Peña Colorada

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Mineral Deposits at the Beginning of the 21st Century

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Cover photograph: Marcasite from the MVT deposits, Pomorzany Mine, S-Poland
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New data on the origin of the Peña Colorada iron deposit (Colima, Mexico): orthomagmatic vs. skarn

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ABSTRACT: In this paper we present previous field description and petrography of the different iron ore bodies that are mined at the Peña Colorada deposit. Our new data suggests that previous interpretations on the origin of the deposit as a skarn is not correct and that a magmatic origin, like in the Cerro de Mercado iron deposit, is more plausible.

1 INTRODUCTION

In Mexico, iron ore deposits are arranged in two major belts: (1) at the NE of the country, young in age (Tertiary) like La Perla (Chihuahua; van Roy 1978), Cerro de Mercado (Durango; Lyons 1988), and Hércules (Coahuila; Velasco-Hernández 1964); (2) SW of Mexico (Corona-Esquivel 1992), probably of Mesozoic age, forming a parallel belt to the Pacific margin, comprising the deposits of Peña Colorada, El Encino, Cerro Náhuatl and Aquila. A skarn origin has been classically proposed for the latter, in close relationship with granodiorite stocks of late Cretaceous to Tertiary age.

Gonzalez-Reyna (1956) gave the first geological report on this area, describing the geology and suggesting a magmatic origin for the magnetite veins and disseminations found at the old workings of "La Chula". More recently, Zürcher (1994) studied the geochemistry of the enclosing rocks and concluded that the magnetite bodies of Peña Colorada originated after the intrusion of a Cretaceous granodiorite that caused the skarnification of the country rocks. Corona-Esquivel (2000) revised the deposit, with a thorough description of the relationship among the different ore shoots and the enclosing rocks (granodiorite, limestones, andesites and conglomerates), depicting a more complex, magmatic origin for the whole deposit. In this work we present a summary and a discussion of the origin of Peña Colorada deposits based on new field and petrological evidence.

2 GEOGRAPHICAL AND GEOLOGICAL SETTING

The Peña Colorada deposit is located in the Sierra Madre del Sur sub-province, more specifically in the Sierra del Mamey area, near the town of Minatitlán, in the NW part of the Colima State (México), 50 km to the NW from Colima city (Fig. 1). The iron bodies are hosted by the middle Cretaceous Tepalcatepec formation, that is represented in the mine by a sequence of sedimentary units (lower clays and marls unit; limestone unit) with an overlying volcaniclastic unit, both of Albian age, and an upper conglomerate formation of Cenomanian age (Corona-Esquivel 2000). The lower clay and marl unit is locally intruded in the mine area by a granodiorite and by an aplite dike complex.

Figure 1. Geographical location and general geological setting of the Peña Colorada iron deposit, state of Colima.

3 ORE DEPOSITS

Peña Colorada is the biggest active iron ore mine in Mexico, containing up to 39% of the total iron ore reserves in Mexico. At the present day, it produces approximately 3 million tons of pellets/year, which represents the 40% of the total iron demand in Mexico. The deposit is mined in an open pit, show-

Figure 2. Image of a vein-like body in the southern part of the deposit ("La Chula" area). It is partly a breccia cemented by magnetite (dark grey) with "drops" of apatite + pyroxene + magnetite, containing sharp-edged fragments of the enclosing granites and aplites.

ing a good display of the general structure and relationship among different ore bodies. We distinguished four different magnetite ore bodies (see Corona-Esquivel et al. 2000).

3.1 *Veins*

A swarm of vein-like ore bodies topographically are located at the bottom part of the mine; in the old mine workings known as "La Chula". Those veins grade from few centimeters to more than 10 meters in thickness and are placed (injected?) within fractures that crosscut the underlying granodiorite. The network of fractures is caused by an earlier intrusion of aplite dikes. It has to be noted that these ore bodies are always in sharp contact with the enclosing rock, often contain angular blocks of either aplite or granodiorite (Fig. 2), and show neither reaction borders with the blocks nor with the enclosing rock. The mineral composition of the veins is very simple. They are composed mainly (95% in volume) of thighly packed, coarse grained, euhedral to subhedral magnetite crystals up to some centimeters in diameter showing triple point grain borders and no evi-

