Gold-silver mineralisations associated with the Vilarja Fault, NE Portugal

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ABSTRACT: The Vilarja structure is a late Variscan left lateral strike-slip fault which metallogenic potential remains obscure. Its Northern segment is often underlined by siliciclastic hydrothermal precipitates of variable shape and thickness, sometimes extremely enriched in iron and other metallic elements. Their development may be explained by deep fluid circulation in restricted areas, certainly related with coalescence of strike-slip fault segments. During the different stages of fault propagation, in the Franca sector some subsidiary structures of the Vilarja system are mineralized, and the gold (as electrum) occurs intimately associated with siderite, arsenopyrite, pyrite and galena. Thus the superficial late metal-enrichment of some brecciated quartz fillings in the product of sulphide and carbonate alteration, structural style, hydrothermal alteration patterns, fluid inclusion data, and the striking development of oxide fronts and breccias in other fault segments, enable the recognition of some strike-slip dilatant jogs as potential ore targets concerning Au-Ag mineralisations at depth.

1 INTRODUCTION

An expressive number of gold-silver + antimony mineralisations occur in the Centro-Iberian Zone (C.I.Z.), a fundamental unit of the Hercynian basement in Northern Portugal (fig. 1A). Most of these have been detected and exploited since (pre-I-Roman times), although only one (Minas de Jalães) is currently being worked.

Existing data relative to some Au-districts in the C.I.Z. show that different types of gold occurrences with different ages can coexist spatially. So, in detail guidance for exploration, it is important to examine the principal metallogenic types pertaining to each gold mineralisation, including structural, lithological, stratigraphical and geochronological controls.

In this work we summarise the preliminary results obtained via study of some metal-rich segments of the Vilarja strike-slip fault. They represent the first example in Portugal of gold-silver mineralisations associated to dilatant jogs of strike-slip brittle and semi-brittle fault systems.

2 REGIONAL GEOLOGY

The C.I.Z. is an important unit of the Northern branch of the Iberian Variscan Fold Belt (e.g. Rubiã, 1974; Rubiã, 1981). The autochthonous domain of this geotectonic unit is essentially composed by lower Paleozoic sediments (mostly slatey and interbedded graywackes of Ordovician age, and odovician quartzites with intercalations of slates), overlying a Precambrian gneissic basement. Generally, these rocks experienced three main episodes of Hercynian deformation and regional metamorphism of low-pressure type (chlorite - amphibole zones), and are intruded by syn- and late-orogenic granitoid bodies (fig. 1A).

The first phase of deformation (D1), of probable Upper Devonian age, is responsible for E-W folds with sub-horizontal axial planes at lower structural levels and subvertical axial planes at upper levels. The third one (D3), of Upper Carboniferous age, generated E-W upright folds in the metasediments, refolding the earlier structures. In some areas (e.g. Trás Minas), the brittle structures in odovician quartzites associated with
Fig. 1 A: Paleogeographic and tectonic Variscan units in the Iberian Peninsula. B: Synthetic geological setting of the Vilarica fault zone (northern segment) and its localization in the CIE (simplified after Kieffer, 1974). 1- Precambrian basement; 2- Pre-Variscan sediment and ultramafic rocks; 3- Upper Precambrian to Cambrian slates and graywacke complex; 4- Ordovician to Upper Devonian (?) slates, quartzites, graywackes, conglomerates, and other basement rocks; 5- a) syn-Variscan granites; b) late-Variscan granites; 6- Cenozoic cover deposits; 7- a) fault, b) Vilarica fault zone; 8- major thrust plane.
this (refolding were object of Roman exploitation: the saddle-backs consist of sulphides (pyrite + arsenopyrite) and native gold (Portuguese Ferreira, 1971). The D3 episode is also responsible for the generation of two sets of subvertical strike-slip shear zones (HNE-SWD, sinistral; and NW-SE, dextral). Spilites and biotites, which are clearly related with some gold occurrences (e.g. Rio de Silos and Penedono – Arraianes. In these cases, the mineralization consists of quartz lenses with sulphides (arenopyrite + galena, and minor pyrit) and native gold + silver.

The second impulse (D3), is a localized episode related to the emplacement of allochthonous units and thrust reactivation of D3 shear zones in some sectors of the autochthon domain (Dias, 1986; sometimes this deformation event constrained the emplacement of syn-D3 acid batholiths (Munhã et al., 1984; Ribeiro et al., in press).

