

**AN EXAMINATION OF ISSUES RELATED TO A EUROPA SUBSURFACE COMPONENT FOR THE JIMO MISSION.** F. D. Carsey<sup>1</sup>, M. H. Hecht<sup>1</sup>, B. H. Wilcox<sup>1</sup>, A. E. Behar<sup>1</sup>, and P. M. Holland<sup>2</sup>, <sup>1</sup>California Institute of Technology Jet Propulsion Laboratory, Pasadena CA 91109, <sup>2</sup>Thorleaf Research, Inc., Santa Barbara, CA 93111

**Introduction:** The Galileo Europa data set served to revolutionize our view of Europa. In particular the strong evidence [1] of a large, cold, salty ocean beneath 5-30 km of ice has profoundly altered the significance of Europa in our thinking, especially of context of habitability in the solar system. While much remains to be learned from spacecraft observations of several sorts, there are significant questions answerable only by in-situ techniques; these relate to the formation of Europa, the nature of its ocean, and the prospects for life in its ocean, sediments, and ice. We feel that wide-ranging discussion of an in-situ subsurface mission to Europa, as part of JIMO, should proceed.

**Science Objective:** The science objective of the mission is to characterize the icy shell of Europa to resolve its provenance, estimate the composition of brine of the Europa ocean, and search for evidence of Earth-like life.

**The Mission Scope:** Probably anyone would agree that an in-situ mission to Europa would be of great value, but he or she would also immediately take the position that such a mission is utterly impractical. We take the position here of defining the least complex mission that can nonetheless justify its cost and to argue that such a mission is realistic enough that it should be seriously considered. Our mission thinking has been:

*Soft landing.* A soft lander is required on a site sufficiently flat to offer a stable platform; no further site selectivity is required.

*Subsurface exploration.* The Europa subsurface must be examined. Surficial processes on Europa arguably have exposed the upper 200 m of shell to chemical effects from the Jovian radiation belts as well as cometary infall, etc; to examine native ice we must descend below that point to, for discussion, 300 m. At that depth we argue that the ice is characteristic of ice at depth and possibly is effectively sea ice.

*Science data.* A few simple measurements at various depths and at 300 m constitute a scientifically successful mission. Measurements would include analysis of meltwater for a few inorganic ions and amino acids and an optical examination of the borehole wall.

*Communication.* Transmission of data to an orbiter is essential, but we will constrain the landed mission to a daily communication over a few days.

*Subsurface access.* Drilling to 300 m is a significant challenge; it can be addressed by several means:

*Thermal Probe (Cryobot) which permits water to refreeze above the vehicle.* This is our tentative choice with plutonium as the fuel to generate thermal energy for drilling and electrical power for operations.

*Open Hole Drill, a thermal system in which the meltwater is removed for greater thermal efficiency.* Meltwater removal on Europa is both a complexity and a risk, but analysis is improved.

*Mechanical Drilling in which cutting or grinding generates ice chips which are removed.* This is too complex at Europa temperatures.

**Measurement Objectives:** The measurement objectives for the mission will be:

Obj. 1: Determine the concentration of simple inorganic salts [2] in the Europa Ice Shell and, by extrapolation, of the ocean. These data will also validate spaceborne sensors.

Obj. 2: Determine the nature and abundance of amino acids [3] in the ice such that cometary infall material in the upper ice can be compared to material at depth.

Obj. 3: Optically examine the ice to resolve inclusion structure, particulate content, and stratification.

**The Drill:** Access to 300 m depth is a significant if not audacious plan; we are aware that this has not been done on any planetary body. Our approach is the use of a plutonium heat source; to overcome Europa's surface temperature and to melt ice a significant amount of plutonium is needed, and significant shielding and other protective steps will be required. The quantity of plutonium is a key concern.

**Sampling:** The mission will require subsurface collection and processing of samples for *in situ* analysis, calling for a miniature, high pressure micro-sampling system designed to meet needs of instruments that require low pressures for operation. The inlet system itself collects a micro-sample in the external high pressure environment, then transfers it into a protected low pressure environment for analysis.

**References:**

- [1] Stevenson, D. (2001) Europa's ocean—the case strengthens, *Science* 289(5483), 1305-1307.
- [2] Kounaves, S. P., S. R. Lukow, B. Comeau, M. H. Hecht, S. M. Grannan, K. Manatt, S. J. West, X. Wen, M. Frant, T. Gillette, (2003) *J. Geophys. Res.*
- [3] Glavin, D.P., Schubert, M., Botta, O., Kminek, G., and Bada, J.L. (2001) *Earth and Planetary Science Letters* 185(1-2), 1-5.