Gullies as geomorphological evidence for transient water flow on Vesta, with a comparison to lunar gullies

Jennifer E. C. Scully[1], Christopher T. Russell[1], An Yin[1], Ralf Jaumann[2], Elizabeth Carey[3], Harry Y. McSween[4], Julie Castillo-Rogez[3], Carol A. Raymond[3], Vishnu Reddy[5,6], Lucille Le Corre[6]

[1]*Dept. of Earth, Planetary, and Space Sciences, UCLA, Los Angeles, CA 90095*
[2]*Institute of Planetary Research, DLR, 12489 Berlin, Germany*
[3]*Jet Propulsion Laboratory, California Institute of Technology, Pasadena, CA 91109*
[4]*Dept. of Earth and Planetary Sciences, University of Tennessee, Knoxville, TN 37996*
[5]*Max Planck Institute for Solar System Research, 37077 Göttingen, Germany*
[6]*Planetary Science Institute, Tucson, AZ 85719*
Contact author: jscully@ucla.edu

Abstract. Vesta, the second most massive asteroid, has long been perceived as anhydrous. However, recent studies suggesting the presence of hydrated minerals[1,2,3] and past sub-surface water[4,5,6] have challenged this perception. Yet, direct geologic indications of water activity on Vesta's surface were unexpected. Herein we show evidence that transient water flowed on the surface, in a debris-flow-like process, and left distinctive geomorphologic features. Based on detailed analysis of high-resolution (~20 m/ pixel) images obtained by the Dawn spacecraft, we identify a class of locally occurring, interconnected and curvilinear gully networks on the walls of young (< 100s Ma) impact craters, ending in lobate deposits near the crater floors. As curvilinear systems only occur within impact craters, we propose that they formed by a particulate-dominated transient flow of water that was released from buried ice-bearing deposits by impact-induced heating and melting. This interpretation is in accordance with the occurrence of pitted terrain on lobate deposits and crater floors. Pitted terrain is proposed to result from the degassing of volatiles[7]. The proposed buried ice-bearing deposits are likely localized in extent and may be currently extant in Vesta's sub-surface. We also identify a second class of more widespread, non-intersecting and linear gullies, which have certain features analogous to those of lunar gullies[8], and are interpreted to form by the flow of dry granular material. Together with the newly expanded understanding of the distribution and behavior of water on other rocky bodies, such as Earth's Moon[9], and elsewhere in the asteroid belt[10,11], our results support the new paradigm that there is a continuum of bodies in the solar system with many intermediate states of hydration.

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