

Oscillatory zoned liddicoatite from Anjanabonoina, Central Madagascar: characterization of trace element variation by LA-ICP-MS

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Summary

Liddicoatite, ideally $\text{Ca}(\text{Li}_2\text{Al})\text{Al}_6(\text{BO}_3)_3(\text{Si}_6\text{O}_{18})(\text{OH})_3\text{F}$, originating from the Anjanabonoina Pegmatites of Central Madagascar, are well-known for their distinct, beautiful patterns of oscillatory colour-zoning. A slab of a liddicoatite crystal, perpendicular to [001] was thoroughly investigated in Lussier *et al.* (2011) and Lussier & Hawthorne (2011). In this crystal, from core-to-edge, four regions of distinct colour occur: purple, light green, dark green and greenish-black. Smaller-scale zones occur within these regions, each marked by a sharp, colour discontinuity, weakening in intensity toward the beginning of the next zone.

The previous, extensive, multi-analytic, characterization of major element composition and crystal chemistry showed that the origin of individual zones was likely due to the operation of element-selective feedback systems between the crystal growth face and the proximal nascent fluid, as opposed to periodic changes in melt composition. A key piece of evidence leading to this conclusion being the disparate shape of continuous major-element profiles along growth faces (pyramidal, {210} and prismatic, {110}) that crystallized simultaneously.

The over-arching goal of our investigations of Madagascar liddicoatite is the development of a general model for multi-dimensional oscillatory growth in tourmaline and other minerals. Accomplishing this requires a more extensive understanding of the mechanisms governing element-selectivity as a function of the crystallographic parameters of the advancing face. Non-essential (*i.e.*, trace) elements can be sensitive indicators of such processes. A comprehensive suite of continuous trace-element profiles, collected by LA-ICP-MS on the previously investigated crystal, will be presented and discussed. By comparing trace- to major-element profiles, details pertaining to the growth process may be inferred, such as site-specific incorporation preferences. Of the 47 elements analyzed, 32 yielded detectable abundances with distinct profiles of concentration variation. For nearly all trace elements, profiles differ significantly between pyramidal {201} and prismatic {110} zones, consistent with the previous studies. Five distinct zoning profiles are recognized and interpreted, these are: (1) *zoned*, mirroring major elements (Mg^{2+} , Ti^{4+} , V^{3+} , Zn^{2+} , Nb^{5+} , Sn^{4+} , Ta^{5+} , Pb^{2+} , Bi^{3+} , Th^{4+}); (2) *flat*, no zoning evident (Cu^{2+} , Ga^3 , W^{4+}); (3) *LREE*, monotonic decrease and inverted zoning patterns (La^{3+} , Ce^{3+} , Pr^{3+} , Nd^{3+}); (4) *HREE*,

very low concentrations and insensitivity to zoning (Sm^{3+} , Eu^{2+} , Gd^{3+} , Tb^{3+} , Dy^{3+} , Ho^{3+} , Er^{3+} , Tm^{3+} , Yb^{3+} , Lu^{3+}); and (5) measurable in $\{110\}$ sector only (Sc^{3+} , Co^{2+} , Sr^{2+} , Y^{3+} , Sb^{3+}).

References: Lussier *et al.* (2011), *Can. Min.* 49 : 63-88; Lussier & Hawthorne (2011), *Can. Min.* 49 : 89-104.