

CHASMATA OF PLANUM AUSTRALE, MARS: ARE THEIR FORMATION AND LOCATION STRUCTURALLY CONTROLLED? E. J. Kolb¹ and K. L. Tanaka², ¹Arizona State University, Dept. of Geological Sciences, Tempe, AZ, ekolb@asu.edu, ²USGS, 2255 N. Gemini Dr., Flagstaff, AZ 86001, ktanaka@usgs.gov.

Introduction. The chasmata within Mars' south pole ice cap of Planum Australe are indicators of large-scale erosional episodes that have resulted in the removal of >kilometer-thick stacks of south polar layered deposits (SPLD). Geologic mapping of a large trough system located between two of the chasmata [1] indicates that the trough's location and erosional morphologies are in large part, structurally controlled by SPLD bedding attitudes. The scarps of Promethei and Ultimatum Chasma also reveal dipping SPLD beds. Therefore, to what degree is the location of these chasmata and their formation history controlled by SPLD bedding and (or) substrate topography? We have undertaken a detailed geologic mapping study of the chasmata using Mars Global Surveyor (MGS) and Mars Odyssey (MO) datasets to determine their bedding features, formation mechanisms, and emplacement timing. Syntheses of these observations allow discrimination and characterization of potential structural controls over chasma formation. This study is part of our 1:1.5M-scale geologic mapping project of Mars' north and south polar ice deposits. A general review of the mapping results is in [2].

Background. The chasmata investigated in this study are located east of Chasma Australe and centered at 150°E, 82.5°S (Fig. 1). The chasmata extend radially outward from the central regions of the cap and are of similar length, width, and thickness (<300 km, <30 km, and <2 km, respectively). Chasmata formation is thought to have occurred by either wind erosion [e.g., 3] or by collapse and removal of overlying SPLD due to ice-cap basal melting [e.g., 4]. MGS-based detailed geologic mapping of Planum Australe by [5] determined that features associated with basal melting or other warm-based ice processes are absent and that chasma formation had occurred entirely from wind action. Further detailed mapping by [1] of a radial trough comparable in size and orientation to Chasma Australe and located between Chasma Australe and the Promethei and Ultimatum chasmata complex identified both streamlined yardangs and an extensive set of ridge-and-groove features. The aeolian stripping that formed these features excavated a > 500-meter-thick stack of SPLD from the trough's Australe Sulci region (informally termed "wire-brush terrain" by [6]). The scarps that enclose Australe Sulci are composed of cliff- and terrace-forming SPLD sequences that dip both into the trough and toward the terminal margin, roughly forming a plunging anticline whose hinge dips northward, parallel to the trough floor. The outcrop patterns within the scarps and along the trough floor are controlled in large part by these SPLD bedding orientations. The orientations are a function of SPLD mantling over either hummocky prominent-relief substrate or SPLD paleosurfaces.

New Observations. Substrate exposed within both chasmata include the chasma member (unit Hdc) of the Hesperian Dorsa Argentea Formation (DAF) and the Noachian subdued crater unit (unit Npl₂) of the plateau sequence. Within Promethei Chasma's poleward floor section is a thick outcrop of finely-layered material of the DAF's cavi member (unit ANdc). The chasmata walls are composed of SPLD material of the Australe 1 unit (unit Aa₁). THEMIS VIS images show a large unconformity within the unit that can be traced along the scarps of both chasmata. Therefore, in this study, we have further divided the Australe 1 unit into the lower and upper members (units Aa_{1a} and Aa_{1b}, respectively).

Local pinch-outs or unconformities are not seen in either chasma. The Australe 2 unit (unit Aa₂) unconformably mantles the unit Aa₁ material. Unit Aa_{1a} bedding is flat-lying throughout the unit's exposure within Ultimatum Chasma and within the eastern walls of Promethei Chasma. Within Promethei Chasma's western wall, where unit Aa_{1a} mantles the unit ANdc outcrop, the sequences dip to the west (Fig. 2). Within the northern sections of the western wall, upper sections of unit Aa_{1a} dip into the chasma ("X" in Fig. 1); a possible unconformity exists within basal unit Aa_{1a} sections below the dipping unit Aa_{1a} sections. Bedding orientations of the unit Aa_{1b} sequence largely appear to dip into the chasmata (Figs. 1 and 2). The sequence is most pronounced within the chasma's poleward sections and western chasma scarps. Lastly, unit Aa₁ bed thicknesses are uniformly thick throughout the stack.

