SPACE WEATHERING ON 4 VESTA: PROCESSES AND PRODUCTS. C M Pieters[1], D T Blewett[2], M Gaffey[3], D W Mittlefehldt[4], M C De Sanctis[5], V Reddy[6], A Nathues[6], B W Denevi[2], J Y Li[7], T B McCord[8], S Marchi[9], E E Palmer[10], J M Sunshine[7], E Ammannito[5], C A Raymond[11], C T Russell[12]. [1]Dept Geological Sci, Brown Univ, Providence, RI, USA, Carle_Pieters@brown.edu, [2]JHU/APL, Laurel, MD, USA, [3]Univ. North Dakota, Grand Forks, ND, USA, [4]NASA/Johnson Space Center, Houston, TX, USA, [5]INAF/IASF, Rome, Italy, [6]MPI for Solar System Research, Katlenburg-Lindau, Germany, [7]Univ. Maryland, College Park, MD, USA, [8]Bear Fight Institute, Winthrop, WA, USA, [9]Universite de Nice, Nice, France, [10]PSI, Tucson, AZ, USA, [11]JPL, California Institute of Technology, Pasadena, CA, USA, [12]University of California, Los Angeles, CA, USA.

Introduction: The bulk properties of Vesta have previously been linked directly to the howardite, eucrite, and diogenite (HED) meteorites through remote mineral characterization of its surface from Earth-based spectroscopy [e.g., 1]. A long-standing enigma has been why does Vesta's surface appear to have suffered so little alteration from the space environment, whereas materials exposed on the Moon and some S-type asteroids are significantly changed (grains develop rims containing nano-phase opaques [e.g. 2]). The Dawn spacecraft is well suited to address this issue and is half through its extended mapping phase of this remarkable proto-planet [3]. On a local scale Dawn sees evidence of recent exposures at craters, but distinctive surface materials blend into background at older craters. The presence of space weathering processes are thus evident at Vesta, but the character and form are controlled by the unique environment and geologic history of this small body.

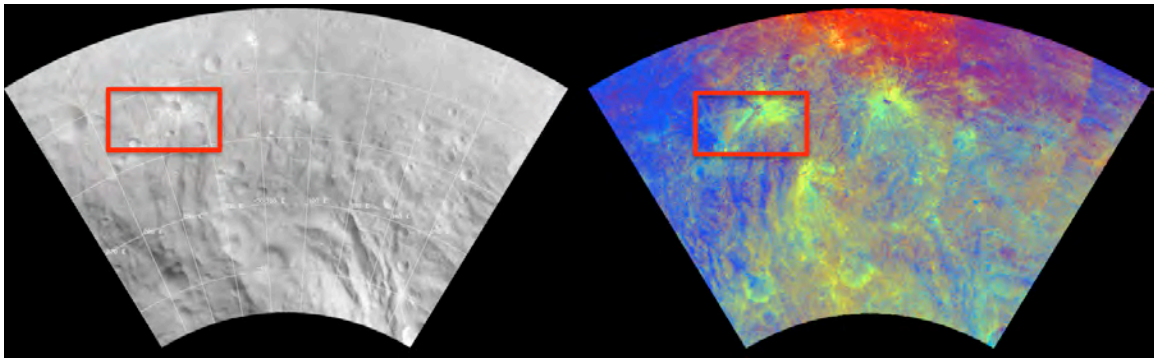

Fig.1 Urbinia quadrangle Av-14 [4]. Left: FC Image basemap. Right: FC color composite using "Clementine" assignments (Red=visible continuum, Green=Ferrous band ratio, Blue=inverse of Red). Region outlined in box includes several craters with diverse deposits analyzed with VIR spectra; crater A is top center.

Dawn data. Analysis currently involves VIR spectroscopic data from the Survey orbit and FC image data from the lower HAMO orbit. Results from Dawn that are documented elsewhere [5] include: a) both regional and local variations in mineralogy occur, b) most morphologically fresh craters have distinctive surrounding deposits, c) prominent dark and bright materials are found, sometimes in close proximity, d) diverse and extensive regolith mobility is observed.

An example of a region containing several craters with deposits distinctive from surroundings is shown in Fig. 1. VIR and FC images are presented in Fig. 2, and representative spectra in Fig 3 to illustrate the range of variations observed. It is clear that many fresh craters (e.g. A) expose material different from surroundings and older nearby craters of similar size have faded into background (e.g. the degraded crater above the Ref Std). Although all areas, including the reference standard, exhibit prominent absorptions due to pyroxene, the deposits around crater A exhibit the strongest and those to the NW of crater B have the weakest. These variations in band strength are readily mapped in Figs 1 (right) and 2B. As seen in the relative reflectance spectra, brightness generally correlates with band strength in this region (except for anomalous area #2), but there is no correlation of NIR continuum slope with brightness, band strength, or with continuum in the visible.

Discussion. It is now well understood that as soils gradually accumulate on the Moon, exposed grains develop thin rims containing nano-phase opaque particles [2, 6, 7]. It is the presence of such particles that result in soils that are darker, have weaker absorptions, and a steeper NIR continuum than their host material [7]. Nano-phase bearing rims are rarely seen in howardite regolith breccias [8]. At Vesta the observed decoupling of the NIR continuum from band strength and brightness precludes significant lunar-like weathering products (nano-phase opaques). With the exception of anomalous area #2, there is also no apparent shift in band centers with band strength in this region, suggesting the presence of similar ferrous minerals but differing abundances of a relatively featureless bright or dark component mixed to different degrees.

