THE OXYGEN ISOTOPE COMPOSITION OF COMET WILD 2 GRAINS FROM THE BULB OF STARDUST TRACK 184 R. C. Ogliore[1], A. J. Westphal[2], K. Nagashima[3], G. R. Huss[3], T. K. Croat[1]. [1]Department of Physics, Washington University in St. Louis, St. Louis, MO 63117, USA, [2]Space Sciences Laboratory, University of California Berkeley, Berkeley, CA 94720, USA, [3]Hawai'i Institute of Geophysics and Planetology, University of Hawai'i at Mānoa, Honolulu, HI 96822, USA.

Introduction: NASA's Stardust mission returned rocky material from the coma of comet Wild 2 for laboratory study. The "Type B" Stardust tracks [1] have a bulbous cavity that tapers into a long and narrow stylus (or several). The impacting cometary particle that created a Type B track was an aggregate of fine-grained material (<2 μm) which ended up in the bulb of the track, and coarse-grained terminal particles (>2 μm) at the ends of the track.

Fine-grained material in Stardust track C2052,2,74 (an 8-mm type B track) showed a very broad distribution of O isotopic compositions ($-70‰ < \Delta^{17}O < +60‰$) compared to larger Stardust terminal particles [2]. This implies that Wild 2 fines are either primitive outer-nebula dust or a very diverse sampling of inner Solar System reservoirs that accreted along with a large number of inner-Solar-System rocks to form comet Wild 2.

Stardust cometary tracks show significant track-to-track heterogeneity [3]. It is possible that large tracks may be compositionally different from smaller tracks. Additionally, fines in small tracks may be better preserved (less mixing with aerogel) than fines in large tracks. For these reasons, we measured the O isotopic composition of bulb material in Stardust track C2086,20,184,0,0 ("Track 184"), a 0.3 mm type B track (Figure 1). We previously reported the O isotopic composition of 47 grains in the bulb of Track 184 [4]. In this abstract, we report the O isotopic composition of an additional 29 grains in this track.

Methods: We compressed the bulb portion of Track 184 into indium using a Teflon-coated anvil and plunger press (Figure 2). The aerogel porosity was sufficiently reduced to allow a conductive $\sim$20 nm C coat to be applied. The samples were then mounted under an Au-coated Si_3N_4 window with a $\sim$300 μm ion-milled hole, to create a flat, conducting surface for SIMS analysis [5]. After our first round of SIMS measurements [4] we analyzed the flattened bulb by SEM-EDX and Auger Electron Spectroscopy to identify other regions containing Mg or Fe. We identified a 25 μm region adjacent to the previous analyzed area (Figures 1 & 2) with several Fe- and Mg-rich cometary grains for SIMS analysis.

We acquired 25×25 μm, 128×128 pixel scanning ion images using the Cameca ims 1280 ion microprobe at the University of Hawai'i. We used a <3 pA Cs^+ primary beam focused to $\sim$250 nm. An electron flood gun was used for charge compensation. We simultaneously collected $^{16}O^-$, $^{17}O^-$, and $^{18}O^-$ on electron multipliers. We used magnetic-field peak-jumping to collect $^{16}OH^-$ (to quantify any contribution to $^{17}O^-$), $^{24}Mg^{16}O^-$, $^{27}Al^{16}O^-$, and $^{56}Fe^{16}O^-$ (to distinguish cometary material from background aerogel). Mass-resolving power for these molecular ions as well as $^{17}O^-$ was $\sim$5500 to minimize interferences. We collected 2400 total frames (39 hours). We monitored O isotope ratios of cometary particles during the analysis to identify any isotopically anomalous presolar grains, in which case the measurement would have been stopped so we would not sputter through them.

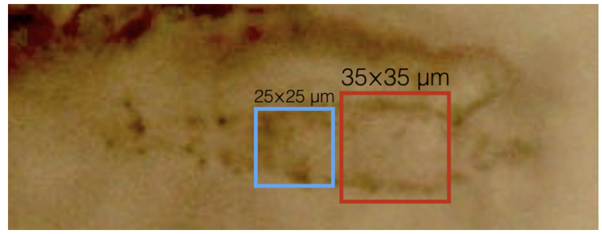

Figure 1: Optical image of Track 184 before compression into indium. Ion probe measurements of the blue 25×25 μm area are reported here; measurements of the red 35×35 μm area were reported in [2].

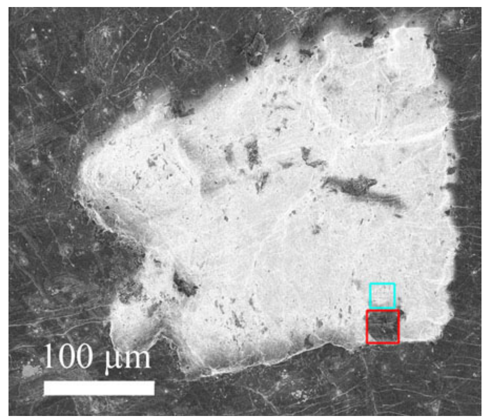

Figure 2: Secondary electron image of Track 184 pressed into indium; boxes show analyzed regions.

Data Analysis: We registered each of the 2400 frames using the $^{16}O^-$ map to account for drift during the long measurement. We also registered the $^{17}O^-$ and $^{18}O^-$ image to the $^{16}O^-$ image. Counts for all species were corrected for electron-multiplier deadtime. We used the $^{24}Mg^{16}O^-$ and $^{56}Fe^{16}O^-$ maps to identify particles (Figure 3). Most particles were entirely sputtered away during the long measurement, so we identified the frames and pixels in each frame where each particle was present.

