IMPACT PROCESSING OF REFRACTORY COMPONENTS FOUND IN COMET DUST.

S. M. Lederer[1] M. J. Cintala[2], R. D. Olney[1], K. Nakamura-Messenger[2], L. P. Keller[3], and M. E. Zolensky[3]. [1]Cal State Univ. SB, [2]ESCG Jacobs Sverdrup, [3]NASA Johnson Space Center.

Introduction: Collisions between small bodies occurred frequently during the formation of the Solar system and continue today. It has been surmised that collisions have heavily damaged the interiors and reworked the surfaces of comets throughout their lifetimes [1, 2, 3]. Durda and Stern [2] estimate that a 2 km diameter object orbiting in the Kuiper Belt (35 – 45 AU) will undergo 90-300 collisions with objects greater than 8 m in diameter in 3.5 Gy. In this same timeframe, collisions between a typical Kuiper Belt Object (KBO) 200 km in diameter and objects with d > 8 m would rework up to one-third of that KBO's surface.

Collisions experienced by a Jupiter-family comet occur during its stay in the Kuiper Belt. Encounter speeds within the Kuiper Belt vary, but typical speeds are 1.5 to 2.0 km s^{-1} [1]. In contrast, the majority of the collisional history of an Oort Cloud comet takes place early in the Solar system's history before it is ejected from the Jupiter-Saturn region to the Oort Cloud. Typical impact speeds range from 1-10 km s^{-1} [4].

Experiments: Because collisions have occurred frequently throughout the history of the solar system, one would expect them to influence various "signatures" of cometary dust (*e.g.*, in infrared spectra, including the size distributions of dust particles; fractal porosity of the grains; the crystalline-to-amorphous ratio for silicates; and shock effects observed in cometary dust samples). Therefore, a set of laboratory impact experiments were designed to investigate the signatures collisional processing might cause that could be detected in telescopic data of comets.

The impact experiments supporting this study were performed in the Experimental Impact Laboratory (EIL) at the Johnson Space Center. We conducted experiments at roughly 2.0, 2.45, and 2.8 km s^{-1} using the vertical gun. 3.2-mm spectrally-neutral ceramic spherical projectiles were shot at targets that were either (a) solid individual minerals, or (b) ground to a granular texture. Target materials selected included common constituents of cometary dust: Mg-rich olivine (forsterite), Mg-rich pyroxene (ortho-enstatite), Fe-rich olivine (fayalite), and iron sulfide (pyrrhotite).

Analysis: The materials will be analyzed for evidence of shock metamorphism and alterations in both spectral and transmission electron microscope (TEM) imaging signatures. Initial analyses indicate that targets impacted at both 2.45 and 2.8 km s^{-1} have been altered, causing changes in our 5-15μm FTIR (Fourier Transform Infrared Spectrometer) spectra (*e.g.*, darkening, shallowing of band depths, and in some cases new spectral lines). However, minimal changes occur when impacted at 2.0 km s^{-1}. The changes can be explained in part by a decrease in the mean free path of signal due to the shock, and possible decay products. Transmission electron microscope (TEM) images of an impacted forsterite grain corresponding to the impact experiment for which the FTIR spectral changes occurred were obtained. Clear evidence of shock in the form of a high density of planar dislocation parallel to Burgers vector b= [001] is demonstrated. The density of dislocations is on the order of 10^{10} cm^{-2}. Such a high density of planar dislocations is known to be due to deformation at high strain rates and low temperatures [5]. Analyses of all target materials will be conducted on minerals impacted at the lower speeds and presented. Results will be compared with samples that have not been impacted.

Ultimately, a database of shocked and unshocked mineral spectra [5, 6, 7] will be used as input for linear mixing model designed to fit telescopic spectra of comets. This model combines a linear mix of over 80 species and includes effects of particle-size distributions, size, temperature, and porosity in generating a model emission spectrum. Modeling the 1.5-35 μm region allows one to constrain the following: the olivine, pyroxene, mass ratios, grain-size distribution, and possibly the crystalline-to-amorphous ratios for olivine and pyroxene, etc. We will use our results to aid in analyzing ground based observations of comets (e.g., 9P/Tempel 1 and Hale-Bopp [5]).

References: [1] Stern S.A. (2002) *Astron. J., 124*, 2297-2299. [2] Durda D.D. and Stern S.A. (2000) *Icarus, 145*, 220-229. [3] Meech K.J. (1991) *CPHE, 1, 629-669.* [4] Charnoz S. and Morbidelli A. (2003) *Icarus 166, 141-156.* [4] Ashworth J.R. and Barber D.J. (1975) *Earth and Planet. Sci. Letters, 27*, 43-50. [5] Harker, D. E., Wooden, D.H., Woodward, C.E., Lisse, C.M. (2002) *Astrophys. J., 580*, 579-597. [6] Harker D.E., Woodward C.E., and Wooden D.H. (2005) *Science,* 5746, 278-80. [7] Harker D.E., Woodward C.E., Wooden D.H., Fischer R.S., and Trujillo C.A. (in press) *Icarus.*