**Crater Count Mapping and Regional Geologic Context of the Area Surrounding the Gale Impact Structure, Mars.** A.L. Bustard, B.E. Elliott, J.G. Spray, L.M. Thompson, Planetary and Space Science Centre, University of New Brunswick, 2 Bailey Drive, Fredericton, NB E3B 5A3, Canada

**Introduction:** An understanding of the area surrounding Gale Crater is important in providing context to findings of the Mars Science Laboratory (MSL) rover mission. The area investigated here extends from 132E to 144E, and 2N to -10N; covering a region of approximately 500,000 km$^2$. The area surrounding Gale Crater is one of complex geology. The center of the area is cut by the crustal dichotomy, which trends from the Northwest to Southeast. The dichotomy appears to control the spacial distribution of certain units. Crater counts have been performed within the study area and these reveal that the terrain comprises several geologic units formed during distinct periods of sedimentary and/or erosional activity.

**Crater Counts:** Crater counts were performed in JMARS [1] using the THEMIS Day IR 100 m/pixel Global Mosaic v11.5. Units were determined visually based on morphology and relationships with reference to the mapping completed by Greeley and Guest in 1987 [2]. Craters larger than approximately 500 m were then counted within each unit and ages calculated using Craterstats II [3]. For the age determinations, only craters larger than 800 m and smaller than 20 km were used to ensure the consistent treatment of data, and to eliminate the drop-off in crater density that occurs near the detection limit. Resurfacing corrections [3] were applied when resurfacing was suspected, whereupon two or more ages were determined for such units. Ages were determined using cumulative fits for both the Ivanov 2001 and Hartmann 2004 production functions included with Craterstats II [3]. The Hartmann 2004 production function appears to provide more accurate fits, and its ages are preferentially used when determining the relationships between different units. Reported ages are calculated using the Hartmann 2004 production function unless otherwise noted. In total, 11 separate morphologic units were dated.

There are several considerations that must be made when interpreting data obtained through crater counts. Since the counts performed for the purposes of this research cover extensive areas, geologic homogeneity can not be guaranteed. Some units may contain anomalous sections, but the influence of these sections is minimized by dilution in the large areas covered and the large sample sizes.

**Groupings:** The 11 morphologic units were reclassified into five groups based on both the calculated ages and their morphology. Crater counts from grouped units were integrated and crater count ages were recalculated for each group. The groups have been provisionally given letters as names: A, B, C, D, and E. The spatial distribution of the groups is depicted in Figure 1.

Group A is characterized by surfaces that appear smoother than the others. Group A is also topographically lower than the other units and is found to the North of the crustal dichotomy. Group A is the youngest group in the area with an age of $3.4^{+0.027}/_{-0.033}$ Ga. No large-scale resurfacing events are evident in the crater count data for group A. There are several units within group A that do not conform with the general morphology of the rest of the unit, and craters are not abundant enough at the resolution used to confidently determine their age(s). It is likely that these units are outliers of unit E, although this is currently under investigation.

Group B consists of deposits belonging to the Medusa Fossae Formation [3]. The age of the unit determined using the Hartmann 2004 production function is $3.55^{+0.019}/_{-0.022}$ Ga, although the Ivanov 2001 production function results indicate that the group formed at 3.62 Ga, and was resurfaced at approximately 3.52 Ga.

Group C is a morphologically diverse unit that is grouped primarily based on age. Most of the unit has a degraded appearance, and the group may have formed

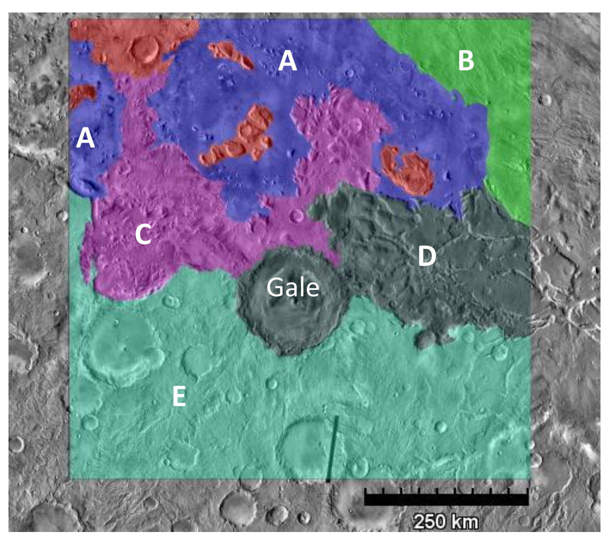


**Figure 1:** Calculated age groups over THEMIS image. Groups and Gale are labeled. North is up. Undated units are colored red.

primarily from the errosion of previous deposits. The age of group C from crater counts is $3.62^{+0.032}/_{-0.041}$Ga, with an apparent resurfacing at $3.35^{+0.036}/_{-0.046}$.

