Data Processing and Experimental Design for Micrometeorite Impacts in Small Bodies

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– Comets and asteroids have been altered from their original "pristine" state by impacts occurring throughout their 4.5 billion year lives [1]. Proof of shock deformation has been detected in the crystal structure of several Stardust samples from Comet Wild 2 [2, 3]. Analyses indicated that the planar dislocations in the crystal structure of the minerals had been imparted by impacts sustained during their lives, and not due to the aerogel capture process. Distortions to crystal structure also affect the ideal absorption spectra in the infrared [4], thus providing indirect evidence of its impact history and a means of remotely investigating the impact history of small bodies through comparing laboratory spectra with spectra observed by telescopes or spacecraft.

–The effects of impacts propagating shock waves through minerals were investigated through laboratory impact experiments. Utilizing NASA Johnson Space Center's Experimental Impact Laboratory, projectiles were fired from the vertical gun at velocities ranging from 2.0 to 2.8 km/sec, projected impact velocities between Kuiper Belt Objects. Two types of projectiles were used, including spherical alumina ceramic, whose density mimics that of rock, and cylinders made from the same material that they impacted. The target materials chosen for testing included: OLIVINES forsterite (Mg_2SiO_4) and fayalite, Fe_2SiO_4); PYROXENES enstatite ($Mg_2Si_2O_6$) and diopside ($MgCaSi_2O_6$); and CARBONATES magnesite ($MgCO_3$) and siderite ($FeCO_3$). Targets were impacted at either 25 C or cooled to -20 C to examine the effects of temperature, if any, on lattice distortions during the shock propagation. As comets and asteroids can undergo a wide range of temperatures in their orbital lifetimes, the effect of temperature on the equation of state of minerals being shocked needs to be examined for interpreting the results of these experiments. The porosity of the target mineral is varied by either grinding it into a powder/granular texture or as whole mineral rocks to investigate the differences in shock propagation when voids are present. By varying velocity, ambient temperature, and porosity, we can investigate different variables affecting impacts in the solar system.

–Data indicates that there is a non-linear relationship between peak shock pressure and the variation in infrared spectral absorbances by the distorted crystal structure. The maximum variability occurs around 37 GPa in enstatite and forsterite. The particle size distribution of the impacted material similarly changes with velocity/peak shock pressure.

–The experiments described above are designed to measure the near- to mid-IR effects from these changes to the mineral structure. See Lederer et al., this meeting for additional experimental results.

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