LARGE HESPERIAN PROGLACIAL LAKE IN SCHMIDT VALLEY, MARS: EVIDENCE FOR MARGINAL PITTED SANDAR DEPOSITS: J. L. Dickson and J. W. Head, Dept. of Geol. Sci., Brown Univ., Providence, RI 02912 USA, james_head@brown.edu.

Introduction and Background: Previous analyses using MOLA data support the general concept that significant volatile-rich deposits formed in the Hesperian period of Mars history in the south circumpolar area [1-4] and that a large quantity of volatiles was lost when portions of the cap underwent retreat toward the present position of the edge of the Amazonian layered terrain [1]. The presence of meltwater is supported by: 1) the presence of sinuous ridges plausibly interpreted as eskers [5], and marking the location of subglacial streams that drained much of the retreating polar cap, and 2) cavi, the surface manifestation of subglacial melting and vertical and lateral movement of water [6]. Portions of the meltwater appear to have ponded in a large lake [7] near the crater Schmidt and then to have drained from a notch in the northern end of the valley, ultimately flowing into the Argyre Basin. Contrasting interpretations are found in [8]. In this contribution we describe the relationships of distinctive topography at the margins of the interpreted lake and the lobate deposits of the Dorsa Argentea Formation (DAF) in the Cavi Angusti region. We assess these features in terms of a range of Earth analogs.

Description: The geologic and topographic setting of Schmidt Valley and the interpretation of the area occupied by meltwater reveals a north-northwest oriented valley approximately 350 km wide that extends from the edge of the present cap north toward the Argyre basin for a distance of over 750 km. It is bounded on the west, north, and east by irregularly-shaped, topographically high segments of Noachian cratered terrain [1,7].

An unusual set of features and deposits is located just to the north of this zone along the western margin of Schmidt valley south of the crater Schmidt and at the edge of the Cavi Angusti deposits (Fig. 1, 2). This region consists of several parallel zones the boundaries of which parallel the topography. At the highest topographic level (in excess of ~1700 m) the morphology is characterized by the cavi and deep sinuous troughs of Cavi Angusti.

At the margins of this zone toward the north and west occurs a transition region about 75 km wide, dominated by smooth plains interrupted by numerous equidimensional and linear pits. This pitted plain lies generally between the elevations of 1000 m and 1750 m and slopes down to the floor of Schmidt Valley at an angle of 0.08°; it extends along the margin for a distance of about 250 km. Pits in this pitted plain number about 310 and are uniformly smaller than those making up Cavi Angusti; the diameters range from <1 km to 8 km, with the mean being about 4 km (Fig. 3). Pits tend to be elongated, with their aspect ratio ranging from ~1 to ~5 but with a mean of ~1.8. The elongation direction is not random, with broad trends in the N-S direction (Fig. 4). There is no evidence for a dominant trend related to the regional slope, or to prevailing wind directions (Fig. 2, 4). Depth of the pits is variable (50-200 m), as is floor elevation (Fig. 2).

Located on the slopes of the pitted plain adjacent to Schmidt Valley are about a dozen parallel linear valleys 1-5 km wide and 10-40 km in length (Fig. 1). These appear steep-sided, flat floored, and range from ~75 m to ~300 m in depth, generally deepening upslope. Several of the valleys flare out at the ends in the downslope directions, several appear connected to large depressions in the adjacent Angusti Lobe, and several have amphitheater-like upslope heads. The most prominent set is located on the upper parts of the pitted plain (Fig. 1).

Adjacent to the pitted plain zone lies an elongated low rise (Fig. 1, 2), which has a much smoother surface and almost no pits. This zone is about 30 km wide and is separated from the regionally smooth, but locally rough topography of the valley floor by a scarp/trough about 100 m in height.

