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Quantitative estimation of shock pressure induced on alkali feldspar using cathodoluminescence spectroscopy

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Shock pressure induced on meteorites and impactites has been estimated by many researchers based on refractive indices of plagioclase-maskelynite to clarify a meteorite ejection process and to interpret a magnitude of impact crater. The refractive index method has been extensively used for a semiquantitative evaluation of induced shock pressure, but not available for weakly shocked materials below 15 GPa and micro-size samples. Cathodoluminescence (CL) spectroscopy provides useful information on the existence and distribution of defects and trace elements in micro-size materials. This technique is, therefore, expected to be applied to estimate shock pressure induced on the feldspar grains in meteorites and impactites shocked at various shock pressures. In this study, the CL properties of experimentally shocked sanidine have been measured to characterize their emission mechanisms and luminescent centers related to shock effect.
Single crystals of sanidine ($Or_{90}Ab_{10}$) from Eifel, Germany was selected as a starting material for shock recovery experiments at 10.0, 20.0, 31.7 and 40.1 GPa by a propellant gun. CL spectra were obtained by SEM-CL system, which is comprised of SEM (JEOL: JSM-5410) combined with a grating monochromator (OXFORD: Mono CL2). CL signals were collected by photon counting method using a PMT in the range from 300 to 800 nm. Chroma CL (Gatan) was used in this CL system to obtain a pseudocolor CL image consisting of RGB components. Operating conditions were set at 15 kV (accelerating voltage) and 1.0 nA (beam current).
Pseudocolor CL images of unshocked and experimentally shocked sanidine at 10.0 GPa show a red-violet emission with homogeneous distribution of their intensities, whereas shocked sample at 20.0 GPa consists of vein-shaped texture with blue CL on red-violet luminescence background. Shocked sanidine at 31.7 and 40.1 GPa, however, exhibit only a blue CL emission. CL spectrum of unshocked sanidine has an emission band at 430 nm in UV-blue region. Shocked sanidine above 20 GPa has UV-blue CL emissions at 380 and 330 nm of which intensities positively correlate with shock pressure. The Raman spectroscopy reveals that shock pressure causes partly breaking of the framework structure with dependence on the pressure induced on the sample, resulting in a transition from sanidine to diaplectic glass. The shocked samples above 31.7 GPa have emission bands at around 380 and 330 nm characteristic of CL signals for diaplectic glass. The deconvolution of CL spectra obtained from unshocked and shocked sanidine can successfully separate the emission bands in UV-blue region into four Gaussian components at 2.82, 2.95, 3.26 and 3.88 eV. A plot of these integral intensities versus shocked pressure indicates a good correlation between shock pressure and the Gaussian component at 2.95 eV (420 nm), which can be assigned to shock-induced defect center. This component increases with an increase in shock pressure. Therefore, the spectral deconvolution method allows us a new indicator of CL emission related to shock induced defect center for an evaluation of shock pressure in a wide range below 40 GPa for the micron-size alkali feldspar in meteorites and impactites.

Keywords: cathodoluminescence, alkali feldspar, shock pressure, shock-induced defect center