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## QUANTIFYING THE EFFECT OF RHEOLOGY ON PLAN-VIEW SHAPES OF LAVA FLOWS; B.C. Bruno, G.J. Taylor (Planetary Geosciences, Dept. of Geology & Geophysics, University of Hawaii, Honolulu, HI 96822) and R.M.C. Lopes-Gautier (Jet Propulsion Laboratory, California Institute of Technology, Mail Stop 183-601, Pasadena, CA 91 109).

**Introduction.** This study aims at quantifying the effect of rheology on the plan-view shapes of lava flows. Plan-view shapes of lava flows are important because they reflect the processes governing flow emplacement and may provide insight into lava flow rheology and dynamics. In our earlier investigation (1), we report that plan-view shapes of tholeiite basalts are fractal, having a characteristic shape regardless of scale. We also found we could use the fractal dimension (a parameter which quantifies flow margin convolution) to distinguish between the two major types of basalts: a'a and pahoehoe. Encouraged by these earlier results, we are currently developing a similar method for use on silicic flows and present our preliminary work,

**Data.** This analysis of silicic lavas is based on measurements of 10 flows. All of these measurements are "from images; no field data have been taken to date. We selected only those lava flow margins that appear unaffected by topography. We divide these flows into two categories based on silica content, separating the basaltic andesites (SiO<sub>2</sub>: 52-58%) from the more silicic flows (SiO<sub>2</sub>: 61-74%).

**Methodology.** This analysis of silicic flows utilizes the same methodology as our earlier basaltic analysis. We calculate the fractal dimensions (D) of lava flow margins using the "structured-walk" method (2). In this method, the apparent length (L) of a lava flow margin is measured by walking rods of different lengths (r) along the margin. Since smaller rod lengths traverse more smaller-scale embayments and protrusions in the flow margin, L increases as r decreases. A linear trend on a log L vs. log r plot ("Richardson plot") indicates the data are fractal. D can then be calculated as  $D = 1 - m$ , where  $m$  is the slope of the linear least squares fit line to the data.

### Results and Discussion.

1) **Basaltic lava flows are fractals.** Our previous analysis of basaltic lava flows indicates that both a'a and pahoehoe flow margins are fractals, within the range of scale studied (r: 0.125m to 2.4km). Richardson plots are linear (Fig. 1a), demonstrating self-similarity.

2) **More silicic lava flows are generally not fractals.** Silicic lava flows tend to exhibit scale-dependent behavior within the range of scale studied (r: 10m to 4.5km). Typical Richardson plots for basaltic andesite (Fig. 1b) and dacite (Fig. 1c) are non-linear (not fractal), most notably for the dacite. Unlike the basaltic case, D tends to increase as r increases (Fig 2). This breakdown of fractal behavior at increased silica content is presumably related to the higher viscosities and yield strengths, which suppress smaller-scale features. Plan-view shapes of basaltic andesites typically have finger-like lobes, hundreds of meters in diameter. Superimposed upon these fingers are smaller-scale features, resembling crenulations. As silica content increases further, the lobes tend to widen (>1 km for typical dacites), protrude less from the main mass of the lava flow, and the smaller crenulations disappear.

3) **New Remote Sensing Tool** We are in the process of developing a remote sensing tool that uses fractal parameters to quantitatively distinguish lava flows of different rheologies. There may be a critical value of r, related to silica content, which serves as a boundary for self-similar behavior (i.e., a value of r above which the flow appears fractal). This critical value may be related to lobe dimensions and/or the degree of suppression of smaller-scale features. We are currently investigating this hypothesis by simulating suppression of smaller-scale features on a synthetic fractal. Starting with an ideal fractal (Fig. 3a), we filter out the smaller-scale features, causing it to no longer be fractal (Fig 3b). Applying the same methodology described above, we generate Richardson plots (Fig. 4). The result is distinctly non-linear (not fractal; Fig. 4b), with a breakdown of fractal behavior at some critical value of r. This critical value is related to the size of the small-scale features suppressed. We liken the ideal case to basaltic flows, and the modified case to silicic flows. Silicic flows may also have critical values, and may be remotely distinguished by these values. We will compare our results to those of other remote sensing techniques aimed at quantifying lava flow morphology (3).

**References.** (1) Bruno, B.C. et al. (1992), *Geophys. Res. Lett.* 19,305-308. (2) Richardson, L.F. (1961) *Genl. Syst. Yearbook* 6, 139-187. (3) Lopes-Gautier, R.M.C. et al. (1992), this volume (and references therein).

