**Implications of Flow and Brittle Fracture of Ice Masses in South Polar Craters**. S. Byrne[1], [1]Division of Geological and Planetary Sciences, California Institute of Technology, Mail-stop 150-21, 1200 East California Blvd., Pasadena, CA 91125, USA. **shane@gps.caltech.edu**

**Introduction:** The Martian layered deposits have long been thought to be mostly water ice with varying admixtures of dust leading to the differing albedos and mechanical strengths of the layers [1]. They have previously been mapped as a distinct unit based on their banded visual appearance [2]. Topography data from the Mars Orbiter Laser Altimeter (MOLA) [3] have confirmed these deposits to be several kilometers thick and broadly dome shaped, similar in many respects to the Greenland ice sheet on Earth.

The degree to which the present layered deposits behave like terrestrial ice sheets is unknown [4]. The possibility of flow has been discussed by several authors [5,6]; conversely brittle fracture and sublimation have been proposed to dominate over flow by others [7,8]. In this work a series of features at the edge of the southern layered deposits are examined for evidence both for and against flow.

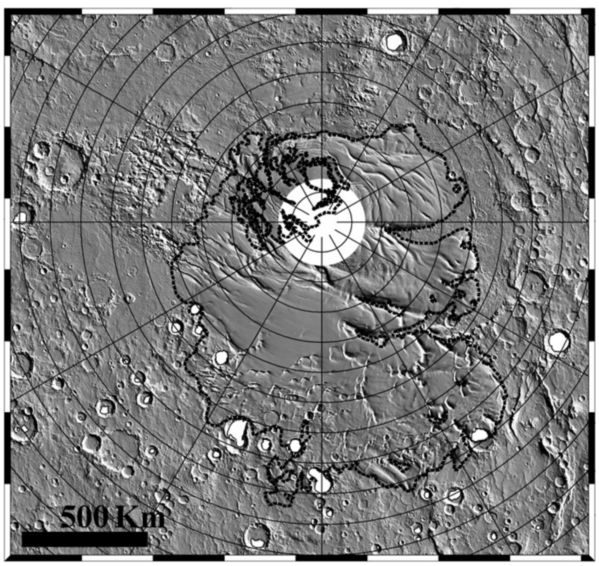


**Figure 1.** MOLA derived shaded relief map of the south polar region. Grid lines every 2° latitude and 30° longitude, shading from upper right. White areas indicate mapped locations of mounds within craters interpreted to be layered deposit outliers. White circle at center represents no data, black dashed line represents mapped boundary [2] of layered deposits.

A series of craters close to the mapped edge of the south polar layered deposits contain large mounds (see Fig 1). These mounds appear to be layered deposit outliers in Mars Orbiter Camera (MOC) images and have previously been mapped as such [2]. Many of these mounds show geomorphic evidence of flow at some point during their history some of which is discussed below. A thorough review of this evidence will be presented and implications for polar history discussed.

**Edge ridges**: A common occurrence where these mounds are in contact with a crater wall are ridges at the edge of the deposit (see Fig. 2).

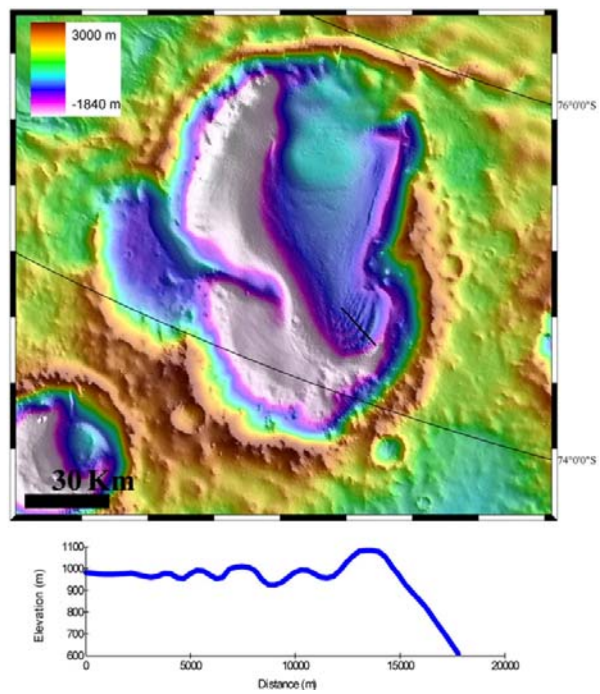


**Figure 2.** MOLA topography shaded from the upper right of a glacier-like feature within two craters. The black line near the interpreted terminus (below and right of center) represents the position of the plotted topographic profile. A series of ridges is visible near the edge of this feature.

These ridges are interpreted here as being due to compression of the ice mass as it flowed into the side of the crater. Its possible that this form of compression could also occur from the ice being pushed uphill by the pressure of the mound upstream. The present day separation between the crater wall and proposed terminus is interpreted to be due to subsequent retreat of the ice by sublimation. Many of these mounds have dunefields superposed on them, care must be taken that large dune formations are not interpreted as ridges within the ice body. MOC narrow angle imagery provides the distinguishing data.

**"Double hump" structure:** Many of these mounds appear as though there are multiple superposed ice masses (see Fig. 3). It has been argued in the past that the southern layered deposits have advanced and retreated [5]. This is further evidence to that effect, each superposed lobe of material can be interpreted as being the result of the main ice sheet advancing over the previous lobes. Periodic glaciation is common on the Earth and could occur on Mars due to deposition enhanced by obliquity variations as has been suggested by many in the past.

