CRATERING AND OBLITERATION HISTORY OF THE SOUTH POLAR REGION OF MARS

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The diverse assemblage of geological units in the south polar region of Mars implies a complex geological history, with exogenic processes strongly modulated by climatic phenomena. In this study results are presented from a comprehensive analysis of crater size frequency distributions compiled from Viking Orbiter images of south polar terrains. Depositional histories for the various terrain units are modelled based on deviations of cumulative crater size frequency plots from an assumed production function. Stratigraphic and morphologic data obtained from visual examination of Viking images are also used, primarily to corroborate inferences concerning ages and obliteration histories derived from the crater data.

The model used for crater production and obliteration is adopted from [1]. We assume a cratering history consisting of an early exponentially decaying rate along with a long-lived steady rate. The amount of obliteration needed to remove a crater of a certain size is assumed to be equivalent to crater depth. These assumptions are incorporated into an algorithm which generates a model cumulative size frequency distribution curve for a given obliteration history and surface age. Actual crater abundance data are then compared with the model curves to select a best-fitting obliteration history.

Application of this model to south polar cratered terrain indicates that an intense depositional episode occurred on this unit during the ending phase of heavy bombardment. We infer a depositional rate of 2.2 +/- 0.4 km/Ga for a period of about 0.5 Ga. A roughly concurrent episode, but with a higher deposition rate and of shorter duration, is recognized in counts done for equatorial cratered terrain. Following this episode the polar cratered terrain appears to have continued to accumulate material at a rate of 0.08 +/- 0.01 km/Ga, while the equatorial areas show crater production only.

In parts of the south polar region, a plains unit with a crater production surface and a model age of 3.5 Ga overlies the cratered terrain. Pitted terrain materials with a thickness up to 1km [2] overlie the plains unit in places. The plains and pitted terrain units are found in similar latitudes as the polar layered terrain, but in the hemisphere on the opposite side of the pole. The plateau surfaces of the pitted terrain have crater production populations also, with a model age of 3.3 Ga, suggesting that erosion has been limited to pit excavation and that obliteration rates have been insignificant. The end of deposition of pitted terrain debris implied by the model age of 3.3 Ga coincides with the end of the inferred depositional episode on the cratered terrain.

Study of high resolution images of a large portion ($\tilde{}3\times10^5$ km^2) of south polar layered terrain yields a dozen features strongly resembling impact craters. The craters range in size from 1km to 5km. The cumulative size frequency distribution for this set of craters implies that the surface that recorded the impacts was in place no later than several hundred million years ago. This crater age is at least an order of magnitude greater than estimates in previous studies [3]. Although statistics are poor due to the small number of craters, the log-log cumulative size frequency distribution is best fit to a slope of -1.3, suggesting that the surface is undergoing some obliteration (the assumed production slope is -2). An obliteration rate of 2.5 km/Ga is implied for a steady state obliteration model.

The continuing deposition on polar cratered terrain noted above appears limited to the areas surrounding the layered terrain. The pitted terrain plateaus and the plains unit, which lie at greater distances from the layered terrain, evidently have not accumulated significant amounts of material since their formation. We suggest that the continuing deposition represents redistribution of layered terrain debris on the cratered terrain. The spatial association, as well as the clearly erosional morphology of the layered terrain support this argument.

A model geological history thus emerges for the south polar region. Formation of the cratered terrain was followed by an intense obliterative episode, of possibly global extent. Polar plains formation occurred toward the end of this episode, and massive poleward transport of debris resulted in emplacement of pitted terrain material on top of the plains. A period of erosion preceded emplacement of layered terrain, evidenced by the unconformable contact between already eroded pits and overlying layered terrain. The timing of initiation of layered terrain accumulation is difficult to constrain, but crater data certainly suggest that much of the deposit was in place by several hundred million years ago. A change from an early (>3.5 Ga) dense atmosphere to one that is thinner and more strongly modulated by orbital variations is consistent with our results. However, the excavation of pits within the pitted terrain and the lack of obliteration on high latitude plains and pitted terrain plateaus also require explanation. We are pursuing a variety of models to explain these observations.

REFERENCES

[1] Phillips, R. and M. Malin, (1980), *Science, 210,* p.185-188.
[2] Guinness, E. et al., (1986), *NASA Tech. Memo. 88383,* p.245-247.