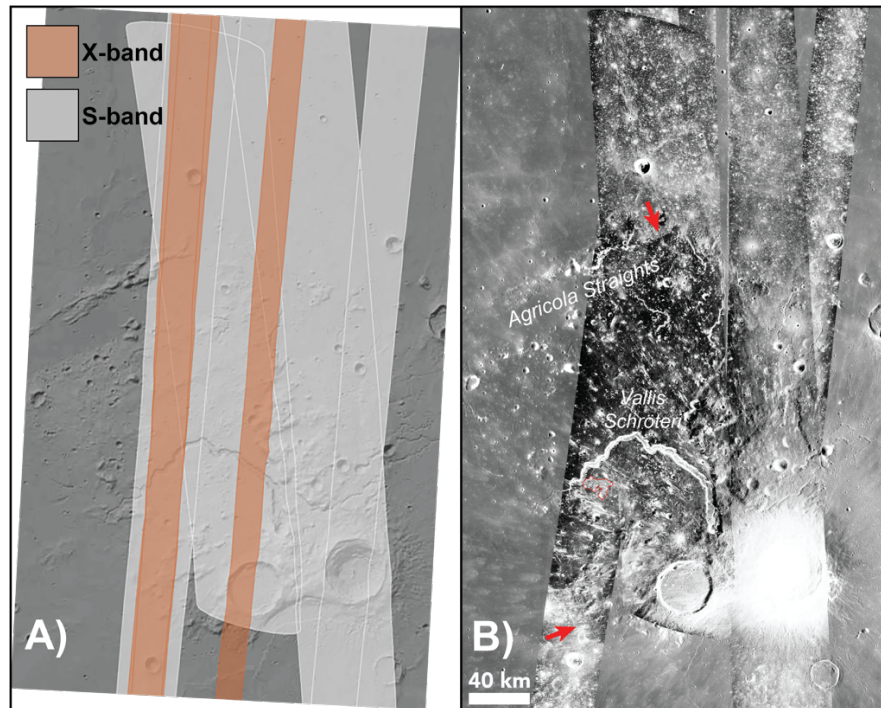


# UNPACKING THE DIVERSITY OF ARISTARCHUS AND PROCELLARUM VOLCANISM WITH MULTI-WAVELENGTH RADAR

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**Figure 1** (A) Mini-RF bistatic multi-wavelength coverage of the Aristarchus Plateau and surrounding Oceanus Procellarum. (B) S-band (12.6 cm wavelength) radar image mosaic (S1 radar data, equivalent to total backscattered power). The radar bright region delineated by the red line correspond to lava flows below a locally thin region of the pyroclastic deposit. Red arrows highlight the terminal extent of the pyroclastic blanket to the SW and NE (see text for more details).

**Summary:** We take a new perspective of the physical extent and stratigraphic relationships between pyroclastic deposits and mare flows in the Aristarchus/Procellarum region of the Moon using Mini-RF X and S-band data.

**Introduction:** The Aristarchus Plateau on the lunar nearside is host to a diverse assemblage of volcanic features including extensive pyroclastic deposits, multiple rilles such as the prominent Vallis Schröteri, in addition to examples of intrusive and extrusive silicic volcanism (**Figure 1**). A small Irregular Mare Patch (IMP) - a pristine and potentially very geologically young (~100 Ma) class of volcanic feature [1] - is also present on the plateau's southern flanks. The plateau is surrounded by the flood basalts of Oceanus Procellarum which, with the possible exception of the enigmatic IMPs, include the youngest volcanic flows identified on the Moon (unit P60 in [2]). Collectively, the Aristarchus Plateau region preserves a full spectrum of eruptive styles that spans the history of lunar volcanic activity.

At the 53<sup>rd</sup> LPSC we will present the results of analysis of Mini-RF S (12.6 cm) and X-band (4.2 cm) bistatic radar coverage of the Aristarchus Plateau and surrounding mare (**Figure 1**). Building off previous, earth-based radar studies [3–7] our new analysis provides unique insights into the volcanic history of the region.

**Mini-RF Data:** The Mini-RF instrument aboard NASA Lunar Reconnaissance Orbiter (LRO) is a hybrid-polarized, dual-frequency synthetic aperture radar (SAR) that operates in cooperation with the Arecibo Observatory (AO) and the Goldstone deep space communications complex antenna DSS-13 to collect data at 12.6 cm (S-band) and 4.2 cm (X/C-Band) wavelengths, respectively. For each observation, the surface is illuminated with a circularly polarized, chirped signal that tracks the Mini-RF antenna boresight intercept on the surface of the Moon. The Mini-RF receiver operates continuously, separately receiving the horizontal and vertical polarization components of the signal backscattered from the lunar surface. In this architecture, the incidence

angle varies as a function of the observation geometry, and the data have a spatial resolution of  $\sim 100$  m in range and  $\sim 2.5$  m in azimuth. The data are coherently processed onto grids with a spacing of 4 m along-track and 25 m cross-track. For analysis, they are then incoherently reduced to a uniform 100 m grid yielding 25 effective looks for each sampled location.

