Corderoite, Kenhsuite, and Perroudite,

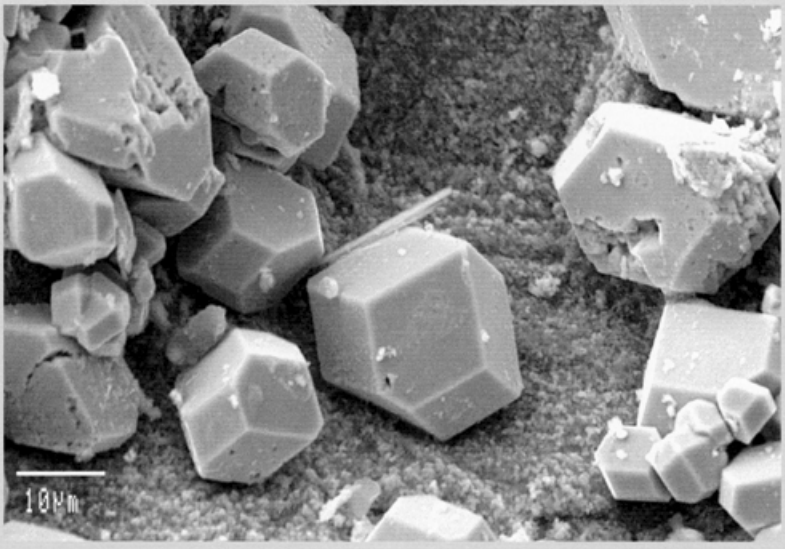
Mercury Sulphohalides from Chóvar (Xòvar), Castelló, Spain.

Joan Viñals and Miguel Calvo

INTRODUCTION

Mercury is an element whose behavior is a bit strange from a mineralogical point of view since it appears as an essential element almost exclusively in one mineral species – cinnabar – and to a much lesser extent native mercury. All other mercury minerals can be considered extremely rare.

Nevertheless mercury does at times occur as a minor constituent of minerals like the tetrahedrite-group species or sphalerite. When these minerals are altered, the usual product is almost always cinnabar, but under certain conditions other species can be formed, the ones considered rare. In this article we describe a find of three of these species in the Chóvar (Xòvar in Catalan language), Castelló, deposit: corderoite and kenhsuite in the Hembrar mines and perroudite in a mine in the Bellota ravine. All three are probably derived from alteration of "schwatzite", a mercury-bearing variety of tetrahedrite, which was the main primary mineral with mercury, and which in the mine in the Bellota ravine was also the main silver mineral. But the tetrahedrite has almost all disappeared due to supergene alteration.



Rhombododecahedrical crystals of corderoite. Photo SEM by Joan Viñals.

THE ORIENTAL MINE

The Oriental mine is one of a group of mines around the Hembrar ravine in the Espadán mountain range, municipality of Chóvar. These deposits were exploited already in the 19th century and the first half of the 20th century, although not continuously. Between 1960 and 1971, the year of their final closure, the mines were worked by the company Espadán Minero Industrial Inc.

The whole group of workings is known as the Hembrar mines, located approximately 1.5 km northeast of Chóvar, between the El Paraíso ravine, and the Ajuez and Hembrar ravines, near Alfondeguilla. The mines are accessible by way of a road that branches off the Chóvar to Eslida highway right before the bridge over the Carbón ravine, approximately 1.5 km from Chóvar, and runs about 4.5 km up to the ruins of the ovens and the mines. The most important mine is the San Francisco, which is the one that was in actual exploitation, and is situated in the course of the Hembrar ravine. The Oriental mine is situated on the east side of the ravine, its principal workings being the Diana gallery and an excavation called "El Anchurón", which is cut by the Diana. Other workings exist in the same zone too, prospect pits in which generally no cinnabar mineralization can be currently observed, although some was produced there in ancient times, albeit in small quantities. Remains of the mineral treatment plant can still be seen, and also the ovens used to roast out the mercury (Calvo, 2000).

