

Processing of the smallest Wild 2 particles in hot silica aerogel

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The comet 81P/Wild 2 agglomerates impacted the underdense silica aerogel tiles of the Stardust collector at 6.1 km/s and, when decelerating to rest velocity, each one carved its own track that is diagnostic of the weakly constructed nature of the particle mixture. In these unique bulbous tracks most nanometer-scale particles that numerically dominated many of the agglomerates were forced into the wall of the track that was expanding into hot aerogel. The entrained particles were flash-heated under reducing conditions to at least $\sim 2000^{\circ}\text{C}$.

Observations

Mostly 10-20 micron sized clumps of melted aerogel extracted along the tracks have a vesicular glass matrix that almost uniformly contains up to several weight percent MgO, Al₂O₃, K₂O, CaO, and MnO, in various combinations, and *ditto* trace amounts of P, Cr and Ti. Chemically pure silica glass is rare. The glassy matrix also contains Mg-rich olivine and pyroxene single-crystals up to $\sim 500\text{nm}$ that show no signs of melting or interactions with the silica-rich glass. Rare, $\sim 100\text{nm}$ 'FeS' (pyrrhotite?) fragments are present. The characteristic feature is the ubiquitous 'shotgun' distribution of numerous mostly Fe-S(\pm Ni) compound, and metallic iron and Fe,Ni-compound inclusions. They range from a few nm to $\sim 150\text{ nm}$ in size. The smallest inclusions are chemically homogenous but larger ones have a low-S (~ 10 -15 el%) Fe-S core and high-S (~ 30 -35 el%) Fe-S rim. Nickel is often absent or $<2\text{ el}\%$. High Ni, up to 10 el%, contents are present.

Discussion and Conclusions

The observations support pervasive melting of comet nanoparticles with a chondritic bulk composition. The closest analog to these particles are Mg-Fe-Si principal components, Mg,Fe-silicates and pyrrhotite grains, all up to $<500\text{nm}$, in chondritic aggregate IDPs. Chemically, the IDPs have a "Mg,Fe silicate (+ other elements)" and a "sulfide" reservoir. When melted during impact the former reservoir in comet particles was fully assimilated in the pure silica melt wherein "sulfide" melts were immiscible. Upon quenching they yielded numerous inclusions. Under the appropriate time-temperature conditions the large Fe-S melt droplets separated into a core and mantle with Fe-S compositions defined by metastable eutectic compositions in the Fe-S phase diagram, including 'mackinawite'. Much information is still present in the controlled chaos that is preserved in the glass matrix.

Mantle flux at lower crust / upper mantle interface: A carbon and hydrogen isotopes study of granulites

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Stable isotopes analysis of C and H of biphasic primary and secondary FI in granulites facies rocks formed in collision and subduction zones dated from Archaean (3,3Ga) to Miocene (16Ma) were performed. The amount of CO₂ extracted from primary FI ($\approx 635\text{ ppm}$) confirms that the formation of granulites is associated with a flux of CO₂ at the base of the crust. The $\delta^{13}\text{C}$ values around -7‰ PDB for the CO₂ together with the δD values of H₂O (average value -78‰) present in the primary FI indicate a mantle origin for the fluid involved in the formation of granulites during peak metamorphism. The scattered $\delta^{13}\text{C}$ values (between -2.5 and -8.9‰) of primary FI from all granulites correspond to the mixing of a "juvenile" carbon source from mantle-derived CO₂ ($\delta^{13}\text{C} = -5 \pm 2\text{‰}$) and a superficial carbon source. However, the situation for hydrogen seems to be more complex. The D/H ratios of the granulites formed in subduction zones are within the range which is considered to be that of mantle derived magmas. For the granulites formed in collision zones, the δD values (-99‰) of recent granulites (-16 Ma) suggest a contamination of juvenile water by meteoric waters of high elevation whereas δD values (-60‰) for Archaean (-3.3 to -1.7 Ga) granulites suggest a contamination of juvenile water by crustal (metamorphic) waters during granulitic metamorphism.