ARTIFICIAL COSMIC SPHERULES PRODUCED BY MELTING EXPERIMENTS OF THE POWDERED CARBONACEOUS CHONDRITES.

T. Gondo[1] and H. Isobe[1], [1]*Dept. Earth Envi. Sci., Grad. Sch. Sci. Tech., Kumamoto Univ., Kurokami, Kumamoto, 860-8555, Japan, e-mail: isobe@sci.kumamoto-u.ac.jp*

Introduction: Micrometeorites (MMs) are extraterrestrial fine particles derived from asteroids and comets and continuously falling to the Earth. Depending on their velocity, mass and entry angle, micrometeorites have undergone various degrees of heating during the atmospheric entry within a few seconds. This heating lead to significant textural, mineralogical and chemical modifications to MMs.

Micrometeorites are steady accumulation flow of planetary materials to the Earth. The annual mass is estimated at approximately 30,000 tons. The MM samples can be collected from Antarctia, ocean floor sediments and suspended particles in the stratosphere. Some MMs show remarkable similarity on mineralogy and chemical compositions to carbonaceous chondrite [1, 2].

MMs can be classified into two groups based on their size and textures: (1) fine-grained MMs (FgMMs), which are dominated by a fine-grained porous groundmass of micron-sized minerals, and (2) coarse-grained MMs (CgMMs), which are dominated by anhydrous silicates with larger than several micron meters, generary with glassy mesostasis [3].

The MMs larger them 70 μm in diameter show variously melted textures. In particular, completely melted micrometeorites are known as cosmic spherules. Cosmic spherules have experienced large degrees of melting of precursor materials during atmospheric entry, and form molten droplets. Cosmic spherules show considerable diversity in textures, compositions and mineralogy depending on characteristics of precursor materials and atmospheric heating [3,4].

In this study, we carried out rapid heating and quenching experiments on fine particles of the Allende meteorite and Murchison meteorite to reproduce cosmic spherules by atmospheric entry.

Experimental: We used powdered Allende meteorite (typical CV3 chondrite) and Murchison meteorite (CM2 chondrite) with approximately 100 μm in diameter as the starting material. The rapid heating and quenching within a few seconds are implemented by free fall of starting material particles through a high temperature vertical furnace with regulated gas flow of H_2, CO_2 and Ar to control oxygen fugacity and total gas flow [5]. Upward gas flow in the furnace tube can reduce falling velocity of the particles to reproduce thermal history of the cosmic spherules. The maximum temperature of the particles in this study is approximately 1520 °C. In the furnace, fO_2 is controlled to oxygen partial pressure of the upper atmosphere at approximately altitude of 86 km where MMs heated. Run products are retrieved from the bottom of the furnace tube and observed with a field-emission scanning electron microscope (FE-SEM, JEOL JSM-7001F) and analyzed with an energy dispersive X-ray spectroscopy (EDS, Oxford INCA system).

Results and Discussion: The run products show quite analogous textures to micrometeorites including scoriaceous, porphyritic olivine and barred olivine. Almost molten particles show spherical shape due to surface tension of the silicate melt. The outside shape of the particles is various depending on melt fraction of the particle.

<u>1. Result of Allende meteorite as starting material</u>

Fe-rich rim in olivine crystals found in the porphyritic olivine spherules, can be considered to be formed during quenching (Fig. 1). Olivine phenocrysts in porphyritic spherules are characterized by hexagonal shape with sharp