Discussion. The outcrop pattern of unit Aa_{1b} where it overlies unit Aa_{1a} in the central region of Ultimatum Chasma ("Y" in Fig. 1) indicates that chasma formation began after unit Aa_{1a} was deposited but prior to unit Aa_{1b} deposition. Within both chasmata, the unit Aa_{1b} bed orientations are the result of unit Aa_{1b} mantle deposition over a sloping unit Aa_{1a} paleosurface. The lack of systematic local pinch-outs and unconformities within both units indicates that their deposition was largely continuous except for the erosional hiatus between units Aa_{1a} and Aa_{1b}. In addition, a smaller, local hiatus may have occurred during unit Aa_{1a} deposition as evident by the unconformity and dipping beds at "X" in Fig. 1. Bedding orientations of both units indicate that the chasmata are structurally controlled. In Promethei Chasma, anticlinal structures formed in unit Aa_{1a} where it mantles unit ANdc provided funnels for off-pole winds. Such early bedding structures facilitated the formation of "seedling chasmata". The regional-scale removal of unit Aa_{1a} followed by the mantling of unit Aa_{1b} over the unit Aa_{1a} paleosurface amplified the chasma's relief and in turn, reinforced the funneling ability of the features. The bedding structures may form zones of weakness that the wind-action exploits, resulting in accelerated down-cutting and widening of the chasmata.

Conclusions. MGS and MO-based geologic mapping of Planum Australe's Promethei and Ultimatum Chasma reveal that chasmata location and formation are structurally controlled by both the substrate topography and intermediate SPLD erosional surfaces. Moreover, unconformable SPLD sequences within the chasmata indicate that chasma formation began early in Planum Australe's history. The chasma formation history consists of (1) deposition of lower SPLD over substrate that resulted in SPLD bedding irregularities, (2) SPLD depositional hiatus during which winds funneled by the structures form both seedling chasmata and a regional erosional paleosurface, (3) mantle deposition of the upper SPLD sequence, which amplifies chasma relief, and (4) enhanced wind funneling, which forms most recent chasma features.

References: [1] Kolb E. J. and Tanaka K. L. (2003) 3rd Intl. Mars Polar. Sci. Conf. #8116 [2] Tanaka et al., this volume (2005), [3] Howard A. (2000) *Icarus* 144, 267-288 [4] Fishbaugh K. E. and Head J. W. (2001) *Icarus* 154, 145-161. [5] Kolb E. J. and Tanaka K. L. (2001) *Icarus* 154, 22-39. [6] Koutnik et al., (2003) 3rd Intl. Mars Polar. Sci. Conf. #8074.

