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Cathodoluminescence color profile of radiation-damage halo in quartz by CCD image analysis

Yoshitada Horikawa[1], Kosei Komuro[2]

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

Under cathodoluminescence (CL), light-colored halo is often seen in quartz adjacent to radioactive minerals in natural uranium ores. This halo is caused by radiation damage due to alpha particles because of the correspondence of its width with calculated range of alpha particle (Owen, 1988) and of experimental reproduction of the halo by He+ ion implantation (Komuro et al., 2002). The CL color of the halo is generally stronger in red component compared to that of the host quartz, considered to be attributed to recombination of electrons at non-bridging oxygen band (Götze et al., 2001). Descriptive studies for various occurrences revealed a wide variety of halos with different color structure. Owen (1988) observed quartz in contact to zircon in quartzite and found color zoning within halo. In the study of sandstone-type uranium ores, halos are reddish to light bluish, some of which have distinct color zoning of reddish at the outside and bluish at the inside (Closel et al., 1992; Komuro et al., 1995). The color profile of halo is considered related with the profile of radiation damage. In this study, some typical color profiles of some CL halos in quartz from sandstone-type uranium ores are described and discussed in relation to profiles of radiation damage intensity previously simulated by Horikawa and Komuro (1999).

The samples used are detrital quartz grains in sandstone-type uranium ores from the Kaneyamba deposit in Zimbabwe of Triassic to Jurassic in age (Komuro and Koyama, 1993; Komuro et al., 1994). Halos can be grouped into three types: (i) rim-like halos in the marginal part, (ii) halos along the fractures, and (iii) ring halos in contact with radioactive inclusion like zircon. The following three cases were examined for color profiling: (a) reddish halo of type (i) in a brownish gray quartz grain, (b) halo of type (i) with zonal color structure from bluish at the inner side to reddish at the outer side in a bluish gray quartz grain, and (c) reddish halo of type (iii) in a brownish gray quartz, from the high grade ores of 4.5 wt% U3O8. The obtained CCD image data originally denoted as the RGB space were corrected clearly visible at the same scale with keeping color balance and converted to the popular L*a*b* color space. We use the L* for the brightness and the R, G and B for color in describing color profile.

In the section of (a), the R, G and B values decrease from the surface to inside. The gradients of the L* and R are gentle near the surface, but gradually change steeper inward. The profiles of the B and G are saw-wave pattern but gradually decrease. The R prevails over the B and G throughout the profile. The difference between the R and B is larger near the surface, but gradually decreases inward. In the section of (b), the L*, R, G and B values slightly increase from surface to 18 um and decrease from 18 to 43 um. The L* and R decreases markedly from 18 to 30 um but gently from 30 to 43 um. The B prevails over the R throughout the profile, but the difference is smaller from surface to 20 um, which corresponds to reddish color part from the surface to 20 um. In the section of (c), the L*, R, G and B values gently decrease from outside to inside with some peaks. The R of bright ring under CL image between 6 and 16 um is slightly higher. This agrees with the simulation that shows the damage intensity suddenly decreases around 16.6 um, due to the ranges of 238U, 230Th and 234U (Horikawa and Komuro, 1999).

The color profiles generally show that the L* of CL in halo decreases with distance. This corresponds well with the simulated damage intensity profile by Horikawa and Komuro (1999). Analysis of color profiles together with the distribution of radionuclides is expected to provide important information on retention and/or migration of radionuclides in geologic media. Application for dosimetric works will be discussed.