Global Map of Spectral Classification for the Mercury and Its Chemical Composition. Makoto Hareyama[1], Yoshiaki Ishihara[2], Chikatoshi Honda[3], Makiko Ohtake[4], [1]St. Marianna University School of Medicine (m-hareyama@marianna-u.ac.jp), [2]National Institute for Environmental Studies, [3]University of Aizu, [4]Japan Aerospace Exploration Agency.

Introduction: The observation result by the US Mercury Explorer MESSENGER has greatly changed the knowledge of Mercury based on past observations such as earth's telescopes and Mariner 10 (e.g. [1]). In particular, the facts of the large amount presence of volatiles such as sulfur on the surface [2] and the presence of carbon relating to graphite crust formation [3] ask us to revise Mercury's formation history, because such volatiles are largely related to the process of magma ocean differentiation, crustal formation and volcanic activity.

The global geological map of Mercury is important for understanding such Mercury's crustal evolution globally. Recently, it is possible to create global geological maps because of releasing Mercury's global spectral data [4] and chemical composition data [2,5] of MESSENGER observation. As a first step, we made a global map of spectral classification by automatic classification method [6]. The spectral data is 8 color (MDR) of MESSENGER / MDIS [4].

Mercury's spectral feature is known to be small in absorption and small in regional differences as compared to the lunar spectra. This work compares the global spectral classification map with chemical content maps [2, 5], and discusses the relation between spectral feature and chemical composition on the Merucurian surface.

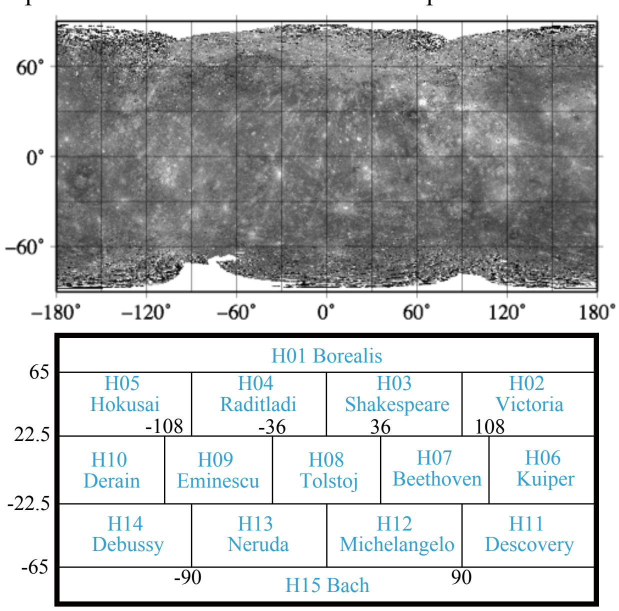

Fig.1 8 color (MDR) 750 nm image of Mercury (top) [4] and Mercury's 15 tiles quadrangle scheme (bottom).

Classification map and average spectra: The analysis data classified was 8 bands cubed global mosaic data called 8 color (MDR) of MESSENGER/ MDIS [4]. This work analyzed the region within ± 65.5 degrees of latitude excluding the high latitude zone where there are many inappropriate data for automatic classification. Also, in order to classify small features of Mercury's spectrum, the normalized PCA components were classed by K-means. For details, see [6].

Figure 1 shows the Mercury 750 nm image and Mercury's 15 tiles quadrangle scheme (name of regions). Figure 2 shows the classification map by K-means (K = 6) and average spectra of each class. Each spectrum has similar spectral shape to each other, and a small absorption is found around 750 nm wavelength of every spectrum. However, the average spectra have been divided largely into two classes. One is steep slope spectral group of Class 1 and 2 (red and

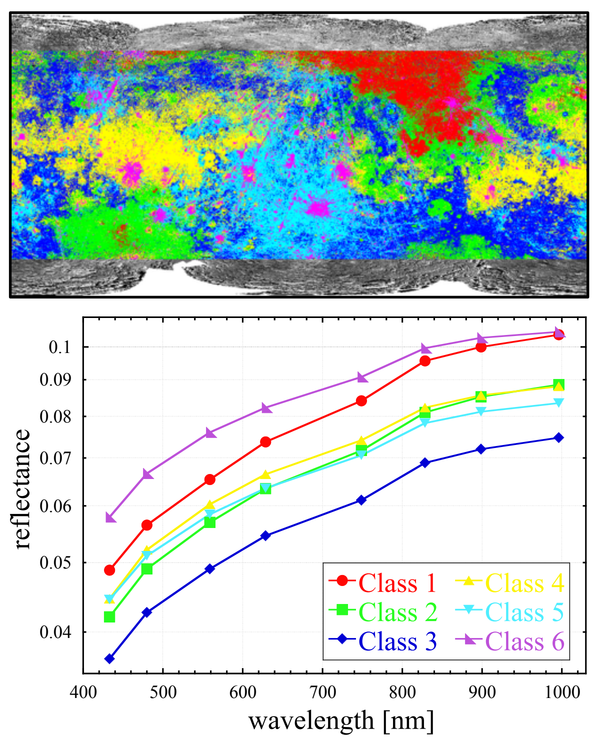

Fig.2 The spectral classification map by K-means (K = 6) (top) and the average spectra of each class [6]. The same color of the top and bottom panels represents the same class.

