U-Pb Dating of Baddeleyite in Zagami by NanoSIMS Imaging Analysis

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Introduction: Shergottites is a group of Martian meteorites, which shows relatively young formation ages [1] and important for investigating history of Martian volcanic activity. There are several reports of U-Pb dating for phosphate grains using an ion microprobe method [2,3]. Baddeleyite is a candidate of dating target because it is uranium bearing mineral [4]. However, their grains are significantly small to obtain the precise age by ion microprobe method. We have developed a new method, "imaging analysis", in which larger area than a target mineral is scanned, and the counting data are extracted from the sample grain using a data-processing program after measurements [5]. In this study, we describe a method of imaging analysis and show the U-Pb age of baddeleyites in Zagami, a basaltic shergottite with enriched geochemical signature.

Experiment: Thick section of Zagami with a basaltic lithology [6] was polished carefully by lapping films and carbon coated. Zr mapping was conducted by an electron microprobe (JXA-8900) to locate baddeleyite grains in the section. Twenty baddeleyite grains were identified where we selected seven grains larger than 3 μm. The U-Pb imaging analysis was conducted using an ion microprobe (NanoSIMS 50). $^{16}O^-$ ion was used as a primary beam with a current of 200 pA and a spot diameter of <1 μm. The raster area of primary beam was set to 3×3 μm where 32×32 pixels data were obtained. The intensities of $^{30}Si^+$, $^{90}Zr^+$, $^{204}Pb^+$, $^{206}Pb^+$, ^{207}Pb, $^{238}UO^+$ and $^{238}UO_2^+$ were measured by a multi-ion counter system with magnetic field scanning. These data were calibrated against those of our baddeleyite standard derived from the Phalaborwa Igneous Complex in the lowveld plains of Northern Transvaal, South America [7]. When the sample grains were significantly small, parts of pixel data among 32×32 pixels were selected based on $^{90}Zr^+$ counts and used for U-Pb dating.

Results and Discussion: Observed $^{238}U/^{206}Pb$ ratios of sample grains were calibrated against the ratio of Phalaborwa standard based on the relationship between UO_2/UO and $^{206}Pb/UO$ ratios. The $^{207}Pb/^{206}Pb$ ratios were corrected by the measurement of glass standard, SRM610 under the assumption that matrix effect on lead isotopes is negligibly small. Observed and then corrected $^{238}U/^{206}Pb$, $^{207}Pb/^{206}Pb$ and $^{204}Pb/^{206}Pb$ ratios of seven grains are plotted in 3-D diagram, where data points are linearly aligned within experimental error. Intersect of the regression line on the Tera-Wassurburg Concordia curve gives the U-Pb age of 194±28Ma, which is consistent with the age of 182.7±6.9 Ma in a literature [8]. Common lead component is estimated as $^{206}Pb/^{204}Pb=12.5\pm1.6$ and $^{207}Pb/^{204}Pb=11.7\pm1.7$ by the intercept of $^{207}Pb/^{206}Pb$-$^{204}Pb/^{206}Pb$ plane. These values are consistent with evolution curve of terrestrial lead at approximately 3.7 Ga [9], suggesting similar U-Pb systematics.

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