pouches are composed by centimeter-size euhedral to subhedral zoned pyroxene crystals (hedenbergite) intergrown with yellow, centimeter-size, zoned apatite crystals. Both pyroxenes and apatites grew as skeleton crystals, resembling myrmekite textures, having a general "V" shape with euhedral faces at the end of the crystals. The apatite crystals display a strong zoning, marked by milimeter-size inclusions of magnetite crystals, lining up the different growth zones. All these features indicate that the magnetite veins where placed long after the aplite veins intruded the granodiorite and cooled down.

Figure 3. Block from the "lower disseminated body" showing cross bedding of pyroxene-rich (light) and magnetite-rich (dark) layers. Polarity from left to right.

3.2 *Lower disseminated ore body*

At a higher topographic level, a roughly tabular ore body appears in a sub-concordant position with respect to the stratification. This ore body is locally known by the miners as the "cuerpo diseminado inferior" (lower disseminated ore body), and is made up by the alternate disposition of black and green layers up to some centimetres thick, attaining a total thicknes of around 20 meters. The black layers are mainly composed by euhedral magnetite crystals, with minor euhedral pyrite and rare chalcopyrite as metallic minerals, and subhedral diopsidic augite crystals as the main silicate phase. At the green layers this ratio is reversed and augite crystals are dominant compared to the metallic minerals. In some of the layers it is possible to discern graded bedding textures, where coarse crystals of pyrite and magnetite, located at the base, grade upwards to a fine augite sand/dust with sporadical tiny crystals of magnetite. Crossed stratification textures are seldom found as well as load structures marking the polarity of those layers (Fig. 3).

blocks are composed of an aggregate of highly perthitic, strongly zoned euhedral microcline crystals, displaying an adcumulate texture. Minute magnetite crystals are found in all the K-feldspars as in-

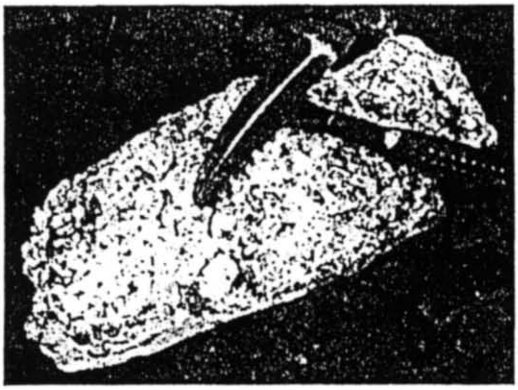


Figure 4. Accumulation of "round" zoned K-feldspar cystals from the main ore body. Notice the high proportion of open porosity.

clusions lining up the growth zones and inside the intercrystalline vugs left by the disposition of the K-feldspars. Plagioclase is only rarely found, always in an intercumulus position. The disposition of the layers suggests a sort of cyclic mechanism of formation that, coupled with the internal structures, indicates a surficial deposition and a possible ash-fall mechanism of formation, as can be seen in some present-day volcanic eruptions (F. Henriquez, comm. pers.). Those blocks with cumulate textures appear to be xenoliths extruded along with the magnetite-augite ashes during the same episodes.

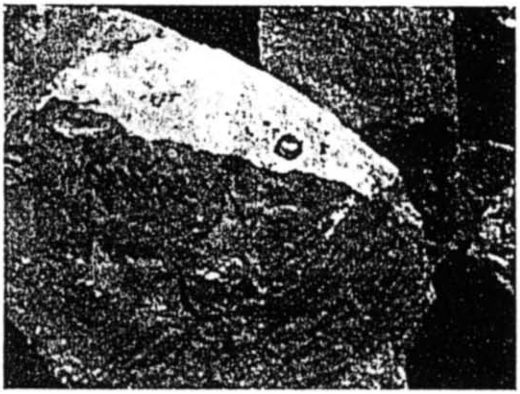
3.3 *Main ore body*

The third ore body, locally known as the "cuerpo principal" (main body), is almost exclusively formed by a tabular, sub-horizontal massive magnetite layer of around 20 meters thick and 1000 meters long. Magnetite is always found as euhedral to subhedral crystals forming 97% in volume of the body. Pyrite, chalcopyrite, augite and K-feldspar are found as accesory minerals, even though locally can be very abundant.

