INVESTIGATING THE FORMATION, EVOLUTION, AND HABITABILITY OF THE GALILEAN SATELLITES WITH HIGH PERFORMANCE MASS SPECTROMETRY. D. Wyrick[1], J. H. Waite, Jr.[1], T. Brockwell[1], M. McGrath[2], W.B. McKinnon[3], O. Mousis[4] and B. Magee[1] ([1] Southwest Research Institute, San Antonio, TX and Boulder, CO.; [2] NASA Marshall Space Flight Center, Huntsville, AL; [3] Washington University, Saint Louis, MO; and [4] CNRS Observatoire de Besancon, Besancon, France**)**

Introduction: High performance mass spectrometry (MS) allows for direct sampling of atomic and molecular species released through intense sputtering on the surface or outgassed volatiles from geologically active regions. New technologies, combining a cryotrapping inlet and multibounce time-of-flight ion optics, boost mass resolution ($M/\Delta M > 20{,}000$) and detection sensitivity (parts per 10^{12}, ppt) to unprecedented levels. In this talk, we detail the science objectives, develop the rationale for the measurement requirements, and describe potential instrument/mission methodologies for studying the formation, evolution, and habitability of the Galilean satellites, with emphasis on key measurements relevant to the proposed Europa Clipper mission.

Measurements of Key Species for Habitability: Both high mass resolution and high sensitivity are required to distinguish isotopologues of SO_2, CO_2, and other species as well as to identify complex organic molecules, measurements that are critical to answering questions of hydrothermal alteration, abiotic/biotic processes, and habitability on Europa, past and present.

Organics and the H, C isotopes of CO_2, CO, CH_4, C_2H_6, and higher order hydrocarbons: The mass resolution of our instrument can determine whether organics are present and what kind (i.e., hydrocarbons, nitriles, amines, alcohols, carboxylic acids). Measurements of the H and C isotopic ratios of carbon bearing compounds can help differentiate (e.g.) Fischer-Tropsch reaction (abiotic; [1]) from cometary (primordial; [2]) from biological [3,4] signatures, of key importance in understanding the potential and/or existence of habitability [5].

Measurement of ratios of key simple volatiles (NH_3 and N_2, CO, CO_2, and CH_4, HCN, O_2, H_2O and H_2): Volatiles ratios that source from Europa's oceans may represent an equilibrium, hydrothermally processed assemblage or a disequilibrium, comet-like assemblage. If the ratios appear consistent with thermochemical processing [6,7], then constraints on the temperature and oxidation state should be possible. Ongoing hydroxylation of mafic and ultramafic silicate minerals can act as a source of hydrogen [8,9], which can fuel microbial ecosystems [10].

H, O isotopes of H_2O: Cycles of vaporization and condensation of water ice lead to fractionation of the O isotopes in water. MS can distinguish between sources of water by measuring H isotopes in water [11,12,13], thereby constraining the past hydrothermal processing of interior minerals.

NH_3 and N_2 isotopes: Primordial N_2 and NH_3 have fundamentally different isotopic ratios, which can be measured to determine if the N_2 derives from primordial materials or has been altered as suggested by measurements at Titan [14]. From a habitability point of view, nitrogen is a biologically essential element, but once tied up as N_2, it is much less available for metabolic processes (life).

Argon: ^{40}Ar forms from the decay of ^{40}K in the crust and dissolved in ocean waters, and should remain trapped in the interior until geologic activity provides an opportunity of release into the exosphere. Detection of ^{40}Ar (which requires a very high sensitivity measurement) would indicate recent or ongoing surface-atmospheric interaction and potentially locate outgassing sites.

SO_2 isotopes: Sulfate salts have been taken as signatures of ocean chemistry (present day oxidation state and thus chemical potential for life) on Europa [15]. Measuring the SO_2 isotopes on the surface of Europa and in orbit closer to Io will allow comparisons to determine the sulfur's origin.

Conclusions: Improved MS performance will allow the measurement of isotopic composition and present day volatile ratios as well as the correct identification of complex organics, all essential to addressing the goal of understanding Europa's habitability.

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