NEW ORBITAL L-BAND RADAR OBSERVATIONS OF ARISTARCHUS PLATEAU. S. S. Bhiravarasu[1], B. A. Campbell[2], G. D. Tolometti[3], J. T. S. Cahill[4], A. Das[1], G. W. Patterson[4], T. Chakraborty[1], G. A. Morgan[5], D. K. Pandey[1], B. J. Thomson[6], and D. Putrevu[1]. [1]Space Applications Centre (ISRO), Ahmedabad, Gujarat, India (sriram.saran@sac.isro.gov.in), [2]Smithsonian Institution Center for Earth and Planetary Studies, Washington DC, [3]Western University, London, Ontario, [4]Johns Hopkins University Applied Physics Laboratory, Laurel MD, [5]Planetary Science Institute, Tucson AZ, [6]University of Tennessee, Knoxville TN.

Introduction: Imaging radar observations provide complementary information on the physical properties of the mantling layers associated with volcanic processes [e.g., 1, 2]. The low radar backscatter and circular polarization ratio (CPR) values associated with pyroclastic material provide a useful method of distinguishing fine-grained volcanic material from the optically dark maria, particularly in cases where optical and near-infrared data are ambiguous about their presence [1–3].

Using the Dual Frequency Synthetic Aperture Radar (DFSAR) instrument onboard ISRO's Chandrayaan-2 mission [4], we are collecting L-band, fully polarimetric radar images of the Aristarchus Plateau, which represents the largest known pyroclastic deposit on the Moon [1, 3]. We report here on the initial observations of thickness variations within the mantled deposit and the Aristarchus crater ejecta that overlies and adds to the near-surface stratigraphy of the plateau.

DFSAR data: The DFSAR is a monostatic SAR system, operating at the 24 cm (L-band) and 12 cm (S-band) wavelengths [4]. Since its commissioning phase in September 2019, DFSAR has been collecting L- and S-band polarimetric data of the lunar poles (75°–90° N and S). Along with this systematic coverage, in imaging seasons that typically lasts 3 months, DFSAR collects data of ~15–20 non-polar targets of interest. To date, DFSAR has collected four L-band fully polarimetric datasets across the Aristarchus plateau (**Fig. 1**) at an incidence angle of 26° and at a slant range resolution of ~0.5 × 9.6 m in azimuth and range directions respectively. Further processing (i.e., multi-look and orthorectification) of these observations produce ~ 22 m/pixel resolution images, with around 45 looks as given in **Figure 1.**

Aristarchus Plateau: The Aristarchus region has been imaged many times, from ground-based (e.g., Arecibo-Greenbank) as well as spacecraft-based (e.g., Mini-RF onboard LRO) radar instruments in both monostatic [1, 3] and bistatic [5] configurations. The plateau hosts perhaps the greatest diversity of both basaltic and silicic volcanic features on the Moon, including pyroclastic deposits [1, 3], the largest sinuous rille, domes, and irregular mare patches [6] that may represent some of the youngest known volcanic deposits. Even though a large portion of the visible surface of the plateau is dominated by radar-dark pyroclastics (very low CPR regions surrounding the Aristarchus crater in **Fig. 1**), there are regional variations across the deposit and Arecibo 12.6- and 70-cm data revealed a marked dichotomy in the thickness and volume rock abundance of pyroclastic material [3]. In particular, the 70-cm radar data has revealed regions of thinly mantled basaltic flows south and east of the Vallis Schrotëri rille and a radar-dark halo surrounding Aristarchus crater where its ejecta overlie mare basalts south and east of the crater, implying that this halo extends onto the plateau [3]. Moreover, the Arecibo 12.6-cm data revealed regions of high backscatter radial to Aristarchus crater (**Fig. 1**) suggesting the presence of numerous ~2cm or larger rocks within the mantling deposit [3].

