Comparing Olivine Compositions from Micrometeorites with those from other Solar System Materials. K. Williford[1], S. Taylor[2], G. Matrajt[3], D. Brownlee[3], D. Joswiak[3], S. Wengert[4] and S. Kuehner[1], [1]Dept. of Earth and Space Sciences, University of Washington, Seattle, WA 98195, [2]CRREL, Hanover, NH 03755, [3] Dept. of Astronomy, University of Washington, Seattle, WA 98195, [4]Dartmouth College, Hanover NH 03755.

Introduction: Micrometeorites are extraterrestrial particles less than 2000 mm in diameter found on the Earth's surface [1]. As the dominant source of ET materials to the present day Earth [2] they contain particles from a variety of sources, mainly asteroidal, and may be a less biased sampling of asteroidal materials than larger meteorites. To assess the relationship between micrometeorites and other types of solar system materials we compared their compositions to those of meteorites, formed in the asteroid belt, and Stardust samples, formed in the Kuiper belt. Olivine ($(Fe,Mg)_2SiO_4$) is one of the most common minerals in the solar system [3], and as such, provides a good comparison. Forsterite (Mg_2SiO_4) with < 0.2 wt.% Fe would have been the first olivine, and among the first solid material, to condense out of the solar nebula at temperatures ~ 1250 K [4,5]. Foresterite relicts were preferentially chosen for this study.

We analyzed 136 olivine grains in 59 micrometeorites from the South Pole water well (SPWW). Here we compare the Al, Ca, Fe and Cr results to literature values for other micrometeorites collections, for meteorites, and for particles returned from Comet Wild-2 by the Stardust spacecraft.

Methods: The micrometeorites studied here come from the SPWW [1]. Fig. 1 shows examples of representative micrometeorites and their olivine grains. Because the olivines are found in both melted and unmelted micrometeorites and are of different size we kept track of these attributes.

Micrometeorites containing low-Fe relict olivines were identified by SEM/EDAX at Dartmouth College. The micrometeorites were photographed and spot analyses made of candidate grains to determine if they were olivines or pyroxenes and how much Fe they contained. The mounts containing micrometeorites with low-Fe olivine grains were prepared for electron microprobe analysis by polishing with a diamond compound and coating with carbon to a thickness of 25 nm. Abundances of SiO, TiO_2, Al_2O_3, Cr_2O_3, FeO, MnO, NiO, MgO, ZnO, CaO, P_2O_5, and Cu_2O were measured using a JEOL Superprobe 733 with 4 wavelength spectrometers at the University of Washington.

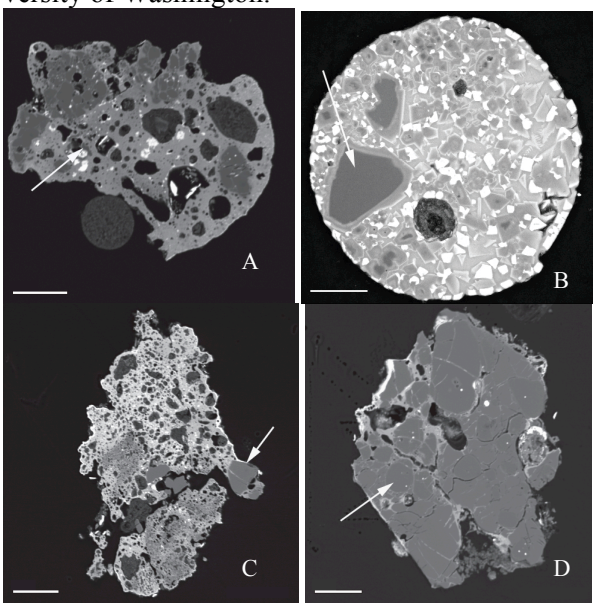

Fig. 1. Images of representative micrometeorites. Scale bars are 50 µm in A, C and D, and 20 µm in B. Arrows show individual olivine grains analyzed.

Results: Element plots for Al and Ca versus Fe show similar trends and the Ca plot is shown in Fig 2. Al and Ca concentrations are highest at the lowest Fe concentrations. In all samples with greater than 3 wt.% FeO, Al_2O_3 is less than 0.3 wt. % and CaO is less than 0.42 wt.%. Five olivines show Al enrichment between 0.3 and 1.2 wt.%, and eight show Ca enrichment up to 0.86 wt.%. Most of the olivines analyzed in this study cluster around the low Ca and Al values typical of C1 meteorites [6] and other micrometeorite collections [7,8] (Fig. 3). However, nine olivines plot well outside the range observed in other micrometeorite collections. The two grains with the highest Al and Ca values have low FeO contents (2.66 and 1.12 wt. %) making them similar in composition to so called "refractory forsterites" with < 1

% fayalite and high refractory lithophile element contents [9].

