MYRIADS OF SMALL, HOT ERUPTIONS ON IO.

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Introduction: Data collected from the close encounters of the Galileo spacecraft with Io in November and December 1999 show spectacular examples of silicate volcanism including the fire fountains (Tvashar) (McEwen et al., 2000). Tvashar was not know to be active previously. The limited spatial coverage of these high resolution Io observations require that additional context be provided to answer the question: Did Galileo get lucky or is Io's volcanism so widespread that it could be expected that this type of phenomena would be observed?

Background: High temperature eruptions, observable from earth, occur roughly 6% of the time (Blaney et al. 1995), based on data from 1984-1994. In addition the long wavelength thermal emission data imply that high temperature volcanism must be occurring on smaller spatial scales significantly more frequently (Blaney et al. 1995). This view is being confirmed by numerous Galileo observations, but does not address the spatial scale that these observations can be expected to be observed at.

Infrared radiometry from spacecraft and groundbased observations has identified significant thermal emission from many major volcanic centers on Io (e.g. McEwen et al. 1998, Lopes-Gautier et al. 1999, Spencer et al. 1997, Goguen et al. 1999). However, these provide only part of the observed infrared emission (e.g. Smythe et al. 1999, Blaney et al. 1999). Thus we need to develop a method that will allow us to characterize the thermal emission on a global basis.

In the 3-5µm wavelength region, Io's volcanos have substantial thermal emission. In daytime spectra of Io, this region is a complex mixture of thermal emission and reflected sunlight. In the Galileo NIMS observations, the data also frequently has artifacts such as "patterning" and "jitter" that complicate the interpretation of the data. Our goal is to look at the distribution of thermal emission and for correlation between spectral properties or geologic environment and thermal emission.

To determine the rate of high temperature eruptions at smaller volcanic centers we searched for previously unrecognized sources in the NIMS C3 High Resolution data. The C3INHRSPEC01 observation was the highest resolution observation of Io obtained by NIMS during the Galileo Prime Mission. The observation was made on November 6th 1996, at a range of 244,000 km. This yielded a maximum resolution of approximately 135 km per NIMS pixel. The observation was made in NIMS Long Map mode, at 408 wavelengths from 0.7 to 5.2 microns. The observation was of the anti-jovian hemisphere of Io, in this case covering longitudes from 120 W to 270 W.

Approach: We used an approach that will identify and classify Io's thermal emission using a relative spectral excess method. This method relies on Io's global average properties to set a slope threshold that identifies regions of thermal emission and that spectral shape of thermal emission is a smoothly varying function. We started with an "average Io" spectrum based on 809 individual spectra. Each spectrum corresponds to a specific location on Io's surface.

Results: About 30% of the spectra had a 5 µm to 3 µm ratio greater than "average Io" and thus are volcanically active. We found no correlation between latitude or longitude and the 5 µm to 3 µm ratio. Regions with a 5 µm to 3 µm > 1.4 seem to be well correlated with previously identified emission sources. Locations with 5 µm to 3 um ratio between 1.1 and 1.4 tend to correlate with small dark volcanic calderas. The other regions with 5 um to 3 um ratio > 1 seem to be associated with darkish plains units, which contain what appears to be flow units. The white sulfur dioxide frost units tend to have 5 m to 3 m ratio < 1.0 while the smallest 5 µm to 3 µm ratio (<0.9) seem to be related to reddish visible units. These patterns have also been observed in the NIMS G2 data set. Our analysis reveals an abundance of previously unrecognized hot, active, volcanic sources and that those small-spatial-scale sources are present over much of Io.

We conclude that although Galileo was particularly fortunate to see one of the larger scale eruptions in progress, the chances of observing some level of active volcanism in any given area covering at least 135 km^2 is quite reasonable and the I27 encounter in late February 2000 may well provide us with more high resolution samples of such phenomena.

Refs: Blaney et al. 30th LPSC 1999;Goguen et al., 30th LPSC,1999; Lopes-Gautier et al. Icarus, in press,1999,McEwen et al. Icarus, 135, 181-219,1998; Spencer et al. GRL, 4,2451-2454 1997; Smythe et al.

30th LPSC,1999.McEwen et al., LPSC 2000 this volume.

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Figure 1. The presence of small scale (NIMS sub-pixel) volcanic emission is shown in this map of Io. "Hot" pixels based on the value of 5/3µm ratio > 1.0 are show as solid circles. Pixels which may contain thermal emission with values between 5/3 µm ratios between 0.9 and 1.0 are shown with open squares. Cold pixels, 5/3 µm < 0.9 are show as +'s.