Morphology and surface topograph of fine particles in the meteorite matrix

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The chondrite matrix had mainly experienced two processes, namely condensation from nebula gas and alteration in the parent body. The purpose of this study is to determine which information has remained in the matrix. In order to do it, a new technique for the investigation of the morphology and the surface microtopograph of particles in the chondrite matrix was established. Samples for surface observation on the nm scale were prepared by soft cracking with rapping in weighing paper. The obtained fragments with a few mm in radius were picked and then mounted on a carbon tape which was fixed on steel disks. Field emission scanning electron microscopy (FE-SEM) (Jeol SM-6500F) was used (acceleration voltage; 1.5 kV) to observe the morphology and surface microtopograph of the particles in the meteorite matrix. The chemical constitution of the particles was analyzed with energy dispersion X-ray (EDX) equipped on the same FE-SEM. High resolution surface microtopography was applied by an atomic force microscope (AFM) (Digital Instruments (DI) Nanoscope IIIa). These procedures enabled us to investigate morphology and surface microtopograph of the particles in the matrix.

The matrix of Allende carbonaceous chondrite were investigated by the technique established in this study. Many faceted particles were observed, and these were recognized to be olivine. These olivines have various morphologies, and these were classified into platy hexagonal, column, platy square, octahedron-like shape, and acicular. These morphologies were also found in synthetic olivines condensed from vapor. Surface microtopograph of these olivine particles were also investigated. Although the matrix had formed 4.6 billion years ago, we found sharp spiral steps on (001) face. These exhibited characteristic pattern of vapor growth, such as the steps develop straight lines arranged in a polygonized shape. Additionally, several types of growth mechanisms were observed, like layered growth (spiral growth), hopper crystal (2D-growth), and droplets resulting from VLS growth. It was concluded from the observation of the morphology and the surface microtopograph that these olivines were formed from the vapor. Furthermore, the variety of morphology and surface microtopograph implies that the environment of nebula, when these particles had been formed, showed very dynamic conditions such as generating locally rapid heating and cooling like a shock wave model and not that the nebula gas cooled uniformity and gradually.

Morphology and structure of magnetite in the matrix of Tagish Lake carbonaceous chondrite were investigated by the same technique. This chondrite is considered to suffer aqueous alteration. It was found that magnetite was ubiquitous in the matrix and has various morphologies and a wide range of distribution in radius. The characteristic structure indicates that magnetite particles had arranged by self-organization. Furthermore, the constituent particles of the self-organization were also distinctive particles. The particles consist of only (110) faces that should not appear in the FCC structure, and these have several boundaries interiorly. Considering these anomalous morphology and structure, it was estimated that these magnetite was formed under a very distinct environment in the parent body.

It was concluded in this study that investigating the morphology and surface microtopograph of particles in the matrix enable us to know that olivine in the matrix has stored information of the early solar nebula. Furthermore, it revealed the environment of the early solar nebula and parent body when the particles of Allende and Tagish Lake chondrite matrix had formed.