Cathodoluminescent and micro-IR characterization of minerals in the mesostasis of Nakhlite

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This study focuses on minerals in the mesostasis of Martian nakhlite. Cathodoluminescent (CL) and Micro-IR characterization provide us important crystallochemical information of the mesostasis composed of the minute minerals.

Two polished thin sections of Yamato 000749 and Yamato 000593, which are possibly paired, supplied from the National Institute of Polar Research (NIPR) were employed for CL and micro-IR measurements. CL image at high magnification and CL spectra were collected using a scanning electron microscope-cathodoluminescence (SEM-CL), SEM (JEOL: 5410LV) with a grating monochromator (Oxford: MonoCL2),where EDS system can be used in combination with SEM-CL. Operation condition is at 15 kV and 1.0-5.0 nA. Ramana spectra were obtained on a micro-Raman spectrometer (Thermo Nicolet: Almega) with a Nd: YAG-laser (20 mW at 532 nm) excitation system. IR spectra were collected using a micro-IR spectrometer (Thermo Nicolt: Centaurus) with ATR mode. These methods can be applied to micro spectroscopic analysis for fine grains with micro meter size.

The analysis with EPMA revealed several types of silica mineral in the mesostasis. Imaging at low temperature shows that these minerals have similar blue emission, but not so bright, whereas quartz exhibits extremely bright emission at low temperature.

Raman spectra of these minerals give two spectral patterns, which can be assigned to tridymite and cristobalite by comparing with terrestrial ones.

Tridymite in the mesostasis coexists with augite, olivine, plagioclase and Ti-rich magnetite. It occurs dispersively as a subhedral grain, of which longer dimension reaches up to 30 micro meters. Zoned augite is embedded in the space among tridymite grains and has Fe-rich rim attached to tridymite. Cristobalite with 5-30 micro meter width occurs as an anhedral interstitial form associate with plagioclase laths.

They show a similar CL spectral pattern with a broad peak at around 400 nm corresponding to lattice defect.

Micro-IR analysis of tridymite and cristobalite in mesostasis revealed that their IR spectra exhibit broad peaks centered at 3100-3400 cm^{-1} assigned to OH stretching vibration, whereas augite and olivine in nakhite and terrestrial silica minerals show no such peak. This suggests that crystallization for the formation of nakhlite involves H_2O in the igneous melt on the Mars at 1.3Ga.