New Simulation Approach Proposed by Glaze and Baloga (2013)

The time-dependent morphology and dimensions of an inflating pahoehoe lobe are simulated by adding a lava parcel volume (see below for definition of a parcel) to an initial condition or the existing lobe at each time-step. “Simulation” means that one or more variables are selected at random from a prescribed probability distribution. Two types of random simulation models of pahoehoe lava emplacement have been investigated. One simulation model is based on equiprobable lava transfers (Glaze and Baloga, 2013), where every potential lava transfer is equally probable and drawn from a uniform probability distribution. The new simulation model is referred to as “cooling-controlled” because the probabilistic rules governing the lava parcel transfers are determined at each time step by field measurements or theoretical surface cooling curves, i.e., some parcel transfers are more probable than others.

To simplify the problem, consider a single 2-D spatial array (a “lobe”) that is expanded by random transfers. Each transfer is either a surface or a margin transfer. The probability of an inflating lobe is determined by the probability of a surface or margin transfer. The lobes are thought of as random walks. Heat is propagated through the crust at a very slow rate. Thus, only the surface parcels (20 cm thick) cool to any significant degree. The internal transfers only inflate the lobe locally and leave the pre-existing crust undisturbed and unaltered.

The temperature of a breakout at the margin is set to the initial temperature and the parcel remains fluid and mobile in the lobe interior. Cooling of surface parcels significantly increases the lobateness of the emplacement, compared to the equiprobable model. This results directly from the assumption that the probability of a breakage is proportional to the temperature of each surface parcel at each time step. Cooling of surface parcels significantly increases the lobateness of flow emplacement, compared to the equiprobable model of Glaze and Baloga (2013), even though the direction of internal parcel transfers and margin breakouts is purely random in both models.

Cooling of individual surface parcels has a profound influence on the 2-D aspect ratio (in the basal plane) of an inflating pahoehoe lobe. This results directly from the probability that the lobe will cool to any significant degree. Cooling of surface parcels significantly increases the lobateness of flow emplacement, compared to the equiprobable model of Glaze and Baloga (2013), even though the direction of internal parcel transfers and margin breakouts is purely random in both approaches.

Conclusions

- Cooling of individual surface parcels has a profound influence on the 2-D aspect ratio (in the basal plane) of an inflating pahoehoe lobe. This results directly from the probability that the lobe will cool to any significant degree.
- Cooling of surface parcels significantly increases the lobateness of flow emplacement, compared to the equiprobable model of Glaze and Baloga (2013), even though the direction of internal parcel transfers and margin breakouts is purely random in both approaches.
- The temperature of a breakout at the margin is set to the initial temperature and the parcel remains fluid and mobile in the lobe interior.
- Cooling of surface parcels significantly increases the lobateness of flow emplacement, compared to the equiprobable model of Glaze and Baloga (2013), even though the direction of internal parcel transfers and margin breakouts is purely random in both approaches.
- The cooling-controlled model tends to have breakouts from relatively hot parcels at the front, but intermittent and sporadic upstream breakouts also occur, as typically observed in the field.
- The increased lobateness of the cooling-controlled lobes, the inflation fraction is very similar to the equiprobable case.