RENEWED ANALYSIS OF BURIED DEEP STRUCTURES IN PLANUM BOREUM WITH THE 3-D SHARAD VOLUME.

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Introduction: The north polar layered deposits (NPLD) together with the Basal Unit (BU) of Mars contain a record of accumulation through time that is expressed in the layers that comprise the ice cap. Much of the NPLD's early history is one of near-uniform accumulation with some lateral variability [1-3]. After about half of the NPLD was in place, the spiral troughs developed [4,5], modifying the accumulation pattern from near-uniform to highly localized, dependent on position relative to the troughs. Trough onset was only one of several major events in NPLD history. The development and burial of a large chasma, equal in size to Chasma Boreale, predated the troughs [6], and several erosional events are preserved in the layers [5-7].

Here we use a newly generated three-dimensional (3-D) radar dataset [8] to detail several events that played roles in development of the NPLD. The first is a large-scale unconformity associated with Gemini Scopuli (Fig. 1). The second is a Buried Chasma (BC). We demonstrate that its initial state is similar to that of Chasma Boreale (CB).

Data and Methods: We interpreted two- and three-dimensional data from the Shallow Radar (SHARAD) instrument [9] on Mars Reconnaissance Orbiter. Thousands of 2-D (single-orbit) observations were processed to create a 3-D volume of radar data [8]. This volume provides more utility than the 2-D dataset because of the geometric corrections applied, reduction of clutter, and viewing geometries that are not dictated by the ground tracks of the spacecraft [10]. This utility makes is possible to demonstrate in one image something that is impossible to visualize in the 2-D data. These and other factors reduce interpretation time by a factor >10 and increase confidence in interpretations.

Findings: We show 3-D and 2-D radar profiles in Fig. 2 that compare the early stages of CB and BC and exhibit major unconformities. For the chasmata, there are many similar observations: both locations have dipping reflectors that nearly reach the basal interface, a portion of the Basal Unit is separated from its main lobe at each section (purple arrows), a steep cliff exists for both on the main-lobe side (orange arrows), and an eroded surface towards the interior of the NPLD (dashed red lines). Nerozzi and Holt [3] interpreted the eroded basal unit to be the initiation surface of both chasmata.

The major unconformity corresponds to U2 and U3 from [11]. This is the event that created the Gemini Scopula region (Fig. 1), with abundant unconformities, at the margin of the NPLD from ~0° E to 180° E.

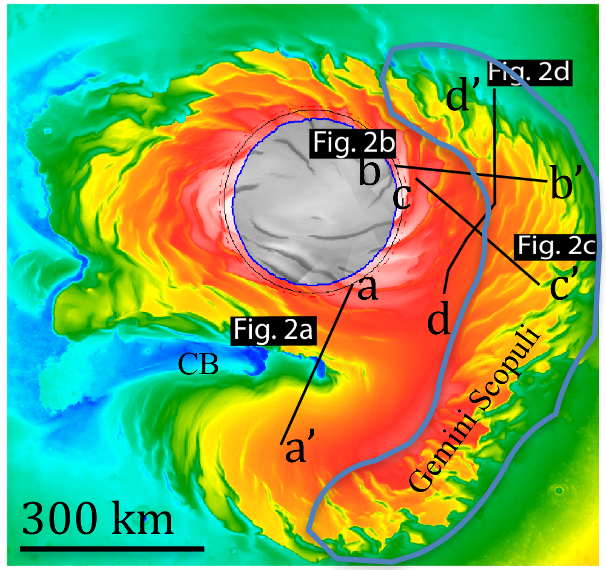

Figure 1: Topographic map of North Polar Layered Deposits with ground tracks for Figure 2.

In Fig. 3 we highlight the buried chasma with a constant-depth slice. Here it is readily visible with approximately the same dimensions as CB. The Gemini Scopuli erosion would have removed a significant quantity of material from the right portion of the image, opposite of Gemini Lingula. The Fig. 3 inset shows the NPLD—basal-unit interface mapped in the 3-D volume and exhibiting another steep cliff.

Interpretations: With these 3-D observations we confirm the prior interpretations [*e.g.*, 1-3, 11] that were done based on 2-D analysis.

At one point the initial stages of both CB and BC would have appeared similar and had similar dimensions. Their subsequent accumulation histories drove different evolutions. Chasma Boreale persisted through many hundreds of meters of accumulation, likely widening as it grew tall due to wind scour on the main-lobe side (with equator-facing slope). This maintained the steep cliff present today.

The buried chasma, on the other hand, began to fill in soon after the red reflector was deposited. This created an accumulation pattern that affects surface topography even today (Fig. 2c). At present, two topographic lows exist on the surface of the NPLD, remnants of the former deepest section of the basal unit erosion. Immediately below, the layers are conformable to the current surface, leaving a U-shaped deposit (immediately above the 'B' in Fig. 2c). A similar pattern likely would have formed had Chasma Boreale also filled in.

