SURFACE AGE AND RESURFACING RATE OF THE NORTH POLAR LAYERED TERRAIN ON MARS; K. E. Herkenhoff[1], J. J. Plaut[1], and S. A. Nowicki[2], [1]Jet Propulsion Laboratory, California Institute of Technology, Pasadena, CA 91109, [2]Arizona State University, Tempe, AZ 85287.

The Martian polar layered deposits are probably the best source of information about the recent climate history of Mars [1-8], but their origin and the mechanisms of accumulation are still a mystery [9]. The polar layers are sedimentary deposits that most planetary scientists believe are composed of water ice and varying amounts of wind-blown dust [3-5], but their composition is poorly constrained [10]. Interpretation of the observed polar stratigraphy in terms of global climate changes is complicated by the significant difference in surface ages between the north and south polar layered terrains inferred from crater statistics. While no craters have been found in the north polar layered terrain, the surface of the south polar layered deposits appears to have been stable for many of the orbital/axial cycles that are thought to have induced global climate changes on Mars. Further studies of the polar layered deposits should ultimately lead to a better understanding of the climate history of Mars.

Using medium-resolution Viking imagery, Plaut *et al*. [8] found at least 15 impact craters in the southern layered deposits and concluded that their surface is at least 120 million years old. In contrast, Cutts *et al.* [2] found no fresh impact craters larger than about 300 meters in summertime images of the north polar layered deposits. Instead of using summertime images, in which differences in surface albedo are difficult to differentiate from shadows cast by topographic features, we studied springtime images. These images show a surface that was covered by a blanket of carbon dioxide frost. This effectively removes the albedo differences and makes topographic features like impact craters stand out clearly. We found no impact craters on the north polar layered deposits or ice cap. The images studied cover 77% of the layered deposits and residual ice cap, with resolutions from 20 to 95 meters per pixel. The uniform seasonal frost coverage, clear atmospheric conditions, and excellent resolution of these springtime images make them an ideal dataset for constraining the surface age of the north polar layered deposits. We have confirmed that craters that are 3 pixels across can be recognized in images of adjacent, older terrains taken during the same orbit as the images of the layered deposits, indicating that the martian atmosphere was very clear at the time these images were taken. We therefore conclude that there are no craters larger than 300 m in diameter in the area of the north polar layered deposits studied.

The absence of impact craters larger than 300 meters in diameter indicates that the surface of the north polar layered deposits is geologically very young. We modeled the production and obliteration of an impact crater population on the layered terrain using the formulation of Phillips and Malin [11] and modeling techniques developed by Plaut *et al*. [8]. The absence of craters allows placement of a upper bound on the age of the surface of the layered deposits, or alternatively, to constrain a minimum rate of vertical resurfacing. We use the estimate of the current crater production rate for Mars obtained by Shoemaker and Shoemaker [12] of 6±2 craters >20 km diameter produced on a surface of 1 million square km in one billion years. A cumulative crater size frequency power law of -2 slope is used to extrapolate this rate to smaller sizes. Over an extended period of time, cratering at this rate should produce a crater >300 m diameter on an area the size of the layered terrains examined in this study (0.81 million km^2) [13] every 46±15 Ka, on average. Uncertainties in this estimate are proportional to the uncertainties in the crater production rate. The absence of any craters >300 m diameter, combined with a "counting error" of ±1 crater, allow us to place a upper bound on the crater production age of this surface at 92±30 Ka. A surface nearly 1 million km^2 in area, older than about 100 Ka, would be expected to accumulate at least one crater of sufficient size to be detected in the Viking images we examined.

The lack of craters can also be modeled as the result of a vertical resurfacing process (either deposition or erosion) that removes craters at a steady rate proportional to crater depth. In this model, an equilibrium is achieved between crater production and obliteration. Rapid crater obliteration rates are required to remove craters from the layered terrain, making the original "age" of the surface inconsequential, since crater production and obliteration come rapidly to equilibrium. Such an equilibrium condition produces a cumulative crater size frequency power law of -1 slope. Ignoring for the moment the poor statistics of small numbers, the presence of a 300 m diameter crater on an area the size that we examined is consistent with vertical resurfacing that operates at a rate no faster than 4000 km/Ga (4.0 mm/yr). Incorporating uncertainties in the cratering rate places uncertainties of ±1.3 mm/yr on this vertical resurfacing rate. If larger craters were observed, a lower resurfacing rate would be implied, since such craters form less frequently and therefore are more likely to be obliterated over their typical lifetime. The absence of any craters larger than 300 m diameter implies that resurfacing occurs at a vertical rate at least as fast as our minimum estimate of 4.0±1.3 mm/yr.

It is clear that the surface of the north polar layered deposits is much younger than that of the south polar layered deposits. Hence, erosional and/or depositional processes have been more active recently in the north polar region than in the south. The north polar resurfacing rate of 4 km/Ma is much greater than the resurfacing rate of 8±2 m/Ma derived for the south polar layered deposits [8]. This contrast implies that the north polar layered terrain is currently an active site of deposition and/or erosion, while the south polar layered deposits have been relatively stable over the past 100 Ma or so. The greater extent of aeolian erosional features in the south polar layered terrain may be evidence that gradual erosive processes (such as aeolian abrasion) have been more important than rapid ice sublimation in the evolution of the south polar layered deposits. Furthermore, the inferred average surface age of the south polar layered deposits (at least 10^8 years [8]) is much longer than the timescales of theoretical orbital/axial variations (10^5 to 10^6 years [14]). At least some areas of the south polar layered terrain have therefore not been greatly modified by global climate changes over the last 100 million years or so. New orbital observations of the Martian polar regions from the Mars Global Surveyor and surface exploration by the Mars Volatiles and Climate Surveyor are likely to greatly enhance our understanding of the polar layered deposits and the climate changes that they record.

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