MAPPING FRESH LAVA FLOWS WITH MULTI-WAVELENGTH RADAR IMAGERY IN SUPPORT OF PLANETARY ANALOGUE STUDIES. M. Zanetti[1], C. Neish[1], B-H Choe[1], J. L. Heldmann[2], and the SSERVI FINESSE Team, [1]University of Western Ontario, 1151 Richmond St, London, Ontario, Canada. [2]NASA Ames Research Center, Moffett Field, CA 94035, USA (Michael.Zanetti@uwo.ca).

Introduction: Impact cratering and volcanism have been critical processes in the geologic history of the terrestrial planets. Investigating these processes on Earth by means of ground-truthed remote-sensing and field measurements provide important information for the study of other planetary bodies. NASA's FINESSE (Field Investigations to Enable Solar System Science and Exploration) project is designed to generate strategic knowledge in preparation for human and robotic exploration of other planetary bodies, including the Moon, Mars' moons, and near-Earth asteroids, by means of remote-sensing and field investigations of suitable planetary analog sites on Earth [1]. The Craters of the Moon National Monument and Preserve (COTM) is a ~1650 km^2 volcanic complex in the eastern Snake River Plain, Idaho (Fig. 1). COTM has long been identified as a strong planetary analog for volcanic processes on the Moon, Mars, Venus, and Mercury [2], as well as a possible proxy for the melt products of the impact cratering process [3]. Basaltic lava flows, formed during at least 8 eruptive episodes between 15,000 and 2,000 years ago, emanate from an 80 km long rift zone. These eruptions resulted in a diverse collection of volcanic structures, producing surfaces with a wide range in morphology, texture, and roughness, making COTM an excellent field analog site.

In this work we seek to use satellite and airborne synthetic aperture radar (SAR) images from the L-Band (24 cm) AIRSAR [4] and C-Band (5.6 cm) RADARSAT-2 [5] polarimetric radars, to investigate the surface roughness of lava flows and volcanic features using the circular polarization ratio (CPR). Information on the surface roughness of flows at different wavelengths from remote sensing will be ground-truthed during a field campaign in August, 2016, to enhance remote predictive mapping techniques useful for planetary missions. We will then compare the returns to polarimetric radar data acquired for lava flows and impact melt flows on the Moon [3], Venus [6], and Mars [7].

Data and Methods: Two SAR radar datasets are used for mapping of lava flows in the COTM volcanic field. AIRSAR was an airborne SAR operated by NASA between 1988 and 2004. It was capable of transmitting and receiving fully polarimetric radar data (i.e., HH, HV, VH, and VV) at C-, L-, and P-Bands. Previous studies of COTM utilized L-Band radar imaging, but these studies did not make use of the full polarimetric potential of the dataset [8-10]. For this project we have used AIRSAR L-Band data collected in March, 2003. From this data, we produced the circular polarization ratio (CPR), useful for characterizing the surface roughness and physical properties of the target surface (Fig. 2b). CPR is the ratio of same-as-transmitted circular polarization signal divided by the opposite-as-transmitted circular polarization signal. Surfaces that are smooth at the radar wavelength exhibit very low CPR (<<1, single bounce backscattering), rough surfaces have moderate CPR values (0.5 – .9, multiple bounce, randomized polarization), and blocky surfaces have very high CPR (>1, corner reflector, double bounce backscattering).

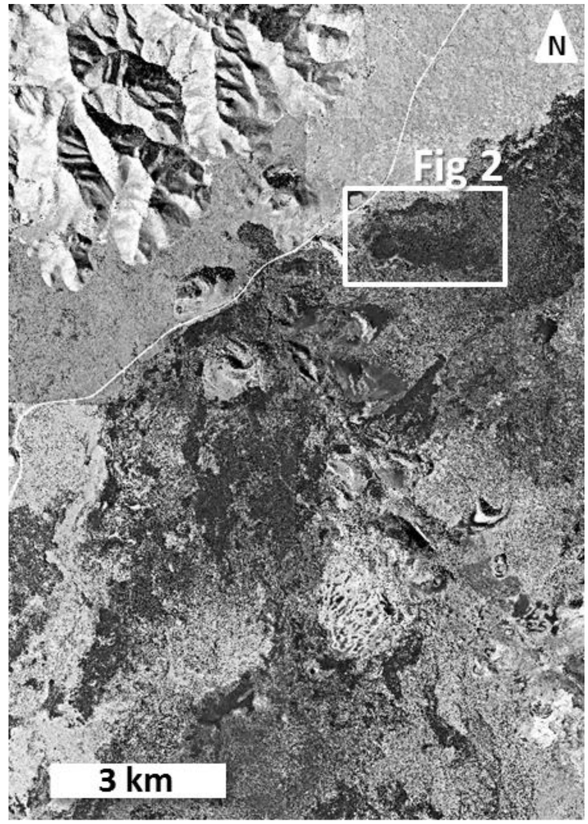

Figure 1: Northern region of the Craters of the Moon volcanic complex and rift system (centered at 43°27'45''N / 113°32'14'') [National Agriculture Imagery Program (NAIP) 0.5 m/pixel image].

RADARSAT-2 is a commercial Earth observation satellite operated by MacDonald, Dettwiler and Associate, Ltd. It carries a fully polarimetric radar instrument operating in the C-Band. Fine quad-pol data was acquired over COTM in October and November 2015. AIRSAR and RADARSAT-2 data were then overlaid on USGS National Elevation Dataset (NED) DEMs (7.5 m/pixel) and visible imagery from the National Agriculture Imagery Program (NAIP) (~50 cm/pixel) in ArcGIS for further study.