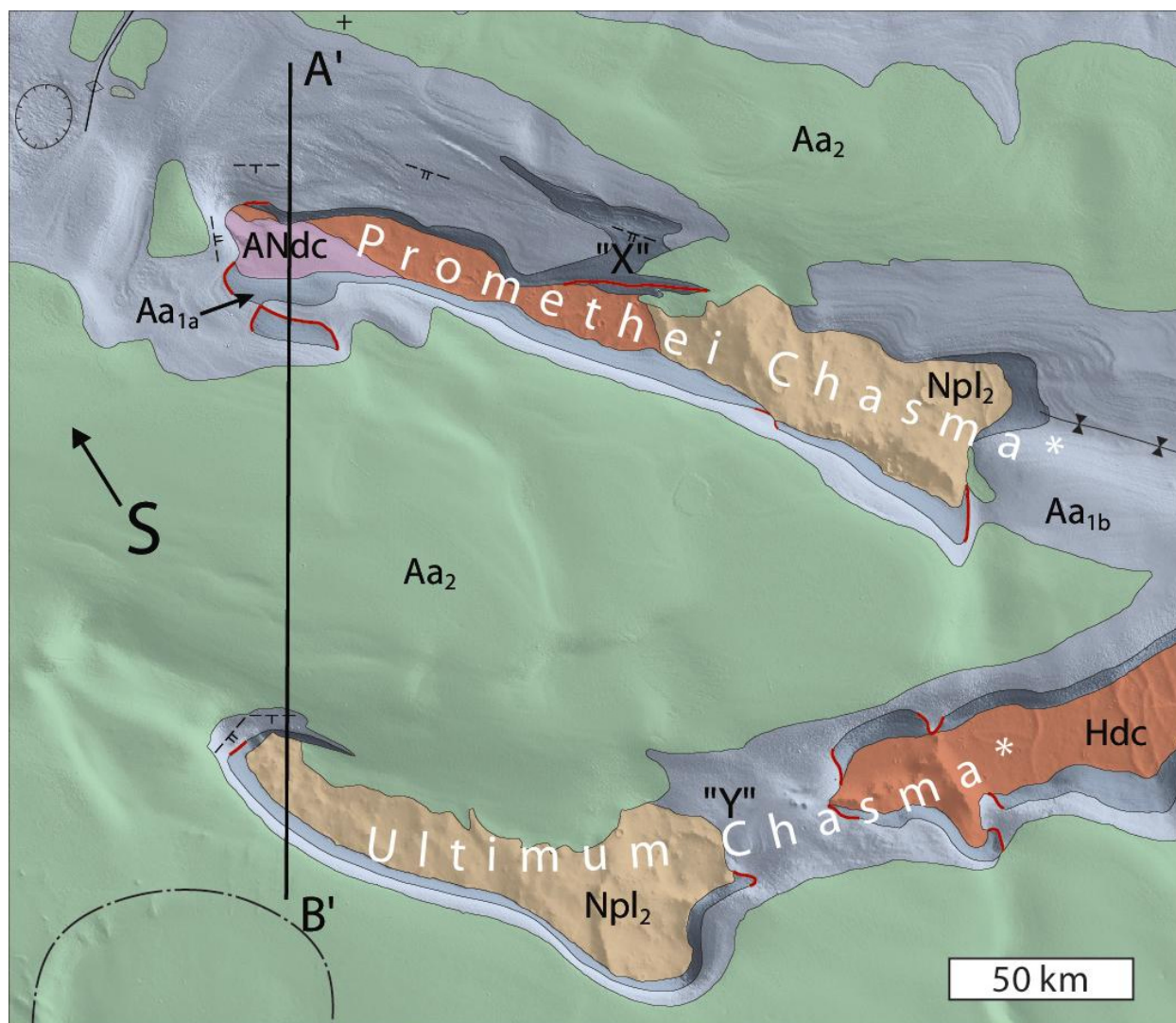


Figure 1. MGS and MO-based geologic map of Promethei and Ultimium chasma complex within Planum Australe, Mars. Map base is a 115 m/pixel MOLA shaded relief image. Red-colored bed contacts mark location of unconformable SPLD sequences as seen in THEMIS VIS images. Strike and dip symbols indicate relative bedding dip values; steeply-dipping beds indicated by double-line dip hachure. Chasma nomenclature is provisional.

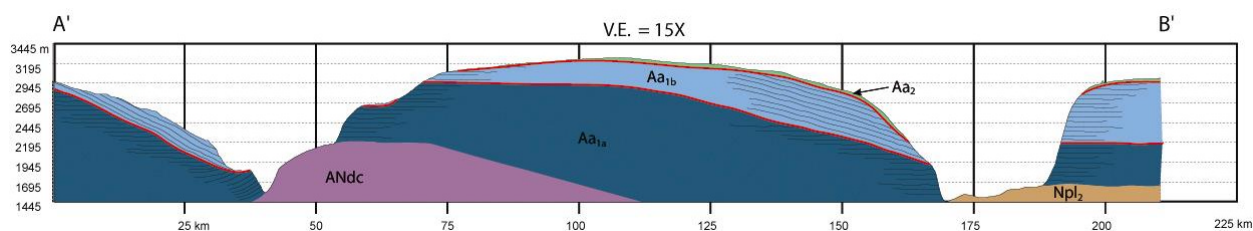


Figure 2. Geologic cross-section of poleward sections of Promethei and Ultimium Chasma. Topographic profile is derived from 115 m/pixel MOLA digital elevation model. Red-colored bed contact marks SPLD erosional paleosurfaces.