**CERES' ASTROBIOLOGICAL SIGNIFICANCE – PRE- AND POST-DAWN PERSPECTIVES.** J. Castillo-Rogez[1], E. D. Young[2], M. Neveu[3], C. A. Raymond[1], A. S. Rivkin[4], T. H. Prettyman[5], O. Ruesch[6], R. Fu[7], A. I. Ermakov[1], M. C. De Sanctis[7], E. Ammannito[2,8], C. T. Russell[2]. [1]Jet Propulsion Laboratory, Pasadena, CA 91109, USA, [2]UCLA, Earth, Planetary and Space Sciences, USA, [3]SESE, Arizona State University, AZ, USA, [4]Applied Physics Laboratory, John Hopkins University, Laurel, MD, USA, [5]Planetary Science Institute, Tucson, AZ, USA, [6]Oak Ridge Associated Universities, NASA Goddard Space Flight Center, Greenbelt, MD, USA, [7]Lamont-Doherty Earth Observatory, Columbia University, Palisades, NY, USA, [8]Instituto di Astrofisica e Planetologia Spaziali, Roma, Italy, (Corresponding Author: Julie.C.Castillo@jpl.nasa.gov)

**Pre-Dawn State of Knowledge:** Ceres is the largest object in the main belt, about the size and density of Pluto's moon Charon. The recognition that Ceres was more akin to icy satellites and likely to have hosted a deep ocean, at least during part of its history, is recent. McCord and Sotin [1] pointed out that the dwarf planet contained the right amount of water and rock both for sustained heating and for the differentiation of a volatile-rich shell. While Ceres does not benefit from tidal heating, it is close enough to the Sun for its surface temperature (below the diurnal thermal skin) to approach the relaxation temperature of water ice. It is also likely to have benefited from short-lived radioisotope decay heat.

Follow-on models addressed Ceres' potential for internal activity both hydrothermal and subsolidus in a thick ice shell [2-5]. Some of these models accounted for the presence of salts leached from the silicates as a consequence of the hydrothermal processing event that led to the pervasively hydrated material making up Ceres' surface [6]. Thermal evolution models agree that temperatures in Ceres' shell could remain warm until present, above the eutectic temperature of relevant salts; lenses of supersaturated brines could exist at present [2, 5]. Modeling of heat transfer in a "mud ball" even proposes that a vast ocean could remain at present [7].

**Dawn's Observations:** Dawn is the first to have performed extensive geological, chemical, and, geophysical observations at an ice-rich body via mapping with a multispectral imager, visible and infrared spectrometer, gamma ray and neutron detector, and radio science [8]. Results released so far can help quantify Ceres' astrobiological significance. First, the surface composition indicates advanced aqueous alteration in the form of Mg-serpentine, carbonates, as well as the presence of ammoniated clays [9]. The surface is punctuated by bright regions identified as sodium carbonate deposits [10, 11], a compound also found in Enceladus' plumes and Earth, typical of alkaline oceanic environments [12]. While bright deposits are mostly found in association with impact craters, their distribution all over the surface suggests abundant material of oceanic nature at shallow depth. Organics have proved elusive so far, although UV observations have revealed graphitized carbon, the likely outcome of organics weathering by charged particles [13].

Additional evidence for salts in the subsurface comes from geological observations. The heavily cratered surface contrasts with predictions that a thick ice shell on Ceres would relax to a smooth surface [14]. Instead topography observations indicate that the shell is strong but of relatively low density [15]. The preferred explanation to date involves clathrate hydrates combined with salts, ice, and clays [16, 17]. Furthermore, at least one feature on Ceres' surface points to recent cryovolcanism: the emplacement of the 4-km high Ahuna mons requires a low-viscosity source, possibly indicating the presence of brines [18].

**Summary:** Dawn's observations of Ceres have confirmed earlier predictions for a warm, volatile-rich, and liquid-bearing interior and have led to Ceres' classification as a candidate ocean world in the Roadmap for Ocean Worlds [19]. Spectroscopic observations have enabled quantification of the extent of hydrothermal activity in Ceres' early history. Ongoing topography relaxation modeling will narrow down constraints on Ceres' current thermal state. The presentation will develop these aspects.

The lack of ice-dominated shell is a major departure from earlier predictions. It may be explained by removal upon sublimation accelerated by impacting during Ceres' early history [20]. In other words, Ceres' surface represents the exposure of a frozen basal oceanic layer. This makes it a playground for investigating the chemical evolution and potential for prebiotic chemistry of large volatile-rich bodies.

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*Acknowledgements: Part of this work is being carried out at the Jet Propulsion Laboratory, California Institute of Technology, under a contract to NASA.*