Pyromorphite crystals on quartz with iron oxides. FOV 9 cm. La Ascension del Señor mine, Munébrega, Zaragoza. Spain. J. L. Sánchez coll.

Pyromorphite crystals in cavernous quartz. Width, 3 cm. V. Tarró coll.

Pyromorphite, prismatic crystals with color zonations. Specimen high 3 cm. J. L. Sánchez coll. Photos J. Callén.

The “La Ascensión del Señor” mine, Munébrega, Zaragoza, Spain

The La Ascensión del Señor mine
Munébrega, Zaragoza, Spain
- A “new” locality for pyromorphite, more than 150 years old-

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Introduction

The Aragonese branch of the Iberian Mountain Range was one of the points in which the “mining fever” that crossed Spain towards the middle of the 19th century was unleashed, motivated by news of the great successes in areas such as Sierra Almagrera, Cartagena, Linares, Hiendelaencina and other locations.

The presence in Calcena of mines of certain importance, known since ancient times, as well as the existence of multiple superficial indications, gave rise to the registration of concessions by local companies, mainly in search of “silver”, the only metal that seemed valuable to them, associated with galena or copper sulfosalts. In the municipality of Munébrega around a dozen concessions were registered during the second half of the 19th century, in the alignment of hills located to the W and NW of the town, formed by sandstones, slate and quartzites of the Upper-Cambrian Lower-Ordovician.

Tracing back the details of the mining history of this area is now practically impossible, first for its relative complexity and second due to the loss of the vast majority of the documentation, which was eliminated in successive expurgations in the changes of the administration responsible for the management of mining, although some data can be provided.

The San Ysidro claim, located in the Cerro de Valgarán, on the right bank of the Valdeovejuela stream, was requested by Alberto Alías, a resident of Munébrega, and demarcated on June 15, 1853. In this mine, some major workings were dug, including a pit about 25 meters deep, with a gallery and an inner pit.

However, it must not have been very profitable, being abandoned after a few years. On March 23, 1858, Juan de Obregón, from Molina de Aragón, registered the La Perla claim on the same area. The concession was published in the Official Gazette of the Province on September 22, 1860. Also in this area the La Buena Fe claim was registered in 1867, to extract “copper-argentiferous mineral”. On the right bank of Barranco del Bollizo, on the NW side of Cerro de la Mayolita, mining was carried out also, possibly the largest in this municipality, and of course those show the largest visible remains.

Dumps of La Ascensión del Señor mine, on the SW slope of Cerro Judío, Munébrega.
The pit, protected with a fence, is located on the right side of the photograph.
Photo M. Calvo.

The time when the first workings were dug, which already existed when the Serafina claim was registered on them in 1882, is unknown.

However, the first record of which we have information corresponds to the La Ascension del Señor claim, filed on May 2, 1845, by Ignacio Gormedino at Val de Sancho for a "barite mixed with various metals" mine. To exploit it, the company La Unión de Ateca (Blasco Sánchez, 2010) was immediately established, which worked it first as an open-pit and then later underground. At the beginning of the 1850s it was active, with 12 workers, of whom 6 were pick miners. The vein, with a roughly E-W strike, 52 meters in length, had a thickness of 0.6 meters and cut the stratification of the slates sub-vertically, with a 80º N dip. To exploit it, a main pit 20 meters deep was dug, with access to a gallery at 8.4 meters from the surface, which followed the vein, communicating with another shaft connected to the surface. In addition, an adit was dug at the base of the slope, to the W of the pit, to be used for drainage. Ordóñez (1851) indicates that the tunnel had at the time he visited a length of 33 meters, with the same distance left to reach the vertical of the pit.

The ore, composed mainly of cerussite and pyromorphite, was melted in a smelter located in Molina de Aragón. The antimony that was present as sulphosalts and as secondary oxide minerals made the obtained lead "sour", that is, hard and brittle. Silver was mainly associated with antimony minerals (Ordóñez, 1851).

A few years later the mine was abandoned, but in 1867 it was registered again under the name San José to extract "argentiferous mineral", by Nicanor Torrecilla, a resident of Molina de Aragón. That same year, less than 500 kg of ore were obtained, which was sent to Cartagena to carry out smelting tests. Exploitation the following years took place discontinuously, and in 1886 the concession was already on the verge of being expired for non-payment of the surface rights.

In the 1880s, the San Carlos concession was registered in this area, but it does not seem that any new work was being carried out. This mine is locally known as the Mercader mine, although the name we consider preferable is La Ascension del Señor mine, since the main workings were carried out under that name and it is the one that appears in the bibliography of the epoch (Ordóñez, 1851).