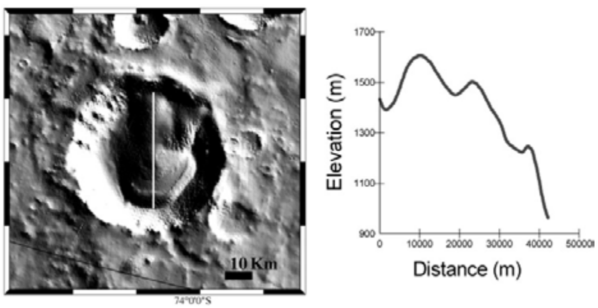


**Figure 3.** MOLA shaded relief of crater containing superposed mounds. White line indicates position of plotted topography profile (top to bottom on figure is left to right on plot). A single ridge at the edge of the deposit is also visible here.

**Indications of Brittle Fracture:** Several locations at the layered deposit boundry exhibit ample evidence of brittle fracture [8] (see Fig. 4).

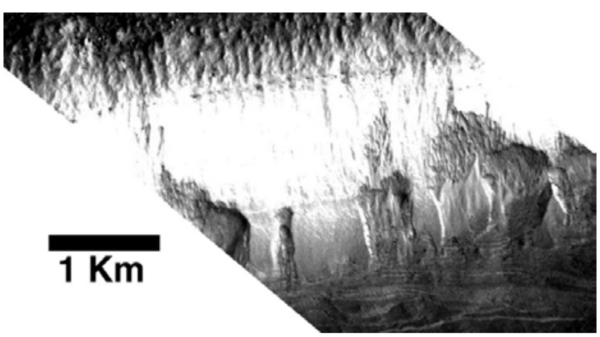


**Figure 4.** Subset of MOC narrow angle image M02/01989 showing bounding scarp of layered deposits. Landsliding is comman in this area.

Offset faulted layers, landslides, and large scale slumping in certain areas indicate that flow is not currently fast enough to accomadate the driving stress which causes these features.

**Possible Moraines:** Terminal moraine like features point to both lateral advancement of ice masses and more recent retreat. The evidence for the existence of these features is weaker than other indicators discussed above since they are in general harder to locate.

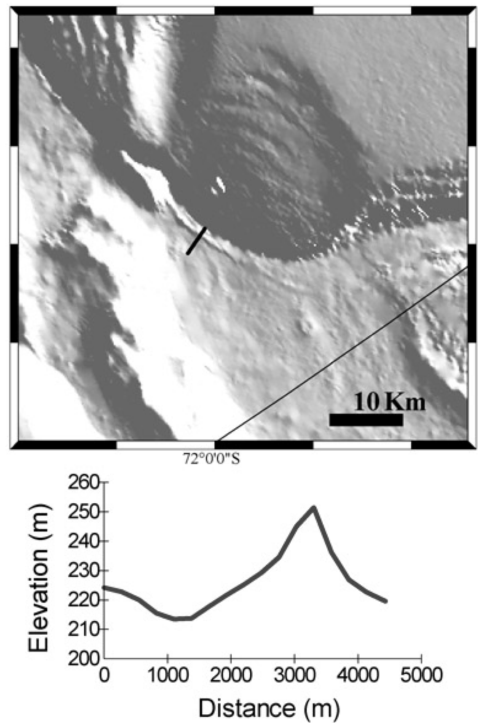


**Figure 5.** MOLA shaded relief near 72° S 145° E. Small moraine like structures are evident in the vicinity of possible flow structures. Black line segment represents the position of plotted profile.

Modeling to try and constrain the length of time it would take for water ice features to retreat due to insolation alone (which varies with obliquity) will be used to attempt to estimate how long ago sublimation overtook flow.

**Preliminary Interpretations:** In many locations these ice rich mounds seem both to be in a state of retreat and display evidence of flow. These two disparate observations can be reconciled by postulating alternating episodes of glacial advance and sublimation-based retreat. The geomorphological evidence seems to suggest that we are currently in an erosive state and have been for some time.

The large quantities of water ice discovered within the mid-latitude regolith [9] and the snow layer proposed [10] as an explanation for the gully phenomena in the middle latitudes could represent the present location of water ice which in glacial periods would be transported poleward and acculuminate as layered deposits. If the polar layered deposits were to wax and wane in thickness then glacial activity at its margins would also respond to the increased pressure and driving force of the thicker ice sheet. Retreat via sublimation is likely operating to some extent at all times but may be periodically overtaken by this glacial activity.

A more complete set of geomorphic evidence will be presented along with modeling results of retreating scarps to attempt to date these events.

**References:** [1] Cutts, J.A.. (1973) *JGR, 84*, 2975-2994. [2] Tanaka, K., and D. Scott (1987) *USGS, Map I1820-C*. [3] Smith, D., et al. (1999) *Science, 284*, 1495-1503.[4] Clifford, S.M. et al. (2000), *Icarus, 144*, 210-242. [5] Head, J.W. (2001) *JGR, 106*, 10075-10085. [6] Nye, J.F. (2000) *J. Glaciol., 46*, 438-444. [7] Ivanov, A.B., and D.O. Muhleman (2000) *Icarus, 144*, 436-448. [8] Murray et al. (2001) *Icarus, 154*, 80-97. [9] Boynton et al. (2002) *Science, 297*, 81-85. [10] Christensen, P.R. (2003) *Nature, 422*, 45-48.