The Chóvar deposits are hosted in the "Buntsandstein" (lower Triassic). The cinnabar appears in two forms, either forming part of the primary mineralization or, to a larger extent, as a secondary mineral produced by alteration of the tetrahedrite. Primary cinnabar has been found in the dump of the Diana gallery as microscopic idiomorphic crystals up to a maximum of 60 microns size (Tritlla, 1994), associated with mercury-bearing tetrahedrite (the variety "schwatzite") with quartz and barite in fractures that cut the sandstones. The secondary cinnabar appears in pulverulent form, accompanied by illite, stibiconite and corderoite, disseminated or encrusting the surfaces of fractures, or in fault zones, which can reach widths up to 10 meters, impregnating the country rock, which is intensely brecciated (Tritlla, 1994). In some cases small masses of pulverulent cinnabar mixed with iron oxides, stibiconite and malachite, produced by the alteration of mercury-bearing tetrahedrite, are also found inside fragments of sandstone with barite (Tritlla, 1994). Barite has also been found as fine tabular crystals with a blue color, in addition to the massive form.

Corderoite $Hg_3S_2Cl_2$

This mineral was reported by Tritlla (1994) in the Oriental mine, situated on the eastern bank of the Hembrar ravine in Chóvar, Castellón. This mine is composed of a gallery, the so-called Diana gallery, which cuts a mineralized fault, with a parallel gallery at a higher level.

In a 15 meter wide shaft known as El Anchurón ("*The Wide One*"), connected to these galleries, an important pocket of cinnabar was found. Corderoite occurs microscopically, apparently as an alteration product of the cinnabar, both the primary microscopic crystals as well as the secondary cinnabar, for which reason it has been considered a product of very late supergene alteration (Tritlla, 1994). It has even been considered locally abundant at this locality (Melgarejo & Alfonso, 1997), but only at a microscopic level in thin sections and by X-ray diffraction, without any mention of specimens with visible crystals.

In 2005, Adrián Pesudo and Juan María Bartol, two local mineral collectors, found specimens with crystals that were later identified as corderoite in a small dump belonging to the Oriental mine workings, probably from the Diana gallery. The corderoite appears as sharp crystals of rhombo-dodecahedral habit, colorless or a very pale greenish yellow, and up to one millimeter in size, which is to say easily visible to the naked eye. In other localites the most usual color is orange or reddish, but this is due to the presence of interstitial cinnabar and is not the real color of the mineral.

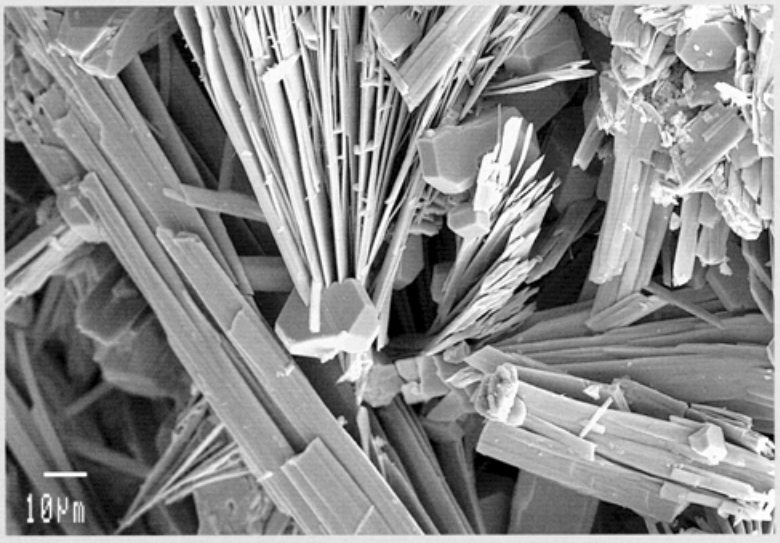
In some specimens from this dump the corderoite is associated with malachite, cinnabar and kenhsuite in a quartzose matrix.

The corderoite crystals and the kenhsuite which form part of this association are the largest found in this deposit. They occasionally exhibit a reddish color due to the presence of cinnabar inclusions.

