HIGH PRECISION OXYGEN THREE ISOTOPE ANALYSIS OF WILD-2 PARTICLES AND ANHYDROUS CHONDRITIC INTERPLANETARY DUST PARTICLES. D. Nakashima[1], T. Ushikubo[1], M. E. Zolensky[2], M. K. Weisberg[3,4], D. J. Joswiak[5], D. E. Brownlee[5], G. Matrajt[5], and N. T. Kita[1]. [1]WiscSIMS, Dept. Geoscience, University of Wisconsin-Madison, Madison, WI 53706 (naka@geology.wisc.edu), [2]NASA Johnson Space Center, Houston, TX 77058. [3]Dept. Phys. Sci., Kingsborough College, City University of New York, Brooklyn, NY 11235. [4]American Museum of Natural History, Dept. Earth Planet. Sci., New York, NY 10024. [5]Dept. Astronomy, University of Washington, Seattle, WA 98195.

Introduction: One of the most important discoveries from comet Wild-2 samples was observation of crystalline silicate particles that resemble chondrules and CAIs in carbonaceous chondrites [1-2]. Previous oxygen isotope analyses of crystalline silicate terminal particles showed heterogeneous oxygen isotope ratios with $\delta^{18}O \sim \delta^{17}O$ down to −50‰ in the CAI-like particle Inti [2], a relict olivine grain in Gozen-sama [1], and an olivine particle [3]. However, many Wild-2 particles [1-5] as well as ferromagnesian silicates in anhydrous interplanetary dust particles (IDPs; [6-7]) showed $\Delta^{17}O$ values that cluster around −2‰. In carbonaceous chondrites, chondrules seem to show two major isotope reservoirs with $\Delta^{17}O$ values at −5‰ and −2‰ [8-9]. It was suggested that the $\Delta^{17}O$=−2‰ is the common oxygen isotope reservoir for carbonaceous chondrite chondrules and cometary dust, from the outer asteroid belt to the Kuiper belt region [8]. However, a larger dataset with high precision isotope analyses (±1-2‰) is still needed to resolve the similarities or distinctions among Wild-2 particles, IDPs and chondrules in meteorites. We have made significant efforts to establish routine analyses of small particles (≤10μm) at 1-2‰ precision using IMS-1280 at WiscSIMS laboratory [10]. Here we report new results of high precision oxygen isotope analyses of Wild-2 particles and anhydrous chondritic IDPs, and discuss the relationship between the cometary dust and carbonaceous chondrite chondrules.

Samples: We prepared two Wild-2 particles (C2092,7,81,1,0 "Pyxie" and Bidi [11]) and three IDPs (L2005, E36, F39, and Z17 [12]). Except for Bidi, they were originally mounted in epoxy potted butts and had microtomed surfaces, which were remounted to flat 8mm epoxy disks and polished according to the procedure [1,10]. A 100μm acrylic cube that contains Bidi was cut out from the potted butt and embedded in an 8mm aluminum disk using indium with a San Carlos olivine standard grain. We used the newly developed sample holding disk for adapting the 8mm sample disks for the ion microprobe analysis [10]. The oxygen isotope analysis was made using 1×2μm Cs^+ primary beam under the conditions similar to those in [1].

Pyxie is the terminal particle (~15×20μm) from Track 81, and consists of low-Ca pyroxene ($En_{92}Wo_3$; ~5×10μm) and plagioclase ($An_{65}Ab_{35}$; ~15×15μm) (Fig. 1a). Bidi is the terminal particle (~6×8μm) from Track 130, which consists of olivine (Fo_{97}; ~4×6μm) and a mixture of high-Ca pyroxene ($En_{55}Wo_{43}$) and plagioclase (An_{97}). The chemistry of Bidi is discussed in [11]. E36 is an anhydrous porous IDP composed mainly of fine-grained low-Ca pyroxene ($En_{>85}Wo_{<5}$; ≤1μm). This IDP contained a large enstatite grain [12], but it was lost. F39 is also an anhydrous porous IDP composed of fine-grained olivine ($Fo_{>95}$) and low-Ca pyroxene ($En_{>85}Wo_{<5}$) (≤2μm). Z17 is an anhydrous compact IDP with coarse (>2μm) low-Ca pyroxene (mostly $En_{>95}$) and fine-grained silicate phase (Fig. 1b). The chemistry of these IDPs was discussed in [12].

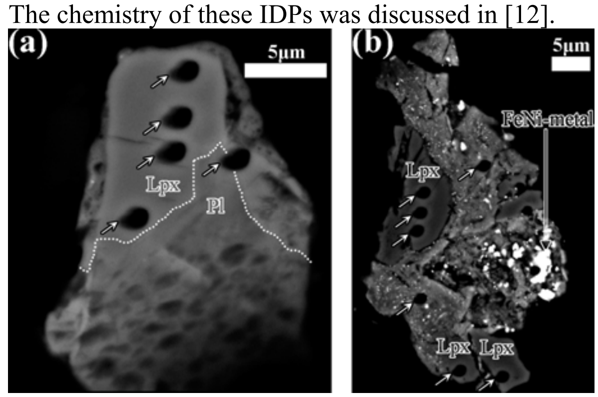

Fig. 1: Backscattered electron images of C2092,7,81,1,0 "Pyxie" (a) and L2005 Z17 (b). The dashed line in panel (a) is a boundary line between low-Ca pyroxene (Lpx) and plagioclase (Pl). Arrows show spots sputtered for oxygen isotope analyses.