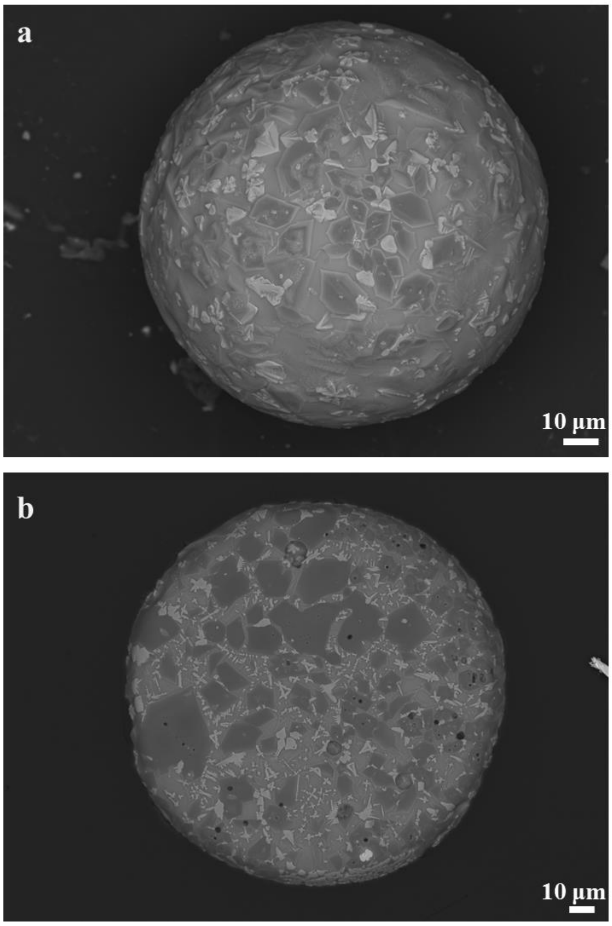

Fig. 1 Backscattered electron images of a porphyritic olivine spherule in the run product as the starting material of powdered Allende meteorite. (a) surface of the spherule, (b) polished section of the spherule shown in (a).

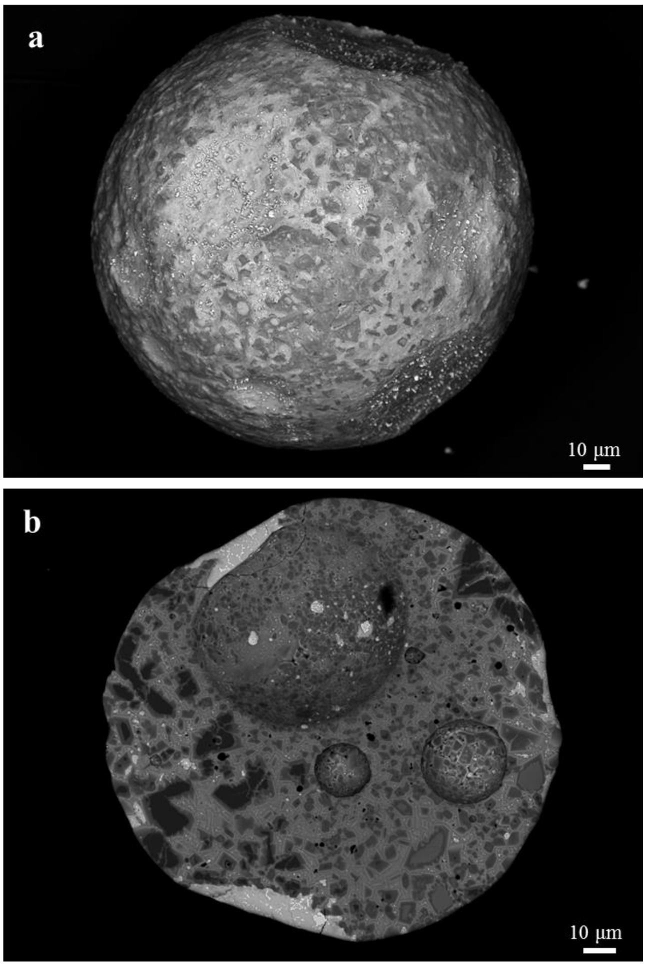

Fig. 2 Backscattered electron images of a porphyritic spherule showing a porous texture with olivine relict grains in the run product from powdered Murchison meteorite as the starting material. (a) surface of the spherule, (b) polished section of the spherule show in (a).

edge. The sharp-edged olivine phenocrysts are quite rare in chondrules. It occurs, however, in molten micrometeorites, known as cosmic spherules. Internal texture of the artificial cosmic spherule produced in this work shown in Fig. 1(b) is remarkably similar to that of the natural porphyritic spherules shown in Figs. 1(A) and (B) of Cordier et al. (2011) [6].