Discussion and Interpretation: Previous interpretations of the origin of the pits in this terrain have focused on eolian processes and deflation pits [e.g., 7]. Although eolian processes have surely influenced and modified the area, the localized distribution of these features, their location at the edge of an extensive deposit of volatile-rich material that is undergoing melting (Cavi Angusti) [9], and their formation along the margin of a valley that was the likely recipient of an extensive volume of meltwater forming a lake, suggests an alternate interpretation. We explore the hypothesis that these morphological zones and the features that they contain are related to lake-ice sheet contact environments. In terrestrial glacial environments, features at the margins of receding ice sheets are often characterized by proglacial fluvial systems known as outwash plains or sandar. Terrrestrial sandar have a proximal zone with a few deep and narrow channels, an intermediate zone with a complex network of wide, braided channels, and a distal zone with shallow, poorly defined channels merging to sheet flow deposits [10]. Polar sandar are often quite different because of low meltwater discharges and negligable precipitation [11]. Polar sandar deposits and facies are distinct [11] and their evolution is estimated to proceed at rates about two orders of magnitude less than lower latitude sandar. Thus, abundant channel deposits are often replaced by broad fans. Continued retreat of the ice sheet can result in the isolation and partial burial of ice blocks. Subsequent melting and sublimation of the ice blocks then leads to the formation of pits or kettle holes. Kettles are partially filled from the collapse of outwash material surrounding an ice block, and can be further buried if sandar aggradation continues during this phase of evolution. The well known outwash plain [12] emplaced in front of the Sandwich moraine of the Cape Cod Bay Lobe contains over 82 kettle holes ranging from 0.28 km to 3.63 km in diameter. In this case, the Sandwich moraine served as a dam for a proglacial lake that formed when the lobe underwent further retreat. This isolated the outwash plain and as the ice blocks melted the kettle holes remained and were preserved.

Thus, outwash plains, polar sandar, and kettle holes may be good analogs for the pitted plain on the distal flanks of the Cavi Angusti lobe. Because of the very low temperatures anticipated at such high latitudes on Mars, there is a high likelihood that this feature would behave in a manner similar to a polar sandur. The sizes of the pits on the pitted plain are much larger on Mars than those on Cape Cod. The size distribution of the isolated blocks is determined by the interplay of top-down melting and sublimation, and sedimentation. Slow rates of sedimentation and ice wastage could lead to larger isolated block sizes, and thus larger kettle holes.

We interpret the pitted plain channels to be a combination of local conditions at the margins of the Angusti Lobe involving both overflow from englacial lakes [13] and raised groundwater table levels due to the presence of the lakes, and subsequent sapping adjacent to these levels. In this scenario, subglacial melting due to magmatism [6,9] creates subglacial and englacial lakes behind the front of the Angusti Lobe. The fate of these lakes depends on the scale and rates of melting and the mechanisms and rates of drainage. Subglacial, englacial and supraglacial drainage from these lakes creates a family of features that includes both large irregular depressions (formed both by enclosed lakes and by subsidence and collapse of overlying ice following drainage of lakes) and smaller sinuous depressions that commonly interconnect the larger depressions (the surface manifestation of large drainage channels from these lakes). Where the large lakes are adjacent to the northward sloping outwash plain, pamet-like linear valleys are formed by a combination of sapping due to the elevated groundwater table and perhaps overtopping and some supraglacial drainage. The present topography is a complex pattern of large drained depressions and partly subsided and collapsed interconnecting sinuous drainage channels, very similar to those seen in Icelandic subglacial eruptions and drainage channels [14].

On the basis of these observations, we interpret these zones to represent the location of a former marginal ice-rich deposit, with the pitted plain representing the location of a decaying ice sheet which left isolated ice blocks surrounded by sediment, which then melted or sublimed to produce the martian equivalent of terrestrial kettle holes. Thus, we interpret these features to have formed at the junction (Fig. 1, 2) between the margin of the ice-rich deposit (Cavi Angusti) and the lake forming on the floor of Schmidt Valley.

References: 1) J. Head and S. Pratt, JGR, 106, 12275, 2001; 2) A. Howard, Sapping Features of the Colorado Plateau, NASA SP-491, 1988; 3) K. Tanaka and D. Scott, USGS Misc. Inv. Map I-1802-C, 1987; 4) J. Plaut et al., Icarus, 76, 357, 1988; 5) J. Head and B. Hallet, LPSC 32, #1366, #1373, 2001; 6) G. Ghatan and J. Head, JGR, 107, 10.1029/2001JE001593, 2002; 7) J. Head and S. Pratt, LPSC 32, #1159, 2001; 8) K. Tanaka and E. Kolb, Icarus, 154, 3-39, 2001; 9) G. Ghatan et al., JGR, in review, 2002; 10) D. Benn and D. Evans, Glaciers and Glaciation, Arnold, 1998; 11) R. B. Rains et al., NZJGG, 23, 595, 1980; 12) A. Strahler, A Geologist's View of Cape Cod, Natural History Press, 1966; 13) A. Sakai et al., Role of supraglacial ponds in the ablation process of a debris-covered glacier in the Nepal Himalayas, in Debris Covered Glaciers, IAHS Publ. No. 265, 2000; 14) F.J. Magilligan et al., Geomorphology, 44, 95-113, 2002.

