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月表層火砕性粒子の化学組成と結晶度の推定
Composition and Crystallinity of Dark Mantle Deposits on the Moon

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The lunar mantle makes up 90% of the lunar volume. Therefore, it is important to determine the mantle composition in order to understand the lunar bulk composition including information about origin and evolution of the Moon. However, the composition of the lunar mantle remains unclear.

Pyroclastic beads are a direct clue to lunar mantle composition. These very low-albedo beads on the lunar surface are Fe-bearing volcanic glass or partially crystallized spheres. The color variation of volcanic glass corresponds to its composition, in the order of higher TiO2 content (e.g., orange glass, yellow glass, green glass). It is believed that if the erupted magma is quenched slowly, the magma of intermediate to high TiO2 content can be small crystallized ilmenite grains and generate black beads, instead of generating orange and yellow glass. Thus, the TiO2 content of the beads and the quenching speed of the erupted magma correlate with the colors and crystallinities of the pyroclastic beads. Chemical studies of pyroclastic beads acquired by Apollo missions indicate that the beads were formed from erupted magma from deeper (300 to 400km) in the mantle than basaltic magma. It is also assumed that the beads retain the original composition of the magma.

Dark Mantle Deposits (DMDs) are one of the darkest and smoothest areas on the Moon and are believed to contain pyroclastic beads, as were found in the Taurus-Littrow region near Apollo 17 site. However, detailed spectral analysis of the DMDs is lacking because of the limited wavelength coverage and spatial resolution of the previous remote-sensing data.

This study focused on DMDs on the Aristarchus Plateau and used spectral data obtained by the Multiband Imager (MI) on the SELenological and ENgineering Explorer (SELENE). We chose this region because DMDs on the Aristarchus Plateau are the largest regional DMDs and because volcanic activity has lasted longer there than in other areas up to the Eratosthenian in this region. Previous studies reported that the crystallinity of this region is the lowest of all DMDs and that its composition is orange glass, indicating high TiO2 content.

This study re-evaluates composition and crystallinity of this region in more detail, using data with wider spectral coverage. The MI is a high-resolution (20m x 20m per pixel) spectral imager with both visible and near-infrared coverages at spectral 9 bands. Using MI spectral data, we can distinguish minerals and glass from the absorption features after removing the continuum.

In order to select locations representing DMDs suitable for checking their compositions, we mapped the Aristarchus Plateau area using the reflectance data at 750nm and then selected locations where reflectance is lower than 5.5%. We also produced an MI color-composite mosaic based on differences in absorption features, in order to distinguish pyroclastic beads from the surrounding mare. We then estimated the TiO2 content of pyroclastic beads by comparing the wavelength of the absorption center in the MI data with that of the laboratory-measured data of Apollo pyroclastic beads from the RELAB database. By comparing the spectra of different mixing ratios of glass (orange, yellow) and black beads from Apollo samples as endmembers, we estimated the crystallinity (estimated content of black beads) of the DMD.

The derived wavelength of the absorption center of the DMD spectra was 1050nm, which is similar to that of yellow glass. Thus, the pyroclastic beads of the DMD are assumed to be yellow glass, which has inter-mediate TiO2 content. Our results suggest that the crystallinity of the pyroclastic beads was 20%, and 40 to 50% of this region comprised materials ejected by the Aristarchus crater.

The result of low crystallinity of the beads possibly shows that only small volatile materials were contained in the magma source in this region because magma with higher volatile content cools more slowly and is likely to have higher crystal content.

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