DIVERSITY OF NEW MARTIAN CRATER CLUSTERS INFORMS METEOROID ATMOSPHERIC INTERACTIONS. Eleanor. K. Sansom[1], Tanja. Neidhart[1], Katarina. Miljković[1], Gareth. S. Collins[2], Jonas. Eschenfelder[2], Ingrid. J. Daubar[3], [1]School of Earth and Planetary Science, Space Science and Technology Centre, Curtin University, Perth, Australia, [2]Department of Earth Science and Engineering, Imperial College, London, UK , [3]Earth, Environmental and Planetary Sciences, Brown University, RI, USA.

Introduction: Meteoroids can disrupt in planetary atmospheres due to stresses from aerodynamic drag [1]. Fragments that survive to strike the ground at high speed form a suite of tightly grouped craters, called a crater cluster [2,3]. The height above the surface of initial meteoroid break-up, as well as subsequent processes of separation and further fragmentation, depend on atmospheric density, meteoroid strength and speed [1]. The sizes and spatial distributions of craters within clusters can inform our understanding of the properties of meteoroids, as well as the atmospheric entry and fragmentation processes in different planetary atmospheres [4]. Of the 1,203 newly formed impact sites on Mars that have been observed to date, 58% are classified as crater clusters [5].

Mapping crater clusters: 557 crater clusters were mapped on Mars using HiRISE imagery, which have since been listed in the most recent crater catalog [5]. Positions, sizes and elevations of individual craters within each cluster were recorded (for diameters >1 m). Crater clusters ranged from having 2 to 2334 individual craters.

Measured and calculated properties: Several crater cluster parameters were investigated in order to compare the new crater clusters to those previously studied in [4]. These are illustrated in Figure 1 and 2, and definitions summarised in Table 1.

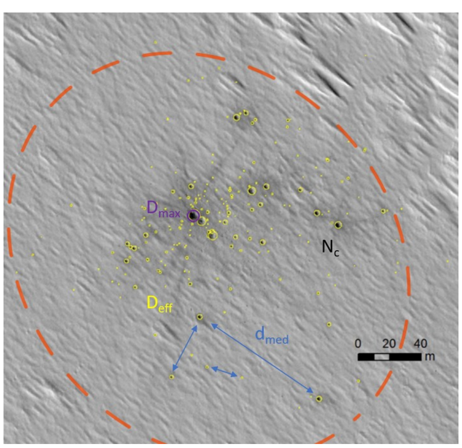

Figure 1: Crater cluster ESP 066902 1830 showing parameters used to describe clusters in this study (refer to Table 1). Individual craters are outlined in yellow. image credit: NASA/JPL/University of Arizona

Table 1: Properties used in this study to describe characteristics of crater clusters.

Parameter	Description
Nc	Number of craters within a crater cluster ≥ 1 m in diameter
D_{max} (m)	Diameter of the largest crater within a crater cluster
D_{eff} (m)	Effective diameter of an equivalent single crater $D_{\text{eff}} = \sqrt[3]{\sum_i D_i^3}$ where D_i is the diameter of individual craters in cluster
d_{med} (m)	Spread of craters in a cluster calculated as the median of the distances between all crater pair combinations in a cluster.
e	Aspect ratio of the major to minor axis of the best fit ellipse e ≈ 1: circular distribution of craters, e<< 1: elliptical distribution of craters
F-value	Fraction of craters > D_{max}/2 to the total number of craters: $\frac{N(>D_{max}/2)}{N_c}$ F-value ≈ 1: craters comparable in sizes F-value << 1: clusters consisting of few larger and many small craters
DSFD slope	Represents the power law exponential *a* in $y = C \times x^a$ of the regression curve used to fit the Differential Size Frequency Distribution (DSFD) of craters in a cluster.
Elevation (m)	Elevation of crater cluster site, from [5]

Summary of results: After investigating the different parameter spaces, we find the following key trends in the data:

- There is a strong correlation between the effective diameter (D_{eff}) and the largest crater within the cluster (D_{max}). The D_{max} can be used as a reasonable proxy for the effective diameter of a crater cluster (which in turn is typically used as a proxy for impactor mass).
- Larger crater clusters (large D_{max}) generally consist of distributed small craters, with a few large members.

