The Gradational History of Southern Ismenius Lacus, Mars; J.A. Grant and P.H. Schultz, Brown University, Providence, RI 02912.

Introduction: The gradational evolution of a heavily cratered region in southern Ismenius Lacus (30°–35°N, 325°–360°W) is assessed through detailed analysis of both surface morphology and crater statistics. The region occurs within a broad area of low thermal inertia (2) and is dominated in central sections by the 110 km diameter crater Cerulli which interrupts the up to 5 km wide Mamers Valles. Primary reasons for selection of southern Ismenius Lacus for study include: A) broad, nearly complete coverage by high resolution Viking images (40–50 m/pixel); B) the abundance of fairly pristine, young craters whose interior walls and continuous ejecta are incised by relatively high drainage densities; and C) large portions of the region are partially/mostly buried by material resembling unconformable air–fall deposits found elsewhere on Mars (1). Results provide further constraints on the timing/intensity of climate–controlled gradation on Mars.

Gradational History: Techniques/assumptions employed in compilation/interpretation of all statistics are discussed in an earlier publication (1). Relative ages are expressed as the log number of craters >5 km as determined by comparison of statistics with the standard crater function for Mars (3). Crater statistics of all superposed craters reveal an oldest recognizable surface with an age intermediate between the Hellas and Isidis Basins (Fig. 1). Following formation of this basement surface, a period of accelerated gradation affected the area as evidenced by: A) departure from the expected production slope in the statistics for crater diameters less than 22 km; B) an abundance of degraded, rimless craters; and C) formation of Mamers Valles. Activity during this early epoch saw the emplacement of a thick basal unit of reworked material possibly containing lenses of volatile–rich material and produced many rimless/mostly rimless crater morphologies. Drainage density along Mamers Valles, whose size typifies similar aged systems, is 0.015–0.020 km/km². Statistics of pristine craters from west and central sections and all craters less than 16 km in diameter from the east yield and N5 age of 2.6; therefore, the end of gradation associated with this first epoch correlates with mid to late Noachian highlands intercrater plains formation (4,5).

The formation of crater Cerulli marked the next major event in the area at an N5 age of 2.5 as determined by crater densities on ejecta surrounding the crater (Fig. 1). Drainage densities in and around Cerulli are at least 0.12 km/km² and 0.13 km/km², respectively; however, occurrence of inverted relief and/or buried segments along some valleys suggests actual densities are slightly higher.

Activity during a second later gradational epoch is constrained by statistics of nearly pristine craters from eastern portions of the study area, small diameter craters superposing crater Cerulli ejecta, and superpristine craters from the western section of the region. These statistics imply that the duration and intensity of activity during the second epoch varied from west to east: gradation ended in the east by an N5 age of ~2.1–2.0, but persisted in central and western sections until N5 ages of ~1.8 and 1.5, respectively (Fig. 1). Abundant relict morphology across the region indicates an extensive air–fall deposit was emplaced and modified during the second gradational epoch: A) isolated remnants of layered deposits in and around some craters throughout the study area; B) occurrence of remnants over a broad range of both regional and local relief; C) the subdued primary morphology around many impact craters (especially in the east) that suggests many remain buried; D) the fine–grained nature of near–surface material implied by low regional thermal inertia; E) examples of inverted topographic valleys (including the interior of Cerulli); F) pedestal craters superposing the thick basal unit; G) occurrence of valley networks lacking identifiable source regions and interpreted as superposed drainage; and H) valley networks incised into deposits that have steep fronted depositional features implying emplacement occurred in craters partially filled by some material. The greater abundance of partially/completely mantled craters in eastern sections coupled with the earlier ending of gradation there during the second epoch reflects the preservation of a relatively continuous layer of air–fall deposits. In contrast, the more sustained gradation in central and western areas along with the more isolated nature of deposit remnants indicates more complete removal. Superposed drainage in

