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Constraints on the geologic history and transport of materials at five Mars landing sites based on clast morphology

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Loose rock fragments on the surface (clasts, here defined as pebble- to cobble-sized) can pro-vide important clues to bedrock geology where bedrock outcrop is either poorly exposed or can-not be readily accessed. This is especially important on Mars, where access to primary sources of information (outcrop, laboratory sample analysis) is highly limited. Morphologic parameters such as size, shape (roundness and sphericity), sorting (range and proportion of clast sizes), and clast distribution (size-frequency and distances between clasts) all may be quantified and used to interpret clast history. We analyzed quantitative morphologic characteristics of surface particles at five different landing sites (Viking 1 and 2, Mars Pathfinder, Spirit at Columbia Hills, and Cu-riosity at Gale Crater).

Morphologic characteristics are sufficiently diverse at these sites that some separation of pop-ulations is possible based on lithology or mode of transport. The single most common character-istic for clast types studied in depth is angularity; nearly every clast type categorized in previous works is sub-angular to very angular. For nearly every population analyzed at every landing site, there are almost no rounded clasts, and the percentage of well-rounded clasts is zero. The excep-tion is the population of rocks from an area in Gale crater near the Link outcrop, associated with a distinctive clast type of sub-rounded to rounded pebbles. For terrestrial clasts, roundness is commonly used as a proxy for time in persistent transport. This implies that while most trans-ported clasts at these sites have been primarily shaped by turbulent, intermittent processes such as mass wasting, ballistic impact, or sediment-gravity flows (including those involving limited water such as debris flows), by comparison, the class of rounded pebbles is likely associated with persistent flow. The physical association of these pebbles in some locations with pebble-rich sandstone or conglomerate outcrops supports this hypothesis.

The prior presence of outcrop may potentially be inferred by the existence of a clast popula-tion with characteristics shared by that particular outcrop. In the case of Gale crater, then, the presence of rounded to sub-rounded pebbles could be considered a proxy for the previous or nearby presence of pebble-rich sandstone or conglomerate units. To test this, we are currently assessing the number, distribution and density of rounded pebbles in these outcrops to compare to clast fields where rounded pebbles are abundant. A similar density may indicate in situ wear of a pebble-rich outcrop, while a different distribution might mean transport of these pebbles to their present location.