

OBSERVING CERES TO STUDY ITS POTENTIAL HABITABILITY. Jian-Yang Li¹ and Mark V. Sykes¹, Julie Castillo-Rogez², Amanda R. Hendrix¹, ¹Planetary Science Institute, 1700 E. Ft. Lowell Rd., Tucson, AZ 85719 (jyli@psi.edu), ²California Institute of Technology, Jet Propulsion Laboratory, Pasadena, CA.

Introduction: Ceres is the largest object in the main asteroid belt of the Solar System, with a diameter of 940 km and accounting for $\sim 1/3$ of the total mass of the asteroid belt. It is the only dwarf planet in the inner solar system. Previous spectral reflectance observations of Ceres reveal the pervasive signature of hydrated minerals and carbonates, but a lack of spectral features of water ice [cf. 1]. The low density of Ceres compared to carbonaceous materials suggested that it possibly contains $\sim 1/4$ mass fraction of water [2]. The albedo and spectral reflectance on Ceres are remarkably homogeneous on a global scale [3, 4, 5]. The recent unequivocal discovery of water vapor associated with localized sources on Ceres by Herschel Space Telescope [6] confirmed its enrichment in volatiles. Hence water must have played a significant role in the evolution of Ceres and even affected its current state.

The current evolution models of Ceres indicate that liquid water was present following an early differentiation and drove hydrothermal activity for a few tens of My following accretion [7, 8]. Silicate leaching could lead to the concentration of soluble species in an ocean that could play a role in lowering the freezing temperature of that layer. The likely accretion of low-eutectic species such as ammonia hydrates could have promoted the long-term preservation of a deep liquid layer at the base of an icy shell over extended periods of time (possibly until present) [8].

Implications on habitability: The significance of water on Ceres and its active nature not only suggest that Ceres is an object that potentially hides important clues about volatile history in the inner solar system and the possible source of terrestrial water, but also indicate a world of potential astrobiological interest. Located at an average heliocentric distance of 2.77 AU, the total energy input to Ceres and its surface temperature are much higher than the icy bodies in the outer solar system. The marginal detection of OH near Ceres in the 1990s [9] and the negative results of OH search from ground-based spectroscopic observations [10] could indicate transient nature of its water activity. Although the particular mechanism or mechanisms of water sublimation on Ceres have not been identified yet, they must involve either solar heating or cryoactivity, or both. Thus water ice must exist in shallow subsurface, either primordial at high latitude [e.g., 11] or be continuously replenished from the interior [12]. The essential elements for habitability exist on Ceres.

Planned observations: The Dawn spacecraft has started the data acquisition for Ceres, and will enter its first science orbit in late April 2015 to perform detailed geological, spectroscopic, and compositional mapping. It will also search for active plumes on Ceres. In the meantime, we have begun an observing campaign using ground- and space-based facilities to characterize the nature of water and hydration features detected at Ceres, and to facilitate theoretical studies. These observations include a thermal mapping with the Atacama Large Millimeter/submillimeter Array (ALMA), a polarimetric mapping with Gemini South and ESO's VLT, and a UV spectroscopy program with the Hubble Space Telescope. We will map the temperature for the whole surface of Ceres at 10-20 km spatial resolution for one full Ceres-year (4.6 years), in order to probe the spatial and depth distribution of water ice within ~ 1 m beneath the surface. The polarimetric mapping will generate maps of Ceres at 10-20 km to search for unusual surface textures and optical properties that are possibly related to activity. The UV spectroscopic observations will investigate the nature of the unusual, strong UV absorption of Ceres [cf. 1]. These observations are complementary to Dawn, all together providing essential input to the modeling of the interior water and energy environment of Ceres. We expect that our knowledge of the history and current status of water on Ceres will be significantly advanced in the coming years.

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