The geologic mapping of asteroid Vesta

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As part of NASA's Dawn mission [1,2] we conducted a geologic mapping campaign to provide a systematic, cartography-based initial characterization of the global and regional geology of asteroid Vesta. The goal of geological maps is to place observations of surface features into their stratigraphic context to develop a geologic history of the evolution of planetary surfaces. Geologic mapping reduces the complexity of heterogeneous planetary surfaces into comprehensible portions, defining and characterizing discrete material units based upon physical attributes related to the geologic processes that produced them, and enabling identification of the relative roles of various processes (impact cratering, tectonism, volcanism, erosion and deposition) in shaping planetary surfaces [3,4].

The Dawn Science Team produced cartographic products of Vesta from the Framing Camera images, including global mosaics as well as 15 regional quadrangles [5], which served as bases for the mapping. We oversaw the geologic mapping campaign during the Nominal Mission, including production of a global geologic map at scale 1:500,000 using images from the High Altitude Mapping Orbit [6] and 15 quadrangle geologic maps at scale 1:250,000 using images from the Low Altitude Mapping Orbit [7]. The goal was to support the Dawn Team by providing geologic and stratigraphic context of surface features and supporting the analysis of data from the Visible and Infrared Spectrometer (VIR) and the Gamma Ray and Neutron Detector (GRaND). Mapping was done using ArcGIS™ software, in which quadrangle mapping built on interpretations derived from the global geologic map but were updated and modified to take advantage of the highest spatial resolution data. Despite challenges (e.g., Vesta's highly sloped surface [8] deforms impact craters and produces mass movements that buries contacts), we were successfully able to map the whole surface of Vesta and identify a geologic history as represented in our maps and the resulting time-stratigraphic system and geologic timescale.

Key results from the geologic mapping of Vesta include:
1) surface units are dominated by features and materials produced by two major impact events, the older Veneneia and younger Rheasilvia impacts at the south pole
2) both impacts produced a ridge-and-trough terrain as a tectonic response to the impacts, mapped as the Saturnalia Fossae and the Divalia Fossae Formations, respectively
3) stratigraphic analysis of Vesta's heavily cratered terrains show that portions of the original crust are preserved and predate the Veneneia impact
4) the Marcia impact event marks the beginning of Vesta's final stratigraphic period, including exposure of fresh bright and dark material and preservation of young bright-rayed and dark-rayed craters.
We conclude that a geologic mapping campaign, including both global and regional mapping, can be conducted during the limited planetary nominal mission timeline, and is an excellent way to engage younger team members (graduate students and postdocs) in mission data analysis activities.

Acknowledgements: We acknowledge the Dawn Science and Flight Teams for obtaining the data on which this work was based. The authors were funded by the NASA Dawn at Vesta Participating Scientists Program.

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