Preliminary fluid inclusion study of the gold-bearing quartz-vein system of the Limarinho Deposit (northern Portugal)

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Introduction

The Limarinho deposit (northern Portugal) is located in the Variscan Iberian Massif and is a set of Au-bearing quartz-arsenopyrite veins hosted by a Variscan S-type granite. This work presents the preliminary results of a fluid inclusion study associated with the Limarinho deposit in order to characterize the fluids involved in the mineralizing process.

Geological setting

The Limarinho deposit is located in "Galicia-Trás-Os-Montes Zone" (GTMZ), one of the axial geotectonic zones of the Iberian Massif (Julivert et al., 1972; Farias et al., 1987). The GTMZ is characterized by allochthonous mafic and ultramafic complexes, surrounded by parautochthonous (Ordovician-Lower Devonian) metasedimentary sequences (Schistose Domain). The GTMZ tectonic style is dominated by the thrust regime related to nappe emplacement with two Variscan deformation stages associated with this emplacement (D1 and D2). The tectonic evolution subsequently became a predominantly wrench regime (D3 stage) characterized by folds with subvertical axial planes and subparallel shear zones.

Variscan granitoids are widespread in the GTMZ and two main groups have been distinguished: synkinematic and post-kinematic. The former are S-type two mica granites (syn-D3: 315-310 Ma) and the latter are biotite granites that were emplaced after the main phases of crustal shortening, thus being late to post-D3 (310-280 Ma) (Noronha et al., 2000, references therein).

The late Devonian - early Carboniferous compressional event described above was followed by deformation in a brittle regime during the later stage of the orogeny, and several E-W, NW and NE trending fault systems were developed. In the studied area, these structures are mainly represented by the Régua-Verín NE trending fault system (N20ºE).

The Limarinho deposit

In this deposit the mineralized structures are a system of subvertical quartz veins with a strike of N30º-40ºE dip. Most of them have a thickness of around 2 cm, although they can reach up to 20 cm. They are hosted by peraluminous muscovite-biotite granite belonging to the synkinematic Chaves Granitic Complex. This is a syn-D3 granitic massif which is located in a D3-antiform core. These quartz-vein sets occur close to the Régua-Verín fault with a trend running almost parallel to this major fault.

Arsenopyrite is the most common sulphide in the ore-bearing quartz veins, and occurs together with base-metal sulphides, native gold, electrum and sulphosalts, mostly tellurides and bismuthides.

Fluid inclusion study

The samples used for this study are apatite and quartz from the gold-bearing arsenopyrite-rich quartz veins. From petrographic, microthermometric and micro-Raman characteristics, three types of fluids were recognized: (i) aqueous-carbonic H_2O-CO_2-CH_4-N_2-NaCl; (ii) aqueous with low to medium salinity H_2O-NaCl (Lw_1, Lw_2) and (iii) aqueous with high salinity H_2O- $CaCl_2$-NaCl (Lw_3).

The aqueous-carbonic fluids have been observed in intragranular fluid inclusion planes

(FIP) and clusters containing Lc-w, Vc-w, Lc-(w), Vc-(w) and Lw-c fluid inclusion types (Boiron et al., 1992; Cathelineau et al., 1993) in quartz and apatite. All of these fluid inclusions have a degree of filling (φ_{liq}), varying from ~0 to 0.70. These fluid inclusions have a melting temperature of CO_2 ranging from –59.6 to –57.2 ºC, the lowest values were observed in apatite. CO_2 is the dominant species in the volatile phase ranging from 85.5 to 98.9 mol%. CH_4 is in the 0-6 mol% range and is not present in apatite fluid inclusions. N_2 content ranges from 0 to 14.5 mol %. Homogenization temperature of CO_2 to the liquid and vapour phase is in the range of 7 to 28.8 ºC (the highest values were observed in apatite). The melting temperature of clathrate is in the range of 3.3 to 11.5 ºC. Total homogenization temperatures, T_h(total) to the liquid phase, range from 260 to 351ºC and from 335 to 365 ºC, to the vapour phase.

The aqueous low to medium salinity fluids are represented by Lw_1 and Lw_2 fluid inclusions occurring as clusters and as fluid inclusion planes (FIP), respectively. The Lw_1 fluid inclusions show T_m(ice) ranging from –4.6 to –2.9 ºC (calculated salinity between 4.8 and 7.3 eq mass% NaCl) (Bodnar, 1993). In these fluid inclusions the total homogenization occurs in the liquid phase between 142 and 270 ºC. In the Lw_2 type the T_m(ice) ranges from -1.1 to -0.2 ºC corresponding to a salinity of 0.35 to 1.91 eq mass% NaCl. Total homogenization in these fluid inclusions occur in liquid state at temperatures between 134 and 183 ºC.

In the aqueous high salinity fluids (Lw_3), the eutectic temperature is around -70ºC and T_m(ice) ranges from -24.3 to -24.1 ºC having the highest salinity of approximately 22.4 eq mass% $CaCl_2$ (Goldstein and Reynolds, 1994). T_h(total) occurs in the liquid phase in the range from 63 to 73 ºC.

Conclusions

The preliminary fluid inclusion studies carried out on quartz from the Limarinho gold deposit reveal an evolution of aqueous-carbonic fluids probably related to the earlier sulphides, to late aqueous fluids with low to medium salinity and finally to high salinity fluids. These fluids display similar features to those found in Variscan gold mineralizations from the Iberia (Noronha et al., 2000 and references therein).

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