green respectively in Fig. 1 and 2), the other is gentle slope group of Class 3, 4, 5, and 6 (blue, yellow, cyan, and purple). The former is seemed to be mainly located on bright areas in relatively high latitude of Fig.1, and this group has been classified to the same class in case of K = 2. The locations of Class 1 and 2 are adjacent to each other, and the Class 1 is inside the Class 2 basically. While the Class 1 is widely spread only in Shakespeare (H03), the Class 2 seems to be located on certain or probable large basins [7] such as Caloris basin. The Class 2, 4, and 5 show similar reflectance, but the spectral slopes are little bit different from each other. The Class 3 and 6 shows the lowest and the highest albedo, respectively. And, the pixels of each class are clustered regionally. This means that the adopting classification method can divide the spectra with spectral and geological meanings.

Comparison to elemental distribution maps: Figure 3 shows the elemental distribution map reported by X-ray spectrometer [2] and gamma-ray spectrometer [5] onboard MESSENGER. The highest Mg region at north-west part called HMR (high-Mg region) has high-Fe, Ca, and S also, while Al is low.

It seems that the steep spectral group of Class 1 and 2 has relatively lower content of S and Ca than the gentle spectral group. Since it has been suggested that a degree of space weathering is depend on the presence of sulfides, the differences of spectral slope between these two groups may be due to this effect.

When we compare the Class 1 with the Class 2, the Class 1 has lower Al content than the Class 2. The Class 1 has the highest potassium content and low iron content, through almost area of Class 1 is not covered for iron observation. Potassium is one of the incompatible elements that is likely to remain in magma. In case of the Moon, potassium is present in relatively high content in maria with high iron content, especially in PKT region. This difference may mean that the Class 1 does not consist of basaltic materials similar to the Moon.

The Class 3 in the gentle slope group indicates the lowest albedo in all 6 classes and looks like relatively high iron content. Since the presence of iron encourages space weathering, these two features are consistent with each other. On the other hand, the Class 6 indicates the highest albedo in all 6 classes, and many locations of Class 6 correspond to ray-craters. Since, due to craft orbit, the elemental map does not cover in northern hemisphere and the spatial resolution of maps is low in southern hemisphere, elemental characteristics for the Class 6 is unknown. However, the positions of Class 6 exist in the areas with middle albedo of Class 1, 2, 4, and 5 except for the Class 3.

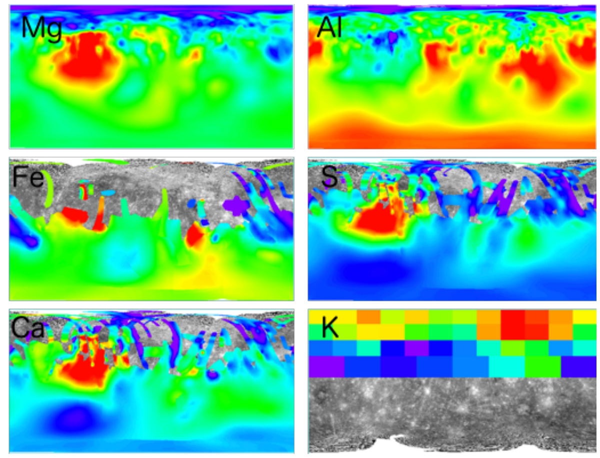

Fig.3 Elemental distribution map. Maps of Mg, Al, Fe, S, and Ca are relative abundance to Si given by XRS observation of Ref. [2]. K map is absolute abundance given by GRS observation of Ref. [5]. Red indicates the highest content and purple indicates the lowest content.

The Class 4 and 5 of the gentle slope group and also the Class 2 of the steep slope group show similar albedo and small differences of spectral slope. Between these three classes, it is difficult to find elemental differences. In fact, the HMR belong to the Class 4 could not be divide as an independent class. However, we have confirmed that the HMR become independent class when the number of classes of K-means is increased. On the other hand, nobody knows how many classes the truth is. We will discuss these classes after adopting improved classifications without giving the number of classes.

Conclusion: The reflectance spectra of the Mercury have been classified globally without any archetypical classification conditions except for the number of class. Although the average spectra of each class show only small differences between each other, it found that the global spectral classification map indicates geological meanings when comparing with the elemental distribution maps.

References: [1] Nittler L.R. et al. arXiv: 1712.02187 [astro-ph.EP], [2] Weider, S.Z. et al. (2016), *GRL*, ***43***, 3653-3661. [3] Peplowski, P.N. et. al. (2016) *Nature Geosci.* ***9***, 273-276. [4] http://messenger.jhuapl.edu/Explore/Images.html#global-mosaics. [5] Evans, L.G. et al. (2015) *Icarus,* ***57***, 417-427. [6] Hareyama, M. et al. (2018) *49th LPSC,* Abstract #1724. [7] Fassett, C.I. et al. (2012) *JGR,* ***117***, E00L08.

Acknowledgements: This study is supported by JSPS KAKENHI (Grant-in-Aid for Scientific Research(C)) Grant Number 17K05641 (P.I.: Makoto Hareyama).