

OXYGEN ISOTOPIC ZONING OF REVERSELY ZONED MELILITE CRYSTALS IN A FLUFFY TYPE A CAI FROM VIGARANO METEORITE. J. Katayama¹, S. Itoh¹ and H. Yurimoto¹, ¹Natural History Sciences, Hokkaido University, Sapporo 060-0810, Japan (juri@ep.sci.hokudai.ac.jp)

Introduction: Oxygen isotopic compositions of minerals of Ca-Al-rich inclusions (CAIs) distribute along a CCAM line [1]. The heterogeneous distribution of intra- and inter-mineral would be resulting from mixing of ¹⁶O-rich and ¹⁶O-poor reservoirs during the CAI formation in the early solar system [1, 2]. Previous CAI studies indicate that minerals of CAIs was crystallized from the ¹⁶O-poor gas and / or ¹⁶O-rich gas in the CAI formation regions [2-5]. This shows that there are two gaseous reservoirs of different oxygen isotopic compositions in the solar nebula. However, it is unclear when and how the two gaseous reservoirs evolved through the nebular history.

Fluffy Type A CAI (FTA) considered as condensates from a hot solar nebular gas, based on their irregular shaped and the existence of reversely zoned melilite crystals [6]. Therefore, the oxygen isotopic compositions of FTA directly reflect the oxygen isotopic composition of the gas [2]. If oxygen isotopic compositions of FTA minerals change with crystal growth, this would indicate direct evidence of mixing between two oxygen isotope reservoirs in the solar nebula. In this study, we report oxygen isotopic variations during crystal growth of reversely zoned melilite.

Analytical Techniques: A FTA, named as V2-01 (6 x 5mm) in a thin section of Vigarano meteorite, was used. Compositional zoning of melilite crystals were determined by X-ray mapping with ~1 μm spatial resolution using a JEOL JSM-7000F field-emission-type scanning-electron-microscope (FE-SEM) equipped with an Oxford INCA energy dispersive spectrometer. Grain boundaries of melilite were determined by orientation mapping using electron backscatter diffraction (EBSD) method by a HKL Channel 5 system equipped with the FE-SEM.

The oxygen isotopic microanalyses were performed by secondary ion mass spectrometry (SIMS) using the Hokudai Cameca ims 1270. A Cs⁺ primary beam of 20 keV was focused to a beam spot of 3 to 5 μm on the the sample surface with a beam current of ~0.2 nA. Negative secondary ions were collected sequentially in an faraday cup for ¹⁶O⁻ of 1 second and in an electron multiplier for ¹⁷O⁻ of 2 second and for ¹⁸O⁻ of 1 second under peak-jumping mode. The mass resolving power M/ΔM was about 5000. The sequence was performed for 30 cycles. Instrumental mass fractionation and matrix effect were corrected by analyzing a synthetic åk-

ermanite standard. The overall analytical precision is about 1‰ (σ).

Results: Most melilite grains show reverse zoning within a single crystal from core (åk~25) to rim (åk~5). The melilite crystals show oxygen isotopic variations along the CCAM line corresponding to the åk contents [3]. Three melilite grains (Grain 1, 8 and 21) have a gradual oxygen isotopic zoning corresponding to the reverse zoning patterns. The compositional and oxygen isotopic variations of each grain are described below:

Grain 1 The åk content decreases gradually from the inner portion (åk14) to the grain boundary (åk5) (Fig.1a). In the inner portion, which composition ranges åk14-7, the oxygen isotopic compositions are homogeneous with δ¹⁸O_{SMOW} = ~-2‰. The δ¹⁸O_{SMOW} values gradually decrease from -2‰ (åk7) to -50‰ (åk5) towards the grain boundary (Fig.2). The crystal growth length showing oxygen isotopic variation is ~40 μm across.

Grain 8 The åk content decreases gradually from the inner portion (åk14) to the grain boundary (åk4) (Fig.1b). The oxygen isotopic compositions are homogeneous (δ¹⁸O_{SMOW} = ~-22‰) in the inner portion (åk14-7). The value is different from that of the inner portion of grain 1. The δ¹⁸O_{SMOW} values gradually decrease towards grain boundary from -22‰ (åk7) to -40‰ (åk4) (Fig.2). The crystal growth length of the oxygen isotope variable area is ~30 μm across.

Grain 21 The åk content decreases gradually from the inner portion (åk22) to the grain boundary (åk2) (Fig.1c). The oxygen isotopic compositions are homogeneous (δ¹⁸O_{SMOW} = ~-7‰) in the inner portion of the crystal (åk22-6). The δ¹⁸O_{SMOW} values gradually decrease from -7‰ (åk6) to -30‰ (åk2) towards grain boundary (Fig.2). The crystal growth length of the oxygen isotope variable area is ~30 μm across.

