ERUPTION EVOLUTION OF MAJOR VOLCANOES ON IO: GALILEO TAKES A CLOSE LOOK.

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Introduction: Throughout the Galileo prime and Europa missions, instruments on Galileo, notably the Solid State Imaging experiment (SSI) and Near Infrared Mapping Spectrometer (NIMS), have monitored volcanic activity on Io. This has allowed the thermal history of a number of individual eruptions to be charted. The close fly-bys of Io during I24 and I25 in late 1999 yielded the highest spatial resolution data yet obtained of the surface of Io [1, 2] and have led to further insight into the previously collected, lower resolution data. More high resolution data will hopefully be forthcoming from the I27 Io encounter in February 2000.

Loki: Of all of the many hot spots on Io, Loki has been the most energetic over the last 20 years. It has been observed by NIMS on a number of orbits, with observations including Loki in darkness being collected during orbits G7, C9, E16 and C22. Other observations of Loki obtained in sunlight are being processed to separate the sunlight and thermal components. Changes at Loki have been tracked using two-temperature fits to the NIMS data. Temperatures are ± 25 K and areas are ± 10%. NIMS observed Loki in darkness during orbit G7 on 4 and 5 April 1997, at ranges of about 1.4 million km and 500,000 km. Some of the middle-range detectors were saturated, but there remains sufficient usable data either side of the saturated detectors to achieve temperature fits. As with all of the analyses, intensities from adjacent pixels were added to account for the instrument point spread function. The full spectrum was divided up into individual grating position spectra, each of which was fitted in turn. At the time of these observations, Loki was at the peak of a major brightening that had begun soon after the E6 encounter, and was observed by ground-based observers on March 12th 1997 from the IRTF. A two-temperature fit to the G7INVOLCAN05 Loki data produced temperatures and areas of approximately 990 K, with an area of approximately 3 km^2, and 460 K covering an area of approximately 2320 km^2. Areas have been corrected for emergence angle. Fits to the G7INTHRMAL06 data produced similar figures. Loki was observed again in orbit C9, the observation also containing Pele and Pillan Patera. By orbit C9, in June 1997, the Loki eruption had died down considerably. At NIMS wavelengths Loki was less energetic, with temperatures of 962 K, covering 5 km^2, and 373 K covering 11,700 km^2. The G7-C9 trend might be indicative of a spreading, cooling flow. The C9INCHEMIS06 observation is of particular value as SSI has dual-filter coverage of Loki which will be used to constrain temperature fits. The C9 NIMS and SSI observation of the hemisphere of Io containing Loki, Pele and Pillan Patera proved to be of great value in determining eruption temperatures at Pele and Pillan [3]. That SSI did *not* see emission at Loki provides an important temperature/area constraint: the same analysis techniques applied to the Pele and Pillan Patera joint NIMS-SSI data are being applied to the C9 Loki data. Loki brightened again in May 1998, and was observed by NIMS in June during the E16 encounter. Temperatures were similar to those obtained during C9, at 345 K (3830 km^2) and 612 K (27.4 km^2), although the area of the cooler component was very much reduced. The low-temperature component may have been stronger during orbit C9 than E16 in part because the 1997 eruption had been under way for four months by C9, whereas the 1998 eruption had been active for two months by E16. Material from the earlier eruption may have been covered by newer material, or may have cooled below NIMS detection limits. During the C22 encounter on 12 August 1999 Loki was observed at a range of 787,000 km. A two-temperature fit to the C22 Loki spectrum as a whole produced temperatures and areas of 576 K, covering 21 km^2, and 339 K covering 2420 km^2, indicating that Loki was at a low point in the eruption cycle. Another way of charting the cycle of eruptions at Loki is by following the evolution of the 3.5 micron brightness. The calculated NIMS 3.5 micron brightnesses are 80 GW/:m/str during G7, 60 GW/:m/str during C9 (both consistant with ground-based observations [4]), 13 GW/:m/str during E16, and 7 GW/:m/str during C22. This last figure is somewhat less than expected when compared with ground-based observations [4]. Possibly this is due to the high incidence angle (64 degrees) of the NIMS observation, which might have the effect of obscuring some hot component, or alternatively there was a dip in activity at Loki on a time scale of about a day. During orbit I24, NIMS observed the Loki "island" and part of the caldera floor at spatial resolutions from 1.3 to 2.1 km/pixel (see Figure 1). The likely source of the major brightening in 1999 was in the southwest corner of the caldera, and was not seen by NIMS. Detailed thermal mapping of the NIMS Loki observation [5] reveals that the dark caldera floor is mostly at a temperature of approximately 300 K, considerably above the maximum Io ambient temperature of approximately 130 K. Given that Loki is the most active volcano on Io, it is most likely that the floor of the caldera is covered with lava flows, or that the floor itself is the crust on a lava lake. The time taken for basalt flows or the crust on a lava lake on Io to cool to this temperature (assuming thermal buffering by the release of latent heat from a still-molten interior) is more than a year [6]. This allows a re-evaluation of fits to the thermal signatures of Loki from previous orbits, with the caldera floor temperature providing an additional constraint.

