UPLANDS/KNOBBY-TERRAIN RELATION ON MARS;

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Martian knobby terrain (KT) occupies two main settings. First, it forms about half of the globe-encircling upland-lowland front [1]. Evidently these knobs are remnants of upland deposits that were broken up by some process related to the frontal upland-lowland transition zone [2]. It is commonly assumed that the front and the breakup were created by the same process. We believe, however, that the front originated along the rim of the giant Borealis impact basin [3] and that the breakup occurred long after that basin formed.

The second main KT, stressed here, is in the lowlands north of the front (0°-30° N, 160°-302° W). We investigated the relation of this KT to the uplands by counting, separately, fresh and degraded craters in two types of KT and two of uplands. Ejecta blankets are visible (at 1:2M scale) around the "fresh" craters and not around the "degraded" craters. The KT is divided by knob spacing into (1) high density (HDK)--closely spaced knobs with little interknob smooth material, and (2) intermediate density (IDK)--fairly high to moderate knob density with significant interknob material. The two types of upland are "primitive" (PU), consisting of abundant craters and basin rings (ancient basement) and "gullied" (GU), in which extensive intercrater deposits overlap the crater rimflanks and are incised by dense gully networks.

The combined curves for both crater classes ("all," Fig. 1) give some first-order results. Cumulative numbers of craters ≥ 4 km diam. decrease in the order: HDK, PU, GU, IDK. Thus, the overall crater densities of the KT bracket those of the uplands. All four terrains are Middle to Early Noachian in the stratigraphic scheme of [4].

This ancient origin is confirmed by the degraded-crater curves, which indicate the ages of the substrates that predate degradation processes severe enough to erode crater ejecta. The substrate ages of PU and GU are very similar. That of IDK is almost as old, and that of HDK possibly even older, than those of PU and GU. (After Fig. 1 was prepared we found more large degraded craters in IDK and HDK than shown.) Large craters and even double-ringed basins [6], defined by knobs, protrude through the lowland deposits. Thus, the KT in the northern lowlands, like that along the upland-lowland front, is modified upland terrain. Sharp's suggested knob origin by the loss of cementing ice [7] is consistent with the observed properties of the KT. The ice was probably driven off by the volcanism or the elevated geothermal gradient that characterize basin interiors (thinned crust and uplifted mantle).

The fresh-crater curves indicate the approx. time interval since crater degradation ceased. The degradation ended earlier or was less severe in PU than in GU. This fact and the equal substrate ages of PU and GU are consistent with the presence of a thick mantling deposit in GU and its absence in PU: the erosion of craters is abetted by this relatively weak deposit [5]. We furthermore believe that the deposit contained interstitial ice whose melting by endogenic heat created the gullies [5].

Degradation ended slightly earlier in GU (Late Noachian Epoch) than in IDK (Early Hesperian Epoch) and possibly slightly earlier in HDK than in IDK (whose fresh-crater curve is statistically poor). HDK and IDK differ in degree of degradation, however, HDK being less disturbed than IDK. We attribute this difference to a difference in the mantling deposit like that between PU and GU--this degradable deposit was thin or absent in HDK and present in IDK.

In summary, the geology in both the uplands (on the Borealis basin flank) and the lowlands (the Borealis interior) was originally similar--ancient densely cratered terrain covered by ice-rich deposits of varying thickness. This geology was modified by internal heating after the early heavy impact bombardment ended. Where the deposit was sufficiently thick, gullies formed in the uplands (GU) and knobs separated by considerable interknob material formed in the warmer lowlands (IDK). The modification was less severe where the deposit was thin or absent (PU and HDK).

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[1] Scott D.H. & Carr M.H. (1978) USGS Map I-1083. [2] Frey H. et al. (1986) LPS XVII, 243; their and our work suggest similar timings despite different methods (Frey, oral comm., 1987). [3] Wilhelms D.E. & Squyres S.W. (1984) Nature **309**, 138. [4] Tanaka K.L. (1986) JGR **91**, 139. [5] Wilhelms D.E. & Baldwin R.J. (1986), LPSC XVII, 948. [6] Schultz P.H. et al. (1982) JGR **87**, 9803. [7] Sharp R.P (1973) JGR **78**, 4073.

