Cathodoluminescence spectrum of recrystallized quartz as an indicator of the degree of mylonitization

*Yukiko Fukushima[1], Hideo Takagi[1]

1. Waseda University

Quartz has CL (Cathodoluminescence) features due to the presence of structural defects and impurities in the crystal, and its CL spectrum is a broad band spectrum with peaks mainly at 450 nm in the blue region and around 630 nm in the red region. The CPO (crystallographic preferred orientation) pattern obtained by SEM-EBSD analysis depends on the deformation temperature of mylonitization. In recent years, studies have been conducted to investigate the effect of mylonitization by separating the CL spectra for each emission component to see if the CL features of quartz can be utilized as an evaluation of the degree of mylonitization (Tano et al., 2017; Kiku et al., 2017). It was found that the blue luminescence decreased and the red luminescence increased with decreasing the grain size of mylonitization, suggesting that ion migration in the Al and Ti defect centers is responsible for the change. However, all of these studies have been performed on quartz in shear zones with complex deformation histories such as the Median Tectonic Line.
SEM-EBSD analysis showed that the average grain size decreased from the edge of the small shear zone to the center of the zone. A gradual shift of the c-axis fabric of the CPO pattern from a low-temperature type I cross-girdle to a medium-temperature type Y-maximum was recorded (Passchier and Trouw, 1996). The transition of decreasing grain size and deformation temperature with increasing shear strain from the edge to the center of the shear zone is consistent with the trend observed in general shear zones.
In the CL image of the recrystallized quartz grains, light area (high luminescence intensity) and dark area (low luminescence intensity) were observed sparsely inside the grains. Comparing with the map of grain boundary (tilting 10° or more after White, 1977) obtained by SEM-EBSD measurements, the dark area is along the grain boundary or sub-grain boundary, and the light area is in the center of the recrystallized grain or sub-grain. Non-luminescent areas observed at some grain boundaries suggest the quartz formed secondarily by dissolution-precipitation process (Shimamoto et al., 1991), so the grain boundaries were excluded for the measurements of CT spectra. The obtained CL spectra were converted from nm to eV, and then fitted with the Voigt function using the least-squares method to separate the peaks (Stevens-Kalceff, 2009). The six emission components used for separation were 1.65 eV (750 nm), 1.95 eV (635 nm), 2.2 eV (560 nm), 2.7 eV (460 nm), 2.95 eV (420 nm), and 3.3 eV (385 nm) (Götze et al., 2001; Stevens-Kalceff, 2009). We used the ratio of the maximum emission intensity in the blue region to that in the red region (R_h/B_h) to clarify the change in the relationship between blue and red emissions. R_h/B_h increases with decreasing grain size of recrystallized quartz. The luminescence of 1.95 eV is caused by NBOHC (non-bridging oxygen hole center), and is the emission component related to the Al defect center, which increases as [AlO_4/M^+] (3.3 eV) changes to [AlO_4]$^-$ +NBOHC (1.95 eV) (King et al., 2011). On the other hand, 2.95 eV, which has the lowest correlation, is divided into two groups by the area ratio. This is due to the incomplete separation of the peaks at 2.95 eV, 2.7 eV, and 2.2 eV, which are the emission components near the peak in the blue region. Among the data obtained from the CL spectral analysis, the occupancy of 1.95 eV and R_h/B_h could be used as an indicator of the degree of mylonitization.

Keywords: cathodoluminescence spectrum, mylonitization, recrystallized quartz, SEM–EBSD, SEM–CL