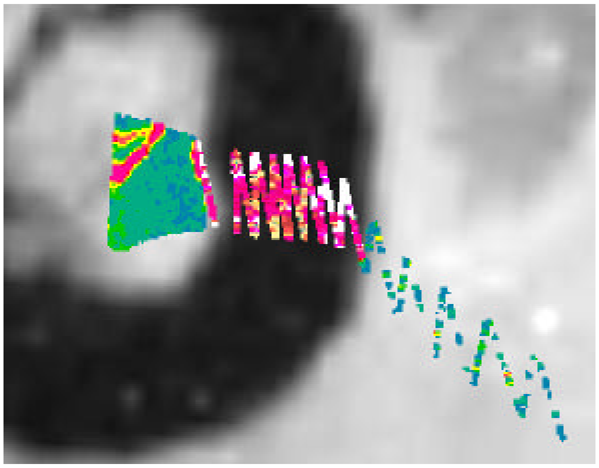

Figure 1. NIMS observes Loki at 4.5 microns, tracking across the ‘island’ and caldera floor before slewing across towards Pele to the SE.

Pele: (24INHSPELE01) From analysis of a number of NIMS observations Pele has been shown to have a remarkably constant thermal output as a function of wavelength. This, and the fact that there is a considerable amount of emission at short wavelengths, indicates that Pele's main thermal source is a lava lake [3]. The lava lake model for Pele is strengthened by a SSI I24 image of what appears to be the active margin of a lava lake in the Pele caldera [2]. During the I24 close fly-by (11 October 1999) NIMS observed a 15 km by 1.3 km strip of Pele at a spatial resolution of about 1 km/pixel. An intense hot spot was observed at Pele, leading to saturation at a number of wavelengths. Although the most active area of Pele was not seen, initial single temperature fits yielded temperature of 700 to 900 K.

Pillan Patera: (24INPILLAN01) NIMS and SSI observed Pillan in full eruption during orbit C9, and NIMS charted the subsequent waning of the eruption over the next year (see Figure 2). The thermal evolution of this eruption is very much in keeping with the emplacement of spreading, cooling lavas [3]. NIMS observed Pillan during I24 at a resolution of about 0.5 km/pixel, although at a phase angle of about 80 degrees. These data are being analysed to determine the temperature and area constraints for this part of the Pillan volcanics.

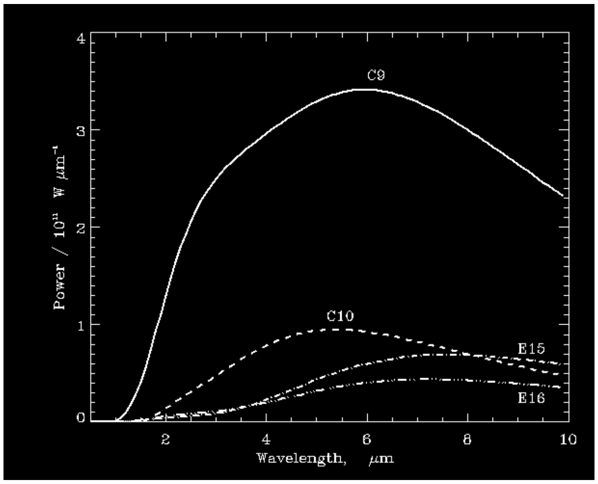

Figure 2. Evolution of thermal signature from Pillan

Tvashtar: (25INGIANTS01) One of the great discoveries of the Io close fly-bys was the imaging of active fire-fountains at Tvashtar during the I25 Io fly-by on 26 November 1999 [2]. Fire fountain activity had been postulated on Io to explain some thermal datasets (e.g., at Loki [6]). The maximum single temperature fit to the NIMS data (which just cover the edge of the fire fountain/flow activity is approximately 1250 K. This is consistent with the expected thermal signature of fire-fountain activity. Measurements of thermal emission from active lava flow "hot cracks" in Hawaii [7] produced a similar single high-temperatures fit.

References: [1] Lopes-Gautier R. *et al.* (2000) this volume. [2] McEwen A. S. *et al.* (2000) this volume. [3] Davies A. G. *et al.* (1999) LPSC XXX. [4] Howell R. *et al.* (1999) *BAAS* **31**, 1164. [5] Smythe W. D. *et al.* (2000) this volume. [6] Keszthelyi L. P. *et al.* (1999) LPSC XXX. [7] Davies A.G. (1996) *Icarus* **124**, 45-61.