THE EUROPA CLIPPER MISSION: PLANNED INVESTIGATIONS OF THE COMPOSITION OF AN ICY WORLD. T. M. Becker[1,2], M. Yu. Zolotov[3], M. S. Gudipati[4], J. M. Soderblom[5], M. A. McGrath[5], B. L. Henderson[4], M. M. Hedman[7], M. Choukroun[4], R. Clark[8], and the Europa Clipper Composition Working Group.

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Introduction: NASA's Europa Clipper mission will conduct a detailed reconnaissance of Jupiter's moon, Europa, with the primary goal of assessing its habitability. Europa is an ocean world, harboring liquid water ocean under its icy outer shell, making it the ideal target for a dedicated mission to search for the signatures of habitability [1].

Through a series of >45 flybys the mission instrument suite will acquire data to investigate Europa's composition of Europa's surface, its collisionless atmosphere and surrounding space environment, morphology and physical properties of surface materials, and interior. Additionally, the mission will search for current and recent activity such as plumes. In this presentation we provide an overview of the planned cross-instrument and cross-discipline approach to assess the composition of Europa's surface, subsurface, atmosphere, and local space environment that will be used to meet the science objectives for the Europa Clipper mission.

The Importance of Compositional Data: Compositional measurements provide key information for determining the habitability of Europa and constraining the moon's origin, evolution, and current processes that effect the composition of the atmosphere, surface, and interior. Constraints on the salinity, acidity, oxidation state, and the concentration of organic and inorganic material in the interior oceanic water, as well as radiolytic products on the surface that can be introduced as an energy source to that ocean, are useful to assess Europa's habitability.

Exchanges between the surface and the subsurface icy, briny and oceanic materials will be constrained through Europa's global and regional surface composition, particularly near geologic features or regions with putative plume deposits (Fig. 1). Irradiation and micrometeoroid bombardment result in the sputtering of volatiles (and their subsequent ionization) and lofting of dust particles from the surface into the atmosphere, such that the composition of the atmosphere and the local space environment can reflect the composition of Europa's interior, including shallow subsurface, deep ice shell, the ocean, and sub-oceanic materials. *In-situ* and remote-sensing measurements of potentially active plumes provide an avenue for more direct constraints on the composition of subsurface liquids (e.g. salt brines) and solids such as gas hydrates.

The Europa Clipper Mission's Composition Investigation Requirements: The composition-related requirements for the Europa Clipper mission include: (1) creating a global compositional map at ≤10 km scale that covers ≥60% of the surface, sufficient to identify non-ice materials; (2) characterize the composition of local landforms at ≤300 m scale, (3) characterize the composition and sources of volatiles, particulates, and plasma in globally-distributed regions of Europa's atmosphere and local space environment, sufficient to identify the signatures of non-ice materials, and (4) search for and characterize any current activity, notably plumes or thermal anomalies.

Payload: To achieve the Europa Clipper mission objectives, including those focused on Europa's composition, the payload consists of ten science investigations and a radiation monitor: The Mapping Imaging Spectrometer for Europa (MISE), the Europa Imaging System (EIS), the Europa THermal EMission Imaging System (E-THEMIS), The Europa Ultraviolet Spectrograph (Europa-UVS), the Radar for Europa Assessment and Sounding: Ocean to Near-surface (REASON), the Europa Clipper Magnetometer (ECM), the Plasma Instrument for Magnetic Sounding (PIMS), the Mass SPectometer for Planetary Exploration/Europa (MASPEX), the SUrface Dust Analyzer (SUDA), the Gravity and Radio Science (G/RS), and the Radiation Monitor (RadMon). These investigations will acquire synergistic observations that will enable a robust, comprehensive analysis of Europa's composition and its implications for habitability.

Global Surface Composition: The Europa Clipper mission will determine the global-scale composition of the surface, identifying units, large-scale variability, exogenic compositional signatures, and evidence of possible large-scale heterogeneity, primarily through global-scale infrared imaging spectroscopy with MISE. This investigation will measure absorption features affiliated with hydrated salts and organics. The MASPEX and SUDA investigations will map

compositionally diagnostic properties in the *in situ* volatile and ice/dust particle datasets to determine the surface composition and chemistry, including the identification of any hydrated minerals and organic compounds, seeking indicators of ocean geochemical processes relevant to habitability.

