VARIATION IN PETROGRAPHY OF BASALTIC LAVA FLOWS WITH SIMILAR SURFACE ROUGHNESS.

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Introduction: Basaltic lava flows are ubiquitous in our solar system, observed on terrestrial planets. After cooling, lava flows develop a range of surface roughness which can be characterized through remote sensing and field investigations [1]. Using remote sensing techniques to distinguish surface roughness is limited because it cannot determine the petrographic properties of the lava that are essential for interpreting geomorphic and physio-chemical properties. By using field analogue sites on Earth, we can tie the detailed geochemical and petrographic properties of lava flows to their surface roughness.

The goal of this study is using Craters of the Moon National Monument and Preserve (COTM) in Idaho as an analog for planetary lava flows and impact melt flows by comparing the petrography and surface roughness of their lava flows,. COTM is host to the largest Holocene lava field in the contiguous United States [2,3]. The lava field is situated on the northern section of the extensive rift zone known as the Great Rift, responsible for the formation of cinder cones, non-eruptive fissures, basaltic and rhyolitic shield volcanoes, and a suite of transitional lava flows produced by evolved magma sources [4-6]. Studying the COTM lava flows reveal that lava flows with similar surface roughness are not limited to one crystalline texture. Blocky, rubbly, and slabby pahoehoe surfaces contain petrographic textures indicating differences in cooling rates, arrangement of minerals, temperature, viscosity and geochemistry. Understanding the relationship between lava flow surface roughness, petrography, and geochemistry at COTM can improve interpretations on lava flows found elsewhere in our solar system.

Petrography and Surface Roughness: At COTM, we sampled six lava flows hosting a variety of surface roughness (e.g. Fig. 1a,b) and contrasting compositions. From these lava flows 45 samples were collected for petrographic analysis (Fig. 2a). Preliminary petrochemistry results from 12 thin sections of North Crater, Big Crater and Devil's Orchard lava flows are compared to their remote sensing data and field observations on surface roughness.

Surface Roughness: The Airborne Synthetic Aperture Radar (AIRSAR) produced L-Band (24 cm) images of COTM in March 2003. From this data, we produced circular polarization ratio (CPR) images to distinguish the decimeter-scale surface roughness of the lava flows (Fig. 2b). Low CPR (<0.5) indicates smooth surfaces while high CPR (0.5-1) indicates rougher surfaces. In cases where double-bounce backscattering dominates (such as in blocky lava flows), CPR may exceed unity. The CPR data shows surface roughness changes along single lava flows and between adjacent flows which occurs with distance and lava flow crystallinity.

Fig 1: (a) Blocky lava flow at Craters of the Moon composed of vesicular basaltic blocks.
(b) Rubbly pahoehoe lava flow at Craters of the Moon.

Petrographic Differences: The petrography of COTM lava flows have been previously studied to estimate their mineral mode and volcanic glass content [3,8] but no detailed comparison has been made to their surface roughness. The AIRSAR L-band radar shows the rubbly and slabby pahoehoe found in North and Big Crater flows to exhibit similar surface roughness. However, their petrography hosts different textures. The rubbly North Crater pahoehoe exhibits trachylitic textures, where applied stress has orientated elongate plagioclase (100μm) along a preferred stress plane (Fig. 3), and the slabby Big Crater pahoehoe exhibits an aphanitic texture with randomly orientated plagioclase enclosed in black hypocrystalline volcanic glass (Fig. 4).

