A New Type of Material Formed by Condensation in the Early Solar Nebula

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We report a new type of materials formed by condensation in the early solar nebula, which was found as a micrometeorite recovered at Cape Tottuki in the blue ice fields in Antarctica. A large micrometeorite 'YYP2K1' with size approximately 150µm shows some unique characteristics. It consists mainly of fine-grained (sub-micron to 10µm) olivine and amorphous silica. Minor phases include low-Ca pyroxene, pyrrhotite and diopside, as well as magnetite presents at the rim. Transmission electron microscope observation revealed that many Mg-rich olivine grains (>$Fo_{99.4}$) and minor amounts of Al,Ti-rich diopside and alteration product are embedded in amorphous SiO_2-rich material. There is no other phase at the boundary between an olivine crystal and surrounding silica-rich amorphous material, which makes this object very uncommon. The amorphous silica consists of 97.9wt% SiO_2, 0.8wt% Cr_2O_3 and 0.7wt% FeO. Oxygen isotope analysis of YYP2K1 using a secondary ion mass spectrometer shows that it has a large oxygen isotope anomaly. The $\delta^{17}O$ and $\delta^{18}O$ values range from ~-45 to -50 ‰, which overlap with those of early solar-system condensates such as CAIs (Ca Al-rich Inclusions) and AOAs (Amoeboid olivine aggregates). This suggests that YYP2K1 formed by condensation from a gas in the solar nebula close to the Sun, like CAIs and AOAs. However, mineralogy of YYP2K1 differs from that of CAIs and AOAs. Amorphous silica is abundance in YYP2K1, but never reported in CAIs and AOAs. Equilibrium condensation from a gas with solar composition cannot condense amorphous silica. Therefore unequilibrated condensation followed by fast cooling is likely to have occurred to form the silica phase after olivine and low-Ca pyroxene condensation.