

# Gold and Iodargyrite in the Gossan of Cerro de Maimón Deposit (Central Dominican Republic)

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## INTRODUCTION.

Cerro de Maimón is a Cu-rich bimodal-mafic-dominated VMS deposit which has been mined since the end of 2008 by GlobeStar Mining through its subsidiary Corporación Minera Dominicana (CMD). Two types of ore are treated, the sulfide ore, to produce a Cu-concentrate (with Au-Ag as co-products) through a classical flotation process; and the oxide ore to recover Au-Ag doré bars by cyanide leaching and Merrill-Crowe precipitation. The current reserves are, 4.8 Mt @ 2.53% Cu, 0.96g/t Au, 34.8g/t Ag (sulfides); and 1.2 Mt @ 1.77g/t Au, 32.9g/t Ag (oxides) (2008 GlobeStar Annual Report).

This report deals with the textural and mineralogical characteristics of the oxide ore focused on the Au-Ag-bearing phases. For this objective reflected light microscopy, XRD, SEM-EDS and EMPA analysis have been utilized.

## GEOLOGICAL SETTING.

Cerro de Maimón deposit is hosted by the Maimón Formation. This formation (together with Los Ranchos Fm. and Amina Fm.) is part of an early Cretaceous bimodal volcanic arc that extends along the Greater Antilles (e.g. Lewis et al., 2000).

The sulfide lens is 1,000m long, 300m wide and 15m thick on average (Ross et al., 2007). It is located in the southern margin of the Maimón Fm., in the thrust-faulted contact with the Peralvillo Fm. The deposit and host rocks lie within the Ozama shear zone and display variable shearing and deformation to greenschist facies that has obliterated the original textures of the protolith (Lewis et al., 2000) to sericite-chlorite schist.

Maimón Fm. hosts most of the massive sulfide occurrences in the Dominican

Republic (Lewis et al., 2000) and is currently an active zone of exploration.

## CERRO MAIMÓN DEPOSIT.

The orebody can be broadly separated, from top to bottom, into: (i) the oxidized zone (or gossan) formed by the weathering and leaching of the underlying sulfides, (ii) the supergene enrichment zone, where Cu-grades increase by up to 12% (Ross et al., 2007). Sphalerite and chalcopyrite are replaced by covellite-chalcocite. This zone is 60 m thick on average, but reaches up to 120m along fractures, and (iii) the primary mineralization, where the Cu:Zn ratio trends to 1:1 at depth (Ross et al., 2007). Gold and silver are mainly hosted in tellurides.

## SAMPLES STUDIED AND ANALYTICAL TECHNIQUES.

The oxidized profile was vertically sampled in the open pit during the summer 2009. The samples collected are representative of the naked-eye textures observed (cellular, botryoidal and fine-grained aggregates).

A total of 15 polished sections out of 21 samples were prepared for study by reflected light microscopy and SEM. In addition, 6 of the samples were analyzed by EMPA at the Serveis Científicotècnics of the University of Barcelona. EMPA analyses were carried out using a CAMECA SX50 analyzer.

## MINERALOGY AND TEXTURES.

The broad mineral paragenesis of the oxide ore can be described as a goethite-hematite-silica (limonitic) assemblage bearing Au-Ag with abundant barite and quartz fragments as gangue minerals. Goethite is much more abundant than hematite. Massive fine gibbsite and goethite were identified in

some centimetric layers in the lower zone of the profile. Kaolinite occurs as clayey layers over botryoidal aggregates (in one of the upper samples) bearing some gold grains. Jarosite, and other common minerals found in oxidation profiles, such as lepidocrocite, have not been identified.

Three broad groups of textures have been distinguished under the microscope: (i) sandy-granular (cellular-boxwork), (ii) sandy-granular (brecciated), and (iii) massive (botryoidal-colloform). Granular samples are characterized by abundant porosity, up to 30%. Cellular-boxwork textures, formed in-situ, consist of a limonitic sponge hosting quartz and barite fragments of the original sulfides. Micro-breccia textures consist of silica and/or barite angular fragments cemented by oxides. Botryoidal aggregates are composed by successive layers of goethite and hematite developed over cores of gangue minerals and infilling voids. The outer rim of these colloform aggregates is always hematite probably due to dehydration (aging) from goethitic phases (Capitan et al., 2003). Moreover, some of the inner goethitic layers show elongated-acicular crystals also suggesting aging processes. A continuous spectrum exists between botryoidal and brecciated zones. Microfacies range from clast supported (cemented by colloform aggregates) where the gangue minerals dominate (barite up to 90%) to massive-colloform zones where gangue only represents nucleation cores. Other samples studied are composed of massive fine-grained goethite and gibbsite. Fine goethite and gibbsite samples are characterized by a deep yellow-mustard color and a very friable consistence. These samples are only representative of thin layers (mm-dm) in the deposit scale, but their significance is important as they were found to contain abundant gold grains (in goethite layers).

**palabras clave:** Iodargirita, Oro, Gossan, Cerro de Maimón, Clima Tropical

**key words:** Iodargyrite, Gold, Gossan, Cerro de Maimón, Tropical Climate

### Gold and Iodargyrite.

Gold and iodargyrite grains are located at different depths but are always related to botryoidal aggregates or fine goethite layers forming rich clusters whereas the remnant material seems totally sterile. Cellular and fragmented areas seem to be poor in Au and Ag. However the abundance of barite fragments within these samples makes the identification of precious metal grains extremely difficult due to their similar electronic reflectivity.