The currently visible workings of this mine are exclusively underground, accessible by a pit, which is fenced for security reasons, located 300 meters SW of the top of Cerro Judío, 2.3 km W of Munébrega. Next to it there are dumps of medium size and the remains of some test pits or almost unrecognizable blind workings. The adit located on the slope has not been located.

All the mineral specimens in this article are from the Ascensión del Señor mine, Munébraga, Zaragoza, Spain.

Underground workings of the La Ascension del Señor mine. Oxide zone located to the right of the main pit. Photo J. L. Sánchez.

It probably did not reach completion, given that the mine does not present, at the depths that were reached, problems with water. Given the danger of underground workings and the possible legal implications, it is formally discouraged to access them.
The main shaft, which has lost all the remains of the extraction facility that accompanied it, and which in the 1850s was operated by a hand winch driven by two workers (Ordóñez, 1851), is excavated on the hillside, with the area in the lower part of the slope protected by masonry. Probably the dumps currently cover part of the outer zone of that protection. It is at least 50 meters deep, but at 25 meters it is currently blocked by the materials thrown into it. When the first exploration of this mine was carried out no communication was found between the visible section of the well and the rest of the underground workings. However, a detailed examination of the walls made it possible to locate about 20 meters from the mouth a crack corresponding to the closure of a gallery that had been condemned, probably to control the movement of air and to use the well as a general outlet in the ventilation of the workings. Broadening this fissure it was possible to access the exploitation area, formed by a network of irregular galleries dug in a disorderly manner, following the mineralization, and two galleries that connect the main shaft with another shaft located approximately E of the first, which currently does not have an exit to the outside.

This adit is about 45 meters deep. Pyromorphite mineralization remains that had not yet been extracted have been found on the walls of the old workings.
A suite of remarkable specimens have been recovered from there, which place the La Ascensión del Señor mine among the more significant Spanish localities for this mineral.

Pyromorphite $Pb_5(PO_4)_3Cl$

The presence of abundant pyromorphite in the La Ascensión mine (La Ascension del Señor) had already been reported during its first period of activity by Ordóñez (1851). Calderón (1910) also points out the presence of pyromorphite in the Valdesancho area, although he places it erroneously about 8 km SW of Munébrega. Since then, specimens of this mineral have occasionally been obtained in the dumps, with crystals a few millimeters in size scattered in small cavities (Calvo, 2008; Calvo, 2014), which simply represented another location for this mineral, without major significance. In a research project of the interior workings carried out by two of the authors (JLS and VT), notable specimens of pyromorphite were recently recovered in some remnants of the ore that were not worked out, especially in one of the vein selvages, less well defined than the other one and where the shale host rock appears altered, with cavernous and hollow areas in which the crystals were able to grow.

Underground workings of the La Ascension del Señor mine. Lower gallery joining the main shaft and the interior shaft. Photo J. L. Sánchez.

Pyromorphite partially coated by a crystalline calcite crust. Field of view 25 mm. M. Calvo collection. Photo J.Callén

One of the peculiar characteristics of this deposit is the variety of habits in which the pyromorphite is found, the only mineral that forms significant specimens, in a space as limited as the one that is currently accessible.
A common pyromorphite habit here is as compact tapestries of pale olive green, more or less yellowish, covering surfaces of up to decimetric sizes of fractures in quartz with iron oxides. These crystals have a prismatic habit with a hexagonal cross-section, sometimes slightly rounded, and a size of about 2 millimeters long by 1 thick. Usually only the faces of the prism $\{10\bar{1}0\}$ and the pinacoid {0001} appear which often have small irregular corrosions.
Color zoning can also be observed along the direction of the prism. In some cases, these crystal carpets are partially covered by a crystalline calcite crust.

In some areas individual pyromorphite microcrystals have also been found, with more elongated morphology, even bacillary, and also more complex crystallographically speaking, formed by the combination of the usual prism and pinacoid, but also with modifications due to faces of the dipyramids $\{10\bar{1}1\}$ and $\{20\bar{2}1\}$, sometimes quite developed.
These microcrystals have color zones transverse to the 0001 axis, so that some of these areas become transparent and almost colorless, while in others the presence of internal microscopic channels aligned parallel to each other and to the 0001 axis, resembles an internal fibrous structure and gives them a silky luster. These microcrystals are associated with black crusts of manganese and lead oxides. Pyromorphite is also found in cavernous ore zones as disordered clusters of crystals, carpeting the walls of irregular cavities that can reach a size of a few centimeters or grow enough to form small walls within them.
These crystals are of the yellowish green color typical for pyromorphite, but in some cases also somewhat more yellowish with more yellowish-orange dominating than usual in this mineral. The individual crystals have a length between 2 and 3 mm, and about 1 mm thick.

Above, mineralization *in situ* of **pyromorphite** coating a fracture.
Photo J. L. Sánchez.

