Chondrule-like objects and refractory inclusions in GEMS-bearing Antarctic micrometeorites and an interplanetary dust particle.

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Glass with embedded metal and sulfide (GEMS) is regarded as a characteristic component of cometary dust. GEMS-bearing Antarctic micrometeorites (AMMs) and interplanetary dust particles (IDPs) containing chondrules and refractory inclusions are important to understand comets as well as P- and D-type asteroids.

We found three chondrules and a refractory inclusion (RI) in GEMS-bearing AMMs and IDP. We investigated them by TEM, FE-SEM, FE-EPMA, and SIMS. All the chondrules belong to type II (Mg# <90). An AMM contains a spinel-hibonite-perovskite (sp-hb-pv) inclusion, in which spinel contains tiny (<100 nm) Ti-bearing Zr oxides and Mo- and Ru-bearing Ir-Os alloy and that perovskite contains Y and Zr, suggestive of ultra-refractory nature. All the fine-grained matrices are highly porous and contain GEMS, olivine, low-Ca pyroxene including enstatite whisker, high-Ca pyroxene, pyrrhotite. In addition, the matrix and the embedded RI contains minor phyllosilicate. Oxygen isotopic ratios of olivine and pyroxene in two chondrules are plotted 0.7‰ below and 2.7‰ above the terrestrial fractionation line on the three-oxygen isotope diagram, respectively. Oxygen isotope ratios of spinel in the RI are $\delta^{18}O$ of -43.8‰ to -45.1‰ and $\delta^{17}O$ of -44.8‰ to -46.8‰, respectively. Resolvable ^{26}Mg excesses ($\delta^{26}Mg^*$ ~ 13±2‰ and 14±3‰) are observed in hibonite with $^{27}Al/^{24}Mg$ ratios of 35-43, while spinel show marginal excess (~1‰).

The olivine/(olivine + low-Ca pyroxene) ratios were deduced from the mid-infrared spectra of asteroids and comets; those of B-, G-, and C-type asteroids, P- and D-type asteroids, and comets are <12%, 36-52%, and >50%, respectively. The ratios of the matrices in the samples range from 0.4 to 0.61, which are well above the values of B-, G-, and C-type asteroids and comparable with those of P- and D-type asteroids and comets. Therefore, P- and D-type asteroids and comets seem to be more plausible as parent bodies of these AMMs and an IDP than B-, G-, and C-type asteroids. If that is the case, P- and D-type asteroids and comets contain abundant GEMS. Ferromagnesian silicates with Mg#<90 in the chondrules distribute around $\Delta^{17}O$ ~0‰ in the Mg# vs $\Delta^{17}O$ diagram like those in the Stardust samples. This seems to be consistent with the hypothesis that P- and D-type asteroids were migrated from the Kuiper belt. The chondrules were formed in more oxidizing conditions than chondrules in CR chondrites because type II chondrules in them occupy only ~1%.

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