

Identification of cathodoluminescence activators in zoned alkali feldspars by hyperspectral imaging and electron-probe microanalysis

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ABSTRACT

Cryptoperthitic alkali feldspars within the Proterozoic Klokken syenite have been pervasively altered deuterically to patch perthites whose constituent subgrains display very fine-scale zoning in optical cathodoluminescence (CL). Electron-probe analyses and hyperspectral maps were acquired from several areas of patch perthite to potentially identify the centers responsible for CL emission and to access information that the subgrains might provide about the late-stage geological evolution of the pluton. Each hyperspectral map is composed of tens of thousands of CL spectra covering a wavelength range of 350–850 nm, and images can be formed from any desired wavelength band. The patch perthite subgrains have two emission bands: one in the blue (~460 nm) and the other at red to infrared wavelengths (~690–725 nm). Cathodoluminescence images formed using both bands show that the optically visible zoning is developed only at blue wavelengths. Comparisons of emission intensities with electron-probe analyses show that the blue band is activated by Ti³⁺ and less than ~25 ppm of the trace element is required for optically detectable luminescence. Adjacent Ab- and Or-rich subgrains can have identical patterns of zoning at blue wavelengths, indicating that they crystallized from the deuteritic fluid simultaneously, but in most cases, differences in zoning within any one area of patch perthite indicate that subgrains grew at different times and slowly relative to the frequent changes in concentrations of Ti within the deuteritic fluid. The red to infrared CL emission band is inferred to be activated by Fe³⁺. Ab-rich feldspar with the greatest intensities of long-wavelength emission and FeO concentrations crystallized from a late-stage and relatively low-*T* fluid that obtained a proportion of its Fe from mafic grains. The generally poor correlation between variations in intensities of the two emission bands within any one subgrain indicates that concentrations of Ti and Fe in the deuteritic fluid varied independently of each other, and one trace element has no sensitizing or quenching effect on emission from the other center. The maximum length of zones within individual subgrains (~0.5 mm) and maximum separation of subgrains with similar zoning patterns (~1 mm) helps to constrain the length and interconnectivity of the thin films of deuteritic fluid that mediated alteration.

Keywords: Cathodoluminescence, feldspar, deuteritic alteration, alkali feldspar, electron microscopy, igneous petrology