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Contrasting fluids on similar vein-type Pb-(Zn-Cu) deposits in Portugal

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Introduction

Fluid inclusion (FI) studies of Pb-(Zn-Cu) deposits are being carried out in 8 deposits in NE and W Portugal: 4 in the Bragança district (NE Portugal): Ferronho (F), Vale da Madre (VM), Estevais (E) and Olgas (O); and 4 in the Aveiro District (W Portugal): Moinho da Pena (P), Carvalhal (C), Palhal (PA) and Telhadela (T). The study of these deposits encompasses mineralogical, geochemical and petrographical studies together with fluid inclusions studies. We now present preliminary results of the petrographic and microthermometric FI studies and the contrasting evolution of their *T-x* paths.

Geology and Mineralogy

The studied deposits are low temperature vein type deposits, formed in late to post-Variscan fractures. In the Bragança district the veins cross Ordovician phyllites and quartzites. The deposits form a lineament parallel to the main NNE-SSW Vilariça regional fault. The deposits of the Aveiro district occur in E-W fractures related to late stages of the Variscan and early Alpine orogenesis. They occur along a NE-SW fault which is a tributary of the main NW-SE Porto-Tomar regional fault. The veins cut across gneisses and mica-schists of lower Ordovician age. On both regions the veins are not spatially related to the synorogenic Variscan granites. All the veins are brecciated and composed of several generations of the main gangue, quartz with calcite (Cc) occurring in the Aveiro district deposits Palhal (PA) and Telhadela (T). In general there are three main quartz generations: earlier massive milky quartz (QI); translucent subhedral quartz (QII) contemporaneous with main ore stages; and late quartz in clear euhedral crystals with comb texture (QIII). Different quartz generations accompany different paragenetic stages. These paragenetic stages are: stage 0 (s0; QI, pre-ore); stage 1 (s1; QI-QIIa, Fe-As); stage 2 (s2; QIIa-QIIb, Cu-Zn); stage 3 (s3; QIIb-QIIc and Cc, Pb); stage 4 (s4; QIII, late). Main sulphides are s1: arsenopyrite and pyrite; s2: sphalerite and chalcopyrite; s3: galena. Several other rarer sulphides, sulphosalts, sulphates, carbonates and oxides occur earlier and later in the paragenesis.

Fluid Inclusion Petrography

Most of the studied FI are hosted by quartz except a few cases of FI in calcite from Palhal and Telhadela mines. All studied FI are two-phase aqueous inclusions (L_w) and present frequently an oval, rectangular or negative crystal shape, with sizes ranging from 5 to 100 µm (most common 10 µm). Petrographical studies enabled us to identify different assemblages of FI: isolated, defining crystal growth zones or in intragranular planes or swarms (primary or pseudosecondary in the last case); in transgranular planes or trails (secondary) (Roedder, 1984; Van den Kerkhof & Hein, 2001). The assemblages were correlated with the host quartz generation and by this way with the paragenetic stage. Flw is constant in most cases within one assemblage, although there are some cases of variable vapour bubble size within the same assemblage.

Microthermometry Results

About 100 FI were microthermometrically analyzed in each deposit, although in some cases results for the pair ice melting temperature - T_m(ice) - and homogenization temperature - T_h - were not possible to obtain, due to decrepitation, leakage or other undesirable irreversible phenomenons. Microthermometric results are summarized in Table 1. For each deposit T_e, T_m(ice) and T_h means with standard deviation are presented according to paragenetic stage. Presence of Ca^{2+} is probable as indicated by most of T_e temperatures (Goldstein & Reynolds, 1994). Plotting a diagram (Fig. 1) of T_m(ice) versus T_h (L and V) of the inclusions allowed us to observe: 1) different fluid "paths" for each district; 2) a distinct separation between the fluids related to PbS deposition in the Bragança district and those from the Aveiro district (Fig. 2). The following bivariate plots are self explanatory.

