IDENTIFICATION OF AN EVOLVED DIOGENITE LITHOLOGY ON VESTA'S NORTH POLE. A. W. Beck[1], D. J. Lawrence[1], P. N. Peplowski[1] and T. H. Prettyman[2]. [1]Johns Hopkins University Applied Physics Laboratory, Laurel, MD 20723, USA. Andrew.Beck@jhuapl.edu. [2]Planetary Science Institute, Tucson, AZ 85719, USA.

Introduction: Neutron and gamma ray spectroscopy is used to measure compositional variability on planetary bodies. As with reflectance spectroscopy, laboratory simulations/measurements of neutron and gamma ray flux in planetary materials provides a context for interpreting remotely sensed gamma ray and neutron data [i.e. 1]. It is well accepted that the eucrite (coarse- to fine-grained pyroxene + plagioclase rocks), diogenite (coarse-grained, orthopyroxene ± olivine ± plagioclase cumulates), howardite (polymict breccias of eucrite + diogenite lithologies) (HED) meteorite clan originated from the asteroid 4Vesta [2]. Vesta was recently mapped by the Gamma Ray and Neutron Detector (GRaND) onboard the Dawn spacecraft. Thus, simulating and/or measuring gamma ray and neutron flux in the HEDs can provide context for GRaND data interpretation. The four observables mapped by GRaND are: Fe abundance, fast neutron counts (fast counts), thermal neutron macroscopic absorption cross section (absorption) and high-energy gamma ray (HEGR) counts (Fig 1).

Previous simulations of these four observables in the HEDs resulted in moderate to poor correlations within most lithologies, and across the clan [3-6]. This limits petrologic/petrogenetic interpretations that can be made from GRaND data. Given the correlations known to exist between gamma ray/neutron observables and composition, better correlations should exist between and/or among the compositionally different HED lithologic groups. Here we create a new dataset of HED bulk compositions designed to constrain variation in the GRaND observables in HED-like compositions, and then use those results to interpret GRaND data.

Methods: We compiled bulk elemental concentrations for 246 different HEDs that met several criteria aimed to assure that: representative bulk compositions were achieved, oxygen was accurately estimated, and only samples with concentrations for all key neutron-absorbing elements were included. We then simulated fast neutron flux and computed Fe abundance, the HEGR compositional parameter (C_p) and neutron absorption in the 246-sample dataset.

Results: A single, well-constrained ($r^2 \geq 0.90$) clan-wide correlation is observed between fast counts and HEGR C_p, fast counts and absorption, and absorption and HEGR C_p in our HED dataset. Interestingly, separate lithologic groupings, or lithologic trends, are observed when comparing Fe abundance with any of the other three observables (Fig 2). The separation of HED lithologic groups from a single linear trend is important, as it makes several sub-lithologies (i.e. cumulate eucrite, ferroan diogenite) unique from a howarditic mixture of basaltic eucrite and typical (orthopyroxenitic) diogenite; a composition that dominates the surface of Vesta [7]. This separation also allows for a more detailed characterization of lithologic content (i.e. % eucritic material or "POEM") in a given portion of the regolith, in comparison to a simple, binary mixing model [5].

Next we compare the meteorite results in Fig 2 to GRaND data. This was achieved by re-binning GRaND data to equal pixel size, converting the data to the same units calculated in the meteorite dataset, and then scaling the GRaND data to mean howardite, which is the mean surface lithologic type on Vesta [7]. Much of the area that is north of 70ºN, including the north pole (hereafter all "the north polar region"), have exceptionally high Fe, but lower fast counts, HEGR C_p values and absorption, relative to other Fe-rich areas on Vesta (Fig 1). In the HED meteorites, this composition is most consistent with ferroan diogenites (Fig 3a, b), a diogenite lithology that is enriched in Fe, incompatible elements and plagioclase, relative to the typical (orthopyroxenitic) diogenites [8]. The north polar region is also consistent with enrichment of CM chondrite in one of the three measurement spaces examined (Fig 3b).

