THE COMPLEX, MULTI-STAGE HISTORY OF MT. SHARP.

Carlton C. Allen[1], Angela M. Dapremont[2], and Dorothy Z. Oehler[3]
[1]NASA Johnson Space Center, Houston, TX carlton.c.allen@nasa.gov, [2]College of Charleston, Charleston, SC amdapremont@gmail.com, [3]Jacobs / LZ Technology, Houston, TX dorothy.z.oehler@nasa.gov.

Introduction: The Curiosity rover is exploring 155 km diameter Gale crater and Mt. Sharp, Gale's 5 km high central mound (Fig. 1). This study addresses the formation and erosion history of Mt. Sharp.

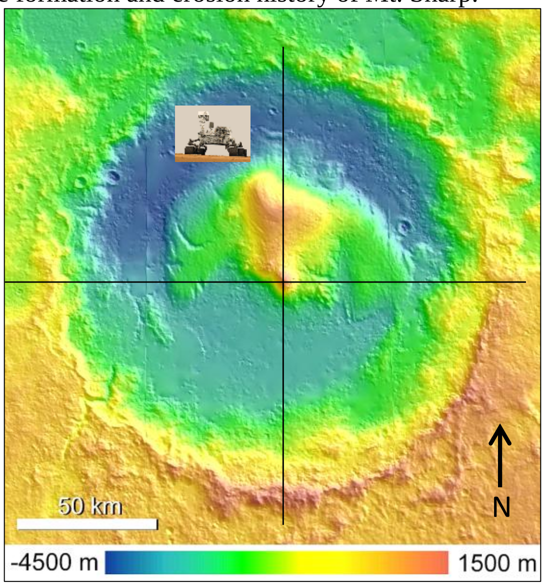

Figure 1. Gale crater and Mt. Sharp, with locations of the Curiosity rover and profile lines (Figures 2,4); MOLA topography

Gale crater lies on the topographic dichotomy between the southern highlands and the northern plains – a drop of over 2 km [1,2]. Altitude differences between the north and south rim reflect this regional slope, as do altitude differences between the deep annulus north of Mt. Sharp and the southern crater floor (Fig. 2).

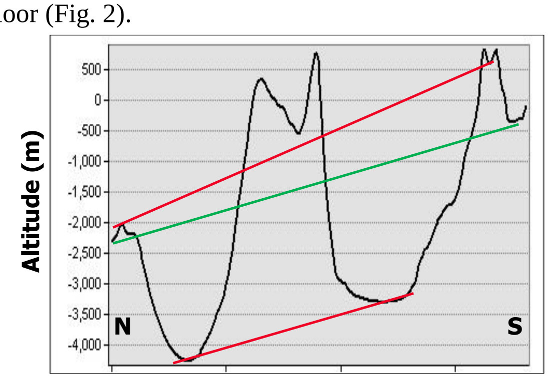

Figure 2. North-South rim-to-rim profile thru Gale's central peak; green line: regional slope; red lines: rim and floor slopes; MOLA data; 26 x vertical exaggeration

Orbiter and rover images demonstrate that most exposed areas on Mt. Sharp consist of thin, sub-parallel units interpreted as sedimentary layers [3]. Gale is typical of many large martian craters that have been totally or partially filled with such layers. In many craters these sediments have been deeply eroded [4,5].

Central Peak and Peak Ring: The highest point on Mt. Sharp, near the crater's center, is interpreted as a central peak [6]. The peak has a massive lower section and a smooth, layered summit. Gale's size is transitional between martian craters with single central peaks and craters with peak rings approximately half the diameter of the crater [2,6]. The boundaries of Mt. Sharp, as well as an arc of hills to the southeast of the mountain, closely match a circle approximately 90 km in diameter (Fig. 3). This morphology suggests that the Gale impact may have formed both a central peak and a partial peak ring, which is covered by the sediments of Mt. Sharp in the north and exposed in the southeast.

