# Magnetite Colloidal Crystals in the Meteorite

# Jun Nozawa[1]; Katsuo Tsukamoto[2]

[1] Geology, Sci., Tohoku Univ; [2] Graduate School of Science, Tohoku University

http://www.ganko.tohoku.ac.jp/shigen/tsukamoto.html

Self-assembled colloid particles are extensively studied in the field of nano-technology, e.g. application for the new functional materials such as photonic device. In the meteorite, we found magnetite (Fe3O4) colloidal crystals of each comprising particles has morphologies and therefore it has unique features not appeared in case that like a latex sphere.

We used the Tagish Lake carbonaceous chondrite as the sample. This meteorite had experienced heavy aqueous alteration at the meteorite parentbody, and magnetite had formed in the solution. The meteorite is aggregate of micrometer size inclusions and few micrometer fine particles, which is comprised by such as silicate and carbonate. Therefore, only cracking the specimen, the micrometer fine particles appeared on the surface of fragment of mm size specimen, and then those were observed by Field Emission Scanning Electron Microscopy and Transmission Electron Microscopy.

Thousands of magnetite particles always appear together at one place. There are cases that magnetite particles appear with same size and various sizes. When the size of magnetite particles is same, morphology of the particles is also the same. When the magnetite particles have various sizes within the one place, there are cases that morphology is same or not. In the case of size and morphology is the same, although magnetite particles usually appear random configuration, there are areas where particles ordered regularly, repeating pattern extending in three spatial dimensions, namely the colloidal crystals. These colloidal crystals have not only the 2-dimentional structure but also a 3-dimensional one. Most of them have sphere in shape, and cubic one is rarely observed. The sizes of bulk colloidal crystals were from 3 to 11 micrometer in diameter.

We could observe three structures of colloidal crystals in this meteorite. First one with body centered cubic (b.c.c.) lattice structure comprised by 150nm particles. This particle is formed only $\{111\}$ face, i.e. octahedron in shape. Second one with face centered cubic (f.c.c.) lattice structure comprised by 200nm particles. This particle is formed only $\{110\}$ face, the shape is rhombic dodecahedron, and has some interesting features, whose details are described later. Third one with f.c.c. and hexagonal close packing (h.c.p.) lattice structure comprised by 600nm particles. The f.c.c. and h.c.p. structure could not distinguish by the applied observation method. Colloidal crystal doesn't appeared when its comprising particles more than 600nm in diameter. Consequently, the morphology of comprising particles determines the lattice structures of the colloidal crystal.

Colloidal crystals with f.c.c. structure consisted by rhombic dodecahedron magnetite particles. It is interesting to note that depressed area on certain edge of this particle was found by FE-SEM observation. Same type magnetite particles observed using TEM. There are clear boundaries in the particles, and these correspond to the depressed area observed by FE-SEM. Furthermore, high resolution TEM observation demonstrates the mismatch of lattice at the position of boundary. Thus, this magnetite particle has a number of boundaries inside. This structure is similar to those of the multiple-twin particle, which are well known in ultra-fine particles. In the case of synthesize the magnetite particles from solution, the ratio of multiple-twin particles are at most several percent of the total magnetite particles. It should make a special mention that the all particles comprising the rhombic dodecahedron are multiple-twin and furthermore the size is uniform.

These structures of magnetite colloidal crystals and magnetite particles would be the hint to reveal the process in the parent-body, and would be the new approach for the planetary science.