Ferroan relict minerals in the Tottuki and South Pole micrometeorites. N. Imae[1], S. Taylor[2] and N. Iwata[3], [1]National Institute of Polar Research, 10-3, Midori-cho, Tachikawa, Tokyo 190-8518 (imae@nipr.ac.jp) [2]U.S. Army Cold Regions Research and Engineering Laboratory, Hanover, New Hampshire 03755-1290, and [3]Department of Earth and Environmental Sciences, Yamagata Univ., 1-4-12, Kojirawaka, Yamagata 990-8560, Japan.

Introduction:

Ferroan olivines and low-Ca pyroxenes (Fe#≥10) occur in type II chondrules in chondrites, equilibrated chondrites, achondrites, and primitive achondrites. In addition, they occur in a chondrule-like object from comet 81P/Wild 2 [1] and in particles from an asteroid, Itokawa [2].

Although most relict olivines and low-Ca pyroxenes in micrometeorites (MMs) are magnesian (Fe#=0-10) [3], ferroan olivines and low-Ca pyroxenes do occur (Fig. 1) and have not been extensively studied. In MMs these relict phases are mostly coarse-grained, and often show poikilitic textures (Fig. 1). This suggests that they crystallized from melts and unlike sub-μm ferroan olivines and low-Ca pyroxenes found in matrices of unequilibrated chondrites and IDPs, which are condensates.

Of 92 MMs bearing relict grains, 26 had ferroan relict minerals. Here we compare the composition of ferroan relict grains in MMs with ferroan minerals in different meteorite types.

Samples and the analytical methods:

The MMs were recovered from the Tottuki bare icefield [4] and from the South Pole water well [5]. We also analyzed nine carbonaceous chondrites (Y980051, Y-791198, B-7904, Y-793495, A-881595, Y-81020, Kainsaz, Allende, and Tagish Lake), seven ordinary chondrites (Semarkona, ALH-764, Y-790448, Mezö-Madaras, Y-82038, Y-791088, LAP 02240), a Rumuruti chondrite (PRE 95404), and an EH3 chondrite (Y-691) and compared their mineral compositions to those of the MMs. All samples were analyzed with an electron probe-microanalyzer (JXA-8200).

Results:

MMs: The FeO contents of ferroan olivines are in the range of 10-40 wt%, and the CaO contents are mainly 0-0.3 wt%. Of 25 MMs bearing ferroan olivines, six MMs coexist with ferroan low-Ca pyroxenes, and four with Mg-rich olivine. Only one MMs consists of ferroan low-Ca pyroxene.

Chondrites: Ferroan olivines: The CaO contents of ferroan olivines in CCs (0.1-0.3 wt%) are slightly higher than those of UOCs (≤0.3 wt%) (Fig. 2b). The MnO contents of CCs (≤0.4 wt%) are slightly lower than those of UOCs (≤0.5 wt%) (Fig. 2e). Thus, only based on the compositional differences of ferroan olivines, CC and UOC are difficult to distinguish.

Ferroan low-Ca pyroxenes: Ferroan low-Ca pyroxenes rarely occurred in CCs, but occurred in UOCs. The CaO contents in UOCs are usually less than 1 wt% (Fig. 3b) and MnO contents are less than 0.8 wt% (Fig. 3e).

Discussion:

Of the 26 MMs with ferroan relict grains, six are classified as equilibrated H chondrite type based on the identical composition of their olivines and low-Ca pyroxenes with those of equilibrated H chondrites. One MM (Fig. 1d) is classified into shock-melted H chondrite type, since it is similar to Y-79088 and LAP 02240 in compositions and textures [6]. Two MMs are classified as UOC type since the CaO contents of heteorgeneous olivine in a MM are low (≤0.05 wt%) and the CaO contents of ferroan low-Ca pyroxene in another MM are plotted within 0-2.5 wt%. Ten MMs are classified into CC type or UOC type since CC and UOC cannot be mostly distinguished based on the compositions of ferroan olivines. Compositions of ferroan olivines in these MMs are not homogeneous but are zoned. One MM is classified into CM2 type (Fig. 1e). One MM is classified as unique type (Fig. 1f), because it does not match any known meteorite. Five MMs are classified as a high-Mn type (Figs. 1c, 2 and 3), as they have higher Mn contents (0.5-1.5 wt%) in their olivines than those of known chondrites.

Of the five high-Mn type MMs three have ferroan low-Ca pyroxenes. The low-Ca pyroxenes of these MMs do not show high-Mn contents, less than ~0.7 wt% (Fig. 3d). The low Mn contents are similar to the pyroxene compositions in unequilibrated ordinary chondrites (Fig. 3e), but the pyroxene CaO contents (~1-3 wt%, Fig. 3a) are significantly higher than those of UOCs (Fig. 3b). The high-Mn content of ferroan olivines and the high-Ca contents of ferroan low-Ca pyroxenes are consistent with a chondrule-like object, Torajiro (Figs. 2c, 2f, 3c, and 3f), which was found from comet 81P/Wild 2 [1].

Summary:

The compositions of the ferroan relict grains in MMs (Figs. 2 and 3) indicate that the MMs are mainly related to carbonaceous or unequilibrated ordinary chondrites and equilibrated H chondrites. We also found MMs with high-Mn olivines that are not related to known meteorites, and may be cometary in origin.

References:

[1] Nakamura T. et al. (2008) *Science, 321,* 1664–1667. [2] Nakamura T. et al. (2011) *Science, 333,* 1113–1116. [3] Imae N. et al. (2010) Ant. Met XXXIII, 28-29. [4] Iwata N. and Imae N. (2002) *Ant. Met. Res., 15,* 25–37. [5] Taylor S. et al. (1998) Nature, 392, 899–903. [6] Niihara T. et al. (2011) Pol. Sci., 4, 558–573.

