Supplementary information for

Volume scattering of radar signals is not a single diagnostic indicator of water ice within permanently shadowed regions near the lunar poles

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Methods

I. **Data used***:* We utilized the 6 DFSAR datasets as given in the supplementary info of *Sinha et al.2026* that covers the 10 investigated south polar craters (F1−F3, S1−S3, H1−H3, Tooley), and two non-polar datasets that cover lunar craters Tycho (ch2_sar_ncxl_20220421t231427182_d_fp_d18) and Byrgius C (ch2_sar_ncxl_20200916t034205894_d_fp_d18). These data were acquired in L-band, fully polarimetric (FP) mode at a nominal (swath-center) incidence angle of 26°, except one dataset that was acquired in dual-frequency (L-&S-bands) hybrid polarimetry (HP) format (ch2_sar_ncls_20200808t201154198_d_cp_d18). For the FP data, we used 45 looks (Azimuth direction) to reduce the speckle noise associated with each radar pixel, and therefore the associated radar parameters reported for these data have an uncertainty of 15% (1/√45). For the HP dataset, the swath-centre incidence angle is 20°, and we used 60 looks to process it (L-band only), resulting in an uncertainty level for radar parameters generated from this dataset at 13%. We then processed all these data to a pixel spacing of 25 m by ortho-rectification using 30 m/pixel LRO LOLA digital elevation models (*Neumann, G. A. 2011*), and projected them to a lunar coordinate system as described in *Bhiravarasu et al. 2021*.

II. **Generation of radar circular polarization ratio from DFSAR data:** There are two ways to generate the circularly polarized components from fully polarimetric (FP) mode of DFSAR, in which the radar transmits and receives linear polarization:

i. For one "snapshot" of the received signal, DFSAR FP data produces a complex 2×2 scattering matrix S and its elements S_{ij} describe the complex-valued voltage measured for transmit polarization *i* and receive polarization *j*. Using the real-valued 4×4 Stokes matrix terms that are derived from S, the expressions in terms of linearly polarized elements are (*Zebker & Lou, 1990; Campbell, 2002*) :

$$\sigma^{\circ}_{OC} = \frac{1}{4}[S_{HH}S^*_{HH} + S_{VV}S^*_{VV} + 2\,Re(S_{HH}S^*_{VV})] \qquad (1)$$

$$\sigma^{\circ}_{SC} = \frac{1}{4}[S_{HH}S^*_{HH} + S_{VV}S^*_{VV} + 4S_{HV}S^*_{HV} + 4\,Im(S_{VH}S^*_{VV} - S_{HV}S^*_{HH}) - 2\,Re(S_{HH}S^*_{VV}))] \qquad (2)$$

This method was utilized to generate the CPR parameter in this work.

ii. The second method involves converting the 3×3 polarimetric coherency or covariance matrix, derived from the original 2×2 scattering matrix S, into a compact polarimetric (CP) data format (*Lee & Pottier, 2009*) such as that of the Mini-RF on board LRO (*Raney et al. 2012*). From such CP format, Stokes parameters can be generated which in turn are used to generate σ°_{OC} and σ°_{SC} (see *Raney et al. 2012; Raney, 2006* for more details).

