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Cathodoluminescence of cristobalite in andesite and obsidian and its application to geosciences

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The CL properties of silica minerals, especially quartz and opal, have been extensively investigated by many researchers, although only a few CL studies on cristobalite have been reported from the point of CL characterization. In this study, the CL of cristobalite in obsidian and andesite have been measured for characterization of its emission mechanisms and assignment of luminescence center.

Cristobalite in andesite from Itoh, Shizuoka, Japan and in obsidian from Thomas Range, Utah., USA were selected for CL measurements. CL spectroscopy were carried on in the range from 300 to 800 nm using a SEM-CL system, which is comprised of a secondary electron microscope (JEOL: JSM-5410) combined with a grating monochromator (OXFORD: Mono CL2). CL images were obtained with a MiniCL (Gatan) equipped with a SEM-CL

CL intensities of blue spectral peaks in both cristobalite decrease with an increase in electron irradiation time as a short-lived luminescence observed in quartz CL, whereas quartz shows a less decrease of CL intensity compared to these cristobalite. At low temperature, both cristobalite indicate rapid decay of CL emission, which is related to $[AlO_4/M^+]^0$ defect center (M; H^+, Li^+, Na^+ and K^+), although quartz shows no obvious change in its intensity on electron irradiation at low temperature.

A confocal micro-Raman spectroscopy on the electron irradiated surface of these minerals indicates that their spectral patterns with weak and broad peaks at the surface lead to the amorphization caused by electron irradiation on the surface, whereas the spectral peaks become enhanced and sharp beyond a depth of 4˜5 micron meters from the surface and exhibit almost complete crystalline feature at least at a depth of approximately 10 micro meters. Direct spectroscopic observation of such amorphization by electron irradiation was first described here. This suggests that such structural destruction diminishes the activity of CL emission centers related to the $[AlO_4/M^+]^0$ defects by migration of monovalent cations associated with exchanged Al in the tetrahedral sites.

CL imaging reveals that the cristobalite from Itoh shows a heterogeneous distribution pattern of CL intensity, which consist of oscillatory CL zoning in the rim and radial aggregate of lath-shaped crystals with bright CL in the core. Although such CL are partly corresponding to the texture observed in an optical microscope, the radial arrangement of the crystal with bright emission can be found only in CL microscopy.