

**POTENTIAL CONTRIBUTIONS OF VNIR IMAGING AND LABORATORY ANALOGUE EXPERIMENTS TO INFORM MODELING EFFORTS.** S. I. Peters, E. L. Rader, E. J. Forsberg, L. L. Baker, and E. Thompson, Department of Geography and Geological Sciences – University of Idaho, 875 Perimeter Dr., Moscow, ID 83844, USA, seanpeters@uidaho.edu.

**Introduction:** The morphology and subsequent emplacement of lava flows is controlled by eruption rate, composition and rheology, cooling rate, and topography [1,2]. The mechanics of lava flow emplacement are crucial to hazard assessment, risk mitigation, and understanding the formation and evolution of volcanoes on planetary surfaces [1–3,4]. For example, distinguishing between a crystallinity or effusion rate cause of a short and stumpy lava flow on a planetary surface would reveal more about magmatic plumbing system such as the magnitude of the volatile content or if the magma stalled in the crust.

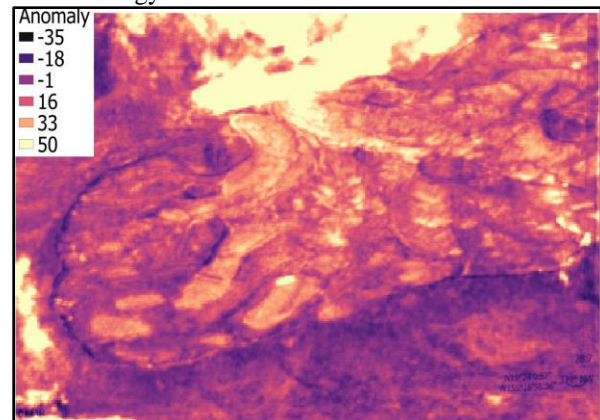
A second area of study that could benefit is terrestrial lava flow modeling. Numerical modeling of lava flows has proven useful for hazard and risk mitigation [5]. Models are generally informed by historical eruptions and fundamental physical equations. At present, many models still rely on simulating lava via channelized emplacement or – as with a few models – a random walk or probabilistic process. These models seek to capture the dominant process happening in a flow using variables to capture aspects of rheology, temperature, and eruption rate. Adding to the complexity are the changing conditions across a flow with time such as crystallinity, temperature, and local flow rate which complicates morphology, propagation, and subsequent emplacement.

Advancements in our understanding of flow conditions has been aided, in part, by laboratory analog experiments [3,4,6–8]. Experiments allow for the creation and observation of complex flow dynamics and phenomenology in the laboratory. Experiments using polyethylene glycol (PEG) wax established  $\Psi$ , a dimensionless parameter that relates crust formation ( $t_c$ ) and lateral advection ( $t_a$ ) timescales of a viscous gravity current [6,7]. Morphologies and processes analogous to those produced under target  $\Psi$  regimes have been observed in nature [6–8]. Recently, studies have investigated the effects of effusion rate on emplacement modes, such as inflation, breakouts, and tube formation [8]. Given that flow morphology has been used to back-calculate eruption conditions, analogue experiments offer a useful check on modelling assumptions and results.

The degree of crystallinity within a flow directly impacts viscosity and thus flow rheology. As flows propagate further from the point of extrusion, they cool (although this can be minimized by an insulating crust) and become more viscous due in part to an increase in crystallinity [1].

There remains a noticeable gap in the literature between lava flow modeling parameters (such as dynamic crystallinity estimates), flow morphology, and mode of emplacement. This work seeks to generate ideas and stoke a dialogue in the community on what variables can be added to models and how analogue experiments can be incorporated in order to foster a better understanding of lava flow morphology, propagation, and emplacement. Our long-term ideal would be to arrive at a point where the observed morphology and/or emplacement mode of a lava flow would determine which model would be used. Such a model would have laboratory analogue experiments and field data incorporated.

