

CHRONOLOGY OF GLACIATION IN THE HELLAS REGION OF MARS; N. Johnson, J.S. Kargel, R.G. Strom, and C. Knight, Dept. of Planetary Sciences, Univ. Arizona, Tucson, AZ

Introduction. The Hellas Impact Basin is one of the oldest features on Mars, as indicated by the high density of large impact craters in parts of the basin. The highly degraded condition of Hellas seems consistent with great antiquity. However, many of the most strikingly modified landscapes in the basin, believed to be glaciogenic [1], also appear to be geologically youthful. Stratigraphic relations suggest two episodes of glaciation. In this report we impose chronologic constraints on glaciation based on the impact cratering record. We focus on the southwestern portion of Hellas (USGS quad MC-27SE). Major terrain units are mapped in Figure 1. The lineated terrain (see also Fig. 1 of reference 1) and ridged plains form the summit and flanks of a large shield volcano, Amphitrites Patera, which was superimposed over the southwestern rim of Hellas toward the end of heavy bombardment. The ridged plains and lineated terrain are crossed by numerous wrinkle ridges. The lineated terrain is distinguished by a pervasive system of deep erosional troughs and sharp ridges thought to have been glacially sculpted by the Hellas Lobe. The heavily cratered Hellas rim shows evidence for both glacial erosion and widespread debris blanketing; most large craters on the Hellas rim are highly degraded, and some have been cut by fluvial channels probably related to deglaciation.

Chronology. Visual inspection of Viking images shows deep erosion of many impact craters in the MC27SE photomosaic, particularly in the lineated terrain. To investigate the history of cratering and crater degradation we generated crater statistics for over a thousand impact craters using 126 high-resolution images (about 100 m per line-pair). Craters were classified according to their state of preservation. Class A craters display sharp rims and crisply-preserved ejecta blankets. Class B craters have partially eroded ejecta blankets. Ejecta blankets of Class C craters are entirely absent. Rim morphology of Class B and C craters ranges from sharp to highly degraded. In the deeply eroded lineated terrain the classification seems to separate preglacial (B and C) from postglacial craters (A) in most instances. In the less deeply eroded Hellas rim (Hellas Montes) and ridged plains the classification is less reliable in this regard. Since the ridged plains and lineated terrain apparently have the same volcanic age, comparison of the cratering record of the lineated terrain and ridged plains provides valuable insights into the nature of the erosional event.

Figure 2 shows crater size-frequency distributions for crater classes (A + B + C) (combined), for the lineated terrain, ridged plains, and Hellas rim. Cumulative crater statistics are provided in Table 1. The density of craters with diameters (D) greater than 16 km on the Hellas rim is comparable to the lunar highlands. Plots for the lineated and ridged plains show much lower crater densities; data for $D > 4$ km indicate that these terrains share essentially the same early Hesperian volcanic age, consistent with the age of the "Hellas Plains" reported previously [2]. However, small craters ($D < 4$ km) with ejecta blankets are sharply depleted on the lineated terrain compared to the ridged plains. For $1 \text{ km} < D < 2 \text{ km}$ this depletion amounts to nearly a factor of two, a statistically highly significant (4 σ) difference. The simplest explanation is that the lineated terrain suffered widespread erosional removal of small craters, consistent with pervasive large-scale scouring most obvious in the lineated terrain [1].

Figure 3 and Table 1 compare class (A + B) craters in the lineated terrain and ridged plains. Figure 4 gives complementary data for class C. Figure 3 shows a greater proportion of ejecta blankets for craters of all sizes on the ridged plains compared to the lineated terrain, indicating less erosion on the ridged plains. Figure 4 shows a sympathetic relationship for craters lacking ejecta, where, at $D > 2$ km, the deeply eroded lineated terrain has more class C craters than the ridged plains; at $D < 2$ km this relationship reverses, consistent with nearly complete removal of small craters, including their rim and bowl as well as ejecta. These data document the deep and widespread glacial erosion and thorough resetting of the relative chronometer based on small craters in the lineated terrain, and less extensive erosion on the ridged plains, consistent with independent morphological observations.

The density of class A craters on the lineated terrain, $280 (+40) > 1 \text{ km per } 10^8 \text{ km}^2$, gives a lower limit on the relative age of glaciation, equivalent to late Middle Amazonian [3]. This age is a younger limit (probably a close limit) since the criteria to qualify for class A were rather stringent. The size-frequency distribution for class A craters is consistent with the characteristic production distribution function known for the younger crater population on Mars, suggesting that erosion of the lineated terrain occurred at a discrete point in geologic time. An upper limiting age of glaciation, $491 (+54) \text{ craters } > 1 \text{ km per } 10^8 \text{ km}^2$, corresponding to early Middle Amazonian, is obtained by considering classes A and B together. This upper limit is unlikely since class B ejecta by definition show evidence of erosion and since Class B craters do not show a production size distribution.

Table 1 provides crater densities for class (A + B) (craters with ejecta blankets) in Argyre's esker plains. The data indicate statistically identical upper limiting relative ages of glaciation in the two regions ($N_1 = 491$ and 511 for Hellas lineated terrain and Argyre esker plains, respectively, for classes A + B). Global age correlations of significant Middle Amazonian events are discussed in more detail in an accompanying paper [4].

Conclusions. Glaciation in Hellas occurred during the Middle Amazonian, roughly coeval with glaciation in Argyre. We compare the maximum and minimum relative ages of glaciation with two models giving absolute age conversions [3], inferring higher and lower absolute age estimates of about 2300 and 250 million years, respectively.

