NORTHERN POLAR LAYERED DEPOSITS, MARS: STRUCTURAL RELATIONSHIPS BETWEEN GEMINA LINGULA, THE MAIN LOBE AND CHASMA BOREALE FROM SHARAD RADAR STRATIGRAPHY. J.W. Holt[1] and A. Safaeinili[2]; [1]University of Texas Institute for Geophysics, Jackson School of Geosciences, University of Texas, Austin, TX 78758 (jack@ig.utexas.edu); [2]Jet Propulsion Laboratory, Caltech, Pasadena, CA 91109.

Introduction: The northern polar layered deposits (NPLD) on Mars exhibit certain features that deviate significantly from what one would expect from deposition, possible flow, and ablation of ice. The most obvious of these are Chasma Boreale, Gemina Lingula, and the spiral troughs (Fig. 1). Until recently, efforts to explain these features have been based on morphological, optical and spectral data. Radar sounding now provides a view into the interior of the NPLD enabling new large-scale stratigraphic and structural studies to test hypotheses regarding the evolution of the NPLD and formation of anomalous features such as these.

The SHAllow RADar (SHARAD) instrument on Mars Reconnaissance Orbiter is an orbital, chirped radar on MRO, operating at a 20 MHz center frequency (15 meters free-space wavelength) with 10 MHz bandwidth and 85 µs pulse duration [1]. Pulse compression yields a theoretical vertical resolution of ~ 8 m in water ice. Horizontal resolution is 0.3 – 1 km along-track and 3 – 6 km across track. All of the NPLD and part of the Basal Unit (BU) [2] beneath is penetrated with SHARAD [3].

Methods: Data from SHARAD passes were processed with a focused synthetic aperture radar (SAR) technique in order to reduce along-track surface clutter and resolve reflectors with relatively steep slopes. After post-processing, incoherent summing results in along-track sampling of ~ 300 meters. Radar reflectors were tracked across distance and between lines using seismic analysis interpretation tools. This also allows the accurate calculation of relative radar layer thicknesses, and the conversion to depth assuming a constant dielectric constant equivalent to water ice.

Overall Stratigraphy: Many radar reflectors exist and most extend across the entire NPLD [3]. Steep surface slopes can result in discontinuous (or loss of) reflectors due to refraction and/or specular reflections. However, due to the uniformity of layering patterns across the NPLD we can deduce that the main lobe and Gemina Lingula (GL) have the same overall depositional history (i.e., they span roughly the same interval of time and other than within certain anomalous zones, are both subject to pan-polar deposition and ablation processes).

The character of radar layering varies vertically, allowing the opportunity to define units with distinctive properties. Four major packets of radar reflectors separated by reflector-poor "dark" zones have been observed and may be attributed to orbital forcing of climate [3, 4]. Alternatively, stratigraphic units can be defined based on the uniformity of layer thicknesses and the presence of unconformities. This is most clearly demonstrated in the "saddle" region between the main lobe and GL (Fig. 1) where four such units are discernible.

The lowest unit (A) is relatively thin, has radar layers that are conformal with the bottom surface of the PLD including the Basal Unit (BU) and extends across the entirety of the NPLD. Unit B lies conformably above unit A but has significant relief on its upper surface, and appears to pinch out beneath the main lobe. It has a convex upper surface within GL and subhorizontal, uniform layering within. Unit C is the thickest unit and contains multiple sets of reflectors separated by radar-dark zones while maintaining lateral uniformity of layer thicknesses throughout. The top unit (D) contains many bright reflectors and is separated from unit C by localized angular unconformities (Fig. 1).

