AN ASSESSMENT OF NEAR-SURFACE CONDITIONS CONDUCIVE TO IONIAN SULFUR FLOWS.
R.M. Ramirez, D.A. Williams, and R. Greeley, School of Earth and Space Exploration, Arizona State University, Tempe, Arizona 85287-1404 ramses.ramirez@asu.edu,

Introduction: Primary sulfur volcanism is caused by chambers of molten sulfur magma within the crust that erupt lavas onto the surface. In contrast, secondary sulfur volcanism results from heat conducted from a silicate magma body that melts surrounding sulfur-rich country rock, which then erupts as surface sulfur flows [1]. The purpose of this work is to assess the potential for secondary sulfur volcanism to have produced the sulfur flows at Sobo Fluctus, a ~15,000 km^2 region of dark and bright lava flows in the Chaac-Camaxtli region of Jupiter's volcanic moon, Io. We used *Galileo* image data to estimate the volumes of inferred sulfur flows, which are compared with the calculated volumes of melted crustal sulfur from a mathematical model of heat conduction in the crust.

Methodology: We measured the areas of three inferred sulfur flows in Sobo Fluctus from the *Galileo* Solid-State Imager (SSI) mosaic of the Chaac-Camixtli region [2] (Figure 1). Because lava flow thickness data for Io are limited, we assumed a 10 m thickness for the Sobo Fluctus flows as a lower limit [2]. This yields an estimated volume of approximately 10^{10}-10^{11} m^3 for these sulfur flows.

We then adapted a near-surface heat conduction model [3] to analyze the thermal effects between a rising hot silicate magma body and a solid sulfur-enriched crust. The silicate magma is assumed to be basaltic in composition, although model runs using an ultramafic composition were also performed. Because Sobo Fluctus is situated in an areally-extensive topographic low between two scarps, we assumed the surface to be relatively flat. The volume of elemental sulfur within the crust of Io was taken to be 1% [4] as a lower limit; [5] suggested an upper limit of 20%. Because previous work has investigated homogeneous sulfur [i.e., 4], this analysis instead considers immiscibile elemental sulfur that is heterogeneously fixed within the pore spaces of a silicate crust (Figure 2).

In our model, a molten silicate diapir rises through a conduit and interacts with the S-enriched crust near the surface. A constant effusion rate induces steady state. Based on observations at the Prometheus volcano [6], we model a single geothermal event with a 6 month duration.

Heat is conducted to the surrounding S-enriched crust along the +x and –x directions (Figure 2) in accordance with the following 1-D, time dependent law:

$$\frac{\partial T}{\partial t} = \kappa \frac{\partial^2 T}{\partial x^2} \qquad (1)$$

in which κ is the thermal diffusivity (~10^{-7} $Wm^{-1}K^{-1}$ for basalt). Isotropic conduction is assumed. The variation in the z-direction is computed with the iothermal gradient:

$$T_i = 130K + 200(Kkm^{-1})z) \qquad (2)$$

in which z is a given depth (m) and T_1 is the temperature (K) at that depth. The chosen thermal gradient (200K/km) was thought to be a good estimate for hot spot regions [2,7]. The volume of sulfur melted is determined by multiplying the sulfur melt zone (x-z plane) by the third dimension (Figure 2). The third dimension is the flow width of the inferred sulfur body as measured from *Galileo* SSI images. The temperature as a function of distance (x) is computed with the semi-infinite half-space model solution [3] expressed as:

$$T(x) = (T_o - T_1) erfc \frac{x}{2\sqrt{\kappa t}} + T_1 \qquad (3)$$

in which T_o is the magma chamber temperature (K). Solving for "x" in Eqtn. 3 gives the furthest distance from the magma body that sulfur melts.

Results: Assuming 1% by volume S in the crust, our model calculates sulfur melt volumes ~10^4 - 10^5 m^3 and ~10^5 - 10^6 m^3 for the 10 and 100 m crustal thickness cases, respectively. However, from the image analysis we estimated that the volumes of the three flow units combined melted approximately 10^{10}-10^{11} m^3, or 3-4 orders of magnitude more sulfur than the model estimates.

These results suggest that a single geothermal episode lasting 6 months would not have been sufficient to produce extensive secondary flows of the sizes seen in Sobo Fluctus. Thus, we infer that primary sulfur volcanism is the most likely candidate to produce the inferred Sobo sulfur flows.

