TOPAZ BEARING TOURMALINITES AND TOPAZITE VEINS FROM QUEIRIGA OLD MINES – VISEU – CENTRAL PORTUGAL

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INTRODUCTION

In Queiriga old mines (Satão, Viseu) occur several lithologies with high modal content of topaz: topazite veins and tourmaline rich metamorphic rocks with topaz, andalusite and arsenopyrite porphyroblasts. These facies with tourmaline are included in the Silurian metasedimentary formations with predominant andalusite schists (Dias et al. 2006). The venular set includes Sn-W mineralization (cassiterite - wolframite).

Topazite is used to refer venular rocks with high quartz and topaz contents (Kortemeier et al., 1988). The internal structure is very similar to the more typical granitic pegmatites. According to Kortemeier et al. (1988) these lithologies result from F culminating fractionation of hyperaluminous magmas or relate to disequilibrium pegmatitic fractionation (fluoride immiscibility / silicate liquid / liquid conditions are not reached for normal F granite content -- Dolejs et al., 2007).

In the region of Queiriga tourmalinites show a consistent disposition with the structures of contiguous metasediments. The metasomatism induced by late to sin D3 granitoids (specifically tourmalinization) doesn't consistently explain the genesis of these rocks. Its porphyroblasts include topaz ± (arsenopyrite>> pyrite> pirrotite) and the tourmaline matrix content has fabric previous to granites installation. The modes of topaz occurrence in the various lithologic supports are given in Table 1. There are three main types of facies with metalliferous specializations and multiphase mineralization of Ti, Nb, Ta, TR, Sn, W, Bi, Au, and Ag.

Modes of topaz occurrence	Associated tipo-morfic minerals	Mineralizatios	Coexistent tourmaline properties
Tourmalinite with porphyroblastic topaz and arsenopyrite. Quartz crack-seal with fibrous tourmaline	Arsenopyrite. Apatite, rutile, muscovite, tourmaline	As>>Py>Pr	Zoned tourmalines with two zones: dravitic core, schorlitic rim.
Porphyroid and volcanoclastic tourmalinite (with brecciation)	quartz fenocrysts. Potassium feldspar with high Ba. Arsenopyrite.		Zoned tourmalines with two zones: dravitic core, schorlitic rim.
Topazite with clasts (xenoliths?) of protovolcanic rock (present porphyroclastic texture)	Arsenopyrite	W-Sn, Nb-Ta	Aggregates of acicular and very thin crystals with c-axis zoning: schorl - foitite.
Vein topazite in subhorizontal fractures. Topaz with comb-structure growth.	4-91% of topaz	W-Sn, Au	Rare homogeneous crystals: schorl-foitite

Table 1 - Modes of topaz occurrence.

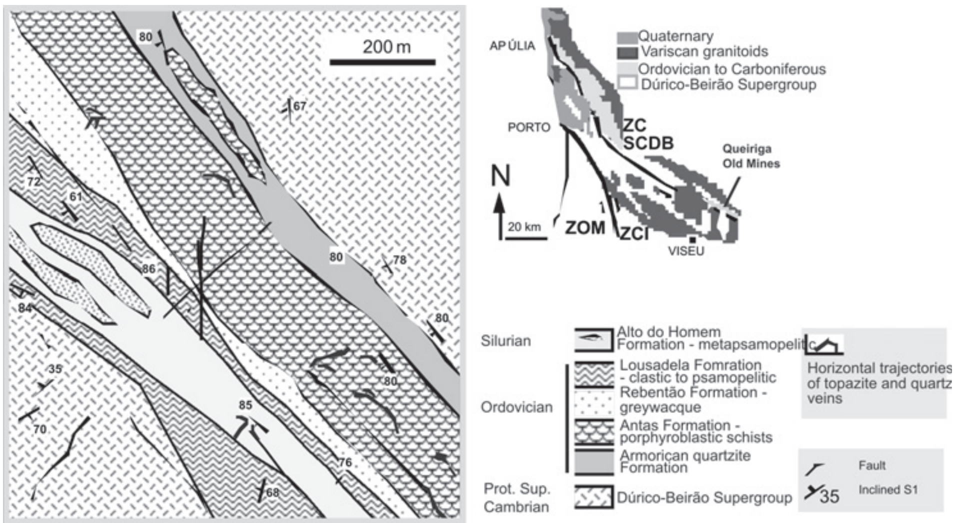

Figure 1 - Location and geological setting of the mineralized veins of topazite (Dias et al, 2006).

