Trapped Noble Gases of Antarctic CO3 Chondrites. S. Matsuda[1], R. Okazaki[2], and K. Nagao[1], [1]Geochemical Research Center, Graduate School of Science, University of Tokyo, Bunkyo-ku, Tokyo 113-0033, Japan. E-mail: matsuda@eqchem.s.u-tokyo.ac.jp. [2]Depertment of Earth and Planetary Sciences, Kyushu University, Higashi-ku, Fukuoka, Japan.

Introduction:

Chondrites contain primitive materials formed in the early stage of solar system evolution, including presolar grains. Formation processes of the various primitive materials should reflect environment, in which nebular accretion processed. Records of secondary alternations reveal the evolution history of meteorite parent body. Noble gas compositions of individual small components of chondrites would play the leading role among various elements to elucidate the origins of those components.

Allan Hills (ALH) 77307 is unequilibrated chondrite (petrologic type 3.0 [1]) and classified as CO chondrite, but there are some questions concerning its classification as a unique chondrite intermediate between the CO and CM classes [2]. Although major constituents in ALH 77307 are chondrules (Fig. 1a), there are many isolated olivine grains (Fig. 1b) surrounded with fine-grained rim in this meteorite. The relationship between these two components has been the subject of some considerable discussion. It has been argued that, in general, an isolated olivine grain is derived from chondrule [3]. However, Steele (1986) has suggested that at least some isolated olivines may be primitive nebular condensate material [4]. Both chondrules and isolated grains are rimmed by fine-grained dust (rim).

We preformed laser microprobe noble gas analysis on chondrules, isolated grains, their rims, and matrix in ALH 77307 [5]. To compare with ALH 77307, we prepared one another CO chondrite Yamato (Y)-82050 (CO 3.2), in which isolated olivine grains seem to be absent. Our goal is to understand the formation processes of isolated grain and rim.

Sample preparations and experimental methods:

Two thick sections with polished surface (~ 170 µm, and ~ 300 µm, respectively) ware made from chips of ALH 77307 and Y-82050. Petrographic observations and quantitative analyses of two CO chondrite polished sections were performed using a JEOL JXA-8530F EPMA at Kyushu University. Chemical compositions were determined with WDS at 15 kV, 10nA and 1 µm focused or 30 µm defocused beam condition. Noble gases were extracted by heating a small portion with a Nd-YAG laser (50 µm in beam diameter). Weights of fused material for one analysis are estimated to be 2-6 µg by assuming densities of chondrule and isolated olivine as 3.2 g/cm^3, and those of rim and matrix as 2.8 g/cm^3. Extracted noble gases were analyzed with modified VG5400 mass spectrometers at Kyushu University and University of Tokyo.

Results and discussion:

Olivine and pyroxene of chondrules in ALH 77307 are significantly Mg-rich, and their Fe/(Fe+Mg) composition (Fe#) are 0.3 - 2 and 0.6 - 3, respectively. In contrast to chondrules, the isolated olivine shows a variety of Fe# components from 1 to 42. Chemical compositions of the matrix and rims are identical (Fig. 2).

Isotopic ratios of He in ALH 77307 and Y-82050 are explained as a mixture of cosmogenic component and radiogenic ^{4}He. Ne analyses show that Ne-HL contained in presolar diamond is rich in the fine-grained rims around chondrules and the isolated grains. In the case of ALH 77307, the concentrations of Ne-HL in rims are (5.3 - 10) × 10^{-7} cm^{3}STP/g, while those in matrices are (2.4 - 3.7) × 10^{-7} cm^{3}STP/g. Isotopic ratios of Ar, Kr, and Xe in matrix and rims indicate the presence of Ar-rich gas, which is so-called "subsolar component " (Fig. 4).

