Oolitic Ironstones of the Iberian Range: Mineralogical and Petrographic Approach

/ GUIOMAR CALVO SEVILLANO (1,*), IGNACIO SUBIAS PEREZ (1), ANTONIO LOPEZ CIRIANO (1,2)

(1) Cristalografía y Mineralogía. Departamento de Ciencias de la Tierra. Universidad de Zaragoza. C/ Pedro Cerbuna 12. 50009, Zaragoza (España)
(2) PROMINDSA. Centro de Negocios Somport. Ciudad del Transporte, Esc 3, oficina 134-135. 50820, Zaragoza (España)

INTRODUCTION.

In this contribution we will focus on the mineralogical characterization of the three Ordovician oolitic ironstone horizons located in the Aragonian Branch of the Iberian Range. From a geological viewpoint, the study area is marked by abundant outcrops of Palaeozoic rocks unconformably overlaid by Mesozoic materials. They all show a dominant NW-SE tectonic direction.

Since mid 1980, PROMINDSA mined the first horizon in the Sandy Mine (formerly named Marité), located in the Abanto mountain, 2,6 km NNW of Luesma village (Calvo, 2009). The oolitic ironstone horizons were extracted for use in the chemical industry and in the manufacture of cement. Mining activity ceased in 2006.

GEOLOGICAL SETTING.

The three ironstone horizons occurring in the vicinity of Luesma village belong to the Ordovician (Llandeilo) sequence. The first two levels are a part of the Castillejo Formation, while the third one belongs to the Fombuena Formation.

The Castillejo Formation, a 250 meters thick sequence formed by an alternation between marls, sandstones and quartzites. The latter is more abundant towards the top of the Formation. The formation is divided in three members named from base up: Marité, Alpartir and Sierra (Villas, 1983). The first ore horizon occurs at the bottom of the Marité member. The second one is located at the bottom of the Alpartir member.

The Fombuena Formation is a 80 m thick alternation between marls and sandstones. The third ironstone horizon is at the lower portion of the sequence.

MINERALOGY OF THE OOLITIC HORIZONS.

The ironstone strata have been studied by means of optical and electron microscopy (SEM) and by electron probe microanalysis (EPMA).

First Horizon.

The first ironstone horizon outcrops immediately above the Cuarcita Armoricana Formation in the Sandy Mine, and is ca. 3.5 meters thick.

The ironstone is formed by up to 80% of ooids. Their size range between 350 and 650 µm and their morphology between spherical and oval. The original texture of the vast majority remains almost intact; that is, the ooid lamination is generally well preserved and individual layers can be distinguished.

Mineral association is made up of chlorite, haematite, goethite, magnetite and maghemite, being haematite and goethite the most abundant minerals.

Microanalyses allow us to infer a chamosite composition for chlorite: $(Fe^{2+}_{4,21}Mg_{0,53}Al_{1,26})(Si_{2,75}Al_{1,25})O_{10}(OH)_8$. This mineral exclusively occurs forming the ooid layers.

Haematite and goethite occur as a matrix and/or cement. Occasionally, small crystals (150 µm) of haematite can be found in the core of the ooids. Musketovitization and subsequent martitization processes have also been observed (Fig. 1). Magnetite forms idiomorphic crystals of ca. 80 µm in size crosscutting the ooid lamination. Microanalyses have confirmed the stoichiometric nature of iron oxides. It is noteworthy that maghemite occurs

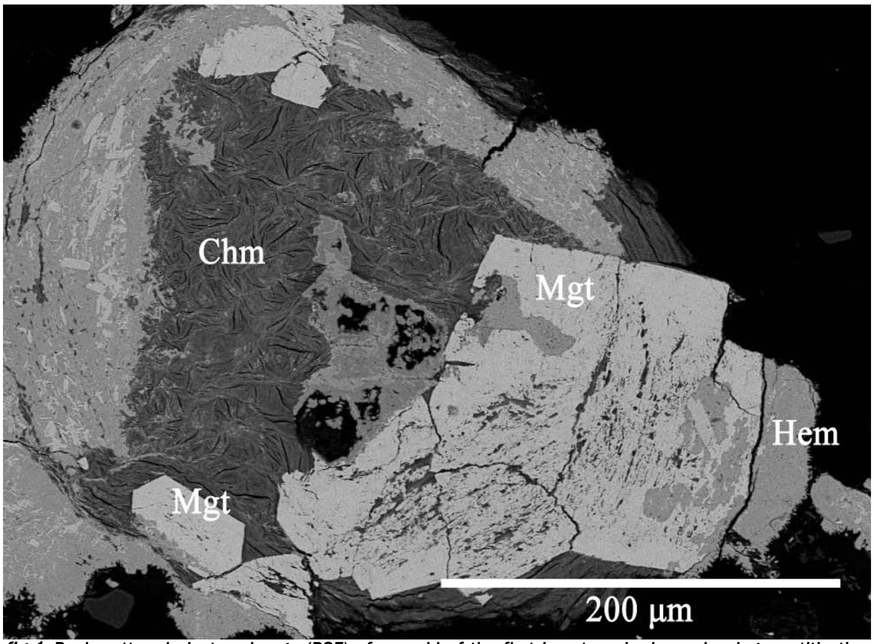

fig 1. Backscattered electron image (BSE) of an ooid of the first ironstone horizon, showing martitization. (Chm: chamosite; Mgt: magnetite and Hem: haematite).

palabras clave: Hierros Oolíticos, Ordovícico, Mineralogía, Cordillera Ibérica.
key words: Oolitic Ironstones, Ordovician, Mineralogy, Iberian Range

* corresponding author: isubias@unizar.es

along with haematite and goethite in the matrix/cement. The occurrence of this mineral was already mentioned by Calvo et al (2001).

