Assessing Zones of Low Radar Reflectivity Across the South Polar Cap of Mars

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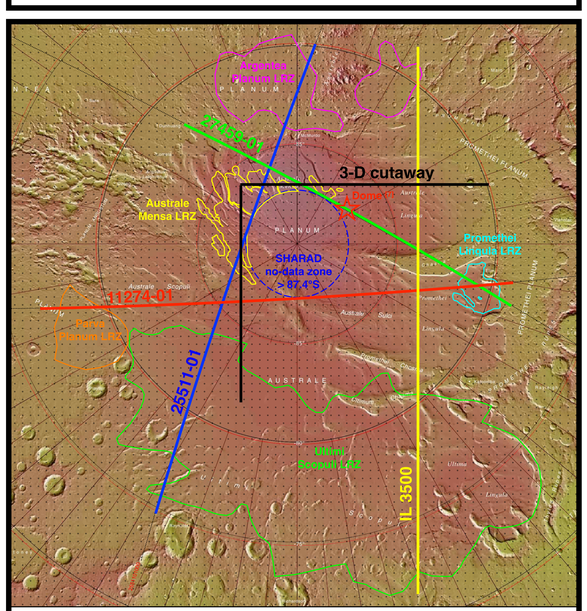
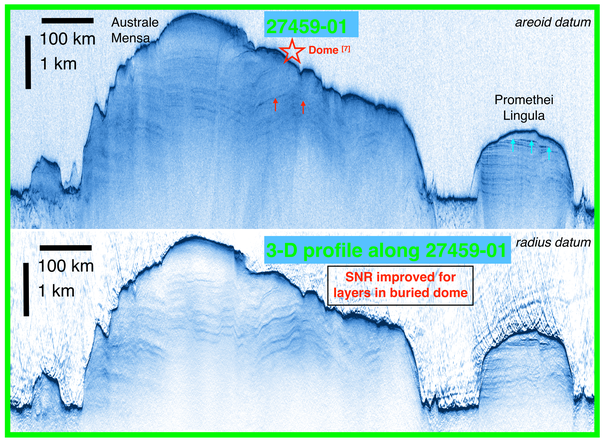
Summary

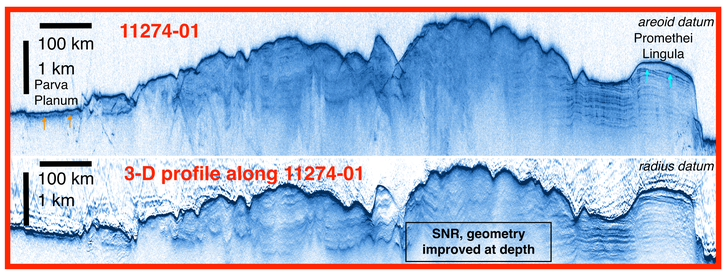
- MRO's Shallow Radar (SHARAD) has revealed near-surface zones of low radar reflectivity in many areas of Planum Australe.[1]
- Low reflectivity zones (LRZ) in Australe Mensa nearest the pole occur in three distinct layers and correspond to geologic unit AA_3 [2] that exhibits sublimation features. Geometric considerations demonstrated that these layers consist of CO_2 ice, preserved from earlier periods of atmospheric collapse.[1,3]
- LRZ elsewhere in Planum Australe have different radar characteristics and they lack sublimation features. Climate models [4] suggest CO_2 ice retention is concentrated at the highest latitudes. These other LRZ may be relatively pure H_2O ice, perhaps coeval with the CO_2 ices.
- We compare profile views of the LRZ from single-orbit 2-D observations with ones from the 3-D volume,[5,6] which provides geometric/clutter corrections and SNR improvement.