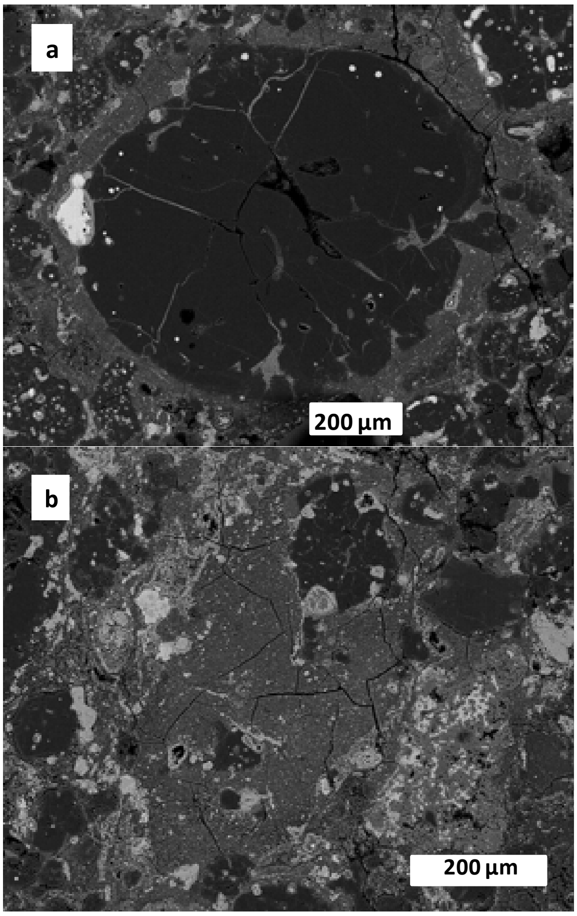

Fig. 1. BSE images of chondrule (a) and isolated grain(b) in ALH 77307.

The concentrations of trapped ^{36}Ar in the rim and the matrix of ALH 77307 are (9.2 - 28) × 10^{-6} cm^3STP/g, and those of Y-82050 are (2.3 - 10) × 10^{-6} cm^3STP/g.

<u>Cosmogenic He and Ne</u>: Cosmic-ray exposure ages are calculated based on the concentration of ^{3}He assuming that the extracted ^{3}He as cosmogenic. On the other hands, the concentration of cosmogenic ^{21}Ne is estimated assuming a two components mixture between Ne-HL [6] and cosmogenic Ne. Production rates of cosmogenic ^{3}He and ^{21}Ne were obtained using the formulae by Eugster (1988) [7] with the average shielding parameter $(^{22}Ne/^{21}Ne)_c$ = 1.11. Exposure ages calculated from the cosmogenic ^{3}He and ^{21}Ne in ALH 77307 are 30 - 47 Ma and 37 - 45 Ma, respectively, and those for Y-82050 are 10 - 19 Ma and 20 - 33 Ma, respectively. The shorter exposure ages calculated from cosmogenic ^{3}He than those from ^{21}Ne are explained by diffusive loss of He probably due to solar heating. These exposure ages of ALH 77307 and Y-82050 fall in the range of CO chondrites group (5 - 64 Ma [8]).

<u>Trapped noble gases in rims and matrices</u>: Two CO chondrites contain similar trapped noble gases in rims and matrices. $^{36}Ar_{trap}/^{132}Xe$ and $^{84}Kr/^{132}Xe$ ratios (Fig. 4) fall in range between those of Q and subsolar components (South Oman [9]). Trapped noble gases reported for other CO chondrites are similar to our data. If the observed $^{36}Ar_{trap}/^{132}Xe$ and $^{84}Kr/^{132}Xe$ ratio lower than those of typical subsolar gas in South Oman were produced by fractionation through loss of subsolar gas, the ratios are supposed to be reduced as the concentrations of trapped noble gases decreases. However, the ratios do not correlate with the concentrations of trapped ^{36}Ar nor ^{132}Xe. Accordingly, trapped noble gases in ALH 77307 and Y-82050 are mixture of subsolar and Q-gas components.