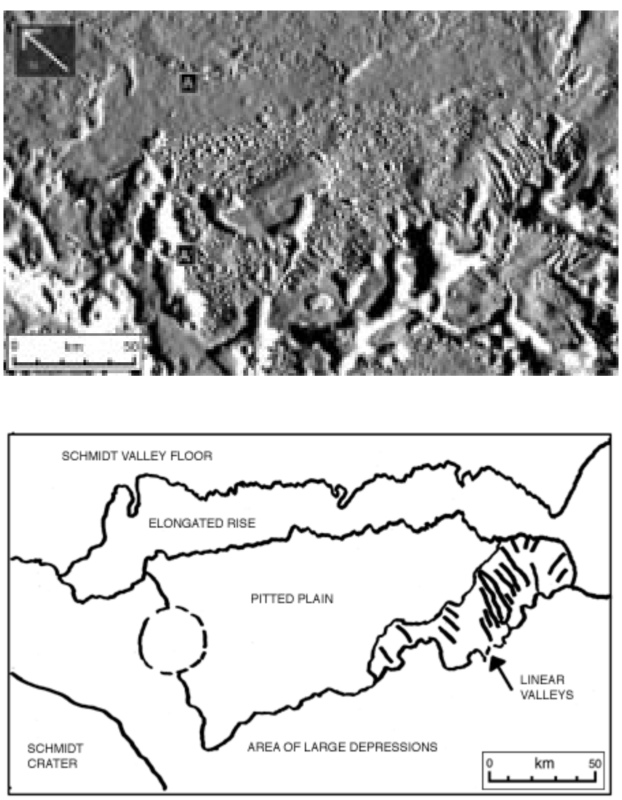

Fig. 1. Gradient map and sketch map of the boundary area between Schmidt valley region and the Cavi Angusti Lobe near the South Pole of Mars.

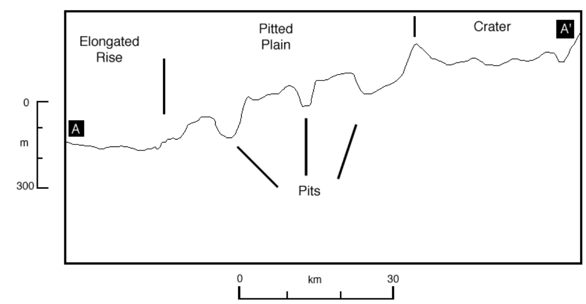

Fig. 2. MOLA profile showing the main features across the boundary. Location shown in Fig. 1.

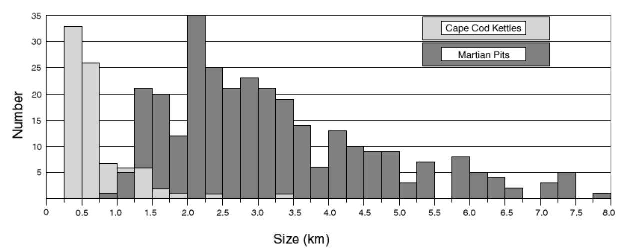

Fig. 3. Size frequency distribution of pits in the pitted plain and kettles in Cape Cod.

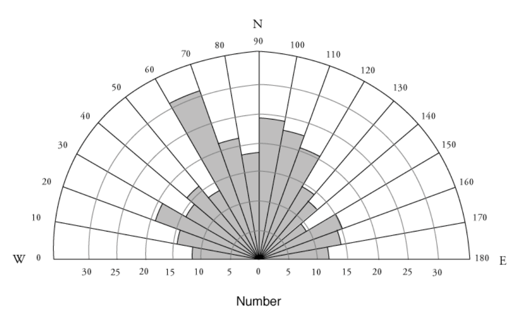

Fig. 4. Long-axis orientation of pits in pitted plain.