G004-P002 Time: May 27 17:00-18:30

Measurement conditions for radiation-damage halos in low-quartz using cathodoluminescence microscope and cooled CCD camera

Yoshitada Horikawa[1], Kosei Komuro[2]

[1] Geoscience, Tuskuba Univ, [2] Geoscience, Tsukuba Univ

Under cathodoluminescence (CL), halo of 30-40 µm in width is often found in quartz adjacent to radioactive minerals. The contrast between a halo and the host quartz is known to increase with age and concentration of radionuclides in the adjacent mineral. It is expected that halo can be used as a new dosimetric tool that registers ancient accumulative dose if we find accurate relationship between accumulative dose and a property of halo. But CL emission of quartz is not so strong that it is difficult to recognize faint CL halos under microscope. What is worse, CL emission in quartz changes continuously with time. Therefore, CL measurement conditions for quantitative analysis of the halos for clarifying the relationship have not been established yet.

Recently, cooled CCD camera has widely been used in the field of CL study for its capability of recording faint luminescence with shorter time of exposure, however, its application for observation of radiation-damage halo under CL has not enough been reported. In this study, the most suitable measurement conditions for quantitative CL analysis of radiation-damage halos in rock samples even of faint CL without distinct beam damage were reported on the basis of a cooled CCD camera, by investigating the relation between beam operating conditions such as bombardment area, voltage and current, and the appearance of CL halo in images. The conditions for beam irradiation time were also examined on the basis of color change with time by taking continuous images. The used CL unit was a Luminoscope® ELM-3R (cold cathode type) equipped with an Olympus BX-60 microscope with a Bitran BS-30C cooled CCD camera furnished in a darkroom. CCD images were expressed as color values in the RGB color space. Samples used were thin sections of some uranium.

The color values of a halo and the host increase with decreasing beam bombardment area under the beam 15 kV-0.8 mA. However, CL emission was seen heterogeneous if a beam bombardment area is smaller than 27 mm2, due to a structural property of the unit. The R, G, and B values of a halo increase with beam current within a beam voltage under the bombardment area of 27 mm2. Brighter CL emission of a halo was obtained within a voltage range from 12.5 to 17 kV with their maximum currents (12.5 kV-1.0 mA, 15 kV-0.8 mA, and 17.5 kV-0.7 mA). Distinct beam damage was not found in low-quartz throughout the examined conditions of 10 to 25 kV with their maximum currents, but the portion of mounting resin was damaged for a beam condition of more than 20 kV with the maximum current.

The quality of CCD image from two types of low-quartz samples (one hosts strong CL halo and the other faint), examined under 15 kV-0.8 mA and the beam bombardment area of 27 mm2, is found good enough to reveal fine CL structure even for the faint CL when an exposure time is longer than 90 seconds. Taking the upper limit of the range of CCD data into consideration, exposure time of 60 to 90 seconds is appropriate for recording CL halo in low-quartz. The CL emission of a halo is stronger in the first 3-5 minutes and decreases gradually with time whereas that of the host quartz gradually increases with time under 15 kV-0.8 mA and the beam bombardment area of 27 mm2. This indicates that the difference in CL color between a halo and the host low-quartz become smaller for longer irradiation and that the CL color contrast between the halo and the host becomes smaller.

It can be concluded that suitable and practical operating and measurement conditions in this CL unit for quantitative analysis of CL halos without any distinct damaging are: 12.5 kV-1.0 mA to 17 kV-0.5 mA, beam bombardment area of around 75 mm2, exposure time of 60-90 seconds, and imaging 3-5 minutes after the start of irradiation.

This work was partly supported by Grants-in-AID of the Japan Nuclear Cycle Development Institute (JNC) Cooperative Research Scheme on the Nuclear Fuel Cycle.