In late Variscan times, the basement was strongly fractured, leading to the development of a profuse set of strike-slip faults (HNE-SWD, sinistral; NW-SE, dextral, in which the Vilarica system is one of the main sinistral structures (Ribeiro, 1974; Archaud and Matte, 1974, 1985). The geometry of these faults is locally constrained by D3 shear zones, namely the dextral ones, and other pre-existing structural anisotropies. Their reactivation during the post-tectonic stages times, with different tectonic styles, is well supported by gold evidence and structural-geological instrumental seismicity (Ribeiro, 1984; Vilarica, 1985; Cabral, 1985, 1986, 1989).

3 STRUCTURAL AND GEOLOGICAL CONTEXT OF MINERALIZATIONS

3.1 The Vilarica Fault

The Vilarica structure is a left-lateral strike-slip fault generated at the end of the late North-South Variscan Orogeny (Upper Westphalian – Stephanian), with a complex reactivation during its propagation (Stephanian – Early Persian) and reactivation episodes in Neogene and Quaternary times (Ribeiro, 1974; Cabral, 1985; Mateus and Barriga, in prep.). The fault zone is nearly 250 km long, HNE-SWD, affected all the structures of the sedimentary basin in Castelo Branco and Guincho – Trás-os-Montes Sub-zone (fig. 18). The displacement of some geological references reaches a maximum of 8 km in the Northern segment, namely in the Monchique area (the nucleation sector of the Vilarica fault; Ribeiro et al., 1983/85, 1985; Vilarica, 1985).

Fracturing and hydrothermal circulation along the Vilarica fault produced a great variety of fault rocks and quartz veins, which are being object of detailed studies in some selected areas (see Mateus, 1985). The siliceous fillings, particularly expressive in the Northern segment of the fault in Trás-os-Montes, show variable shape and thickness. Nevertheless, their development suggests extensive circulation of hydrothermal fluids in restricted areas, certainly related with coexistence of an echelon strike-slip fault segments during the successive episodes of fault propagation. In some domains, the quartz fillings are strongly brecciated and enriched in iron and other metallic elements. The striking development of oxide crusts and red breccias (hematite-enriched), besides their chemical signature, suggests the presence of primary gold-silver-sulphide-carbonate mineralizations at depth (Mateus and Barriga, 1990; this study).

3.2 The Franca gold deposit

In the Franca area (N of Bragança), the Vilarica fault is divided into various branches striking E-W to E-W (fig. 2). This is a typical phenomenon at brittle shear transitions (Patach, 1970; Wilcox et al., 1973; Sylvester, 1961). These branches cut all the Upper Ordovician sequence (quartzites interbedded with black shingles), and are generally undeformed by abundant fault gouge. Quartz fillings with chloroblastic or phyllicite are also present; usually they are brecciated and exhibit predominant metasomatic alteration in hematite + goethite. Near the fault planes, the alteration is accompanied by quartz + tourmaline + epidote, parallel to the fault plane, while quartz + sericite + muscovite at the fault is strongly developed. North of the fault and to the west, the siliceous fillings are partially altered to more clay minerals and carbonate minerals. In the South, the fault is strongly developed at the base of the Ordovician sequence. The solutions of pyrite and arsenopyrite were strongly transported by the fault, and are present in the hanging wall of the fault. The alteration and mineralization are strongly developed in the hanging wall of the fault, and are present in the hanging wall of the fault.
Fig. 2. Geological map of the França sector. 1- Slate with thin iron lenses and carbonaceous horizons (Lendéllian); 2- Quartzites interbedded with (black) schists (Aremigian/Lanzirian?); 3- "Bala" cover deposits; 4- Fault zone underlined by brecciated, iron-enriched quartz fillings; 5- Regional foliation S; 6- Mining works.
subsidiary structures of the Vilarica system (W15-30W, subvertical) are part of the Francia lode deposit. These irregular veins show discontinuous development, and are often cut by late subvertical fracture arrays trending NS0-40E. Sometimes accompanied by another system (NS0-30W, 35-65E) Gold (as electrum) occurs associated with arsenopyrite, pyrite, and galena. Quartz and carbonates (mostly siderite) are the main non-metallic minerals in the mineralised veins. The wall rock alteration is given by the association of quartz + carbonate + high Fe-chlorite + sericite + pyrite, which is consistent with the circulation of reduced and slightly acidic fluids at temperatures and pressures lower than 300 °C and 2 kbars, respectively. This mineral paragenesis is often replaced by low-temperature assemblages (< 200 °C).

