SPECTRAL CHARACTERISTICS OF POSSIBLE EJECTA DEPOISTS ON THE ANTIPODE AND ITS SURROUNDINGS OF TYCHO CRATER. N. Hirata[1], M. Hareyama[2], Y. Ishihara[3], Y. Yokota[4], R. Nakamura[5] and M. Ohtake[3], [1]ARC-Space/CAIST, University of Aizu (naru@u-aizu.ac.jp), [2]St. Marianna University School of Medicine, [3]Japan Aerospace Exploration Agency, [4]Tsukuba Planetary Study Group, [5]National Institute of Advanced Industrial Science and Technology.

Introduction: Melt deposits have been identified at the antipode of crater Tycho on the lunar farside by LROC-NAC image, Diviner rock abundance map, and Mini-RF backscatter image [1, 2]. Because of absence of a potential source crater nearby this region, these deposits are formed by concentration of ballistic ejecta from Tycho crater at its antipode. Coincidence of model ages by crater counting of these deposits and impact melt deposits on Tycho ejecta also supports this interpretation [1, 3].

We examine multi spectral data of the Tycho antipode region to describe spectral characteristics and regional extent of these possible antipodal deposits of Tycho crater. Our results will give us constraints on material type, chemical composition, and mode of emplacement of these deposits, and provide some suggestions on their origin.

Data and Analysis: Global spectral cube data of Spectral Profiler (SP-Cube) [4] is used in this study. SP-Cube provides lunar spectral reflectance 510-1600 nm covering the whole surface of the Moon with 0.5˚ mesh. This data set is produced by compiling observation data of SP onboard KAGUYA (SELENE). Band-depth of each mesh in the region of latitude ±72.5˚ is also obtained from SP-Cube by removing a continuum component of reflectance spectra.

In addition to conventional spectral analysis such as extraction and plotting of reflectance spectra at regions of interest, Independent Component Analysis (ICA) is applied to SP-Cube to identify spectral characteristics of the target materials. ICA can extract significant spectral components from original spectral cube data as independent components [5]. It is powerful method to visualize distribution of geological units with distinct spectral features.

FeO and TiO_2 abundance maps are also examined. Two chemical composition maps are produced from multispectral image obtained by Multiband Imager (MI) onboard KAGUYA (SELENE) [6], and distributed at the KADIAS (KAguya Data Integrated Analysis System) website by JAXA [7].

Results: Pseudo color composite of the ICA component can visualize a distinct structure at the Tycho antipode (Fig. 1A). A white circular spot with a ~150 km of diameter is located on 167.25˚E and 43.25˚N and a dark red-pink tail extending over 1000 km to the west. Shorter light pink streaks are also found. The location and size of the white spot exactly correspond to a rocky region found in Diviner rock abundance map [2]. The associating tail and streak structures have not been reported in previous works.

Spectral characteristics of the Tycho antipode structure are examined in the SP reflectance cube and SP band depth cube (Fig. 2). Even though the head and tail have different color in the ICA composite image, they share common spectral characteristics; 1) low albedo, 2) bluish spectral slope in a VIS range, and 3) weak or no 1-μm absorption feature. These features are recognized in another pseudo color composite (Fig. 1B, R: spectral slope in the VIS range, G: band depth at 900 nm, and B: albedo at 750 nm). Because spectral characteristics of the Tycho antipode structure exhibit low values for every three-color component, entire of this structure is indicated as a dark spot in the spectral feature color composite image. FeO and TiO_2 abundance maps show that this structure seems to be slightly enriched in these two chemical components comparing to surrounding lunar highlands.

Discussions: In previous studies, only impact melt deposits with high rock abundance are reported at the Tycho antipode [1, 2]. We found that the antipode structure has wider distribution than previously believed. The head part of the Tycho antipode structure corresponds to the rocky region that is already reported. The tail part shares common spectral characteristics to the head part, but doesn't exhibit high rock abundance. It can be interpreted that ballistic ejecta from Tycho is concentrated at the head, whereas they deposit wider and thinner over the tail.

There are two possibilities on an extension of the tail to the East. As the Moon rotating, an antipodal focusing point of ejecta is shifting to west with a rate of ~0.5˚ or ~15 km (along the equator) per hour of flight time of ejecta. Actually, the head is centered at a point 1-2˚ offsetting to the west from the true Tycho antipode, suggesting that flight duration of ejecta is about 2-4 hour [8]. Ejecta with higher launch angles will take more flight time, and their antipode focusing point will be more shifted to the west. It is difficult to explain the observed length of the tail by the rotational shift of the focusing point because it requires unusually long flight duration over 60 hours.

