ANALYSIS OF COMET PARTICLES COLLECTED BY THE STARDUST MISSION, FINDINGS VERSUS EXPECTATIONS. D. E. Brownlee[1], P. Tsou[2], D. Joswiak[1], , G. Matrajt[1] and J. Bradley[3], [1]Dept. of Astronomy, Univ. of Washington, Seattle, WA 98195, (brownlee@astro.washington.edu), [2]Jet Propulsion Lab, Pasadena, CA 91109 (Peter.Tsou@jpl.nasa.gov) [3] IGPP, Livermore Natl. Lab. Livermore CA 94550, (bradley33@llnl.gov)

Introduction: The Stardust spacecraft collected thousands of particles from comet Wild 2 and returned them to Earth where they are being studied in laboratories around the world. The analysis of these particles is producing significant new insight into the nature and origin of the silicate and other nonvolatile contents of a Jupiter Family Comet. The collected particles were ejected from ice-rich regions of the comet and are expected to be representative materials that were in the Kuiper Belt at the time that comet Wild 2 formed.

Expectations: While the study of the samples is still in early phases, the micron and larger components that have been studied are quite different from common expectations. While it was expected that much of the comet would be composed of presolar grains, the measured isotopic compositions indicate that this is not the case. Recent estimates by Stadermann and Floss[1] suggest that the isotopically anomalous presolar grain content of the Wild 2 is actually less that that of primitive meteorites and common interplanetary dust particles. A common expectation was that the comet would be dominated by a combination of amorphous presolar grains and presolar grains that had experienced some level of annealing, a solid state process where moderate heating to ~1000K would cause partial devitrification into crystalline materials.

Findings: Most of the comet samples that we have worked have properties that are not consistant with formation by annealing of presolar grains. Laboratory experiments with 1000K heating of chondritic composition glass yield end products that usually consist of crystals of olivine in a solid glass matrix, somewhat similar to the fusion crusts on primitive meteorites. Most of the comet samples do not resemble this type of material. Instead they are much more complex and appear to be the products of severe heating where the precursor materials were either melted or vaporized. The isotopic compositions imply that that this process occurred in the solar nebula and not in previous environments. Olivine is a major component of the comet materials but its minor element composition (Al, Ca, Cr and Mn) is similar to that of olivine grains in primitive meteorites and not what would be expected for are origin by devitrification of glass. Some of the silicate grains have Mg/Fe ratios >1000, a state that is difficult to imagine forming by annealing of glass.

High Temperature Materials: A major fraction of the comet sample is composed of materials that formed at high temperatures that would have melted or vaporized original presolar solids. In most cases these cometary materials are similar if not identical to analogous materials found in primitive meteorites. While the comet is a remarkably rich mix of components that have been seen in meteoritic materials, the comet seems to be a winder ranging assortment of components that are normally seen in any particular type of meteorite of interplanetary dust particle. The comet is composed of meteoritic-like materials but the overall mix certainly does not match any particular class of meteoritic object.

Two of the most significant high temperature components are materials that can be associated with chondrules and those associated with Calcium Aluminum Inclusions (CAIs). Chondrules were heated above 1500C by transient conditions in the nebula that resulted in melting most or all of the precursor materials. Nakamura[2] has provided convincing mineralogical and isotopic evidence that chondrule fragments have been found in Wild 2. The particle that made track #25 (Inti) is a CAI that is identified on the basis of its elemental composition, its content of charastericstic CAI minerals and its O16 rich composition that is a distinctive property of CAIs. Inti also contains tiny inclusions of TiN and Pt group elements. The incusions have compositions consistent with the first (highest temperature) condensates from cooling solar composition gas.

Conclusions: The particles collected from comet Wild 2 imply that the mass of this comet is dominated by materials that formed at high temperatures in the inner regions of the solar nebula and were then transported beyond the orbit of Neptune. These materials could have been transported in or above the nebular disk. Comet Wild 2 is a mix of ices formed at the edge of the solar nebula disk mixed with silicates and other materials that formed in the central regions of the solar system at much higher temperatures than expected. There are significant similarities as well as differences between the mineralogical composition of Wild 2 and that implied by anlysis of IR features of comet Tempel 1 liberated by the Deep Impact spacecraft.

References:

[1] Stadermann, F. J and Floss, C. (2008) LPSC XXXIX, No. 1391., p.1889 [2]Nakamura, T. et al. (2008) LPSC XXXIX, No. 1391,1695.