

GEOSCIENCES AT JUPITER'S ICY MOONS: THE MIDAS TOUCH J. H. Lipps¹, G. T. Delory¹, M. Manga¹, I. De Pater¹, J. Graham¹, S. Reiboldt¹, J. Pitman², and A. Duncan² ¹University of California at Berkeley Center for Integrative Planetary Sciences, Berkeley CA 94720 (jlipps@uclink.berkeley.edu), ²Lockheed Martin Advanced Technology Center, 3251 Hanover Street, Palo Alto, CA, 94304-1191 (joe.pitman@lmco.com)

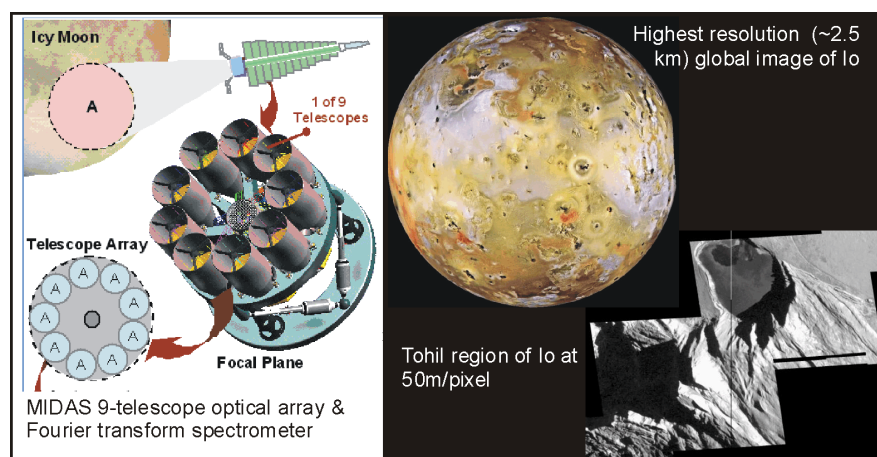
Introduction: The Galileo mission revealed that the Jovian Icy Moons (JIM) and Io are dynamic worlds possessing possible subsurface oceans, magnetism, spectacular volcanic activity, and potentially life. While Galileo's images and spectroscopic measurements have greatly increased our understanding of these bodies, higher spectral and spatial resolution measurements are clearly needed in order to begin to address the myriad of new questions and uncertainties regarding these moons [1]. Here we describe the potential science objectives on the Jupiter Icy Moons Orbiter (JIMO) mission enabled by the Multiple Instrument Distributed Aperture System (MIDAS), a low-volume, 1.5m aperture imaging spectrometer capable of ~nm spectral resolution at spatial resolutions of ~2cm-1m/pixel from orbit (Figure 1).

Geology: An abundance of geologic structures, units, colors, and other features are currently observed on JIM. These can be studied informatively by image analyses and topographic mapping at scales from kms to cms. Images at any one resolution would have value, but together they significantly increase the total science output, significance and understanding. Most of the geologic features of JIM identified in Galileo's low-resolution images are not well understood [2,3,4] and need study at the higher resolutions, including global mapping at resolutions of 1-10 m/pixel and vertical resolution of 1m, coupled with targeted imaging at spatial scales on the order of cm. Images with resolution like these will allow the testing of models of formation of major and minor features and determination of structures within the features. Observations at these spatial scales will also greatly facilitate future landing site selection for Europa in particular.

Astrobiology: JIM might harbor abundant and varied life that could be preserved in the moons' surface ice. Habitats for life could exist in benthic soft and rocky substrates below the water-slush, in the water column, and in the ice crusts. These habitats may well have been preserved or have signatures in the surface ice where it has been disturbed by tectonic activity (Europa and Ganymede), cryovolcanism (Europa), or bolide impacts (all JIM). Life below the icy crusts has a likelihood of being carried to the surface and preserved there, as on Earth's ice covers. Life might live and be preserved in ice associated with the large fissures and refrozen areas, areas below clear ice that transmits light, tiny cracks, brine channels, inter-crystal water films, ice surfaces in the water, surface-water accumulations, and oases caused by impact, volcanic heat, or surface meltwater, as on Earth [5-9]. Some of these places might be inhospitable to life because of extreme chemical, radiation or other conditions, but are included here for more careful analyses with improved remote techniques, given the tenacity of life in Earth's ice-influenced environments. Many of these geologic features and potential habitats are shown in Figure 2, along with the capability of the MIDAS instrument to detect them at varying spatial scales and altitudes.

