FAST NEUTRONS IN HEDS: NEW INSIGHTS INTO DAWN DATA AND NEUTRON SPECTROSCOPY

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Introduction: Simulations of neutron flux in lunar samples demonstrated that the fast neutron flux is a linear function of average atomic mass (<A>) (r^2=0.99), which led to mapping the <A> composition of the lunar surface from Lunar Prospector fast neutron measurements [1]. Consequently, it was anticipated that fast neutron measurements from Dawn would help determine surface composition on Vesta. However, initial laboratory simulations of neutron flux in the HED meteorites (samples from Vesta) did not produce a strong correlation with <A> (r^2=0.77), hindering compositional interpretation from Dawn fast neutron data [2].

At 1,401 kg [3], the HED meteorite clan is the most voluminous suite of samples from another planetary body in our Solar System. The data set initially used to simulate HED fast neutrons – 4% of the clan sampled and only 10 elements used – did not fully exploit the volume of the clan. Here we construct a new dataset that samples 17% of the clan, uses 47 elemental concentrations, and takes other steps to insure high-quality neutron data.

Results and Discussion: The new data set results in a strong linear correlation (r^2=0.99) between the high-<A>/fast count basaltic eucrites and low-<A>/fast count diogenites. Predictably, howardites, polymict eucrites and dimict diogenites are well constrained along the linear fit between the basaltic eucrites and diogenite end members. Interestingly, cumulate eucrites, dunitic diogenites, and olivine-/chondrite-rich howardites display unique, systematic offsets from the main <A>/fast count trend. These residuals correlate with Fe concentrations, where Fe depletion (cumulate eucrites) and enrichment (olivine-/CM-rich samples) correlate to negative and positive offsets from the trend, respectively. CM-rich howardites display an exceptional positive offset from the main trend, likely caused by Ni enrichment.

Results from this study suggest that cumulate eucrite- and olivine/CM-rich areas on Vesta may be separable with Dawn GRaND measurements (neutron absorption, <A>, Fe, and high-energy gamma rays). Since the 1.2-μm VIS/NIR absorption feature that distinguishes cumulate vs. basaltic eucrite [4] may be confused with the 1.2-μm olivine feature, results from this study could assist in definitively identifying cumulate eucrite-rich areas. Identifying depth/extent of cumulate eucrite exposures could provide insights into vestan differentiation. In the presentation, we will provide an update on applying these results to Dawn data.

This work is useful not only to Vesta, but can be applied to other fast neutron measurements on dry, airless bodies. Specifically, this study presents a robust <A>/neutron/chemistry dataset for the largest sample suite from another planetary body. We provide the first documentation of deviations from expected <A>/fast count trends due of Fe and Ni variations. This is likely due to Fe and Ni having significant (n,2n) cross sections, making them "neutron amplifiers" (divergent from expected <A>). Perhaps this was not observed in previous works (Moon) because Fe and Ti (primary sources of fast neutrons [5]) are dominant and ubiquitous. Or, perhaps the constraints used to construct this dataset aided in observing these new trends.

References: [1] Gasnault O. et al. 2001. *GRL* 28:3797-3800. [2] Lawrence et al. 2013. *MAPS* 48:2271-2288. [3] Data from the *Meteoritical Bulletin*, April 2014. [4] Mayne et al. 2010. *MAPS* 45:1074-1092. [5] Gasnault et al. 2000. *JGR* 105:4263-4271.