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Gold in the Lousal mine, Iberian Pyrite Belt, Portugal

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Abstract. Recent exploration boreholes in the Lousal Mine, located within the Portuguese sector of the Iberian Pyrite Belt (IPB) yielded marked concentrations in gold/electrum in a section of core consisting of banded metasediments with massive pyrite. Preliminary research indicates that the gold is associated with native bismuth and bismuthinite and is clearly late in the paragenetic sequence occurring in fine chalcopyrite (± covellite)-bismuthinite-gold filled veinlets within the dominant and more massive pyrite. The pale yellow gold grains are fine, seldom reaching more than 6 µm in length and half of that in thickness. EPMA results indicate that silver concentrations in gold grains can be as high as 27 wt.%. The results show similarities with conclusions drawn from the IPB on the Spanish side where gold of Co-Bi geochemical association is found as electrum with abundant to common Co and Bi minerals. These associated with pyrite and/or chalcopyrite are characterized by an abundance of sedimentary facies and show that the gold association formed at high temperature (>300 °C) during the initial phases of massive sulphide formation.

Keywords. Lousal, Iberian Pyrite Belt, gold, electrum

1 Introduction

Over the past decade the Iberian Pyrite Belt (IPB) has been an area of intense mining activity and scientific research that has resulted in a wealth of new data, new geological and metallogenic concepts and the latest discovery of a new massive sulphide copper rich deposit (Semblana, Neves Corvo) has once again revived the interest in this metallogenic belt.

The Lousal mine, is located in the Lousal-Caveira IPB NW sector, an area limited by the Sado Tertiary Basin sediments to the N, E and S (Matos and Oliveira 2003; Oliveira et al. 2005). To the SW the ore bearing IPB Volcanic Sedimentary Complex (VSC) is covered by the Baixo Alentejo Flysch sediments. Pyrite ore concentrates were produced at Lousal between 1900 and 1988. Presently the mine is in rehabilitation to acid mine drainage control (Silva et al. 2009). The Lousal massive sulphide deposit is located ~65 km NW of Neves Corvo and is a target of renewed exploration.

At Lousal a VSC sequence occur with N40W main direction. The eastern Lousal sector is characterized by the Phyllite-Quartzite Group (PQG) IPB basement unit (Strauss 1970; Schermerhorn et al. 1987; Matos and Oliveira 2003; Matos and Relvas 2006). The Lousal basement structure is dominated by a narrow anticline with a nucleus formed by the PQG sediments. The VSC volcanic and sedimentary units are present in both anticline limbs. This Complex is overthrusted in a SW direction by the PQG sediments (Rosa et al. 2010; Matos et al. in prep). In addition, Late-Hercynian N-S oriented normal faults cut the sequence with downthrown and tilting of the west block. In Lousal four separate volcanic centres could be outlined, where coarse-grained porphyritic feldspar rocks with minor associated breccias may pile up, and due to the Variscan folding and faulting can reach thicknesses of 850 m or more (Strauss and Madel 1974).

The Lousal VMS deposit is situated in the vicinity of the southernmost and northernmost, respectively, of the four acid eruption centres and the orebodies are lined up along one horizon of 1.5 km length in strike (Strauss and Madel 1974). The ore-bearing facies are predominantly fine-grained volcaniclastic units and black shales. Two massive sulfide horizons can be considered at Lousal antiform structure (Matos and Oliveira 2003; Matos et al. in prep.), the western group formed by the Extreme South, South and West lenses and the eastern group formed by the Central, Miguel, José, Fernando, North, Northeast and António lenses.VMS-type deposits of the IPB have always been known to contain other trace metals apart from the traditional base metals such as gold (Strauss and Beck 1990) and even some of the high-tech metals such as Ge (Reiser et al., in press) and In (de Oliveira et al. in press).

This study is a preliminary insight into the occurrence of gold in the Lousal mine from samples obtained from two recently drilled boreholes in 2008 by Lundin Mining.

2 Gold in Lousal

Significant gold values were detected in a recent exploration borehole (LS08/01) at approximately 730 m depth. This hole intersected a chloritic stockwork over a width of 263.9 m followed by 12.3 m (7.6 m true thickness) of semi-massive sulphide mineralization with chalcopyrite and sphalerite as accessory minerals. Gold has been found to occur mostly associated with massive pyrite (close to a quartz-rich shear zone) that is replacing metasedimentary banded black shales. In hand specimen the pyrite appears as deformed rounded to subrounded grains and coalesces in places into more massive sections (Fig. 1).

Figure 1. Hand specimen sample of gold-rich banded black shales with pyrite. Massive pyrite dominates the mineralogy at the hand specimen scale. (Borehole sample LOU08/01-7).

2.1 Petrography and paragenesis

Petrographically, samples from the Lousal Mine are rich in pyrite. This pyrite is present as homogeneous-looking masses with smaller irregular shaped grains of chalcopyrite that invades fine fractures within the pyrite (Fig. 2). Chalcopyrite occurs locally associated with native bismuth and bismuthinite.

