THE FORMATION AND EROSION HISTORY OF MT. SHARP.

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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.

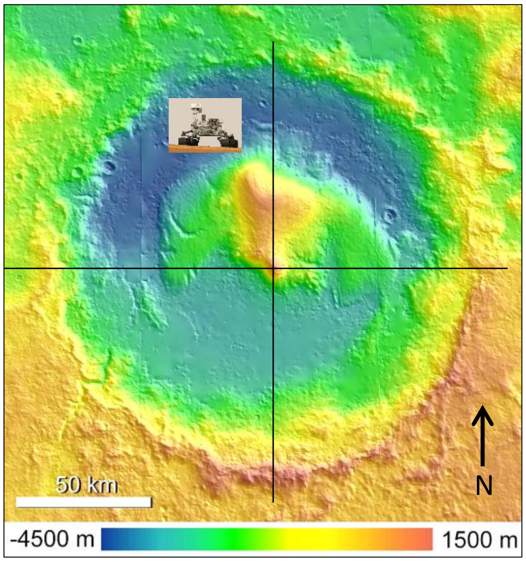

Figure 1. Gale crater and Mt. Sharp, with locations of the Curiosity rover and likely central peak; MOLA topography

Gale 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.

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 the 50 large martian craters that have been totally or partially filled with such layers [4,5]. In many craters these sediments have been deeply eroded.

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 portion and a thin, smooth capping deposit (Fig. 2).

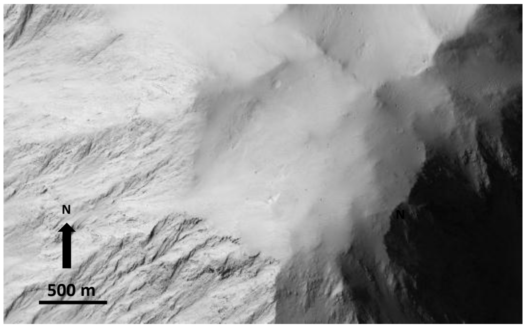

Figure 2. Gale's central peak, with a massive lower portion and a smooth capping deposit (HiRISE PSP_010428_1745)

Gale's size is transitional between martian craters with single central peaks and craters with peak rings approximately half the crater's diameter [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 80 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 possibly exposed in the arc of eroded hills in the southeast quadrant (Figs. 3,4).

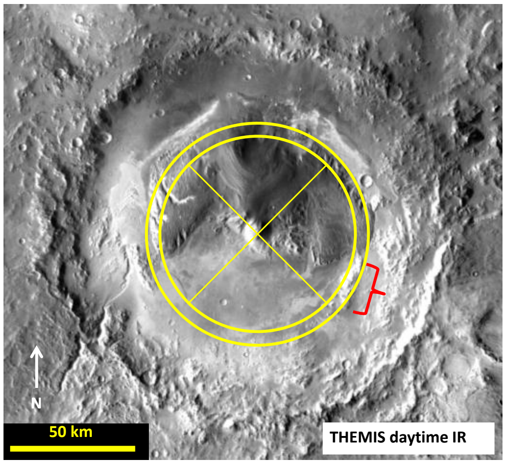

Figure 3. Locations of central peak and modeled peak ring (circles), with a possible peak ring exposure (bracket)

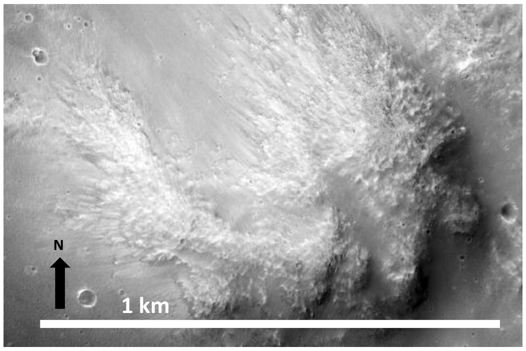

Figure 4. Eroded hill in possible peak ring exposure (HiRISE ESP_018643_1745)

Lower and Upper Mound: Mt. Sharp consists of distinct lower and upper mound units [1]. The E and W lobes of the lower mound rise to an altitude of approximately – 2,300 m. Most lower mound units consist of sub-horizontal sedimentary layers, eroded by the wind. Portions of the lower mound were affected by flowing water, resulting in canyons and inverted stream channels [1]. Some lower mound sediments have been altered by water to clay and sulfate minerals [7].

A 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 remaining deposit, lithified and altered, is the lower mound [2].

The upper mound rises to approximately + 600 m, with some units separated from the lower mound by an erosional unconformity [1,4]. Upper mound units are sparsely cratered indicating a relatively young age, easily-eroded material, or both. These units show 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. 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, we propose that windblown sediments over 3 km thick were deposited throughout the crater. They piled to an altitude of + 600 m on the elevated lower mound, 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. A thin layer of sediments capped the central peak. This sequence may have been part of a late Noachian deposit mapped along the dichotomy boundary [9], and perhaps included an outlier of the Medusae Fossae formation [10].

Wind Erosion: Many lower and upper mound units exhibit yardangs [1]. Lower mound yardangs are oriented almost exclusively N-S, consistent with wind flowing northward from the highlands to the plains. Upper mound yardangs are oriented in several directions, including N-S, NE-SW and NW-SE [12]. These differences likely reflect a significant gap in time, which accords with the mapped unconformity and changes in erosion and alteration between the upper and lower mound.

A Model for the Geologic History of Mt. Sharp:

- Impact onto the dichotomy boundary, resulting in a crater sloping downward to the north
- Formation of a central peak along with a peak ring approximately 80 km in diameter
- Deposition of layered sediments to an altitude of approximately – 2,300 m
- Erosion of sediments outside of the peak ring; preservation 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 + 600 m altitude on the lower mound
- Erosion of sediments outside of the peak ring; preservation and lithification of the upper mound
- Erosion of upper mound sediments by winds from multiple directions
- Deposition of a layer of sediments, preferentially preserved on the central peak

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