SMALL CRATER EJECTA RETENTION AGES INSIDE GALE CRATER: RECENT EROSIONAL HISTORY AND POTENTIAL SAMPLING LOCATIONS FOR THE MARS SCIENCE LABORATORY.

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Introduction: The Mars Science Laboratory (MSL) is the first rover selected to visit a "go to" landing site in the search for past habitable environments and organic material [1]. The first part of the nominal mission will require traversing outside a 25km x 20km landing ellipse to the high-value science area beyond; the northwestern lower formation of the Gale crater mound contains orbital spectroscopic evidence of Fe-smectite (nontronite) stratigrapically below Mg-sulfates (likely, kieserite) indicating a transition from neutral to acidic water-deposited sediments during the late Noachian/Early Hesperian [2].

However, several proposed water-deposited geologic units have been reported by [3] within the current landing ellipse: proximal low (460 TIU) and distal high (640 TIU) thermal inertia alluvial fans, inverted channels, all overlying a "hummocky plain" that has light-toned polygonal fractures (see Figure 40 in [3]). While these geologic units are not the prime scientific draw of Gale crater, they do represent excellent water-derived materials that MSL can test its full suite of instruments on. Interestingly, work by [4] has shown crater densities in the proximal low thermal inertia alluvial fan are 2x higher than those in the distal high thermal inertia alluvial fan, hummocky plains and mound-skirting units (Figure 1).

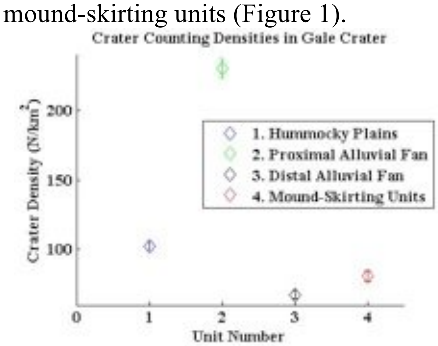

Figure 1. Crater density on units within the Gale landing ellipse. Data modified from [4].

It is antithetical to our understanding of thermal inertia that a denser (i.e. higher TIU) layer retains fewer craters than a more unconsolidated (i.e. lower TIU) layer. In this case, the difference in TIU is <200, the source region, environment of deposition, and method of emplacement are likely identical as far as can be ascertained, so one would expect at least similar crater retention. Stratigraphic relationships (see Figure 47 in [3]) dictate that the proximal fan is 'younger' than the distal fan and hummocky plains (TIU 480). One hypothesis is that the proximal fan in indurated by some as yet unknown mechanism, possibly an intergranular cementing agent [4]. Only direct sampling during the mission may confirm this hypothesis.

Sampling Strategies: The search for organics is hindered by Mars' thin atmosphere. Organic material can be destroyed by ionizing radiation from cosmic ray exposure (CRE) such as Galactic Cosmic Radiation (GCR) and Solar Cosmic Radiation (SCR) up to a maximum bedrock penetration depth of ~1 m [5]. Solar ultraviolet (UV) radiation, while having only a few cm penetration depth in regolith (e.g. Martian soil), creates a greater hazard from the creation of superoxide ions that destroy organics [6]. The oxide extinction depth, where superoxides are neutralized by interaction with the surrounding material [7], can reach a depth down to 4 m from impact gardening [8]. It is recommend that "fresh" craters (<100 Ma old) and surfaces with high erosion rates (~10 nm/a) be sought as prime candidates for sampling outcrops containing preserved extant/extinct organics for analysis with the MSL Sample Analysis at Mars (SAM) suite of instruments [8]. The goal of this study is to identify small 'fresh' craters (SRC) with diameters < 1 km, and calculate ejecta retention ages (the length of time ejecta remains around a crater rim) in or near the landing ellipse. Eject retention age can serve as a proxy for recent erosion and the age of exposed ejecta blocks/crater rim material. It has been shown empirically and observationally that the depth to diameter ratio (d/D) falls from ~0.1 for secondary craters to ~0.2 for primary unmodified simple craters [9]. Therefore, craters with diameter (D) > 40 m, should have ejecta blocks near their rim that contain 'fresh' organic material (if it exists) that has

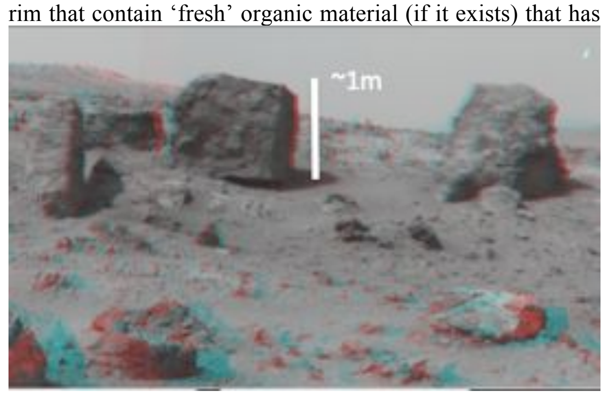

Figure 2. Ejecta blocks outside the crater Odyssey on Cape York. Image courtesy NASA/JPL/MIPL.

reduced exposure time to harmful CRE and UV radiation. In addition, these craters serve as the perfect opportunity to sample the intringuing geologic units in the landing ellipse at depths and levels of pristiness not readily accessible by MSL. For example, Mars Exploration Rover (MER) Opportunity drove by a fresh ~20 m *D* crater once it arrived at Cape York on the Endeavor crater rim. Several 1 m^2 ejecta blocks were readily accessible by Opportunity and showed clean, flat surfaces originating from several meters below the surface (Figure 2). Similar 'fresh' ejecta may occur in Gale crater.

