AGE AND ORIGIN OF LARGE MARTIAN POLYGONS; G.E. McGill, Department of Geology and Geography, University of Massachusetts, Amherst, MA 01003

The spectacular "polygonal terrane" of the Acidalia, Elysium, and Utopia Planitia regions of Mars has intrigued investigators ever since its discovery. Four hypotheses for its origin have been proposed: contraction cracking of cooling lava, contraction cracking of dessicating clay, frost wedging, and tectonic fracturing. Pechmann (1) very effectively eliminated the first 3 of these by showing that the processes are mechanically unsound at the scale necessary to form the martian polygons. Although tectonic fracturing remains feasible, there is no independent evidence to support or constrain a tectonic model. Besides, the martian polygons do not look like tectonic structures.

A thorough re-examination of this terrane is in progress that includes: 1) crater dating of polygonal terrane and of the fractures bounding the polygons; 2) evaluating processes of fracture formation for mechanical soundness and for consistency with the crater age(s) of the terrane and the fractures; 3) explaining the map pattern of the fractures; and 4) developing a comprehensive hypothesis for the genesis of both the terrane and the fractures that is consistent with mechanical principles and with martian crustal history. The results summarized in this abstract deal mostly with the ages of the polygonal terrane and fractures of Adamas Labyrinthus (MC-6SE, 7SW, 14NW, 14NE). A tentative hypothesis relating the origin of polygonal terrane to rapid deposition and differential compaction is also outlined.

The polygonal terrane of Adamas Labyrinthus has a crater age of 5000-6000 (Fig. 1). It can be divided into 2 mappable units that differ in sharpness of the fractures. I believe that this difference in sharpness reflects a difference in age; crater counts appear to support this, but the age difference is not large enough to be statistically reliable (Fig. 1).

The craters that fit the Mars production curve (2) and thus are used to determine a crater age are larger than about 4 km in diameter. All of these craters appear to be superposed on the fractures bounding the polygons, implying that the fractures must be about the same age as the material itself. Furthermore, material underlying the plains east of Adamas Labyrinthus clearly is superposed on the fractures bounding the polygons. The crater age of this material (4700) provides a young limit for the age of the fractures, reinforcing the implication that fractures and fractured terrane are coeval (Fig. 1). If so, the fracturing process must be related to the deposition of the material rather than to younger tectonic events or periglacial processes. But the 2 hypotheses that satisfy this constraint, dessication cracking of clay and contraction cracking of cooling lava, are not capable of producing such large fractures and polygons (1).

The presence of numerous fractures defining single and double rings implies that polygonal terrane has buried an older, cratered surface (1). The crater age of deposition and fracturing of the polygonal terrane suggests 2 possible sources for this blanket (2): pyroclastics related to pre-Tharsis volcanism; or wet sediments delivered to the northern lowlands by large outflow channels. I prefer the latter, but either process could supply materials with very high porosity when deposited so that extensive compaction during and immediately following deposition would be expected. Preliminary calculations of the tensile stresses that would result from bending due to differential compaction over buried topography indicate that fracturing of the surface would be expected with reasonable combinations of buried topography, thickness of deposit, degree of compaction, and rheological properties of the material.

The advantage of differential compaction over frost-wedging and contraction is that the very large size of the polygons reflects the scale of the buried topography, and thus need not be explained by the fracturing process itself. This removes the major obstacle to a non-tectonic origin for polygonal terrane. It thus appears that the topographically low region north of the martian dichotomy boundary was blanketed, probably more than once, by rapidly deposited, very porous, wet sediments (or ignimbrites?) that quickly compacted. Where conditions of buried topography and blanket thickness were favorable, differential compaction produced tensile stresses near the surface sufficient to produce visible fracturing.

Pechmann, J.C., 1980, Icarus, 42, 185-210.
Neukum, G., and Hiller, K., 1981, Jour. Geophys. Res., 86, 3097-3121.

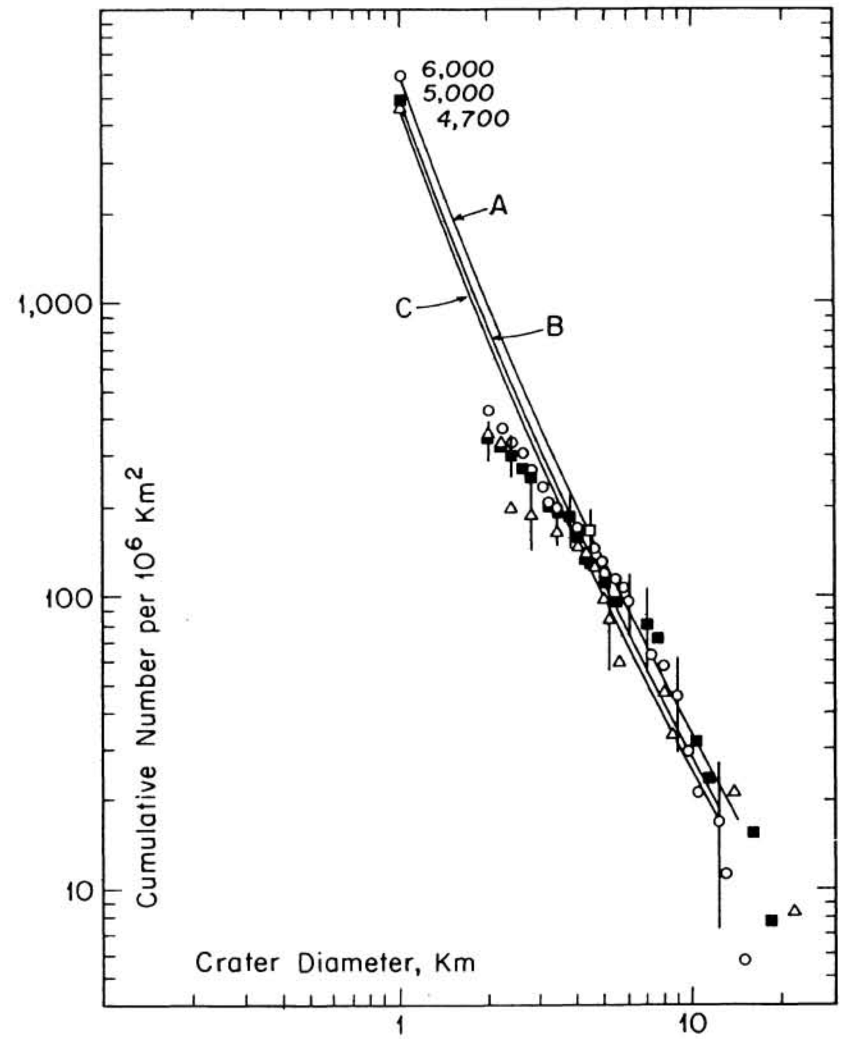

Fig. 1. Cumulative diameter/frequency plots of craters $\gtrsim$ 2 km in diameter. A = polygonal terrane with subdued fractures (n=75); B = polygonal terrane with sharp fractures (n=43); C = plains superposed on fractures (n=28). Most error bars omitted to avoid clutter. Curve used for extrapolation to D = 1 km from (2).