Lava Lakes in the Solar System

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Lava lakes are rare on Earth but common on Jupiter's moon Io and likely occurred on other bodies such as Venus and Mars. Data from the Galileo spacecraft revealed that many Ionian paterae (calderas) are active, and several showed greater thermal emission around their edges (Lopes et al., 2004), which can be explained by the crust of a lava lake breaking up against the patera walls. Observations from both Galileo and ground-based telescopes reveal that several paterae, including Pele and Janus, have persistently high thermal output with regions of exposed, high-temperature lavas, indicative of large, vigorously active lava lakes similar to the Marum/Mbwelesu lava lake on Ambrym, Vanuatu. The volcano on Io that is the largest and has the greatest thermal output, Loki, has semi-periodic cycles of intense activity, interpreted as the foundering crust of a lava lake (Rathbun et al., Geophys. Res. Lett. 29; de Kleer et al., DPS, 2016), similar to the crusted, active lava lakes in Erta Ale, Ethiopia and Halemaumau, Hawaii. Alternatively, Loki Patera could be underlain by a thin, persistent magma "lens" that feeds thin, temporary lava lakes within the patera (Gregg and Lopes, 2008, Icarus 194). One significant and yet unexplained difference between Ionian and terrestrial paterae is the existence of cold "islands" in Ionian paterae that persist for decades (e.g., observed by both Voyagerand Galileo) despite intense and likely continuous activity.

Field studies on Earth can help investigations into the nature and dynamics of Io's lava lakes. Remote, handheld observations of the Marum/Mbwelesu lava lake in May 2012 (Radebaugh et al., 2016) and Erta Ale in 2011 (Carling et al., 2015, GeoResJ 5) revealed exposed, high-temperature lavas at cracks and fountains. These observations help us identify similarities (or differences) between the morphology, temperatures, and eruptive behavior of lava lakes on Earth and those on Io.