Gold mineralisation is sometimes found in fault gouge zones and red breccias clearly related to the Vilarica system. However, in the Franga area, the Vilarica fault system intersects a nearly gneissose 1970-90W, subvertical) auriferous sinistral shear zone (0, ε0, δ 0, η0). In this main structure the mineralisation occurs generally along the footwall of thin and irregular quartz veins oriented NS0-100E, 40-90W. These veins usually exhibit "an eche-lon" disposition and sometimes there is evidence of horizontal left displacements.

As a consequence it is difficult to trace a genetic relationship of the Franga gold-silver mineralisation with basic fault activity related to the Vilarica system. This can only be accomplished through the study of other Vilarica fault segments, away from a larger area where available data, pertaining to Tras-os-Montes segments of the Vilarica fault where hydrothermal activity was detected, enabled selection of Quintela de Lavaqueira area (Mucedo de Cavaileiros) as the best sector for study.

3.3 The Quintela de Lavaqueira segment

Geological mapping of the Quintela de Lavaqueira area show that the fault zone has an anomalously direction (N060W) plane, and brings to contact the para-autochthonous formations (quartz-pelites with thin intercalations of massive) with allochthonous units (essentially greenishwite and adularia) - fig. 3. The fault zone is here underlined by expressive quartz fillings (mainly 2 km long and 0.5 to 2 km thick), which experienced strong brecciation and spectacular enrichment in iron and other metallic elements. The chemical signature of these breccias and quartz suggests that they can be interpreted as a surface expression of deep gold-silver-sulphide-carbonate mineralisation (Mateus and Marreiros, 1995). The silicicastic mass comprises different quartz generations, and the typical microstructures exhibited by the main generations are typical of semi-brittle and brittle deformation regimes. The earlier quartz generations are characterized by temporal cyclicity and spatial coexistence of brittle and plastic deformation. This behaviour is probably related to tectonic stress cycling along the fault zone at temperatures between 250-300°C and pressures lower than 1.5-2 kbars (Mateus et al., in press). The subsequent quartz generations are affected by brittle structures only, attesting the action of fragile mechanisms under temperatures and pressures lower than 250°C and 1 kbar, respectively. Locally, the brittle mechanisms promote the development of quartz-calcite veins (with abundant apatitic haematite and box-works) and different kinds of breccias (Mateus, 1989; Mateus et al., 1993).

The hydrothermal alteration experiment, evidenced by the wall rocks, is very extensive and the earlier association quartz + sericite + chlorite + albite + epidote + calcite reflects the circulation of reduced and acidic fluids, CO2 and H2O enriched, at temperatures and pressures lower than 300°C and 2 kbars, respectively (Mateus, 1989; Mateus and Queiraga, in prep.). These results are consistent with some pegmatite signature given by the 18O/16O contrast in the earlier quartz generations (Mateus et al., in prep.). Moreover, preliminary results on primary fluid inclusions in quartz of this stage (Verrina et al., 1987), show that deep homogenisation temperatures ranging from 164 to 273°C, low salinities (near 2-5 eq wt. % NaCl), and a submicron fraction of CO2 around 10-20% at room temperature. Subsequent alteration parageneses are restricted to the domains of high permeability, and the stable association of quartz + adularia + verticulur
chlorite + hematite + high Fe-sericite supports the circulation of oxidising and slightly alkaline fluids at temperatures between 210 ± 20°C and 150 ± 5°C and pressures around 1 kbar. These conditions are characteristic of hydrothermal solutions with average values of δ18O (≈ 3.1±0.2) and high a(S²)/aq(Fe²⁺) ratios (≈ 10³). This mineral assemblage is usually replaced by illite/smectite + goethite + quartz, suggesting the action of oxidising and near alkaline fluids under temperatures and pressures lower than 150°C and 1 kbar, respectively. In this context, the deposition of new oxides, namely hematite and pyrolusite, within the quartz fillings is compatible with primary sulphides and carbonates alteration in an environment characterised by average values of δ18O and δD around 1 and -1.3, respectively (metates and barriera, in prep.)

4. Concluding statement

The similarities between the alteration patterns and the chemical signatures of crusts/breccias from the França lode gold deposit and Quintela de Lampacas quartz fillings, suggest that the hydrothermal system associated to the Vilarinho Fault was productive in gold and silver. The structural control of mineralisation is related with the development of dilatant, joint and subsidiary structures generated in tensile and brittle deformation re-
gime, during Vilarica strike-slip fault propagation. However, not all the seismic precipitates were metal enriched. The study of the geochemical constraints imposed by host lithologies, as well as the analysis of the physical-chemical conditions for gold-silver deposition in this hydrothermal system and subsequent probable reworking, are major issues for further work.

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