EPSC Abstracts
Vol. 9, EPSC2014-547, 2014
European Planetary Science Congress 2014

Brumalia Tholus: A magmatic intrusion on Vesta

D. Buczkowski (1), M. De Sanctis (2), C. Raymond (3), D. Wyrick (4), D. Williams (5), M. Toplis (6), E. Ammannito (7), A. Frigeri (2), F. Tosi (2), A. Nathues (8), M. Hoffman (8) and C. Russell (7)
(1) Johns Hopkins University Applied Physics Laboratory, Maryland, USA, (2) INAF-IAPS, Rome, Italy, (3) Jet Propulsion Laboratory, Pasadena, USA, (4) SWRI, San Antonio, USA, (5) Arizona State University, Phoenix, USA, (6) IRAP, Observatoire Midi Pyrenees, Toulouse, France, (7) UCLA, Los Angeles, USA, (8) Max Planck Institute, Katlenburg-Lindau, Germany, (Debra.Buczkowski@jhuapl.edu)

Abstract

Geologic mapping of the asteroid Vesta [1] resulted in the identification of an unusual hill, now named Brumalia Tholus. We here present our hypotheses that Brumalia Tholus represents a dike that formed due to magmatic intrusion into subsurface fractures under the Vestalia Terra plateau (VT).

1. 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).

2. Observations

The equatorial region of Vesta displays numerous wide, flat-floored troughs whose formation has been tied to the Rheasilvia impact event [2] but these troughs do not cut VT [3]. However, there are three long pit crater chains observed on the surface of the plateau [1,3]. A strong correlation between pit crater chains and fault-bounded graben has been observed on other planetary bodies [4]; pit crater chains are hypothesized to form when dilational motion on buried normal faults cause overlying material to collapse into the opening portions of the buried fault. Consistent with this hypothesis, the merged pits of the VT pit crater chains show signs of collapse but distinct fault faces can also be observed [1]. It has thus been suggested that the pit crater chains on VT are representative of subsurface faulting of the plateau [3].

As Albalonga Catena, the pit crater chain located in eastern VT, progresses westward it phases from being a topographically low feature of merged pits into being the topographically high Brumalia Tholus [1], an elongate hill that is evident in both the photographic and topographic data of Vesta (Fig. 1a,b). Westward of the hill, merged pits are again visible in the slope data (Fig. 1c).

If Albalonga Catena does represent a buried normal fault, then the topographic high that emerges along its length could have been formed as a magmatic intrusion utilizing the subsurface fracture as a conduit to the surface, intruding into and deforming the rock above it [1]. The core of Brumalia Tholus should thus be comprised of a more plutonic rock [1], such as diogenite, than the basaltic eucrites and brecciated howardites that have been observed in the equatorial region of Vesta [5]. Teia crater impacts the northern face of Brumalia Tholus (Fig. 1d) and thus its ejecta is likely sampling Brumalia's core material [1,5]. Color data from Dawn's FC instrument indicates that ejecta from Teia have a distinct composition. The false-colors orange and red correspond to the ratio of 749/438 nm and are observed to directly relate to ejecta material with a smeared and flow-like texture [1]. Analysis by VIR has shown that while the background VT material is howarditic [5], these Teia ejecta are more diogenitic [6]. The identification of diogenite on the top of Brumalia Tholus and in the Teia ejecta is consistent with the hill being the surface representation of a magmatic intrusion [1,5].

3. Conclusions

It has been suggested that the following sequence of events may have occurred on Vesta [1]. Ancient fracturing and faulting occurred in the Vestalia Terra sub-surface, forming the Albalonga, Robigalia and unnamed subsurface faults in the same orientation. The Albalonga fault sampled a region of partial melt and served as a conduit for this mantle or lower-crustal material to move upward and deform the

surface. Brumalia Tholus formed due to magmatic injection and laccolith doming. The core molten material cooled slowly at depth, forming diogenite. Sometime later the Rheasilvia impact occurred, reactivating (and perhaps reorienting) the Albalonga and other Vestalia Terra faults. The surface of Vestalia Terra was covered by loose regolith material (i.e. ejecta) which collapsed into dilational openings along the steep sub-surface faults, forming the pit crater chains. Then the Teia impact event occured and incorporated the diogenitic Brumalia core material into its ejecta.

