CARBON AND ORGANICS ON CERES: EXPLORATION CONNECTION. T. H. Prettyman,[1] S. Marchi,[2] M. C. De Sanctis,[3] A. R. Hendrix,[1] [1]Planetary Science Institute, Tucson AZ (prettyman@psi.edu), [2]Southwest Research Institute, Boulder CO, [3]National Institute of Astrophysics, Rome, Italy.

Introduction: Carbon, the primary element in organic compounds, is central to astrobiology. Carbon is also a potential resource that could be used to support of human exploration. The surface of the dwarf planet Ceres, which is rich in both water and carbon-bearing compounds, provides a laboratory for studies of pre-biotic chemistry [1] as well as materials needed for In Situ Resource Utilization (ISRU). Carbonaceous near-Earth asteroids can be accessed by low-energy missions and may be an economical source of such materials. Data acquired by Earth-based telescopes, the NASA Dawn mission and meteorite studies provide insights into the composition of water-rich asteroids that could guide planning of future missions. We present what is known about carbon and organics on Ceres and discuss implications for science and exploration.

Ceres' composition: The NASA Dawn mission and UV telescopic observations of Ceres reveal a C-rich surface (Fig. 1). Differences in carbonate composition suggest a complex history, with Na-rich brines sourced from a subcrustal ocean and/or produced in impact-induced hydrothermal systems. Ceres' evolution may have involved several phases of hydrothermal alteration in different environments leading to the oxidation of accreted organics to produce carbonates followed later by abiotic synthesis of aliphatic organic molecules [2]. This is consistent with temporal changes in alteration chemistry inferred from organo-carbonate relationships in meteorites [3]. As such, the organic matter found in and around Ernutet may have an endogenic origin. High concentrations of C inferred from GRaND, VIR, and telescopic observations suggest organics altered by weathering processes are pervasive.

Exploration connection: Studies of carbon on Ceres support the use of space-based telescopic UV facilities to identify potential C-rich asteroids and in situ characterization using optical and nuclear spectroscopy. Future missions to water-rich, carbonaceous asteroids will provide new insights into the hydrothermal evolution of protoplanets. ISRU may involve extraction of water and production of propellant via methanation.

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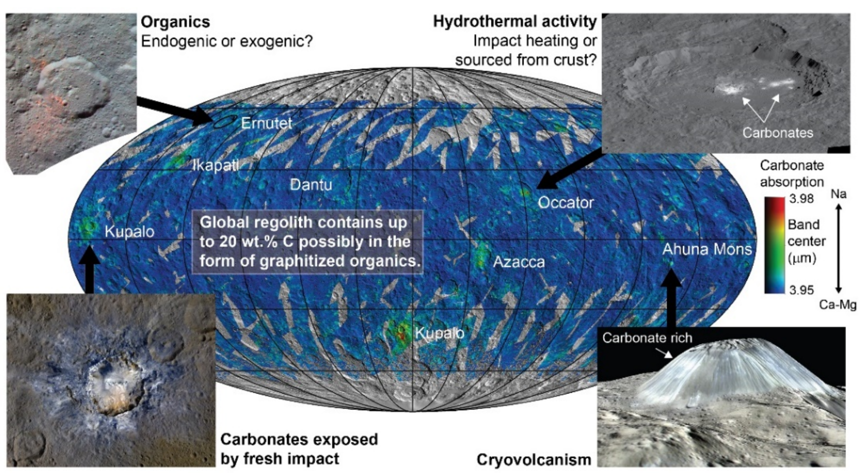

Figure 1. Carbon and organics on Ceres: The map shows the 4 µm carbonate band center observed by Dawn's visible and infrared mapping spectrometer (VIR) [4]. The global surface is rich in Mg carbonates [5]. Na carbonates (longer wavelengths) are concentrated in bright regions that dot the surface. Clockwise from top left, insets show the distribution of organic matter (orange) near Ernutet crater [6, 7], the carbonate-rich faculae within Occator crater [8], the largest mountain on Ceres, Ahuna Mons, and carbonates excavated by the impact that formed Kupalo crater. Analyses of Dawn's Gamma-Ray and Neutron Detector (GRaND) indicate the global regolith contains elevated C concentrations [9]. Joint constraints from GRaND and VIR allow up to 20 wt.% C [10]. Telescopic UV observations suggest that graphitized organic matter is pervasive [11].