VESTA’S “DARK RIBBON”: A FLUIDIZED EJECTA FLOW? Buczkowski, D.L.¹, DeSanctis M.C.², Nathues, A.³, Hoffman, M.³, Roatsch, T.⁴, Preusker, F.⁴, Raymond, C.A.⁵, Russell, C.T.⁶. ¹JHU-APL, Laurel, Maryland, USA; ²INAF-IAPS, Rome, Italy; ³Max Planck Institute, Katlenburg-Lindau, Germany; ⁴DLR, Berlin, Germany; ⁵JPL, California Institute of Technology, Pasadena, California, USA; ⁶UCLA, Los Angeles, California, USA.

Introduction: NASA’s Dawn spacecraft collected imaging, spectroscopic, and elemental abundance data during its one-year orbital mission. Geologic mapping of Vesta’s surface was based on compositional data from the Visible & Infrared Spectrometer (VIR) and Framing Camera (FC) images obtained during the High-Altitude Mapping Orbit (HAMO) and the Low-Altitude Mapping Orbit (LAMO). Mapping of Vestalia Terra [1] resulted in the identification of an unusual feature, informally referred to as the “dark ribbon” in the Av-9 quadrangle. We propose that the dark ribbon represents a fluidized ejecta flow from Drusilla crater.

Data: Variations in surface composition of Av-9 are revealed by FC color ratio images (250 m/pixel) from Survey orbit (Fig. 1a). FC color ratio images using standard Clementine ratios [Red (750/430 nm); Green (750/920 nm); Blue (430/750 nm)] [4] show compositional variations. Several of the craters have “colorful” ejecta, indicating spectral and possibly compositional diversity. Further study utilizing VIR hyperspectral images from Survey (700 m/p) and HAMO (200 m/p) orbits investigated the significance of these false-color variations [5]. The topography of Av-9, is observed in a colororized Digital Terrain Model (DTM) derived from Survey orbit FC data [2,3] (Fig 1b). Clear filter (monochrome) FC HAMO images (spatial resolution of ~70 m/pixel) were mosaicked to make a base for this quadrangle.

Observations: Clearly evident in FC color ratio data of the Av-9 quadrangle is a roughly linear unit of a distinct material crossing Vestalia Terra from the northwest to the southeast (Fig. 1a). Referred to as the “dark ribbon”, this material is also discernible in clear filter data as being of relatively low albedo. Dark ribbon material extends from the northwest to the southeast for 259 km across the Av-9 map area, constrained to a linear topographic low on top of the regionally high Vestalia Terra (Fig. 1b). LAMO FC images of the material reveal flow features and linear striations are in line with the outcrop axis, rather than being radial to nearby craters, such as the unnamed crater at ~2º latitude, ~228º longitude (Fig. 2, white arrow). What appears to be a continuation of the dark ribbon extends for an additional 133 km southeast of Drusilla crater (Fig. 2, arrow 3), into the Rheasilvia basin.

Dark layers are observed at the top of the Numisia crater wall, but only where the crater cuts the dark ribbon (Fig. 2), suggesting that the dark layer is in fact an exposed section of dark ribbon material. Measuring the thickness of the Numisia dark layer, from the top of the crater to the top of the bright layer immediately below, suggests that the dark ribbon is approximately 100 – 250 m thick in this region.

VIR analysis shows that dark ribbon spectra have the same band centers as the surrounding terrain, but greatly reduced band depths [6]. While no OH is detected in the surface exposures of the dark ribbon, there is OH detected in the subsurface dark ribbon exposed by Numisia crater [6].

Discussion: The ejecta to the north of Drusilla crater has a low albedo [1]. This ejecta appears to be radial to the crater, with three distinct fingers of dark material (Figs. 1a, 2); a fourth line of dark material extends to the southeast of the crater (Fig. 2, arrow 3). The westernmost of these dark ejecta fingers continues past the length of the other two northern lobes and is the southeastern end of the dark ribbon material. This
suggests that the dark ribbon is in fact Drusilla ejecta. The reduction in band depth in the dark ribbon materials [6] could be a result of reduced particle size of the material, as would be expected in an ejecta deposit relative to the pre-impact bedrock. However, while the radial Drusilla ejecta extends only two crater diameters away from the crater, the dark ribbon extends seven crater diameters from Drusilla. Proposing that the dark ribbon is Drusilla ejecta requires some explanation of how this putative ejecta could travel so far from the source crater in this one, relatively narrow, direction.

We present the possibility that the dark ribbon may represent an ejecta flow bearing entrained gases released during the impact event. OH has been identified in Drusilla crater [6]. While impact into other hydrogen-bearing craters resulted in pitted terrain [7,8], it is possible that the volatiles released during the Drusilla impact were trapped under the ejecta and enabled it to undergo “basal glide” [9], resulting in a long-runout flow. The detection of OH in the subsurface dark ribbon exposed by Numisia crater [6] is consistent with this hypothesis. Furthermore, while the Drusilla ejecta radial to the crater has no correspondence to topography, the dark ribbon extends to the northwest following a local linear topographic low (Fig. 1b). We thereby suggest that the dark ribbon material is ejecta directed into a channelized flow within this “corrugation” on the top of the Vestalia Terra plateau. It was this channelization, in combination basal glide over impact-released gases, that we propose enabled the dark ribbon to reach such great lengths from its source crater.


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Figure 2. FC color ratio data overlain on FC clear filter image of Vesta that includes the Av-9 region; Drusilla crater (D), Numisia crater (N) and the south pole of Vesta are all shown. Black arrows point to possible Drusilla ejecta. Arrows 1 and 2 bracket the dark ribbon in Av-9, while arrow 3 points to end of dark material that extends into Rheasilvia. The double-headed black arrow points to dark material extending radially from Drusilla. White arrow points to location of ejecta scour features in dark ribbon that are radial to Drusilla not the most proximal crater (unnamed).