Lava lake volcanism on Io: Insights from Erta Ale observations

Jani Radebaugh[1], Rosaly M. C. Lopes[2], Ralph D. Lorenz[3]

[1]Department of Geological Sciences, Brigham Young University, Provo, UT, USA, [2]Jet Propulsion Laboratory, Pasadena, CA, USA, [3]Johns Hopkins Applied Physics Laboratory, Laurel, MD, USA

E-mail: janirad@byu.edu

Jupiter's moon Io hosts dozens of erupting volcanoes, many of them lava lakes. Lava lake volcanism is an important mode of heat release for Io's interior, though the dynamics of heat transfer through lava lake systems are not fully characterized. Remote observations of the Erta Ale lava lake system inform our studies of Io's Pele volcano.

The Pele volcano is the source of a large plume of sulfur and mafic pyroclastics and has been observed to be active nearly continuously from 1979 (for the Voyager flyby) through the present (via ground-based observations). Night side observations of Pele by the Galileo spacecraft in 2001 indicate much of the 30 km diameter volcano-tectonic depression, and perhaps to an outer 60 km depression, is a lava lake. Hotspots had brightness temperatures on average 1100-1200 C, similar to hawaiian basalts. The hotspots are distributed such that a central, bright region 10 km across is surrounded by an arcuate distribution of smaller, isolated hotspots, all separated by cool material.

The Erta Ale lava lake has been observed by many groups to be active at least intermittently since the early 1900s. We observed the lake in early 2010 to be 10 m below the rim of a 45 m pit crater and in a particularly actively fountaining phase. Despite the appearance of fountains of varying size, one every 1-2 minutes over about 90 minutes, the lake was dominated by a cool (though rolling) crust that formed rapidly over newly exposed material. Most fountains were found near the lake margin, where the crust interacted with the crater walls. Thermal images obtained near 1 micron using a handheld camcorder reveal brightness temperatures of 1150 C at the center of the fountains, which are likely eruption temperatures, since they reflect temperatures from collected samples and because many pixels were filled by exposed lava. Slightly lower temperatures were found at cracks in the lake surface and cool temperatures were observed in the insulating lava lake crust. Some experiments with an inexpensive three-channel radiometer are also described, analogous to many spacecraft observations where hot lava only fills a small fraction of the beam footprint.

The hotspot distribution at Erta Ale lava lake, with a large, actively fountaining region surrounded by cool crust and an arcuate distribution of smaller hotspots at the crater margins, is similar to that observed at Pele. The dimensions of Pele, however, are almost two orders of magnitude larger than those of Erta Ale, and reflect a much greater heat flow through the lake system. Temperatures obtained by the handheld camcorder reveal it is possible to obtain eruption temperatures of lavas if there is enough exposed material to completely fill pixels. That similar temperatures were obtained for Pele indicates similar compositions for the volcanoes and that lava was exposed in great volumes by large-scale fountaining, observed by the more distant and lower-resolution Galileo observations.