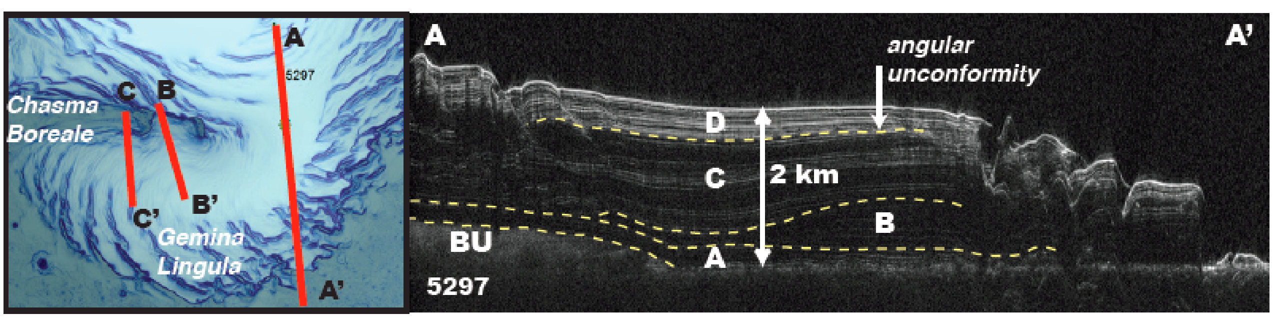

Figure 1. (left) Portion of northern polar layered deposits (NPLD) showing Chasma Boreale and Gemina Lingula. (right) SHARAD orbit 5297 (adapted from [3]) with stratigraphic units A-D delineated based upon layer conformity and geometry.

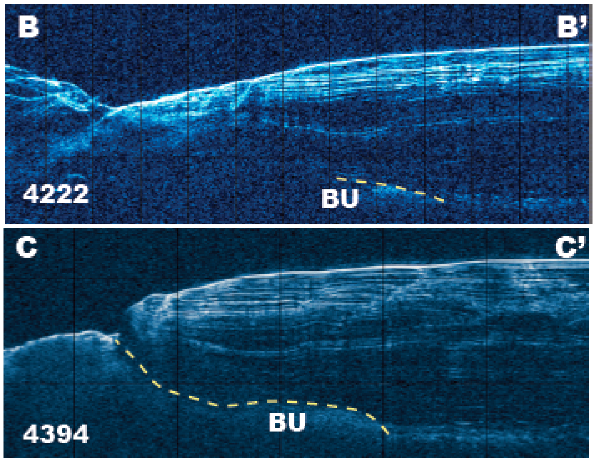

Figure 2. Portions of SHARAD orbits crossing the Gemina Lingula -- Chasma Boreale Margin. See Fig. 1 for locations. Note that upper layers (unit D) are conformal to the surface where Gemina Lingula protrudes into Chasma Boreale but intersect the surface where the margin is a steep slope. Lower unit layers rise toward the margin, indicating a different history consistent with flow toward a margin where ablation outpaced deposition.

Gemina Lingula: The presence of a thick unit B in Gemina Lingula, possibly the erosional remnant of a paleo-ice-sheet, impacted subsequent deposition as evident by the draping of layers in unit C. The dome-shaped topography on unit B therefore provided a topographic high that continued throughout the deposition of unit C. The angular unconformity apparent at the top of unit C within Gemina Lingula indicates that unit C extended higher and farther south prior to erosion and then deposition of unit D over the eroded surface.

Gemina Lingula -- Chasma Boreale Margin: Along a line that includes a protrusion of GL into CB (the "ice bridge") we see that unit D is conformal with the surface topography and layers do not intersect the surface, even to the distal end of the ice bridge [Fig. 2, upper]. This indicates deposition over an existing topography with little subsequent modification. Layers from lower units (it is not clear which ones are present here) are not conformal with the surface and curve upward toward the GL/CB margin. Such a layer geometry indicates ablation at the margin of a flowing ice sheet, in support of flow modeling results that exclude troughs within GL [5]. Hence, CB (or some similar margin) must have existed there prior to the deposition of unit D.

Farther down-chasma where the ice bridge is absent, layers in Unit C are truncated by the surface without significant change in layer orientation, while lower units still show an upward-bending geometry. This, along with the limited extent of the "ice bridge" is consistent with recent erosion of much of GL's northern edge by katabatic winds, and/or slumping and subsequent removal.

Conclusions: SHARAD observations of the NPLD support the following: (1) Gemina Lingula has been a topographic high distinct from the main lobe for most of NPLD history, possibly due to the existence of a remnant ice sheet whose thickest portion was located away from the geographic pole. (2) Chasma Boreale is a long-lived feature of the NPLD. (3) The most recent of four major depositional episodes resulted in ~ 500 meters of layered deposits draping a pre-existing surface of an ice sheet (paleo-GL) that may have flowed. (5) Erosion within, and perhaps growth of, Chasma Boreale continued after deposition of the most recent unit.

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