**Pyroclastic/Mare Stratigraphy:** Quantifying the scale of the explosive eruptions responsible for the Aristarchus pyroclastics and the volume of the associated resources - due to the high  $\text{H}_2\text{O}$  content - requires accurate knowledge of the spatial extent of the blanket. Such mapping efforts are also important as they enable the stratigraphy of the deposits relative to other units to be established, which in turn provides insights into the timing of the eruptions. We find that backscatter boundaries in the southwest and northeast (described below) may provide bookends on the timing of the formation of this pyroclastic deposit, offering constraints on eruptions to between 1 and 3 Ga.

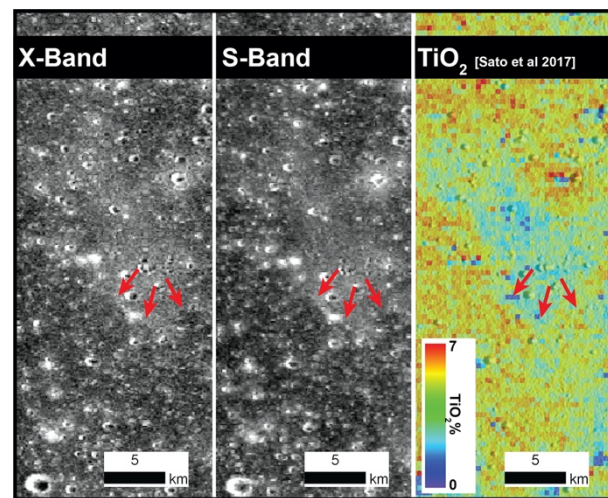
**Southwest:** In the southwest region of the plateau, both wavelengths display a low backscatter signature which abruptly terminates along the boundary where the Procellarum mare flows embay the plateau flanks (**Figure 1**). This distinct contrast in radar backscatter was also noted by [7] and suggests these mare flows postdate the pyroclastics. Dating efforts have identified the basaltic flows to the southwest to constitute the youngest mare surfaces on the Moon (excluding the potentially very juvenile age of the IMPs), with an age  $\sim 1$  Ga [2,8].

**Northeast:** To the northeast of the plateau, the two radar datasets suggest the pyroclastics extend onto the surface of the mare flows that are situated between the plateau and Montes Agricola (the Agricola Straights). **Figure 1** shows low backscatter values (relative to those returned from the mare as a whole) extend from the plateau and onto the eastern side of the mare within the Agricola Straights, thus suggesting the pyroclastic blanket in this region sits stratigraphically above the mare flows. It therefore appears that this region of the mare was emplaced prior to (at least) the final phase of pyroclastic eruptions. No age estimates have been presented within the literature for this region of the mare. If the Agricola Straights mare are associated with the adjacent P26 unit, then the associated 3Ga age [2] places constraints on the timing and duration of explosive eruptions on the plateau.

**Plateau Center:** In contrast to the relatively radar dark pyroclastics that blanket most of the Aristarchus Plateau, a small region within the center of the plateau exhibits relatively high backscatter in the Mini-RF data (**Figure 1**). This region was also highlighted by [7] - due to the enhanced Earth-based S and P-band backscatter - and was interpreted to be due the presence of shallow mare below regions where the blanket was relatively thin. At both Mini-RF wavelengths, anonymously bright

radar returns can be traced extending from the southern rim of Vallis Schröteri for  $\sim 20$ km in a southeastern direction.

**Young Mare Flows:** Mini-RF coverage (at both wavelengths) of Oceanus Procellarum have also shown that fine-scale flow boundaries between Eratosthenian-age units can be traced. For example **Figure 2** highlights a potential flow boundary in northern Oceanus Procellarum. The boundary likely reflects concentrations of blocky material in the upper 10s of cm in the younger flow relative to the older unit, but the boundaries may also be due to differences in composition. Mapping such flows will provide new insights into mare stratigraphy, that can be compared to regional age dating efforts [2].



**Figure 2.** Mare unit boundary (red arrows) identified in X and S-band S1 radar images in northern Procellarum. Boundaries are mapped at much finer scale (sub km) relative to the [2] studies. Note the flow boundary shows some agreement to  $\text{TiO}_2$  abundances [9], suggesting the flows exhibit different compositions.

**Complementary Radar Investigation at the 53<sup>rd</sup> LSPC:** Please see Bhiravarasu et al [10] presentation of Dual Frequency Synthetic Aperture Radar (DFSAR, onboard ISRO's Chandrayaan-2 mission) L-band (24 cm) data analysis of the Aristarchus Plateau.

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