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Terrestrial Lava Lake Physical Parameter Estimation Using a Silicate Cooling Model – Implications for a Return to the Volcanic Moon, Io

Ashley Davies

Jet Propulsion Laboratory-California Institute of Technology, Pasadena, CA, United States (ashley.davies@jpl.nasa.gov)

Active lava lakes are open volcanic systems, where lava circulates between a magma chamber and the surface. Rare on Earth, lava lakes may be common on Io, the highly volcanic moon of Jupiter (see [1]). Lava lakes are important targets for future missions to Io [2, 3] as they provide excellent targets at which to measure lava eruption temperature (see [2] for other targets). With this in mind, hand-held infrared imagers were used to collect *in-situ* thermal emission data from the anorthoclase phonolite lava lake at Erebus volcano (Antarctica) in December 2005 [1, 3] and the basalt lava lake at Erta'Ale volcano (Ethiopia) in September 2009. These data have been analysed to establish surface temperature and area distributions and the integrated thermal emission spectra for each lava lake. These spectra have been used to test models developed for analysis of remote sensing data of lava lakes and lava flows on both Earth and Io, where no ground-truth exists. The silicate cooling model [4] assumes, for the lava lake model variant, that the existing surface crust has been created at a fixed rate. Model output consists of a synthesized thermal emission spectrum, estimate of surface age range, and a rate of surface crust area formation. The cooling model provides accurate reproductions of actual thermal spectra and the total emitting area to within a few percent of actual emitting area. Despite different composition lavas, the integrated thermal emission spectra from the two terrestrial lava lakes studied are very similar in shape, and, importantly, bear a striking similarity to spectra of Pele, a feature on Io that has been proposed to be a persistent, active lava lake [1]. The 2005 Erebus lava lake had an area of $\sim$820 m^2 and a measured surface temperature distribution of 1090 K to 575 K with a broad peak from 730 K to 850 K [5]. Total heat loss was estimated to be 23.5 MW [5]. The model fit yielded an area of $\sim$820 m^2, temperatures from 1475 K to 699 K, and an average coverage rate of 0.4 m^2/s [6]. The oldest surface age was $\sim$40 mins. The 2009 Erta'Ale lava lake had an area of $\sim$2130 m^2, surface temperatures from $>$1350 K to $\sim$550 K, and a total heat loss of $\sim$42 MW. The model yielded an area of $\sim$1970 m^2, a temperature range from 1475 K to 657 K, a maximum surface age of $\sim$1 hour, and an areal coverage rate of $\sim$0.58 m^2/s. Model resurfacing rates broadly agree with observed behaviour at both lakes. This work was conducted at the Jet Propulsion Laboratory, California Institute of Technology, under contract with NASA, and is supported by the NASA PG&G Program. AGD thanks the BBC for transport to the Erta'Ale lava lake. Copyright 2010 California Institute of Technology. References: [1] Davies, (2007) Volcanism on Io, Cambridge. [2] Keszthelyi et al. (2009) LPSC abstract 1943. [3] McEwen et al. (2009) LPSC abstract 1876. [4] Davies (1996) Icarus, 124, 45-61. [5] Davies et al., (2008) JVGR, 177, 705-724. [6] Davies et al. (2008) LPSC abstract 1896.