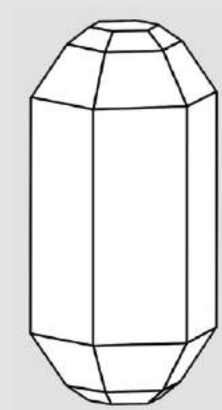
On the left, **pyromorphite** carpet with crystals showing slight corrosion.
Field of view 26 mm.
M. Calvo collection.
Photo J. Callén.

At the top, **pyromorphite** in a cavernous matrix. FOV 5 cm. M. Calvo coll. Photo J.Callén.

Above, group of **pyromorphite** crystals *in situ*, of the same type. FOV 5 cm. M. Calvo coll. Photo J. L. Sánchez.

Facing page: Group of **pyromorphite** crystals, on quartz, and detail (in this page, photo on the right) of one of them. The color zoning and the cavernous termination of the crystal are remarkable. Crystal 12 mm tall. J. L. Sánchez coll. Photo J. Callén.

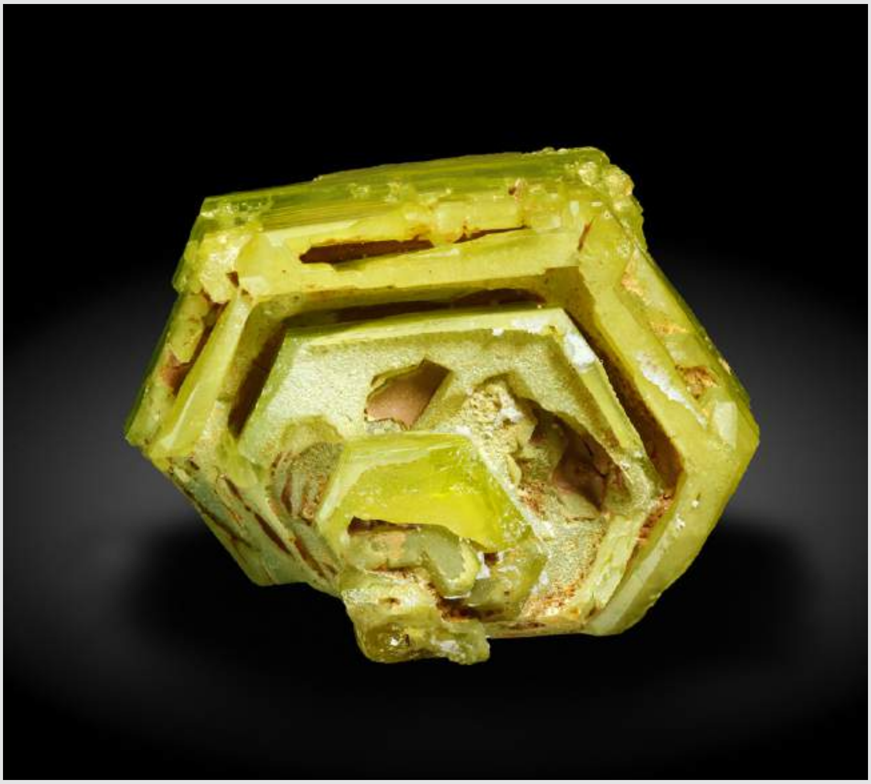
Pyromorphite crystal formed by the combination of prism {$10\bar{1}0$}, pinacoid {0001} and dipyramid {$10\bar{1}1$} and {$20\bar{2}1$}. In the specimen, on the right, the presence of a striated zone corresponding to the oscillating growth of non-determined figures is also observed. Crystal 6.5 mm high. M. Calvo coll.



Crystallographic diagram of a **pyromorphite** crystal which illustrates the crystal of the previous photograph. You can see the hexagonal prism, two pyramids of first degree with different inclinations and a pinacoid.

Cavernous termination of **pyromorphite** crystals. Crystal width 7 mm. M. Calvo coll.

Pyromorphite crystals on decomposing host rock, with abundant iron oxides. Height of the largest crystal, 9 mm. M. Calvo coll. Photos J. Callén.



However, the most interesting specimens of pyromorphite from this locality are those formed by crystals of a much larger size than those described up to now, up to 2 cm long and 1 cm thick, which appear isolated or forming groups of a few individuals, occasionally on quartz, or practically loose within a clay material in the altered selvage of the vein.
They are green, lustrous, with marked color zoning along the prism.
These crystals usually exhibit skeletal growth of different types, produced by the regrowth as individual crystals in parallel of zones of the initial crystal. This growth is most common among large pyromorphite crystals, in the relatively limited number of localities in which they have appeared.

Cavernous termination of a **pyromorphite** crystal.
Crystal width 10 mm. J. L. Sánchez coll.

