# Characteristics of GEMS-bearing MMs: IDPs that fell on the surface of the earth several thousands years ago.

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Antarctic micrometeorites (AMMs) have been collected from blue ice fields in Antarctica. Vast majority of AMMs recovered from blue ice fields (hereafter blue ice field MMs) are similar to heavily hydrated carbonaceous chondrites, which were probably derived from asteroids. On the other hand, about a half of interplanetary dust particles (IDPs) collected in the stratosphere has anhydrous mineralogy. Most of the anhydrous IDPs are quite porous and fragile and at least a part of them were probably derived from comets. Such chondritic porous IDPs (hereafter CP IDPs) are characterized by the presence of abundant GEMS (glass with embedded metal and sulfides), enstatite whisker, and carbonaceous material that connect the other components. However, no blue ice field CP IDPs have not been discovered to date. Discovery of MMs indistinguishable with CP IDPs are quite important to testify that probable cometary material could have reached the surface of the earth in the past. In this paper, we would like to report the first discovery of two blue-ice field MMs that contain GEMS and enstatite whiskers.

We found a small number of porous blue-ice field MMs among more than 3000 ones at Tottuki Point, Antarctica. Synchrotron radiation X-ray diffraction (SR-XRD) data show that they contain pyroxenes as well as olivine and magnetite and/or wustite. High magnification secondary electron images of the porous MMs revealed at least two of them contain acicular, blade-shaped, and rod-shaped objects (0.1 to 0.5 micrometer x 2 to 5 micrometer) on their surfaces. A Focused ion beam system for TEM sample preparation) was used to make TEM sample of a rod-shaped object on the surface of a MM To440020. SAED pattern of the object displays that the rod-shaped object revealed that it is a unit-scale mixture of clino- and ortho-enstatite with many stacking disorders that are parallel to (100) of them. Its elongated direction is parallel to a-direction of the crystal. No screw dislocations along a-direction of the pyroxene were observed. These features are common to those of enstatite whisker in CP IDPs. TEM observation of ultrathin sections of this MM and another one TT54C394 revealed that both of them contain elongated low-Ca pyroxene crystals that have common crystallographic features to enstatite whiskers in CP IDPs. Their chemical compositions are also almost the same with those of the enstatite whiskers. Both of the MMs contain 100- to 400-nm across spheroidal objects, containing small amounts of Fe-Ni metal and Fe-bearing sulfide. Their chemical composition overlaps with those of GEMS in CP IDPs. Therefore, these two MMs contain both enstatite whiskers and GEMS. Based on the mineralogy, they are regarded as CP IDPs that fell on the surface of the earth in the past (about several thousands years ago).

Both of them contain carbonaceous nanoparticles (or organic globules) that are common among heavily hydrated carbonaceous chondrites and micrometeorites. In TT54C394, carbonaceous nanoparticles are more abundant than those in To440020. In the former, there are abundant poorly crystalline material containing aggregates composed of (Mg, Fe) oxide. Because the oxide contains small amounts of Ca and Mn, they were Mg- and Fe-carbonate before entering the atmosphere of the earth. Therefore, it is suggested that TT54C394 experienced aqueous alteration on its parent body. It has been a problem whether CP IDPs experienced aqueous alteration on their parent bodies or not although there are rare CP IDPs containing phyllosilicates. Our findings indicate that (1) CP IDPs could reach the surface of the earth in the past and been preserved in blue-ice and (2) at least a CP IDP-like MM had experienced aqueous alteration on its parent body.

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