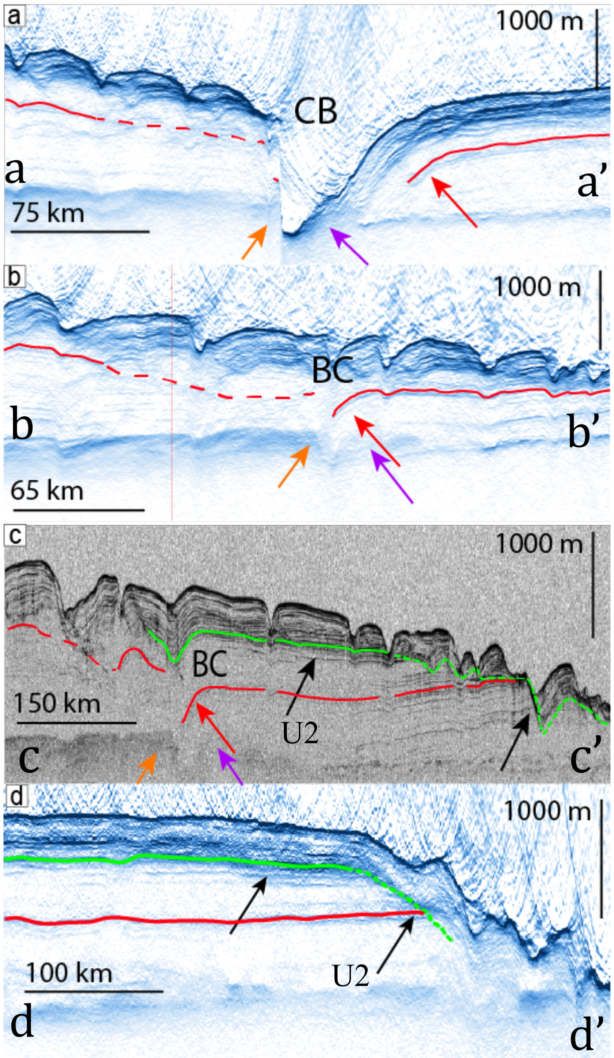

Figure 2: *Radar images of deep structures in the NPLD. a) + b) Profiles from 3-D radar [10] that provide evidence that Chasma Boreale (CB) and the buried Chasma ([6] BC) formed under similar circumstances and exhibit the same features. c) SHARAD radar image 7616_02 crossing BC and exhibiting a major unconformity (U2 and U3 from [11]). d) 3-D radar image exhibiting the major unconformity. In each panel the dipping reflector (red line), erosional surface (dashed red line), steep cliff (orange arrow), discontinuous basal unit material (purple arrow), and major erosional surface (green line and black arrows).*

The leading hypothesis for the divergence in the history of the two chasmata is that CB was ideally situated so that katabatic winds driven by the Coriolis Force would funnel into the canyon and then outward towards its mouth [11]. The same winds would have funneled headward into the buried chasma and been hindered when they met the saddle region that connects Gemini Lingula [11]. Thus, the icy material or

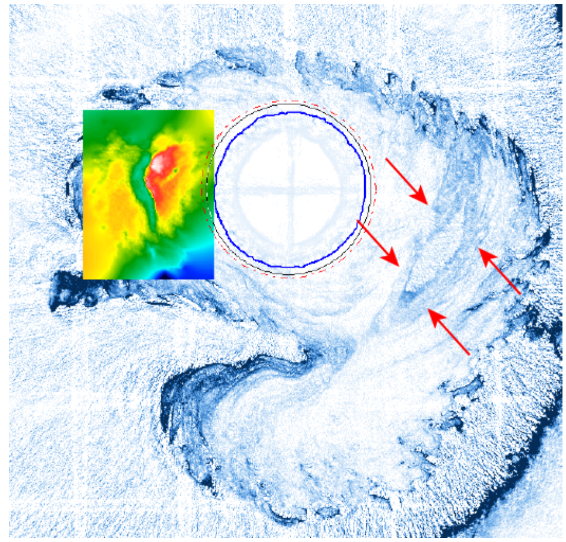

Figure 3: Slice of constant depth of the NPLD, highlighting the outline of the buried chasma (red arrows). Colorful topography is the structure of the basal unit directly beneath the NPLD.

water vapor would have only been transported a short distance and never away from the NPLD.

Conclusions: Structures deep within the NPLD provide information about events that occurred at various stages in NPLD development. Significant amounts of mapping in 2 dimensions have been completed, and here we use the 3-D data volume to revisit and reinterpret those features. With few exceptions, 2-D mapping has been very successful in describing different chosen features. However, there are many deep structures that have not been interpreted because of the difficulty to do so with the 2-D dataset. 2-D observation geometries and clutter hindered potentially important discoveries of structures that inform the history of accumulation at the NPLD. We will present these and new observations at the conference.

Additional Information: The 3D dataset is available for public use at https://sharad.psi.edu/3D/.

Acknowledgments: Thanks to *SeisWare* for the academic license that makes interpretation possible. MDAP grant NNX16AN90G supported this work.

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