Results: Oxygen isotope ratios of coarse low-Ca pyroxene (>2μm; Fig. 1a) in Z17 and Pyxie plot between the CCAM [13] and Y&R [14] lines (Fig. 2). Isotope ratios of a mixed phase (low-Ca pyroxene + plagioclase) in Pyxie are within the range of those of low-Ca pyroxene and do not deviate from the slope-1 lines, suggesting that oxygen isotope ratios in Pyxie plagioclase were not affected by secondary alteration which induces mass dependent fractionation towards higher $\delta^{18}O$. Isotope ratios of olivine (+high-Ca pyroxene) in Bidi deviate slightly from the slope-1 lines (Fig. 2). This may be due to instrumental fractionation induced by mixing between Bidi silicate and a tiny fraction of acrylic under the ion probe beam [2] and/or by deformation of electrostatic field on the sample surface [15] (Bidi was in a rectangle-shaped dent made by rastering of SEM electron beam).

Isotope ratios of fine-grained phases in E36 and F39 deviate from the slope-1 lines more than 10‰ in $\delta^{18}O$ (Fig. 2). Spots in E36 and F39 were mixtures of submicron silicate and epoxy. Measurements of epoxy usually result in low $\delta^{18}O$ value (-31‰; based on the test analyses with 10µm spots) with significantly low ^{16}O count rates (~1/20 of olivine). Since we did not see a significant drop in ^{16}O counts, we conclude that the low $\delta^{18}O$ values of the two IDPs cannot be explained by simple mixing between epoxy and submicron silicate. We speculate that unknown instrumental fractionation occurred due to ion bombardment of the silicate-epoxy mixture at the sub-micron scale, though it does not affect $\Delta^{17}O$ values. One data point of fine-grained phases in Z17 deviates from the slope-1 lines towards high $\delta^{18}O$, which is common for hydrous IDPs [7]. Since Z17 is anhydrous [12], it is considered that the high $\delta^{18}O$ value is not a result of aqueous alteration but caused by instrumental fractionation or indigenous to this IDP.

The $\Delta^{17}O$ values of coarse low-Ca pyroxene in Z17, Pyxie, and Bidi are internally homogeneous within the analytical uncertainties (±2‰, 2SD). The average $\Delta^{17}O$ values are −4.3±0.9‰ (2SE, n=5) for coarse low-Ca pyroxene in Z17, −1.2±0.8‰ (2SE, n=5) for Pyxie, and −1.9±1.2‰ (2SE, n=3) for Bidi. The $\Delta^{17}O$ values of fine-grained phases in the IDPs are from −5‰ to +1‰. The average $\Delta^{17}O$ value of Bidi is consistent with those of NanoSIMS analyses (1σ error~±4-40‰ for $\delta^{17,18}O$; [11]). The average $\Delta^{17}O$ value of coarse low-Ca pyroxene in Z17 is lower than those of crystalline silicate in other anhydrous IDPs (~−2‰; [6-7]).

Discussion: Most of the ferromagnesian Wild-2 particles including Pyxie and Bidi cluster at $\Delta^{17}O$ ~−2‰ [1-5], though the particles were extracted from twelve different tracks. It may be concluded that −2‰ is the representative $\Delta^{17}O$ value for crystalline silicate particles in comet Wild 2. The −2‰ cluster is also seen in carbonaceous chondrite chondrules [8-9] and anhydrous IDPs [6-7]. It is suggested that the $\Delta^{17}O$=−2‰ is the common oxygen isotope reservoir for carbonaceous chondrite chondrules and cometary dust (Wild-2 particles and probably most of the anhydrous IDPs) [8]. However, $\Delta^{17}O$ values of the fine-grained phases in the IDPs range from −5‰ to +1‰. Coarse low-Ca pyroxene in Z17 shows a cluster at $\Delta^{17}O$~−4.3‰, which is closer to the −5‰ group of carbonaceous chondrite chondrules [8-9]. It is not clear if Z17 is of cometary origin. Z17 is not porous [12], and many believe that only anhydrous porous IDPs are of cometary origin [16]. If Z17 is cometary, the range of $\Delta^{17}O$ among cometary dust could extend to slightly lower values. If Z17 is asteroidal, this IDP was derived from an anhydrous carbonaceous chondrite parent body, because the oxygen isotope ratios are within the range of those of carbonaceous chondrites [17].

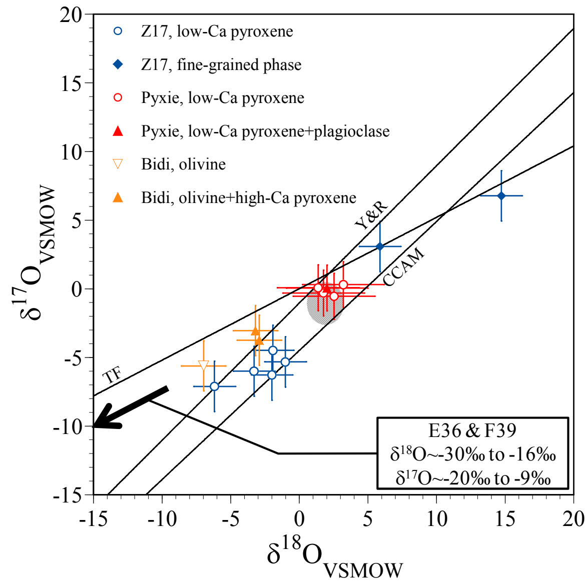

Fig. 2: Oxygen isotope ratios of the IDPs and Wild-2 particles. TF (terrestrial fractionation), CCAM [13], and Y&R [14] lines are shown as reference. The gray area represents the cluster of oxygen isotope ratios of Wild-2 particles with $\Delta^{17}O$ values of ~−2‰ [1-2,5].

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