QUANTIFYING THE SURFACE ROUGHNESS OF THE 2014–2015 HOLUHRAUN LAVA FLOW USING RADAR AND LiDAR REMOTE SENSING

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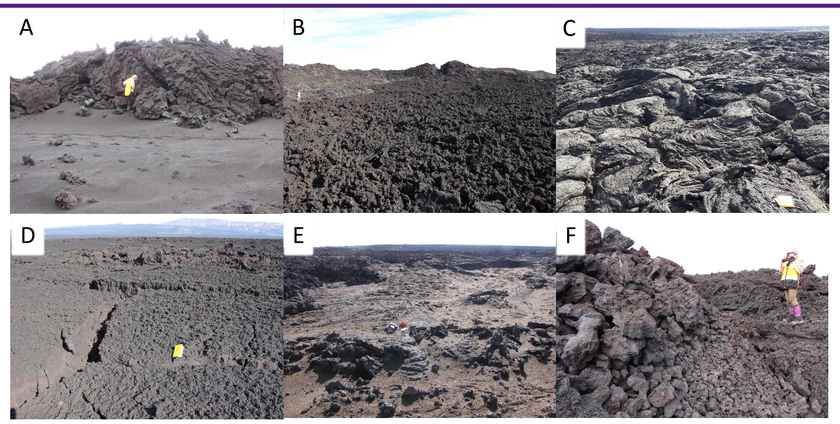
1. Introduction

- The surface roughness of lava flows is used to infer their emplacement processes and surface modifications on planetary bodies [1,2,3].
- Surface roughness is scale dependent, which provides different data (e.g., cm vs dm).
- Comparing the surface roughness of lava flows at cm and dm scales can help us interpret the emplacement of lunar lava flows where high-resolution remote sensing data is limited or absent.
- This study focuses on the 2014-15 Holuhraun lava flow-field in Iceland as it exhibits analogous morphologies and roughness to lunar lava flows [4].

2. Field Observations: Lava Flow Types

A – Spiny Toes
B – Spiny Polygonal Plates
C – `A`ā-like
D – Shelly Pond
E – Pāhoehoe-like
F – Rubbly



3. Remote Sensing Analysis

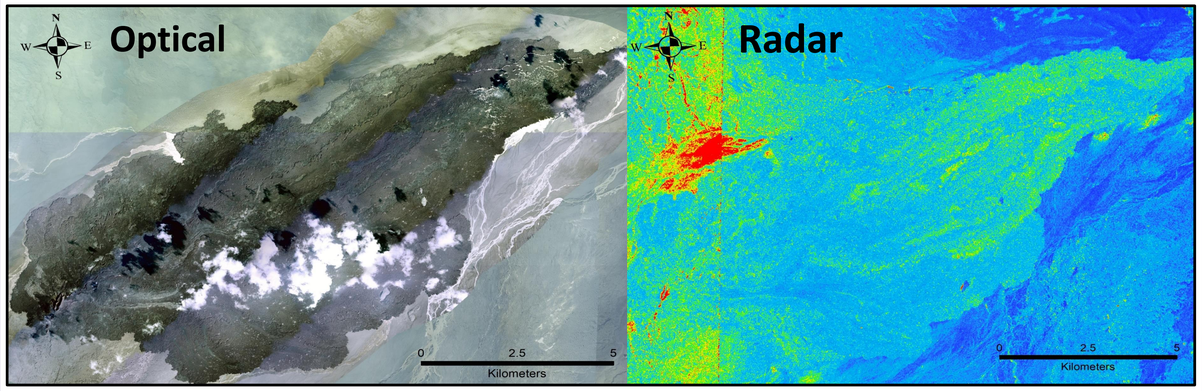


Figure 1. Optical and radar remote sensing data sets. (A) Aerial image mosaic (50 cm/pixel) of the Holuhraun lava flow-field acquired by Lofmyndir. (B) Circular polarization ration (CPR) data (8 m/pixel) acquired from the Unmanned Aerial Vehicle Synthetic Aperture Radar (UAVSAR) L-band (λ = 24-cm) instrument operated by JPL in 2015.