Corderoite occurs more commonly in small vugs in an earthy matrix, as crystals of the same habit, smaller, but better formed and sometimes totally transparent, associated with cinnabar, kenhsuite and goethite, but not malachite or other copper minerals. The material on this dump probably came originally from El Anchurón at the Diana gallery, given the similarity of the rock, with its earthy iron oxides, and the proximity of the dump, although no samples of such corderoite have yet been found inside the old workings.

Corderoite is a very rare mineral, known only from a few deposits worldwide. Specimens visible to the naked eye or with a binocular scope are even more rare. According to Anthony et al. (1990) corderoite from the type locality, the Cordero mine in Nevada, occurred as grains smaller than two microns. Consequently, the corderoite crystals from Chóvar could be considered among the best in the world at the present time, for their size, their purity, and morphological quality. Crystals of similar size and habit, although only of a brown to reddish color, have been found only in Hohe Buche (Palatinate, Germany) (Weiss, 1990).

We have already mentioned that Tritlla (1994) considered the corderoite from Chóvar to be a late-stage alteration product of cinnabar. In the case of the specimens discovered recently, it seems more probable that both the corderoite and the kenhsuite formed directly by alteration of the mercury-bearing tetrahedrite in a zone that had access to solutions rich in chlorine ions. This hypothesis would be in better agreement with the absence of any significant amounts of relict cinnabar either within the corderoite crystals or the kenhsuite, as well as the large size of the crystals, much larger than the cinnabar grains.



Acicular crystals of kenhsuite with a rhombododecahedrical crystal of corderoite. SEM photo by Joan Viñals.

Both corderoite as well as kenhsuite are unstable in the light, which darkens them and liberates mercury, so specimens should be kept in the dark.

Kenhsuite γ-$Hg_3S_2Cl_2$

Kenhsuite is a mineral first described in 1998 on specimens obtained from the McDermitt mine in Nevada (McCormack & Dickson, 1998), as acicular crystals up to 10 microns in length. The Oriental mine is the second world locality for this mineral. Nevertheless, the size of the crystals found in Chóvar is far superior, with some of them reaching more than a millimeter, more than 100 times bigger than those from the type locality.

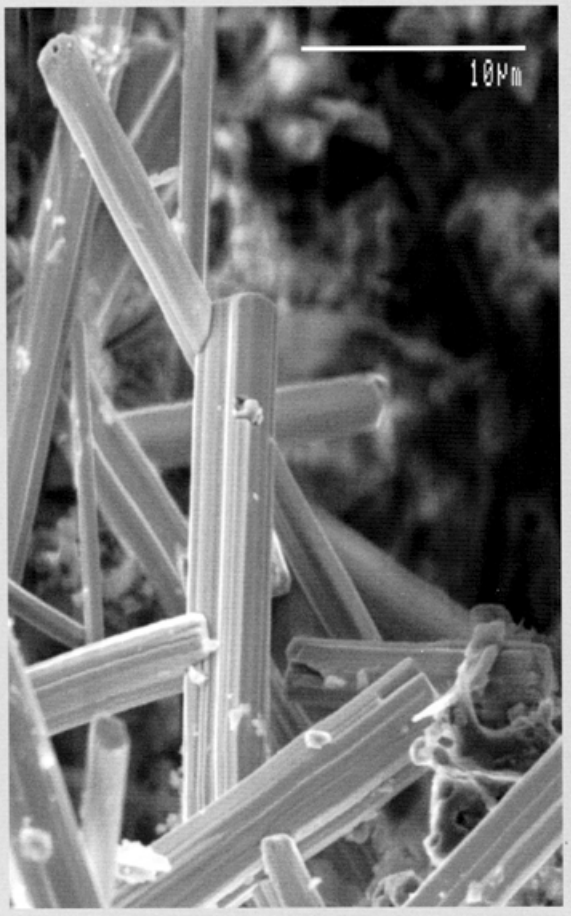
In Chóvar, the kenhsuite occurs as acicular crystals of prismatic habit, very flattened in one direction, which can reach millimeter lengths, forming groups which occasionally surpass a centimeter in size. The crystals form subparallel or divergent aggregates filling cavities left by tetrahedrite grains, although they also occur directly on the sandstone or in the iron oxides. It is often associated with microcrystals of corderoite.