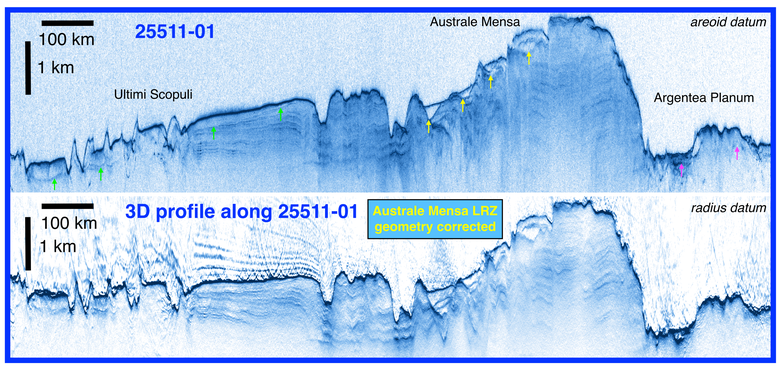


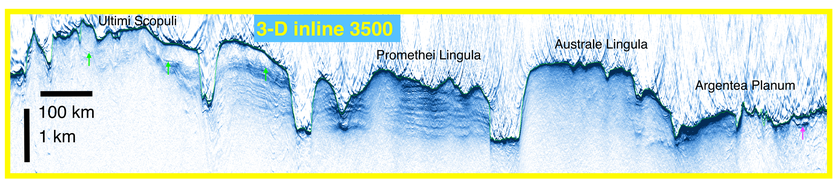
MOLA shaded relief map of Planum Australe and environs, showing the extent of low reflectivity zones (colored polygons) identified in SHARAD 2-D profiles [7,8] and 3-D volume (grid dots posted every 50th inline/crossline, ~24 km). Colored ground tracks correspond to 2-D profiles and 3-D cutaway view at right.

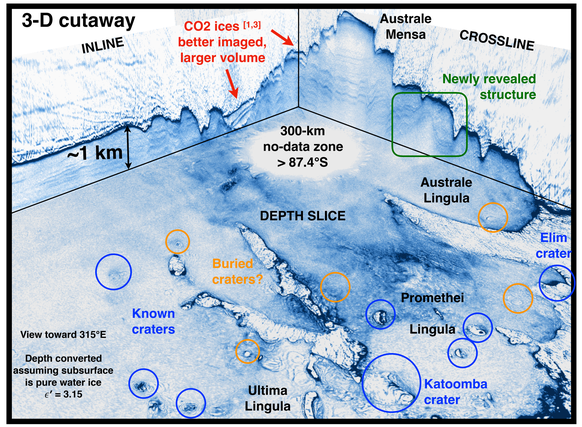
Below: Profiles from individual SHARAD observations (upper panels) and corresponding data extracted along the same tracks from the 3-D volume (lower panels). Lowermost panel (yellow box) is a single inline from the 3-D volume. Arrows show base of LRZ and dome [7] crossed by profiles.
Right: Cutaway view into the 3-D volume with newly revealed features.
3-D data and movies available at: sharad.psi.edu/3D





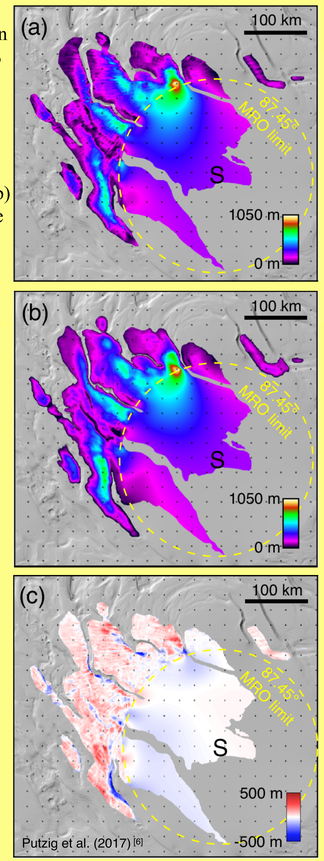






Australe Mensa LRZ mapping improvements [6]

(a) Intensive prior mapping [1,3] of the extents of CO_2 ices atop Australe Mensa employed hundreds of 2-D SHARAD observations and entailed many months of work. **(b):** With the 3-D volume, the deposits were rapidly remapped, revealing a 10% larger deposit, now shown to contain 108% of the mass of Mars' current atmosphere. **(c):** The difference between panels (a) and (b) shows where the 3-D data made the largest corrections to the 2-D geometry.