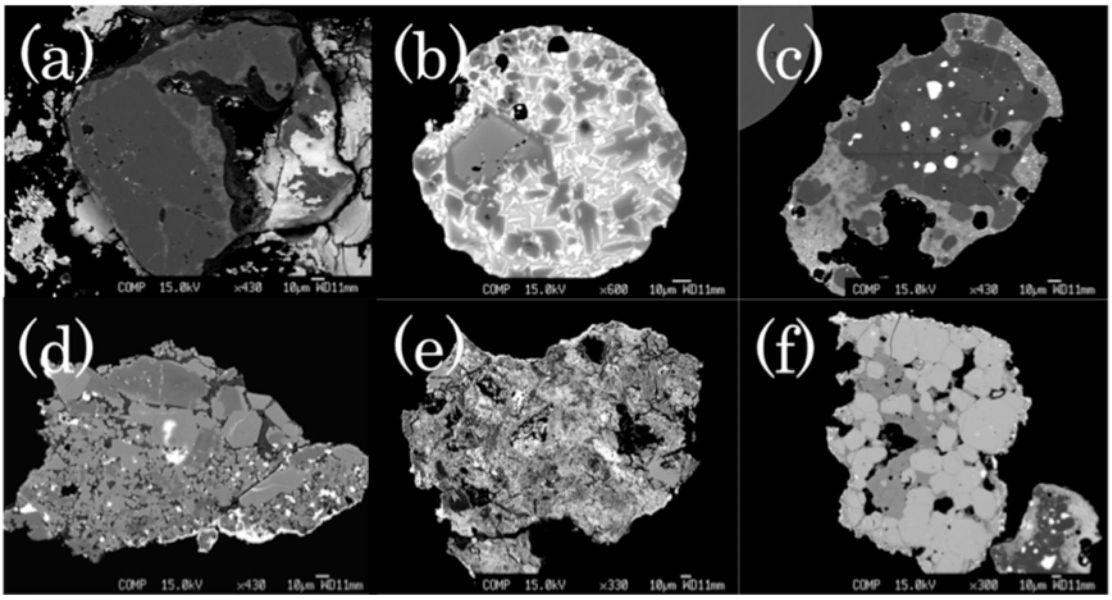

Fig. 1. (a) SP00-8-227. Equilibrated H chondrite type including ferroan olivine grain (Fa_{18-20}). (b) SP00-8-257. Carbonaceous or unequilibrated ordinary chondrite type including ferroan olivine grains. The core in a large olivine grain shows normal zoning (Fa_{26-35}). Also note that the Mg-rich rim shows reverse zoning formed by atmospheric melting. (c) SP00-8-181. High-Mn type showing pokilitic texture, rounded olivines (Fa_{12-15}) and rounded kamacites enclosed in low-Ca pyroxene ($Fs_{11}Wo_3$). (d) SP00-53-106D-50. Shock-melted H chondrite type, showing igneous texture. Darker phase is low-Ca pyroxene ($Fs_{12-16}Wo_{1.3-4.1}$) and lighter phase is ferroan olivines (Fa_{17}). (e) SP00-53-106D-08. CM2 type including magnesian phases ($Fa_{1.6}$ and $Fs_{1.5}Wo_1$) and ferroan olivine grains (Fa_{33}). (f) SP00-53-106D-02. Unique type mainly consisting of hexagonal shaped ferroan olivines (Fa_{43}). Low-Ca pyroxene, chromite, and plagioclase also occur.

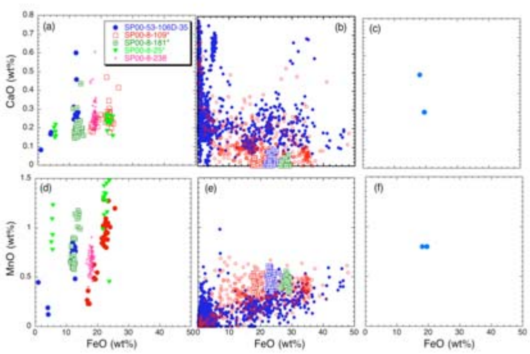

Fig. 2. FeO-CaO and FeO-MnO plots of olivines. Five MMs classified into high-Mn type (a & d). Carbonaceous (blue), unequilibrated ordinary including a Rumuruti (red), and equilibrated ordinary (rectangulars) chondrites (b & e). A chondrule-like object (Torajiro) from comet 81P/Wild 2 [1] (c & f).

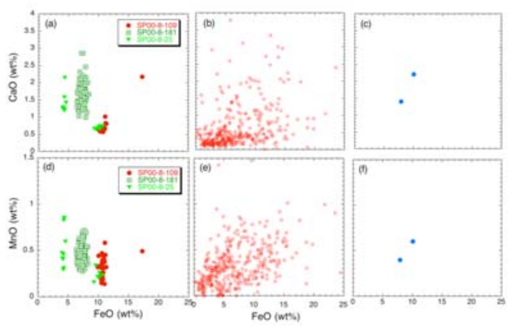

Fig. 3. FeO-CaO and FeO-MnO plots for low-Ca pyroxenes. Three classified into high-Mn type based on the olivine compositions (a & d). Note that the Mn contents for low-Ca pyroxenes in these MMs are not so high. Unequilibrated ordinary and a Rumuruti chondrites (b & e). A chondrule-like object (Torajiro) from comet 81P/Wild 2 [1] (c & f).