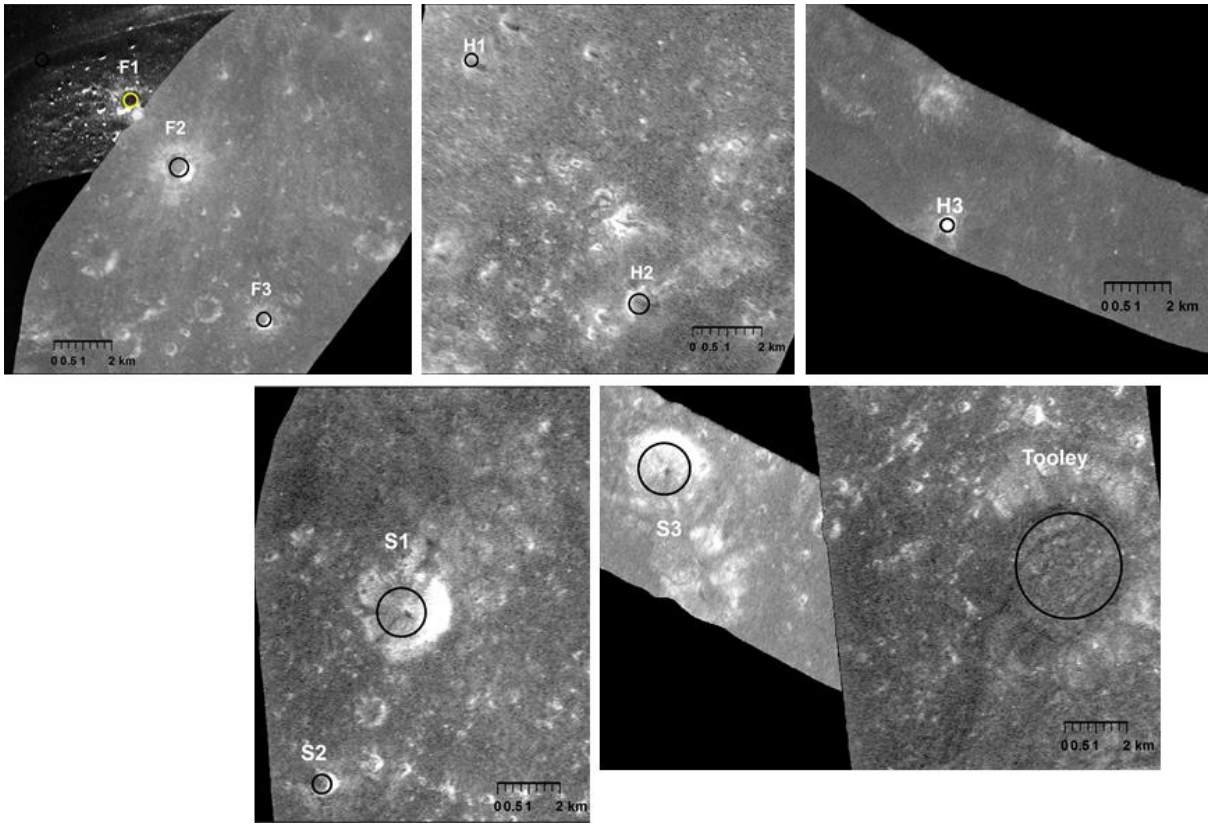

Figure **S1.** Region of interests (ROIs) of the interior (shown in black circles) of all the south polar craters analysed in *Sinha et al (2026)*. The images shown here are the same sense circular backscatter coefficient (σ°_{SC}) generated from DFSAR data.