<u>Formation stage of rim in ALH 77307</u>: Amount of the presolar diamond in rims surrounding chondrules and isolated grains are higher compared to those in matrices. This suggests that the rims were produced from fine grained condensates in the early solar nebula by sticking onto chondrules together with presolar diamonds, prior to the formation of meteorite parent bodies. Because Ne-HL was detected even in aqueously altered Murchison (CM) [5], unequilibrated ALH 77307 (CO3.01) is quite unlikely to have lost Ne-HL in parent body. The different amounts of presolar diamonds between rim and matrix would reflect accumulation process of ALH 77307 parent body.

References:

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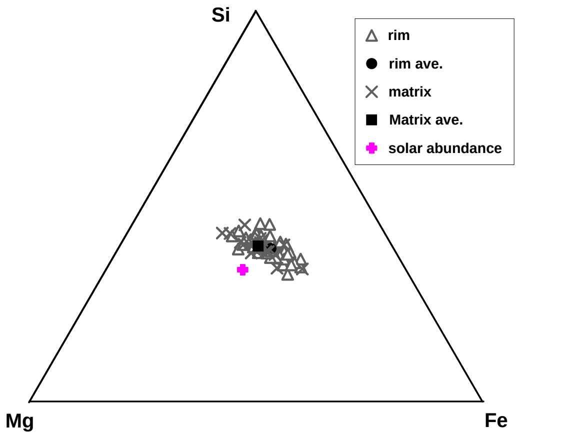

Fig. 2. Ternary Si-Mg-Fe wt% diagram for chemical composition of rim and matrix in ALH 77307 (CO3.0).

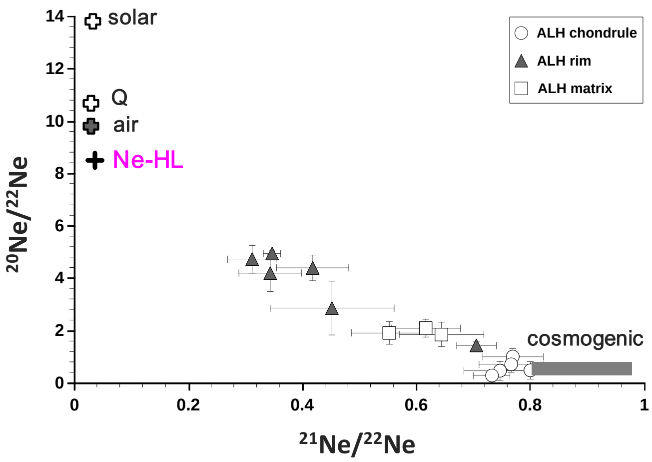

Fig. 3. Ne isotopic ratios of chondrule, rim, matrix in ALH 77307.

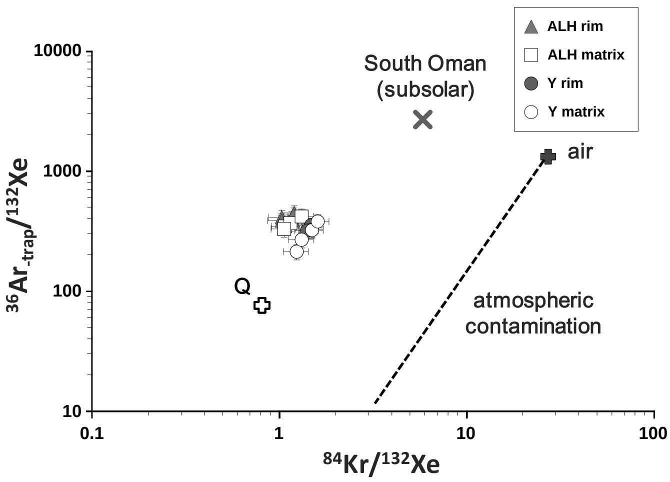

Fig. 4. Elemental ratios of trapped noble gases in rims and matrices in ALH 77307 and Y-82050. Dotted line indicates the fractionated terrestrial atmosphere.