Mineral chemistry of tourmalines from the Variscan Tormes Dome, Central Iberian Zone (Salamanca and Zamora Provinces, Spain)

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ABSTRACT

Tourmaline is a common mineral in different lithologies from the Variscan Tormes Dome (Salamanca and Zamora, Spain). Schorl is the most common phase, although Mg-rich and Li-rich tourmalines are also observed related to some lithologies. Here, a complete study on the mineral chemistry of tourmalines from this Dome is made, assessing the extent to which tourmaline chemistry reflects the bulk composition of the related rocks and discussing its geological significance.

Keywords: *tourmaline, mineral chemistry, pegmatite, leucogranite, migmatite, Variscan Tormes Dome, Spain.*

INTRODUCTION

Tourmaline is a common accessory mineral in a variety of sedimentary, igneous and metamorphic rocks, as well as in associated hydrothermal rocks. This diversity is due to the ability of the tourmaline structure to accommodate different cations in a number of non-equivalent sites. Because of its refractory character, it is considered a good petrogenetic indicator. This work describes tourmaline from different lithologies from the Variscan Tormes Dome (TD) (Salamanca and Zamora Provinces, Spain), comparing the paragenesis and chemistry of each occurrence, assessing the extent to which tourmaline chemistry reflects the bulk composition of the host-rocks, and discussing the geological significance of the tourmaline. The techniques used are electron microprobe analyses (EMPA), laser ablation (LA) and Mösbauer spectroscopy (MS).

GEOLOGICAL SETTING AND TOURMALINE OCCURRENCE

The Variscan Tormes Dome (TD) is located in the northwestern and southwestern parts of the Salamanca and Zamora Provinces respectively (Spain). This Dome is an internal orogenic area in the Iberian Massif, which is characterized by the development of high-grade plutono-metamorphic complexes of dome-like geometry (Martinez et al., 1988); and where migmatized augen gneisses are found in association with anatectic granites (López-Plaza, 1982, Martinez et al., 1988). The TD is bounded to the north and south by two major conjugate strike-slip shear zones (López-Plaza and López-Moro, 2003).

Tourmaline is a common mineral in the TD and in its surrounding areas. Tourmaline-bearing leucogranites define two external belts: the Northern Tourmaline Belt and the Southern Tourmaline Belt (López-Plaza and López-Moro, 2003). In the granitic rocks inside the TD, tourmaline is rare or absent. In the westernmost part of the Southern Tourmaline Belt, tourmaline, together with zinnwaldite, is a minor constituent of a metasomatized leucogranite, intruded by a Li-bearing pegmatite. Tourmaline also appears in some migmatitic facies related to the anatectic granites that belong to the Southern tourmaline belt, but only just as an accessory mineral. On the contrary, tourmaline is common and locally abundant in numerous pegmatites from the TD, which show different degrees of evolution, and different relationships with the granitic rocks. In addition, quartz-tourmaline veins, related with the hydrothermal activity are common in some localities of the TD. Finally, tourmaline is frequently present in the metamorphic hosting-rocks of some pegmatite units.

Representative tourmaline samples were selected from the following localities and lithologies in the TD and surrounding areas: (1) the barren to intermediate pegmatite units of the Fregeneda pegmatitic field, in the southwestern part, as well as their tourmalinized country rocks, hydrothermal veins, and metasomatized leucogranite; (2) the Valderrodrigo barren pegmatite and leucogranite, in the middle south part of the area; (3) the Cañada P-rich pegmatite, in the south-eastern part of the region; (4) the Corporario barren pegmatite, in the midle western part; (5) the Pinilla de Fermoselle (PF) highly evolved pegmatite, northeast of the TD; (6) the barren pegmatites from Almaraz de Duero and Dehesa de Fontanillas, in the northernmost part; (7) the Villaseco-Pereruela leucogranite, also in the northernmost part of the TD; and, (8) the Lumbrales migmatite, in the south-western part.

PETROGRAPHY

Tourmaline associated with pegmatites occurs as subhedral to euhedral crystals, fine to coarse grained, usually with a strong to moderate pleochroism. Typical colours are brown, bluish, greenish and greyish. It frequently represents the only ferromagnesian component in pegmatites, but in barren and intermediate pegmatites tourmaline may coexist with biotite ± garnet ± Fe-Mn phosphates. Tourmaline from the country rocks coexists with biotite. It forms very fine, prismatic-euhedral crystals, with a pleochroism ranging from green to deep blue cores and from brown to greenish yellow rims. In leucogranites tourmaline occurs as the only ferromagnesian phase, or coexists with biotite ± garnet as accessory phase. Tourmaline from granitic rocks appears as fine to medium sized, subhedral to euhedral crystals. In metasomatized leucogranitic facies, fine subhedral tourmaline, deep brown to beige, occurs generally related to zinnwaldite. In migmatites, tourmaline forms very fine subhedral crystals with a strong pleochroism, from light bluish or greenish to colourless. Tourmaline from hydrothermal quartz veins is fine to coarse, with subhedral prismatic habit and a moderate pleochroism from brownish to light yellow. In most of these lithologies tourmaline commonly shows a more or less pronounced chromatic zonation.

