

FIELD DETECTION OF CHEMICAL ASSIMILATION IN A BASALTIC LAVA FLOW. K. E. Young¹, J. E. Bleacher², D. H. Needham³, C. A. Evans⁴, P. L. Whelley⁵, S. P. Scheidt⁶, D. A. Williams⁷, A. D. Rogers⁸, and T. Glotch⁸, ¹University of Texas, El Paso/Jacobs JETS Contract at NASA Johnson Space Center, Houston, TX (kelsey.e.young@nasa.gov); ¹University of Texas, El Paso/Jacobs JETS Contract at NASA Johnson Space Center, Houston, TX; ²NASA Goddard Space Flight Center, Greenbelt, MD ³NASA Marshall Space Flight Center, Huntsville, AL; ⁴NASA Johnson Space Center, Houston, TX; ⁵USRA, NASA Goddard Space Flight Center, Greenbelt, MD; ⁶Univ. of Arizona, Tucson, AZ; ⁷Arizona State Univ., Tempe, AZ; ⁸Stony Brook University, Stony Brook, NY

Introduction: Lava channels are features seen throughout the inner Solar System, including on Earth, the Moon, and Mars. Flow emplacement is therefore a crucial process in the shaping of planetary surfaces. Many studies, including some completed by members of this team at the December 1974 lava flow, have investigated the dynamics of lava flow emplacement, both on Earth and on the Moon [1,2,3] and how pre-flow terrain can impact final channel morphology, but far fewer have focused on how the compositional characteristics of the substrate over which a flow was emplaced influenced its final flow morphology.

Within the length of one flow, it is common for flows to change in morphology, a quality linked to rheology (a function of multiple factors including viscosity, temperature, composition, etc.). The relationship between rheology and temperature has been well-studied [4,5] but less is known about the relationship between an older flow's chemistry and how the interaction between this flow and the new flow might affect lava rheology and therefore emplacement dynamics.

Lava erosion. Through visual observations of active terrestrial flows, mechanical erosion by flowing lava has been well-documented [i.e. 6,7]. Lava erosion by which flow composition is altered as the active lava melts and assimilates the pre-flow terrain over which it moves is also hypothesized to affect channel formation. However, there is only one previous field study that geochemically documents the process in recent basaltic flow systems.

Ape Cave Chemical Assimilation Study: [8] documented chemical assimilation in the Cave Basalt from several samples and field data throughout the lava tube system near Mount St. Helens, WA, in Ape Cave (Fig. 1). Chemical analyses document that erosion occurred both in areas near the vent and in steeper sections of the tube. This assimilation process has not been quantified in open surface channels in terrains and flow-types like those seen on other planetary surfaces. Our study documents the first example of chemical assimilation in the December 1974 flow (D1974) at Kīlauea Volcano, HI, a surface basaltic flow we use as a lunar and martian analog.



Figure 1: The Ape Cave lava tube, as shown in Williams et al., 2004. “1” represents the pre-flow sediments fused by the heat of the forming tube; “2” and “3” show the wall of the Ape Cave lava tube that indicate thermal erosion has occurred in the tube.

December 1974 Flow: The D1974 lava flow is located in the SW rift zone at Kīlauea Volcano, HI. The 13-km long flow was emplaced from a series of en echelon fissures over a course of ~6.5 hours as a sheet flow over a series of older lava flows, active fumarolic vents, ash units, and basaltic aeolian and fluvial deposits [i.e. 9]. It has been identified as a planetary analog due to the ongoing interaction between the flow and the sulfuric gases erupted at the active Kīlauea summit lava lake, the presence of overlapping basaltic flows, ash, and sediment, and the low-slope morphology over the pre-existing terrain. Our main interest is the interaction of the D1974 flow and the flow beneath it, a hummocky pāhoehoe flow field that is tens of thousands of years old. As the D1974 flow was not thick enough to completely inundate this hummocky terrain, it flowed around tumuli of the older flow, forming “islands” known as kīpuka [10].

