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Intra-crystal luminescence and trace element concentrations of topaz from igneous to hydrothermal systems.

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The influence of trace element concentrations on luminescence in natural topaz is not adequately described in the literature. Investigating the luminescence and geochemical characteristics of topaz could lead to a better understanding of peraluminous, P-rich, and Ca-poor igneous rocks, which are associated with rare metal ore deposits. To evaluate the intra-crystal relationship of trace element concentration, color, and luminescence, we present ultra-violet (λ ~ 225 nm) luminescence assisted LA-ICPMS, FTIR, and Mössbauer spectroscopy results for 108 alluvial topaz from Guyana, Brazil, Zimbabwe, and Mexico. FTIR spectroscopy suggests a substitution of F by OH of ~42%, likely corresponding with pegmatite to hydrothermal paragenesis. Mössbauer spectroscopy of colorless, orange, and blue topaz indicates no detectable Fe^{2+} whereas green topaz records Fe^{3+}/Fe^{2+} ~ 2.23. Our results indicate green topaz may be influenced by the relative contributions of Fe^{3+} and Fe^{2+} and form in a more reducing environment. We also demonstrate trends amongst color, growth zones, and luminescence related to the concentrations of Fe, Cr, Mn, Li, V, P, Ti, Ta, W, Nb ($\pm 1\sigma$). Orange topaz has the highest concentration of Fe (3430±64.3 ppm) followed by sherry (244±33 ppm), green (137.9±49.3 ppm), and blue (39.6±64.1 ppm). Euhedral and luminescent red, teal, and blue zones reflect different growth events. Red luminescent zones occur as a thin rim along blue and/or teal luminescent cores. Red luminescence zones have high Fe (1735.4±124.5 ppm), Cr (99.6±96 ppm), V (15.9±15 ppm), and low P (148.2±68 ppm), Li (1.5±0.7 ppm), and Ti (10.4±2.4 ppm). In contrast blue and teal luminescence zones have lower Fe (74.6±84.2 ppm), Cr (2.8±7.3 ppm), V (0.4±0.4 ppm), and higher P (326.7±239.3 ppm), Li (13±23.4 ppm), and Ti (61.1±38.4 ppm). Red luminescent zones have < 0.2 ppm Ta, W, and Nb, but blue to teal luminescent zones have higher Ta (0.7±0.9 ppm), W (0.7±0.9 ppm), and Nb (1.2±1.5 ppm). Relatively high P and Li cores and low Fe, Cr, V, rims suggest strongly differentiated host rocks altered by hydrothermal mineralization. Furthermore, enrichment of Ta, W, and Nb corresponding with alluvial topaz luminescence color may be a quick indicator of rare metal mineralization in nearby rocks.