	Stage 0 Pre-ore			Stage 1 Fe-As			Stage 2 Cu-Zn			Stage 3 Pb			Stage 4 Late		
	T e	*T* mi	*T* h	*T* e	*T* mi	*T* h	*T* e	*T* mi	*T* h	*T* e	*T* mi	*T* h	*T* e	*T* mi	*T* h
Moinho da Pena (108)				-54.3 (6.4)	-1.2 (1.5)	261.2 (57.7)	-60.1 (5.6)	-22.5 (2.1)	164.2 (28.1)	-57.5 (7.6)	-20.6 (4.6)	99.6 (8.9)	-55.7 (5.7)	-17.2 (5.4)	68 (4.4)
Carvalhal (106)				-59.4 (6.3)	-1.2 (1.6)	228.6 (50.3)	-63.7 (7.9)	-24.6 (1.6)	122.2 (30.6)	-62.9 (5.5)	-23.2 (2.6)	101.6 (11.1)	-62.2 (3.8)	-22.2 (2.7)	83.6 (13.5)
Palhal (112)	-65.7 (3.3)	-0.3 (0.2)	337.7 (18.9)	-53.5 (8.2)	-0.5 (1.1)	196.5 (34.3)	-67.1 (5.3)	-24 (2.4)	108.1 (16.1)	-59 (1)	-22 (1.6)	92.8 (2.5)	-71.3 (3.2)	-18.6 (3)	70.2 (4.8)
Telhadela (90)				-55.3 (5)	-1.8 (1.8)	255.5 (86)	-59 (4.8)	-23 (2.2)	104 (14.8)	-65.4 (4.1)	-23 (1.8)	107.3 (9.8)			
Ferronho (123)	-53.3 (3.4)	-4.9 (4.8)	325.8 (51.4)	-54.2 (4.6)	-1.1 (0.5)	226.7 (14)	-53.2 (3.4)	-6.9 (2.6)	154.4 (15)	-55.6 (6.3)	-0.9 (0.4)	156.8 (19.9)	-57.4 (3.4)	-16.1 (3.2)	103.1 (8.8)
Vale da Madre (110)	-54.3 (12)	-3.9 (3.1)	295 (53.9)	-55.6 (7.4)	-3.5 (0.4)	253 (18.3)	-55.3 (5.2)	-0.8 (0.7)	213.2 (27.4)	-56.9 (5.8)	-2.3 (1.5)	129.1 (11.1)			
Estevais (110)	-56.8 (4.6)	-10 (7.6)	335 (46.7)	-51.7 (3.6)	-8.6 (0.9)	244 (18.3)	-57.6 (6.3)	-6.8 (1.3)	147 (21.9)	-56.5 (6.8)	-0.7 (0.7)	141.4 (25.6)	-61.3 (4.4)	-15.4 (7)	93.4 (10.5)
Olgas (97)	-54.3 (6.1)	-0.4 (0.3)	264 (22.5)	-46.7 (11.2)	-4.1 (1.5)	178.1 (37.1)	-52.8 (7)	-0.3 (0.2)	177.8 (23.2)	-44.6 (9.7)	-0.2 (0.1)	119.8 (11)			

Table. 1. Microthermometric data according to paragenetic stages. Values are means with std. dev. in parenthesis; all values in ºC. Total FI analysed in each deposit in parenthesis after the name of the deposit.

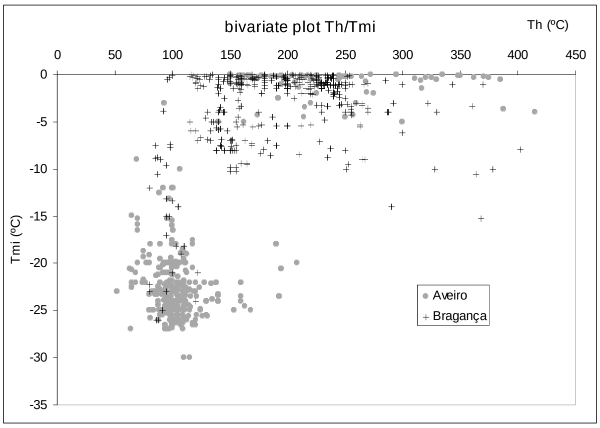

Fig. 1. T_h / T_m(ice) plot for all the FI analysed. Observe distinct paths of Aveiro vs Bragança deposits.

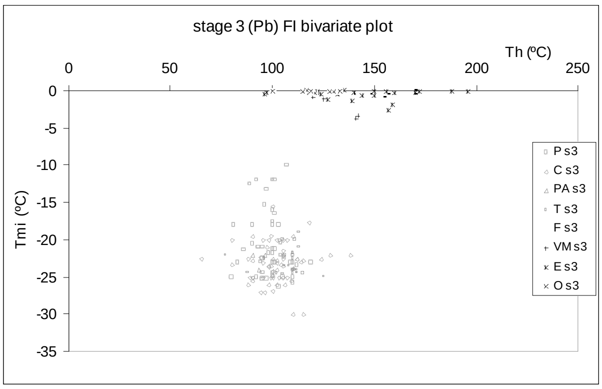

Fig. 2. T_h/ T_m(ice) plot for Pb stage FI in each deposit. Observe contrast Aveiro vs Bragança deposits.

Conclusions

The fluids responsible for the galena deposition in the Aveiro district deposits have different characteristics (temperature and salinity) from those of the Bragança district. The different "fluid paths" (T_h/T_m(ice) plot) suggest that different series of reactions were responsible for ore deposition. Boiling is evidenced in some cases by similar values of T_h (L) and T_h (V), by the dispersion of the T_h values, variable Flw and petrographical textures (Roedder, 1984; Bodnar et al., 1985). Aveiro district deposits have similar "fluid path" to other Pb-Zn deposits studied before (Marques de Sá, 2008). The "fluid path" in the Bragança district is similar to the one registered on later stages of W-Sn vein deposits in northern Portugal (Noronha, 1984). Recently obtained stable isotopes results also point out contrasting characteristics of these otherwise mineralogically and texturally very similar deposits.

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