Landform Composition: The MISE investigation will obtain regional-scale observations of the surface composition to identify exogenic compositional signatures and to understand the chemical pathways between the interior (e.g. ocean) and surface, and their implications for habitability.

Atmospheric Composition: The composition of Europa's atmosphere and local space environment will be investigated through *in situ* and remote observations. The MASPEX investigation will identify the global distribution of major volatiles in the atmosphere and local space environment and resolve key organic compounds, their possible sources, and their relative abundances. The SUDA investigation will characterize the composition of near surface exospheric ice/dust particles, including any organic compounds, if present, and distinguish between exogenic (e.g., originated at Io's volcanoes) and endogenic sources of material. The Europa-UVS investigation will map the vertical structure and composition of the atmosphere that are globally distributed and sample on timescales of the Europa-Jupiter half-synodic period. The PIMS investigation will measure the energy per charger characteristics of the Europa ionosphere and the magnetosphere to characterize their compositions and plasma sources.

Current Activity: To search for current activity, the Europa-UVS investigation will search for and characterize the vapor composition of any present plumes. The E-THEMIS investigation will map daytime and nighttime temperatures to characterize the thermal state of the ice shell and identify heat glow anomalies, regolith depth, and block abundance. The SUDA investigation will identify and characterize the potential recent and/or ongoing activity in any active plumes and determine the composition, including organic compounds if present, number density, and size distribution of any plume ice/dust particles to identify and constrain the plume's source mechanism and salinity of the source. The MASPEX investigation will measure the composition of volatiles at <110 km spatial scale to characterize any active geological features and determine relative fluxes of endogenous particles and gasses in any encountered plume material in order to constrain interior (e.g. oceanic) geochemical characteristics relevant to habitability.

This presentation will further describe the compositional goals of the Europa Clipper mission and the observational techniques that will be used to achieve them, which have recently been captured in an upcoming Space Science Reviews publication.

References: [1] Carlson, R. W. *et al.* (2009). *Europa. Eds. R. T. Pappalardo, W. B. McKinnon, K. K. Khurana,* 283.

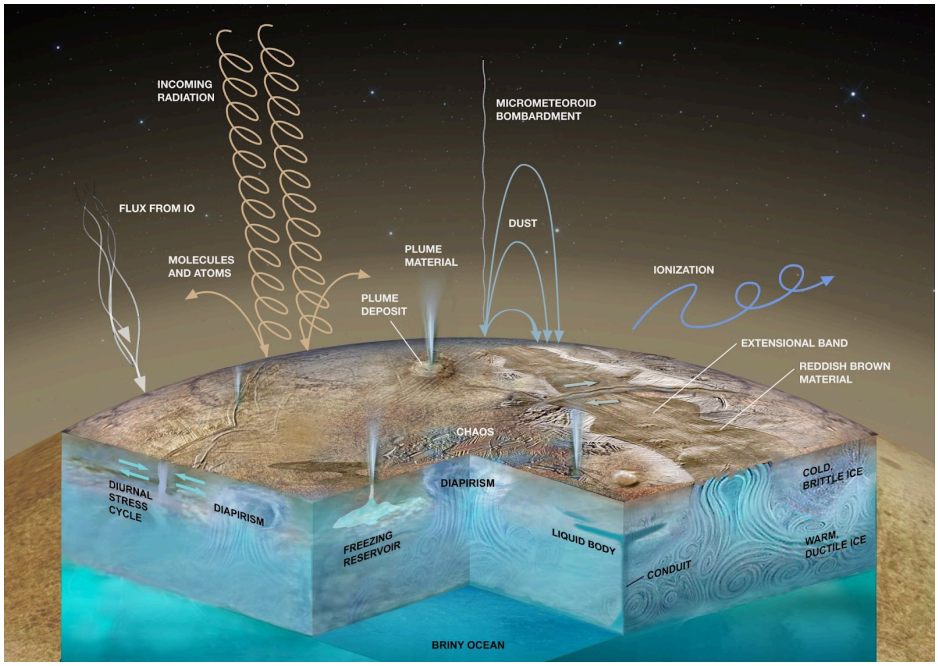

Fig. 1: Artistic depiction of the processes that affect the composition of Europa.