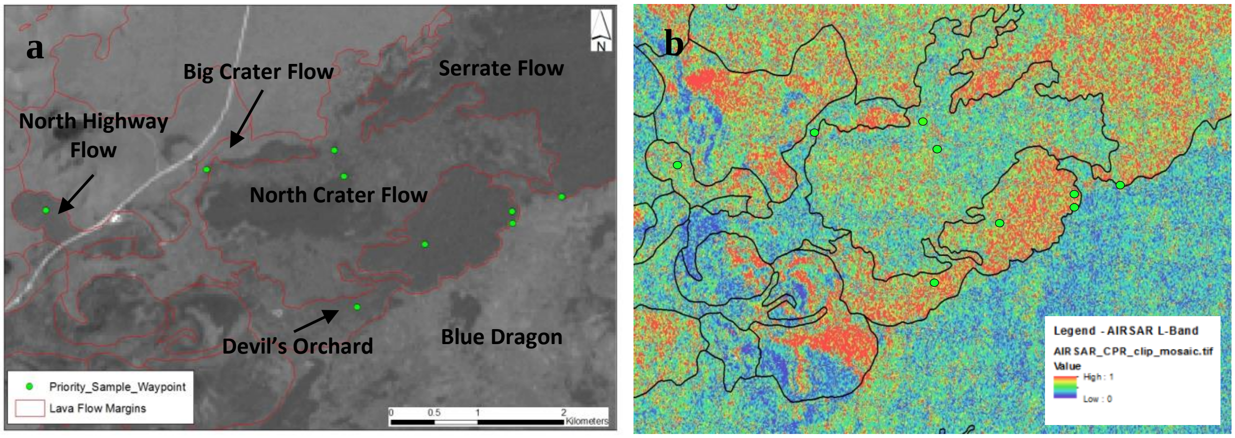

Fig 2: (a) The left image is an overview of the field site with labels of the lava flows at COTM. The green dots mark the locations of samples collected. **(b)** AIRSAR L-band CPR radar data distinguishes the surface roughness of the lava flows in the image on the right. Red indicates rough surfaces while blue indicates smooth.

The aphanitic textures in the slabby Big Crater flow represent samples taken 3cm beneath the surface. Aphanitic textures form from rapid cooling which typically produces smooth surfaces [9]. In this case, a pahoehoe crust likely formed first, and a later disruption of the lava flow caused the crust to fracture into large slabs. This process appears to be distinct from the process that produced the rubbly flow at North Crater, which may have involved more viscous tearing. The trachylitic textures are distal from North Crater source which is excepted as crystallinity and viscosity of the lava flow increases the further it flows from its source.

In the case of Devil's Orchard lava flow a transition from hypocrystalline to trachylitic to microtrachylitic textures is observed from its source to lip. Composition has negligible influence on Devil's Orchard because its geochemistry is uniform from source to lip. A petrographic change of this nature requires variations in lava rheology. Rheology of lava is controlled by its viscosity and yield strength which are altered when crystallinity and bubble content increases [10].

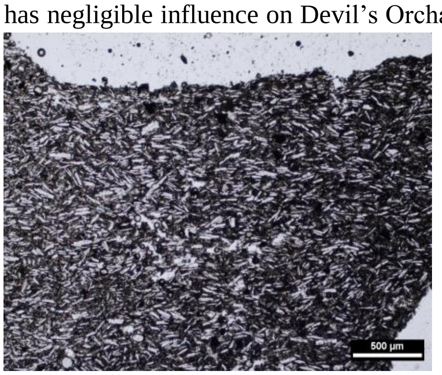

Fig 3: Trachylitic texture from the rubbly pahoehoe at North Crater Flow.

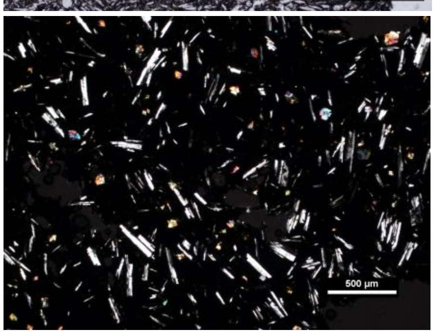

Fig 4: Slabby pahoehoe at Big/North Crater flow with aphanitic black volcanic glass matrix.

Ongoing research analyzing whole-rock geochemistry using X-ray fluorescence, and plagioclase crystals and volcanic glass using an electron microprobe will provide geochemical data on why this petrographic variation is present at COTM.

Conclusion: The surface roughness of the basaltic lava flows at COTM is comparative to other volcanic lava fields in our solar system, allowing for a field analogue study. Petrographic properties of North Crater, Big Crater, and Devil's Orchard vary despite having similar surface roughness as observed from radar remote sensing. Trachylitic and aphanitic textures in North and Big Crater flow would require changes in cooling rates while the texture change along the Devil's Orchard flow is more likely related to changes in rheology.

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