Multiscale parametric imaging of basaltic lava flows

Michael S. Ramsey[1], Rachel J. Lee[1], Steven W. Anderson[2], David A. Crown[3]

[1]University of Pittsburgh, USA, [2]University of Northern Colorado, USA, [3]Planetary Science Institute, USA

E-mail: mramsey@pitt.edu

Basaltic volcanism is widespread on the terrestrial planets and recent orbital data from Mars have revealed excellent examples of flow morphology. On Earth, it is the most common form of extrusive activity, with over half of the volcanoes consisting largely of basalt. For example, the recent 2012 eruption of Tolbachik volcano in Russia was large enough to produce significant flows that were emplaced over snow/ice and observed with both ground and satellite based imaging. Larger outpourings of basaltic lava in the past have been coincident with mass bioextinction events, and even small eruptions can pose hazards to the local and regional populations. Therefore, understanding flow emplacement, cooling, and morphology is important, with one approach being the use of thermal infrared (TIR) data. Basaltic flows rapidly form a chilled glassy crust after emplacement, with a lower percentage of preserved vesicles than the lava directly below. With time, the crust will stretch, cool, thicken, fold, and possibly spall off due to vesiculation of the lava and continued flow. The crust can also remain intact to form the exposed primary flow surface, which can be later disrupted on a larger scale during the emplacement process and flow inflation. The thicknesses of a glassy crust directly affects the interpretation of the TIR temperature and emissivity data. The TIR wavelengths are particularly sensitive to silicate mineralogy because of the presence of the strong absorption bands formed by vibrational motions of the Si-O and Al-O bonds. However, there has been a debate on whether molten materials have dramatically lower TIR emissivities than their solidified counterparts. This unknown not only affects the derived compositional information, but also feeds into models of the radiative cooling efficiency and flow formation. Moreover, the crustal rheology of active flows can be directly estimated once the TIR data is corrected for the emissivity of the molten/glassy components. We have performed multiscale parametric imaging of basaltic lava flows over the past decade, including the development of a novel laboratory-based micro-furnace to acquire the first TIR emissivity measurements of molten silicates. Results confirm the dramatic lowering of emissivity following the phase change from a solid to a melt. We have also collected and analyzed field-based TIR and LiDAR data of active pahoehoe flows at Kilauea volcano, Hawaii. Spaceborne data of these flows in Hawaii and the new ones in Kamchatka are now being compared to laboratory and field data as well as to similar flow morphologies on Mars. The goal of all these studies is to accurately determine flow mineralogy/vesicularity, model crust formation, cooling, and inflation using TIR data at multiple spatial and topographic scales. The results are providing a better understanding of the morphology and emplacement dynamics of basaltic flows.