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Sediment Fan Evolution and Hydrologic Activity in Mojave Crater, Mars

Kate Goddard (1), Sanjeev Gupta (1), Alexander Densmore (2), Jung-Rack Kim (3), Nicholas Warner (1), Patrice Carbonneau (2), and Jan-Peter Muller (4)

(1) Earth Sciences and Engineering, Imperial College, London, United Kingdom (kate.goddard09@imperial.ac.uk), (2) Geography Department, Durham University, United Kingdom , (3) Ziin Consulting, Seoul, South Korea, (4) Mullard Space Science Laboratory, UCL, London, United Kingdom

Introduction: Catchment-fan systems with well-defined catchments and fan surfaces with channel networks have been observed in Mojave crater, Mars [1]. Catchment-fan systems respond in complex manners to changes in hydrological conditions, tectonic subsidence and base level [2,3,4]. The geomorphology of fan bodies can provide a past record of changes in these variables. The ∼60 km diameter Mojave crater formed no later than the Late-Hesperian [1]. Since then the Martian climate is thought to have had surface conditions largely below the triple point of water. Thus, the presence of channeled fan surfaces in Mojave crater raises questions regarding how such features may have formed in this climatic period. Additionally, the mechanism of liquid water production/delivery is poorly understood [1].

Methods: (1) Mapping of fan systems using a HiRISE DTM of ∼1m grid spacing and complimentary orthoimage. (2) Analysis of morphometric properties of catchment-fan systems. (3) Flow routing/watershed delineation using ArcHydro Tools, and extraction of topographic profiles. (4) Volume estimation of fan deposits using two methods: (a) GIS analysis of the catchments to estimate the volume of material removed, and (b) GIS analysis of the fans, by predicting the underlying montane surface.

Results and interpretation: Many of the catchment-fan systems have proximal surfaces characterized by fingers of sediment which extend upstream into the lower catchments. This indicates that as fan building progressed, localized topography at the range-front was buried. This is explained by the concept of a finite "accommodation space" [5] for sediments to infill, driven by a lack of tectonic subsidence. Some of the fan surfaces show evidence of multiple cycles of incision and deposition in the form of incised remnant surfaces; indicative of fluctuating hydrology. We see a positive correlation (R2=0.8) between fan and catchment area. Mojave systems show a relationship equivalent to terrestrial fans in areas with low tectonic subsidence, reflecting the fact that vertical accommodation space is limited so fans must spread out more.

Long profiles through the fans catchments are convex. Terrestrially, convexity usually indicates the hillslope domain, whereas predictable concavity occurs when the contributing area is constantly increasing. We suggest that these profiles are evidence that discrete flow events were responsible for fan deposition. Volume estimation is ongoing, but we expect method (1) to provide a lower constraint, and method (2) to provide an upper constraint. So far, results show that fan volumes are low. A fan with area 168,447 m2 shows a volume of ∼1,900,000 m3 or thickness of 11 m using method (1), and volume of ∼2,800,000 m3 and thickness 17 m using (2).

Conclusion: We present new ideas regarding catchment-fan evolution and past water activity in Mojave crater. Importantly, we have observed evidence of multiple episodes of incision/deposition on certain fans, indicating that water activity may have been episodic or fluctuating. Fan sediments have backfilled into catchments, a feature sometimes seen in terrestrial fans with low subsidence [7]. We suggest that discrete flow events in the catchment were responsible for fan deposition, rather than a frequently reactivated tributary system. Fan thicknesses may be low, likely < 20 m.

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