2. Result of Murchison meteorite as starting material

Many run products show relict-bearing PO spherules containing relict anhydrous silicates (olivine and pyroxene) derived from mineral fragments in Murchison meteorite (Fig. 2). Olivine phenocrysts in porphyritic spherules are also characterized by hexagonal shape with sharp edge. Olivine phenocrysts are smaller than those in the run product of the Allende meteorite, and many voids numerous bubbles with various diameter can be seen in the spherules of run products. Internal texture of the artificial cosmic spherule produced in this work shown in Fig. 2(b) and Fig. 3(b) are remarkably similar to those of the natural porphyritic

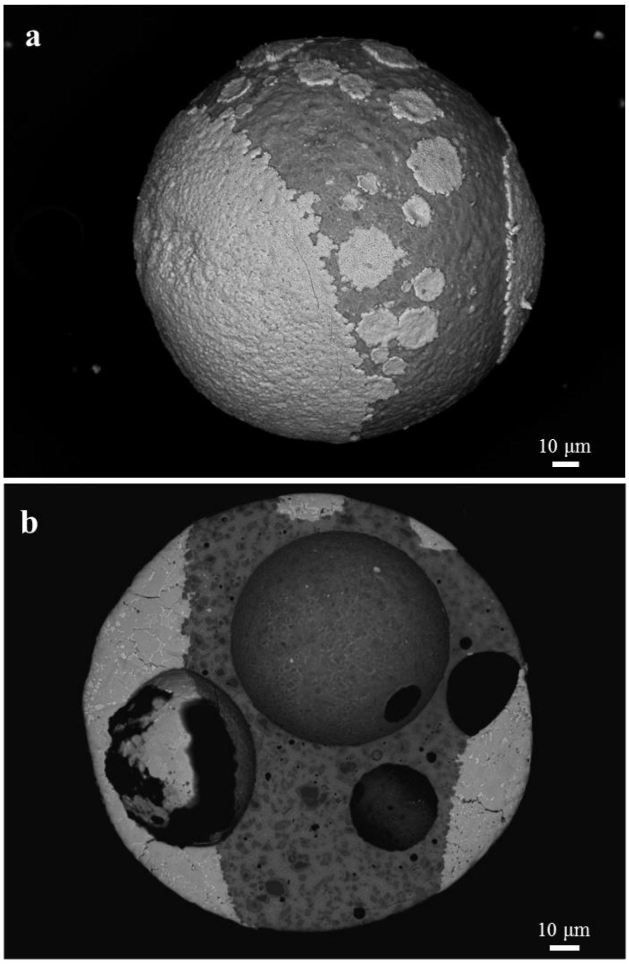

Fig. 3 Backscattered electron images of a porphyritic spherule showing a porous texture with olivine relict grains. (a) surface of the spherule, (b) polished section of the spherule show in (a).

spherules shown in Figs. 1(C) and (D) of Cordier et al. (2011) and Fig. 1 (u) and (v) of Genge et al (2008) [3, 6].

On the surface of molten spherules, Fe sulfide also occur (Fig. 3). Immiscibility between sulfide melt and silicate melt may induce sulfide melt discharge from silicate melt. Iron-nickel metal is contained in the sulfide melt of spherules both run products (Figs. 2, 3).

In this study, we successfully reproduced artificial cosmic spherules with remarkably analogous textures to natural ones. We can compare each of the natural ones and these run products, and analogy of the run products to micrometeorites can be discussed on textural, mineralogical and chemical modifications during atmospheric entry of inter planetary materials.

References: [1] Love, S.G. & Brownlee, D.E. (1993) *Science*, *262*, 550-553. [2] Reietmeijer, F.J.M. (2000) *Meteoritics & Planetary Science*, *35*, 1025-1041. [3] Genge, M.J. (2008) *Earth Moon Planet*, *102*, 525–535. [4] Love, S.G. & Brownlee, D.E. (1991) *Icarus*, *89*, 26-43. [5] Isobe, H. & Gondo, T. (2013) *Jour. Mineral. Petoral. Sci.*, 108, 227-237. [6] Cordier, C. et al. (2011) *Meteoritics & Planetary Science*, *46*, 1110–1132.