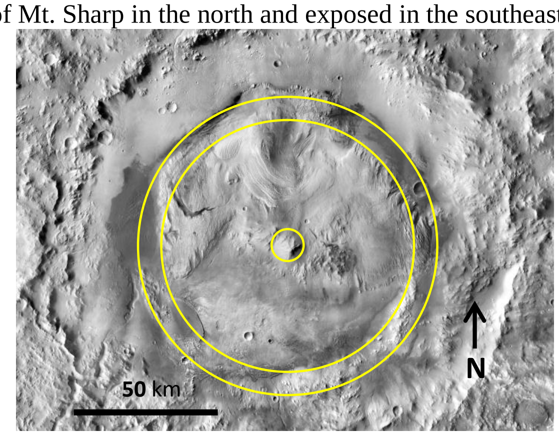

Figure 3. Locations of central peak and modeled peak ring (yellow circles); THEMIS visible light mosaic

Lower and Upper Mound: Mt. Sharp consists of distinct lower and upper mound units [1]. The eastern and western lobes of the lower mound, as well as terraces on the crater walls, rise to an altitude of approximately – 2,300 m (Fig. 4). The crater retention age of the lower mound surface is late Noachian [1]. Most lower mound units consist of nearly horizontal sedimentary layers that have been eroded by the wind. Portions of the lower mound were affected by flowing water, as evidenced by canyons and inverted stream channels [1]. Some lower mound sediments – key exploration targets for the Curiosity rover – have been altered by water to clay and sulfate minerals [7].

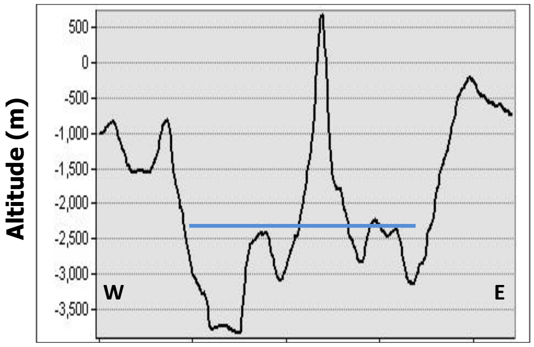

Figure 4. West-East rim-to-rim profile thru Gale's central peak; blue line: – 2,300 m altitude; MOLA data; 37 x vertical exaggeration

A partial peak ring could have determined the shape and location of Mt. Sharp. In this model, sediments filled the crater to an altitude of approximately – 2,300 m, but wind erosion stripped these friable materials from the deep northern annulus and the southern half of the crater. The peak ring shielded an arcuate deposit of sediments from this initial erosion. The deposit was subsequently lithified and altered, and is preserved as the lower mound [2].

The upper mound, centered on the lower mound platform, rises to approximately + 700 m (Figs. 2,4). Some upper mound units are separated from the lower mound by an erosional unconformity [1,4]. Upper mound units are sparsely cratered indicating either a relatively young age, easily-eroded material, or both. This 3 km stack of sediments is deeply eroded by wind and mass wasting. The upper mound shows little evidence of flowing water or mineral alteration [7].

The peak of the upper mound is over 2.5 km higher than the northern crater rim (Fig. 2). This fact has been used to argue that sediments must have completely filled, and over-filled, the crater [2]. Another model suggests that aeolian deposition by slope winds produced the high upper mound [8].

Alternatively, our model proposes that windblown sediments totaling over 3 km thick were deposited throughout the crater. They piled to an altitude of + 700 m on the elevated lower mound platform, but did not over-fill the crater's deeper portions. These sediments were subsequently wind eroded from the deep areas, leaving a remnant in the form of the upper mound. This pile of sediments may have been part of a late Noachian deposit mapped along the dichotomy boundary [9], or an outlier of the younger Medusae Fossae formation [10].

Wind Erosion: Many lower and upper mound units exhibit yardangs – parallel ridges formed by long-term, unidirectional wind erosion [1]. Lower mound yardangs are oriented almost exclusively north-south, and have shapes consistent with wind flowing northward from the highlands to the plains. Upper mound yardangs are oriented in several directions, including north-south, northeast-southwest, and northwest-southeast [12].

These differences likely reflect a significant gap in time, which is in accord with the mapped unconformity and differences in erosion and alteration between upper and lower mound units. Mt. Sharp may thus record evidence of two distinct episodes of sedimentary deposition and erosion within Gale crater.

A Model for the Geologic History of Mt. Sharp:

- Impact onto the sloping dichotomy boundary
- Formation of a central peak and a partial peak ring approximately 90 km in diameter
- Deposition of layered sediments to an altitude of approximately – 2,300 m
- Erosion of sediments outside of the peak ring; preservation of sediments within the northern arc of the peak ring
- Lithification and alteration of sediments within the peak ring, forming the lower mound units
- Erosion of the lower mound by wind from the south
- Partial filling of the crater with sediments that piled to approximately + 700 m altitude on the lower mound platform
- Erosion of sediments outside of the peak ring and on the platform by winds from multiple directions, shaping the upper mound

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