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Determining Io Lava Eruption Temperature: Strategies for a New Mission to the Solar System's Most Dynamic Satellite

A. G. Davies (1), L. P. Keszthelyi (2) and **A. S. McEwen** (3)

(1) Jet Propulsion Laboratory-California Institute of Technology, Pasadena, CA 91109, USA (Ashley.Davies@jpl.nasa.gov / Tel: 818-393-1775); (2) USGS Astrogeology Team, USGS, Flagstaff, AZ 86001, USA (laz@usgs.gov) (3) Lunar and Planetary Laboratory, University of Arizona, Tucson, AZ 85721, USA (mcewen@pirlmail.lpl.arizona.edu)

Abstract

In the wake of the NASA *Galileo* mission to Jupiter and to Io, the volcanically-active moon, a major unanswered question concerns Io's lava eruption temperature. We propose that spacecraft observations of lava fountains [1, 2] and skylights (holes in the roof of a lava tube) [2, 3] offer the best opportunities for determining the eruption temperature of Io's dominant lavas. Determining if these lavas are mafic (<1550 K) or ultramafic (>1850 K) immediately applies strong constraints to lava composition and the state of Io's mantle [1]. We have evaluated the best observations to be made, from an Io-dedicated mission such as the proposed Discovery-class *Io Volcano Observer* (*IVO*) [4], or another mission that includes a close Io flyby, to answer this question. We also examine what is required to determine eruption mode using the most efficient selection of imager wavelengths [2].

Lava fountains and skylights

Episodes of lava fountaining during fissure eruptions are the cause of large thermal outbursts from Io. The magnitude of the thermal emission means that this mode of eruption has the advantage of being easily detectable from great distances, allowing identification during Io monitoring phases of spacecraft missions. Variability in fountain activity and the need to isolate fountain thermal emission from that of associated lava flows requires detailed modelling of clast cooling and the integrated fountain and flow thermal emission. Also required is the almost contemporaneous (<0.1 seconds) acquisition of unsaturated multi-spectral data [2].

Lava fountains are a relatively rare phenomenon. Skylights provide another opportunity to constrain eruption temperature. Models of skylight thermal emission reveal that a narrow range of high temperatures are exposed. The resulting thermal emission spectrum should be diagnostic of lava eruption temperature [3]. *Galileo* observations support the presence of lava tubes (e.g., at Prometheus, Amirani and Culann), so it is natural to expect skylights. Skylights are very small and so will have to be searched for in data acquired during Io flybys. An advantage is that they do not have to be resolved in imaging data, especially if the surrounding area is relatively cool (and therefore contributing little thermal emission at short wavelengths). Regardless of eruption style, the most valuable data would be obtained at night or with Io in eclipse, to avoid complications created by the need to remove sunlight.

The requirements to make these observations are being used in designing instruments for *IVO* [4].

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