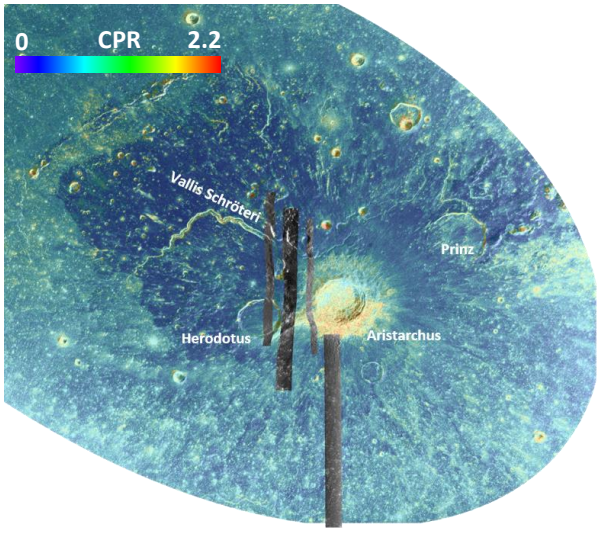

Figure 1: L-band DFSAR HH polarization images overlaid on an Arecibo S-band (12.6 cm) radar image (colorized CPR overlaid on opposite-sense circular polarization, where purple is 0 and red is 2.2 and above) of the Aristarchus plateau.

Using L-band DFSAR data, we are particularly interested in (i) providing new estimates on the thickness of Aristarchus pyroclastics by identifying the smallest young craters that excavate rocky (radar bright) debris for detecting thick, rock-poor layers and (ii) characterizing the Aristarchus crater secondary ejecta that are possibly buried within the pyroclastic mantle as observed from the 12.6-cm radar observations [3]. Due

to their low TiO_2 content (and therefore low loss tangents), the pyroclastics may allow a penetration depth of ~3–5 m at 24 cm, intermediate to those possible at 12.6 cm and 70 cm wavelengths.

Initial results: In DFSAR L-band data, we observe that the mantling deposits and crater ejecta are distinctly highlighted in the cross-polarization (HV) images compared to the co-polarization (HH) images. This can be observed from **Figure 2**, in which we show an L-band DFSAR data strip that covers a portion of the pyroclastic deposit and Aristarchus ejecta southwest of the crater. Within this ejecta region, the L-band radar echoes, which are sensitive to rocks ~2 cm and larger, are nearly as bright as observed from the Arecibo S- and P-band data of this region [3].

Future work: We will use both the S-band (Arecibo and Mini-RF) and L-band (DFSAR) high-resolution data to study the thickness variations within the mantling materials and abundance of centimeter- to decimeter-scale rocks on and within the plateau regolith. Moreover, combined with loss tangent values derived from microwave radiometer data [7], modeling/retrieval of dielectric constant values associated with Aristarchus pyroclastics from DFSAR fully polarimetric data may provide additional information on the composition of resource-bearing glass beads for in situ exploration [8]. The DFSAR team is currently planning to acquire complete coverage of the Aristarchus Plateau in L-band fully polarimetric mode. Combined with the radar data available at X-, S-, and P-bands, along with the newly available/planned X-band bistatic data from the Mini-RF, we aim to understand the diversity of volcanic features and geologic structures of this important region in more detail.

References: [1] Zisk et al., The Moon, 17, 59-99, 1977. [2] Carter et al., JGR, 114, E11004, 2009. [3] Campbell et al., Geology, 36, 135-138, 2008. [4] Bhiravarasu et al., PSJ, 2, 134, 2021. [5] Patterson et al., Icarus, 283, 2, 2017. [6] Braden et al., Nat. GeoSci., 7, 787, 2014. [7] Siegler et al., JGR, 125, 9, e2020JE006405, 2020. [8] Glotch et al., PSJ, 2, 136, 2021.