Discussion: The three melilite grains (Grains 1, 8 and 21) show gradual oxygen isotopic zoning corresponding to the crystal growth of reversely zoned melilite. The oxygen isotopic zoning is observed in the gehlenetic portion less than åk7 and is gradually changed from ¹⁶O-poor to ¹⁶O-rich over the growth length of 30~40 μm.

These results indicate that the melilite condensation region changed temporally or spatially from ¹⁶O-poor to ¹⁶O-rich nebular environments during the crystal growth.

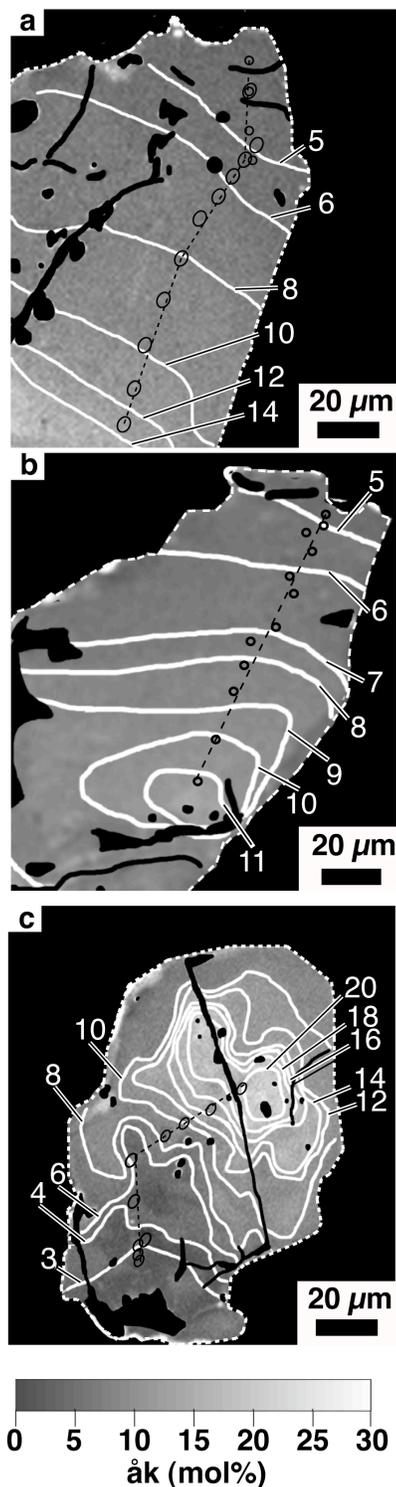


Fig.1. X-ray map of melilite crystals shown in åk composition for (a) Grain 1, (b) Grain 8, (c) Grain 21.. White dashed lines show grain boundaries of single crystal. The number in the contour line are corresponding to the åkermanite contents. Open circles along black dotted lines are analysis points by SIMS and the compositions are plotted in Fig. 2.

References: [1] Clayton R.N (1993) *Annu. Rev. Earth Planet. Sci.*, **21**, 115. [2] Yurimoto H. et al. (2008) *In Reviews in Mineralogy & Geochemistry.*, **68**, 141-187. [3] Harazono K. and Yurimoto H. (2003) *LPSC XXXIV*, No. 1540. [4] Krot A.N. et al. (2002) *Science*, **295**, 1050-1054. [5] Itoh S. and Yurimoto H. (2003) *Nature*, **423**, 728-731. [6] MacPherson G.J. and Grossman L. (1984) *GCA*, **48**, 29-46.

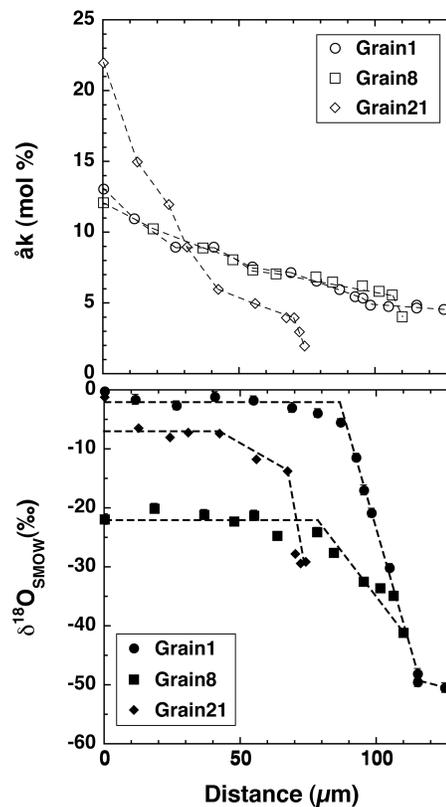


Fig.2. Plot of åkermanite contents (mol%) and oxygen isotopic compositions along the line traverses of Grains 1, 8 and 21 denoted in Fig.1.