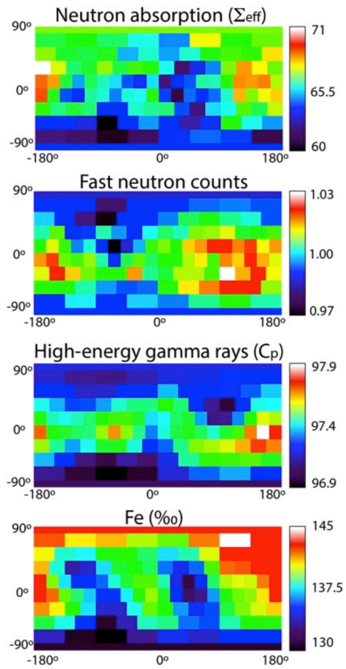

Figure 1. Maps of absorption, fast counts, HEGR and Fe on Vesta, plotted in the Claudia double prime coordinate system. Data from [3-6].

Discussion: We propose two hypotheses for the occurrence of a diogenite lithology in the north polar region that is more evolved than the orthopyroxenitic diogenite-rich Rheasilvia basin and its associated ejecta:

1. Ferroan diogenite in the north polar regions was sampled *in situ* via the Albana impact crater.

Albana, a 96 km-wide impact crater, occupies ~1/4 of the north polar region and excavated to a depth of 8-9 km [9]. Some geochemical studies suggest that ferroan diogenite petrogenesis is more closely tied to partial melting and eucritic (crust) magmatism than it is to the petrogenesis of typical, orthopyroxenitic diogenites (mantle) [8]. Thus, ferroan diogenites could be emplaced at relatively shallow depths within, or just beneath, eucritic lithologies in the vestan crust and have been sampled by relatively shallow impacts.

2. Alternatively, ferroan diogenite lithologies in the north polar region may have been delivered as Rheasilvia ejecta.

In their simulations of the Rheasilvia impact, [10] modeled deposition of ejecta in the north polar region of Vesta that had a 10-20 km deep initial provenance in the pre-Rheasilvia vestan south pole; Rheasilvia ejecta in the southern hemisphere was modeled to have come from deeper units (60 km) [10]. The ferroan diogenite-like compositions in the north polar region occur just north of an orthopyroxenitic diogenite-rich ejecta lobe, which extends north from the Rheasilvia basin to ~60ºN [5]. In this scenario, the ferroan diogenite north polar region is the top of a layered Rheasilvia ejecta lobe. A layered sequence going from a deeper-seated orthopyroxenitic into shallower ferroan diogenite in the pre-Rheasilvian vestan south pole is consistent with some petrologic models, which hypothesize that these two diogenitic lithologies formed as a single fractionation sequence in the lower crust/upper mantle of Vesta [11].

Conclusion: Here we present a new HED dataset that can be used to aid in the interpretation of Dawn (GRaND) data. Our data show that the north polar regions on Vesta are most consistent with ferroan diogenite-like compositions.

Though two different models can be evoked to explain the presence of ferroan diogenite in the north, both suggest that the vestan crust contains a relatively evolved, Fe-rich orthopyroxenite (ferroan diogenite) somewhere between an ultramafic, lower curst/upper mantle orthopyroxenite (typical diogenite), and a basaltic upper crust (basaltic eucrite). This petrologic sequence is significant, as it strongly supports the hypothesis that Vesta is an *intact* differentiated protoplanet.