MARS UPLANDS-KNOBS RELATION

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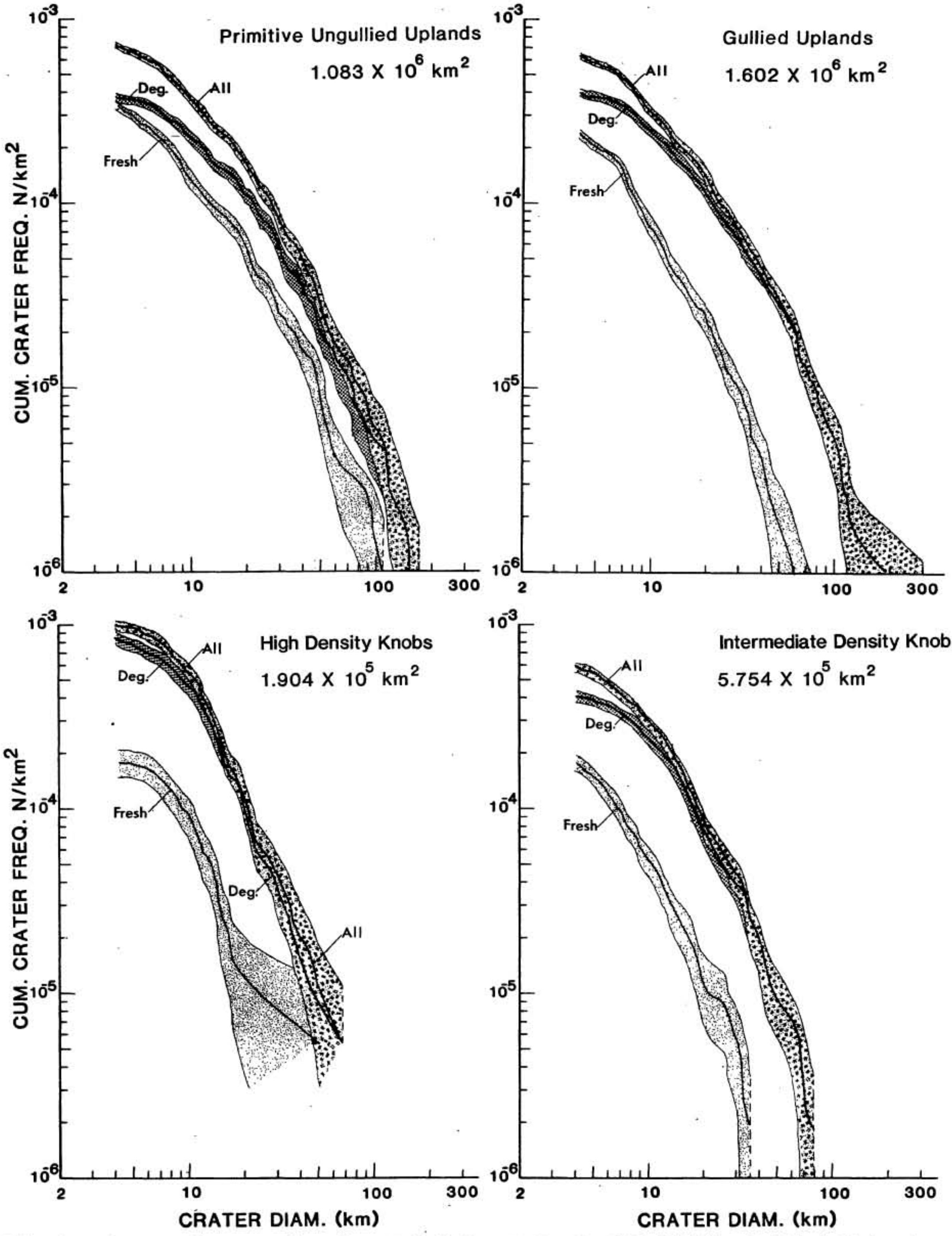

Fig.1: Crater frequencies for Primitive Uplands (MC-16SW), Gullied Uplands (MC-23SW and SW part of MC-23SE), and two types of Knobby Terrain (lat. 0°-30° N, long. 160°-302°). Error envelopes: ± square root of each point.