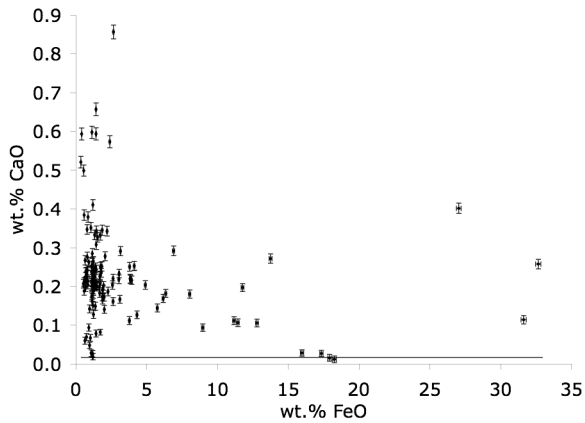

Fig. 2. CaO wt% versus FeO wt% for 136 olivine analyses. Error bars and detection limits shown.

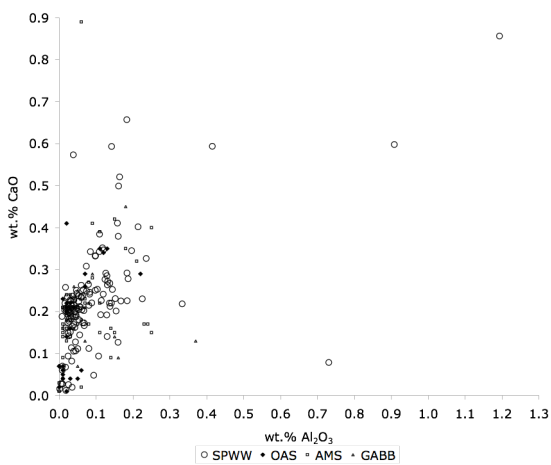

Fig. 3. CaO versus Al_2O_3 for SPWW, Orgueil and Allende (OAS) [10], Antarctic (AMS) [6] and Greenland/Antarctic olivines (GABB) [8].

The Cr_2O_3 distribution (Fig. 4) in the SPWW samples is also similar to that found in the Orguiel and Alais (C1) meteorites [10] as well as other micrometeorite collections from Antarctica and Greenland [6,8]. Of the SPWW olivines 108 have CrO > 0.3 wt. %, consistent with C1, but not C3 meteorites [6]. Olivines with FeO < 2 wt. %, 96 in all, show a positive linear trend in CrO (r = 0.29), similar to C2 meteorites [7]. Overall the compositional data are in general agreement with similar studies on micrometorites [6, 7, 8] and with the few olivine analyses from Comet 81P/Wild2 [3].

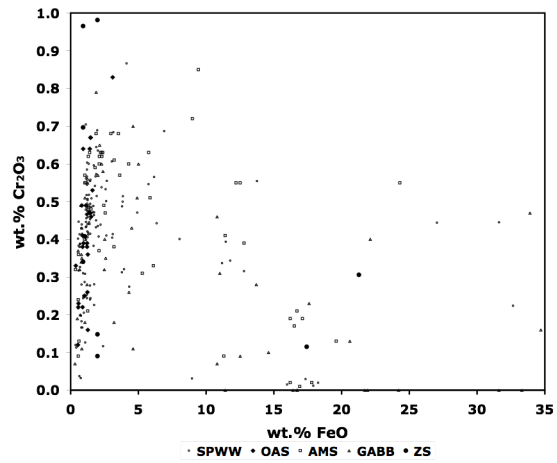

Fig. 4 Chromium oxide versus FeO for SPWW, Antarctic (AMS), Greenland & Antarctic (GABB), Orgueil & Allende (OAS),and Comet Wild 2 olivines (ZS).

Conclusion: Olivine grains in SPWW micrometeorites show a compositional overlap with olivines in Orgueil and Alais, C1 meteorites, and with other micrometeorite collections. This data along with other meteoritc data, such as from Tagish Lake, provides support that the micrometeorites data extend and complement the meteorite data. These data also provide a means of comparing minerals formed at 2-3AU in the asteroid belt with those formed beyond 30 AU and collected by Stardust.

References: [1]Taylor et al. (1998) *Nature* **392**, 899-903. [2] Love S.G. and Brownlee D.E., (1993) *Science* **262**, 550-553. [3] Zolensky et al. (2006) Science 314, 1735-1739.[4] Palme and Fegley (1990) Earth and Planetary Science Letters 101, 180-195. [5] Ebel and Grossman, 2000 Geochimica et Cosmochimica Acta 64, 339-366. [6] Steele, 1992 Geochimica et Cosmochimica Acta 56, 2923-2929. [7] Steele et al., 1985 Geochimica et Cosmochimica Acta 50, 1379-1396. [8] Beckerling and Bischoff (1995) *Planetary Space Science* 43, 435-449. [9] Pack et al. (2005) Geochimica et Cosmochimica Acta 69, 3159-3182. [10] Steele (1990) Meteoritics 25, 301-307.