Native gold grains are rounded; their grain size ranges from 2 to 10µm. They always appear in voids between botryoidal layers or intergrowth between two successive layers (Fig. 1). Gold grains found in samples composed of a fine goethite matrix appear related to shrinkage cracks, mixed with barite grains (Fig. 2). EMP analysis for gold grains show extreme purity (99.1 at.%Au). Common impurities such as Ag, Cu and Sb appear only in trace amounts (<0.1; 0.21; 0.18 at.% respectively).

Silver occurs as iodargyrite (AgI) in very porous (or mixed with goethite) grains whose size ranges from 1 to 15µm. It is always found in voids between botryoidal aggregates adapted to the shape of the pore (Fig. 3) or as fragments mixed together with barite cemented by colloform goethite (Fig. 4). Their location and shape (inside pores) suggest a late deposition. Furthermore, fragments mixed with barite, evoke an even later remobilization. EMPA returned 45.4 at.%I and 44.7 at.%Ag. Other halides are very low (0.20 at.%Cl; 0.16 at.%Br), as well as Cu (0.21 at.%) a common element in Ag-iodine (Millstead, 1998). However, the results returned important quantities of As (5.19 at.%). Fe contents (4.12 at.%) are due to contamination of the goethite.

### DISCUSSION AND CONCLUSIONS.

Gold and iodargyrite are precipitated *in situ*. Gold purity (99.1 at.%Au) suggest that it has been chemically purified since gold in the primary ore is found as Au-Ag tellurides, and its spatial position (in voids or shrinkage cracks) also support this fact.

Gold can be transported as thiosulfates ( $\text{Au}(\text{S}_2\text{O}_3)_2^{3-}$ ), or as bisulfide complexes ( $\text{Au}(\text{HS})_2^-$ ) under acidic conditions, or even as organic or inorganic ligands

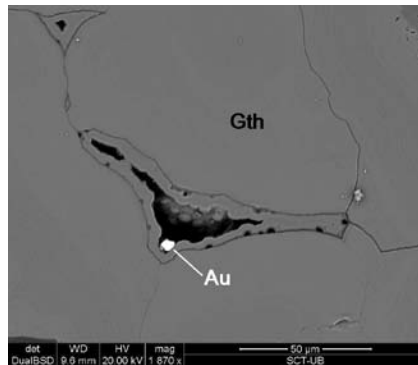


fig 1. Gold grain inside a pore among colloform goethite aggregates.

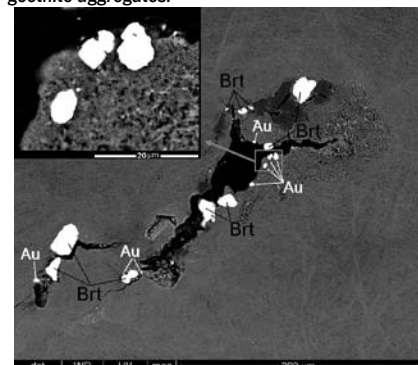


fig 2. Gold grains together with barite next to a shrinkage crack in a fine goethite groundmass.

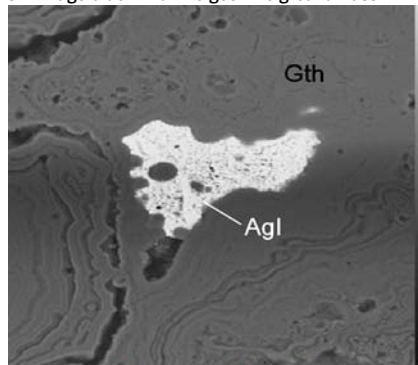


fig 3. Porous iodargyrite filling a pore among colloform goethite aggregates.

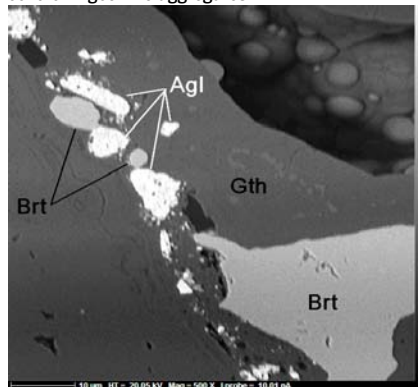


fig 4. Rim of iodargyrite and barite fragments cemented by colloform goethite.

such as  $\text{Au}(\text{OH})_3(\text{H}_2\text{O})^0$ ,  $\text{AuClOH}_7$ , or  $\text{Au}(\text{OH})_2\text{FA}_7$  (this last one involves fulvic

acid, present in tropical soils) (Colin, 1993). Experimental work (Mann, 1984) indicates that at low pH and high Eh ( $\approx 0.9\text{V}$ ) and in the presence of  $\text{Cl}^-$  ions, Au can be transported as the  $\text{AuCl}_4^-$  complex. Silver will go into solution earlier, under more reducing conditions as a chloride complex ( $\text{AgCl}^0$ ,  $\text{AgCl}_2^-$  or  $\text{AgCl}_3^{2-}$ ). Silver-halides are typically classified of indicators of arid or semi-arid climatic conditions where halides are common in the ground waters (e.g. Boyle, 1997; Reich et al., 2009).

The Caribbean zone is characterized by tropical conditions since the formation of the primitive volcanic arc to the present days. Thus, we doubt that iodargyrite could be used as a climate indicator. In this case, the source of iodine may be a marine influence on rainfall (Mann, 1984) or even oceanic water lifted up and transported by the seasonal hurricanes.

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