RIS⁴E at the D1974 flow: The RIS⁴E SSERVI (Remote, In Situ and Synchrotron Studies for Science and Exploration; Solar System Exploration Research Virtual Institute) team and previously-funded MMAMA and PG&G projects have been conducting fieldwork at the D1974 flow for the last several years. RIS⁴E team goals are to investigate the emplacement, mineralogy, and geochemistry of the analog and to develop an exploration strategy for similar environments using field portable instruments. Field technolo-

gies tested include x-ray diffraction (XRD), handheld x-ray fluorescence (hXRF), multispectral imaging, light detection and ranging (LiDAR), and airborne imaging using a kite-mounted camera system. Figure 2 shows an image taken with this kite-based platform of a tumulus of the older flow embayed by the D1974 flow.

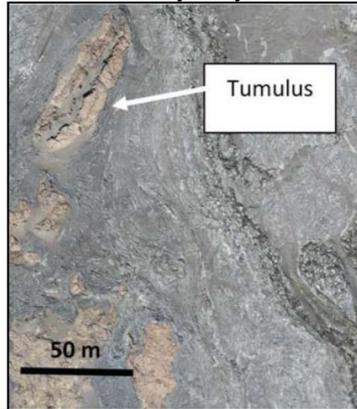


Figure 2: Image taken from the kite-based camera platform showing the younger, darker D1974 flow inundating the older, redder flow. Sites like this were sampled to investigate if there was any chemical

Chemical Assimilation at the D1974 Flow: Using a hXRF analyzer, we sampled a tumulus (Figure 3) where the D1974 flow is in direct contact with a kīpuka of the older flow in order to determine if any chemical exchange occurred between the D1974 flow and the older flow, and whether the hallmark geochemical fingerprints of assimilation could be detected in the field. Operational details of the hXRF analyzer can be found in [11], which highlights the ability of the hXRF technology to analyze volcanic environments. Several hXRF analyses were performed at the feature shown in Figure 3. The measurement strategy involved analyzing basalt from the older flow ~1m from the D1974 flow, at the contact between the flows, and in the D1974 flow itself. Table 1 show data of four key elements. These data demonstrate that for these elements, the composition of the younger D1974 is starting to influence the older flow near the contact between the two units. We see this as, for example with Fe_2O_3 , the concentration is increasing in the older flow closer to the contact with the younger and more Fe_2O_3 -rich D1974 flow. We interpret this evidence that chemical assimilation has occurred between the two flows. These data show that it is probable that the chemical interactions between the two flows occurred and that field portable technology can detect this relationship.



Oxide (results show in wt. %)	D1974 Bulk	Older Flow at Contact	Old Flow Inches from Contact	Old Flow Bulk
MgO	22.54	22.46	19.15	16.05
SiO ₂	39.02	41.22	48.17	58.24
CaO	7.31	6.31	5.67	3.61
Fe ₂ O ₃	17.49	14.76	12.88	12.11

Figure 3: Field photo of analyzed D1974 kīpuka taken from the D1974 flow across the contact into the older flow. **Table 1:** hXRF data show assimilation between the younger D1974 flow and the older, redder flow for four key elements.

Moving Forward: After the initial observations of chemical assimilation at the D1974 flow, it is clear that detecting this process *in situ* is possible. However, more work is needed to characterize the extent of chemical assimilation across the entire D1974 flow to unravel what role this process may play in flow emplacement. Future work will include an in depth characterization of the variations of the bulk D1974 flow in order to isolate chemical assimilation from the older flow from variations in the D1974 flow itself. This characterization should identify any chemical gradients that may exist within the D1974 flow as well as pull out how chemical assimilation might have varied from the flow margins to the multitude of kīpuka that cross the flow. Additionally, modeling chemical assimilation both on Earth and for lunar flows could tell us more about how the interaction between a new flow and surrounding terrain could impact flow emplacement.

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