

MIXING AND FORMATION OF PURE LAYERS OF SPECIFIC MINERALS ON VESTA. M. Hoffmann¹, A. Nathues¹. ¹Max Planck Institute for Solar System Research, Katlenburg-Lindau, Germany, hoffmann@mps.mpg.de.

Introduction: The surface of Vesta has a remarkably consistent signature of HED mineralogy. Local variability is mostly observed for the albedo. Influence by probably exogeneous dark carbonaceous material [1] has been identified plus some influence from involved volatiles [2]. Inter-crater surface without influence from fresh impacts show mostly a quite homogeneous mixture of all of these minerals (maturity). Locally, however, quite dark deposits are visible while very bright patches found in young ejecta zones and even more in some slopes inside craters. Much of the surface of Vesta apparently consists of very mobile material. Therefore quite different mechanisms of mixing and deposition have to be considered.

Data: Spectroscopic and morphologic properties of apparently pure or extreme areas in terms of albedo have been inspected using images obtained by the Dawn Framing Camera [3]. Areas were excluded which may have been influenced by extreme illumination conditions on possibly unresolved topography.

Evidence on distribution of distinct minerals: Extremely dark or bright deposits are found in different environments on Vesta. Surprisingly, such deposits are found far in the heavily cratered northern hemisphere as well as inside the Rheasilvia basin for both cases. The distribution of very pure deposits of the HED subclasses is not identical with the extremes in albedo. On smaller scales similar details can be studied in some outstanding craters. The crater Canuleia is remarkable in this respect, as it shows distinct layers whose ratio of reflectivity becomes reversed if different spectral bands of the framing camera are considered. Furthermore, strong sectorial differences in spectral behavior are present. In other cases different distributions of grain sizes play a role. In the spectra, there is a trend for a decrease in band depth among darker material.

Processes of generation: Visible and inferred total sizes of pure deposits and their depth below the surface are related to the history of differentiation of Vesta [4], and later to giant impacts like the formation of the Rheasilvia basin, and subsequent cratering. A part of the darkening of the surface may have been caused by shocking of minerals, in particular from many unresolved small impacts. Other dark material has its origin in the projectiles of impacts.

Evidence on mixing processes: The evolution of pure deposits can be traced back by the morphology of mixing patterns such as gullies and ejecta blankets. Outcrops of compacted material nearby have to be considered. Associated with avalanches, differential effects

in granular flow phases can be noticed by characteristic patterns. However, these have not been found to have led to an enrichment of specific materials, but only to a lack of homogenization. The second prominent mixing process is secondary cratering. Homogeneous deposits are expected if either pure material, e.g. pieces from a projectile, remain on the surface, or pure sub-surface material is laid bare by the secondary cratering. There are indications that both processes have been active on Vesta. Additionally, the morphology shows indications of both crushing and compaction, as also supported by evidence from meteorites [5].

Age discrepancy: Fresh craters are too young to be dated precisely by even younger impacts into them. On the Moon and Mercury morphologic information is used in order to estimate young ages: Progressive erosion [6], and the discussion of ray formation processes [7],[8],[9]. On Vesta, these tools are ambiguous, as craters with soft rims and extended rays systems can be found next to craters with sharp profiles but without any obvious diversity in albedo. Apparently quite individual mixing processes have shaped the surface of Vesta.

Conclusions: While quite pure deposits of characteristic minerals are found on the surface of Vesta, no obvious mechanism of enrichment after the original formation during the differentiation or exogenic import has been identified yet. Pure deposits have to be identified with quite fresh exposure of the respective material, in some cases probably also younger than associated impacts. Otherwise the mobility of the surface material helped to homogenize the surface material efficiently. Local diversity in this respect is another clue that Vesta has to be interpreted as a small planetary world rather than a simple asteroid.

References: [1] Reddy V. et al. (2012) *Icarus*, in press. [2] Scully J. E. C. et al. (2012) *GSA* 44. [3] Sierks H. et al. (2011) *Space Science Reviews* 163. [4] Keil K. (2002) *Asteroids III*. [5] Mittlefehldt D. W. (2003) *Treatise on Geochemistry*. [6] Craddock R. A. and Howard A. D. (2000) *J. Geophys. Res.* 105. [7] Hawke B. R. et al. (2004) *Icarus* 170. [8] McEwen A. S. and Bierhaus E. B. (2006) *Ann. Rev. Earth Planet. Sci.* 34. [9] Neish C. et al. (2012) *DPS* 44.