Characterization of luminescent minerals in CM2 chondrite (Jbilet Winselwan)

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Cathodoluminescence (CL), the light emission induced by electron irradiation, has been widely applied in mineralogical and petrological investigations. The nature of the luminescent centers for a CL emission results from an intrinsic (lattice defects) and/or extrinsic (impurities) properties of the crystal. CL method enables observation of trace element distribution and defects in the lattice, which is quite hard to be detected with other techniques. CL has been used to characterize meteoritic minerals, especially olivine (forsterite), for the investigation of their thermal history, due to high detection sensitivities for structural defects and activator elements, with high spatial resolution. We have confirmed several luminescent minerals from the CM2 chondrite (Jbilet Winselwan) under CL examinations. Therefore, we will conduct to characterize the luminescent minerals for the identifications of the emission centers using SEM-CL and to discuss the formation of the luminescent minerals under aqueous conditions in this meteorite.

Polished thin sections were employed for CL measurements after an optical observation under a polarizing light microscope, which shows chondrules up to 500 μm and their fragments with fine-grained matrix. CL spectra and CL images were obtained employing a new system of CL-SEM, which comprises a SEM (Jeol JSM-5400) combined with an integral grating monochromator (Oxford Mono CL2) with high sensitive and high spatial resolutions over the wide wavelength range of 300 nm to 800 nm. The system was operated at 15 kV with 1 nA to 2 nA of the incident beam current in a scanning mode to prevent the surface damage of the sample by electron bombardment.

Color CL imaging confirmed three types of luminescence; red emission for forsterite, blue emission for diopside and green emission for spinel. CL spectral analysis of forsterite gives a broad band peak centered at 620-640 nm in a red region, whereas any emissions in a blue region could not be detected. According to Gucsik et al, 2013, the emission is assigned to Mn^{2+} impurity center as an activator, where Fe^{2+} ions should be absent or extremely low due to intensively quenching effect of Fe^{2+}. The luminescent forsterite contains irregular grains of FeS in the core, and is accompanied with Fe-enriched inhomogeneous olivine on the outer side of the forsterite. The facts imply that aqueous alteration might take place the reduction of Fe ions and reduction of the defects for a blue emission. Diopside with 20-80 μm size emits characteristic luminescence with three broad bands at 410 nm, 580 nm and 650-750 nm. Blue emission at 410 nm can be assigned to defect center and yellow emission at 580 nm to Mn^{2+} impurity center in Ca site. Red emission might be composed of Mn^{2+} activation in Mg site at around 580 nm and doublet emission peak at 680-750 nm derived from Cr^{3+} ions in Mg site. In this case, the defects survived during aqueous alteration. Spinel exhibits green emissions at around 530 nm and 700 nm with multiple peaks. The green luminescence at 530 nm might be assigned to Mn^{2+} activator in four-coordinated site (Al), and red one with a broad peak to Cr^{3+} activator in six-coordinated site (Mg). This mineral shows almost nonluminescence in a blue region possibly related to defect center due to aqueous alteration.