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References: [1] Greeley, R., et al. (1984), *Icarus, 60*, 189-199. [2] Williams, D. A. et al. (2002) *JGR, 107*, doi:10.1029/2001JE001821. [3] Turcotte, D.L. and Schubert, G. (2002) *Geodynamics*. p. 456. [4] Jaeger, W.L., and Davies, A.G. (2006) *LPS XXXVII*, Abstract #2274. [5] Carr, M.H. (1986) *JGR, 91*,3521-3532. [6] Davies, A.G. et al. (2006*) Icarus, 184*, 460-477. [7] Leone, G. and Wilson, L. (2001) *LPS XXXII, Abstract* #1358.

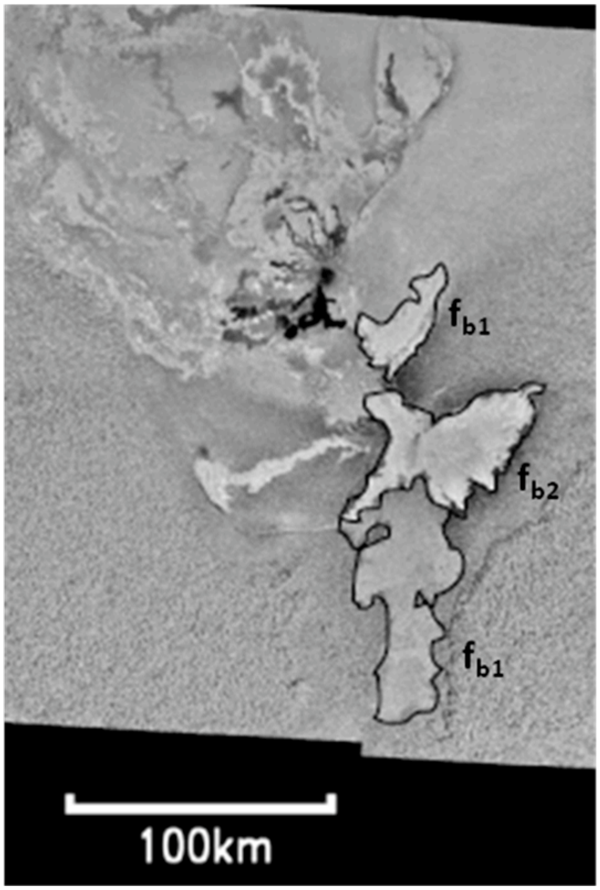

Figure 1. *Galileo* SSI mosaic of Sobo Fluctus (14N,150W). The "f_b" units refer to "bright flow deposits" and were interpreted as being secondary sulfur flows [1]. The small "f_{b1}" unit to the right of the black silicate flow has an area ~300km^2. The larger "f_{b2}" and "f_{b1}" units have areas of ~2700 and ~1600 km^2 respectively. Flow "f_{b2}" is lighter than "f_{b1}", and is inferred to be a comparatively younger sulfur flow. Sulfur flows generally darken as they age, whereas silicate flows brighten. Adapted from *Williams et al*. (2002).

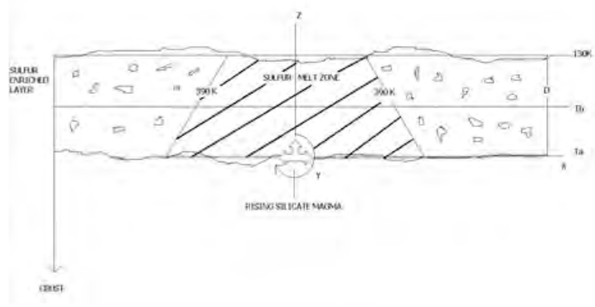

Figure 2. Schematic diagram of our heat conduction model for the secondary volcanism case. Rising silicate diapir interacts with a sulfur-enriched near-surface crust of thickness "D." The sulfur solidus temperature (390 K) marks the outer boundaries of the sulfur melt zone. T_a (132K for 10m flow thickness, 150K for 100m flow thickness) and T_b (131 for 10m flow thickness, 140 for 100 flow thickness) represent the thermal gradient temperatures at the base and halfway point of the sulfur-enriched crust, respectively.