NON-GLACIAL INTERPRETATIONS OF LONG-TERM MARS SOUTH POLAR VOLATILE HISTORY BASED ON MGS DATA AND NEW GEOLOGIC MAPPING. E.J. Kolb[1] and K.L. Tanaka[2], [1]Arizona State University, Dept. of Geological Sciences, Tempe, AZ 85287, ekolb@asu.edu, [2]Astrogeology Team, U.S. Geological Survey, 2255 N. Gemini Dr., Flagstaff, AZ 86001, ktanaka@usgs.gov

Introduction: Previous geologic maps of the martian south polar region were compiled from Mariner 9 images by [1] and from medium-resolution Viking images by [2]. Exciting new insights into the polar geology of Mars are being provided by data from Mars Global Surveyor (MGS). In particular, altimetry data acquired by the Mars Orbiter Laser Altimeter (MOLA) are revealing more precisely the topography of the surface and thus the geometric characteristics of and relations among polar materials and landforms. Further, the Mars Orbiter Camera (MOC) is providing meter-scale resolution of the geomorphological and albedo character of the surface (MOC Narrow-Angle Camera) and lower resolution images necessary for regional geologic mapping (MOC Wide-Angle Camera). By incorporating these data into our new geologic mapping and associated studies of the martian south polar terrain (>lat 60°S), we have made significant advancements in the identification and interpretation of geologic units and features. In particular, new mapping observations have enabled us to address issues related to the long-term south polar volatile history, including: What geologic activity affected the south polar region during the Noachian and Hesperian Periods? What type of long-term modificational processes have shaped the polar dust and ice deposits of the south polar layered deposits (SPLD), and to what extent have glacial-type processes such as basal melting and ice-flow occurred?

Noachian/Hesperian regional geology: As mapped previously [1, 2], Noachian and some of the Hesperian units consist of cratered, deformed, and finely dissected materials similar to those appearing in lower latitude regions of Mars. We find no clear evidence for a Noachian polar deposit, although one potentially could be incorporated within the terrains and/or subsequently resurfaced, including by Hesperian and Amazonian polar deposition, or otherwise modified sufficiently to obscure it. A set of 21 mountains (Sisyphi Montes) have been proposed to be subice volcanoes by [3]. Five of these occur within Noachian cratered highland materials; the remainder appear embayed by the DAF. Thus all may be Noachian. Alternatively, we suggest that they may be volcanic edifices composed largely of relatively viscous lavas resulting from silicic or volatile-poor magmas, low eruption temperature, high degree of vesiculation, and/or high phenocryst content.

Hesperian polar deposits: Previously, the Dorsa Argentea Formation (DAF), which surrounds and underlies about half of the Amazonian south polar layered deposits, was divided into the upper (unit Hdu) and lower units (unit Hdl), by [2] on the basis of stratigraphic position and degree of degradation. MGS data further clarifies the stratigraphic, morphologic, and topographic relations, permitting the dividing of the DAF into eight members [4]. The DAF now includes six major outcrops of plains materials: (a) northern Argentea Planum (Argentea member of DAF, unit Hda; 64-81°S, 18-104°W), (b) Parva Planum (Parva member of DAF, unit Hdv; 71-81°S, 85-130 °W), (c) southeastern Argentea Planum (dorsa member of DAF, unit Hdd), (d) Sisyphi Planum (Sisyphi member of DAF, unit Hds; 61-77°S, 327-18°W), (e) Promethei Planum (Promethei member of DAF, unit Hdp; 77-84°S, 230-315°W) and (f) Chasma Australe (chasma member of DAF, unit Hdc). Newly designated DAF members include the rugged and knobby material between Argentea and Sisyphi Plana (unit Hdr) and the previously mapped [2] Noachian and Hesperian undivided material pocked by Cavi Angusti as the cavi member of DAF (unit ANdc).