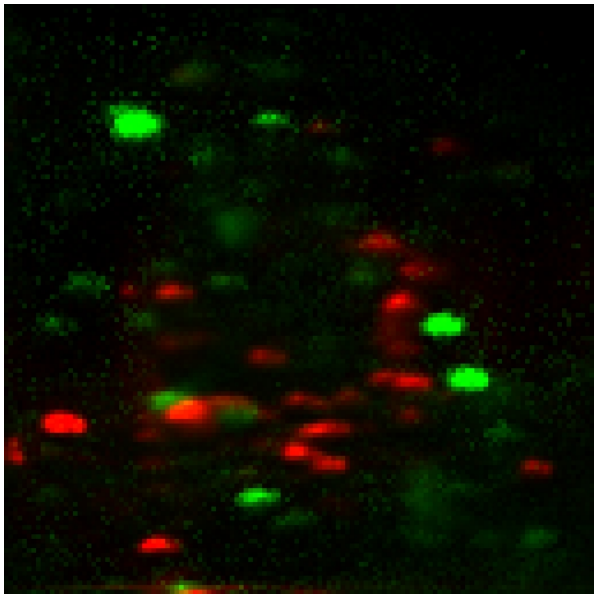

Figure 3: Scanning ion iron-magnesium map (25×25 μm, Red=FeO, Green=MgO) of a section of the bulb of Track 184.

We summed the counts of ^{16}O, ^{17}O, ^{18}O for each particle as well as the aerogel (pixels in the map that lack AlO, MgO, and FeO). We used the aerogel as our O isotope standard (δ^{18}O ≈ -1.1‰ and δ^{17}O ≈ -0.5‰ [6]), which was measured in the same frame and at approximately the same ^{16}O count rate as the cometary particles. We used a Monte Carlo method to calculate the uncertainties for O isotope ratios of the cometary particles (described in detail in [2]). This method accounts for the variation in measured isotope ratios of the aerogel, which may arise from topography created by sputtering. Uncertainties calculated by this method were about 10% larger than statistical uncertainties for both δ^{18}O and δ^{17}O . Additionally, the MgO/FeO ratio were calculated for each particle. This ratio is qualitative because of unknown sensitivity factors for these species in the measured phases.

Results: We measured the O isotope ratios of 29 particles, 1–3 μm in size, in the bulb region of Track 184. The results from this region, along with analyses reported in [2], are shown in Figure 4.

Discussion: The range of δ^{18}O values in the Track 184 bulb material is smaller than that in the Track 74 bulb material. Most grains from Track 184 have compositions within errors of the terrestrial fractionation line. The ^{16}O-poor, Fe-rich material found in Track 74 [2] is absent from Track 184.

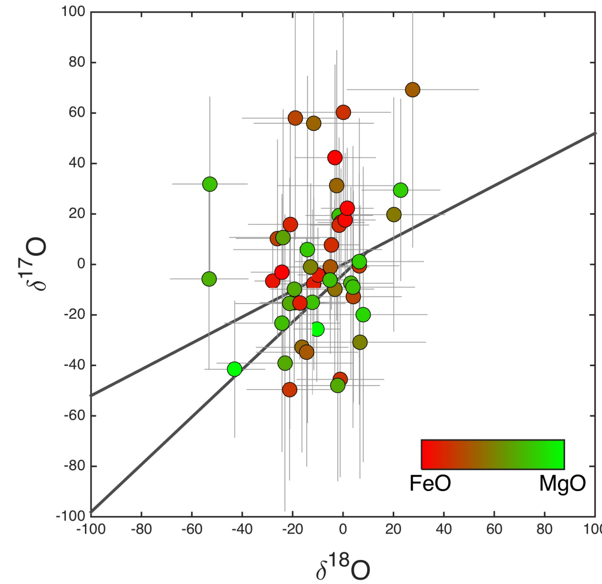

Figure 4: Oxygen 3-isotope plot of the 49 largest particles measured in the bulb of Track 184 from both the 25×25 μm (this abstract) and 35×35 μm regions [2]. The qualitative MgO–FeO composition is shown by the colored markers. Error bars are 2σ.

None of the 29 particles we measured in the Track 184 bulb had a significant O isotope anomaly that would be diagnostic of a presolar grain. Combining this with the zero presolar grain detections in the other Track 194 measurement (47 particles), and the Track 74 bulb material (63 particles), we calculate a 95%-confidence, single-sided upper bound of 2.2% for the abundance of oxygen-anomalous presolar grains in Wild 2 fines.

Conclusions: The described method of measuring O isotopes in the bulb of Stardust tracks is complementary to measurements of grains individually mounted in potted butts [e.g. 7, 8]. With this method we are able to measure a large number of grains at once, but compromise with larger uncertainties ($\sim$20‰ vs. $\sim$2‰) and less is known of each particle's mineralogy. With this lower precision data, we are able to estimate the spread of O isotopes in Stardust cometary fines, as well as identify interesting particles (e.g. ^{16}O-poor, ^{16}O-rich, presolar grains) for further analysis.

References: [1] M. Burchell, et al. (2008) *Meteoritics & Planetary Science* 43(1-2):23. [2] R. C. Ogliore, et al. (2015) *Geochimica et Cosmochimica Acta* 166:74. [3] A. J. Westphal, et al. (2009) *The Astrophysical Journal* 694(1):18. [4] R. C. Ogliore, et al. (2016) in *Lunar and Planetary Science Conference* vol. 47 1721. [5] A. J. Westphal, et al. (2011) *74th Annual Meeting of the Meteoritical Society* 74:5274. [6] K. McKeegan, et al. (2006) *Science* 314(5806):1724. [7] D. Nakashima, et al. (2012) *Earth and Planetary Science Letters* 357:355. [8] R. C. Ogliore, et al. (2012) *The Astrophysical Journal Letters* 745(2):L19.