The top of this body is locally very vesicular, with cavities lined by euhedral magnetite crystals and late chlorite. The lower contact with the enclosing rock is sharp but, in some parts of the mine, the magnetite mass passes abruptly to a silicate-rich body with disseminated magnetite, which does not appear continously all along the mine. The green silicate layers display some kind of deformation, resize K-feldspar crystals (Fig. 4), loosely packed (porosity is 20 to 30%), only partially filled with a late generation of minute K-feldspar crystals.

At the SW part of the mine, the main body digitates laterally (Fig. 5) and vertically into three main lateral bodies that are intruded through the sedimentary joints of the limestones, acting as channelways.

Figure 5. Contact between the main ore body and the host limestones as digitations, in the SW part of the open pit. Orientation of the picture is S-N. Notice the dipping of limestones to the south contrasting with the sub-horizontal dipping of the ore body. This emphasizes the intrusive character of the ore body.



It is noteworthy that the contacts between the magnetite bodies and the limestones are intrusive, sharp and that the limestones in direct contact with the magnetite bodies are recrystallised only few centimeters in the vicinities of the contact (Fig. 6). In some cases, a chilled border of magnetite can also be observed in direct contact with the enclosing rock. Only rarely some thin reaction borders are observed, up to 10 cm thick, with the formation of grossular (skarnoid).

3.4 *Breccia*

The fourth recognized ore body is a polymictic breccia that crosscuts all the previous ore bodies, locally incorporating fragments of every kind or rocks and ores that it intrudes: granodiorite, aplites, andesite, veined, disseminated and massive ore. All those fragments are cemented by fine-grained magnetite and there is an utter lack of hydrothermal alteration at the lower parts of this breccia, while at the upper parts an intensive veining was recognised. Veins are composed mainly by magnetite and epidote. Most of the late hydrothermal phases recognized to affect the three main ore bodies can be linked with this late event. The field dimensions, structure and the abrupt contact with the other ore bodies suggests a "diatreme" origin for this breccia.

4 DISCUSSION

The Peña Colorada deposit has previously been interpreted by Zürcher (1994) as a skarn produced by the intrusion of the granodiorite into the overlying sedimentary and volcanic materials. The presence of scarce and irregular grossular-andradite garnet horizons and even scarcer wollastonite has been used as a proof of such an origin. Our new observations indicate that, even though the origin for the garnet-wollastonite could be metasomatic at a local level (skarnoid), there is no metasomatism derived from the granitoid intrusion. On the contrary, field and petrological evidences suggest that there is an important time gap between the emplacement of the granitoids and the emplacement of the magnetite veins. Therefore, there is no genetic relationship among the granitic melts and the iron ore veins and bodies. Thus, the intrusive character of the veins, the lack of hydrated minerals and the pyroxene-apatite-magnetite intergrowths indicate that their origin could be linked with the intrusion of an iron-bearing, Cl-rich magma and, moreover, that the silicate assemblages could represent the portions of the parental melt from which the iron ore magma unmixed. Probably, these veins were the feeder channels for the overlying massive iron ore bodies.

The lower disseminated ore body is puzzling. It shows a mineralogy that does not match with a metasomatic body and, moreover, their macroscopic structures (cross bedding, graded bedding, load structures) and the presence of xenoliths of shallow magmatic rocks suggest that was formed in a shallow or subaerial environment (ash-fall?). The presence of a K-feldspar-bearing adcumulate rock as xenoliths also suggests that an iron-bearing volatile-rich magma

All these characteristics make the Peña Colorada deposit similar to the magmatic deposits of Cerro de Mercado (Durango, Mexico), El Laco (Chile) and Kiruna (Sweden). The most interesting feature of Peña Colorada is the redundancy in time of different mineralizing episodes forming different orebodies with disctint characteristics, leading to an important accumulation of iron ore in a discrete place.

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