MORPHOLOGIC VARIATIONS OF DEGRADED IMPACT CRATERS IN THE MARTIAN HIGHLANDS; Robert A. Craddock and Ted A. Maxwell, Center for Earth and Planetary Studies, National Air and Space Museum, Smithsonian Institution, Washington, D.C. 20560

Mariner spacecraft data revealed that impact craters in the Martian highlands possess a variety of morphologic types, unlike their lunar counterparts [1]. Crater classes were found to be representative of the amount of degradation which took place following the period of heavy bombardment [2,3]. Determining the styles of highland impact craters is important for understanding the mechanism responsible for degradation in the early history of Mars. Generally volcanism [4] or, more commonly, aeolian processes [e.g., 5] have been invoked to explain these morphologic variations. However, our investigation of the Martian equatorial region indicates that fluvial processes were responsible.

Figure 1a shows a typical fresh impact crater with a sharply defined rim and radial ejecta deposit. Prior to extensive degradation, runoff channels form on the rim and ejecta (Fig. 1b). The ejecta often appears etched or hummocky, and the floors appear deep and smooth. With time, the ejecta is completely removed (Fig. 1c). A few runoff channels originating from the crater rim crest remain, however, and interior chutes become the dominant features. The crater also becomes shallower, perhaps because of infilling of material eroded from the surrounding plains. Infilling continues to bury the crater (Fig. 1d) and the apparent diameter of the crater decreases [2] from excessive erosion of the crater exterior [6]. Finally, the rim is breached and the crater is completely buried (Fig. 1e).

Obviously, a complex sequence of events involving both erosion and deposition has taken place on the highlands in order to produce craters with these characteristics. Deposition of lava or dust could produce a flat-floored, rimless crater (Fig. 1c); however, only at a crater diameter which had a rim height equivalent to the thickness of the deposit. Smaller diameter craters would be completely buried, and larger diameter craters would be unmodified or subdued [6]. Erosion by aeolian or volcanic processes is also very inefficient and would be incapable of removing the 100's of meters of relief associated with impact craters. Neither process explains the runoff channels or interior chutes associated with the stages of degradation.

The viable alternative is degradation by ancient fluvial processes; specifically sapping and seepage [7] or rainfall [8] as evidenced by the runoff channels. In order to explain modification of craters up to 60 km in diameter by sapping alone, -500 m of water would have to have been released and standing on the surface at one time. Since there is no evidence for an ancient highland ocean (e.g., shorelines) and this amount of water is equivalent to estimates of the total amount degassed from Mars [9], release of smaller amounts is likely. These volatiles probably established a hydrological cycle in the ancient, dense atmosphere. Severe, periodic thunderstorms, similar to those produced in the Southwestern United States, may have occurred [10]. Because of the differences in slope, slopewash would have been prevalent on the crater exterior rather than the interior, similar to desert pediments [11]. The effect would be to erode a higher percentage of material from the exterior rim and ejecta deposit, thus explaining the decrease in apparent crater diameter during degradation. These observations suggest that the ancient environment on Mars was very dynamic.
Figure 1. Variations in the morphology of Martian highland craters: (A) Fresh crater, (B) crater degraded by runoff channels, (C) flat-floored, rimless crater, (D) crater becoming infilled by eroded material, and (E) buried crater. Scale bar in (E) relates to all the craters shown.