EPSC Abstracts
Vol. 10, EPSC2015-156, 2015
European Planetary Science Congress 2015

Science Objectives for the Europa Clipper Mission Concept: Investigating the Potential Habitability of Europa

R. Pappalardo (1), D. Senske (1), L. Prockter (2), B. Paczkowski (1), S. Vance (1), A. Rhoden (2), B. Goldstein (1), T. Magner (2), and B. Cooke (1)
(1) Jet Propulsion Laboratory, California Institute of Technology, Pasadena, CA 91109, (2) Johns Hopkins University Applied Physics Laboratory, Laurel, MD 20723.

Abstract

Advancing our understanding of the icy worlds of the outer solar system will provide a basis to better evaluate potential habitability across the solar system. The exploration of Europa is at the forefront of gaining insight into the key components, water, chemistry, and energy, which make a world potentially habitable. The Europa Clipper mission concept would provide a systematic study of Europa, extending from its exosphere to the deep interior, providing significant knowledge as to how this icy water world formed and evolved.

1. Introduction

Understanding the processes that lead to potential habitability across the solar system is a key recommendation of the Planetary Science Decadal Survey, "*Visions and Voyages*" [1]. Fundamental to implementing this recommendation is evaluating the astrobiological significance of the icy satellites of the giant outer planets. It is in this context that Europa is at the forefront for recommended outer planet satellite exploration [1].

2. Europa's Potential Habitability

Advancing the state of knowledge of Europa's potential habitability has its basis in understanding the three "ingredients" for life: water, chemistry, and energy. It is hypothesized the Europa may have all three of these ingredients in the form of: (1) an extensive saltwater ocean beneath an ice shell that is geodynamically active and relatively thin (several kilometers to several tens of kilometers thick); (2) key chemical elements derived from the primordial chondritic composition of the Jovian protoplanetary disk, plus delivery by asteroids and comets over time; and (3) a source of chemical energy for life, from the combination of irradiation of its surface to produce oxidants, plus hydrothermal activity and/or serpentinization at its ocean floor to produce reductants. Key to this, the processes that shape Europa's ice shell, and the exchange processes between the surface and ocean, are not well understood. Even the existence of a subsurface ocean—while the evidence for its presence is compelling—is not proven.

3. Science Objectives for Europa Exploration

A NASA chartered Europa Science Definition Team (SDT) formulated the goal for future Europa exploration as: "Explore Europa to investigate its habitability." That group formulated objectives for a mission in Jupiter orbit that would make multiple-flybys of Europa:
(1) *Ocean and Ice Shell*: Characterize the ice shell and any subsurface water, including their heterogeneity, ocean properties, and the nature of surface-ice-ocean exchange;
(2) *Composition*: Understand the habitability of Europa's ocean through composition and chemistry;
(3) *Geology*: Understand the formation of surface features, including sites of recent or current activity, and characterize high science interest localities.

The Europa SDT also considered implications of the Hubble Space Telescope detection of a possible plume at Europa [2]. They concluded that the mission concept as conceived, if well instrumented, could do an excellent job of searching for and characterizing plumes, if they exist.

Science achieved by the Europa Clipper mission concept would provide global and regional characterization of this satellite. It is anticipated that a future step in addressing key scientific questions regarding the habitability and composition of Europa would be to land a spacecraft capable of *in situ* sampling and analysis. Based on a recent study of a Europa lander concept [3], additional information is needed regarding Europa's surface characteristics and properties to robustly architect a low-risk lander concept. To maximize technical and scientific success of a potential future landed mission, high fidelity surface reconnaissance is essential.

The SDT formulated a separate goal for reconnaissance of Europa as: *Characterize scientifically compelling sites, and hazards, for a potential future landed mission to Europa*. From this goal flow the two objectives of reconnaissance for the Europa Clipper mission concept:
(1) *Site Characterization*: Assess the distribution of surface hazards, the load-bearing capacity of the surface, the structure of the subsurface, and the regolith thickness, for at least 15 sites of interest;
(2) *Science Value*: Assess the composition of surface materials, the geologic context of the surface, the potential for geologic activity, the proximity of near-surface water, and the potential for active upwelling of ocean material, for at least 15 sites of interest.

4. The Europa Clipper Mission Concept

Based on the science and reconnaissance objectives, a joint technical team from the California Institute of Technology's Jet Propulsion Laboratory and the Johns Hopkins University Applied Physics Laboratory has devised a flight system and mission design that can accommodate a capable science payload responsive to the defined science objectives. A mission design has been developed that incorporates 45 close flybys of Europa, to achieve globally distributed regional surface coverage. The overall mission architecture is optimized to achieve science while minimizing radiation exposure inherent in the Jupiter system. The baseline concept is for a solar-powered spacecraft, launched on NASA's Space launch System (SLS).

5. Conclusions

A Jupiter-orbiting spacecraft that makes many flybys of Europa would provide an excellent platform from which to conduct measurements to investigate Europa's ocean and ice shell, composition, and geology, and thus the potential ingredients for life. Development of the Europa Clipper mission concept is ongoing, focusing on requirements development and spacecraft design trades.

It is anticipated that NASA will complete its initial phase of instrument selection in the spring of 2015. We will provide an update on status of the science and reconnaissance development of this mission concept.

References

[1] Space Studies Board: Vision and Voyages, The National Academies Press, Washington, DC, 2011.

[2] Roth, L. *et al.*: Transient Water Vapor at Europa's South Pole, *Science*, 343, 171-174, 2014.

[3] Europa Study Team: Europa Study Final Report—Lander: JPL Internal Document D-71990, 2012.