DEPRESSION SYSTEMS IN WESTERN PLANUM BOREUM, MARS: DISTRIBUTIONS, ORIENTATIONS AND CROSS-CUTTING RELATIONSHIPS. J.A.P. Rodriguez[1], K.L. Tanaka[2], and D.C. Berman[1]. [1]Planetary Science Institute, 1700 E. Fort Lowell Rd. 106, Tucson, Arizona, 85719-2395, USA (alexis@psi.edu), [2]USGS, 2255 N. Gemini Dr., Flagstaff, Arizona, USA.

Introduction: Planum Boreum, in the north polar region of Mars, forms a domical plateau largely dissected by depression systems of various dimensions (Fig.1). The largest and most deeply incised of these is Chasma Boreale, a unique canyon that divides Planum Boreum into a main lobe and a smaller lobe east of the chasma known as Gemina Lingula. Other widespread depression systems include undulations (linear surface depressions in the upper layered deposits) and troughs (linear depressions that extend into the lower layered deposits). We have mapped the distribution of troughs and undulations in western Planum Boreum (~180 to 360°E.) and investigated their stratigraphic relationships relative to one another, as well as relative to Chasma Boreale.

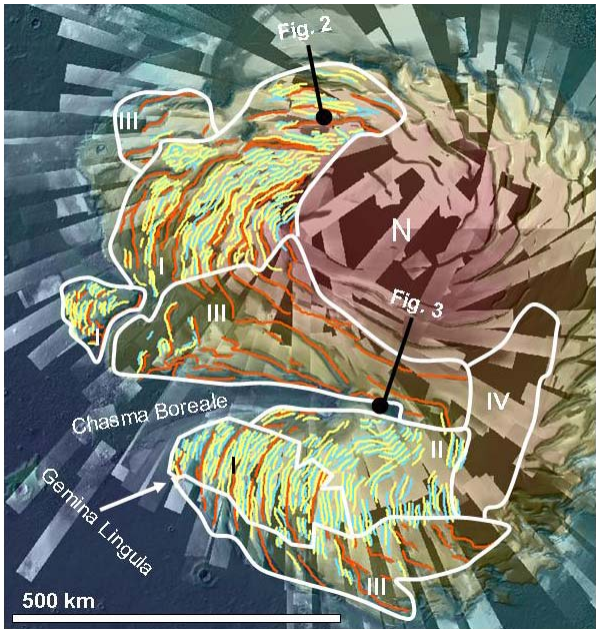

Fig. 1. Outlined in white are regions of Planum Boreum where we have mapped the various types of surface depressions. Red lines trace the floors of troughs, blue lines trace the floors of surface undulations, and yellow lines ridges along trough margins. Superposed MOLA (512 pixels per degree) DEM and its shaded relief . Image centered at 46° 25 E, 88°48 N.

Distribution of depression systems: In western Planum Boreum we have indentified (I) three zones of densely clustered undulations, which are sparsely dissected by troughs, (II) one zone where undulations form disjointed clusters, (III) three zones extensively dissected by troughs but where undulations are rare or absent, and (IV) one zone which shows neither undulations nor troughs (Fig.1). The contacts between these zones are sharp and well-defined.

Orientation of depression systems: Troughs generally form parallel systems of aligned canyons which initiate from the central zones of Planum Boreum and progagate at oblique angles relative to regional contours towards the peripheral and lower-lying zones of the polar plateau, where they parallel the regional topographic contour (thus the spiral-like pattern in planimetric view). Undulations on the other hand tend to parallel the topography regardless of their location within Planum Boreum. In some cases, undulations and troughs branch at Y-shaped junctions, but X-shaped junctions are rare (e.g. Fig. 2), indicating poor integration of depression systems. Both undulations and troughs parallel the margins of Chasma Boreale (Fig. 1), which is consistent with this depression being an early polar feature.

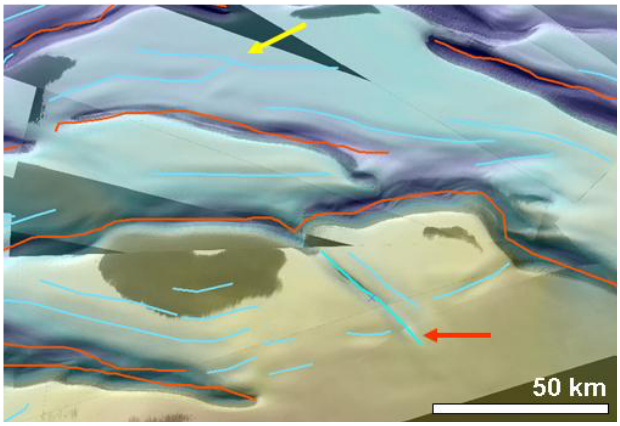

Fig. 2. Yellow arrow shows an undulation that branches at a Y-shaped junction. The red arrow shows the location of an undulation that trends at an oblique angle to the strike, which cuts another undulation. The trends of these undulations form an X-shaped pattern. Superposed MOLA (512 pixels per degree) DEM, its shaded relief and CTX mosaic. Image at 152° 55 E, 86° 59 N.

