VISUALIZATION OF SEDIMENTARY STRUCTURE IN CHONDRITE BY 2-D HELIUM IMAGING.

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Introduction: Gas-rich meteorites incorporate large amounts of solar wind noble gases. Ingredients of the gas-rich meteorites contain noble-gas-rich rocks derived from solar wind implantation into outermost rocks of the parent body [1]. The solar wind gases in the meteorites were incorporated by mixing the implanted rocks and the internal solar noble gas free materials through an impact gardening [2]. Therefore, gas-rich meteorites commonly show a prominent brecciated appearance [2]. Noble gas studies were conducted for one of the gas-rich chondrites Northwest Africa 801/852 (NWA 801/852) paired CR chondrites [3, 4]. Nakashima and coauthors reported that some chondrules in NWA 852 contained solar wind derived noble gases [4]. The distribution of solar wind gas in the gas-rich chondrites may provide insight into an evolution of the chondrite parent body according to the solar wind acquisition. Here we present solar wind He distributions in the matrix from NWA 801, which could imply a regolith sedimentation process by the impact gardening.

Experiment: In this study, we used a polished section of NWA 801. Petrographic observations were conducted using a field emission scanning electron microscope (FE-SEM: JEOL JSM-7000F). Ion imaging was carried out using laser ionization mass nanoscope (LIMAS). LIMAS is a time-of-flight (TOF) secondary neutral mass spectrometer that can measure noble gases with a high spatial resolution (lateral and depth resolution ~20 nm) using a femtosecond laser for postionization and Ga focused ion beam [5, 6]. We have developed a large-area ion imaging technique, which enabled us to perform He imaging of 200 × 100 µm square [7]. Primary ion beam pulse of $^{69}Ga^{+}$ (32 nA for the beam current, ~1 µm in diameter, and 300 ns for the pulse width) was scanned on the sample surface for an area of 150 × 100 $µm^2$ with 1 µm step interval. Post ionized ions were introduced into multi-turn TOF mass spectrometer MULTUM II [8] with an acceleration voltage of −5 kV. We measured $^{4}He^{+}$, and major element ions of chondrites, $^{56}Fe^{2+}$, $^{24}Mg^{2+}$, $^{16}O^{+}$, $^{32}S^{2+}$, and $^{28}Si^{+}$, of which mass resolving power was 20,000.

Results and Discussion: The He ion images show that the matrix of NWA 801 is a mixture of He-poor and He-rich areas. He-poor and He-rich mean He-undetectable and He-detectable by LIMAS under the above measurement conditions. The He-poor areas appear as blocks ranging from several tens to several hundred micrometers across. The He-poor blocks are randomly stacked in the matrix. The interstitial spaces between He-poor blocks are filled by He-rich areas. The He-poor blocks are composed of unidentified sub-micrometer sized matrix silicates. Fine-grained minerals (mostly less than micrometers) of olivine, pyroxene, Fe-hydroxide, magnetite, and troilite are embedded in the matrix silicates. The grains of Fe-hydroxide, magnetite, and troilite might be originally metal grains. The He-rich areas are also composed of unidentified sub-micrometer sized matrix silicates. However, coarser sizes of olivine, pyroxene, Fe-hydroxide, magnetite, and troilite grains (up to several ten micrometers) are scattered in the matrix silicates in addition to finer minerals observed in He-poor blocks.

Variations for He intensities in minerals of He-rich area are more than two orders magnitudes. The variation in He intensity should reflect differences in the duration of solar wind irradiation. Such wide variation of solar wind irradiation suggests that the materials of He-rich areas correspond to surface soils of the CR chondrite parent body. On the other hand, the He-poor blocks are subsurface materials of the CR chondrite parent body. The He distribution texture would result from gardening sedimentation.

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