TRANSIENT LANDSCAPE EVOLUTION IN THE AMAZONIAN-AGE MOJAVE CRATER, MARS. K. Goddard[1], S. Gupta[1], N. H. Warner[1], J-R. Kim[2], J-P. Muller[3]. [1]Dept. Earth Science & Engineering, Imperial College London, South Kensington Campus, SW7 2AZ, UK, kate.goddard09@imperial.ac.uk. [2]Dept. Geoinformatics, Univ. of Seoul, Seoul, Korea. [3]Mullard Space Science Laboratory, University College London, Holmbury St. Mary, Surrey, RH5 6NT, UK.

Introduction: Mojave crater (7.6ºN 33.0ºW) contains the most impressively preserved examples of catchment-alluvial fan systems discovered on Mars to date [1, 2]. They are present upon a series of down-stepping, isolated ranges present within the inner crater rim (Fig. 1). It is extraordinary in that it likely records a morphology that represents an early and transient stage of crater rim degradation by precipitation. In contrast, ancient (~4.1 to 2.9 Ga) Martian craters are often highly degraded and infilled partially or completely by sediment [3], whilst youthful (< ~3.0 Ga) craters remain largely unaffected by fluvial modification. The topographic evolution of the rims of large impact craters subject to runoff-based erosion is poorly understood to date. Here, we use topographic and morphologic observations of the rim of Mojave crater to develop a conceptual model that explains the evolution of catchment-fan systems at intracrater ranges under conditions of precipitation. We then extend this model to explain the past evolution of older, more degraded craters such as Holden.

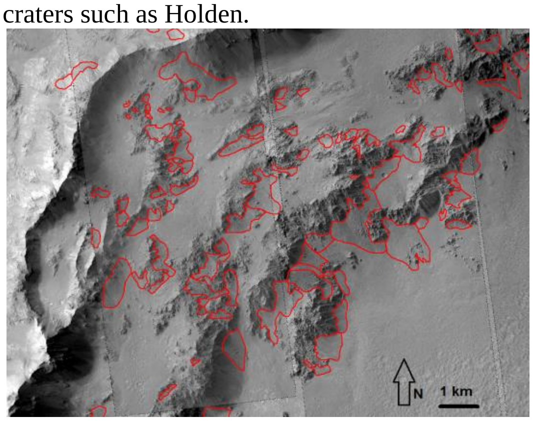

Figure 1: Fans sourced from ranges inside rim

Methods: We used MRO HiRISE ortho-imagery (~25 cm pix^{-1}) and derived topography data (~1 m grid spacing) and to carry out: (1) morphologic observations, (2) mapping of catchment-alluvial fan systems on the western crater rim, and (3) gather across-strike topographic swaths of ranges with catchment-fan systems. In addition, we used MRO CTX imagery (~6 m pix^{-1}) and derived topographic data (~18 m grid spacing) to (1) carry out topographic observations, and (2) carry out crater counting of the crater's target material, deriving crater cumulative frequency curves for a dataset of 1239 craters > 200 m diameter, over an area of 5900 km^2.

Geologic Setting:
Mojave crater is impacted into the flood channel floor between Tiu and Simud Valles, which form part of the Circum-Chryse outflow channel system. The rim-to-floor relief of the ~60 km diameter crater is ~2.3 km. Immediately inwards of the crater rim is an ~8-km-wide platform comprising concentric rings of discontinous ranges and basins produced during gravitational collapse shortly after impact [4]. Sediment fans can be divided into two types based upon sediment source area: (1) range-derived, and (2) intermontane basin-derived. We look only at the former in this study.

Results

Chronology
Mojave crater's ejecta and secondary crater chains are superimposed upon material which infills the flood channel floor, as confirmed by embaying morphologies. Crater count data shows a poorly constrained fit of ~3.0 Ga for craters > 1.2 km diameter. A kink in the cumulative frequency curve is present at diamaters < 1.2 km and indicates a resurfacing event. A resurfacing correction applied to this smaller crater population provides a resurfacing model age of ~1.5 Ga.

Structural Topography of Ranges
We focus our analysis on two ranges, A and B, which are each < 10 km long and are separated by an intermontane basin. The ranges are asymmetric in the across-strike direction with the drainage divide recessed toward the crater rim (Fig. 2). This is explained by the erosional competition between opposing range flanks, due to the difference in relief from drainage divide to adjacent basin floor. We interpret the differences in range flank relief to be related to normal fault geometries, produced during crater modification [4, 5].

Spatial Distribution of Catchment-Fan Systems
On range A, crater-centre facing catchments are 0.03 - 0.16 km^3, whereas rim-facing catchments are 0.01 - 0.05 km^3. This trend is replicated on other ranges. Fans are largely only present on crater-centre facing range flanks. Catchment development therefore depends on the magnitude of range flank relief and differences in local base level elevation.

