DESTRUCTION OF PRESOLAR SILICATES BY AQUEOUS ALTERATION OBSERVED IN MURCHISON CM2 CHONDRITE.

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Introduction: Primitive meteorites contain presolar grains that predate the formation of our Solar System. Recently, presolar silicates are found in primitive chondrites and the abundance of presolar silicates is higher than those of most other presolar phases [1-4]. These studies conducted on the least thermally metamorphosed and aqueously altered chondrites. In this study, *in situ* search for presolar grains in Murchison CM2 chondrite were conducted. Because Murchison has undergone aqueous alteration, the comparison between the abundances of presolar silicates and carbonaceous grains allow us to look at the effects of aqueous alteration processes on presolar grain destruction.

Experimental: The sample used in this study is a polished thin section from Murchison CM2 chondrite. Areas of matrix and fine-grained rim around chondrules of Murchison were selected for the *in situ* survey of presolar grains. Isotope images (Isotopographs) were obtained by the TiTech isotope microscope (Cameca ims-1270 + SCAPS [5]). The analytical techniques for isotopographs basically followed those described elsewhere [3]. We acquired the following secondary ion images for one analyzing field as a sequence of $^{12}C^-$, $^{13}C^-$, $^{12}C^-$, $^{27}Al^-$, $^{28}Si^-$, $^{16}O^-$, $^{18}O^-$, $^{16}O^-$, $^{17}O^-$, and $^{16}O^-$. Total integration time for one field was ~1 hour. In order to obtain better lateral resolution of isotopographs than the case of [3], smaller contrast aperture (50 µm in diameter) was used in this study except for the case of C-isotopes. The contrast aperture (150 µm in diameter) was used for C-isotopographs in order to save sample consumption by sputtering with an enough precision of isotope ratio through the sequence. The lateral resolutions of the isotopographs using contrast aperture of the 50 µm and the 150 are ~0.3-0.5 µm and ~1 µm, respectively. These analytical conditions keep the sputtering depth is less than 100 nm through the sequence. The digital image processing using a moving-average (3 x 3 pixels for O and 5 x 5 pixels for C) were applied to simple secondary ion ratio images in order to reduce the statistical error. C- and O-isotopic ratios of matrix for Murchison chondrites [6] were used for normalization from secondary ion ratios to the isotope ratios. The selection criterion for distinguishing presolar grains and estimation of the errors of the grains are same as [3].

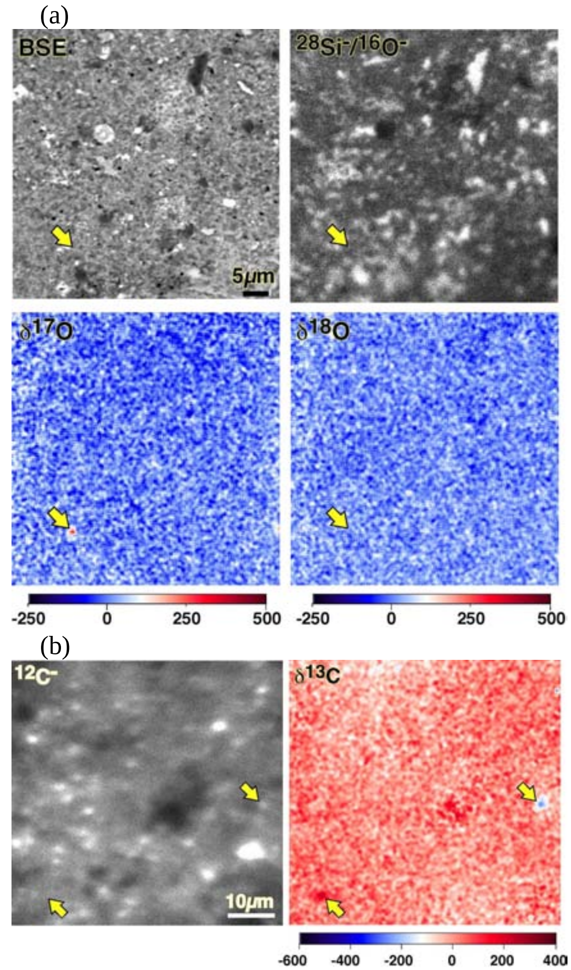

Figure 1(a). Corresponding images of BSE, secondary ion ratio ($^{28}Si^-/^{16}O^-$), and O-isotope ratios ($\delta^{17}O$ and $\delta^{18}O$). (b) Corresponding images of secondary ion ($^{12}C^-$) and C-isotope ratios ($\delta^{13}C$). Yellow arrows indicate location of presolar grains.

Results: Thirty-six regions of matrix and of fine-grained rim (usable areas are ~140,000 and ~130,000 µm^2 for C- and O-isotopographs, respectively) were analyzed. Based on the O-isotopographs (Fig. 1(a)), a total of 4 presolar O-rich grains were identified. The O-isotopic compositions of these grains are shown in Fig. 2 along with those of isotopically normal matrix grains. Because the isotopically anomalous values of the presolar grains will be diluted by the surrounding isotopically normal matrix grains, the measured isotopic ratios of each presolar grain represent the lower limits of the true isotopic anomalies. From the

O-isotopic characteristics, three grains enriched in ^{17}O and one grain depleted in ^{18}O are categorized to group 1 and group 3 presolar oxide grains [7], respectively. The location of the grains are composed of aggregates of 0.1~0.5 µm grains. Isotopographs and SEM-EDS investigation show no intense Al peaks and show high abundance of Si, Mg, and Fe at the location of the grains. These characteristics suggest that the presolar O-rich grains found in this study are probably silicates although grain identification has not been conclusive. The grain densities of presolar silicates relative to matrix fraction are estimated to be ~30 /mm^2, and the abundance is calculated to be ~3 ppm if we assume the size of presolar silicate grains are 0.3 µm which is typical size of presolar silicate grains in chondrites [1-4].