Second Horizon.

The second level of ironstones outcrops in Azarollos site and is about 3 meters thick. The ooids are by far less abundant (40%) than in the aforementioned horizon with a size between 150 and 350 µm (Fig. 2). They are oval in shape, showing deformation evidences. Despite of this, a few ooids show lamination and even complete ooids can be found. Nevertheless, most of the nuclei exhibit a replacement of the original material by iron oxides. Also rounded quartz crystals have been observed in the core of some ooids.

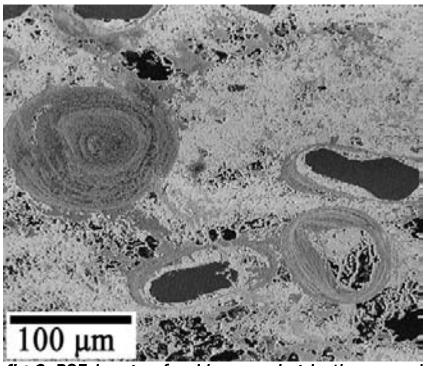

fig 2. BSE image of ooids occurring in the second ironstone horizon.

Mineral association is marked by chlorite, apatite, haematite, goethite and quartz. Zircon crystals can also be found inside the ooids and disseminated in the matrix.

Although chlorite constitutes most of the ooids laminae, electron microscopy has revealed a chlorite - apatite alternation in the ooids lamination. In addition, chlorite veinlets partially crosscutting the lamination were also found. Since these veinlets occasionally include fragments of the ooid layers, their formation must be simultaneous with the mineralogical transformation of the ooids.

EPMA revealed that chlorite composition of this horizon is similar to that of the first one; that is, it belongs to the chamosite end member. Although haematite along with goethite mainly show a massive texture as in the first horizon, elongated haematite and fibrous crystals and colloform textures in goethite have been observed. In this latter case, Fe content decreases outwards colloform zoning.

Pertinent to this study and to future research is that a volcaniclastic bed showing spherical disjunction occurs ca 20 cm above this second ironstone horizon.

Third Horizon.

The third ironstone horizon outcrops in two localities, in the mining area and in the surroundings of the Fombuena village. In both cases, the horizon is 50 cm thick and ooids are up to 50% of the rock. They are 200 to 350 µm in size and oval-shaped. However, most of them are deformed and fragmented. In addition, original lamination was virtually absent due to the replacement of precursor minerals by chlorite.

Mineral association is composed by chlorite, apatite, haematite and goethite. Rutile, zircon and pyrite were also found.

Ooids are mainly formed by massive chlorite of chamosite composition, although a few apatite remnants are observed (Fig. 3). Small zircon (100 µm in size) crystals were also found in the ooids.

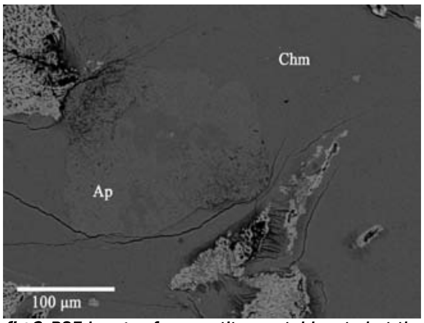

fig 3. BSE image of an apatite crystal located at the core of a chamosite ooid occurring at the third ironstone horizon. (Chm: chamosite; Ap: apatite).

Haematite and goethite only show a massive texture in the matrix surrounding the ooids. Some elongated rutile crystals were also found clearly postdating both the ooids and iron oxide matrix, maybe as a consequence of hydrothermal processes that took place after the formation of the ooids.

Pyrite was only found in this horizon as 5 µm crystals of framboid appearance.

CONCLUSIONS.

Except for the occurrence of magnetite and maghemite in the first horizon, ironstones from the Iberian Range show similar mineralogical and textural characteristics. Iron oxides show a stoichiometric character, while chlorite composition can be included in the Fe-rich chamosite like the one from Wales and Prague Basin (Mücke, 2006).

According to Mücke and Farshad (2005) the Luesma oolitic ironstones belong to the chamosite type and to the moderately ferruginized chamosite subtype.

ACKNOWLEDGEMENTS.

This study was supported by the Program of Research Groups of the Gobierno de Aragón (Mineral Resources Group).

REFERENCES.

*Calvo, M. & Viñals, J. (2001): Maghemita y otros óxidos de hierro de Luesma (Zaragoza). Revista de minerales, **2**, 2, 36-38.*

Calvo, M. (2009): Minerales de Aragón. Ed. Prames. 463 pp.

*Mücke, A. (2006): Chamosite, siderite and environmental conditions in chamosite-type Phanerozoic ooidal ironstones. Ore Geol. Rev., **28**, 235-249.*

*Mücke, A. & Farshad, F. (2005): Whole-rock and mineralogical composition of Phanerozoic ooidal ironstones: Comparison and differentiation of types and subtypes. Ore Geol. Rev., **26**, 227-261.*

*Villas, E. (1983): Las formaciones del Ordovícico medio y superior de las Cadenas Ibéricas y su fauna de braquiópodos. Est. Geol., **39**, 359-377.*