MARTIAN BURIAL AND EXHUMATION THEME: EXAMPLE OF OLDER CRATERED TERRAIN EXPOSED FROM BENEATH LAYERED ROCKS EAST OF THE ELYSIUM RISE. M. C. Malin and K. S. Edgett, Malin Space Science Systems, P.O. Box 910148, San Diego, CA 92191-0148, USA.

Synopsis: Mars Global Surveyor (MGS) Mars Orbiter Camera (MOC) observations support two themes speculatively posited a quarter-century ago based on examination of Mariner 9 images [1]: that the upper crust of Mars is generally layered, and that burial and exhumation of ancient cratered terrain beneath layered rock and regolith material attests to a substantially more complicated geologic history than previously thought. Although evidence of this complicated history is patchy owing to the nature of exposures on Mars, some clear indications are present. This note addresses one of the more dramatic examples seen during the Science Phasing Orbits of April 1998.

Observations: Figure 1 provides context for this discussion. It shows the location of a MOC high resolution view of the floor and wall of a valley that trends east-southeast down the eastern slope of the Elysium rise. This valley is one of several "volcano/tectonic depressions" that surround the Elysium rise. Although the western valleys are often considered the source of, and partly shaped by, some form of geophysical fluid (alternatively lahars or fluvial outflows), those to the east do not display the landforms that suggest such origins to others, tapering downslope to a thin crack or graben. Figure 2 shows an example of the wall and floor of this valley. Note that the wall exhibits many layers expressed as rocky ledges, as well as smooth-surfaced mantles. The valley floor exhibits many crater-forms, including two relatively large, degraded, raised-rim craters that are only partially exposed from beneath the valley wall. The larger one is nearly 1 km in diameter, the smaller closer to 500 m in diameter. Also of interest are the many small craters (Figure 3) found on the valley floor. Similarly sized craters on the plains surrounding the valley are less abundant and heavily mantled.

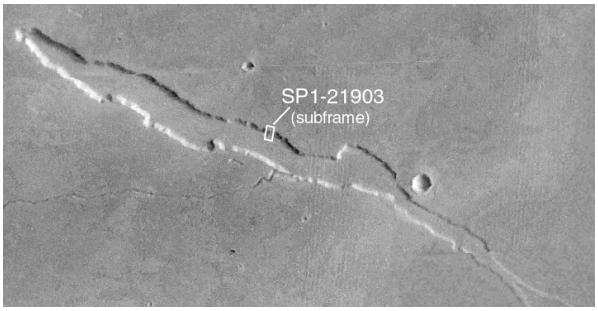

Figure 1. Viking Orbiter view of valley east of the Elysium rise with context of Figure. 2. Center is near 24°N, 206°W. North is up.

Figure 2. Cratered valley floor emergent from beneath layered wall within volcanic plains. Wall materials are known from context to include lava flows. Weathering of the dense, layered rock produces boulders. The upper layer appears smooth and is interpreted to be mantled with fines. Figure 3 subframes shown as boxes. (MOC image SP1-21903 near 24.4°N, 206.4°W).

Discussion: The difficulty in establishing that a crater is exhumed is self-evident. A crater immediately subjacent to a cliff but uncovered could have formed after the wall. A crater whose rim is partly buried could have formed close enough to the superjacent cliff to permit talus to cover a portion of the crater. A cliff that appears to overlie a crater rim is likely to have shed sufficient material as talus to cover most or all of that crater. And debris from a superjacent cliff will more than likely completely hide a crater if the cliff transects the crater. Despite the low probability of finding craters being exhumed from beneath cliffs, a "not insignificant" number of candidate examples have been found; the two larger craters in the MOC image are such examples.

The higher crater abundance at smaller diameters can be attributed to the absence of mantling on the valley floor relative to the surrounding plains, or to exhumation.

What does this all mean? These and other examples suggest that Mars has had a very diverse geologic history wherein surfaces have been exposed to impact cratering, buried for indeterminate periods, subsequently exhumed, and re-exposed to further impact cratering. The processes of burial and exhumation vary from place to place, and no inference is made here as to their nature and timing. Rather, the issue most easily (and perhaps most importantly) considered is the ramification of these observations for crater age determinations, and martian chronologies and stratigraphies based on such determinations.

References: [1] Malin M. C. (1976) PhD Diss., Ch. 3, Calif. Inst. Tech., Pasadena.

Figure 3. Detail of cratered surfaces on Elysium plains (left) and subjacent valley floor (right). See Figure 2 for context.