Conclusions. Some form of space weathering occurs on Vesta, gradually blending freshly excavated material into the background. However, the dominant process active on Vesta is not the accumulation of opaque nano-phase bearing rims on grains. Instead, processes involved in the creation, mobility, and mixing of fine-grained regolith across Vesta is hypothesized to dominate.

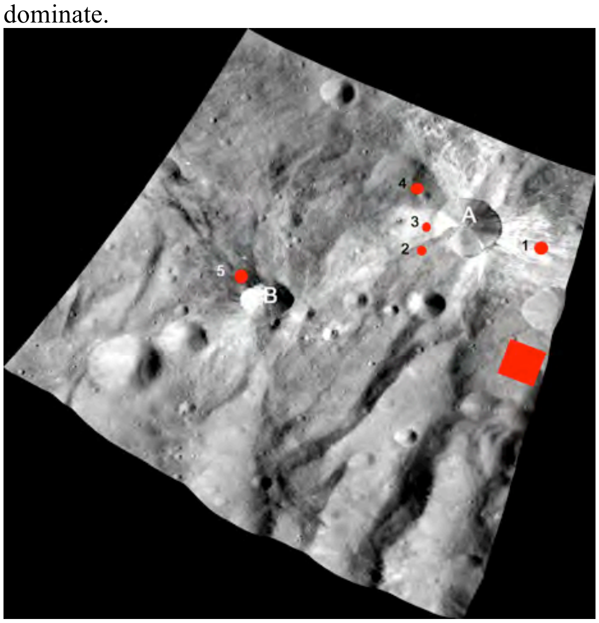

Fig. 2A. HAMO FC image FC21B0010860 in the region outlined in Fig1. Labels are the same as Fig 2B.

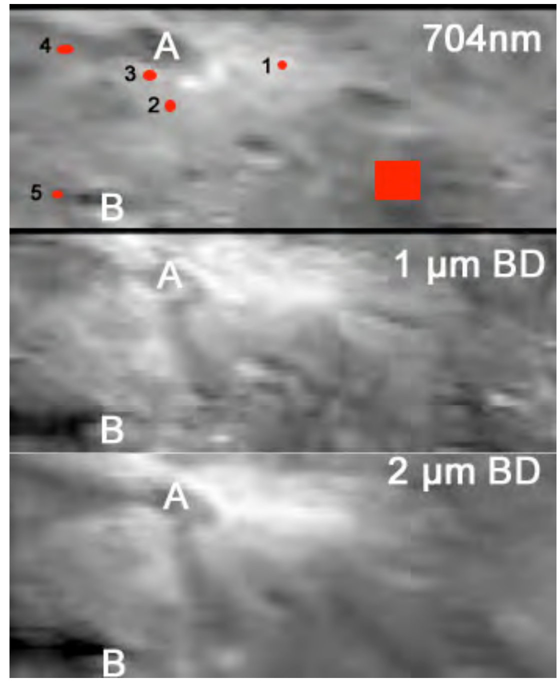

Fig 2B. Survey VIR image for the region outlined in Fig.1. The large square is a bland region of soil used as reference (Ref Std) in relative reflectance spectra. Crater A is ~11 km in diameter at ~37.4S, 288E. Maps of band depth (BD) derived from VIR data is shown for the 1 and 2 µm ferrous pyroxene bands.

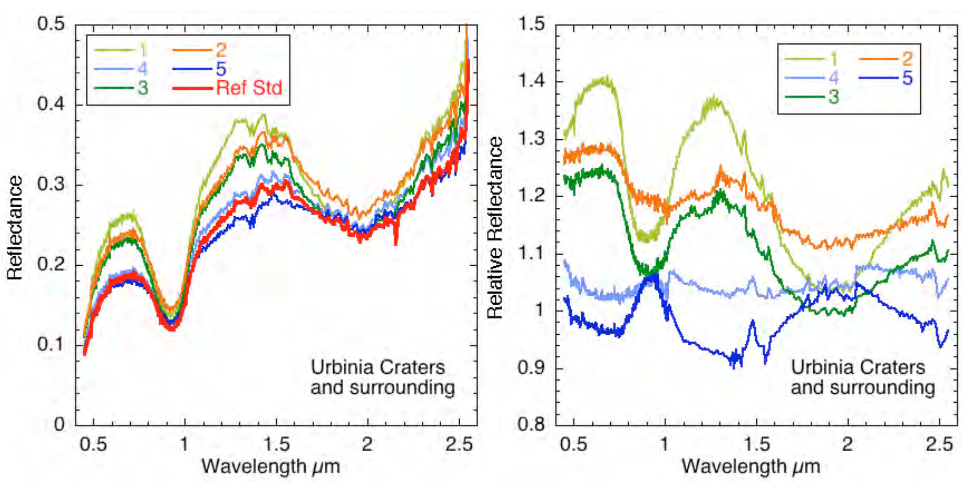

Fig. 3. VIR spectra for areas shown in Fig. 2 associated with crater deposits. Relative Reflectance spectra (right) are relative to the large soil Ref Std area in Fig. 2. With the exception of spectrum #2, most variations in crater deposits reflect differences in pyroxene band strength, which are generally correlated with brightness, but not NIR continuum. Anomalous area #2 appears to be a stream of material associated with the impact (see [4]).

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References: [1] McCord et al., 1970 *Science*, 1445. [2] Pieters et al., 2000 *MaPS*, 1101-1107. [3] Russell et al., 43LPSC 2012; and 2011 *SSR*. [4] Mest et al, 2012 43LPSC. [5] 43LPSC Dawn Special Session, 2012 [6] Taylor et al., 2001 *JGR* E11, 27985 [7] Noble et al., *Icarus*, 2007 192, 629-642. [8] Noble et al., 2010 *MaPS*, 45, 2007.