Cross-cutting relationships: In one location we have identified cross-cutting relationships between systems of undulations (Fig. 2). Troughs cut undulation systems in numerous locations, particularly near the center of Planum Boreum, where they respectively trend at different angles. In some instances, undulations and troughs are aligned and grade into one another [1]. Both troughs and undulations are cut in zones where the walls of Chasma Boreale have undergone retreat

(e.g., Fig. 3). However, these are gross relationships that tend to emphasize the most recent history, and there is likely complexity such as multiple stages of depression enlargement, particularly for the troughs and especially for Chasma Boreale.

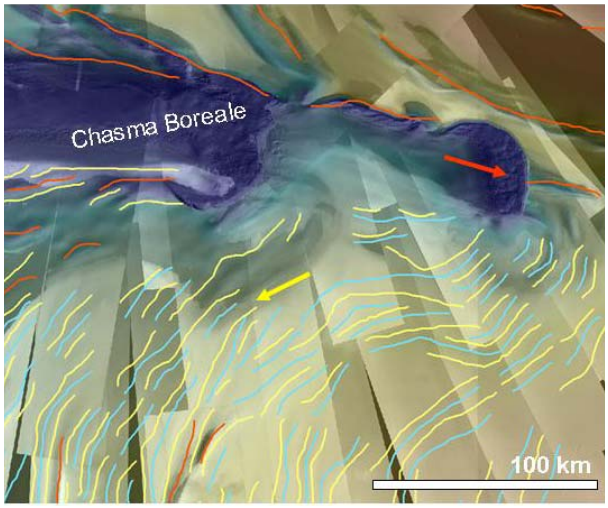

Fig. 3. Chasma Boreale cuts systems of undulations (yellow arrow) and a trough (red arrow). Based map includes shaded-relief MOLA (512 pixels per degree) DEM with color elevation scale overlain by CTX image mosaic. Image centered at 10° 18 E, 84° 46 N.

Discussion: Undulations may represent zones where canyons within the top of the lower layered deposits (LLD) were buried, but not completely infilled, by upper layered deposits (ULD) [1,2] Emplacement of dark sedimentary intermediate deposits (ID) exposed at the interface between LLD and ULD may have been responsible for exhumation of pre-existing canyons in LLD [1,2].

Formation of undulations concentric to Planum Boreum. Assuming that after the emplacement of Planum Boreum 1 unit, Planum Boreum had an overall domical shape but with local irregularities and that ID were emplaced on top of the troughed terrain (as indicated by previous work [1,2]), then the following geologic scenario is proposed.

Wherever dark sediments accumulated initially on equator-facing slopes, ice sublimation will produce localized depressions, which for simplication purposes here we assume to have been circular in shape. Over time, shifting of dark sands will progressively increase the number of equator-facing depressions. Retreat along the equator facing hesmispheric slopes will continue to enlarge the diameter and depth of indivial depressions leading to individual depressions merging with proximal ones. Depression growth will cease once they are deep enough for the dark lithic deposits to migrate from their equator facing slopes to their floors (thus, depth may have controlled the decline and cessation in the growth of individual depressions). We assume that LLD must have had similar physical and chemical attributes, so that polar materials must have sublimated at similar rates and thus the maximum depth of individual depressions must have been similar.

Due to the fact that Planum Boreum has a domical shape systems of depressions located at similar elevations will have their maximum depths at similar elevations, thus when they merge they would form continous canyons. On the other hand, the floors of depressions located at different elevations would not merge into a canyon with a topographically equipotential floor. Instead, they would remain separated by a ridge. Thus, as depressions merge sytems of parallel equator-facing canyons would form. These canyons and depressions will act as sand traps, and wind funneling along them may have produced saltation of sand and resulted in high rates of canyon growth.

Undulation-free terrains. Zones where undulations are absent may represent either LLD zones that (1) were not eroded, (2) were eroded in a different manner, such as by katabatic winds to form low-relief yardangs, or (3) zones where ULD are thick enough to completely infill and suppress the topographic signature of the canyons in the LLD.

Trough-free terrains. The formation of troughs involves retreat of ULD, thus regions where they are absent may represent terrains where this unit has remained relatively stable since during the stage of trough formation. Zone IV in Fig. 1 is located between Chasma Boreale and a system of troughs that open up in the opposite direction. Thus, katabatic and anabatic winds in zone IV may be complex and not unidirectional, which may have prevented erosional processes.

Formational history of Planum Boreum depression systems. After LLD were locally eroded into systems of canyons oriented parallel to regional contours, there was a period of deposition including the emplacement of the ID and ULD [1,2], and other finely layered materials within Chasma Boreale [2]. This period was followed by the exhumation and perhaps modest enlargement of “spiral troughs”, which in zones of densely clustered undulations exhumed ID materials. We find that whereas Chasma Boreale is the oldest recognized depression in Planum Boreum, it has undergone a recent stage of growth involving retreat of its floor and margins, including steep-walled cavi depressions (Fig. 3), which modify and thus postdate both undulations and troughs.

References: [1] Rodriguez J.A.P. et al. (2007) *Mars 3*, 29-41. [2] Tanaka K.L. et al. (2008) *Icarus, 196*, 318-358.