TOWARDS A REGOLITH MATURITY INDEX FOR HOWARDITES.

D. W. Mittlefehldt[1], J. A. Cartwright[2], J. S. Herrin[3] and K. N. Johnson[4]. [1]NASA/Johnson Space Center, Houston, TX, USA. david.w.mittlefehldt@nasa.gov. [2]Max-Planck-Institut für Chemie, Mainz, Germany. [3]ESGC/Johnson Space Center, Houston, TX, USA. [4]Arizona State University, Tempe, AZ, USA.

The Dawn spacecraft has just arrived at asteroid 4 Vesta, parent of the howardite, eucrite and diogenite (HED) meteorites [1], to begin a yearlong surface study from orbit [2]. As Dawn will view a debris-covered surface, understanding the formation and mixing processes for the debris layer will strongly aid surface data interpretations. Howardites are polymict breccias mainly composed of clasts derived from basaltic (eucritic) and orthopyroxenitic (diogenitic) parent materials [3]. Some howardites are poorly reworked (fragmental howardites) whilst others have been extensively gardened in an active regolith (regolithic howardites) [4]. The latter may represent an ancient, well-mixed regolith, whilst the former may be from more recent ejecta deposits [4]. Due to environmental differences, regolith development on Vesta differs in detail from that on the Moon [4-6].

We have been developing petrological criteria to apply to howardite thin sections to determine their relative regolithic maturity, which we are fine-tuning with comparison to noble gas data [7, 8]. Whilst we previously emphasized the abundance of "reworked" clasts (fragmental and impact-melt breccia clasts), this is an imperfect criterion: one howardite with abundant reworked clasts (EET 99408) shows no evidence of solar wind Ne (SW-Ne), yet, two of our alleged fragmental howardites have clear SW-Ne signatures (LEW 85313, MET 00423) [7, 8].

We are now investigating the diversity in minor and trace element contents of low-Ca pyroxene clasts in howardites as a measure of regolith grade, and will begin analyses of such grains within reworked clasts. Our hypothesis is that regolithic howardites (and the breccia clasts they contain) will show greater diversity because they sampled more diverse diogenitic plutons than fragmental howardites, which formed from ejecta from only a few impacts [e.g. 4]. Our initial LA-ICP-MS work showed ranges in trace element diversity in low-Ca pyroxenes (estimated from the standard error of the mean of analyses), where those howardites considered of medium to high regolithic grade showed greater diversity [9]. Our EMPA results (from a larger howardite suite) show an overall greater diversity in our putative medium to high regolithic grade howardites, though there are exceptions. The greatest diversity is found for paired howardites GRO 95574 and GRO 95581, which were not considered regolithic in our initial study. We will continue investigating avenues to determine regolith maturity in thin section, factoring in bulk rock compositional data, and will coordinate these studies with noble gas results.

References: [1] Drake M. J. 2001. *Meteoritics & Planet. Sci.* 36:501–513. [2] Russell C. T. et al. 2006. *Adv. Space Res.* 38:2043-2048. [3] Mittlefehldt D. W. et al. 1998. *Rev. in Mineralogy* 36, chapter 4. [4] Warren P. H. et al. 2009. *Geochim. Cosmochim. Acta* 73:5918-5943. [5] Housen K. R. and Wilkening L. L. 1982. *Ann. Rev. Earth Planet. Sci.* 10:355-376. [6] Mittlefehldt D. W. et al. 2011. Abstract #2569. 42nd Lunar Planet. Sci. Conf. [7] Cartwright J. A. et al. 2011. Abstract #2655. 42nd Lunar Planet. Sci. Conf. [8] Cartwright J. A. et al. 2011. Abstract #5042. This conference. [9] Johnson K. N. et al. 2011. Abstract #2073. 42nd Lunar Planet. Sci. Conf.