NORTH POLAR LAYERED DEPOSITS ON MARS AS REVEALED BY HiRISE IMAGES. K. L. Tanaka[1], [1]Astrogeology Team, U.S. Geological Survey, Flagstaff, AZ 86001, ktanaka@usgs.gov.

Introduction: The High Resolution Imaging Science Experiment (HiRISE) camera onboard Mars Reconnaissance Orbiter has obtained scattered high-resolution images (many are 32 cm/pixel) of the north polar layered deposits (NPLD) on Mars [1]. Most of the released images are monochromatic (red), but a few are three-band color images. These initial images have been acquired during the northern hemisphere's summer. Here I describe some of the apparent stratigraphic, structural, and modificational features of the NPLD apparent in these images. Previously, many aspects of the NPLD have been described with Mars Orbiter Camera (MOC) images at order-of-magnitude lower resolution.

Layering: The HiRISE resolution has enabled recognition of thinner (and thus more) NPLD layers than could be discriminated in MOC images. Individual layers generally are recognized as either alternating light vs. dark colored beds or as pairs of bright and dark stripes consisting of obliquely lit layer tops and strongly or weakly lit layer margins. Thus discrimination of layers involves their thickness, albedo, color, texture, outcrop expression, and continuity. These characteristics can vary dramatically in appearance within and between images due to lighting, slope, frost distribution, and other factors. For example, on gentle slopes in PSP_001374_2650, dozens of layers converge into just a few readily discernible continuous ones on steep sun-facing slopes, where secondary textures have effectively masked the finer layering. In addition, the thinnest layers group into packages commonly bounded by thicker, relatively resistant layers that display thick, steep margins. Some steeper slopes have undulations parallel to the bedding that could be mistaken for individual layers in lower-resolution images, but in fact include multiple layers.

At the head of Chasma Boreale on the east side of Boreum Cavus (Fig. 1), a color HiRISE image reveals similarly colored, cross-bedded layer sets bounded by lenses of dark, loose material. These form part of a locally recognized basal unit of the NPLD [2-3].

Surface features: At sub-meter resolution, the NPLD display a wealth of textures. Pits are common on some gently sloping surfaces and in particular layers. They range in size from >10 m across and resolved in MOC images down to meter-size ones at the limit of recognition in HiRISE images. The pits locally have relief similar to that of layer thickness, which results in discontinuous layers both in plan view and in sloping exposures in NPLD trough walls. Pits deeper than layer thickness may account for discontinuous layers in places. Pervasive pits and organized linear grooves and ridges also mark some marginal surfaces of the residual ice cap. Solar insolation and wind processes may sculpt these features into the NPLD surface. In addition, some may be the result of collapse.

Fig. 1. Part of cliff bounding Boreum Cavus shows fractured, cross-bedded light-colored layers interspersed by dark layers covered by transverse ripples. (Part of HiRISE PSP_001334_2645 centered at 84.4N, 343.5E; image width ~210 m; north at lower left.)

Some aligned ridge-and-groove sets in exposed NPLD surfaces may be yardangs (see also [3]). In some cases, they form distinctive sets associated with particular layers. Many have a degraded appearance, indicating that after forming, wind sculpturing ceased but other processes, perhaps involving weathering and sublimation, modified them. It may be that some of the degraded yardangs are exhumed and formed during hiatuses between episodes of layer deposition. Such yardangs may account for aligned ridges trending oblique to scarp faces that might otherwise be interpreted as low-angle faults or aligned, tilted beds.

Aligned, meters-wide ridges and ripples cover some Planum Boreum surfaces, including residual ice (Fig. 2). The ridges form aligned trains with periodic spacing and have asymmetric profiles--likely dune forms controlled by a dominant wind direction. The ripples are ~1 m wide and cover much of the interdune surface. The ripples and dunes may be composed largely of H_2O snow or ice grains.

NPLD at the head of Chasma Boreale appear mantled, perhaps by fine-grained loess eroded from the NPLD. These deposits obscure NPLD surface textures and locally form mounds [3].

Fig. 2. Section of an asymmetric, WNW-trending trough interpreted to be a graben that cuts the residual ice cap of Planum Boreum. Large depression (60 x 160 m) contains layers and dark soil. Depression and small pits form along and near trough margins. Surface covered by NW-trending ridges and ripples. (Part of PSP_001513_2650 centered at 85.1N, 137.6E; north at top.)

