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Science of the Europa Clipper Mission: Comprehensive Remote Sensing to Investigate the Ice Shell

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Abstract

A key driver of the exploration of Europa is to understand the processes that lead to potential habitability of the icy worlds of the outer solar system [1]. To address this goal, understanding the composition of and mechanisms by which material is exchanged between the Europa surface, the icy interior, and the ocean is of substantial importance. The Europa Clipper Mission supports a highly capable payload of both in situ and remote-sensing instruments to observe Europa and its environment and investigate geophysical processes associated with the ice shell.

1. Introduction

The science goal of the Europa Clipper mission is to explore Europa to investigate its habitability. Following from this goal are three Mission Objectives (1) Characterize the ice shell and any subsurface water, including their heterogeneity, ocean properties, and the nature of surface-ice-ocean exchange; (2) Understand the habitability of Europa's ocean through composition and chemistry; and (3) Understand the formation of surface features, including sites of recent or current activity, and characterize high science interest localities. To address the science requirements of the Europa Clipper mission, a highly capable suite of nine instruments that comprise the mission's scientific payload are now under development. This payload includes four in situ instruments that measure fields and particles, The Europa Clipper Magnetometer (ECM), the Plasma Instrument for Magnetic Sounding (PIMS), the SUrface Dust Analyzer (SUDA), and the MAss Spectrometer for Planetary Exploration (MASPEX) that are discussed in a companion paper [2]. Five remote sensing instruments will observe the wavelength range from the ultraviolet through radar. In addition, gravity science will be achieved via the spacecraft's telecommunication system in combination with radar altimetry. Moreover, valuable scientific data could come from the spacecraft's planned radiation monitoring system. In this paper, we discuss the set of remote sensing investigations.

2. Remote Sensing Investigations of Europa's Ice Shell

To understand the processes associated with ocean-ice shell interactions, transport within the ice shell, tectonism, the surface expression of cryomagmetism, establish stratigraphic relations through geologic mapping (Fig. 1), and search for possible plumes, the Europa Clipper remote sensing payload provides the capability for in-depth study. Below we summarize the key characteristics of each investigation.

Europa Ultraviolet Spectrograph (Europa-UVS). Operating at ultraviolet wavelengths, Europa-UVS is designed to be the Europa Clipper's key plume searching instrument with the goal of characterizing the distribution, structure, composition, and variability of any active plumes. Relative to directly understanding the surface, data to be collected by Europa-UVS will be used to constrain surface composition and microphysics and relationships to endogenic and exogenic processes. In addition, it will be possible to interrogate the composition and chemistry, sources and sinks, and structure and variability of the tenuous Europa atmosphere. With respect to the jovian environment, Europa-UVS data will permit a better understanding of the plasma environment, notably the energy and mass flow into Europa's atmosphere, neutral cloud, and plasma torus.

Europa Imaging System (EIS). Composed of narrow- and wide-angle cameras with stereo and color imaging capability, EIS will map Europa globally at 100 m resolution and image almost any point on the surface at better than 20 m resolution, providing a foundation for geologic mapping and the formulation of geophysical models to understand the formation of surface features. Very high-resolution imaging (meter-scale or better) addresses small-scale regolith processes and will characterize sites amenable for a future lander. Distant imaging by EIS will aid in the search for active plumes and provide a means to characterize the ice shell through modelling of the limb shape.

Mapping Imaging Spectrometer for Europa (MISE). Operating in the 0.8–5.0 μm wavelength range, MISE data will be used to assess the habitability of Europa's ocean through the examination of the inventory and distribution of surface compounds, including any biologically relevant deposits. MISE data will be used to identify and map the distributions of organics, salts, acid hydrates, water ice phases, altered silicates, radiolytic compounds, and warm thermal anomalies at global, regional, and local scales.

Europa Thermal Imaging System (E-THEMIS). The E-THEMIS investigation permits the detection and characterization of thermal anomalies that may indicate recent activity. Thermal inertia information derived from E-THEMIS temperature measurements will be used to characterize regolith particle size, block abundance, and subsurface layering. This investigation will also aid characterization of any active plumes.

Radar for Europa Assessment and Sounding: Ocean to Near-surface (REASON). REASON data will permit mapping of Europa's vertical crustal structure and search for subsurface water with emphasis on the study of the distribution of any shallow subsurface water and to search for the deeper ice-ocean interface, while characterizing the ice shell's global thermophysical structure. Insight will also be provided into material exchange among the ocean, ice shell, surface, and atmosphere. The investigations' solid body geophysical measurements will constrain the amplitude and phase of the tides and the derived dielectric and other physical properties will support characterization of the scientific value and hazards of sites for a potential future lander.

3. Summary and Conclusions

The investigations for the Europa Clipper mission are now in their critical design phase of development. Working together, those with a focus on remote sensing, will provide data to analyze the three-dimensional structure and properties of the ice shell. Combined with a mission design that provides 46 globally distributed flybys over a period of ~3.5 years, it will be possible to access a diverse and widely distributed set of geologic terrains (Fig. 1), providing data to constrain and test geophysical models of the ice shell.

References

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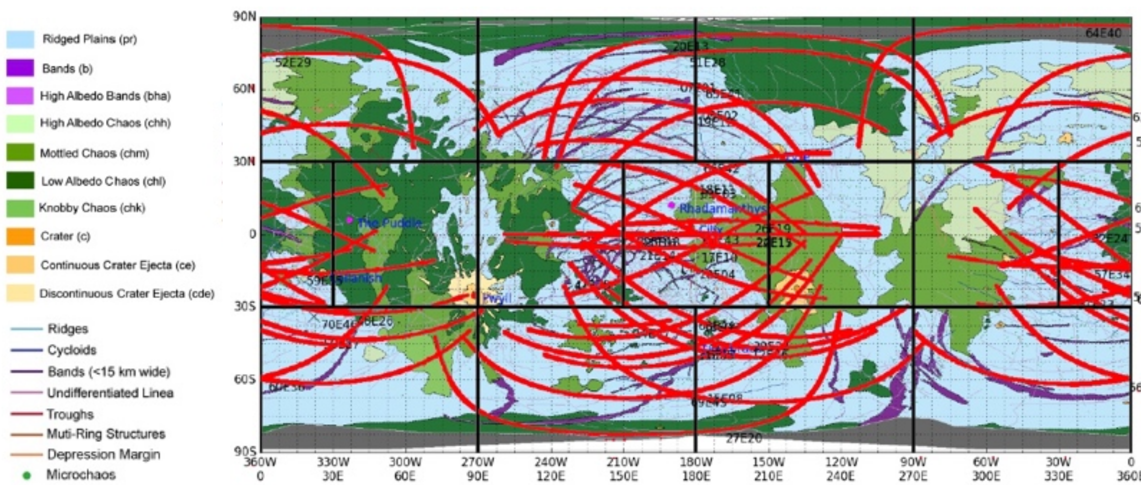

Figure 1. Europa global geologic map and units [3,4] with ground tracks for spacecraft altitudes of less than 1000 km [5]. The general geologic terrain types include regional plains (blue), chaos (green), bands (purple), and crater materials (yellow and orange). The Europa Clipper will be able to globally access an extensive array of widely distributed geologic units.