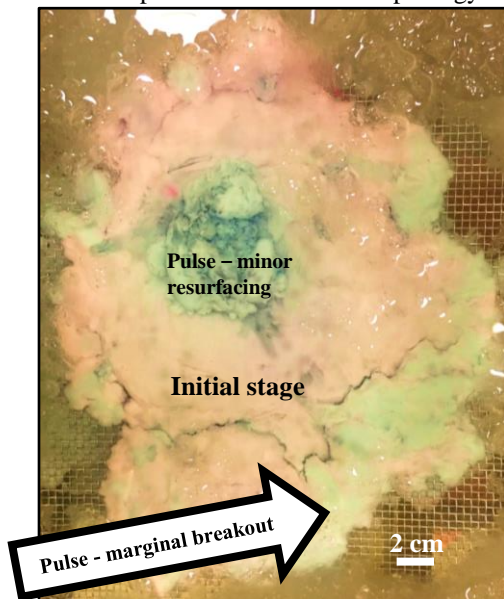
**Methods:** To illustrate how morphological and crystallinity observations could be incorporated as quantifiable model inputs, we observed an active lava lake in the visible near-infrared (VNIR) and compared the observations from 150 laboratory analogue experiments to morphological observations of lava flow fields. 1 – *VNIR*. Observing active lava flows in the visible near-infrared yields differences in brightness which correspond with temperature, glass and/or crystal content, and surface roughness. By controlling for temperature and surface roughness, we can use crystal content to understand the petrogenesis and emplacement environment of flows on planetary surfaces as well as inform flow rheology for models.



**Figure 1:** A thermally-corrected average reflectance map of a lava lake indicating regions of high glass content and/or increased surface roughness (dark regions) or regions of high crystallinity and/or smoother surface roughness (lighter regions). Images like this can inform sampling site selection.

2 – *Analogue Experiments*. We analyzed data from 150 laboratory experiments using a programmable pump to erupt dyed wax into a temperature controlled chilled

bath in a tank with a flat, roughened base. Approximately 250 mL of wax was erupted between 1–6 cm<sup>3</sup>/s across a target  $\Psi$  regime, followed by 10–300 mL erupted at a lower or higher eruption rate for either 10 or 50 seconds. We varied the eruption rate to determine what conditions were most favorable for creating surface breakouts (resurfacing), marginal breakouts (which advanced the flow front), inflation, and tube formation. These emplacement modes result from varying effusion rates and produce distinctive morphology.



**Figure 2:** Example of a wax flow produced in the lab. White arrow denotes the marginal breakout that occurred when the eruption rate was decreased. Blurry zones in image due to ice.

**Preliminary Observations and Discussion:** Our preliminary observations suggest the wedding of laboratory analogue experiment results and dynamic crystallinity estimates with modelling is crucial to better understand, and forecast, lava flow emplacement. Both methods have implications for planetary exploration and could be built into routine observations of volcanic systems with readily available equipment.

**Numerical modelling.** Both VNIR and experimental observations have the potential to better inform the assumptions and variables of existing models. Conversely, parameters necessary for increasing model efficacy require an understanding of what data is needed. Laboratory experiments allow for the study of more complex flow dynamics and flow scenarios. This could lead to the creation of models that better simulate dynamic flow phenomenology and allow for the selection of certain models given known flow criteria. For instance, if a flow exhibits decreasing flow rates, increasing crystallinity, and inflation, then the simulation of the

flow is inherently different from a channelized flow exhibiting sustained, high eruption rates.

**Eruption Monitoring.** Observing active lava flows and lava lakes in the VNIR is possible on Earth (and theoretically on Io and Venus). Understanding how these active systems will evolve (and their potential risks when relevant) requires a better understanding of surface morphology and texture and crystallinity (which relates to petrology and subsurface processes). This data can provide information on glass content, crystallinity, and surface texture. Despite the convolution of crystallinity and surface texture in the spectra, this method provides valuable information on the characteristics and mechanics of active lava flows.

**Planetary Applicability.** While flow morphologies have been utilized to broadly constrain effusion rates on planetary surfaces, that data is typically on too great of a scale to assist with modeling constraints, although submeter resolution data could improve.. VNIR observations of preserved lava flows might provide information on crystallinity and glass content as well as surface texture which could point back to magma production and processes during flow emplacement. Improved modelling in conjunction with laboratory analogue experiments could help produce better estimates of past eruption and emplacement conditions on other planets.

**Ongoing and Future Work:** Further excursions to active or recently erupted lava flows and lava lakes are necessary as is the decoupling of flow surface texture from crystallinity in the VNIR. Analysis of high resolution planetary data in conjunction with field studies would prove invaluable. Incorporation of such studies and laboratory experiments into dynamic models would be ideal.

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