A Single Grain U-Pb Dating and D/H Ratios of Phosphate Minerals in ALH84001. M. Koike[1, 2] , Y. Ota[1, 2], N. Takahata[2], Y. Sano[2], and N. Sugiura[1], [1]School of Science, the University of Tokyo, [2]Atmosphere and Ocean Research Institute, the University of Tokyo.

Introduction:

There are many studies that determine U-Pb and Pb-Pb ages of phosphate minerals such as apatite ($Ca_5(PO_4)_3(F,Cl,OH)$) and whitlockite ($Ca_9(Mg,Fe^{2+})(PO_4)_6PO_3OH$) in Martian meteorites. These minerals are important carriers of rare earth elements (REE) and water in the form of OH. Age determination of a single phosphate grain can be related with its hydrogen isotopic ratio to obtain valuable insight into the evolution of Mars surface.

ALH84001 is unique for its extremely old age compared to other Martian meteorites and thought to have information of ancient history. U-Pb-Th ages of its phosphates were reported to be about 4 Ga [1]. Its carbonates and maskelynite showed high D/H ratios with large deviations, which indicate large fractionation at early Mars surface [2]. Due to small grain sizes and limited spatial resolutions of measurements, previous studies used several grains for one age or one series of isotopic distributions. Here we measured ages and D/H ratios in a single grain using a NanoSIMS with a high spatial resolution.

Experimental:

Two thick section of ALH84001 were polished and gold-coated. They were then observed by SEM-EDS to locate phosphates. Several large phosphate grains (>~50μm) were found and analyzed using a NanoSIMS (Fig, 1). A ~10nA O- primary ion beam (with spot diameter of ~20μm) was used for U-Pb and Pb-Pb measurements and a ~1nA (spot diameter of <10μm) was for D/H ratio measurements. An apatite from Prairie Lake circular complex, PRAP, with a known age of 1156 Ma [3] was used as a standard for U-Pb dating. For D/H ratio measurements, we used an apatite from Imilchil, Errachidia, Morocco as standard. The water of this apatite was extracted by heating to 1300 ℃ under oxygen atmosphere and its concentration and D/H ratio were determined by a conventional method.

Results and Discussion:

^{238}U-^{206}Pb isochron, ^{207}Pb-^{206}Pb isochron, and total U-Pb isochron, a regression line in 3-D space ($^{238}U/^{206}Pb$-$^{207}Pb/^{206}Pb$-$^{204}Pb/^{206}Pb$), showed ages of ~4 Ga. The ages obtained in this study were also consistent with previous studies within experimental errors. D/H ratios in the same grains had high values and considerable deviation (from ~0‰ to ~800‰). This result is in agreement with the whole rock composition by stepwise heating [4]. D-enrichment in the phosphates suggests that a large fraction of surface water had escaped before the time of crystallization (~4 Ga). Hydrogen with low D/H ratio may be contaminated by terrestrial water.

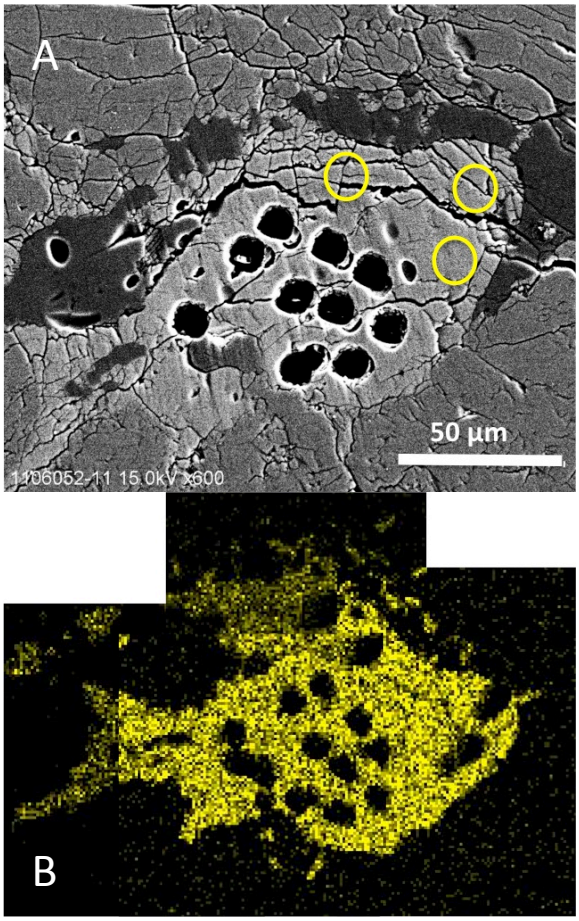

Figure 1. Scanning electron microscope image of a phosphate grain of ALH84001. (a) Backscattered electron (BSE) image. 10 pits and additional 3 yellow circles are ion microprobe spots for U-Pb dating. D/H ratios were measured later on residual space. (b) EDS mapping of phosphor of the same grain.

References:

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