Japan Geoscience Union Meeting 2013
(May 19-24 2013 at Makuhari, Chiba, Japan)


PPS23-04 Room:201A Time:May 23 09:45-10:00

# Constrains on the igneous activity of basaltic magma based on the distribution of radioactive elements on the Moon

Yutaka Hirai[1], Yuzuru Karouji[2*], Makoto Hareyama[2], Hiroshi Nagaoka[1], Yukari Fujibayashi[1], Shunichi Kamata[3], Tomokatsu Morota[4], Shingo Kobayashi[5], HASEBE, Nobuyuki[1]

[1]Research Institute for Science and Engineering, Waseda University, [2]Japan Aerospace Exploration Agency, [3]Graduate School of Science, The University of Tokyo, [4]Graduate School of Environmental Studies, Nagoya University, [5]National Institute of Radiological Sciences

Investigation for the eruption ages and causes of mare volcanism on the Moon is essential for understanding the thermal evolution inside the Moon. Morota et al. [1] estimated the eruption ages of mare basalt units in the nearside of the Moon by using the image data obtained by the Terrain Camera (TC) [2] onboard Kaguya. In addition, Kaguya Gamma-Ray Spectrometer (KGRS) [3] successfully observed global distributions of radioactive elements (K, Th, and U) on the Moon [4, 5]. These observations present that most of the relatively young basalt units ($<$ 2.5 Ga) locate in the Procellarum KREEP Terrane (PKT) [6] enriched in radioactive elements. The radioactive heating produced by the decay of the radioactive elements in KREEP may affect the volcanic activities in the PKT [e.g., 7]. Studies of lunar basaltic meteorites indicate that the younger basalt is more enriched in K and Th than the older basalts. However, such an investigation has not been conducted for globally distributed maria using remote sensing data. Therefore, we investigated the relationship between the abundance of radioactive elements and eruption ages of mare basalts by Kaguya data in this study. Moreover, we discussed the effect of radioactive heating for the igneous activity of the Moon.

We used the gamma-ray spectral data obtained by the KGRS at the low altitude (50 +- 20 km) from February to May, 2009. The gamma-ray counts observed by the KGRS were integrated on each of basalt units defined by previous studies [e.g., 8]. The peaks at 1461 keV ($^{40}$K) and 2615 keV ($^{232}$Th-$^{208}$Tl) were used to estimate their intensities. The eruption ages of each mare basalt unit are derived by [e.g., 1]. The counting rates of gamma-rays from K and Th were calibrated to elemental concentrations by an empirical method using returned samples as ground truth. We have chosen Apollo and Luna soil samples as ground truth [9].

The K and Th contents of mare basalts in PKT are higher than those of mare basalts outside PKT. In the PKT, the eruption lasted for a long time, and each unit is enriched in K and Th. As the eruption ages of basalt units in the PKT are younger, their K and Th contents increased more. It seems reasonable that a region in PKT has more heat source elements, more magma might have been generated. The partial melting zone below the layers enriched in heat source elements might last longer time than other regions in PKT. The source regions of younger magma needed more heating by the decay of radioactive elements for its remelting to offset cooling associated with heat loss of the Moon as a time went on. Thus, the younger basalts contain more K and Th contents than the older basalts.

In contrast, most of the basalt units outside the PKT have low abundances of K and Th. This implies that the effect of radioactive heating by the KREEP layer is small. In other words, there must be no or very small volume of KREEP layer outside the PKT. Moreover, most units erupted by 2.5 Ga. This result implies that the mare eruption without heat from KREEP layer drastically decreased around 2.5 Ga. Previous calculations of lunar thermal evolution suggest that the volume of partial melting zone decreases with time and may be very small around 2.5 Ga without KREEP layer [e.g., 10]. Our results of mare basalts outside the PKT are supported by the assumption inferred from thermal evolution calculations.

References: [1] Morota T. et al. (2011) EPSL, 302, 255-266. [2] Haruyama J. et al. (2008) EPS, 60, 243-255. [3] Hasebe N. et al. (2008) EPS, 60, 299-312. [4] Kobayashi S. et al. (2010) SSR, 154, 193-218. [5] Yamashita N. et al. (2010) GRL, 37, L10201. [6] Jolliff B. L. et al. (2000) JGR, 105, 4197-4216. [7] Wieczorek M. A. and Phillips R. J. (2000) JGR, 105, 20,417-20,430. [8] Hiesinger H. et al. (2003) JGR, 108, 5065. [9] Lucey P. et al. (2006) Rev. M& G, 60, 83-219 [10] Spohn T. et sl., (2001) Icarus, 149, 54-65.

Keywords: igneous activity, basaltic volcanism, radioactive elements, Kaguya (SELENE), gamma-ray spectrometer