The Mineralogy of Comet Wild-2 Nucleus Samples- What We Think We Know And What We Do Not Know

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[1] NASA/JSC

Introduction: The sample return capsule of the Stardust spacecraft was successfully recovered in northern Utah on January 15, 2006, and its cargo of coma grains from Comet Wild-2 has now been the subject of intense investigation by approximately 200 scientists scattered across five continents. We can now perform mineralogical and petrographic analyses of particles derived directly from the Jupiter-family Comet Wild-2.

The Mineralogy of harvested Wild-2 grains from 52 impact tracks, and have obtained a rudimentary understanding of the mineralogy of 26 of these (ref. 1). Crystalline materials are abundant in Comet Wild-2 and many are coarse-grained relative to the submicrometer scales characteristic of many anhydrous IDPs and interstellar dust populations. Of the best studied 26 tracks, eight are dominated by olivine grains, seven by low-calcium pyroxene, three by a fairly equal amount of olivine and pyroxene, and the remaining eight are dominated by other minerals, mainly Fe-Ni sulfides. The recovered Wild-2 samples are mixtures of crystalline and amorphous materials. We do not yet know how much of the observed amorphous material is indigenous to the comet, and how much was produced upon impact into the aerogel. Our emerging model for the structure of the captured grains is that many were predominantly very fine-grained (sub-micrometer), loosely-bound aggregates with a bulk chondritic composition, most also containing much larger individual crystals (most commonly) of olivine, pyroxene and Fe-Ni sulfides, similar to chondritic IDPs.

Olivine and Low-Calcium Pyroxene is present in the majority of Wild-2 particles, with observed grain size ranging from submicrometer to over 10 micrometers. Wild-2 olivine has an extremely wide compositional range, from Fo4-100, with a pronounced frequency peak at Fo99. The wide Mg-Fe compositional range of Wild-2 olivine is similar to anhydrous chondritic IDPs. However, the range of these olivine compositions is also similar to what is found in the matrix of the chondrites Murchison (CM2), and Orgueil (CI1), which have experienced significant-to-pervasive aqueous alteration. Both low- and high-calcium pyroxenes are present among the Wild-2 grains, with the former being dominant. The compositional range displayed by the low-calcium pyroxene is also very extensive, from En52-100, with a significant frequency peak centered at En95.

Sulfides are the only mineral group found in all extraterrestrial materials. Fe-Ni sulfides are also ubiquitous in the Wild-2 grains. FeS predominates, but the few (three to date) verified pentlandite crystals in Wild 2 tracks are intriguing since this phase is frequently an indicator of low-temperature metamorphism under oxidizing conditions, and/or aqueous alteration. The presence of these few Ni-rich sulfides suggests that some Wild 2 particles could have experienced aqueous alteration.

Carbonates have been reported among the Wild-2 samples, as rare Ca-Mg-Fe carbonate grains (including calcite). At first we assumed these must be some kind of ground contamination, because usually these grains were buried within pure aerogel, not generally located directly within Wild-2 grains. It is obviously critically important to definitively determine whether carbonates are truly present among the Wild-2 samples, and if so how they formed, and their relative abundance.

Reference: (1) Zolensky M. et al. (2006) Mineralogy and Petrology of Comet Wild 2 Nucleus Samples. Science 314, 1735-1740