Evaluation of shock pressure for Martian meteorites using cathodoluminescence method

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Shock pressures for Martian meteorites such as shergottite and nakhlite have been estimated by CL and Raman spectral analysis.

Polished thin sections of maskelynite in Dhofar 019 ($Or_{1-4}Ab_{41-57}An_{39-58}$), Shergotty ($Or_2Ab_{54-57}An_{41-44}$) and NWA 2975 ($Or_1Ab_{49}An_{55}$) meteorites and plagioclase in Yamato 000593 ($Or_5Ab_{54}An_{41}$) meteorite were employed for CL and Raman measurements. Experimentally shocked plagioclase (Ab_{40}) at 20, 30 and 40 GPa were used as a reference sample for known shock pressure. CL measurements were carried out in the range from 300 to 800 nm using a secondary electron microscope-cathodoluminescence (SEM-CL) system, which is comprised of an SEM (JEOL:JSM-5410) combined with a grating monochromator (OXFORD:Mono CL2).

CL spectrum of plagioclase in nakhlite shows emission bands at around 400, 560 and 780 nm, which are assigned to Al-O^--Al defect center, Mn^{2+} and Fe^{3+} impurity centers, respectively. Similar emission bands are recognized in CL spectra of terrestrial plagioclase and unshocked reference sample. Experimentally shocked plagioclase at 20 and 30 GPa, however, exhibit an emission band at around 620 nm, which is related to Mn^{2+} impurity center. Shock pressure higher than 20 GPa results in the peak shift of Mn^{2+} emission to higher wavelength side. In the case of experimentally shocked samples, CL intensity of all emission bands decrease with an increase in shock pressure. CL of maskelynite in Dhofar 019, Shergotty and NWA 2975 give an emission band at 370-380 nm. The similar blue emission has been observed in plagioclase shocked at 40 GPa, whereas it has not been detected in the plagioclase in nakhlite and experimentally shocked samples at 0, 20 and 30 GPa. This emission band might be assigned to self-trapped exciton (STE) center.

The intensities of Raman peaks assigned to T-O atomic vibrations decrease for experimentally shocked samples with an increase in shock pressure. Maskelynite has no obvious Raman peaks as well as high shocked samples at 40 GPa. High shock pressure above 40 GPa induces structural breakdown in most feldspar minerals.

Shock pressure might cause a change of structural configuration in the framework, suggesting an alteration of crystal field related to emission centers. Maskelynite in all shergottite and highest shocked plagioclase at 40 GPa, however, have an emission band at 370-380 nm related to STE center. It implies that STE center acts as a luminescence center in maskelynite structure at around or above 40 GPa. The detection of this emission can be applied to an identification of maskelynite in various types of shocked meteorites.