INVESTIGATING ANOMALOUS LUNAR RADAR DETECTIONS USING ORBITAL DATASETS. C. P. Harris\textsuperscript{1}, B. J. Thomson\textsuperscript{1}, G. W. Patterson\textsuperscript{2}, E. G. Rivera-Valentín\textsuperscript{3}, J. T. S. Cahill\textsuperscript{2}, \textsuperscript{1}Department of Earth and Planetary Sciences, University of Tennessee, Knoxville, TN (charr144@vols.utk.edu), \textsuperscript{2}Johns Hopkins University Applied Physics Laboratory, Laurel, MD.

**Introduction:** The Atlas crater region of the lunar surface can be characterized by its interesting and unusual thermophysical properties. The region surrounds and includes Atlas, Hercules, Keldysh, and Burg craters (Figure 1). Previous investigations utilized Lunar Reconnaissance Orbiter (LRO) orbital data, including Diviner H-parameter maps and Mini-RF synthetic aperture radar (SAR) observations, and indicate that the region has low radar backscatter properties similar to radar-dark halo craters [1]. The region’s relatively high H-parameter values, however, are more anomalous and not as consistent with radar-dark halo craters. These properties may be indicative of a region of high porosity, fine grain regolith largely devoid of surface or shallow subsurface scatterers. Formation mechanisms for the region remain unclear [1].

*Figure 1: Area map of the Atlas crater region [2].*

In recent Mini-RF bistatic observations of the Atlas crater region, some small-scale anomalous features have been identified in the vicinity of Atlas crater. These features most notably exhibit very high circular polarization ratio (CPR) values relative to their surroundings. Positively identified high-CPR features are linear in shape ranging from roughly 3 to 7 km along the longest axis, and some 600 to 700 m at their widest points. Features identified thus far appear to have a northwest-southeast orientation, although the precise orientation of the long axis varies slightly between features. The most prominent features have been identified within the Atlas crater ejecta blanket, but similar anomalous high-CPR features have also been identified south of the Atlas ejecta blanket as well. This work seeks to better define and identify these anomalous features, which appear in a region of the Moon already characterized by its distinct physical properties.

**Methods:** The anomalous high-CPR features in question were initially identified in Mini-RF bistatic observations [3] in X-band (~4.2 cm). We have attempted to further characterize these high CPR anomalies by mapping their extent and distribution in various radar parameter maps [4] (Figure 2), creating topographic profiles from lunar digital elevation models (DEMs) [5], and examining Lunar Reconnaissance Orbiter Camera (LROC) Wide Angle Camera (WAC) global maps [2] for coincident photometric anomalies. Other lunar datasets are overlayed and compared with the bistatic X-band observations in question to identify any additional surface properties that could be associated with these anomalous features. Mini-RF data was processed using USGS Integrated Software for Imagers and Spectrometers (ISIS) [6], and mapping efforts and measurements done using Esri ArcGIS Pro.

**Results:** Currently, twelve anomalous high-CPR features have been identified across four Mini-RF bistatic swaths, along with several other potential but unconfirmed anomalous features. They appear on the Atlas crater ejecta blanket to the north and west of the crater, and far to the south as well with some being identified near Newcomb crater. These features have not yet been identified in overlapping Mini-RF monostatic CPR observations in S-band (~12.6 cm), which tend to be much more radar-dark in the areas of interest, or in 8CPR data derived from the monostatic S-band data [7]. As of yet, no association has been found between these anomalies and any noticeable features in Diviner Rock Abundance maps, or surface compositional data.

**Discussion:** High radar CPR values typically are associated with wavelength-scale complexity, such as rough-textured surfaces, rock abundance, scatterer morphology, and size frequency distribution [8, 9, 10]. These features are anomalous because not only do they exhibit relatively high-CPR values, but they are also not associated with any visible surface expression or feature that would explain their shape or orientation. They are not radially or concentrically aligned with proximal craters and do not appear to have any clear correlation...
with surface topography. One potential hypothesis is that these features could be collections of blocky or rough material in the immediate subsurface, and that their appearance in only a subset of bistatic observations is a function of incidence angle. It is also possible that these features represent surface roughness at a scale resolvable in X-band, but not necessarily in S-band observations. Their common orientation could be interpreted as possible rocky ejecta from a distal as-of-yet-identified source crater, perhaps buried under a thin layer of regolith. Another possibility is that these represent a type of radar data artifact. While not yet ruled out, the appearance of these features across multiple collects and their consistent, non-random appearance and orientation is unusual should this be the case.

To further investigate the properties of these features, additional radar data products will be incorporated to better characterize the scattering properties of these features. The orientation of each identified feature will also be traced in both the northwest and southeast directions along the long axis to determine if multiple features align with a potential source crater elsewhere on the lunar surface. This could be indicative of buried crater ray material.

**Conclusions:** These anomalous high-CPR features remain enigmatic. Their properties and origins continue to defy rigorous description beyond basic identification. This work is ongoing, and the list of lunar datasets utilized thus far is far from exhaustive. More work is required to either confirm or rule out the possibility that these features are simply data artifacts, or if they are indeed representative of buried objects or surface scatterers only detectable at certain wavelengths or incidence angle thresholds.


**Figure 2:** Region north of Atlas crater. (A) Mini-RF bistatic X-band CPR data, anomalous features appear as red streaks in the center of the image [5]. (B) Mini-RF monostatic S-band CPR data [5]. (C) Mini-RF S-band δCPR data [7]. (D) Diviner rock abundance data [11], location of anomalous features highlighted in pink for clarity.