This study seeks to characterize the diversity of lithologies with topaz and the rare metal mineralization that is associated, and infer trends of fractionation from the composition of some tourmalines that accompanies the observed paragenetic relationships.

STRUCTURAL AND PARAGENETIC ANALYSIS OF THE TOPAZ TOURMALINITES

The tourmalinites are fine grained showing two distinct metamorphic planes (S1 and S3) marked by phyllosilicates and tourmaline. Occasionally topaz and arsenopyrite are expressed in sinkinematic porphyroblasts relative to the regional crenulation and the more penetrative foliation (S3) - intertectonic to syntectonic porphyroblasts – and present sector zoning affected by rotational deformation, muscovite strain-caps (replacement of topaz), helicoidal inclusions (of tourmaline, muscovite, apatite and rutile) and complex strain shadows and fringes formulated by rotation, crenulation, simple shear and stretching with left sense (Fig. 2) (2nd phase of local deformation = 3rd regional - Rodrigues, 1997). The porphyroid and volcanoclastic tourmalinites (with micaceous textural relics of ejects) show remnant blasts of quartz protofenocrysts. In the surroundings tourmaline is finer grained.

Compositionally they show variable contents of quartz, orthoclase (with BaO = 1.3% - volcanogenic igneous affinity?), albite and white mica. Close to the topazite venules the aspect of the porphyroid tourmalinite is sometimes breccioid.

STRUCTURE AND PARAGENESIS OF THE TOPAZITE VEINS

The topazite veins are installed in subhorizontal post-D1 fractures whose chronological relationship with D3 is not entirely clear. They are folded with bands of fibrous tourmaline (Fig.2). The thicker topazite veins (multidecimetric) show zoned internal structure (Table 2):

- Periphery: micaceous to tourmaline outer zone, showing rutile and columbite-tantalite;
- Intermediate zone: topaz> quartz, with cassiterite and wolframite;
- quartz core and late units with products of metasomatic evolution.

The internal zones are geometrically equivalent to those typical of magmatic heterogeneous pegmatites – by fractionation. The internal heterogeneous structure and the presence of comb-structured topaz crystals suggest in situ conditions of crystallization. The topaz alteration products include mica, fluorapatite, viseite and mimetite.

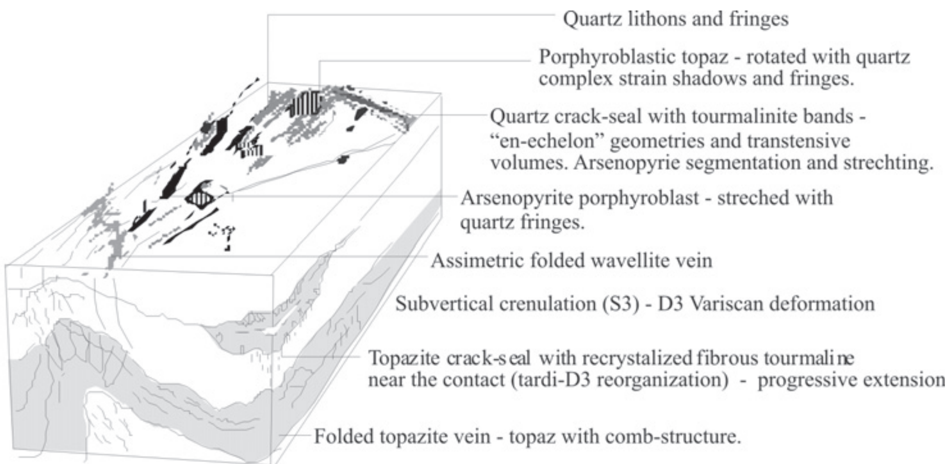

Figure 2 - Three-.dimensional representation of the intersection relationships between the different topaz bearing facies.

Unit	Mineralogical composition
Outer zone	topaz (comb-structure) >> quartz >> mica > tourmaline > cassiterite > columbite-tantalite > rutile > zircon (with Sc)
Intermediate zone	topaz > quartz > cassiterite > arsenopyrite > wolframite>native gold
Core	quartz > ferberite > mica;
Late units	chlorite/mica > sulphides (Fe, Cu) > fluorite > carbonates / phosfates

Table 2 - Internal zonality of the thicker topazite veins.

