A Pb-DOMINANT MEMBER OF THE TOURMALINE GROUP, MINH TIEN GRANITIC PEGMATITE, LUC YEN DISTRICT, VIETNAM

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The Minh Tien granitic pegmatite, in the Luc Yen district of Vietnam, probably of late Eocene to early Oligocene age, is emplaced in ruby-bearing marble of Cambrian age (Giuliani *et al.* 2003). It is a NYF pegmatite of anatectic origin, known for the unusual occurrence of "noble" (*i.e.*, transparent) amazonitic K-feldspar, locally rather "gemmy" and apparently unexsolved. Where the "nobility" of the material is destroyed owing to interaction with an aqueous fluid, a subsolidus assemblage of white microcline + albite develops and, as a result of the ensuing shrinkage of the primary feldspar, cracks appear. Along these microfissures, lined dominantly with albite + quartz, we have identified zoned crystals of tourmaline with anomalously high amounts of lead.

The crystals of tourmaline are tiny, from 20 to 150 μm across, locally of highly irregular outline, and characterized by a prominent compositional zonation. We document a distinct negative correlation between Fe and Pb. Such a chemical variation is also manifested optically, in plane-polarized light, by a bluish iron-rich core with up to 10 wt.% FeO and a colorless, Pb-enriched periphery; the Pb content of the outer tourmaline varies from a few weight percent to as much as 17.5 wt.% PbO (electron-miproprobe data). Representative structural formulae of the Fe-rich core and the Pb-rich rim are: $(Na_{0.79}Ca_{0.07}Pb_{0.05}\square_{0.09})_{\Sigma 1.00}$ $(Fe^{2+}_{1.51}Li_{0.85}Al_{0.57}Mn_{0.05}Ti_{0.01})_{\Sigma 2.99}$ $Al_{6.00}$ $[BO_3]_3$ $(Si_{6.06}O_{18})$ $(OH_{3.61}F_{0.39})_{\Sigma 4.00}$ and $(Pb_{0.74}Na_{0.16}Ca_{0.08}\square_{0.03})_{\Sigma 1.00}$ $(Li_{2.11}Al_{0.78}Fe^{2+}_{0.08}Mn_{0.03})_{\Sigma 3.00}$ $Al_{6.00}$ $[BO_3]_3$ $(Si_{6.14}O_{18})$ $(OH_{3.18}F_{0.82})_{\Sigma 4.00}$ (the presence of Li is confirmed, but amounts are inferred, to satisfy stoichiometric constraints). In some crystals, the distribution of Pb is distinctly patchy and irregular, and there are abundant micro-inclusions of quartz that coprecipitated with the tourmaline.

The "noble" amazonitic K-feldspar contains close to 0.7% PbO. The intrinsic greenish coloration comes from the presence of lead ions associated with a defect according to the scheme of substitution $Pb^{2+} + \square \rightarrow 2\ K^+$. The color develops as a result of ionizing radiation acting on H_2O trapped in the vacancy (Hofmeister & Rossman 1985). Upon Al–Si ordering reactions, which involve countless solution-and-redeposition steps, the Pb is progressively released to the fluid medium from the feldspar host, which becomes bleached as a result. The paragenesis is clearly a hydrothermal one, and formed in an almost "closed

system", in the sense that the zonation in the tourmaline crystallites is progressive, and the degree of Pb enrichment, extreme. The fluid responsible is likely to have involved a mixture of H_2O, issued from the crystallizing evolved silicate magma, and CO_2, emanating from the ruby-bearing marble wallrocks. The pegmatite is considered to have become contaminated with components of the host rock, namely Ca, B and Al, and presumably Li, at the pocket stage of the pegmatite, such that after the crystallization of the amazonitic K-feldspar, the assemblages becomes more typical of an LCT assemblage. For this reason, the term "hybrid" has been applied to such occurrences elsewhere.

We can report in a preliminary way the existence of a plumbian tourmaline in a similar amazonite-bearing pegmatite in the Alto Ligonha area, northern Mozambique. There, the zoned crystals attain 15.4% PbO. The Vietnamese occurrence thus is not unique; lead-rich secondary minerals can be expected adjacent to amazonitic K-feldspar undergoing "cleansing". In our future work, in preparation for a submission to the IMA Commission on New Minerals, Nomenclature and Classification, we will seek to document the light elements Li, B and H in the tourmaline, and to characterize the outer portions of the crystal by X-ray diffraction.

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