References. [1] Kargel, Strom, and Johnson, 1991, ABSTRACT, this volume. [2] Strom, R.G., S.K. Croft, and N.G. Barlow, 1991, chapter in Mars book, IN PRESS, Univ. Arizona Press. [3] Tanaka, K.L., 1986, *Proc. Lun. Planet. Sci. Conf.* 17th, J. Geophys. Res., 91, suppl., E139-E158. [4] Strom et al., 1991, ABSTRACT, this volume.

HELLAS GLACIAL CHRONOLOGY: JOHNSON, N., et al.

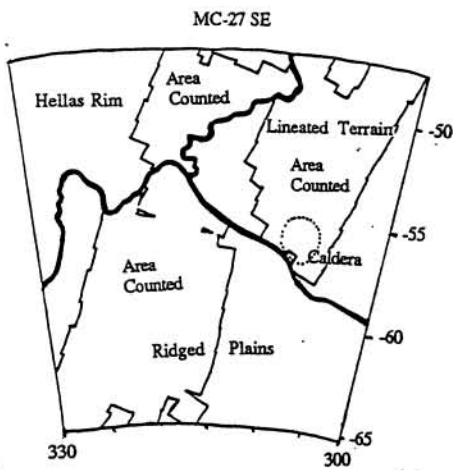


Figure 1. Terrain map of the region MC-27SE showing crater counting areas.

Table 1. Cumulative numbers, N, of craters > 1, 4, and 16 km diameter per 10⁶ km²

TERRAIN	AREA (km ²)	N ₁ (error)	N ₄ (error)	N ₁₆ (error)
Hellas Lineated Terrain	169,000			
Class A (min. glacial age)		284 (41)	18 (10)	0
Class B		207 (35)	41 (16)	0
Class C		792 (68)	284 (41)	59 (19)
Class A + B + C		1283 (87)	343 (45)	59 (19)
Class A + B (max. glacial age)		491 (54)	59 (19)	0
Hellas Ridged Plains	249,000			
Class A		394 (40)	24 (10)	4 (4)
Class B		752 (55)	145 (24)	32 (11)
Class C		611 (50)	458 (85)	32 (11)
Class A + B + C		1756 (84)	285 (34)	68 (17)
Class A + B		1145 (68)	169 (26)	36 (12)
Hellas Rim	71,000			
Class A		140 (44)	0	0
Class B		519 (85)	42 (24)	28 (20)
Class C		2034 (169)	785 (105)	210 (54)
Class A + B + C		2707 (195)	842 (109)	210 (54)
Class A + B		659 (96)	42 (24)	0
Argyre Fesher Plains	43,000			
Class A + B		511 (109)	116 (52)	0
Class A + B + C		1695 (198)	186 (66)	0

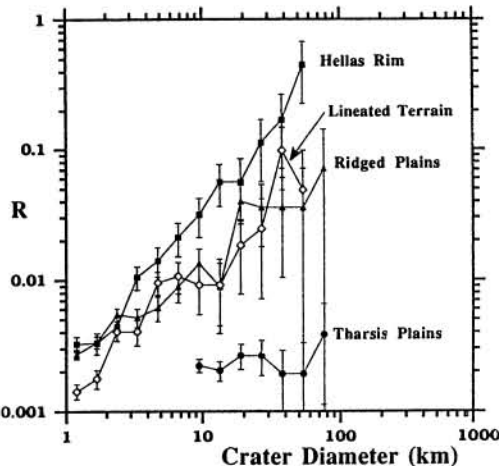


Figure 2. 'R-plot' showing crater size-frequency distribution for craters of classes A, B, and C, combined, in the lineated terrain, ridged plains, and Hellas rim.

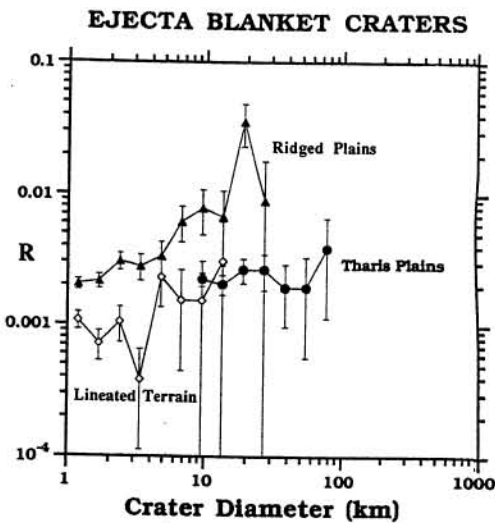


Figure 3. 'R-plot' showing crater size-frequency distribution for Classes A and B, combined (those having ejecta blankets), in lineated terrain and ridged plains.

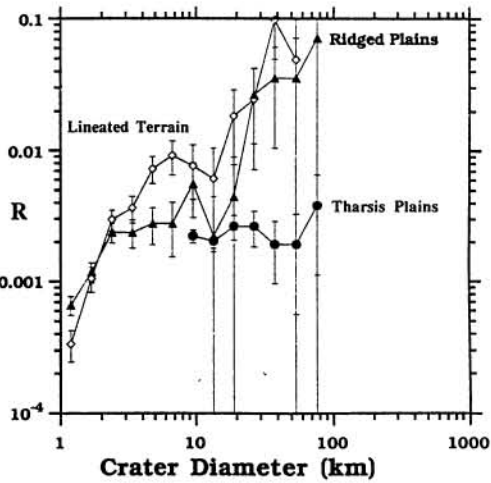


Figure 4. 'R-plot' showing crater size-frequency distribution for Class C craters alone (those lacking ejecta blankets) in the lineated terrain and ridged plains.