Pyromorphite crystal showing color zoning and an irregular termination on which dipyramid faces can be seen. Crystal height 13 mm. J. L. Sánchez coll.

Facing page:
Group of **pyromorphite** crystals with evident color zoning. Specimen height 32 mm. J. L. Sánchez coll. Photos J. Callén.

Cesarolite as small botryoidal crusts on quartz, together with iron oxides. FOV 14 mm. M. Calvo coll.

In some cases, hexagonal cavities occur at the end of the crystals, within which smaller crystals that respect the crystallographic structure of the main crystal grow in parallel.
This is probably due to the presence of clay deposits in some areas of the crystal, limiting growth. Even more frequent are those in which growth retardation affects some sides of the crystal, causing regular cavities to develop with zones in which the faces corresponding to the dipyramids $\{10\bar{1}1\}$ and $\{20\bar{2}1\}$ are highly developed, whereas in areas of regular growth of the same crystal they are very small or do not appear at all.

Pyromorphite crystals on iron oxides, with undetermined manganese oxides. FOV 5 cm. J. L. Sánchez coll.

Pyromorphite crystals in disordered growth with a more yellowish color than usual. The main crystal size is 3 mm. M. Calvo coll. Photos J. Callén.

Cerussite crystals forming two twins, in a vug with iron oxides, which also covers some of the crystals. Main crystal is 4 mm. M. Calvo coll.

This type of irregular growth was observed by Pardillo and Gil (1916) in pyromorphite crystals from El Horcajo (Ciudad Real). The faces of the prism have a smooth central part, and quite frequently the ends striated transversally.
These striations are formed by the oscillating growth of prism faces and one or several very sharp dipyramids. Lacroix (1894) identifies one of the dipyramids that appear in crystals from New Caledonia and El Horcajo (Ciudad Real) as $\{90\bar{9}1\}$, and that is probably one of those found in Munébrega, but it has not been possible to determine it with certainty.
The presence of disseminated pyromorphite within clayey material lends weight to the assertion of Ordóñez (1851) that it was one of the minerals exploited, since in this form it was easy to recover simply by washing.

Although pyromorphite is found in greater or lesser amounts in many galena mines (several thousand) it only very rarely represents a significant proportion of the ore mined.

Other minerals
Although the only mineral that appears as spectacular specimens is the pyromorphite, other species are also found in this mine, some of them with interesting features.

Galena PbS
Galena was the most abundant primary mineral in the ore of the La Ascensión del Señor mine, although a significant proportion has been transformed into secondary minerals. Nowadays it is very difficult to find anything more than small spots of it either in the dumps or in the underground workings.

Bournonite $PbCuSbS_3$
Bournonite has been found very occasionally in the dumps of this mine in the form of masses inside barite. Apparently, most of the silver in this deposit was associated with it, possibly as inclusions of other sulfosalts.

Oxiplumboromeite $Pb_2Sb_2O_6O$
This mineral is part of the yellow earthy masses known as "bindheimite", produced by alteration of the bournonite, which are found sporadically on the dumps and in the underground workings.

Quartz SiO_2
Quartz is the main component of the mineralized vein, along with barite. The visible remains of the vein, which correspond to the contact with the selvages, have a cavernous appearance, with cavities covered with iron oxides and with hollows of geometric contours produced by the disappearance of another mineral, probably iron-rich dolomite or siderite. Within these cavities there are often small pyromorphite crystals, evidently formed in a later stage after the dissolution of the primary mineral. Small vugs also appear with colorless quartz crystals of millimeter size, which in some cases also have pyromorphite microcrystals on them.

Cesarolite $Pb(Mn^{4+})_3O_6(OH)_2$
In this mine manganese oxides are relatively common, and in some cases are found as small botryoidal formations and quite negligible crusts associated with pyromorphite crystals.
Analysis of one of these formations identified cesarolite as the main mineral present. Although it is likely that it could be found in other deposits too, forming part of the lead oxides and earthy manganese, this is the first time that it has been identified in Spain.

Calcite $CaCO_3$
Calcite is not an abundant mineral in this deposit. Its most notable feature is that at some points it appears with some frequency as crystalline white crusts over the small-sized pyromorphite crystals that have been described above.

Cerussite $PbCO_3$
Cerussite appears as crystals a few millimeters in size, colorless, transparent and lustrous, or white, usually grouped according to the typical twins of this mineral, in small vugs in the massive quartz. It also appears as crystalline masses of up to one centimeter, filling gaps in the quartz. Along with it are oxides of antimony, iron and manganese. It has not been found directly associated with pyromorphite.

Baryte $BaSO_4$
Barite was a minor component of the exploited vein, and is currently very difficult to find. The direct association with bournonite probably implies that during mining, fragments of ant significant size of this mineral were not discarded but were crushed to recover it.

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