The lobate fronts yet lack of other typical volcanic-flow morphology of the plains units of DAF indicate that the units may be made up of debris flows. We think that these flows, tens of meters to 200 m thick, may have originated by the discharge of huge volumes of slurry fluidized by ground water or liquid CO_2, perhaps triggered by local impacts, igneous activity, or basal melting beneath polar deposits [4]. The cavi (unit ANdc) and rugged members (unit Hdr) of the DAF include irregular depressions, some with raised rims that penetrate the subsurface. The depressions may have formed by collapse due to expulsion of subsurface material in which local explosive activity built up the raised rims. Further, smaller eruptions of volatile-rich material may have resulted in coarse-grained, narrow, sinuous channel deposits within aggrading, fine-grained unconsolidated material perhaps produced by gaseous discharge of subsurface volatiles. Preferential erosion of the fines could have produced the Dorsa Argentea-type sinuous ridges associated mainly with the DAF. Alternatively, features within or associated with the DAF have been offered as evidence supporting both a previously larger extent of polar ice deposits during the Hesperian and their subsequent removal by glacial-type processes. This scenario suggests that narrow, sinuous ridges are eskers [5-6], valleys in terrain adjacent to the DAF drained meltwater into Argyre basin [7-8], and patches of depressions (the larger ones form the cavi terrains) are glacial kettles [6]. Inferred thicknesses and areal extent of this proposed Hesperian-age polar deposit by [9] would indicate ~0.5 x 10^6 km^3 of volatile-rich material have been removed. Our mapping of DAF regions has not been able to identify any substantial remnant ancient polar ice deposits given that such deposits would have covered an area nearly twice as large as Planum Australe.

Furthermore, our examination of Viking images and MOLA digital terrain models (DTM's) generally supports the more conservative mapping of channel systems surrounding Argyre basin by [2] in which only one modest channel system (Doanus Valles/Oceanidum Fossa) of the four proposed actually extends to the margin of Hesperian polar deposits and thus potentially drained south polar melt water into Argyre basin. The remaining proposed drainage courses do not display channels cutting through Middle to Late Noachian rocks. Thus any surface drainage through the valley systems must have predated these units. Alternatively, subsurface drainage may have occurred along the proposed courses, such as is apparent between Uzboi and Ares Valles north of Argyre basin where collapse features indicate such activity [7]. Given these observations and our preferred explanations for the narrow sinuous ridges and rimmed depressions, we see no unequivocal evidence for an extensive, wet-based ice sheet during the Hesperian in the south polar region.

Amazonian Units: South polar Amazonian geology is dominated by the formation and modification of the polar layered deposits. MGS data show that the south polar layered deposits (SPLD) consist of finely bedded strata remarkably undeformed over distances of tens to hundreds of kilometers, leading us to conclude that the deposits have not experienced widespread lateral flow by simple shear [10]. Our observations also include the lack of observed ice-flow deformation of the large, McMurdo impact crater (lat 84.5°S., long 0°W) on the margin of Planum Australe and the lack of observed glacial shearing features or planation of exposed underlying topography within reentrants of Planum Australe (including Chasma Australe). Our detailed analysis of south polar spiral-trough topography, in conjunction with the identification of similar layered stratigraphy within adjacent troughs of the north polar spiral troughs, suggests that trough migration due to preferential ablation of sun-facing slopes did not occur. Within the layered sequences, we have not identified widespread unconformities, discontinuities or pinch-outs that would indicate an accublation origin of the PLD's [11]. Minor, local deformation is evident in MOC narrow angle images of the lower regions of the SPLD such as high-angle faults within the bounding scarps of Ultimi lobe [12] while potential boudinage structures noted by [13] may indicate squeezing of layers by pure shear caused by compositional variances within the SPLD.

Topographic and morphologic features of a smaller trough east of Chasma Australe (centered at 83°S., 217°W) were used to interpret the likelihood of sub-ice discharge events accounting for trough formation as proposed by [14]. In MOLA DTM's, a sequence of the SPLD >500 m thick and 83 km long encloses the distal end of the trough. Analysis of the DTM reveals layered sequences within the trough walls extending continuously and undisrupted through the lower sections of the SPLD that enclose the trough, demonstrating that the SPLD was never breached down to the trough-floor level. Inside the enclosed trough, exposed Noachian basal material extends across the trough and rises ~500 m above the surrounding floor. Also, narrow sinuous ridges of unit Hdc of the DAF orientated perpendicular to the presumed discharge flow extend across the trough floor, precluding any basal glacial scouring or sub-ice discharge events. Furthermore, at the base of the obstructions' northernmost extent, narrow-angle MOC imagery reveals undisturbed layered stratigraphy and an absence of features indicative of sub-ice meltwater discharges such as collapse of overburden material. Based on these observations, we favor an eolian mechanism for the formation of the striated chasmata, such as erosion by katabatic winds as proposed by [15].

We conclude from MOLA and MOC observations of Amazonian PLD morphology, composition, and thickness [10], that the PLD's are composed of porous unconsolidated layers that have not experienced significant basal melting or glacial flow, although boudin formation among the layers is evident. We therefore postulate that the well-defined PLD's eventually reached and maintained their present form following deposition without extensive flow deformation or redeposition. However, local resurfacing of the SPLD may have been effective at removing impact craters. Further work is needed to strengthen our hypotheses, as many alternative views are also being promoted based on MGS data.

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