POSSIBLE IDENTIFICATION OF SURVIVING IMTERPLANETARY DUST PARTICLES IN A MARS REGOLITH BRECCIA. G. J. Flynn[1], S. R. Sutton[2,3], S. Wirick[2], A. Lanzirotti[2], and W. Rao[4], [1]Dept. of Physics, SUNY-Plattsburgh, 101 Broad St., Plattsburgh, NY 12901 (george.flynn@plattsburgh.edu), [2]CARS, Univ. of Chicago, Chicago IL 60637, [3]Dept of Geophysical Sciences, Univ. of Chicago, Chicago IL 60637, [4]College of Agriculture, Univ. of Kentucky, Lexington, KY, 40506.

Introduction: Spacecraft impacts indicate that currently more than 30,000 tons of interplanetary dust strikes the Earth's upper atmosphere annually [1]. This accretion rate is likely to have been significantly greater during the heavy bombardment recorded over the first ~0.6 b.y. of Solar System history in the lunar cratering record. Only the smallest particles, typically <50 μm, survive Earth atmospheric entry unmelted. Most larger particles, up to several millimeters in size, which are at the peak of the mass-frequency distribution of the dust incident on the Earth, experience significant thermal modification during atmospheric deceleration.

Mars, because of its lower surface gravity and greater atmospheric scale height, is a more favorable site for the survival of interplanetary dust during atmospheric deceleration [2]. Entry heating modeling indicates many of the larger interplanetary dust particles survive atmospheric entry on Mars without significant thermal alteration [2], potentially perturbing the chemical composition of the regolith of Mars and providing pre-biotic organic matter that could be an important resource for the development of life on early Mars [3]. The identification of NWA 7034 and NWA 7533 as fragments of Mars regolith breccia [4, 5] provides the first opportunity to search for surviving interplanetary dust in a sample of the planet's regolith.

Measurements: Because Ni, Ir and some other elements are abundant in primitive chondritic Solar System materials, but are soluble in the molton Fe core, these elements are severely depleted in the surface rocks of differentiated parent bodies such as the Earth and Mars. As a result, we can distinguish chondritic materials, such as most of the interplanetary dust particles, accreted onto the surface of a differentiated parent body from the indigenous surface material by relatively high abundances of these elements. The bulk Ni/Fe and Ir/Fe ratios of NWA 7533 are much higher than those in the Mars basaltic meteorites, suggesting the addition of ~5% of an exogoneous chondritic component to the Mars regolith [5]. However, the elements in the interplanetary dust would be added to the regolith even if the particles themselves were vaporized on atmospheric entry or destroyed on the surface of Mars due to harsh surface conditions.

Ni-mapping. Nickel is the most abundant of the major rock-forming elements that is severely depleted in Mars or Earth surface rocks compared to its chondritic abundance. The chondritic Ni/Fe ratio is ~0.05, while the Ni/Fe in the Mars basalts is lower by a factor of 100 or more. So we conducted a preliminary search for surviving interplanetary dust particles in NWA 7034 by searching for Ni hot-spots using the X-Ray Microprobe (XRM) on Beamline X-26a of the National Synchrotron Light Source (Brookhaven National Laboratory, Upton, NY). We mapped an area measuring ~1.5 mm by 4 mm in 7 μm steps, on a sample >1 mm thick and plotted the Ni fluorescence intensity, shown in Figure 1. We identified several Ni hot-spots in this small volume. For comparison, we mapped the Ni distribution in a similar area of a Mars basaltic meteorite, ALH84001, and found no Ni hot-spots (see Figure 2), suggesting that Ni-rich minerals are rare in the indigenous near surface rocks on Mars, the material that is ground up to form the regolith.

Other Elements. We selected two of these Ni hot-spots, identified in Figure 1, for XRM elemental analysis. Spot 1 is ~20x10 μm, and Spot 2 is ~20x14 μm. Because hard x-rays penetrate hundreds of microns into an ~1 mm thick sample, the XRM fluoresces a cylinder hundreds of microns into the sample, diluting the contribution to the fluorescence spectrum by an interplanetary dust particle that is only tens of micrometers in size. Nonetheless, the spectrum of the volume that includes each Ni hot-spot also exhibits peaks at Zn, and Ga, both moderately volatile elements that are significantly enriched in chondritic materials compared to basalts. This is consistent with the identification of these Ni hot-spots as surviving interplanetary dust. Quantitative elemental compositions of the Ni hot-spots will require analysis of thin sections comparable in thickness to the size of the Ni hot-spots.

Discussion: If surviving interplanetary dust particles are convincingly identified in the Mars regolith, then measurement of their abundance, coupled with a measurement of the interplanetary dust flux at Mars, will provide the opportunity to quantify the regolith production rate [2], compare the elemental and mineralogical compositions of these ancient interplanetary dust particles with contemporary interplanetary dust collected from Earth's stratosphere, and characterize the types and abundances of organic matter delivered to the surface of Mars by the interplanetary dust [3].

