

Cathodoluminescence characterization of the minerals in Dhofa019

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Dhofar 019 found in the desert of Oman is classified as an olivine-bearing basaltic shergottite. It consists of subhedral grain (0.2-0.5 mm) of pyroxene (pigeonite and augite), olivine and feldspar mostly converted to maskelynite and minor K-feldspar, merrillite, chromite, ilmenite and pyrrhotite, with terrestrial secondary phases. The presence of maskelynite and mosaic texture in olivine lead to a shock pressure in the range of 30-35 GPa. In this study cathodoluminescence (CL) microscopy and spectroscopy were carried out on various luminescent minerals such as maskelynite, K-feldspar and calcite to estimate their shock stage.

A cathodoluminescence scanning microscopy (SEM-CL), SEM (JEOL: JSM-5410) combined with a grating monochromator (OXFORD: Mono CL2), was used to measure CL spectra in the range from 300 to 800 nm at operating condition of accelerating voltage of 15 kV and beam current of 1.0 nA. CL color images were obtained with Luminoscope (ELM-3R) at acceleration voltage of 15 kV and beam current of 0.5 mA. CL color images reveal that blue and red CL emissions are recognized in the maskelynite. Their CL spectra exhibit a broad band peak at around 400 nm, which can be assigned to self-trapped exciton (STE). Similar peak is observed in plagioclase shocked by rail gun experiment at 40 GPa, whereas no blue emission exists in CL spectra of plagioclase shocked at 0, 20 and 30 GPa. Maskelynite in Dhofar 019 and plagioclase experimentally shocked at 40 GPa show a weak Raman spectral peak at around 450 cm^{-1} , suggesting T-O-T (T = Al or Si) symmetrical stretching, although unshocked plagioclase exhibits pronounced peak at around 280, 480 and 500 cm^{-1} . These facts imply that impact pressure shocked on this meteorite is relatively high at near 40 GPa.

Alkali feldspar has a bright blue emission with homogeneous feature of CL intensity and color in CL image. Its CL spectrum exhibit a broad band peak at around 400 nm in blue region attributed to Al-O^- -Al defect center. Such blue CL emission is also observed in alkali feldspar in suevite from Ries crater (stage IV: ~40 GPa). It suggests an estimation of shocked pressure at around 40 GPa for this meteorite.

Small calcite grains coexisted with merrillite and olivine show CL emission of dull orange color in CL images. CL spectra of these calcite have a broad band peak at 420 nm, which is related to defect center. Terrestrial calcite usually emits more or less red CL, whereas less emission in red region can be detected in this sample. Raman spectroscopy reveals low crystallinity of the calcite. Therefore, this calcite, which had been formed on Mars, was impact-shocked in this meteorite.