DAWN'S EXPLORATION OF VESTA'S SOUTH POLE BASIN – WHERE'S THE MANTLE?

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Introduction: Estimates of the transient (pre-collapse) crater size of the giant Rheasilvia basin [1] on asteroid 4 Vesta using several scaling laws give diameters of 325-430 km, corresponding to excavation depths of 38-51 km. Rheasilvia is superimposed on an older basin, Veneneia, which also excavated some crust. A chondritic-bulk asteroid would, if fully melted, produce a crust ~19 km thick, and HED parent body models have crusts ranging in depth from 24-41 km [2]. It thus seems likely that Rheasilvia should have exposed the Vestan mantle. Large amounts of olivine in the mantle are predicted because chondritic precursors contain high abundances of that mineral.

The HED Perspective: Rheasilvia is thought to have produced the vestoids, which in turn were likely sources for HED meteorites. Harzburgitic diogenites and the related MIL 03443 dunite [3] contain significant olivine. Cooling rates for diogenite pyroxenes suggest a deep crustal origin [4]. Mineral compositions indicate that olivine-bearing diogenites are not partial melting residues, but rather are cumulates formed in multiple plutons. This origin implies either ultramafic parental magmas or formation of complementary gabbroic rocks.

Dawn Observations: Dawn instruments indicate that the floor of Rheasilvia is dominated by diogenite. VIR spectra reveal strong 1 and 2 μm pyroxene absorption bands. Olivine should affect the 2 μm:1 μm band ratio in mixtures with orthopyroxene, but no effect is apparent. The ≤30% olivine abundance in harzburgites is below the VIR threshold for olivine detection [5], but dunite should be detectable. Rheasilvia's large central uplift [1], especially, should expose mantle, but it has not yet been observed by VIR, nor have FC's limited spectral bands distinguished olivine. The average bulk Fe elemental abundance in diogenites is lower than for basaltic eucrites, and a preliminary GRaND neutron map suggests low Fe in Rheasilvia relative to other parts of Vesta. The Fe content of the MIL 03443 dunite is significantly higher, so large amounts of olivine should be revealed in GRaND Fe data, but that has not yet been noted.

Discussion: Olivine seems likely to occur in Rheasilvia, as inferred from olivine-bearing diogenites, but olivine-bearing materials on Vesta have so far eluded detection by Dawn. Perhaps the assumption that the uppermost Vestan mantle is olivine-rich is faulty, and instead it is characterized by diogenite plutons emplaced at the crust-mantle boundary. Other possibilities are that olivine-bearing mantle rocks in the central uplift were impact-melted or diluted by impact mixing, or that existing (extrapolated) models overestimate Rheasilvia's excavation depth.

References: [1] Schenk P. et al. 2012. *Science* 336:694-697. [2] Ruzicka A. et al. 1997. *Meteoritics & Planetary Science* 32:825-840. [3] Beck A. W. and McSween H. Y. 2010. *Meteoritics & Planetary Science* 45:850-872. [4] Zema M. et al. 1997. *Meteoritics & Planetary Science* 32:855-862. [5] Beck A. W. et al. 2012. *LPSC* 43, CD #2218.