Based on the C-isotopographs (Fig. 1(b)), a total of 14 presolar carbonaceous grains were identified. The C-isotopic compositions of these grains are shown as a histogram in Fig. 3. The carbon isotopic ratios of these grains fall within the range of values for presolar SiC [8] and graphite grains [9], and have similar distribution to that of mainstream SiC [8]. Although identifications of these carbonaceous grains were not conclusive, these isotopically anomalous carbonaceous grains should be SiC or graphite, which are abundant types of presolar grains in Murchison [10]. The grain densities of presolar carbonaceous grains relative to matrix fraction are estimated to be ~100 /mm^2, and the abundance is calculated to be ~9 ppm if we assume the size of presolar carbonaceous grains are 0.3 µm.

Discussion: The abundances of presolar silicates are estimated to be 15-110 ppm in type 3 primitive chondrites [1-4] and are higher than those of other presolar species in meteorites, with the possible exception of diamonds [11]. In contrast, the abundance of presolar silicates in Murchison is much lower than those of [1-4, 12]. Moreover, the abundances of presolar silicates seem to be lower than those of presolar carbonaceous grains. This contrast comparing with the abundances of presolar grains in type 3 primitive chondrites suggests that preferential destruction of presolar silicates by aqueous alteration and/or heterogeneous distribution between presolar silicates and presolar carbonaceous grains among chondrite forming regions in the solar nebula. Because not only Mg-rich olivine and pyroxene are unstable under aqueous alteration conditions but also carbonaceous grains are resistant against aqueous alteration [10], the aqueous alteration effect is preferable to interpret the results. In other words, presolar silicates were preferentially destroyed than presolar carbonaceous grains by aqueous alteration processes on Murchison parent body and/or in the solar nebula. We will conduct further studies on different classes and petrologic types of meteorites to understand quantitative destruction processes of presolar grains in the early solar system.

References: [1] Mostefaoui S. et al. (2003) *Meteorit. Planet. Sci. 38,* A99. [2] Nguyen A. N. and Zinner E. (2004) *Science, 303,* 1496-1499. [3] Nagashima K. et al. (2004) *Nature, 428*, 921-924. [4] Mostefaoui S. and Hoppe P. (2004) *ApJ, 613,* L149-L152. [5] Yurimoto H. et al. (2003) *Appl. Surf. Sci., 203-204*, 793. [6] Clayton R. N. and Mayeda T. K. (1999) *GCA, 63*, 2089-2104. [7] Nittler L. R. et al. (1997) ApJ, 483, 475-495. [8] Hoppe P. et al. (1994) *ApJ, 430*, 870-890. [9] Hoppe P. et al. (1995) *GCA, 59*, 4029-4056. [10] Huss G. R. et al. (2003) *GCA, 67*, 4823-4848. [11] Zinner E. (1998) *Ann. Rev. Earth Planet. Sci., 26*, 147-188. [12] Kobayashi et al. (2005) *LPS XXXVI*, this volume.

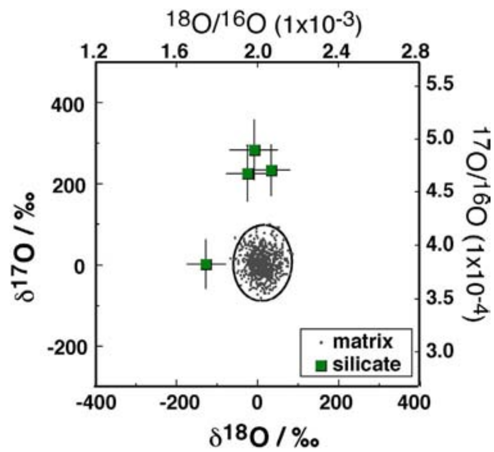

Figure 2. Oxygen isotopic ratios of presolar silicate grains. Also shown are the isotopic ratios of isotopically solar matrix. Error ellipse around plots for the matrix have axes that are 3 times the standard deviation in the direction of the correlation line for the matrix and normal to it. Error bars for presolar grains denote 2σ.

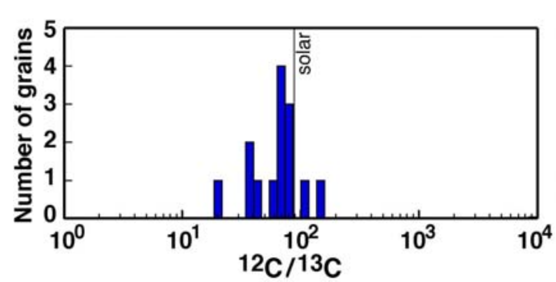

Figure 3. The distribution of carbon isotope ratios of presolar carbonaceous grains.