Pale yellow gold, which may be early in the context of the whole paragenetic sequence, is observed in fine fractures within the pyrite often as grains not exceeding 6 μm in length, half of that in thickness and in close proximity to chalcopyrite and bismuthinite (Fig. 2).

The chalcopyrite is often replaced by (supergene) covellite in places.

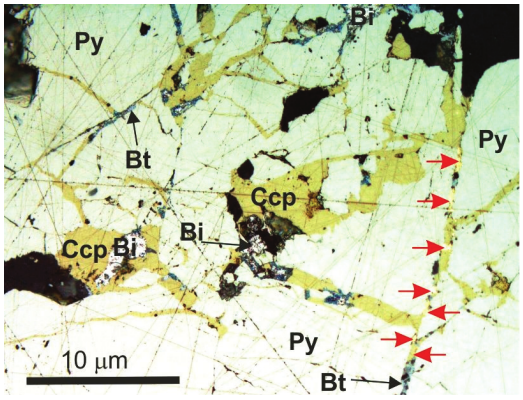

Figure 2. Photomicrograph of a sample from the Lousal Mine. Py – pyrite, Ccp – chalcopyrite (with supergene covellite, vivid blue colour), Bi – native bismuth, Bt – bismuthinite, Red arrows – gold.

Large subhedral cobaltite grains were observed as independant clusters in the metasedimentary gangue or adjacent massive pyrite grains.

2.2 Ore geochemistry

Analytical results of selected samples in borehole LS08/01 indicate elevated concentrations of not only gold but also other elements (see Table 1; 700 m – 733.5 m borehole samples), namely bismuth, arsenic and cobalt. Maximum values of 66 g/t Au (which far exceeds those reported previously in the IPB, e.g., Strauss and Beck 1990) and 11 g/t Bi were obtained in one sample.

Table 1. Analytical results for selected samples from borehole LS08/01. Sample depth in brackets; all values in ppm; number in brackets refers to the sample collection depth.

Sample #	Cu	Pb	Ni	Bi	Sn	Au	As	Co	Zn
LOU 08/01-5(700)	7850	845	99	5140	34	722	2070	1980	292
LOU 08/01-6(719,5)	6980	147	26	143	12	2200	588	502	841
LOU 08/01-7(732,4)	9380	1850	694	11400	44	66700	42800	48400	41
LOU 08/01-8(733,5)	3350	1230	477	7750	23	29400	38800	26000	189

Statistically, gold shows very high correlation coefficients with As, Co and Bi.

2.3 EPMA characterisation

Electron-probe microanalyses (EPMA) were carried out using a fully automated JEOL JXA-8500F microprobe, equipped with one energy dispersive (EDS) and five wavelength dispersive (WDS) spectrometers. 20 kV and 20 nA were used to produce an electron beam with a diameter of 1 μm (at the sample surface) to analyze the gold grains.

The preliminary analyses shown in Table 2 indicate that apart from the one sample with approximately 5 wt.% Ag, most of the gold grains have a high percentage of Ag varying from 24 to 27 wt.% which would classify it as auriferous electrum. Gold also contains significant amounts of Hg, Fe, and in two cases, Co as well.

Table 2. EPMA results of preliminary analysis of gold grains in sample LS08/01-7 (732.4 m).

Element	Sample point #			
	4	5	6	7
Co	0,05	2,86	-	-
S	-	0,63	0,31	0,51
As	-	1,27	-	-
Ag	27,49	4,86	26,13	24,14
Fe	2,67	0,25	0,43	1,41
Cu	0,24	-	-	0,02
Hg	-	2,78	8,11	8,21
Au	68,93	87,60	66,77	67,32
Total	*99,38*	*100,25*	*101,75*	*101,61*

3 Discussion

Gold grains found in Lousal contain approximately 26 wt.% Ag with Hg contents that vary from 3 to 8 wt.%.

One analysis detracts from this trend with only 5 wt.% Ag, and therefore it will have to be further determined whether at Lousal there are two distinct gold generations.

The Ag-rich gold is very similar to the results presented by Leistel et al (1998) in the Spanish side of the IPB. Here, two typical gold parageneses are found: 1- Gold of Co-Bi geochemical association found as electrum with abundant to common Co minerals such as cobaltite, alloclasite, glaucodot and common Bi minerals

such as kobellite, tintinaite, bismuthinite and joseite associated with pyrite and/or chalcopyrite and, 2- Gold of the Zn-Ag-As geochemical association occurs in electrum and/or auriferous arsenopyrite within a more polymetallic paragenesis (predominantly Pb-Zn).

In the first type, gold mineralization occurs associated with abundant sedimentary facies and shows that the gold association formed at high temperature (>300°C) during the initial phases of massive sulphide formation.

In Lousal preliminary analogies exist with the first type of paragenesis but further study is necessary to determine the existence of one or two distinct hydrothermal fluids and stages of gold mineralization and refine the paragenetic sequence. Late deformation of the massive ore represented by shear zones with silica remobilization and sulphides may also explain metal remobilization during tectonic events. Research continues.

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