TOURMALINE GEOCHEMISTRY

In terms of the physical properties and the geochemical point of view, tourmalines present progressive zoning with two or three most marked zones developed concentrically around the c-axis. In general they are schorl-dravite-foitite type, alkaline and OH-F rich. Crystals from facies correlated with volcanogenic protoliths are essentially dravitic showing Mg enrichment and Na depletion. The chemical composition of tourmalines has most amplitude in the tourmalinites with porphyroblastic topaz. The compositional variation from core to rim shows Fe enrichment, up to schorlitic compositions located in the periphery. In the case of topazite hosted tourmalines there is no zoning.

Tourmalines intergrown with topaz have prismatic and acicular habit and include foitite terms with high Al and low F. The high Fe/ (Fe + Mg) and Al contents that occur in the range of foitite compositions suggest a magmatic contribution that is comparable to that found in granites.

PARAGENETIC ANALYSIS OF Sn-W-As-Bi-Ti-Au MINERALIZATIONS

The diversity of metal mineralization may have been caused firstly by the operation of D3 multiphase shear structures over the Dúrico - Beirão Carboniferous lineament (Fig1).

Native gold, electrum and native bismuth are hosted in wolframite, arsenopyrite and products of phylitic alteration of topaz and may result from cycles of annealing-recovery triggered by deformation / metamorphism.

Porphyroblastic arsenopyrite presents inclusions of native Bi, cervelleite (AgTeS), galena and stannite. The average As-Fe-S composition of porphyroblasts is 32.00-34.40-33.35 (atom %), suggesting high deposition temperatures.

Rutile or brookite show W enrichment in the periphery and also anomalous contents of some other constituents: $C_{r2}O_3$ = 1.74%, SnO_2 = 1.52 to 2.59%, 0.45% = Ta_2O_5, WO_3 = 0.28 to 5.76%. These trends relate to the geochemical patterns of tourmalinite metasomatism. The whole rock compositions also express Cr, Sn, Ta and W variations in some analyzed facies.

CONCLUSIONS AND PETROGENETIC IMPLICATIONS

In Queiriga old mines unusual topaz rich lithologies are the result of the metamorphic evolution, fractionation/ mineralization only partially related to residual granitic differentiation. The coexistence of tourmaline facies (possible protoporphyroid tourmalinized rhyolites) and topazites suggests a concomitant genesis or at least related for the two types of lithology.

Porphyroblastic andalusite, typical of the regional essentially pelitic formation, in the tourmaline horizons leads to porphyroblastic topaz with the same kinematic niche. The two minerals are equivalent to the same thermotectonic conditioning. Topaz and arsenopyrite porphyroblasts express the metamorphism and Variscan D1 and D3 deformation. Topaz formation in tourmalinites can happen at the expense of other aluminosilicates, by interaction with F rich fluids, as in the reaction: $(K_2Al_4(Si_6Al_2O_{20})(OH)_4$ (muscovite) + $6HF = 3Al_2(SiO_4)(OH,F)_2$ (topaz) + $3SiO_2 + 2K^+ + 4H^+$. The arsenopyrite blastesis can also be linked to alkaline F rich fluids.

Two distinguished tourmaline populations (in texture and composition) are related to two tourmalinization episodes corresponding to hydrothermal inflows (metasomatic) with distinct Fe/Mg relation.

The first tourmaline - D1 sinkinematic in tourmalinites - comes from the replacement of volcanic and sedimentary protoliths. Mg enrichment may indicate the primary affinity to rhyolites.

Subsequent tourmaline remobilization in D3, reorganizes the crystals in the outer zones of the topazites. Relations between the geochemical characteristics of tourmaline, including F, Al and Fe contents (even low F in foitite), suggest a link with magmatic evolution.

The internal zonality of topazites suggests a geometric and petrogenetic equivalence with the typical pegmatites. Topaz is in place of feldspar and expresses the existence of peculiar fractionation conditions with separation of a volatile phase rich in alkalis, when crystallization results from hyperaluminous magmatic differentiates with high fluorine content (Dolejs et al., 2007).

The subhorizontal veins of topazite probably set in the context of D3 stage under relaxation ("uplifting") conditions - the magnitude of the vertical extension component is greater than the confinement and tangential pressures in almost fragile rheological state. The existence of a hidden, subjacent granite dome could potentiate these conditions.

The set of data suggests the existence of pre-Variscan volcanism rich in F and B. The subsequent installation of a topazite vein field from pegmatitic differentiates filliated in a hidden granite reformulates the previously established geochemistry nature. The existence of abnormal topaz contents related to the development of many pegmatitic and hydrothermal systems of the region (Kelly & Rye, 1979; Neves, 1959) may indicate the digestion of host rocks of primary volcanogenic affinity, F and B rich.

Acknowledgments

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