Uranium-Lead dating of Zagami and RBT04261 phosphates by NanoSIMS

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[1] Introduction

Martian meteorites are only samples of Mars that can be measured directly on the Earth. Zagami and RBT 04261 are classified into basaltic and lherzolitic shergottite, respectively. Although chronological information of shergottites, especially, their crystallization ages are important for constraining the geological history of Mars, there are controversial debates about its geological ages [1][2].

The uranium-lead dating has been used for Martian meteorites because the uranium has a long half-life and two decay series. The ^{238}U-^{206}Pb age of Zagami was 230±5 Ma using TIMS instrument [3]. A recent study reported the ^{238}U-^{206}Pb age of Zagami phosphates as 153±81 Ma using IMS-1280 instrument [4]. On the other hand, the ^{207}Pb-^{206}Pb age of Zagami obtained by mineral separation using MC-ICP-MS instrument gave an ancient age of 4048±17 Ma [2]. It is not settled that the old age shows crystallization or mixing with the Martian surface or terrestrial lead.

For RBT 04261, ^{238}U-^{206}Pb age of baddeleyite grains was reported as 235±37 Ma using SHRIMP instrument [5].

In this study, we conducted uranium-lead dating, lead-lead dating of phosphate minerals in Zagami and RBT 04261 using NanoSIMS instrument installed in Atmosphere and Ocean Research Institute, The University of Tokyo. We also calculated “U-Pb 3D age” from the two chronologies in order to obtain crystallization ages of the meteorites.

[2] Analytical Methods

Polished thick sections of Zagami and RBT 04261 are used in this study. The RBT 04261 section was allocated from NASA-JSC. The sections were firstly observed using SEM-EDS (S-4500) installed in Department of Earth and Planetary Physics and EPMA (JXA-8900) in Atmosphere and Ocean Research Institute. Merrillite [$Ca_9NaMg(PO_4)_7$] grains were identified in the both sample.

The U-Pb dating was conducted using NanoSIMS 50 at Atmosphere and Ocean Research Institute, The University of Tokyo. After ^{238}U-^{206}Pb dating, the ^{207}Pb–^{206}Pb age was determined on the same spots.

[3] Results

The uranium-lead ages are determined as 164±240 Ma for Zagami, and 261±72 Ma for RBT 04261, respectively. All errors are 2-sigma.

The lead-lead ages have large errors and no meaningful ages were obtained.

The 3D ages of the two meteorites were obtained as 245±80 Ma for Zagami and 248±41 Ma for RBT 04261.

The initial lead isotopic ratio (hereafter called common lead) of Zagami was calculated as ^{206}Pb/^{204}Pb =14.46±0.82 and ^{207}Pb/^{204}Pb =15.45±0.65. The common lead of RBT 04261 was estimated as ^{206}Pb/^{204}Pb =10.1±2.2 and ^{207}Pb/^{204}Pb =12.7±1.1.

Concordant ages were obtained for both meteorites, indicating that U-Pb system in the phosphates was not disturbed by secondary metamorphism. We claim that the approx. 250 Ma ages show the crystallization of these meteorites.

[4] Discussion

Since the two meteorites differ in common lead, it is possible that they crystallized from either different magma source at the same time or single magma with different common lead. Therefore, we consider that (1) there were a few magmas with different common lead formed in 250 Ma and the two meteorites crystallized independently, or that (2) although Zagami and RBT 04261 crystallized in the same magma in 250 Ma, evolved common lead of Martian surface was mixed into Zagami in the shallow part of Mars, while RBT 04261 keeps primitive common lead in deep. Further discussion is needed about these hypotheses in combination with the information of other radiometric ages or trace elements in the meteorites.

[5] References

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