Remote Sensing Measurements to Reveal Aqueous Alteration on Ceres and Key Needed Future Landed Measurements

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The Dawn mission at Ceres, largest asteroid and dwarf planet, has revealed a long history of water-related processes on a still geologically active world. Ubiquitous ammoniated phyllosilicates, depletion in Fe relative to carbonaceous chondrites, elevated C content, and abundant evidence for ice and possibly cryovolcanic processes point to distinctive processes with liquid water on this small body. (De Sanctis et al., 2015; 2016; 2017; Ammannito et al., 2016; Prettyman et al., 2017). Possibly the most unexpected phenomenon discovered was the widespread occurrence of "bright spots": high albedo deposits of salts, including substantial concentrations of sodium carbonates, which may be geologically young. Are they recent brines, solid-state diapirs, or simply exposed remnants of Ceres' differentiation? Here I review the latest findings on the bright spots and our investigations to understand their origins. We show that their association with crater interiors and domes and modeling suggests an origin within the last ~1.5 Ga (Stein et al., 2019).

This talk also highlights key needed future measurements at Ceres: (1) measurements of isotopes of C, N, O, and H in Ceres materials to understand where in the solar system the materials comprising Ceres originated from; (2) measurements of organic compounds to understand pathways of prebiotic organic synthesis, the prevalence of amino acids, and the reasons for Ceres' organic enrichment relative to chondrites; (3) detailed study of the geology and geochemistry and timescales of creation of landforms related to liquid water; and (4) a quantitative assessment of Ceres' habitability potential as a relict ocean world that once hosted an ocean and may still harbor deep-subsurface brines. A landed mission to Ceres would achieve these measurements and reveal key early planetary chemical processes and organic synthesis pathways (proposed to Discovery 2019, PI House); such understanding would help guide future astrobiology missions throughout the solar system.