According to the authors of its original description (McCormack & Dickson, 1998), kenhsuite from its type locality fluoresces red under ultraviolet light, at 366 nanometers, which could be of help in searching for it in old mine workings. The kenhsuite from Chóvar, however, does not seem to be especially fluorescent and, as mentioned previously, both ultraviolet light as well as visible light cause it to alter, for which reason it should be exposed as little as possible.

Lealtad mine

This mine is situated in the Bellota ravine, which is also in the municipality of Chóvar. Small artesanal workings have been carried out here, including a small gallery, for the purpose of recovering cobalt minerals for producing blue pigments for the local pottery industry.

It is a deposit relatively well known for the complexity of its mineralization, since, in addition to asbolane, which was the main economic mineral exploited here, there were also malachite, azurite, cinnabar, conichalcite, barium-pharmaco-siderite, metazeunerite, and other secondary copper and iron minerals, products of the alteration of tetrahedrite group minerals (Casanova & Canseco, 2002). The country rocks here are the same as described for the previous mine: very hard sandstones, almost quartzite, of the "Buntsandstein" (lower Triassic). Other minerals present in this deposit, and not yet mentioned, include perroudite, arthurite, chenevixite and cornwallite. The perroudite deserves special mention, being a sulphohalide of mercury and silver, identified on specimens obtained at this locality by Adrián Pesudo and Juan María Bartol around the year 2000. Initially it was considered to be cuprite, given its appearance and its association with copper minerals, as a consequence of which no one paid it much attention.



Acicular crystals of perroudite. SEM photo by Joan Viñals.

Perroudite $Hg_5Ag_4S_5(Cl,I,Br)_4$

Perroudite was originally described from the Cap Garonne depost in Var, France (Sharp et al., 1987), well known to mineralogists for its abundance of rare secondary species.

The origen of the Chóvar perroudite is the same as at the type locality, Cap Garonne, an alteration of a mercury-bearing tetrahedrite group mineral which also held some silver content. It is also very similar with regard to size of the crystals.

In the Lealtad mine the perroudite occurs in small vugs in the sandstone, as minute "porcupines" of an intense red color, composed of acicular crystals varying in length from a tenth to a half millimeter, longitudinally striated. The holes were formed by the destruction of the primary mineral, a somewhat arsenical tetrahedrite. In direct association with the perroudite, the only other mineral occasionally found in these vugs is arthurite, as globules up to a maximum half a millimeter in diameter.

Perroudite has been found so far in about a dozen localities worldwide, always only microscopically, although it is probable that it will eventually be found in many more. The minute size of its crystals, and its frequent association with copper minerals, make it easy to confuse at first sight with acicular cuprite (chalcotrichite). In Spain, perroudite had been found before only as minute grains in the gossan at Ríotinto.

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SEM photos by Joan Viñals.

Digital multifocus photomicrography (Helicon Focus) by J. Callén, D. Hospital and J. Rosell.

1.- Corderoite. 0.6 mm.

2.- Perroudite as divergent acicular crystals. 0.2 mm.

3.- Crystal of tetrahedrite pseudomorphosed by cinnabar, with barite. 1.2 mm.

4.- Corderoite with cinnabar and malachite. 0.8 mm.

5.- Corderoite, cinnabar and kenhsuite.

6.- Tetrahedrite pseudomorphosed by limonite with a crust of corderoite crystals. 1.1 mm.

7.- Kenhsuite. Parallel aggregate of lamellar crystals. 1 mm.

8.- Kenhsuite, with malachite and cinnabar. 1.2 mm.

Specimens 1 to 4, Adrià Pesudo collection; 5 to 8, Juan Maria Bartol collection.

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