Acknowledgements

The authors gratefully acknowledge the support of the Dawn Instrument, Operations, and Science Teams. This work was funded by the Dawn at Vesta Participating Science Program, grant number NNX10AR58G S06.

References

[1] Buczkowski, D. L. et al.: The unique geomorphology and physical properties of the Vestalia Terra plateau, Icarus, doi: 10.126/2012GL05259, 2014.

[2] Jaumann, R. et al.: Vesta's shape and morphology, Science, doi: 10.1126/science.1219122, 2012.

[3] Buczkowski, D. L. et al.: Large-scale troughs on Vesta: A signature of planetary tectonics, Geophysical Research Letters, doi:10.1029/2012GL052959, 2012.

[4] Wyrick, D. Y. et al.: Distribution, morphology and origins of Martian pit crater chains, Journal of Geophysical Research, doi:10.1029/2004JE002240, 2004.

[5] DeSanctis, M. C. et al.: Spectroscopic characterization of mineralogy and its diversity across Vesta, Science *doi:*10.1126/science.1219270, 2012.

[6] Des Sanctis et al.: Compositional evidence of magmatic activity on Vesta, Geophysical Research Letters, doi: 10.1002/2014G:059646, 2014.

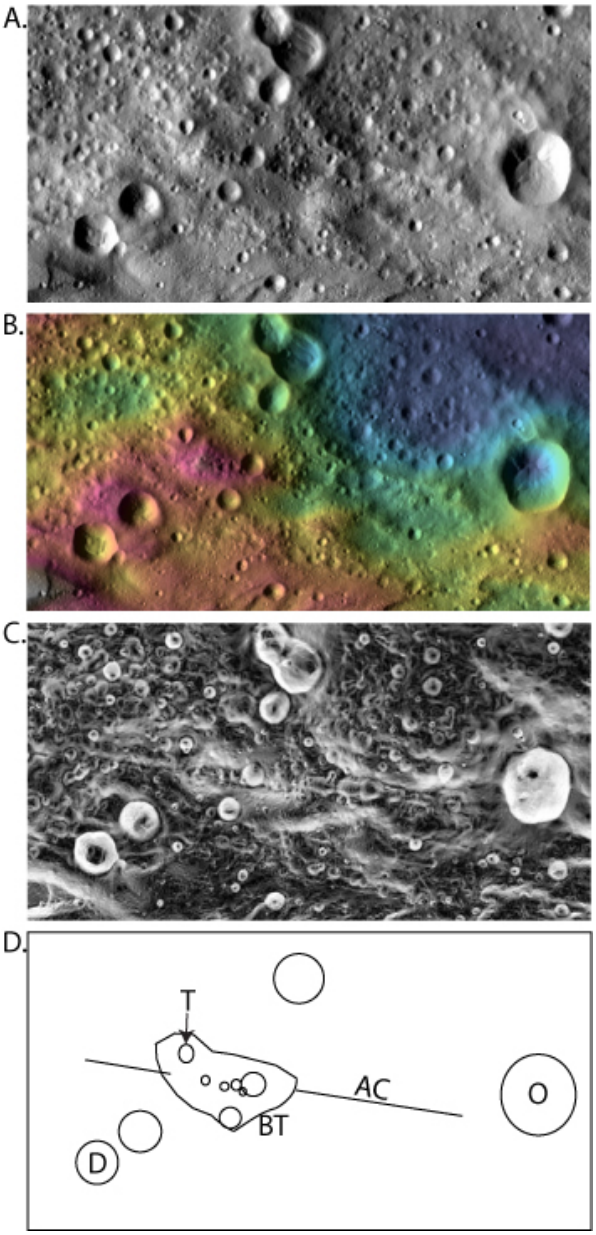

Figure 1: Eastern Vestalia Terra showing Albalonga Catena. A) FC HAMO mosaic. B) Topography overlying HAMO mosaic. C) Slope data. Albalonga Catena is distinctly visible in this data set. D) Sketch map of features in region. BT = Brumalia Tholus; AC= Albalonga Catena; O= Oppia crater; D= Drusilla crater; T= Teia crater. Some unnamed craters and the probable extension of Albalonga to the west of Brumalia are also drawn.