A Search for Ongoing Geologic Activity on Jupiter's Satellites.

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Introduction: The timing of the Galileo mission to Jupiter and the New Horizons flyby of Jupiter allowed for an excellent opportunity to examine the surfaces of Jupiter's Galilean satellites for changes. Changes to the surface would indicate ongoing geologic activity. This activity would be possible due to the tidal heating supplied by the resonance of the satellites' orbits.

The Galileo spacecraft arrived at Jupiter on December 7, 1995 and orbited the planet 35 times over the course of the following eight years. Onboard were several instruments, including the Solid State Imager (SSI) camera. New Horizons is a New Frontiers class mission on its way to Pluto, expected to make its flyby of the Pluto-Charon system in 2015. During a flyby of Jupiter in 2007, New Horizons observed the Galilean satellites (Io, Europa, Ganymede and Callisto). Two of the instruments used were the Linear Etalon Imaging Spectral Array (LEISA), an infrared spectrometer, and the Long-Range Reconnaissance Imager (LORRI), a visible-wavelength CCD camera [1]. The LORRI images were much lower resolution than the SSI images, but we were still able to identify individual surface features.

The overarching goal of this project was to compare images of Jupiter's satellites from these two missions to look for changes of surface features to indicate ongoing geologic activity. To do this, the project was split into two tasks. The first was to use Galileo basemaps of Europa, Ganymede and Callisto to make simulated views of the surfaces that match up with the views seen by New Horizons. The second task was to compare New Horizon's LORRI images with similar views of Io taken by the Galileo spacecraft. Io is already known to be currently active, so we couldn't use the basemap for a comparison because it is already outdated.

Methods: To accomplish the first task, we used the planetary image processing software ISIS ([2]; Integrated Software for Imagers and Spectrometers). This U.S. Geological Survey (USGS) software can be used to make mosaics and map projections. We found the sub-spacecraft latitude and longitude of each New Horizons image and reprojected the Galileo basemap to be centered on that coordinate. We translated the basemap, a sinusoidal map projection (used to preserve area and minimize distortion) made from a mosaic of dozens of images, to an orthographic map projection, which simulates a view from overhead. To aid in surface feature recognition, the new orthographic maps were also trimmed at the terminator (day/night boundary) in the same location as the New Horizons image's terminator. We also added grids with a spacing of 30° in latitude and longitude to the reprojections.

To accomplish the second task of looking for changes on Io, the Io basemap was not used. Rather, we compared the New Horizon's LORRI images directly with Galileo images that had similar sub-spacecraft latitudes and longitudes. There are two types of major changes on Io's surface that we looked for: new dark lava flows and new bright plume deposits.

Results: No surface changes were seen on Europa, Ganymede or Callisto. This was not surprising, as Callisto's orbit is not in the resonance with the others so it does not get any energy from tidal heating. Europa and Ganymede are further out than Io, the most geologically active, so the gravitational forces are not as strong. However, Europa likely has a liquid ocean under its icy surface so changes are possible and worth looking for.

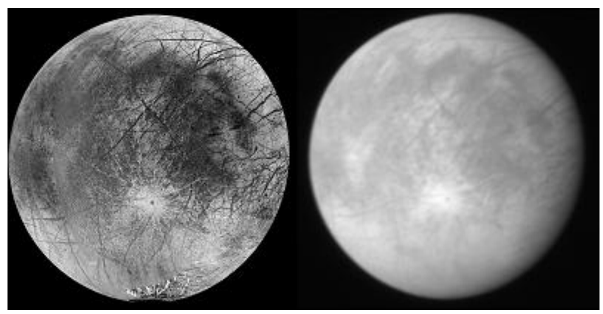

Fig. 1. Galileo reprojection (left) of Europa made to match the New Horizons LORRI image (right). No changes to the surface were identified.

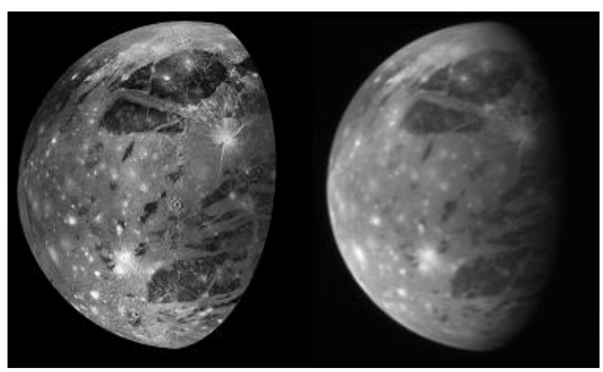

Fig 2. Galileo reprojection (left) of Ganymede made to match the New Horizons LORRI image (right). The reprojection was trimmed so that the image matched the terminator on the LORRI image. No changes to the surface were identified.

