SHARAD MAPS A LARGE CO_2 MASS IN THE SOUTH POLAR LAYERED DEPOSITS OF MARS.

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Introduction: The Shallow Radar (SHARAD) instrument on the Mars Reconnaissance Orbiter (MRO) generates a chirped pulse of 15–25 MHz at a free-space wavelength of 15 m (~5–10 m in the subsurface). With MRO's 255–320-km orbit, SHARAD achieves a lateral resolution at the surface of 3–6 km, reducible to 0.3–1.0 km in the along-track direction with SAR processing. SHARAD records returned signals that are reflected by the surface and by subsurface interfaces with a dielectric contrast, which may be provided by changes in material properties, either in their composition (e.g., variations in the lithic content of ice layers, CO_2 overlying water ice) or in their physical characteristics (e.g., density variations due to changes in pore volume). Lossy or highly scattering materials reduce the strength of transmitted signals and may mask underlying interfaces that might otherwise be detected.

SHARAD soundings of the north and south polar layered deposits (NPLD and SPLD) have yielded detailed internal structure to depths of several kilometers. The characterization of water-ice deposits is richest in the north, where packets of internal layers can often be traced throughout Planum Boreum. In the south, while the water-ice layering is more complex and discontinuous (consistent with these deposits being substantially older), a newly discovered deposit of massive CO_2 ice has significant implications for recent changes in Mars' climate [1].

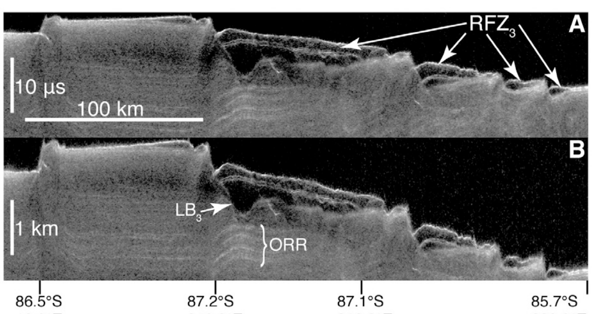

Figure 1. SHARAD radargram 5968-01 traversing RFZ_3 unit shown in original time-delay format (**A**) and converted to depth (**B**) using water-ice permittivity. "Organized radar reflectors" (ORR) and RFZ_3 lower boundary (LB_3) are indicated. Minimizing the distortion in the ORR sequence was the basis for estimating the permittivity of RFZ_3. From [1].

CO_2 Deposit: In the SPLD, organized sets of radar reflectors are limited to specific regions, and it is difficult to map SPLD-wide radar stratigraphy. SHARAD results do show four regional reflection-free zones (RFZs) distinguished by their qualitative radar characteristics [1]. In one zone (RFZ_3, Fig. 1), which occurs beneath the South Polar Residual Cap (SPRC) and has a good spatial correlation with stratigraphic unit "AA_3" [2, 3], multiple techniques were used to invert for the real permittivity, ε', on 41 SHARAD observations. The resulting ε' of 2.0–2.2 with standard deviations of 0.1–0.2 is remarkably close to the laboratory-measured permittivity value of bulk CO_2 ice [4] and distant from the bulk water-ice value (ε' = 3.15). The permittivity estimates yield a mean thickness of 200–230 m and a volume of 4,000–4,500 km^3 for RFZ_3 where it is observed by SHARAD. Unit AA_3, which shows good morphological evidence for CO_2 sublimation features, was used a basis for extrapolating poleward of ~87°S (where MRO's orbital inclination precludes SHARAD sounding), yielding a total volume estimate for RFZ_3 of 9,500 to 12,500 km^3 (Fig 2).

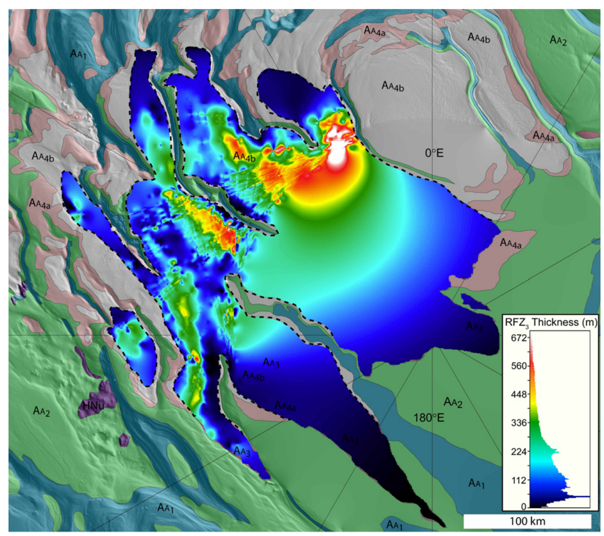

Figure 2 Bright colors show thickness data from the SHARAD-mapped RFZ_3 unit (using ε' = 2.1) extrapolated (smoother color pattern) over and constrained by the lateral extent of the AA_3 unit (dashed lines) using a minimum-curvature interpolation function. The histogram shows relative occurrence of thicknesses. Base map (muted colors) shows SPLD stratigraphy [2,3]. From [1].

Climate Implications: If entirely released to the atmosphere, this volume of CO_2 would add 4–5 mbar, nearly doubling the current atmospheric pressure of ~6 mbar. Such a release is likely to have occurred at times of high obliquity, such as ~600,000 years ago. GCM simulations for this time period predict the sublimation of these CO_2 deposits, though there is more seasonal CO_2 frost on the ground than at present. The net increase of atmospheric pressure should have provided greater stability of surface water against boiling and more frequent and intense dust storms.

References: [1] Phillips, R. J., et al. (2011) *Science*, *332*, 838-841, 2011. [2] Tanaka, K. L., et al. (2007) *7th Int'l Conf. Mars*, Abstract # 3276. [3] Kolb, E. J., et al. (2006) *LPSC XXXVII*, Abstract # 2408. [4] Pettinelli, E., et al. (2003) *J. Geophys. Res.*, *108*, 8029.