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THE USE OF TIMS FOR MAPPING DIFFERENT PAHOEHOE SURFACES: MAUNA IKI, KILAUEA

Scott K. Rowland

Planetary Geosciences, Dept. of Geology & Geophysics
2525 Correa Rd. Honolulu, Hawaii 96822

INTRODUCTION

S-type and p-type pahoehoe record different mechanisms and vigors of activity within an active flow field (e.g. Swanson 1973; Hon 1991; Multhaup & Walker 1992). There is some controversy about what these mechanisms are exactly, and this study was undertaken with the idea that an accurate map of the two surfaces within a pahoehoe flow field could be helpful in solving the problem. TIMS allows discrimination between s-type and p-type pahoehoe, and this ability has been used to map the two surface types on the Mauna Iki satellitic shield (southwest rift zone, Kilauea Volcano).

TIMS has previously been used to discriminate a'a from pahoehoe as well as to determine relative age relationships of different flows (e.g. Kahle *et al.* 1988; Abrams *et al.* 1991). Although inter-flow variation was minor in the data published by these authors, a second goal of the work presented here is to understand such variations to better constrain intra-flow differences used for age dating.

DATA USED

The TIMS data were collected in November 1985 and have a spatial resolution of ~10 m. An image consisting of the first 3 principal components (PC) and detailed field checking were used to derive a unit map (Figure 1). The PC image was useful for unit discrimination but because we found that the spectral character of the two pahoehoe surface types changed downflow, no rigorous classification scheme was devised.

After constructing the unit map, we extracted broad-band TIMS spectra to aid in explaining the mechanism behind the ability to discriminate the two lava types. We also made measurements of surface temperature in the field using a thermocouple. Quantitative analysis of the PC image, the spectra, and the surface temperature measurements (in collaboration with colleagues at JPL) is ongoing.

S-TYPE AND P-TYPE PAHOEHOE

S-type and p-type pahoehoe differ both in their character and their distributions within a flow field. In short, s-type pahoehoe is vesicle-rich (s stands for spongy), and is erupted directly from a lava tube. The surface of s-type consists of stretched and broken vesicles, and often spalls off shortly after emplacement. P-type pahoehoe is vesicle poor, and its chilled margin resembles obsidian. The reason for the paucity of vesicles comprises the present controversy. The most commonly-held idea is that p-type pahoehoe resides within a flow field for a period of time long enough to degas. If that particular storage area is then invaded by fresher lava, the degassed lava is pushed out on to the surface. This explains the transition from early p-type to later s-type lava often seen while watching a lava breakout. A large amount of degassing is known to take place during flow in tubes (also recently investigated using TIMS: Realmuto *et al.* 1991).

The competing idea is that p-type pahoehoe is actually richer in gas than s-type, and the pressure provided by the overlying flow field in which it resides causes solution of gas back into the lava. P-type pahoehoe often has a lower aspect ratio, possibly reflecting a lower viscosity generated by the higher dissolved gas content. Arguing against this is the fact that reabsorbtion of gas is endothermic whereas p-type pahoehoe is often hotter than s-type upon eruption.

S-TYPE AND P-TYPE DISTRIBUTION AT MAUNA IKI

In Figure 1, the "main shield" and "downrift flow" were determined by field mapping and studying the eruption chronology. Within these two zones, the distribution and relative amounts of s-type and p-type pahoehoe differ greatly. On the main shield, p-type pahoehoe is restricted to 3 small patches along the northwest margin of the flow. It is here that lava flows from the Mauna Iki summit ponded against pre-existing topography. This is a condition conducive to stagnation of the flow and consequent inflation. The p-type pahoehoe erupted out of storage within this stagnated flow. The major activity on the main shield was the overflowing of relatively gas-rich lava from a small lava pond, and the formation of p-type pahoehoe was an exception.

The downrift flow was emplaced by lava tubes, and the distribution and relative abundance of the two pahoehoe types are very different. They make up roughly equal proportions of the flow and at contacts p-type overlies s-type. Overall, the Mauna Iki eruption had a low eruption rate, and this was particularly true of the final lava tube stage. This low eruption rate meant that once the flow field was established, it was difficult to supply all of it with fresh lava.

The distribution of p-type pahoehoe on the flow field can be used to constrain the conditions required for formation. First, there is a paucity of p-type pahoehoe where lava tubes were well-established (i.e. on the shield and the main axis of the downrift flow). This indicates that initially, lava erupted directly from tubes was too gas-rich to form p-type. The downrift flow field averages ~1 m in thickness, and is even thinner along its margins. The large amount of p-type pahoehoe compared to the flow volume as a whole argues against the existence of an overburden capable of pressurizing the lava. The field relations suggest instead, that even though gas-rich lava established the distal end of the flow initially, in the waning later stages all the lava degassed during sluggish travel down the tubes prior to being erupted onto the surface.

Kipukas (inliers) of s-type tumuli form semi-linear trains branching off from the main axis of the downrift flow. These may indicate the lines of subsidiary early-formed tubes, and the ability to map tubes long after a lava flow has stopped erupting would be a very useful tool. We are in the process of conducting this same type of analysis on the Mauna Ulu flow field where the positions of lava tubes were closely monitored during the eruption.

FUTURE WORK AND CONCLUSIONS

The TIMS data indicate that at Mauna Iki the radiometric temperature of s-type pahoehoe is hotter than that of p-type, supported by the fact that PC1 discriminates the two types most strongly. Further analysis of the TIMS data, as well as more complete field temperature measurements,will help to determine if these differences are due to different physical temperatures or emissivities. In conclusion, it is possible to discriminate pahoehoe surface types using TIMS data. Quantitative analyses of the causative relationships, however, have not been completed, and these are the next goals. With regard to the formation of p-type pahoehoe, the large area covered by p-type, including areas where the flow as a whole is thin, suggests that the availability of an overburden is not required for its formation, in turn supporting the degassed origin.

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Figure 1. Unit map derived from TIMS data for the Mauna Iki flow.