Group D is dated to be $3.77^{+0.016}/_{-0.024}$Ga with a resurfacing event at $3.57^{+0.014}/_{-0.016}$Ga. Group D is characterized by "fretted terrain", which is described by Irwin et al. [4], and the group may consist of loess deposits. Preliminary work includes Gale Crater in Group D, suggesting that Gale may have been completely filled by similar sediments. The age of the Gale impact structure, when calculated as a separate unit with the same methods, is $3.74^{+0.021}/_{-0.024}$ Ga.

Group E is located to the South of the Martian dichotomy and is the oldest group in the study area. Group E is characterized by heavy cratering and areas locally cut by channels. The age of group E is $3.81^{+0.014}/_{-0.015}$ Ga with a resurfacing event at $3.64^{+0.006}/_{0.006}$ Ga.

**Discussion:** Several relationships can be inferred from preliminary age determinations and observations in the area. The formation ages of certain groups correlate with the resurfacing of others. The age of group A, the youngest observed, overlaps with the resurfacing of group C. The formation age of group B corresponds with the resurfacing of group D, and the formation of group C corresponds with the resurfacing of group E. These relationships can be seen in Figure 2. The nature of these age relationships is currently uncertain, although there are several possible explanations.

Based on the spatial relationships of the groups, some groups may be draped over others and form a thin layer that manifests as a resurfacing event in crater counts. The correlation of formation and resurfacing ages may also be due to periods of increased geologic activity, and/or the result of material being eroded in one group and then deposited in another.

The placement of Gale Crater in group D is of particular interest; this may have implications for the interpretation of sediments found within the crater. The 3.74 Ga age of Gale should be regarded as a minimum for the formation of the structure, as processes may have resurfaced the area and reset the cratering record. The upper age limit of the Gale impact structure is the formation of the crustal dichotomy, as Gale cuts and so post-dates this boundary. Current work places the formation age of the crustal dichotomy in the early Noachian to pre-Noachian time period [5].

**Conclusions**: Comprehensive crater counting has determined the ages of units in a 500,000 $km^2$ area surrounding and including Gale Crater. The area has been divided into five distinct groups based on age and appearance. Future work will concentrate on determining the nature of the materials forming the different groups and confirming the correlations of the units. This will help to place Gale in its broader, regional context as a complement to results obtained from the more focused MSL rover activities.

**References:** [1] Christensen, P.R. et al. http://adsabs.harvard.edu/abs/2009AGUFMIN22A..06C [2] Greeley, R. and Guest J.E (1987) U.S. Geol. Surv. Map, I-1802-B [3] Michael G.G. and Neukum G. (2010) *Earth Planet Sci. Lett. 294*, 223-229 [4] Irwin III, R. P et al. (2004) *JGR Planets 109*, E09011 1-20 [5] Irwin, R. P. and T. R. Watters (2010) *JGR Planets 115*, E11006

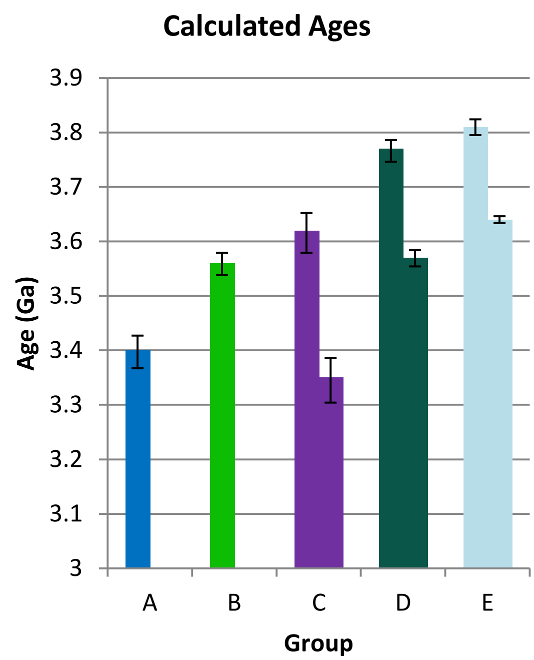


**Figure 2**: Ages of the various groups determined by crater counts using the Hartman 2004 production function [3]. Peak of columns indicate age with error bars, and shorter columns indicate resurfacing events when present.