CALCIUM DISTRIBUTION IN ELEPHANT MORAINE A79001: COMPARISON WITH OTHER MARTIAN METEORITES.
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Introduction: Shergottites and Nakhlites generally formed by igneous (volcanic) activities and experienced several degrees of secondary events such as shock metamorphism or aqueous alteration. Moreover, some shergottites include Elephant Moraine (EET) A79001 and Zagami contain several lithologies with different petrological signatures in a single rock [1-5]. These differences among lithologies are often constrained as fractional crystallization. In fact, these shergottites contain late-stage products of Fe-rich minerals (fayalite and/or hedenbergite) and incompatible element-rich melt pockets. Pyroxene grains in Dark mottled lithology show chemical zoning with homogenous Mg-rich core and Fe-rich rim usually accompanying break down product of pyroxyferroite at rim of pyroxene grains [6]. However, composition of pyroxene core in the lithology has more Fe-rich than those in normal Zagami lithology. Moreover, minor elements (e.g., Al and Ti) show compositional jump in mantle of the grain. Therefore, these characteristics may indicate mixing phenomena (magma mixing or crustal assimilation) during volcanic activity on Mars [6]. However, shergottites experienced severe shock metamorphism. Therefore, estimate of shock metamorphism on each rock, lithology and minerals are important to understand martian geological history. In this study, we focus on Ca distribution in olivine grains of martian meteorite as well as other mineral compositions in EETA 79001 lithologies A, B and C [1] and compare them with other martian meteorites to clarify secondary event(s).

Sample and method: Thin sections of EETA 79001 allocated from the Meteorite Working Group were observed under an optical microscope. Scanning electron microscope observation has conducted using a JEOL JSM-6490 at Okayama University of Science. Electron microprobe analyses were performed on JEOL JXA-8900 at the University of Tokyo and JEOL JXA-8230 at Natural Museum of Nature and Science.

Results: EETA 79001 contains several lithologies; olivine-phyric (lithology A), basaltic (lithology B) and glass pods (lithology C). We performed major and minor element analysis for pyroxene grains and found that each lithology shares its compositional signature but has differences in detail [1]. Lithologies A and B show igneous textures with pyroxene and maskelynite with minor accessory minerals. Lithology A contains glassy materials with flow texture (melt veins). Lithology C mostly contains vesicle rich glass with some relict of volcanic clasts. Boundary between relict and melt shows corroded texture.

Olivine grains (up to 500 μm) are found in Lithologies A and C. These olivine grains show chemical zoning trend in Fe/Mg compositions. Lithology A shows Mg-rich core (Fo_{64}) and Fe-rich rim (Fo_{53}). Lithology B shows Mg-rich core (Fo_{68}) and Fe-rich rim (Fo_{54}). Olivine grains in both lithologies generally contain ~0.2 wt.% of CaO and does not show zoning pattern. Rims of the olivine grains in Lithology C have thin pyroxene overgrowth and/or corroded texture with glassy materials. Cracks are ubiquitous in olivine grains in both lithologies. We found CaO enrichments along the cracks in Lithologies A and C, CaO contents is 1.4 wt.% and 3.7 wt.%, respectively.

Discussion and Summary: All lithologies contain pyroxene grains. Our previous study showed that pyroxene grains in Lithologies A and B shows normal

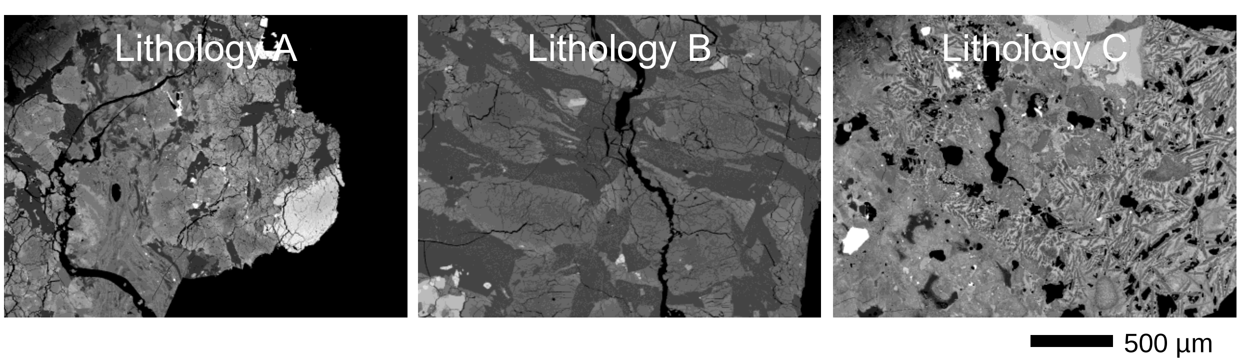

Figure 1. Backscattered electron images of lithologies A, B and C from EETA 79001. Lithologies A and B show basaltic texture mostly consists of pyroxene and maskelynite. Lithology C contains vesicle-rich glass with fine-grained minerals with some relict of basaltic texture.

igneous zoning and sharing similar core compositions may indicate that both lithologies crystallized in similar condition [1]. Therefore, we suggest that Lithologies A and B may fractional crystallization products from the same magma [1]. Pyroxene in Lithology C have similar composition however, homogeneity of lithology C indicate secondary heating event [1].

