LOKI PATERA: A MAGMA SEA STORY. G. J. Veeder[1], D. L. Matson[1], J. A. Rathbun[2], A. G. Davies[1], and T. V. Johnson[1], [1]Jet Propulsion Laboratory, California Institute of Technology, ms 183-501, 4800 Oak Grove Drive, Pasadena, CA 91109-8099 (Glenn.Veeder@jpl.nasa.gov), [2]University of Redlands, 1200 East Colton Avenue, Redlands, CA 92373.

Introduction: We consider Loki Patera on Io as the surface expression of a large uniform body of magma. Our model of the Loki magma 'sea' is some 200 km across; larger than a 'lake' but smaller than an 'ocean' [1]. The depth of the magma sea is unknown, but assumed to be deep enough that bottom effects can be ignored. Edge effects at the shore line can be ignored to first order for most of the interior area. In particular, we take the dark material within Loki Patera as a thin solidified lava crust whose hydrostatic shape follows Io's isostatic surface (~1815 km radius of curvature) [2]. The dark surface of Loki appears to be very smooth on both regional and local (sub-resolution) scales [3]. The thermal contrast between the low and high albedo areas within Loki is consistent with the observed global correlation [4]. The composition of the model magma sea is basaltic and saturated with dissolved SO_2 at depth. Its average, almost isothermal, temperature is at the liquidus for basalt.

Sea State: At "sea" the state of the dark region within Loki is controlled by relatively local processes. Our model includes (1) the exposure and cooling of fresh molten lava on the surface, (2) the formation of a lava crust on the surface of the sea, (3) the quasi-periodic breakup and foundering of the 'sea crust', and (4) the replacement of the lost surface material.

Sea Chantey: After fresh magma appears on the surface, it cools very rapidly. With time the rate of cooling slows greatly, but it never stops entirely [5, 6]. This new surface material quickly forms a crust as it solidifies. The crust thickens as magmatic material attaches to its bottom. The crust also develops a porosity gradient due to trapped bubbles of exolved SO_2. Initially the sea crust floats, but its buoyancy decreases as it thickens. Eventually, it becomes negatively buoyant. Then the sea crust founders, plates sink and are replaced by fresh, liquid lava [7].

Sea Crust. An important theme under development for our magma sea story about Loki Patera is the evolution of the crustal interface with the subsurface material [1]. Latent heat from magma solidifying on the underside of the sea crust is continually transferred through the crust and radiated into space. When liquid magma is initially exposed, its surface is "flash-frozen" by radiation and a thin glassy film is formed. As additional material solidifies on the underside of the film, it tends to exclude dissolved gas molecules. For the most part, this gas remains trapped in the solidified lava. As the new sea crust grows in thickness, the lithostatic pressure becomes greater, the bubbles smaller, and the porosity less. A depth is reached where the solidifying rock has the same density as that of the liquid basaltic magma. Until this time, the solidifying rock is intrinsically buoyant with respect to the magma sea. Afterwards, the continued accretion on the bottom of the sea crust serves to reduce buoyancy. This trend continues for the remainder of the life of each plate until it becomes negatively buoyant and finally sinks. Sinking plates are then replaced by fresh rising magma [7].

Sea Chest. Another part of our magma sea story, introduced here, follows the sinking plates or blocks. While at the surface, the plates have cooled significantly due to radiation. A large thermal gradient exists across their thickness. That is, their upper surfaces have cooled to a few hundred degrees K, while their bottoms are at the basalt liquidus temperature. As soon as they have sunk, the blocks are surrounded by magma. At this time, they can be thought of as having a heat deficit equal to the total amount of energy that they previously radiated at the surface. As they equilibrate (*i.e.*, become isothermal), the blocks use latent heat and solidify new material about themselves. In this way, they 'bulk-up' and carry additional material to the depths of the sea. Conservation of mass insures that an equal amount of liquid magma must move upward.

Victory at Sea: This magma sea story is consistent with the observed high heat flow at Loki Patera. In fact, Loki is the most powerful persistent volcanic feature on Io. By itself it accounts for a significant portion of Io's total global heat flow [6, 8-16]. The elevated surface temperatures at Loki are supported by this heat flow which is also the governing parameter of Loki's thermal engine.

Acknowledgements: This work was carried out at the Jet Propulsion Laboratory, California Institute of Technology, under contract to NASA. AGD, DLM and GJV are supported by grants from the PG&G program.

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