IMPACT EXPERIMENTS OF CHONDRULE FRAGMENTS ON STARDUST ANALOGUE FOILS: CLUES TO THE NATURE OF CHONDRULE-LIKE MATERIAL IN WILD 2

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Introduction: NASA's Stardust mission was the first mission to bring back to Earth material from a celestial body, i.e. the Jupiter Family Comet (JFC) 81P/Wild 2 (hereafter Wild 2) [1]. Cometary dust was captured via impact into a silica aerogel collector that was deployed during a fly-by through the coma of Wild 2 at a relative speed of 6 km s^{-1}. The collector was secured into a metal frame by aluminum 1100 foil (hereafter Al foil). A major result of the mission was the discovery that, contrary to expectations, Wild 2 was not predominantly composed of presolar grains and low temperature outer solar nebula material, but rather high temperature (>>1000 °C) material typical of primitive meteorites [e.g., 2]. This suggests that the rocky part of Wild 2 is mostly made of high-temperature components that formed in the inner solar system before being transported outward to the comet-forming region. Most of the surviving supra-µm particles studied exhibit high-temperature chondritic material, including Calcium-Aluminum Inclusions (CAIs) and chondrule fragments [e.g., 3]. However, the number of chondrule fragments extracted from aerogel and analyzed so far is limited, preventing a clear comparision to the population of chondrules in Wild 2.

An alternative to the study of particles from the aerogel is the study of microscopic crater resulting from the impact of Wild 2 dust on Al foil. Impact experiments of silicate minerals on Al foil at normal incident and 6.1 km s^{-1} velocity, have shown that the shape of craters depends mainly on the physical properties of the impactor (i.e. solid grain vs. loose aggregates) [4], whereas residues in craters give information on the bulk chemistry of the original particle [5]. For instance, ferromagnesian compositions typical of chondrules can be recognized with confidence with EDX surveys. Occasional presence of relict crystals have been interpreted as unmelted crystalline material rather than recrystallization products after total melting of the impactor [6]. Experimental works have also shown that residues of anhydrous minerals can be confidently identified using conventional analytical techniques [7-9]. However, experimental works using poly-mineral samples are lacking. Being able to characterize such craters may allow drawing a comprehensive picture of the chondrule population in Wild 2.

Here we will present preliminary data of a study of craters and residues resulting from the impact of fragments of chondrules on Stardust analogue foils. We aim to determine whether the different chondrules produce craters and residues that may be distinguished from one another by chemical or morphological differences.

Method: Impact experiments were carried out at the Light Gas Gun facility at the University of Kent, U.K. Chondrules several hundreds of micrometres in size were extracted from the chondrites Allende (CV3), Karoonda (CK3), Chainpur (LL3) and Northwest Africa 801 (hereafter NWA 801; CR2). After extraction, chondrules were fragmented in roughly two equal parts. One part was embedded in epoxy resin and characterized by SEM-EDX, determining their main textural, mineralogical and chemical properties. The other part was used in impact experiments, being crushed for further fragmentation to produce particles tens of micrometers to sub micrometer sizes, to simulate the grain-size of Wild 2 particles. Impact experiments were carried out at approximately 6 km s^{-1}. Al foil analogue targets were 4 x 4 cm in size. Resulting craters were investigated using a Hitachi S-4700 field-emission scanning electron microscope coupled with a Bruker XFlash annular EDX detector, allowing for precise chemical maps of residues lining the craters.

Results: Impact experiments resulted in thousands of microscopic impact craters on each target. Crater size ranges from submicrometer to several tens of micrometers in diameter. The vast majority of craters are bowl-shaped and exhibit residues that contain apparent fragments of the impactor. About 50 craters ~1 µm to ~30 µm were selected in each sample for chemical mapping. Obvious EDS peaks for Si and Mg are observed in most of the residues observed, along with detectable amount of Fe. Two occurrences of S-rich residues were observed in craters from Karoonda and Allende, whereas two occurrences of Ca-rich residues are observed for Chainpur and NWA 801.

Discussion: Preliminary observations show that impacts are consistent with previous observations that chondrule material prominently produces bowl-shaped craters, further constraining craters of interest on Stardust foil. The chemistry of the residues is mostly akin to Fe-poor silicate-like (i.e. Si, Mg-rich, with detectable Fe), consistent with type I POP chondrules that are prominently common in carbonaceous chondrites. Moderately refractory elements Mg and Fe are depleted in most residues, whereas refractory Ca is increased, consistent with high temperatures during impact.

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