STARDUST CRYSTALLINE RESIDUES: SURVIVING COMET DUST OR CRYSTALLIZED IMPACT MELTS?

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Introduction: Since the return of samples from comet 81P/Wild2, residues from numerous craters in Stardust Al foils have been analyzed by transmission electron microscopy (TEM). They commonly contain a mixture of crystalline and amorphous material [e.g. 1,2,3]. The crystalline material origin is uncertain: is it original to the impactor or the result of melting and recrystallization? While this question stands, the value of crater residues to our understanding of cometary grains is unclear. To answer it, we must study the residues of a material with some distinguishing structure that would be lost on melting and could not reform under impact conditions. Wollastonite is an anhydrous silicate typically formed by thermal metamorphism which occurs as characteristic acicular crystals [4]. It has a melting temperature within the range of silicates commonly identified in comet 81P/Wild2 dust, and from light gas gun (LGG) experiments is known to generate craters that exhibit wollastonite Raman signal [5] with a range of morphologies thought indicative of crystal orientation [6]. We prepared and compared TEM sections perpendicular to the direction of elongation of wollastonite projectile and crater to determine whether crystalline particles in residues were original.

Method: Powdered wollastonite was fired in LGG shots [7] at flight spare Al foils. Scanning electron microscopy with energy dispersive X-ray analysis (SEM EDX) was used to identify regions of residue in elongated craters. The focused ion beam (FIB) was then used to prepare sections for analysis by TEM. Since directional information was of upmost importance, access to the residue by FIB was made possible by flattening crater rims by hand rather than the established method of epoxy embedding [8].

Results and Discussion: SEM analyses identified needle-like features at the bottom of elongated craters. The long-axes of these needles are aligned with that of the crater. Sections were prepared, and TEM reveals these needles to be crystalline. Details of the compositional and structural analyses and comparisons to the original projectile are presented and discussed. High pressure polymorphs are considered. Evidence of highly shocked crystal structures indicate recrystallization from the melt did not occur.

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