ROADMAP FOR THE EXPLORATION OF DWARF PLANET CERES. J. C. Castillo-Rogez[1], C. A. Raymond[1], A. S. Rivkin[2], M. Neveu[3], C. T. Russell[4]. [1]Jet Propulsion Laboratory, California Institute of Technology, Pasadena, CA (Julie.C.Castillo@jpl.nasa.gov), [2]Applied Physics Laboratory, John Hopkins University, Laurel, MD. [3]School of Earth and Space Exploration, Arizona State University, Tempe, AZ, [4] Institute of Geophysics and Planetary Physics, University of California, Los Angeles, CA.

State of Knowledge: Ceres, the largest asteroid, and only dwarf planet found in the inner solar system, offers a playground for testing hypotheses pertaining to the early Solar system evolution as well as the habitability potential of large volatile-rich bodies. New evidence allows for a fresh assessment of Ceres' astrobiological significance, which was identified prior to Dawn's arrival [1, 2] and have led Ceres to turn from a "*credible*" possible ocean world to a "*candidate*" ocean world [3]. Specifically, in the frame of the Roadmap for Ocean Worlds Goals, Dawn brought positive answers to the following questions: *Goal 1 (Identify Ocean Worlds), A.1 Is there remnant radiogenic heating? B.1 Do signatures of geologic activity indicate the possible presence of a subsurface ocean? B.7 Can the surface composition be linked with the presence of a sub-surface ocean?*

It has been suggested that the deep oceanic material could be exposed via the removal of an ice shell via impact-induced sublimation [4]. This combined with clues for carbon suggests that the study of Ceres' surface directly addresses the ROW *Goal II B.3 "Characterize the ice-ocean interface"* and offers a playground for testing hypotheses aboud the chemical evolution and habitability potential of Ocean Worlds.

A Roadmap for Ceres Exploration: If pursuing the exploration of Ceres in the context of the Roadmap for Ocean Worlds, a future mission to Ceres could address key questions under ROW's *Goal II (Characterize the Ocean).* This questions might be addressed by studying the interaction of Ceres with the solar wind although this remains to be quantified. Comparison between images returned by Dawn and a future mission could be used to search for the signature of a deep liquid layer in Ceres' rotation and possibly also reveal telling changes in surface properties. Indeed the key to evaluating Ceres' internal structure might come from the long-term observation of the faculae (bright deposits) observed in the Occator crater.

Further assessment of Ceres' habitability may be accomplished by investigating the chemical fingerprints contained in bright deposits to infer constraints on the environment in which they formed. Geophysical measurements are required to study the endogenic processes driving cryovolcanic features. A Dawn follow-on mission could also aim to clarify the nature of the dark material covering the surface and the mechanisms involved in its formation (hydrothermal, space weathering).

The answers to these questions would drive the third step in Ceres' exploration, with regard to better understanding "*how life might exist at each ocean world and search for life*" [ROW *Goal IV*]. Exploration strategies developed for Mars may be applicable there, in particular planetary protection technologies.

Finally, the exploration of Ceres and large icy satellites requires a theoretical framework and experimental progress to assess, e.g., the stability and thermophysical properties of salt-rich materials, the physics driving endogenic processes in a (relatively) small gravity body, exogenic processes altering its surface, and the development, thriving, and preservation of life and biosignatures in salt-rich environments.

Ceres as a Stepping Stone for the Exploration of Ocean Worlds: Ceres represents a critical data point for understanding the chemical evolution of volatile-rich worlds and especially their potential for forming and preserving organic compounds. With it low gravity and relative begnin environment, Ceres also offers easy surface access (in comparison to Mars or Europa) whereas the roundtrip light-time to/from Ceres requires the introduction of semi-autonomous techniques for advanced surface operations. Hence a long-term exploration program of Ceres is compelling, not just for the anticipated science return, but also because it will help us practice and hone new technologies of relevance to the future exploration of ocean worlds, such as surface operations, planetary protection, and end-to-end sample collection and return to Earth.

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