the air-fall deposits indicates at least a locally volatile-rich nature during emplacement/modification. Based on the scale of drainages interpreted as superposed, the buried appearance of many craters in eastern sections, and the thickness of deposit remnants, an original deposit thickness of up to several hundred meters is estimated. The density of small valleys (100-150 m wide) preserved in surfaces formed during the second epoch of activity are locally as high as 0.36 km/km², but are up to 0.85 km/km² on some crater walls; however, densities in most parts of the study area are much lower if any valleys are present at all. Cessation of gradation following the second epoch of accelerated geomorphic activity in east and central areas correlates with ridged plains emplacement 500-700 km to the east (6) and the end of accelerated Hesperian gradation elsewhere on Mars (1,7-9). The end of gradation farther west coincided with peak outflow channel formation (10). Emplacement and modification of the air-fall deposit marked the end of significant gradation in the region; however, deposition and subsequent reworking of relatively thin deposits (11) at scales too small to be recognized in this study may have continued into recent martian history.

Summary: Two epochs of accelerated gradation affected the geomorphic evolution of southern Ismenius Lacus (Fig. 1). These periods of enhanced gradational activity were likely related to periods of more clement climate induced by release of either recycled exogenic or juvenile endogenic (12) atmospheric volatiles (1). Variations in the intensity and duration of gradation during the second epoch are indicated by the variability in the timing of cessation and degree of air-fall deposit removal across the study area. Over-all intensity of gradation decreased through succesive epochs based on: A) the decreasing diameter at which cumulative statistics from the respective surfaces cease to follow the expected production function; and B) the decrease in size/increase in density of preserved valley networks incised into surfaces of differing age (Fig. 1). A comparable decrease in valley density with time has been noted in the Isidis region (13).

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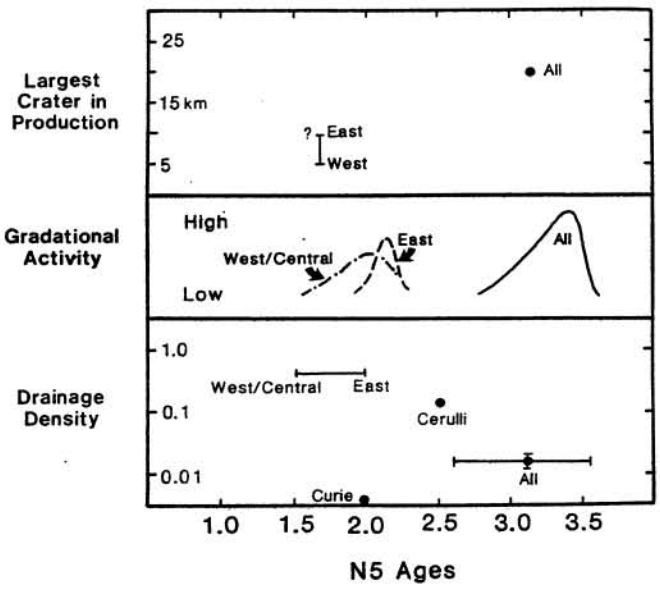

Figure 1. Summary of geologic processes in southern Ismenius Lacus. Gradational activity in the region occurred during an early period of intense, widespread activity (N5 age 3.6-2.6) that ended about the time of initial activity at Tyrrhena Patera and is widely recognized on the planet. This first epoch led to formation of a thick (>0.5 km) basal unit in the region. A second period of accelerated gradation occurred concurrent with increased activity northwest of Isidis, in the vicinity of crater Millochau, the Electris region, Sinus Meridiani, Margaritifer Sinus, the interior of Isidis basin, and elsewhere (1,7-9). This later period was shorter lived in eastern sections (N5 age ~2.1-1.9) than farther to the west (N5 age 1.5). Nearby crater Curie (100 km in diameter) formed at an N5 age of 2.0. Drainage size/density decrease/increase in scale with decreasing age with the exception of Curie which shows no incisement. Based on this observation and the diameter at which crater statistics from modified surfaces cease to display a production population of craters, it is concluded that the intensity of gradation in the study area decreased with time.