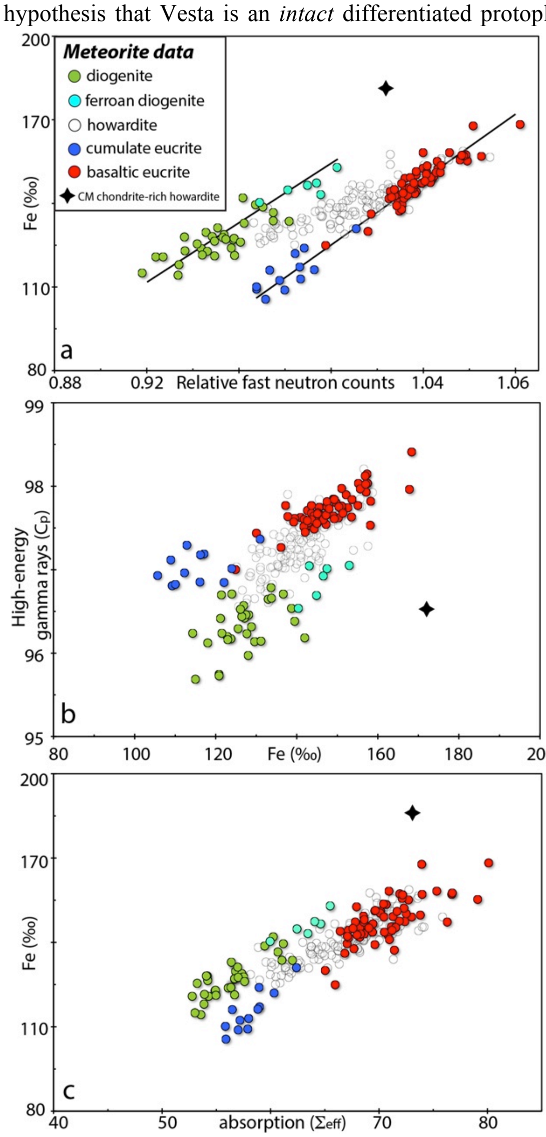

Figure 2. HED meteorite data. Fe vs. fast counts (a), where diogenite and eucrite lithologic trends have been identified, Cp vs. Fe (b), and Fe vs. absorption (c).

It is important to note that though less supported, we cannot rule out CM chondrite-enrichment as a cause for the compositions observed in the north polar regions at this time. We have also not accounted for all possible systematic errors in the GRaND data introduced during data reduction.

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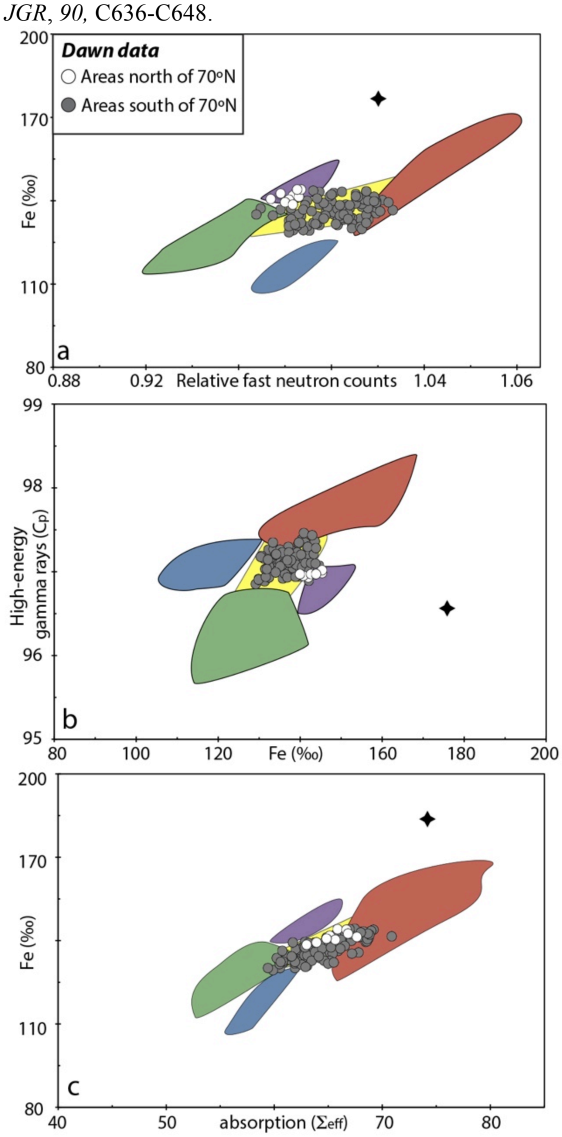

Figure 3. Data from Vesta (Dawn) superimposed on the HED fields identified in Fig 2. Shade of Dawn data denotes latitude. See Fig 1 map projection of data.