Uranium-Lead dating and Rare Earth Element analysis of phosphates in Enriched Shergottites using NanoSIMS

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Shergottites, the largest group among Martian meteorites, show a relatively young formation ages between 165-475 Ma (Nyquist, 2001). They are the only records of the recent activities of magma on Mars. They provide an important geochemical information concerning the environmental change of Mars. Analyzing micro regions, we can obtain local information which is not obtained in bulk analyses. In this study, we have established an in-situ analytical method of rare earth element (REE) abundances using NanoSIMS, and have applied to shergottites to extract their geochemical records from micro regions. The concentrations of REE of phosphates in two shergottites, Zagami and Roberts Massif 04261 (RBT04261), are measured with the micro-region analysis. Before that, we have also conducted ^{238}U-^{206}Pb dating in the same mineral grains. Combing the new knowledge, we discuss the recent magmatic activity on Mars.

Both ^{238}U-^{206}Pb and ^{207}Pb-^{206}Pb ages of phosphates in the two samples were analyzed using NanoSIMS 50 installed at Atmosphere and Ocean Research Institute, the University of Tokyo. First, ^{238}U-^{206}Pb dating was conducted. We also conducted ^{207}Pb-^{206}Pb dating to obtain "3-D Total U/Pb age (3-D age)".

In addition to ^{238}U-^{206}Pb ages of the phosphates, we have also analyzed their REE concentrations. NanoSIMS analytical technique of REE in phosphates by NanoSIMS has been established in this study to obtain chondrite normalized REE patterns.

A conventional method of REE analysis was the energy filtering method, which needs much effort for accurate measurement because interference effects of light REE oxides and/or fluorides on heavy REE isotopes are not negligibly small in the case of phosphates. To get over this problem, we applied the high-mass-resolution method. The entrance and emission slits of NanoSIMS were narrowed to achieve the mass resolution power (MRP) of approximately 10,000 at the peak height of 10 %. This MRP value is high enough to separate the peak of light REE oxide from that of heavy REE adequately.

There are two important advantages with this method; (i) the intensities of secondary ions of REEs are kept relatively high, and (ii) we do not need to compromise the product rates of REE oxides. First, terrestrial apatite standards, PRAP (Sano et al., 2006) and Morocco, were analyzed to confirm the accuracy of our NanoSIMS measurements. The REE concentrations of the two standards were previously confirmed by conventional ICP-MS analyses. After that, this new method was applied to the phosphates in Zagami and RBT04261.

Calculated 3-D ages of Zagami and RBT04261 were respectively 113±70 Ma and 230±50 Ma (all errors are 2σ). A previous study of SIMS (Cameca IMS 1280) reported the ^{238}U-^{206}Pb age of Zagami phosphates as 153±81 Ma (Zhou et al., 2013). For RBT04261 phosphates, no studies have previously reported their ^{238}U-^{206}Pb ages. On the other hand, its baddeleyite has the ^{238}U-^{206}Pb age of 235±37 Ma (Niihara, 2011). The 3-D age of phosphate in Zagami obtained in this study is consistent with the literature. Also, we obtained the crystallization age of phosphate in RBT04261 which is consistent with that of baddeleyite. We discuss these crystallization ages and REE of phosphates in this presentation.

Keywords: Martian meteorite, uranium-lead dating, rare earth element