RESULTS AND DISCUSSION

Chemical composition of tourmaline varies depending on the lithology where it appears. Most of the analyzed tourmalines fall in the schorl field with variable amounts of Mg (Fig.1). Tourmalines from the intermediate and evolved facies of the PF pegmatite have compositions along the schorl-elbaite series. Tourmalines from the migmatites, hydrothermal veins, and some barren pegmatites mainly fall in the dravite field. The FeO/(FeO+MgO) ratio ranges from 0.54-0.95, 0.88-1, and 0.93-1 for tourmalines from the barren; intermediate, and evolved pegmatite units; respectively, which is consistent with a normal sequence of pegmatitic evolution. Tourmalines from leucogranites are characterized by ratios of 0.62-0.95, whereas those from the metasomatized granite of the Southern Tourmaline Belt have FeO/(FeO+MgO) = 0.75-0.86. Tourmalines associated with country rocks of the pegmatites from the Fregeneda field, have values ranging from 0.53 to 0.94. A relationship between the degree of evolution of the pegmatites and the tourmaline chemistry of the contact country rock was documented by Roda et al. (1995), the FeO/(FeO+MgO) ratio decreasing with the evolution degree of the pegmatites, which denotes a major influence of the bulk composition of the host-rocks in the tourmalines from the host-rock of the most evolved pegmatites. Tourmaline from hydrothermal veins shows more magnesian compositions with FeO/(FeO+MgO) ratios ranging from 0.48 to 0.74. Finally, tourmaline growing in the migmatites have the lowest values, ranging from 0.48 to 0.64.

Mösbauer spectroscopic data reveal the presence of small amounts of Fe^{3+} in some of the analysed tourmalines. The highest contents ($Fe^{3+}/\Sigma Fe \approx 11\%$) have been observed in tourmalines from barren pegmatites in the Fregeneda area, as well as in tourmalines related to the intermediate pegmatitic facies of the PF pegmatite. Lower Fe^{3+} values correspond to Li-rich schorls from the evolved facies of the same pegmatitic body ($Fe^{3+}/\Sigma Fe \approx 9\%$); whereas values of $Fe^{3+}/\Sigma Fe$ up to 4% are observed in other barren pegmatites. No Fe^{3+} is detected in the tourmalines from the hydrothermal veins, nor in some of the tourmalines from barren pegmatites. Such differences in the $Fe^{3+}/\Sigma Fe$ may be attributed to different redox conditions during tourmaline formation.

In general, trace element and REE contents are very low for the pegmatitic tourmalines. By contrast, tourmalines associated with the metasediments have higher REE values, with moderately fractionated patterns, which is interpreted to be an inheritance from the host-rocks in which these tourmalines developed.

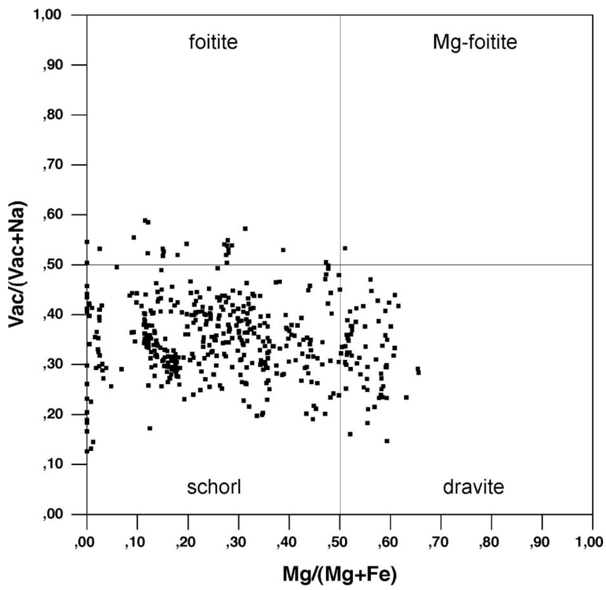

FIGURE 1. Plot of the chemical composition of the tourmaline from the TD.

Except for the Li-rich tourmalines, in which $^{Y}Fe^{2+}_{-2}{}^{Y}Al_1{}^{Y}Li_1$ and $^{X}Na_{-1}{}^{Y}Li_{-0.5}[X]^{Y}Al_{0.5}$ appear to be the main vectors to incorporate Li in the octahedral sites, the Fe-Mg-rich tourmalines show similar substitution mechanisms mainly including the vectors $[X]AlNa_{-1}R^{2+}_{-1}$ and $AlOR^{2+}_{-1}(OH)$. In addition to Al, other major substitution in these tourmalines is $Fe^{2+}Mg_{-1}$, that corresponds to the dravite-schorl solid-solution.

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