Internal isochron of CAI using high precision SIMS Mg isotope analyses

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The ^{26}Al-^{26}Mg decay system ($\tau_{1/2}$= 7.3×10^{5} y) is a useful chronometer providing ≤0.1 Ma resolution for the earliest history of our solar system. Recent estimates on the initial $^{26}Al/^{27}Al$ ratios of Ca, Al-rich inclusions (CAIs), the oldest refractory solids in the solar system are controversial, varying between "canonical" $^{26}Al/^{27}Al$ ~5×10^{-5} and supra-canonical (6-7)×10^{-5} [1–2], equivalent to a time period for CAI formation of less than 0.1 Ma to as long as 0.4 Ma. In order to estimate the initial $^{26}Al/^{27}Al$ ratios of individual CAIs, we developed high precision (0.1–1‰) and high spatial resolution (8-20μm) Mg isotope analytical techniques using the WiscSIMS IMS-1280, equipped with multiple Faraday cup detectors. We calibrated SIMS relative sensitivity factor (RSF) of $^{27}Al/^{24}Mg$ by using melilite and plagioclase standards that were analyzed carefully by EPMA, reducing the uncertainty of the isochron slope to be less than 1% for melilite and 5% for plagioclase.

We analyzed the Al-Mg systematics of zoned melilite mantle and interstitial anorthite in the core of a type B1 CAI, Leoville 3535-1 [3]. Melilite grains were analyzed (20 μm beam spot) in multicollection mode and anorthite grains (8 μm beam spot) in single collector mode with an electron multiplier. We applied an exponential law with (β=0.514) for the Mg isotopic fractionation correction [4]. Typical precisions for $\delta^{26}Mg$ for melilite and anorthite are 0.1‰ and 2‰, respectively. The results show a well-defined isochron with a slope of (5.00±0.04)×10^{-5} (MSWD=1.04), indicating no evidence for multiple reheating events or any isotopic disturbance more than 40,000 years after its formation. Athough the uncertainty of the anorthite RSF degrades the error of the isochron by 5%, this new result does not indicate a supracanonical value. This is inconsistent with the idea that the canonical isochron resulted from redistribution of the Al-Mg system through multiple reheating events occurring over a few kyr in the solar nebula [1].

[1] Young *et al.* (2005) *Science* **308**, 223-227. [2] Thrane *et al.* (2006) *Astrophys. J.* **646**, L159–L162. [3] Richter *et al.* (2006) *Lunar Planet. Sci.* **38**, #2303. [4] Davis *et al.* (2005) *Lunar Planet. Sci.* **37**, #2334.

U-Pb geochronology of apatite by high lateral resolution SIMS (NanoSIMS)

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Introduction

To determine the absolute ages using radiogenic isotopes is important for reconstruction of paleo-environments, estimate of secular changes and define the timing of geological events. U-Pb isotope geochronology for high uranium minerals such as monazite, zircon and apatite has been carried out from Hadean to Phanerozoic samples. The U-Pb dating was divided into two types: solution (TIMS) and *in situ* (SIMS/SHRIMP/LA-ICP-MS) analyses. *In situ* analyses provide isotope ages from several tens of micron in spot diameter. Recently, high lateral resolution SIMS (NanoSIMS) has been developed by Cameca, which provides submicron analysis spots. This powerful feature is advantage for analyzing the samples which have tiny mineral inclusions, chemical zonings and micro-cracks. The dating of apatite is useful because of direct dating of (micro-) fossils which are occurred as phosphate.

Method

We report that method and results of U-Pb dating by Cameca NanoSIMS 50 installed at Ocean Research Institute (ORI), The University of Tokyo. U-Pb dating at ORI is using $^{16}O^{-}$ primary beam and measurements are separate 2 sessions. At first, we analyzed $^{204}Pb^{+}$, $^{206}Pb^{+}$, $^{238}U^{16}O^{+}$, $^{238}U^{16}O_2^{+}$ by magnet-static, multi-collection mode for estimating $^{238}U/^{206}Pb$ with Pb^{+}/UO^{+}-UO_2^{+}/UO^{+} calibration, then $^{204}Pb^{+}$, $^{206}Pb^{+}$, $^{207}Pb^{+}$ are measured by magnetic switching mode with single collector for $^{207}Pb/^{206}Pb$. 15-20 nA primary beams were used to spatter 15-20 μm-diameter craters.

Results and Discussions

We analyzed three apatite samples (PRAP, POAP and BNCF) which were measured by SHRIMP with 30 μm-diameter craters [1]. Obtained ^{207}Pb-^{206}Pb isochron ages of PRAP, POAP and BNCF are 1256±56 Ma (SHRIMP: 1156±45 Ma), 2790±550 Ma (2701±86 Ma) and 1224±140 Ma (918±45 Ma), respectively.

NanoSIMS provides useful apatite ages with smaller spot size than SHRIMP and a new insight to *in situ* geochronology.

[1] Sano *et al.* (1999) *Chem. Geol.* **153**, 249-258.