

Characteristics of emission centers in alkali feldspar: A new approach by using cathodoluminescence spectral deconvolution

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ABSTRACT

Alkali feldspars in syenite from the Cerro Balmaceda pluton in the Patagonian Andes, Chile, show various petrographic microtextures formed during the magmatic to high- and low-temperature hydrothermal stages in which cathodoluminescence (CL) shows a wide range of blue, violet, and pink to red colors with variable brightness. Their CL spectra exhibit two emission bands: one at 405–420 nm in the blue region and the other at 700–760 nm in the red-infrared (IR) region. Asymmetrically shaped spectral peaks in energy units suggest overlapping of each individual emission, which corresponds to various luminescence centers. Blue emission bands were separated into two spectral peaks fitted by Gaussian curves centered at 3.055–3.076 and 2.815–2.845 eV. A positive correlation is found between emission intensities at 3.055–3.076 eV and TiO₂ contents, suggesting the activation of a Ti⁴⁺ impurity as an emission center. The intensities at 2.815–2.845 eV, where clear and featureless feldspar (CF; not affected by hydrothermal metasomatism) is shown under optical microscopy, which have intensities appreciably higher than those showing patched microperthite (PMP), formed during low-temperature hydrothermal reactions, correlate reciprocally with the intensities of red-IR emission caused by a Fe³⁺ impurity center. The peak at 2.815–2.845 eV can be attributed to oxygen defects associated with Al-O-Al and Al-O-Ti bridges. Most of the areas show CL emissions at 700–760 nm in the red-IR region, in which intensities increase with an increase in Fe₂O₃ contents as impurities. The Fe³⁺ ion acts as an activator for the red-IR emission. The Ab-rich and Or-rich phases of PMP have emission components at 1.644 eV (754 nm) and 1.727 eV (717 nm), respectively. The red-IR emission from CF consists of emission components at 1.677 eV (739 nm) and 1.557 eV (796 nm), according to an Fe³⁺ impurity center in the Or-rich phase and in the Ab-rich phase as cryptoperthite, respectively. Both components are centered at a wavelength longer than the emission band of Ab-rich and Or-rich phases of PMP, suggesting a change in configurational state around the Fe³⁺ ion from the T2 to the T1 site by low-temperature hydrothermal metasomatic reactions. Accordingly, the peak positions of the red-IR emission are controlled by the ordering state of Fe³⁺ ion into the T1 site, the existence of multiphase perthite and chemical composition.

Keywords: Cathodoluminescence, alkali feldspar, Ti⁴⁺ center, Al-O-Al center, oxygen defects associated with Al-O-Al and Al-O-Ti bridges, Fe³⁺ center, hydrothermal metasomatic reaction, cathodoluminescence spectral deconvolution