APPLICATIONS OF POLARIMETRIC RADAR REMOTE SENSING FOR PLANETARY VOLCANIC EXPLORATION. G. D. Tolometti[1,2], C. D. Neish[1,2], G. R. Osinski[1,2], C. W. Hamilton[3]. [1]Department of Earth Sciences, University of Western Ontario, 1151 Richmond Street, London ON N6A 3K7, Canada (gtolomet@uwo.ca), [2]Institute for Earth and Space Exploration, University of Western Ontario, 1151 Richmond Street, London ON N6A 3K7, Canada. [3]Lunar and Planetary Laboratory, University of Arizona, 1629 E. University Blvd., Tucson, AZ 85721.

Introduction: Radar remote sensing is commonly used to analyze the surface of lava flows on Earth. This is typically achieved by measuring the backscatter and polarimetry of returned radio waves [1–2]. These data are influenced by the surface roughness of a lava flow, which can be quantified by measuring the total backscatter (S1) and the circular polarization ratio (CPR) of the signal [3–5]. The surface roughness is a topographic property that can provide insights into the emplacement style of a lava flow, which is linked to the eruption dynamics of a volcanic event [6]. The use of radar to analyze and differentiate the surface roughness of lava flows offers opportunities for the remote study of volcanic deposits on other planetary bodies, including the Moon and Mars. If we can use radar to differentiate the surface roughness of lava flows on planetary bodies, we will be able to acquire information about planetary volcanic processes that have occurred in our solar system without the use of more expensive ground-truth observations (i.e., observations acquired by humans or robots on the surface).

To determine if radar can differentiate lava flow types, we need to understand the capabilities and limitations of the data. To address this, we need to compare field observations of a diverse array of lava flow textures to Synthetic Aperture Radar (SAR) data with wavelengths and resolutions comparable to available planetary SAR data. In this study, we ground-truth SAR data using observations acquired from two terrestrial analogue sites: (1) Craters of the Moon (COTM) National Monument and Preserve, Idaho and (2) the 2014–2015 Holuhraun lava flow-field, Iceland.

Methods: To measure the surface roughness of the lava flows, we used quad-polarized L-band (λ = 24 cm) radar data acquired by two airborne platforms operated by the Jet Propulsion Laboratory: the Airborne Synthetic Aperture Radar (AIRSAR) and the Unmanned Aerial Vehicle Synthetic Aperture Radar (UAVSAR). From the polarimetric radar data collected by both platforms, we measured CPR (e.g., Fig. 1) of the lava flows studied at COTM and the lava facies (a mixture of lava flow types) studied at Holuhraun.

Results: Our results revealed that \`a\`ā, transitional lava flows, and a siliceous (>55 wt %) block–\`a\`ā lava flow returned similar CPR values, making it difficult to distinguish them with SAR data alone. At Craters of the Moon, a rubbly pāhoehoe lava that formed from the mechanical fracturing of a stagnant, solidified lava crust returned similar CPR as a siliceous block–‘a‘ā flow that formed via viscous rupturing and creep fracturing [4]. At Holuhraun, we discovered that a spiny facie (comprising mainly spiny pāhoehoe with minor amounts of toothpaste lava, slabby pāhoehoe, rubbly pāhoehoe and ‘a‘ā [7]) and a rubbly facie (comprising mainly rubbly pāhoehoe lava with minor amounts of slabby pāhoehoe and ‘a‘ā [7]) both returned similar CPR values.

Discussion/Conclusion: Observing similarities in CPR between different lava flow types and facies demonstrates that there are limitations to using SAR data to differentiate surface roughness in volcanic regions. Despite differences in their emplacement, eruption dynamics, and magmatic origin, in SAR data their surfaces appear analogous. Without the inclusion of field observations, misinterpretations about the lava flows surface roughness, and therefore, emplacement styles and volcanic eruption history would occur. To further investigate the limitations and capabilities of using SAR to differentiate lava flow types, we need to include more study sites that are host to different forms of volcanism (e.g., fissure-fed vs. cone). Based on our results, it will be challenging to reliably identify lava flow types present in remote volcanic locations on Earth and on the surface of other planetary bodies.

Acknowledgments: Special thanks to the Canadian Space Agency for funding field deployments.

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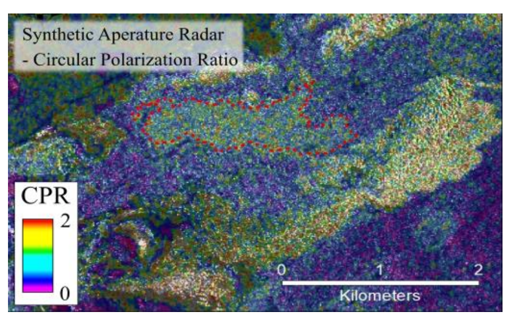

Figure 1. Example of SAR CPR data coverage of COTM. Red margins outline a rubbly pahoehoe flow