TOPOGRAPHIC AND THERMAL INVESTIGATIONS OF ACTIVE PAHOEHOE LAVA FLOWS: IMPLICATIONS FOR PLANETARY VOLCANIC PROCESSES FROM TERRESTRIAL ANALOGUE STUDIES. David A. Crown[1], Steven W. Anderson[2], David C. Finnegan[3], Adam L. LeWinter[3], and Michael S. Ramsey[4], [1]Planetary Science Institute, 1700 E. Ft. Lowell Rd., Suite 106, Tucson, AZ 85719, crown@psi.edu; [2]MAST Institute, University of Northern Colorado, Greeley, CO 80639; [3]US Army Corps of Engineers, Cold Regions Research and Engineering Laboratory, 72 Lyme Road, Hanover, NH 02755; [4]Department of Geology and Planetary Science, University of Pittsburgh, Pittsburgh, PA 15260.

Introduction: Terrestrial analogue studies, coupled with the acquisition of high-resolution datasets for planetary surfaces, provide critical insights for interpreting geologic processes in different planetary environments. New capabilities for field analyses of active lava flow emplacement provide important constraints from both the process-oriented and surface morphologic perspectives. Our analyses are designed to qualitatively and quantitatively characterize pahoehoe lava flows in order to directly link surface morphology to observed emplacement processes, providing a robust foundation for interpretations of planetary volcanic features.

Background: Pahoehoe lava flows consist of multiple overlapping and interfingering lobes and exhibit morphologically diverse surfaces characterized by channels, smooth-surfaced sheets, and numerous, small networks of interconnected pahoehoe toes [e.g., 1-3]. Previous work compiled detailed planform maps of solidified pahoehoe toe networks to document their morphology, morphometry, and connective relationships [4] and to provide constraints on lava transport models [5]. In order to incorporate and analyze the thermal characteristics and temporal variability of pahoehoe lava, we collected new topographic and thermal datasets at regular time intervals for active tube-fed pahoehoe flows on Kilauea Volcano, Hawaii.

Field Investigations: Instrumentation and Methodology: Field investigations were conducted in February and March, 2012 on tube-fed pahoehoe flows in the Pu'u 'O'o flow field. We employed a ground-based, full-waveform scanning LiDAR and FLIR SC645 thermal infrared camera, supplemented by high-definition video and time-lapse photography. The LiDAR scanner (Riegl VZ-1000) is capable of acquiring rapid, successive scans with reproducible 5 mm resolution data at a rate of 300 kHz. Its range is up to 1400 m with a measurement rate of up to 122,000 points/sec. The FLIR camera acquires calibrated thermal images in the 7.5 – 13 µm atmospheric window over a temperature range from -20°C to +2000°C, with a thermal sensitivity of <0.05°C at 30°C and an accuracy of ±2°C. An RTK GPS was used to acquire precise locations of scan positions and to georeference the LiDAR data. The combined LiDAR/FLIR system provides rapid acquisition of high-resolution spatial and high-precision thermal datasets for advancing pahoehoe flows.

Datasets for Active Pahoehoe Flows: High-definition video and time-lapse photography document the nature and changes in flow behavior and are used for interpretation and analysis of thermal and topographic data. The thermal data show the distribution of lava surface temperatures and are used to identify new lava breakouts and to define and chart the evolution of discrete lava units. Repeat LiDAR scans at regular intervals during flow emplacement are used to document morphometric characteristics of individual pahoehoe elements and compound lobes, directly link quantitative morphometric measurements to other flow characteristics, such as flow morphology and temperature, and calculate flow volumes and advance rates. LiDAR derived point clouds collected at given time intervals can be easily manipulated and displayed in different ways for geological analyses; for example, points in the LiDAR data can be assigned color values recorded by camera systems or surface temperatures recorded by the FLIR camera. High resolution DEMs and slope maps can also be generated. These complementary datasets provide the following constraints on pahoehoe flow emplacement: 1) quantitative characteristics of the pre-flow surface; 2) morphologic, morphometric, thermal, and kinematic characteristics of individual pahoehoe elements (toes, sheets, small channels); and 3) detailed documentation of the growth and development of compound flow lobes, including the effects of flow inflation at various scales [6]. Maps showing the distribution and connective relationships of various pahoehoe elements within a compound lobe are being generated to document and analyze patterns in flow behavior [7].

Results: Figure 1 shows LiDAR point cloud data and a derived slope map at a single time interval for a ~41 m long channel system and associated pahoehoe breakouts. We documented the formation of these features over more than 3 hours in March, 2012. These data products demonstrate the capabilities of the LiDAR system for lava flow analyses and show in detail the following: 1) dimensions and surface morphology of the channel, 2) dimensions, orientations, and surface characteristics (including surface folds) of individual pahoehoe toes, and 3) spatial and connective relationships for various flow elements in the scene.

Figure 2 shows a comparison in flow surface height over a 209 minute period for an advancing lobe in March, 2012. Scans were acquired every ~30 seconds and show in detail active flow advance, new breakouts of lava, and flow inflation. The local lava supply rate was calculated to be ~1 m^3/minute.