Deformation features: Relatively thick, resistant layers in NPLD sequences generally display what appear to be conjugate fracture systems having fracture spacings on order of several meters and less, down to the limit of resolution (Figs. 1 and 3). The cracks have relatively steep walls, locally casting shadows. On steeper slopes, some of the material cleaved by the cracks and layer interfaces have failed, resulting in small scarp re-entrants and boulder-rich avalanche deposits. Some of the cracks appear filled with resistant material, as they weather out into sharp, narrow ridges (as in lower left part of Fig. 3).

Some layer sequences have irregular, wavy, and locally discontinuous profiles. These layers appear fractured, faulted, and folded. Some layer sequences are more deformed than underlying sequences, indicating that mechanical discontinuities divide them. Fracturing likely is pervasive in many outcrops down to sub-meter spacings, particularly in brighter layers. Darker layers appear fractured as well, but commonly have rugged surfaces. Possibly, the dark layers are relatively ductile. Origin of the fracturing may be related to pervasive compaction and shrinkage of some parts of the NPLD. Another possibility is that steeper parts of the NPLD have undergone modest gravitational spreading, resulting in grinding and thinning of layers. However, large faults associated with such movement are yet to be seen.

Small irregular, aligned troughs interpreted to be grabens cut the polar residual ice (Fig. 2). In MOLA data, the grabens align with the crests of broad ridges between troughs in Planum Boreum. Graben walls include sharp, steep-sided, partly shaded pits mostly aligned with graben-bounding scarps. A particularly large pit reveals what may be fine layering in the residual ice, including dark layers that may be rich in dust and poorly consolidated. Larger surficial ridges terminate at the graben walls, but finer ripples are ubiquitous, indicating that the graben forms have only affected ridge development. Some of the pits do not lie over obvious graben structures but are generally located appropriately to be related to collapse along buried faults. The faults bounding and underlying the grabens may extend downward form 100 m or more, deep into the NPLD.

Unconformities: In Fig. 4, an unconformity is marked by the surface of a dark, ledge-forming, massive deposit It may be a lag of eolian fines that settled on an eroded surface prior to renewed layer deposition. The deposit locally bifurcates and is draped over multiple beds. This seems to indicate that the unconformity represents a complex episode of erosion and deposition.

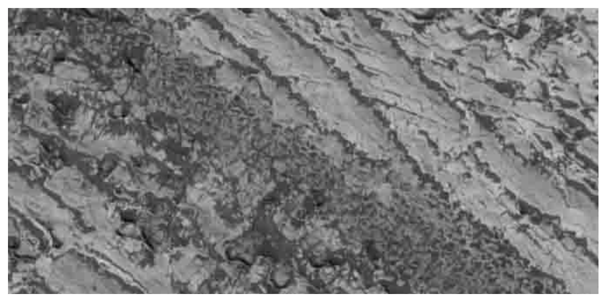

Fig. 3. Sample of highly fractured and deformed NPLD; note two of the bright layers become mottled and perhaps brecciated. (Part of HiRISE PSP_001398_2615 centered at 81.5N, 47.3E; image width ~170 m; north at top.)

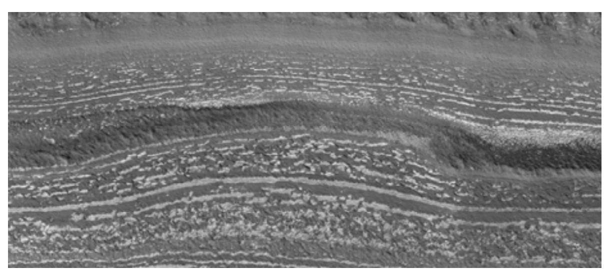

Fig 4. Dark, hummocky surface marks unconformity in NPLD trough; bifurcates at left. (Part of HiRISE PSP_001398_2615 centered at 81.5N, 47.3E; image width ~1140 m; north at top.)

References: [1] I thank with great pleasure the HiRISE Team for obtaining, processing, and publicly releasing the images used in this abstract so rapidly. [2] Byrne S. and Murray B.C. (2002) *JGR 107*, 5044. [3] Tanaka K.L. and Bourke M.C. (this volume).