The olivine grains in Lithologies A and C also show chemical zoning trend in Fe and Mg contents, however, minor element composition especially CaO composition is disturbed by secondary event and have several CaO-rich spots. Similar CaO distribution were found in Larkman Nunatak 12011 [7] and samples from shock recovery and annealing experiments after annealing at 1000 ˚C for 3 hrs [8]. Therefore, CaO distribution in olivine of Lithologies A and C would be result of shock annealing. The Miller Range (MIL) 090032 nakhlite has different CaO distribution: olivine grains contain alteration veins and CaO contents decrease around the alteration veins. Calcium might be removed by volatile-rich fluids [7].

Calcium compositions of olivine grains in martian meteorites are sensitive for secondary events such as shock metamorphism and/or aqueous alteration. The enrichments of CaO in olivine imply relatively higher shock annealing effects.

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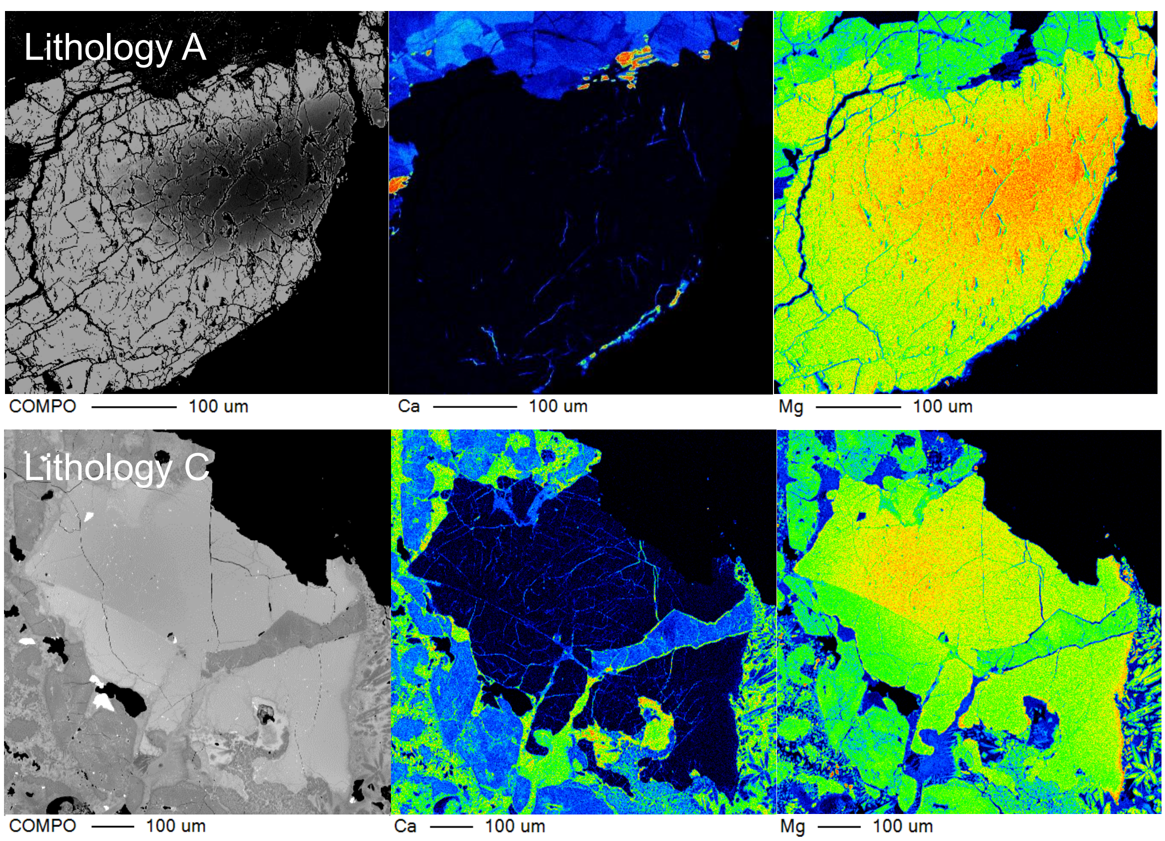

Figure 2. Back scattered electron images and elemental maps (Ca and Mg) for olivine grains in Lithologies A and C. Olivine grains in both lithologies contain numerous cracks with enrichment of Ca.