SILICATE-SULPHUR INTERACTIONS ON IO - IMPLICATIONS FOR PELE TYPE PLUMES. Ashley G. Davies and Lionel Wilson. Institute of Environmental & Biological Sci., Univ. of Lancaster, Lancaster LA1 4YQ, U.K.

The volcanic plumes of Io are a visible manifestation of the high level of volcanic activity found there, the result of intensive tidal heating [1]. The ionian plumes can be divided into two classes [2], small SO_2 rich plumes with lifetimes of months to years and large sulphur-rich plumes with lifetimes of days to weeks. These plumes are thought to be driven by the thermal interaction between silicate intrusions and sulphur compounds which are easily mobilised. A model is proposed along these lines. A sill intruded at the base of, for example, a 1 km thick sulphur layer will lose heat by conduction to the underlying silicate crust, and will lose heat to the overlying sulphur, initially by conduction and then by convection in a liquid sulphur layer. If the silicate magma is at its melting temperature, the cooling of the sill surfaces and formation of solid crusts at the base and top of the sill can be modelled seperately for as long as part of the sill remains liquid, using models in [3,4]. The convecting sulphur layer forms very quickly, and the melting of the solid sulphur above is determined using a model of heat conduction in a melting solid [5].The rate of melting of sulphur depends on the amount of heat convected away from the sill, which in turn depends on the sill surface temperature, which falls as heat is removed and the solid crust thickens. The removal of heat from the top of the sill is balanced between the heat transfer efficiency of the liquid sulphur, which is strongly temperature dependent [6], and the rate at which heat is conducted through the solid crust. Melting of sulphur stops when the flux supplied to the solid/liquid sulphur interface has dropped sufficiently so that all the energy is removed by conduction into the solid sulphur. After the sill has completely solidified, heat transfer to the liquid sulphur is determined using a finite element model for one dimensional heat conduction.

It is found that, for a given depth of intrusion, there is a maximum amount of sulphur that can be mobilised by a sill, and a minimum thickness of sill that will yield this amount of sulphur. The flux supplied to the solid sulphur is a function of sill surface temperature, and when the temperature has fallen below the critical level, melting ceases. the temperature of the host material is also critical. The deeper the intrusion, the greater the host rock temperature and the less heat is needed to raise the sulphur to its melting point. Thus more sulphur is melted. The Io thermal gradient is imposed on the model, as the more sulphur that is melted, the cooler is the new sulphur close to the liquid/solid interface.

The maximum vertical extent of the sulphur that can possibly be melted (never more than 350 m) for any thickness of sill is generated at a depth of intrusion where the host rock temperature is close to the melting temperature of sulphur. Large molten bodies can form in the crust, and these can be enlarged by further intrusions of silicate material. The volumes of sulphur produced in this way are sufficient to supply the Pele type plumes at a calculated mass eruption rate of 2.3×10^9 kg/s for 10 days or 7.7×10^8 kg/s for a month. The removal of this amount of material (assuming to have been sulphur of density 2000 kg/m^3) from a magma chamber is sufficient to explain the appearance of the resulting caldera for at least one of the Pele type eruption sites.

If, early in the mobilisation process, a conduit opens to the surface, sulphur can be erupted onto the surface as fast as it is melted. Figure 1 shows the calculated mass eruption rates for sills of various lateral extents at an intrusion depth of 850 m. The mass eruption rates are initially high, but soon drop to the levels calculated for Prometheus type plumes, around 10^7 kg/s [7,8]. As the sill surface temperature drops, the sulphur melting rate decreases, until the point is reached where either (i) the level of plume activity could not be detected by the Voyager systems, or (ii) the supply of sulphur is exhausted, or (iii) sulphur mobilisation ceases, or (iv) the geometry of the conduit changes in such a way as to alter drastically the style of the eruption [9]. Little detailed modelling has been done to determine the minimum detectable level of plume activity.

