Chemistry and paragenesis of tourmaline from the Variscan Tormes Dome, Central Iberian Zone (Salamanca and Zamora Provinces, Spain): implications concerning granite and pegmatite evolution

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The Variscan Tormes Dome (TD) is located in the northwestern and southwestern parts of the Salamanca and Zamora Provinces respectively. 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, except for some anatectic granites of the middle east area, where tourmaline and garnet bearing small miarolitic cavities occur (López-Plaza and López-Moro, 2003). 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. Moreover, tourmaline is frequently present in the metamorphic hosting-rocks of some pegmatite units as a result of the B-metasomatism.

Over 60 representative tourmaline samples from these localities were selected for this study. We evaluate the chemical variation and significance of tourmalines from different localities and lithologies in the TD: (1) the barren to highly evolved pegmatite units of the Fregeneda pegmatitic field, in the southwestern part of the TD, as well as their tourmalinized country rocks, and hydrothermal veins; (2) the Valderrodrigo barren pegmatite and leucogranite, in the middle south part of the area; (3) the Cañada phosphates-bearing pegmatite, in the southeastern 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 (AD) and Dehesa de Fontanillas (DF), in the northernmost part; and, (7) the Villaseco-Pereruela leucogranite complex, also in the northernmost part of the TD. Major element analyses were performed on polished thin sections with a Cameca SX50 electron microprobe. Trace elements of a subset of tourmaline samples were analyzed using an inductively coupled plasma mass spectrometry (ICP-MS) technique.

Tourmaline associated with pegmatites is fine to coarse grained, with subhedral to euhedral habit, and it usually exhibits an strong to moderate pleochroism, being brown, bluish, greenish and greyish the most usual colors. It appears frequently as the only ferromagnesian component in pegmatites with different evolution degrees, but in some barren and intermediate pegmatites tourmaline coexists with biotite, garnet and/or Fe-Mn phosphates. Tourmaline from the country rocks coexists with biotite. It appears as very fine, prismatic-euhedral crystals, with a pleochroism ranging from green to deep blue in the cores and from brown to greenish yellow in the rims. In the leucogranites tourmaline may appear as the only ferromagnesian phase, or coexisting with biotite ± garnet. In the granitic rocks it occurs as fine to medium sized, subhedral to euhedral crystals. Tourmaline from hydrothermal quartz veins is fine to coarse, with subhedral habit, and a moderate pleochroism from brownish to light yellow. In all these lithologies tourmaline commonly shows a chromatic zonation, with a different color for the core than for the rim.

Chemical composition of tourmaline is highly influenced by the lithology where it appears. Most of the analyzed tourmalines belong to the schorl-elbaite series, with chemical compositions ranging between the two end-members. For the tourmalines associated with pegmatites, the Fe/(Fe+Mg+Mn) ratio ranges from 0.448 to 0.897 for the barren pegmatitic facies; from 0.846 to 0.986 for the intermediate pegmatites, and from 0.007 to 0.983 for the evolved pegmatite units. In the case of tourmalines associated with granites, this ratio changes in relation with the paragenesis, with the lower values in the biotite-bearing leucogranites (0.597-0.611) and the highest in the biotite-absent granites, with or without garnet (0.630-0.810). Tourmaline from hydrothermal veins shows a general tendency toward more magnesian compositions, nearer the schorl-dravite solid solution, with values for the Fe/(Fe+Mg+Mn) ratio ranging from 0.465 to 0.527. This is also the case of some tourmalines from the country rocks of the intermediate and evolved pegmatites from the Fregeneda field, with Fe/(Fe+Mg+Mn) values ranging from 0.385 to 0.729. This metasomatic tourmaline precipitated in the surrounding metapelitic rocks, and it reflects the composition of the host-rock.

Tourmaline chemistry from granitic and pegmatitic rocks clearly reflects the sequence of increasing differentiation from the leucogranites (Villaseco, Valderrodrigo and Pereruela) and barren pegmatites (pegmatites from the southern part of the Fregeneda field, lower border zone in the PF pegmatite, border zone of the Cañada pegmatite, and Valderrodrigo, AD and DF barren pegmatites) to the most evolved pegmatitic facies (upper border zone in the PF granitic pegmatite), through pegmatitic facies with intermediate degrees of evolution (intermediate zone from the PF pegmatite, inner zone of the Cañada pegmatite, and some pegmatite units from the Fregeneda field).

The chemical differences observed between tourmaline from the biotite-bearing and biotite-absent leucogranites, suggest that the former bodies are less evolved than the latter, as it is expected in a normal differentiation process. Tourmaline from the barren pegmatites of the TD shows a similar composition than that of tourmaline from the tourmaline-bearing leucogranites, whereas in the granites associated with these barren pegmatites tourmaline is absent. This could indicate that B fractionated into fluids during the evolution of the granite-pegmatite system. Tourmaline crystallized during the early stages of differentiation from these pegmatitic melts shows the same chemistry than that primary tourmaline crystallized in the leucogranites. Evolution of the pegmatite system would give rise to more evolved facies, where Li-enriched tourmalines appear. The best sample of a highly degree of evolution is the upper border zone of the PF pegmatite, were elbaite with a high rossmanite component coexists with lepidolite in the most evolved pegmatitic facies observed in the TD region.

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