OXYGEN ISOTOPIC COMPOSITION OF STELLAR WIND FROM THE PROTOSUN. H. Yurimoto[1], S. Itoh[1] and S. Ebata[1], [1]Department of Natural History Sciences, Hokkaido University, Sapporo 060-0810, JAPAN (yuri@ep.sci.hokudai.ac.jp).

Introduction: Recently, NASA's Genesis mission has clarified that the sun has a very different oxygen isotopic composition than the earth, planets and meteorites [1]. The observed isotopic composition of the Sun is enriched in ^{16}O (60-70‰) relative to terrestrial and planetary compositions, which supports self-shielding models for the origin [2, 3, 4, 5]. This value is generally believed to be representative of the solar system because greater than 99% of the mass of the solar system has been concentrated in the Sun. However, self-pollution of the convective zone of the Sun might have occurred via the infall of planetary embryos during the planet formation epoch of the early solar system [6] because the solar photospheric composition is enriched in metallicity relative to nearby Galactic neighbors [7].

Oxygen isotopic compositions of planetary embryos are close to the terrestrial value [8]. This means that the oxygen isotopic composition of the solar photosphere may not be representative of the solar system, and the interior of the Sun should be more enriched in ^{16}O than the convective zone if self-pollution occurred. Furthermore, the oxygen isotopic composition of the solar photosphere would become more ^{16}O-rich with time because the metal-rich convective zone would be diluted by deeper layers with solar evolution [6]. This self-pollution model of the solar system can be tested if we determine oxygen isotopic compositions of the solar photosphere during the planet formation epoch [9]. Here we report oxygen isotopic compositions of solar wind trapped in meteorite during the planet formation epoch.

We studied the NWA 801 carbonaceous chondrite, which is extremely enriched in noble gases of solar origin [10, 11, 12]. The noble gases are observed in matrices and also in chondrules that trap the gases with concentration of up to about 10^{-4} and 10^{-6} cm^{3}STP/g for ^{20}Ne in the matrices and chondrules, respectively. The solar wind oxygen is expected to be at ppm levels if solar abundances were preserved during trapping.

We measured oxygen isotopic compositions of metals embedded in the matrices and in chondrules by secondary ion spectrometry [9].

Results and Discussion: In the metal grains, oxide inclusions less than 1 μm are common (Fig. 1). Characteristic X-ray signals of Mg have not been observed from the inclusions, but Si and O signals have been observed, and a sulfide phase coexists in most cases. The chemical compositions show the oxide inclusions are different from chondrule melt, indicating direct segregation from metal. Oxygen ion intensities from metals containing the inclusions were primarily from the inclusions. The oxygen isotopic compositions lie along the terrestrial fractionation line (Fig. 2) indicating that the metals formed with planetary oxygen isotopic compositions.

After the inclusion segregation, oxygen contents in the metals would significantly decrease. Therefore, the metal is a good target to determine trapped oxygen of stellar winds during the planet formation epoch. We selected inclusion-free areas in the metals and analyzed the oxygen isotopes (Fig. 1). The oxygen isotopic compositions from metals without inclusions mainly plot around the terrestrial fractionation line, but several analyses clearly deviate downward from the terrestrial fractionation line (Fig. 2). In order to clarify the deviation from the terrestrial fractionation line, we introduce Δ^{17}O (Fig. 3).

The histogram of Δ^{17}O is composed of two Gaussian curves (Fig. 3). The main peak curve consists of Δ^{17}O=2.3‰ for the peak and ±7.5‰ for the standard deviation. This curve is probably due to terrestrial adsorbed water or to oxide inclusions <<0.1 μm because these contributions cannot be completely removed during the experiments. However, the accompanying curve consists of Δ^{17}O=-35.0‰ for the peak and ±7.1‰ for the standard deviation. The oxygen contents are less than 10 ppm (Fig. 3). This concentration level is expected for solar origin oxygen in this chondrite based on the noble gas contents of the chondrite [10, 11, 12] and assuming solar abundance of elements [13].

These results have the consequence that the accompanying curve consists of trapped stellar winds from the protosun during the planet formation epoch. Therefore, the oxygen isotopic composition of the protosun is enriched in ^{16}O and calculated to be Δ^{17}O=-35.0±2.1‰ where the error is standard deviation of the mean. The composition quantitatively agrees with the value of the present photosphere composition [1] and the most ^{16}O-rich composition from meteorites [14].

Because self-pollution changes oxygen isotopic compositions of the solar convective zone, the agreement of oxygen isotopic compositions between the protosun and present day sun demonstrate that self-pollution by planetary embryos was not significant for solar system evolution. The results reported herein demonstrate that the solar photosphere has the representative composition of the solar system.