Figure 1: Ni fluorescence map of an area of NWA 7034. Spots 1 and 2 are regions where we obtained longer dwell time fluorescence spectra.

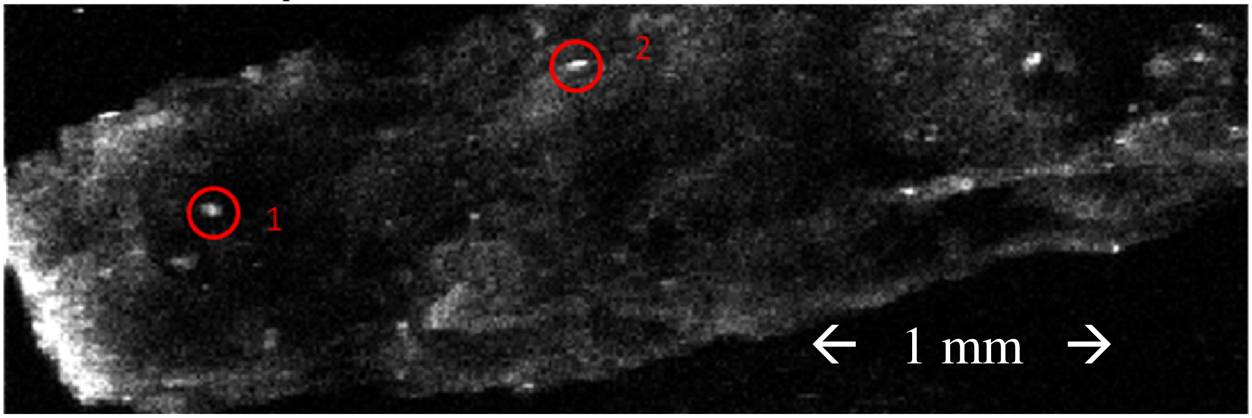
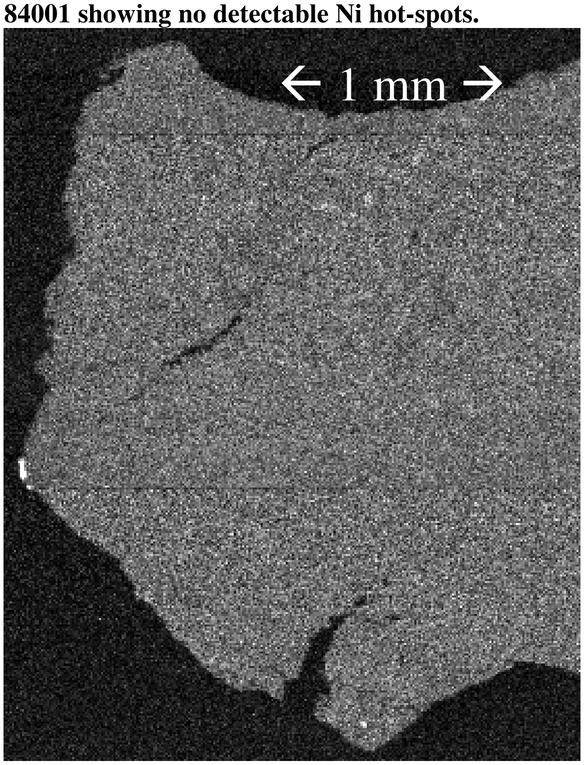


Figure 2: Ni fluorescence map of an area of ALH 84001 showing no detectable Ni hot-spots.



Regolith Production Rate: In the same way that the Ir concentration is used to infer the accretion rate of ocean sediments on the Earth, the Ni or the Ir concentration in the regolith of Mars can be used to infer the regolith production rate. Modeling by Flynn and McKay [2], assuming a uniform distribution of interplanetary dust in a soil with a mean planetary production rate of regolith of 1 m/b.y. produced a meteoritic concentration of 2 to 29% in the Mars regolith, with much of the uncertainty due to modeling the Mars dust flux from measurements at Earth. The observation of an ~5% concentration [5] suggests the mean regolith production rate is not far from that value.

Organic Matter on Mars: Calibration experiments demonstrated that the Viking GCMS instruments had the sensitivity to detect naphthalene, found at 1 ppm in CI chondrites, at 0.5 ppb level by Viking 1 and at 0.015 ppb by Viking 2 [6]. However, the Viking GCMS failed to detect organic matter at either of its two landing sites, which is puzzling given the large amount of organic matter in the interplanetary dust particles collected from the Earth's stratosphere [7].

Conclusions: Ni hot-spots in a Mars regolith breccias have characteristics consistent with surviving interplanetary dust particles. Detailed characterization of these spots could allow comparison of the compositions and mineralogies of ancient interplanetary dust in NWA 7034 and NWA 7533 with contemporary interplanetary dust particles collected from the Earth's stratosphere, place constraints on the regolith production rate on Mars, and characterize the types and abundances of pre-biotic organic matter contributed to the surface of Mars by these particles.

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