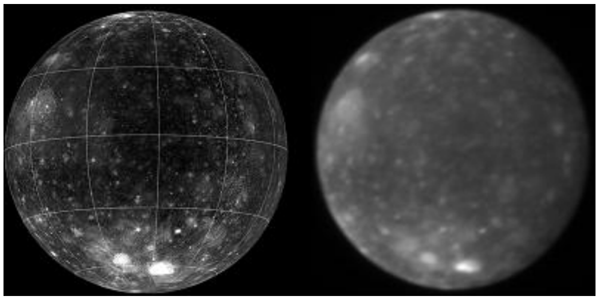

Fig. 3. Galileo reprojection (left) of Callisto made to match the New Horizons LORRI image (right). The reprojection has had a grid added to it to aid in feature identification. No changes to the surface were identified.

Changes to the surface of Io during the lifetime of the Galileo mission have already been documented [3], [4]. We found multiple surface changes when comparing the Galileo SSI images and the New Horizons LORRI images, some of which were not previously documented. We found both categories of major changes (dark lava flows and bright plume deposits).

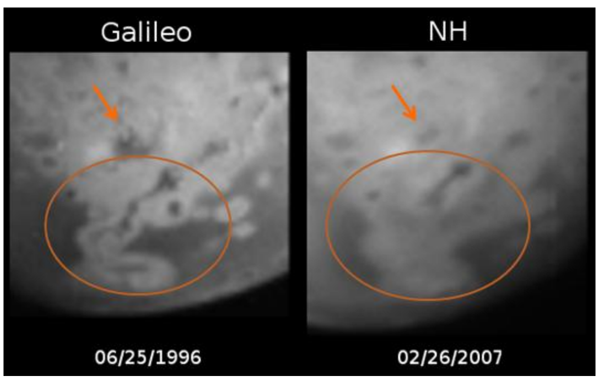

Fig. 4. New bright plume deposits, covering old lava flows, found in Tarsus Regio on Io

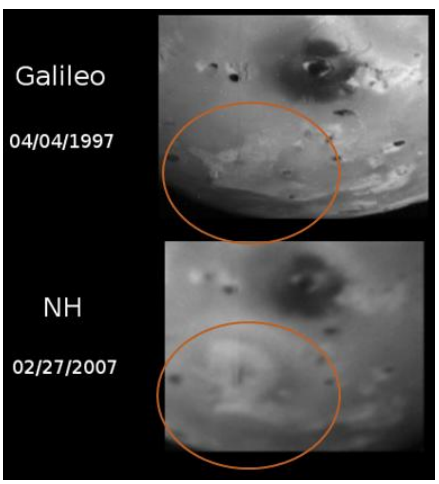

Fig. 5. New dark lava flow surrounded by a bright plume in Lerna Regio on Io

Feature Location	*Lat*	*Long*	*Galileo Image ID*	*NH Image #*
Sengen Patera	-30	299	G8ISMARDUK01	lor_0034889879
Inti Patera	-70	351	15ISKANEHI01	lor_0034889879
Donar Fluctus	20	186	C9ISSRFMON02	lor_0034821014
Surya Patera	22	150	C9ISSRFMON02	lor_0034821014
Tarsus Regio	-58	67	G1ISGLOMON01	lor_0034785119
Shango Patera	30	99	C9ISSRFMON01	lor_0034785119
Lei-zi Fluctus	10	44	C9ISSRFMON01	lor_0034785119
Altjirra Patera	-34	110	10ISIOGLOC01	lor_0034966577
S. of Itamna Patera & N. of Arusha Patera	-25	103	10ISIOGLOC01	lor_0034966577
Between Arusha & Catha Pateras	-46	103	10ISIOGLOC01	lor_0034966577

Table 1. Table of Io locations with new changes.

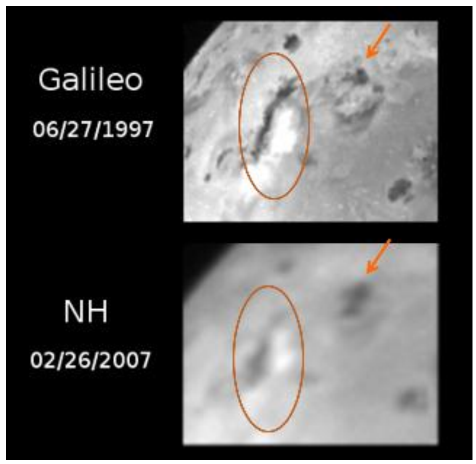

Fig. 6. New dark lava flows near Amirani and Shango Patera on Io

Future Work: The Galileo views of Europa, Ganymede and Callisto will be used by researchers for comparison with the New Horizons' LEISA spectral images to determine composition of the surface. The higher resolution maps will help researchers determine which spectral units (composition) correspond to which geological units (surface features). We are in the process of measuring the areal coverage of new dark lava flows and bright plume deposits on Io to help constrain resurfacing rates.

Because New Horizons is a new camera, we couldn't work with the images directly in ISIS. The USGS is now working on camera models for New Horizons so that quantitative ratios can be taken in the future to determine resurfacing rates due to volcanic activity in the locations where changes were found.

References: [1] Cheng A.F. et al (2008) *Space Sci Rev*, 140, 189-215. [2] Gaddis, L. et al. (1997) LPSC, 28, #387; [3] Geissler P. et al (2004) *Icarus, 169,* 29–64. [4] Spencer, J.R. et al (2007) *Science*, 318, 240-243.