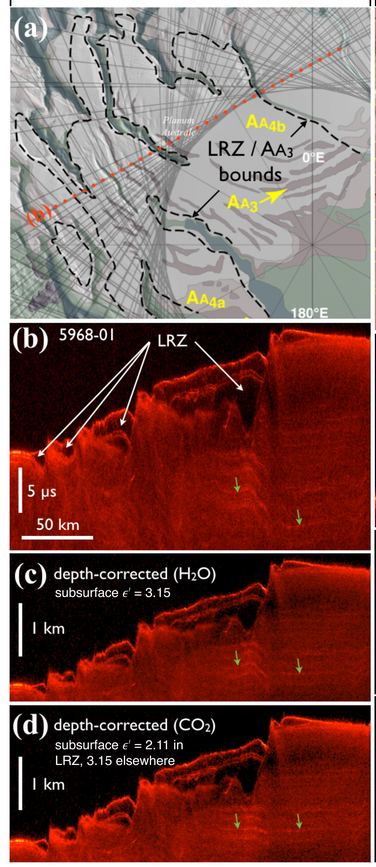


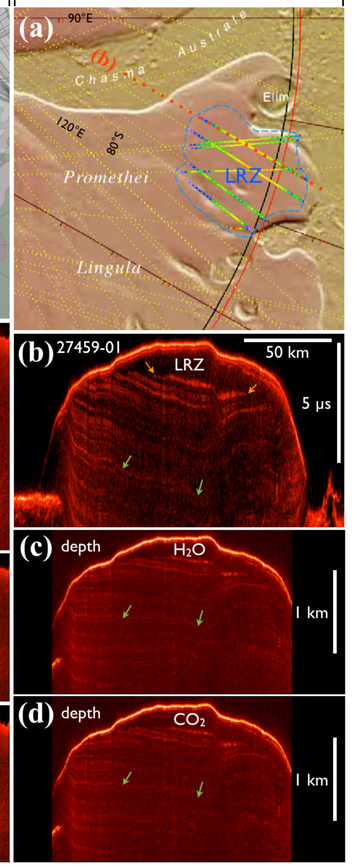
Australe Mensa LRZ Composition [1]

(a) LRZ extent corresponds to that of geologic unit AA_3. **(b)** LRZ extends partially over deeper layers (green arrows). Layering distortion **(c)** is not fully removed if LRZ are H_2O but **(d)** it is removed if LRZ are CO_2.

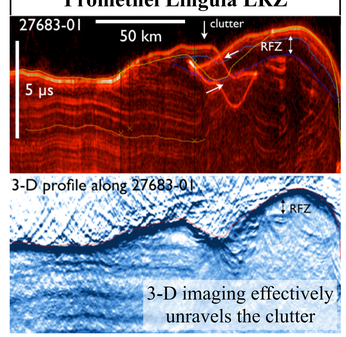
Promethei LRZ Composition

LRZ **(a)** in northern Promethei Lingula **(b)** overlies an unconformity (orange arrows). **(c,d)** Thinner LRZ (vs. Australe Mensa) and deeper structures (rightmost green arrows) disallow composition test.





Clutter Poster Child Crossing the Promethei Lingula LRZ



Conclusions

- The compositions of LRZ outside of Australe Mensa remain in question. Their distinct characteristics and associated surface features are suggestive of water ice.
- 3-D imaging improves SNR and corrects geometries, but the reduced vertical resolution means 2-D analysis remains critical to assessing the nature of the polar layered deposits.

References: [1] Phillips, R.J., et al., 2011. Massive CO_2 ice deposits sequestered in the South Polar layered deposits of Mars. *Science 332*, 838–841, doi:10.1126/science.1203091. [2] Tanaka, K.L., et al., 2007. Recent advances in the stratigraphy of the polar regions of Mars. *7th Int. Mars Conf.*, Abstract 3276. [3] Bierson, C.J., et al., 2016. Stratigraphy and evolution of the buried CO_2 deposit in the Martian south polar cap. *Geophys. Res. Lett. 43*, 4172–4179. [4] Wood, S.E., et al., 2016. Modeling of the Recent Evolution of Mars Perennial CO_2 Caps and Atmospheric Mass. *Lunar Planet. Sci. XLVII*, Abstract 3074. [5] Foss, F.J. II, et al., 2017. 3-D Imaging of Mars' Polar Ice Caps Using Orbital Radar Data. *The Leading Edge 36*, 43–57, doi:10.1190/tle36010043.1. [6] Putzig, N.E., et al., 2017. Three-dimensional radar imaging of structures and craters in the Martian polar caps. *Icarus*, in press, 10.1016/j.icarus.2017.09.023. [7] Whitten, J.L., et al., 2017. A subsurface depocenter in the South Polar Layered Deposits of Mars. *Geophys. Res. Lett. 44*, 8188–8195, 10.1002/2017GL074069. [8] Whitten, J.L., Campbell, B.A., 2017. Internal stratigraphy of the South Polar Layered Deposits, Mars from SHARAD data. AGU Fall Meeting, Abstract P43C-2891 (this conference). **Acknowledgments:** We are grateful to all of the people and organizations who have helped facilitate this work, including the SHARAD Instrument Team, the Italian Space Agency, the MRO Project, SeisWare International, and Landmark Graphics. This project is funded by the Mars Data Analysis Program, Grant #NNX17AC62G.