Preliminary Results and Discussion: Significant differences in the apparent surface roughness of lava flows can be seen between the L- and C-Band radar imagery. A useful example can be seen at the 2 km long North Crater flow in the northern part of COTM (Fig. 2). Red and yellow regions of the flow have a high CPR, indicating they have high surface roughness at L-Band wavelength (24 cm). This is sharply contrasted with the low CPR values observed at C-Band wavelengths (Fig. 2c), indicating that the surface roughness at ~5.6 cm wavelength contains many fewer corner reflectors and appears much smoother. This major discrepancy between the apparent surface roughness at L- and C-Band radar wavelengths highlights the importance of multiple observations at different frequencies to completely describe the surface characteristics of potential landing sites for future landed planetary missions. For example, the lava flow may appear to be 'smooth' at C-Band, but given the decimeter scale roughness observed at L-Band, spacecraft and astronauts would have difficulty operating in such terrain.

Future Work: Detailed maps of lava flows at COTM in both L- and C- Bands will be correlated with ground measurements during a field campaign in August 2016, with focus on nested block size measurements at different scales. Understanding lava flow roughness at various scales will help us to understand how the flow are emplaced, providing analogues for similarly rough lava flows and impact melt flows on the Moon and Mars.

Acknowledgements: Data from the AIRSAR project was freely obtained at airsar.jpl.nasa.gov. RADARSAT-2 data and products are copyright of MacDonald, Dettwiler and Associates Ltd. (2015), All Rights Reserved. RADARSAT is an official trademark of the Canadian Space Agency.

References: [1] Heldmann et al., 2013 AGU #P54B-01 [2] Greeley *et al*. 1977. In "Volcanism of the Eastern River Plain, Idaho", 171. [3] Neish et al., 2015 DPS meeting #47, id. #107.08 [4] Evans et al., 1988 IEEE Trans. Geosci. Remote Sens., 26 (1988), pp. 774–789 [5] Ali et al., 2004 Canadian Journal of Remote Sensing V30, 3 [6] Carter et al., 2006 JGR, V111, E6 [7] Harmon et al., 2012 Icarus, V220, 2, 990-1030 [8] Greeley and Martel, 1988 Int. J. Rem. Sens., 9 (1988), pp. 1071–1085 [9] Campbell et al., 1989 Remote Sensing of Environment V30, 3, 227-237 [10] Kahn and Heggy, 2007 Geophysics, V72, 6, 161-174

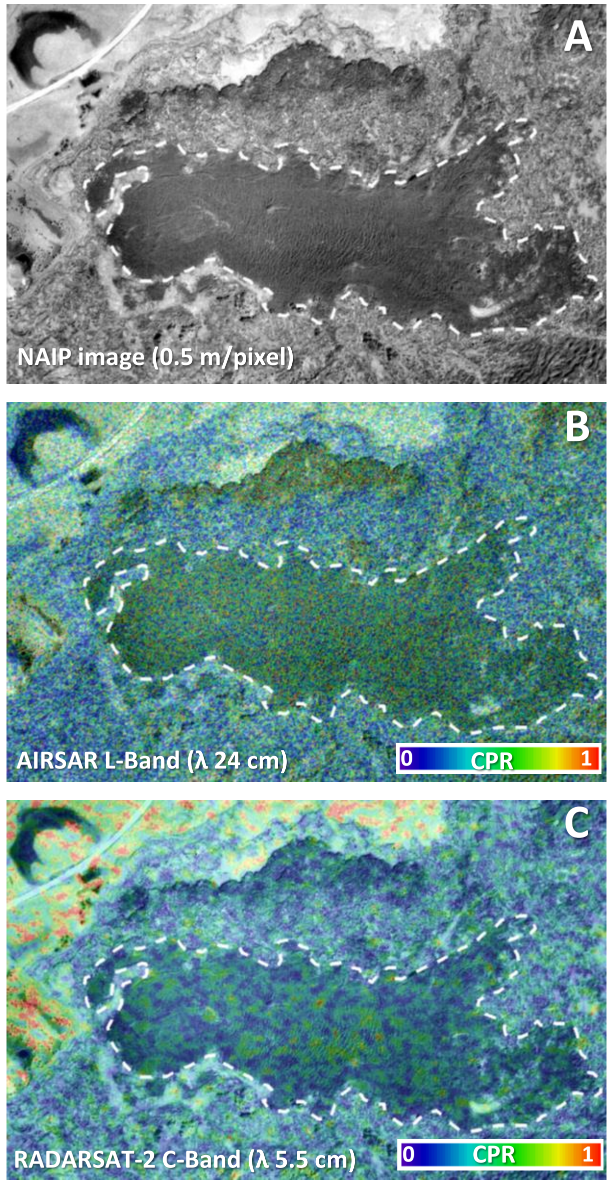

Figure 2: A) High resolution image of the 2 km long North Crater Flow in the northern part of Craters of the Moon National Monument and Preserve. The flow appears relatively rough in visible imagery, with a ropey/wavy texture. B) AIRSAR L-Band radar imagery draped over (A). Areas of high CPR across the flow and in areas to the north suggest a blocky texture at 24 cm wavelength. Field reconnaissance in 2015 confirmed the texture at this scale. C) RADARSAT-2 C-Band radar imagery draped over (A) shows very low CPR values at 5.6 cm wavelength, in contrast to the rough appearance of the flow in L-Band. Further reconnaissance and field measurements are necessary to determine the nature of the differences between the two radar datasets.