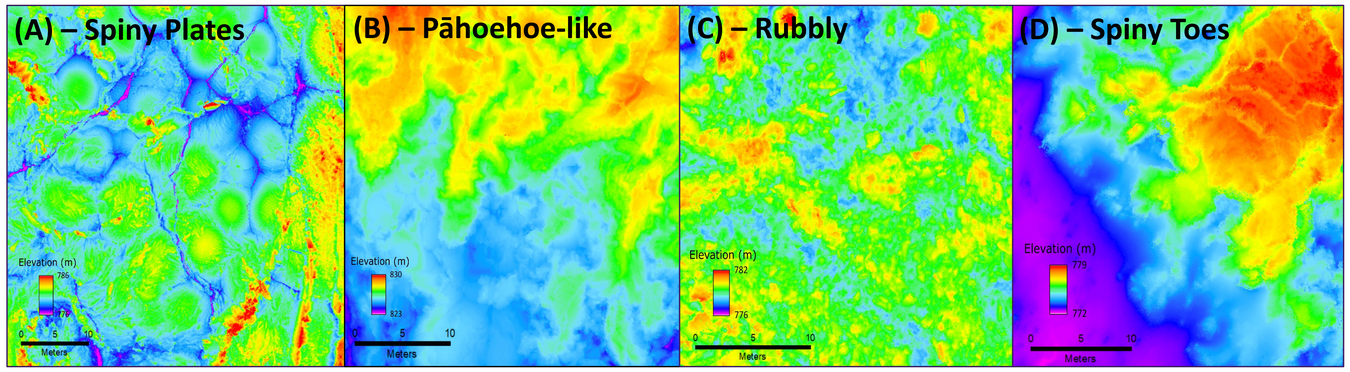


Figure 2. Digital Elevation Models (DEM) generated from high-resolution (2.5 cm – 5 cm/pixel) point clouds collected using a backpack-mounted LiDAR system [5]. Cm-scale roughness was extracted from the DEMs as RMS slope (Cs). DEM data set examples of four of the lava flow types are presented: (A) Spiny Plates, (B) Pāhoehoe-like, (C) Rubbly, and (D) Spiny Toes .

4. Centimetre vs Decimetre-Scale Roughness

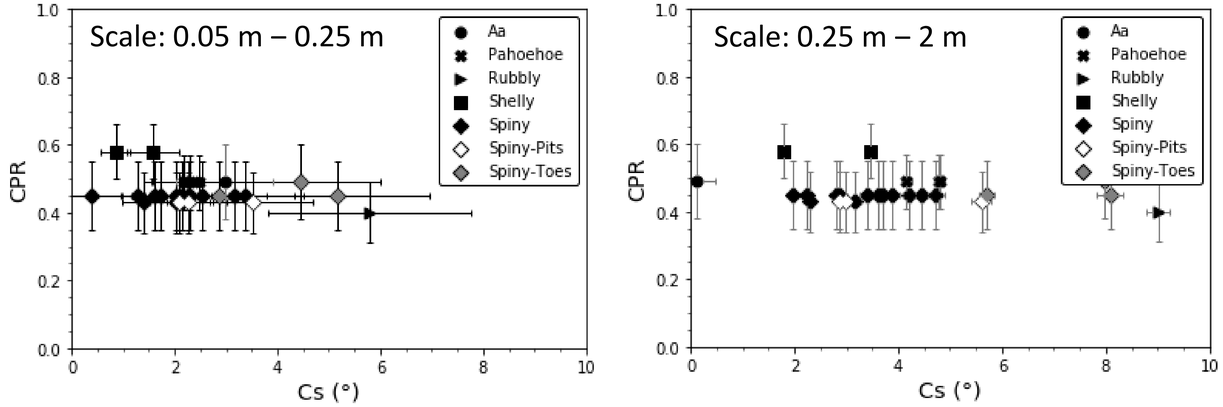


Figure 3. Dm-scale CPR data from UAVSAR plotted against Cs values extracted from the cm-scale LiDAR DEMs. No correlation is observed between L-band UAVSAR and high-resolution topographic data. The spiny lava flow types overlap with every other lava flow type at Holuhraun. The shelly pond surface can be distinguished from spiny toes and the rubbly flow, but only at the cm-scale.

5. Summary

- Cm-scale roughness is quantified using RMS slope (Cs) from the DEMs and dm-scale roughness is quantified using CPR from UAVSAR L-Band data.
- No correlation is observed between Cs and CPR.
- At the cm-scale, the lava flow types are not homogenous in roughness across the lava flow-field.
- CPR may not be the appropriate parameter to infer emplacement processes of lava flows.

References: [1] Campbell B.A. and Shepard M.K. (1996) J. Geophys. Res. *101*, 8, 18941–18951. Lava flow surface roughness and depolarization scattering [2] Shepard M.K. et al. (2001) J. Geophys. Res. *106*, 12, 32777–32795. The roughness of natural terrain: A planetary and remote sensing perspective. [3] Tolometti G.D. et al., (2020) Plan. and Space Sci. *190*, 104991. Interpretations of lava flow properties from radar remote sensing data. [4] Neish C.D. et al., (2017) Icarus. *281*, 73–89. Terrestrial analogues for lunar impact melt flows. [5] Kukko A. (2013) Pub. Finnish Geodetic Institute. 153. Mobile Laser Scanning – System development, performance and applications.

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