OXYGEN ISOTOPE MEASUREMENTS OF SIMULATED WILD 2 IMPACT CRATER RESIDUES. C. J. Snead[1], K. D. McKeegan[1], M.J. Burchell[2] and A.T. Kearsley[3] [1]Dept. of Earth & Space Sciences, UCLA, Los Angeles, CA, 90095-1567, USA. stardust2006@ucla.edu. [2]School of Physical Science, University of Kent, Canterbury, Kent CT2 7NH UK. m.j.burchell@kent.ac.uk [3]Dept. of Mineralogy, The Natural History Museum, London SW7 5BD, UK. a.kearsley@nhm.ac.uk.

Introduction: Samples from Comet 81P/Wild 2 collected by NASA's Stardust mission provide the first opportunity to measure the average (bulk) oxygen isotope composition of a known comet. An important motivation for collecting material from a Kuiper belt object was to constrain models for maintaining oxygen isotope heterogeneities in the early solar nebula. $\delta^{17}O$ and $\delta^{18}O$ values of calcium-aluminum rich inclusions define a mixing line of slope ~1 between a ^{16}O rich reservoir and a ^{16}O poor reservoir [1]. Results from the Genesis mission place the sun near the ^{16}O-rich end of the CAI mixing line [2]; therefore, some mass-independent process enriched planetary materials in proportionally equal amounts of ^{17}O and ^{18}O. UV photodissociation has been suggested as the mechanism for producing such a ^{17}O and ^{18}O enriched reservoir [3]. One prediction of the UV self-shielding model is that primordial ice should have a composition of ~200-300‰ and dust should have a ^{16}O-rich composition close to solar (~-60‰).

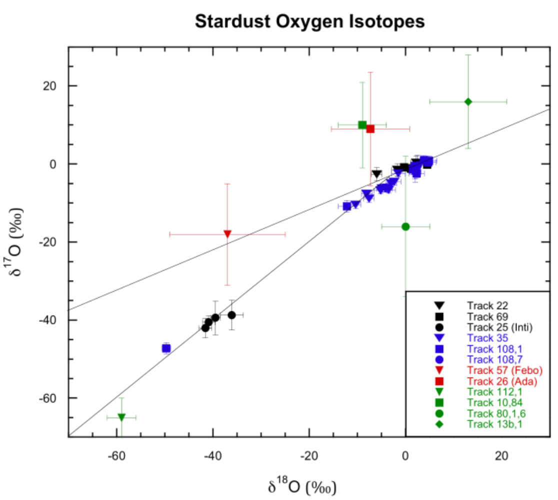

Figure 1: Summary of oxygen isotope measurements of Wild 2 materials. Most measurements indicate compositions consistent with inner solar system high temperature minerals [4-7].

In meteorites, heating and aqueous alteration have caused exchange between the water and the dust, obscuring the original compositions of the dust. A fresh Kuiper belt object like Wild-2 should contain dust that has undergone significantly less aqueous alteration than a main belt asteroid meteorite. To date, several studies have produced values for the oxygen isotopic compositions of large terminal particles extracted from Stardust aerogel tiles [4-7]. Thus far, measurements made on these Wild 2 grains have revealed oxygen isotope values that are consistent with refractory inclusions found in carbonaceous chondrites (figure 1). Petrological studies of these particles have indicated that many of the terminal particles represent inner solar system high temperature minerals that have been transported to the Kuiper Belt via large scale mixing mechanisms [8]. However, none of these studies has produced values for compositions of the fine-grained, primordial component of the impacting particles.

Synchrotron X-ray analyses suggest that in at least some tracks, 65% to 90% of the collected grain mass resides in the upper bulbous portion of bulbous and carrot shaped aerogel tracks as submicron particles, while 10% to 35% of the mass resides in the larger (>1mm) terminal particles located at the end of the track [9]. These analyses have led to a model (e.g. see Fig 11 of [10]) of impacting Wild 2 dust as aggregates of loosely bound fine-grained material containing the occasional larger olivine, pyroxene, iron sulfide and iron oxide grains. Intimate mixing of the fine-grained component with the oxygen-rich aerogel due to melting during capture process obscures the original oxygen isotope composition of the fine-grained component that constitutes the bulk of the dust mass. Complementary aluminum foil substrates on the Stardust collector provide a low background alternative to the aerogel collectors for measuring the O-isotopic composition of both the coarse and the fine-grained components of impacting particles. Craters in the foils likely retain much of the impactor material in a well defined location (the crater) regardless of whether it was fine grained or not. However, it will have been shocked and heated in the process. Efforts to precisely measure residues contained within these craters will present unique challenges that must first be assessed by measuring standards of known oxygen isotopic composition. Here we discuss techniques developed to analyze the oxygen isotopic compositions of impact crater residues and we present results of such measurements of simulated impact crater residues of several mineral standards.

Experimental Techniques: To determine the feasibility of making precise measurements of impact crater residues, simulated impacts were produced by firing minerals of known oxygen isotopic composition into foil targets at ~ 6 km/sec using a light gas gun at the University of Kent in Canterbury (see [10] for examples of this). Craters ranging from 20-100 microns were cut from foil targets, carefully flattened and pressed into indium-filled reservoirs in an aluminum ion probe mount (figure 2). Polished mineral standards were also included on the mount to enable calibration of instrumental mass fractionation. The craters had to be flattened to establish a uniform accelerating electric field with the immersion lens.