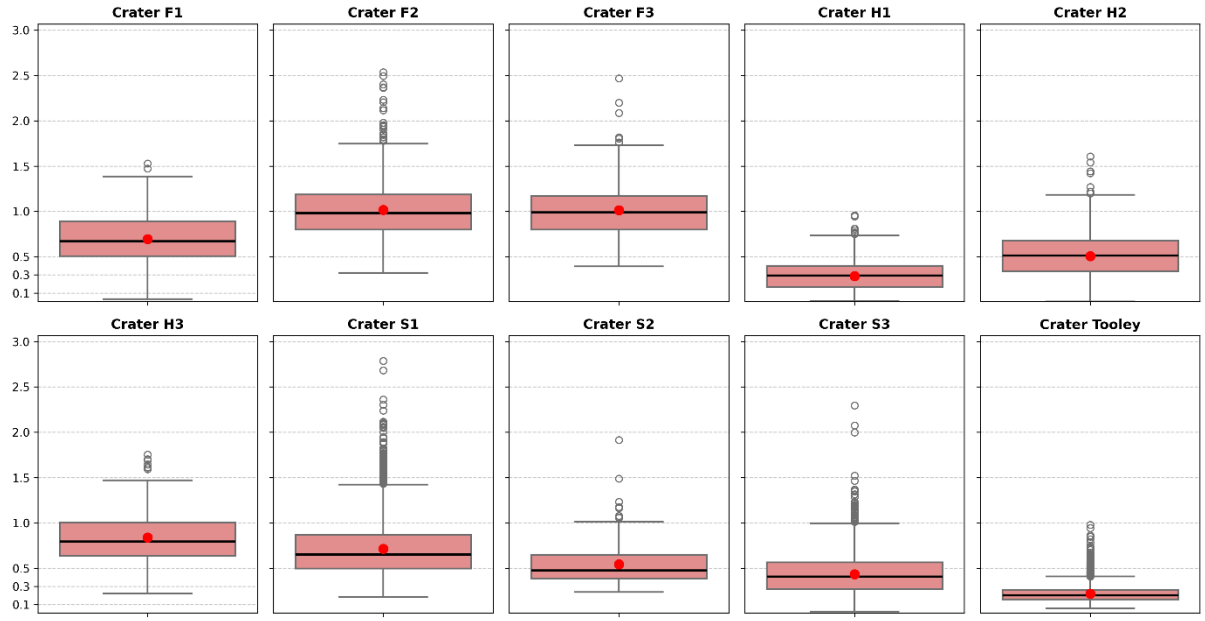

Figure **S2**. Statistical representation of CPR distributions (generated from equations 1, 2) for the interior regions of 10 craters given in *Sinha et al (2026)*. The box and whisker plots are generated from CPR values sampled from crater interior regions, and show the mean (red circle), median (dark black line), quartiles (top and bottom edges of the box), along with whiskers (lines extending from the top and bottom of the box), and outliers (black open circles).

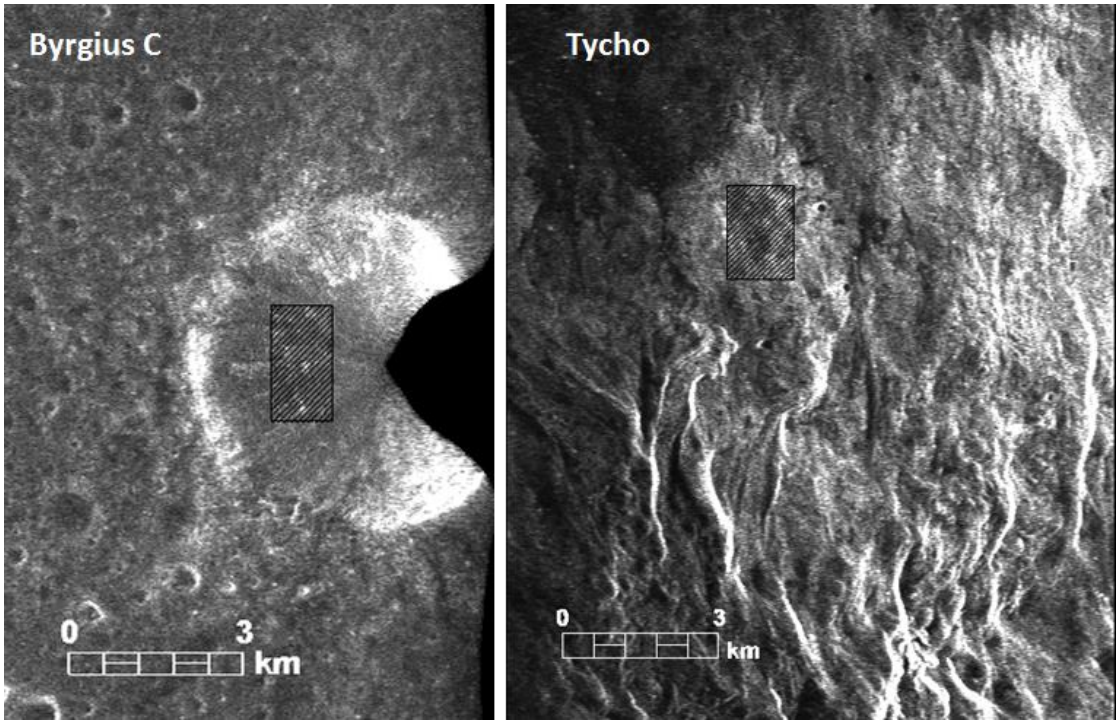

Figure **S3**. Region of interests (ROIs, shown in black polygons) from non-polar crater regions analysed in this work. Interior of Byrgius C crater (left) and an impact melt-rich ejecta blanket associated with Tycho crater (right). The images are the same sense circular backscatter coefficient (σ°_{SC}) generated from DFSAR data, and North is to the top.