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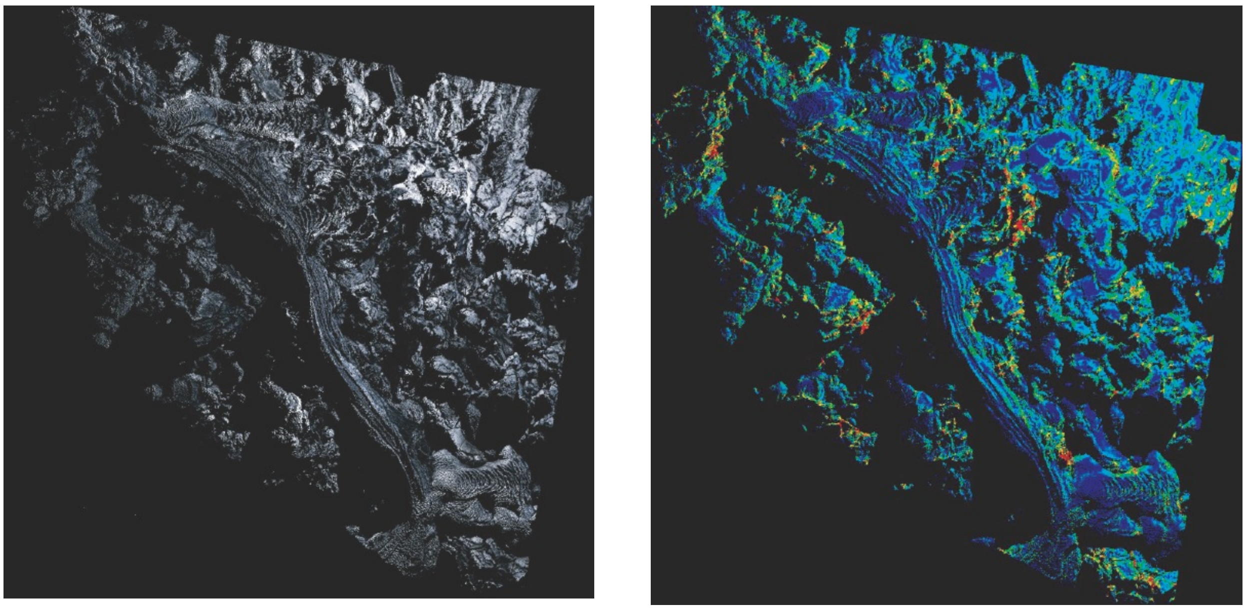

Figure 1. left) LiDAR point cloud colored by calibrated DSLR camera image of ~41 m long lava chanel and associated breakouts. Point cloud includes 1.2M points. Right) Slope map derived from LiDAR data; slopes range from 6 to 90° (blue to red).

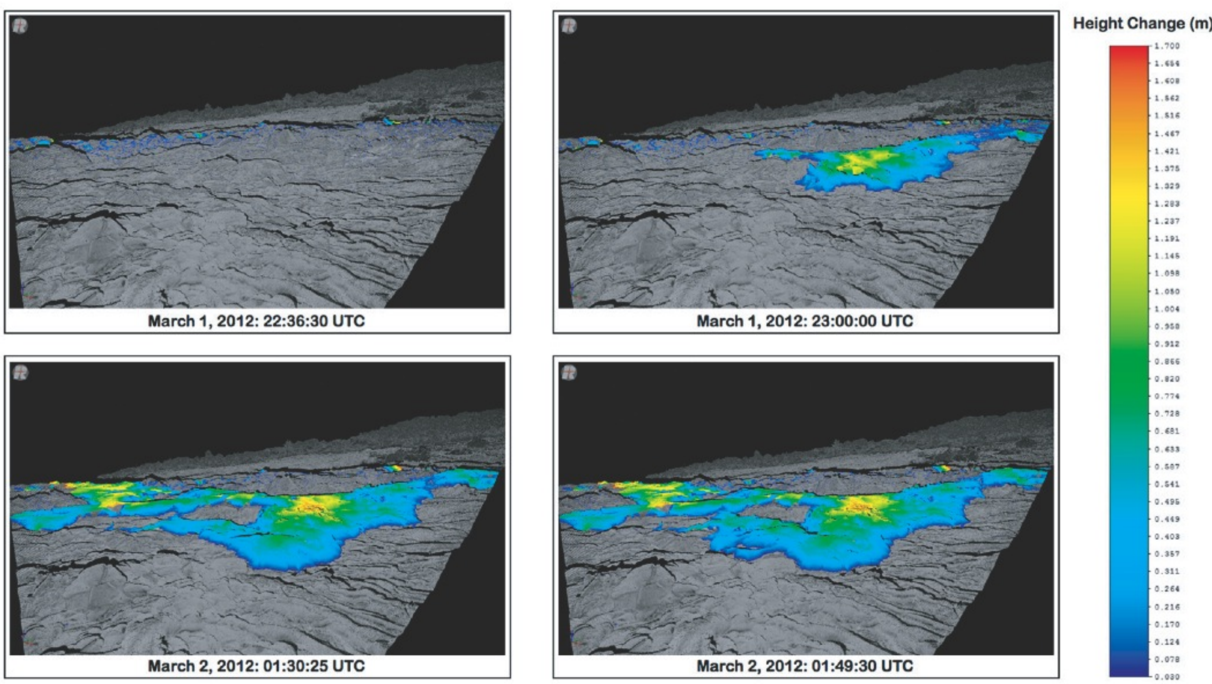

Figure 2. Comparison of four LiDAR scans for active lava flow, March 2012. Scene width at center is ~37 m.