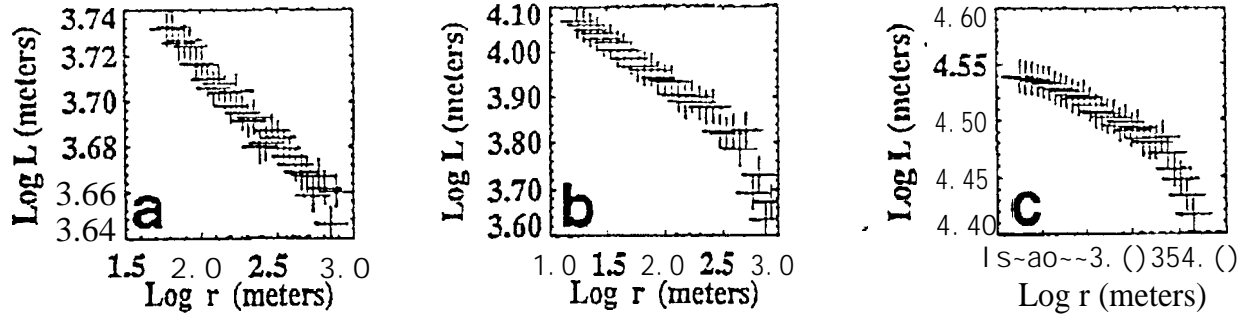


Figure 1. Typical Richardson plots for representative lava flows: (a) a'a basalt, (b) basaltic andesite, (c) dacite.

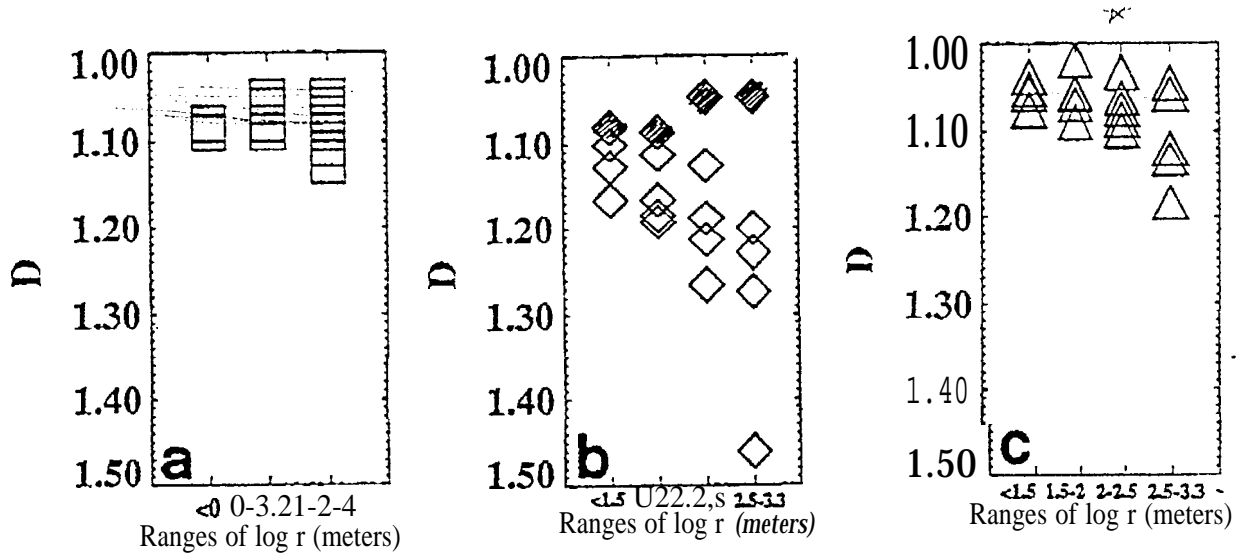


Figure 2. D vs. log r for all measured lava flows: (a) a'a basalts, (b) basaltic andesites, (c) dacites.

Figure 3. (a) Ideal Koch Triad (fractal); (b) Modified Koch Triad (not fractal), generated by filtering out smaller-scale features from (a). We compare (a) with basalt, as both are self-similar. We compare (b) with more silicic flows (e.g., dacite), where high viscosities and yield strengths suppress smaller-scale features.

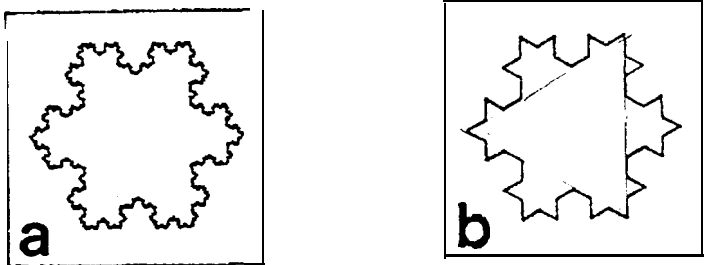


Figure 4. Richardson plots. Axes are in data numbers. (a) Ideal Koch Triad: linear plot, compare with basaltic plot (Fig. 1a); (b) Modified Koch Triad: non-linear plot, compare with dacitic plot (Fig. 1c).