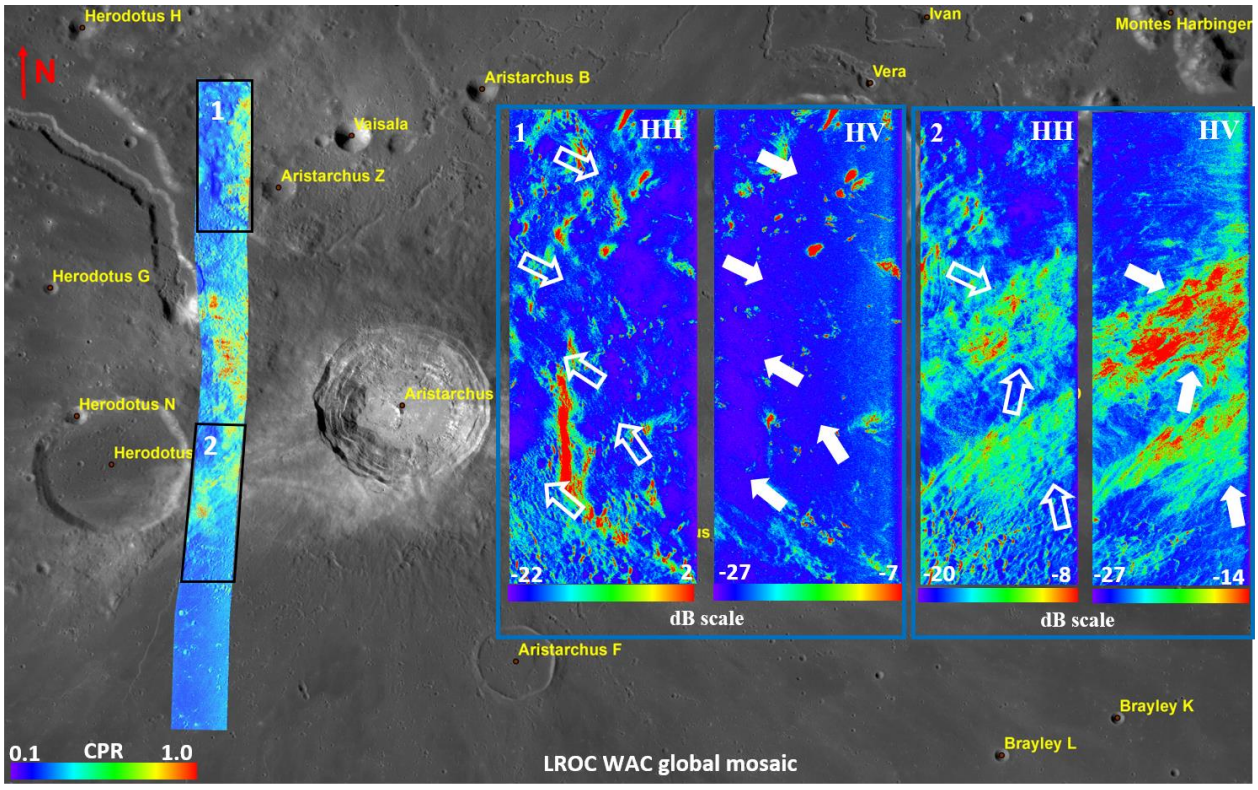

Figure 2: An L-band DFSAR Circular Polarization Ratio (CPR) image cross-cutting the Aristarchus region and overlaid on an LROC WAC optical image mosaic. Changes in the CPR values across the DFSAR data strip show areas with increased rock abundance (from Aristarchus crater ejecta) as well as mantling deposits that are shallower. The cross-polarization (**HV**) images in the zoomed-in subsets (with a color scheme, on the right) distinctly highlight the dark-mantled pyroclastic deposits (left, set 1) and Aristarchus crater ejecta (right, set 2) that are not readily apparent in the corresponding co-polarization (**HH**) radar images, as indicated by the open white (**HH**) and solid white (**HV**) arrows.