References: [1] Mckeegan, K. D. et al. (2009) *LPS XL*, Abstract #2494. [2] Clayton, R. N. (2002) *Nature 415*, 860-861. [3] Yurimoto, H. and Kuramoto, K. (2002) *Meteoritics & Planet. Sci., 37*, A153. [4] Yurimoto, H. and Kuramoto, K. (2004) *Science 305*, 1763-1766. [5] Lyons, J. R. and Young, E. D. (2005) *Nature 435,* 317-320. [6] Gonzalez, G. (1997) *Mon. Not. R. Astron. Soc 285,* 403-412. [7] Snow T. P. and Witt, A. N. (1996) *APJ 468,* L65-L68. [8] Yurimoto, H. et al. (2007) *PPV,* 849–862. [9] Fujimoto, K. et al. (2009) *Geochem. J. 43,* e11-e15. [10] Matsuda, S. et al. (2009) *LPS XL,* Abstract #1628. [11] Nakashima, D. et al. (2009) *LPS XL,* Abstract #1661. [12] Nakashima, D. et al. (2009) *LPS XL,* Abstract #1674. [13] Lodders K. (2003) *APJ 591*, 1220-1247. [14] Kobayashi, S. (2003) *Geochem. J. 37*, 663-669.

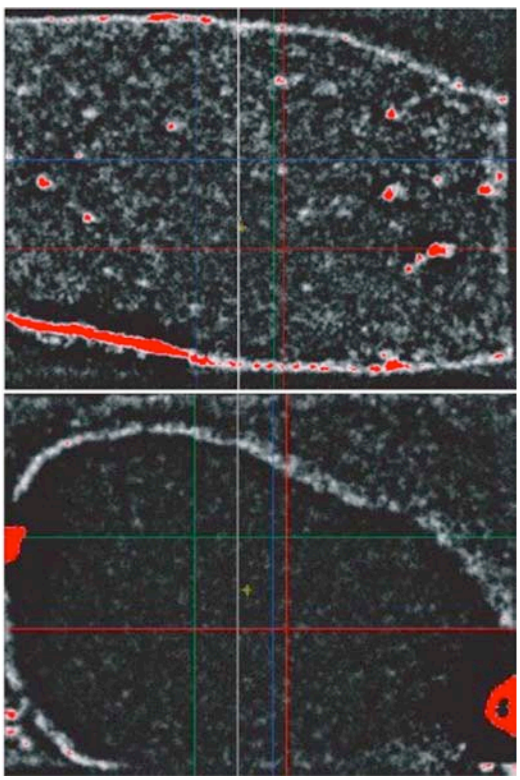

Fig. 1. Secondary $^{16}O^-$ ion images from different metal grains in NWA 801 CR2. Width of images are 100 µm. $^{16}O^-$ ion emission from adsorbed water on the surface is observed as a ring which corresponds to edge of primary beam. Spots of red color in the primary beam irradiation area correspond to oxide inclusions. Many inclusions are observed in the upper image, but not in the lower image.

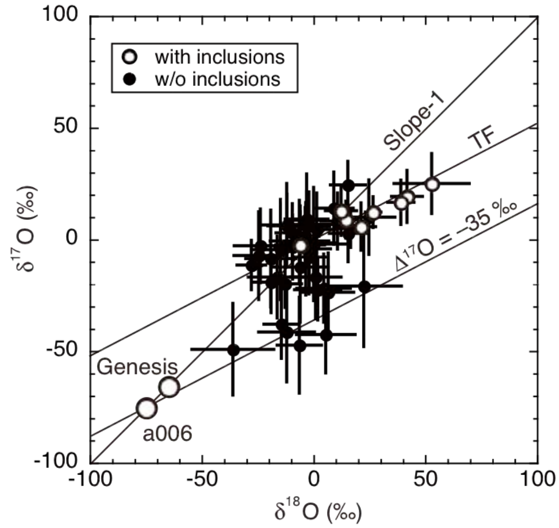

Fig. 2. Oxygen isotopic compositions of metal grains in a gas-rich chondrite, NWA 801 CR2. Genesis, and a006 correspond to representative oxygen isotopic compositions for present day solar wind by NASA Genesis mission [1], and a chondrite with the most ^{16}O-rich composition [14] ever found, respectively. $\delta^{17,18}O$ is normalized to a standard of the NIST 665 metal.

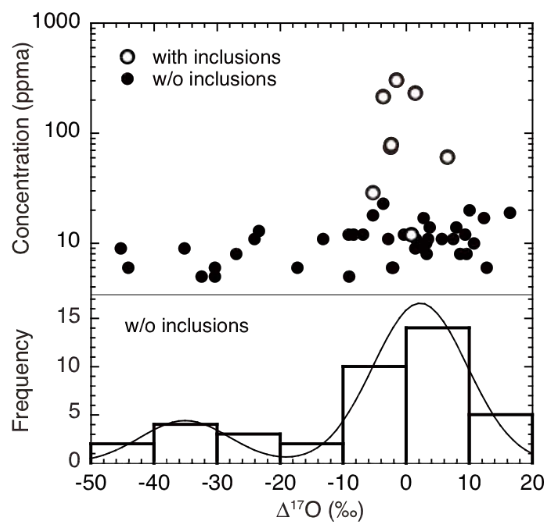

Fig.3. Oxygen concentrations and histogram of metals in NWA 801 CR2 versus $\Delta^{17}O$. The histogram can be interpreted by two Gaussian curves characterized by the solar and planetary oxygen isotopic compositions. $\Delta^{17}O = \delta^{17}O - 0.52\delta^{18}O$.