TUMULI AND TUBES: TEACHING SCIENTIFIC TECHNIQUES; Michelle J. Tatsumura, G.J. Taylor, and P.J. Mouginis-Mark, Planetary Geosciences, Dept. Geology & Geophysics, SOEST, University of Hawaii, Honolulu, HI 96822

Planetary and space science is the best way to teach basic chemistry, physics, and math. Einstein once said that "man is drawn to the mysterious and it is from that that we achieve true art and science." Planets and the processes that shape them are especially mysterious and fascinating to students, young and old, and because of this planetary geology kindles interest that draws them further into the world of science. At the very least, they are engaged enough to learn how science works, a key ingredient in scientific literacy. This paper describes a project involving field measurements on Kilauea volcano, Hawaii, by a Geology 101 honors class.

In Hawaii, we are blessed with spectacular, active, accessible, and relatively safe basaltic eruptions. The study of volcanoes, the landforms they produce, and the processes that operate on and in volcanoes, combined with the study of volcanoes on other planets, is an excellent way to link aspects of Hawaiian geology to the planets.

During the past year we have taken advantage of our setting to organize a NASA field workshop for junior investigators and senior graduate students, made field trips and planetary volcanism the centerpieces of our annual Summer Workshop for Teachers, and led a field trip around Kilauea Volcano during the Challenger Center Faculty Development Conference, held on the island of Hawaii last summer. We are presently planning an activity for the honors Geology 101 class (all undergraduates) at the University of Hawaii. Our goal is to give them some hands on experience working on a field project and applying what they've learned to planetary volcanoes. The work will include qualitative observations and quantitative measurements on volcanic lava flows. Follow-up activities will involve data analysis. The trip requires planning (at least 3 months before hand) everything from accommodations and insurance to the actual activities we will be doing. Our goal is to stimulate interest and awareness in the students' surroundings, in this case, our volcanoes, and to include planetary applications and how studies of terrestrial geology greatly aids studies of the other planets. We plan two studies, both of which are active research projects being conducted by the authors. These projects are described below.

**Tumuli in pahoehoe flow fields.** Work being done by MJT for her masters' thesis focuses on lava flow emplacement mechanisms via the study of tumuli in lava flows in Hawaii and on Venus and Mars. It has yet to be explained why tumuli form where they do and how their distribution and sizes relate to ground slope. These results may shed some light on the subsurface plumbing system of pahoehoe lava flow fields. The work involves measuring strike and length of the tumulus' longest axis, width, the amount of dilation or opening of the axial cleft, plus any other notable characteristic of the tumulus. These data in turn will be used as a tool for analysis by way of graphing, charting, and describing the features studied eventually to provide some qualitative and marginally quantitative statements about tumuli and what may have caused them to form in their present locations (Fig. 1). We hope that data such as air photography, SIR-B, Magellan, and Viking photographs can be utilized in studying remote areas where field work on tumuli is impossible. Comparative studies with the remotely sensed data combined with ground field work in Hawaii may provide insight into lava flow emplacement processes on other volcanoes on Venus and Mars as well as remote volcanoes on Earth.

**Lava tube cross-sectional areas.** GJT has been studying the fractal properties of lava tube systems [Taylor G.J. (1992) EOS 73, p. 648]. This work has shown that the cumulative number of tubes is a power-law function of tube cross-sectional area (Fig. 2). Many more measurements are needed, however, so the undergraduates in the Geology 101 honors course will be able to contribute in a significant way to this study. Students will make measurements in the field of tube width and height, photograph each tube for later measurement of cross-sectional area, and make other appropriate observations of each tube. Furthermore, analysis of the data...
TUMULI AND TUBES: M. J. Tatsumura et al.

will involve use of logarithms, the concept of binning data (how many categories of tube size?), and practice in plotting graphs and testing for linearity.

These activities are scientifically useful, educationally sound, and accomplish several goals. The first, to address a specific scientific problem, consider explanations that satisfy the question, to practice making observations and taking notes, and finally, to get them out into the field and getting hands-on experience with things most people only see in postcards. The students learn more specifically about volcanoes, the complexity of pahoehoe lava flow fields, and get a glimpse of science works. The trip is scheduled for February 19 through February 21, 1993 and results of the trip will be presented at the LPSC meeting in March.

Acknowledgments. This work was supported by NASA grant NAGW 2955 (MJT and PJMM).

Fig. 1. Drawing of a typical tumulus in Hawaii. Widths at the base ranges from 1-10's of meters. The students will be undertaking a project that involves measurements of lava tubes and tumuli on the Big Island of Hawaii.

Fig. 2. Plot of the number of lava tubes of a given cross-sectional area or larger, versus cross-sectional area. Straight line (R^2=.98) indicates a power-law (hence fractal) relation. Acquiring and plotting data like these and testing for linearity is manageable and useful task for students in freshman geology.