Composition & Distribution of Surface Materials: High spatial and spectral resolution broadband imaging in the infrared will greatly enhance our understanding of the surface compositions, chemistry, and thermal properties of the JIM. Galileo NIMS observations of Europa clearly show asymmetric water absorption bands mainly attributed to hydrated salts, sulfates, or carbonates [10,11], while Callisto and

Figure 1: MIDAS utilizes 9 telescopes in a coordinated array to form a 1.5m synthetic aperture with diffraction-limited performance. From Europa, MIDAS can image Io at a spatial resolution of ~50m, yielding global images with qualities similar to the Galileo fly-bys (of the Tohil region shown for example.)



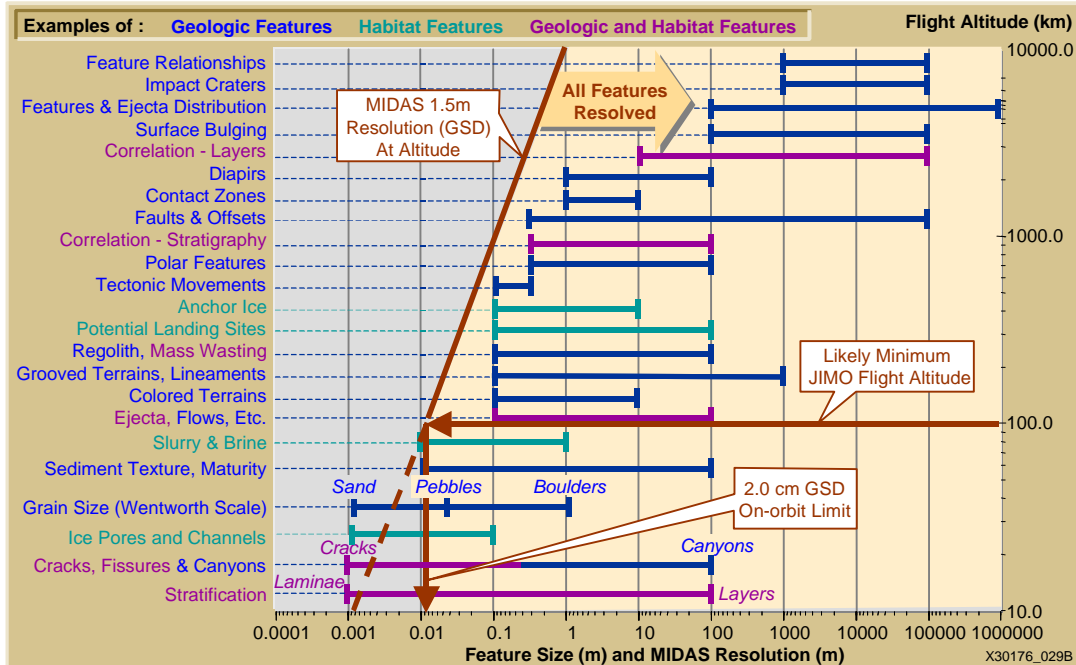


Figure 2: Geologic features and targets of potential astrobiological interest resolved by MIDAS

Ganymede indicate the presence of organics [12]. There remain significant ambiguities in the identification of hydrates and possible sulfur compounds, in part due to the relatively low spectral resolution of the current data set. A spectrometer with <2 nm spectral resolution in the near-to-mid IR (0.7-15 μm) would potentially resolve fine structure within these spectra, particularly within the broad absorption bands, and further constrain surface composition. At this resolution, detection of other volatiles such as clathrates [13], differentiation between chondrites and sulfates, and increased capability to detect and classify organic material will be enabled for all JIM. High spatial resolution further enhances the sensitivity of these spectral observations; many of the non-ice materials on Europa are thought to be concentrated near the lineaments and chaos/mottled terrain. High ($<1\text{m}$) spatial resolution IR spectra of small scale dark regions seen in Galileo SSI data will help isolate these sources from the ubiquitous water-ice features found throughout much of the icy moon surfaces. Equally important in these investigations will be adequate spectral characterization of candidate surface materials in the laboratory, under the environmental conditions expected on JIM. Acting as a Fourier-transform imaging spectrometer, MIDAS has the capability to fulfill all of these science objectives in both flight and the laboratory.

Future Missions The capabilities of the MIDAS instrument concept facilitate many of the science objectives for future missions to Jupiter's moons and

objectives further out in the Solar System. For JIMO (launch in ~2011), in addition to the investigations outlined above, global imaging of Io will be possible at 50m/pixel from the orbit of Europa (~250,000 km), enabling long duration monitoring of volcanic and surface processes. From 650,000 km MIDAS can image Jupiter at ~130m scales to study the atmosphere and details of ring structure. Additional studies of topography and surface dynamics will be possible using MIDAS in an active mode (i.e., as part of a laser altimeter). During the cruise stage, observations of other bodies such as Titan and Kuiper Belt Objects as well as extrasolar targets can be accomplished with resolution comparable to the Hubble Space Telescope.

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