- Small crater clusters (low D_{eff}) do not have large numbers of individual craters and show a range of dispersion and relative crater sizes.
- Crater clusters with many individual craters (Nc>100) generally consist of many distributed, small craters with only a few large members.
- Crater clusters with low Nc typically show a more even distribution of individual crater diameters.
- With increasing elevations, crater dispersion decreases, as does the large crater fraction, while size (D_{eff}) appears to increase. Sites at higher elevations therefore form many small, closer craters with only a few large members.
- Elevations up to 5 km show a steady increase in the number of detected crater cluster sites, above which they begin to decrease.

Conclusion: When interrogating the newly mapped craters, with those previously published in [4], we find a large diversity in the properties of the 634 crater clusters.

There are general trends in cluster sites with elevation, dispersion and large crater fractions, that support atmospheric filtering effects on impacting material. Crater clusters at lower elevations are smaller and more dispersed, reflecting increased ablation, lower impact speeds and greater spreading.

Although atmospheric filtering accounts for differences in size and dispersion of crater clusters, the number of craters within a cluster (Nc) also does not really vary with elevation. The variation in Nc is more likely related to the material properties of the impactor, such as its bulk strength.

Mars' crater cluster population samples elevations that represent a factor of ninedme difference in atmospheric density. The trends we observe in their properties due to atmospheric filtering would indicate that cratering mechanisms were similar in the past.

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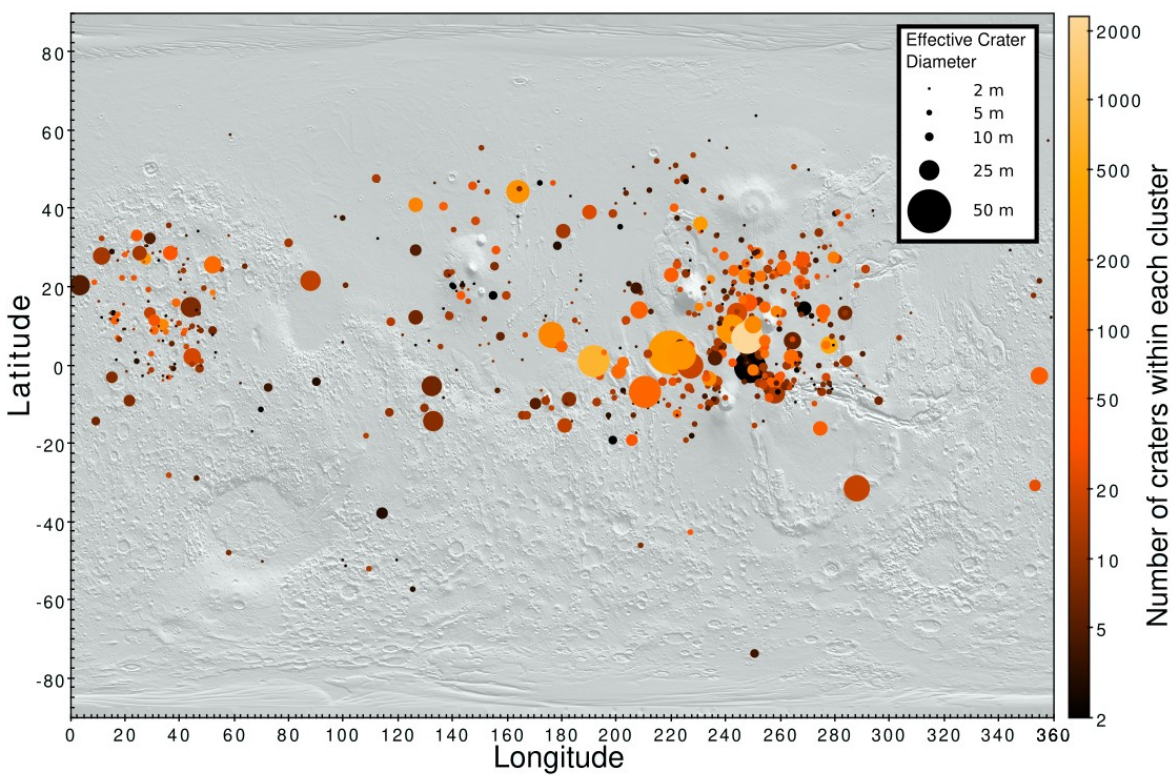

Figure 2: Crater clusters on Mars from [4] and mapped in this study (since published in [5]) shown on a topographic shade map of Mars [6]. The marker size denotes the cluster effective diameter. Shading represent the number of craters in a cluster.