Another interpretation is that this structure reflects radial heterogeneity of ejecta distribution from the origin. It is suggested that Tycho is formed by an oblique impact with the W-E direction, and has preferential ejecta distribution to the East [9]. It is expected that asymmetrical deposition near the antipode. Distribution of rocky deposits is consistent to this view. Diviner rock abundance map shows that the rocky deposits have preferred orientation of local slope azimuth [2, 10]. Also the streak structures observed in the tail would be another evidence.

As possible ejecta from Tycho, the antipode deposits have unique spectral characteristics. Morphological observations suggest that they are rich in impact melt, but a dark ring material around Tycho, in which many melt pond deposits exist, has redder spectral slope (Fig. 1B, C, and Fig. 2). Difference of reflectance spectra may originate from variation of source materials or cooling history of impact melt. Impact melt on the dark ring near the crater rim is ejected with slower velocity, while that reaching to the antipode has a higher ejection velocity. Considering excavation process of crater cavity, slow ejecta should originates from a deeper region of impact point, while fast ejecta does from shallower region. Mixing with local materials on the farside is potentially affected chemical composition of the antipode deposits.

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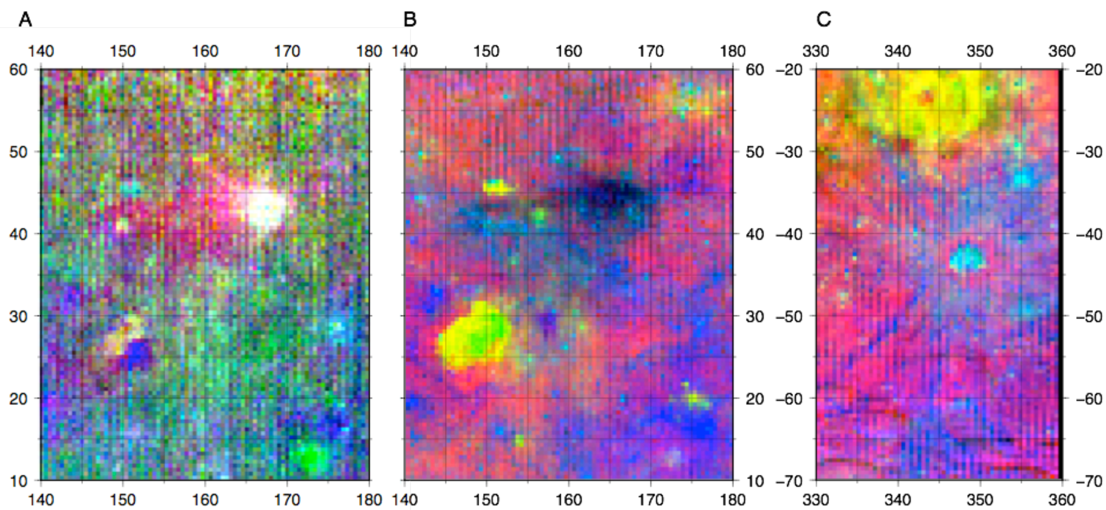

Fig. 1 A) ICA pseudo color composite image (ICA1: Red, 2: Green, and 3: Blue) and B) Pseudo color composite image of spectral slope in the VIS range (Red), band depth at 900 nm (Green), and albedo at 750 nm (Blue) of Tycho antipode region. C) Pseudo color composite image with same scheme as the panel B of Tycho.

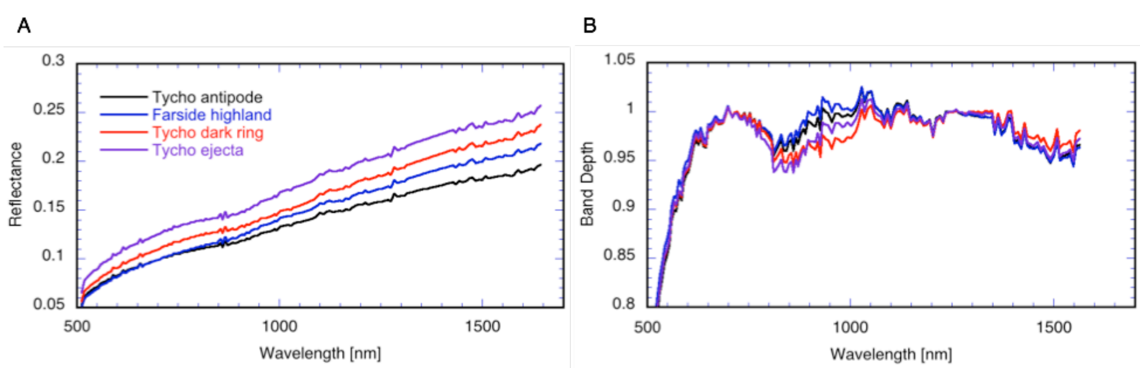

Fig. 2 A) Reflectance and B) band depth spectrum of Tycho antipode. For comparison, spectrum of farside highland, the dark ring, and flesh ejecta of Tycho are also plotted.