Craters were analyzed during three separate sessions using a Cameca IMS-1270 ion probe with a Cs primary beam. Because the secondary signal will necessarily vary during the measurement, acquisition of precise data requires the simultaneous counting of the different oxygen isotope beams (i.e., multicollection). During the first two sessions, the detectors were configured of for 2-oxygen isotope composition measurements of craters produced from San Carlos olivine, Admire olivine, Eagle Station olivine and Burma spinel projectiles. For the third analysis session, detectors were configured for 3-oxygen isotope measurements of craters produced by Burma spinel, Eagle Station olivine and Allende inclusion projectiles. Measurements were also made on unflattened craters produced by firing projectiles directly into polished aluminum ion probe mounts; however, distortion of the local accelerating electric field due to crater topology created very strong and irreproducible mass fractionation effects. Thus, the latter approach was abandoned as a way to develop standards.

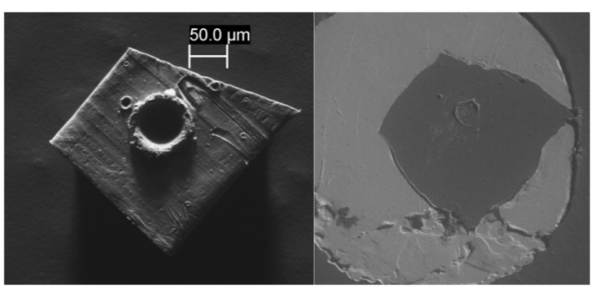

Figure 2: SEM images of a 50mm crater before and after the flattening process.

Results and Discussion: Results of crater measurements of analog samples are shown in figure 3. The bulk $\delta^{18}O$ compositions of the olivine crater residues are consistent with their accepted values to within a few per mil in this particular mounting configuration; however, they appear systematically shifted to lighter values. In the 3-isotope plot, it can be seen that this shift is mass-dependent. We are continuing to work on understanding the nature of this shift (e.g., charging, topography); however, it appears to be consistent amongst mineral types and can be corrected for by normalizing to the impact crater standards. If this second-order correction is made (i.e., normalizing Stardust crater residue to crater residue shots of standards), data that are precise and accurate to within a few permil can be obtained with care and repeated analyses.

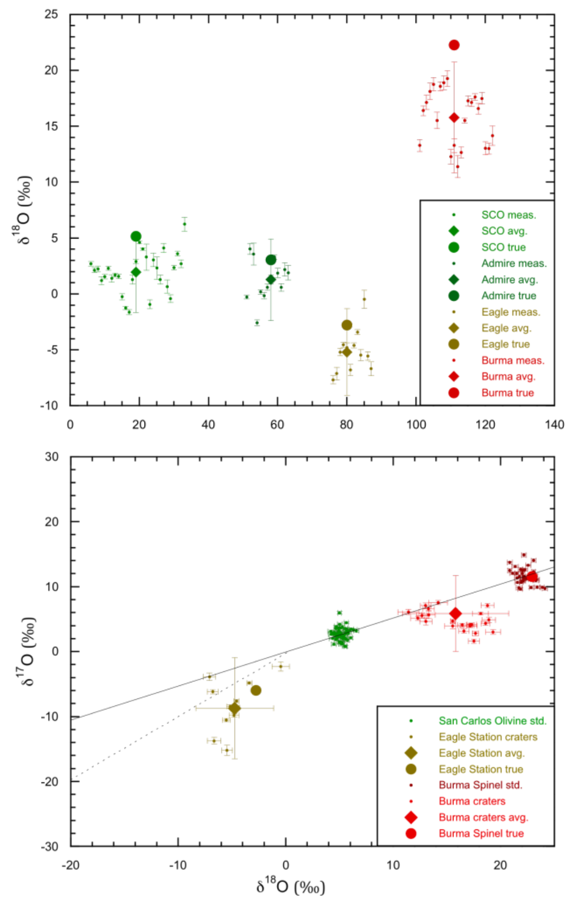

Figure 3. Two and three oxygen isotope measurements of crater residues of several mineral standards. Accepted values for each mineral are plotted for reference.

References: [1] Clayton R. N. et al. (1973) *Science, 182,* 485-488. [2] McKeegan K. D. et al. (2011) *Science, 332,* 1528-1532. [3] Clayton, R.N. (2002) *Nature, 415,* 860-861. [4] McKeegan, K.D. et al. (2006) *Science, 314,* 1724-1728. [5] Messenger S. et al. (2008) *Meteoritics & Planet. Sci, 43(7)* A97-A97. [6] Matrajt G. et al. (2008) *Geochimica Et Cosmochimica Acta, 72,* A603-A603. [7] Nakamura T. et al. (2008) *Science, 321,* 1664-1667. [8] Brownlee D. et al. (2006) *Science, 314,*1711-1716. [9] Flynn G. J. et al. (2006) *Science, 314,* 1731-1735. [10] Kearsley A.T. et al. (2009) *Meteoritics & Planet. Sci, 44* 1489-1510.