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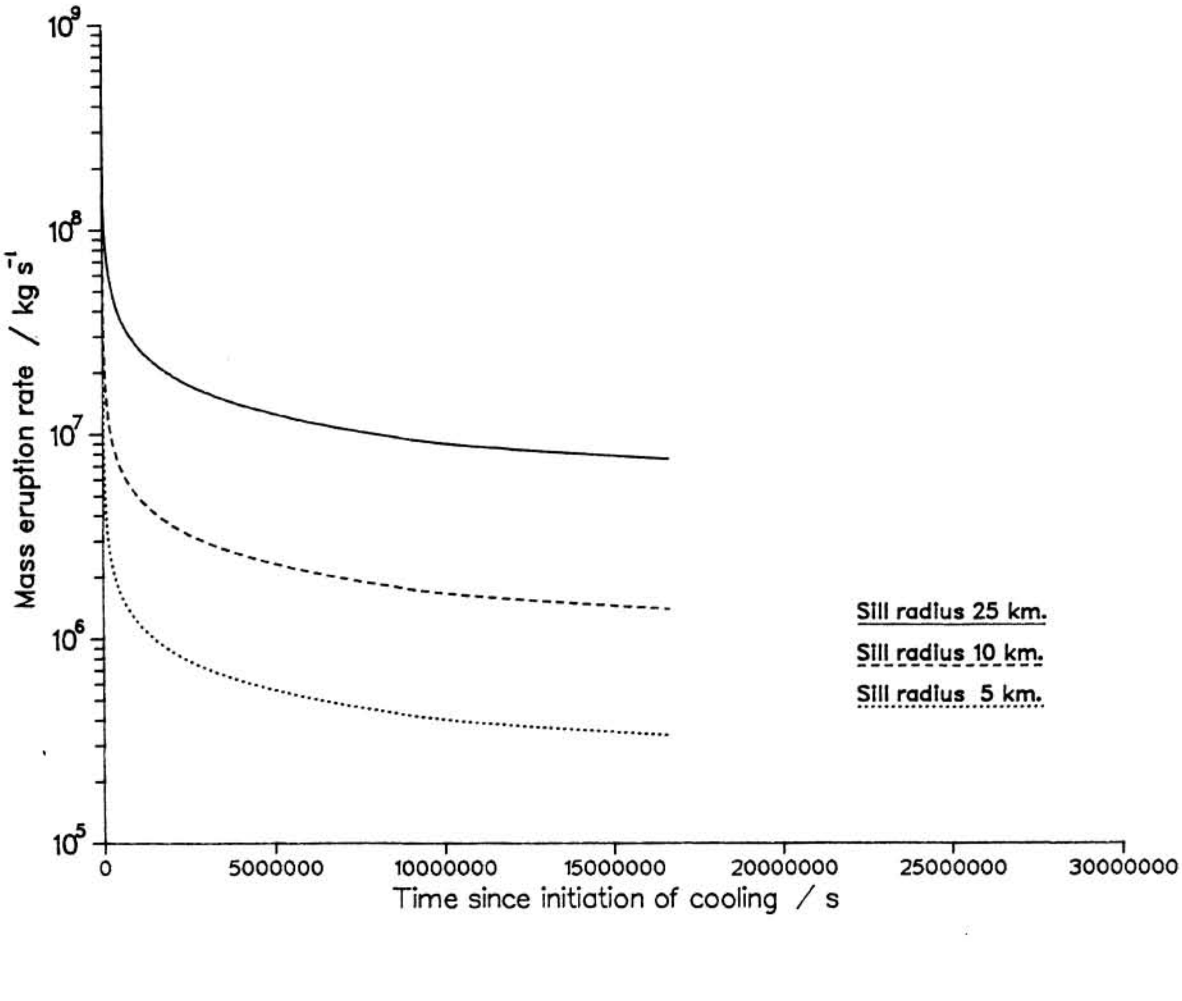
The process of eruption of hot sulphur through a cool sulphur crust is complex, involving thermal erosion of the conduit walls. The mass eruption rate and conduit geometry are strongly interdependent [10]; the conduit geometry may limit the maximum mass eruption rate. Work is proceeding on modelling the dynamic evolution of such an eruption.

References: [1] Peale, S.J. et al. (1979). Science **203**, 892-894. [2] McEwan, A.S. & Soderblom, L.A. (1983). Icarus **55**, 191-217. [3] Turcotte, D.L. & Schubert, G. (1982). *Geodynamics*. Wiley, New York. [4] Head, J.W. & Wilson, L. (1986). J. geophys. Res. **91**, 9407-9446. [5] Landau, H.G. (1950). Quart. appl. Math. **8**, 81-94. [6] Lunine, J.I. & Stevenson, D.J. (1985). Icarus **64**, 345-367. [7] Johnson, T.V. et al. (1979). Nature **280**, 746-750. [8] Wilson, L. & Head, J.W. (1980). *Lunar plan. Sci. Conf. XII*, 1191-1193. [9] Kieffer, S.W. (1982). Ch. 18 in *Satellites of Jupiter*. Univ. Ariz. Press. [10] Wilson, L. & Head, J.W. (1981). J. geophys. Res. **86**, 2971-3001.

Figure 1. Mass eruption rate as a function of time for 850 m sill intrusion depth.



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