an orthogneiss). This rock was first described by Schäfer (1969) as a small elongated body, 1 km long and 50-200 m wide, concordant with the surrounding Ollo de Sapo.

It is composed of Qtz, Kfs, Ab, Olg, scarce Bt (forming ellipsoidal clusters), secondary Ms, and Ap and Zr as accessory phases. It has a border porphyritic facies with Qtz and Ab phenocrysts, and a core facies with Kfs megacrysts.

It has been interpreted as small subvolcanic body intruded in the Ollo de Sapo Formation

Stop 3. The fine grained facies

In this road cut it is possible to observe the characteristics of the Ollo de Sapo fine-grained facies.

Lunch at Villares de Jadraque

Stop 4. Hiendelaencina: The coarse grained facies

In the outskirts of Hiendelaencina, there is a good exposure of the Ollo de Sapo porphyroid, with huge Kfs porphyroclasts.

Stop 5. Antoñita Gneiss: All that's gneiss is not Ollo de Sapo

At this point, we will take a look at a different gneiss formation, the Antoñita Gneiss. The mineral composition is similar to the Ollo de Sapo porphyroids, but it is characterized by the presence of leucocratic dykes. This formation is structurally located below the Ollo de Sapo Formation (Fig. X).

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