Mineralogy and crystallography of Comet 81P/Wild 2 particles: Unique components

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NASA's Stardust mission successfully collected coma grains from Comet 81P/Wild 2 on Jan. 2004 and the recovered samples returned the earth on Jan. 15, 2006. We performed mineralogical and crystallographic studies on Comet Wild 2 particles as a part of preliminary examination (PE) by FEG-SEM (Hitachi S-4500 with EDS and EBSD), TEM (JEOL JEM2010 with EDS) and single crystal X-ray diffraction using synchrotron radiation (SR-XRD) (BL47XU, SPring-8).

The size of particles studied ranged from 1 to 10 microns. Most particles are composed of amorphous silica with tiny spherules of Fe(+Ni) sulfide and Fe-Ni metal (up to 100 nm). These particles contain abundant vesicles, suggesting melting with aerogel during the capture process. Several particles contain crystalline silicates. Major crystalline phases are olivine and pyroxene. These crystals are usually less than 1 micron. The chemical compositions of both olivine and pyroxene show wide ranges (mg#=0.6-1) even in the same particle. SEM-EBSD analysis identified augite in one microtomed slice, although most pyroxenes are low-Ca pyroxene. CF12,0,16,3,0 contains a 1.5x2.5 microns grain whose composition is close to K-feldspar. We tried EBSD and SR-XRD analyses, but no diffraction was obtained in either analysis. In CF6,0,10,7,23, olivine and pyroxene (mg#=0.70-0.95) dominate, but there is a possible Mg-Fe carbonate (breunerite) in this particle. This carbonate occurs as a cluster measuring 200x300 nm associated with amorphous silica. EDS analysis suggests that it is a mixture of Mg-Fe carbonate, amorphous silica and Fe sulfide. No Ca was detected. The SAED pattern of this cluster shows powder rings with some sharp spots generally consistent with magnesite. Mg-rich chromite is also present in this particle, associated with amorphous silica and Fe sulfide. Only 1 sample was crystalline among 6 particles analyzed by SR-XRD. The obtained diffraction pattern of C2126,2,68,1,0 shows sharp spots from multiple domains that match with tridymite and cristobalite.

Thus, Comet Wild 2 coma grains studied here contain several different phases. Submicron olivine and pyroxene with variable compositions are major phases except for abundant amorphous silica contaminated with aerogel. Unique phases (although they are rare) are possible Mg-Fe carbonate, Mg-rich chromite, K-feldspar glass and silica. Because they are all associated with amorphous silica and Fe sulfide (except for K-feldspar glass), they are probably indigenous to Comet Wild 2. Many other PE studies (including other particles in this study) show that Comet Wild 2 particles are most similar to anhydrous IDPs because neither phyllosilicates nor carbonates were found so far in Comet Wild 2. Therefore, the discovery of Mg-Fe carbonate in CF6,0,10,7,23 is the first evidence for aqueous alteration of Comet Wild 2. The presence of tridymite and cristobalite is also unique. Thus, Comet Wild 2 contains more variable components than previously thought, suggesting complex nature of its parent body.