Methodology: We searched all current HiRISE orthophotography at 0.25cm/pixel (6 images in total) within or crossing the nominal landing ellipse (~80% areal coverage) for small 'fresh' craters (D < 1 km) (Figure 3). We defined 'fresh' as craters with extant ejecta morphology, having several ejecta blocks around or near the rim, sharp rims (compared to others in the vicinity), and/or those with

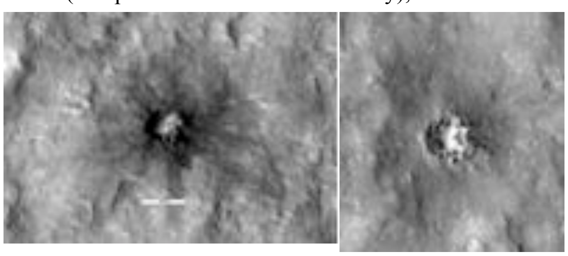

Figure 3. Fresh craters in or near the Gale landing ellipse. Each crater is ~D=40 m. Image courstesy NASA/JPL/USGS.

visibily distinct ejecta regardless of whether individual blocks could be resolved. These were mapped in a geographic information system (ArcGIS, version 10) to analyze their spatial location in reference to the units defined by [3] and [4], as well as to conduct crater counts by binned diameter. We used crater counting techniques to calculate ejecta retention ages (the length of time ejecta remains around a crater rim), which in this case is also the crater retention age. This in turn is equivalent to the exposure age of the subsurface and the ejecta blocks.

Results: We mapped 437 fresh craters with ejecta or ejecta blocks in or near the Gale landing ellipse (Figure 4). Of these 77 are greater or equal to D = 40m and each of the geologic units mentioned previously have several fresh craters on them. Ejecta retention ages show that most craters D < 100 m are 10 My old or less (Figure 5). This leaves a total of 53 fresh craters that have subsurface material exposed for <10 My within the landing ellipse. These craters are approximately randomly distributed across the ellipse. MSL should have an excellent chance to encounter or target several fresh craters in its nominal traverse without grossly impacting its strategic destination near the mound. Qualitatively, the area inside the ellipse has more fresh craters than at the base of the mound and even fewer in the upper part of the mound that displays prominent yardangs. This implies the mound material is eroding at a faster rate than the alluvial fan and plains units between the Gale crater rim and its central mound.

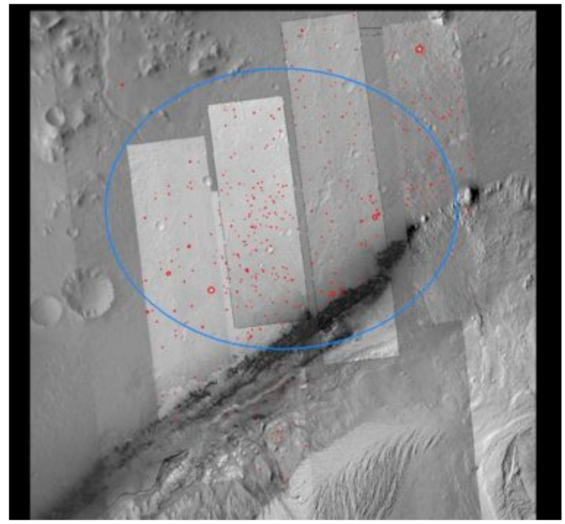

Figure 4. Fresh craters (red) within or near the Gale landing ellipse (blue). North is up. Images courtesy NASA/JPL/USGS/MSSS.

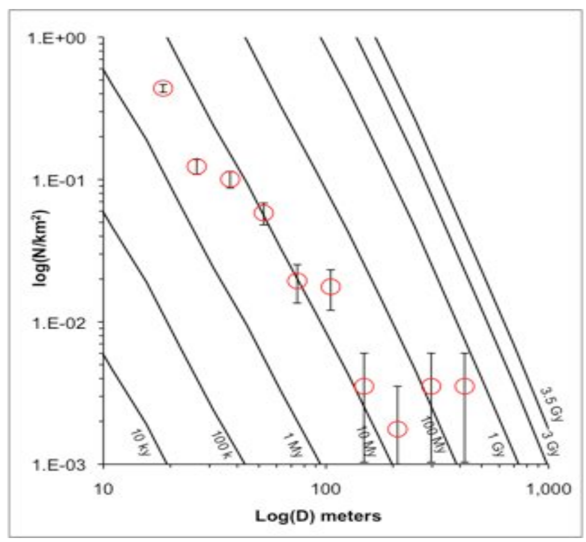

Figure 5. Fresh crater retention rates at Gale.

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