Catchment-Alluvial Fan Morphology

Catchments comprise bedrock channels which extend to the main drainage divide of the range. Fans have surfaces connected to the fan apex by cross-cutting channels. Downstream profiles are linear to convex-up. Proximal fan surfaces extend into the lower reaches of catchment channels, deposited between irregular shaped bedrock topography (Fig. 3). Close to the fan apex, bedrock protrudes through fan surfaces.

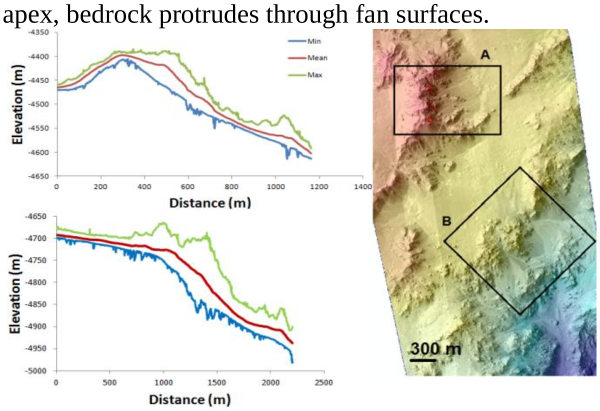

Figure 2: Ranges A and B Swath Profiles

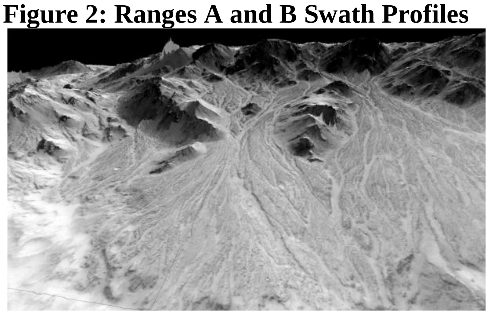

Figure 3: Fan confined by bedrock topography

Discussion

We propose that during gravitational collapse immediately after impact, activity along normal faults created a series of downstepping fault-blocks which formed topographic ranges [4, 5]. Termination of faulting gave rise to static asymmetric ranges separated by infilling material (possibly impact melt; [6]).

Coupled Evolution of Catchment-Fan Systems

Onset of precipitation eroded the pristine rim topography [1, 7]. Catchments expanded preferentially on crater-centre facing flanks due to base level contrasts between adjacent downstepping fault blocks. A forst order estimate of range retreat is made by observing the positions of bedrock spurs which emerge through fan surfaces. At first the catchment-fan morphology would have been similar to that observed in emerging ranges controlled by normal faults on Earth: the range front would have been linear and aligned with the fault (Fig. 4B). However, the static range topography led to a progressive backfilling of fan surfaces into catchments, and a sinuous range front (Fig. 4C).

Continued Evolution of Crater Rims

We propose that with continued precipitation, headward retreat of catchments would have led to capture of upstream catchment-fan systems (Fig. 4D). For example, the eastern crater rim shows linked catchment-fan systems with throughput of material. Over time this would lead to extended sediment routing systems that connect multiple intermontane basins. At this stage, significant relief would still remain between the edge of the crater rim and the platform which contained the range topography. Over a longer timescale and/or wetter conditions the crater rim may erode, forming large alluvial fan deposits which infill the crater. We postulate that older craters, such as Holden crater, which are partially infilled with alluvial fans represent this next stage. Mojave represents a scenario in which erosion by precipitation terminated before the interior basin and range topography was fully subdued.

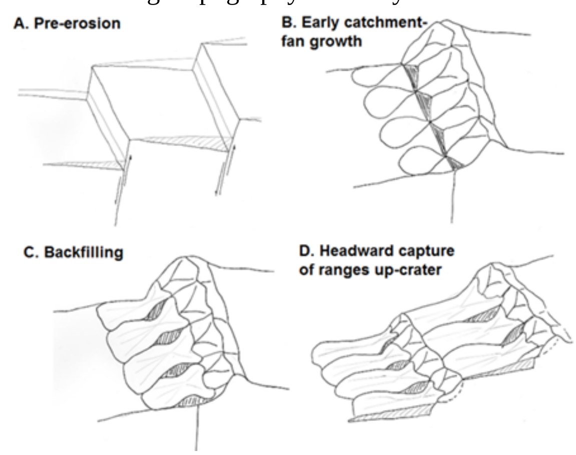

Figure 4: Conceptual model of crater rim evolution

Conclusion: Craters subjected to erosion by precipitation may evolve through a series of stages: (1) development of asymmetric basin and range topography following gravitational modification, (2) catchments develop in areas where range flank relief is significant, (3) ranges integrate due to headward erosion, leading to longer, integrated drainage systems, and (5) larger alluvial fans are sourced from the outer crater rim wall.

References: [1] Williams R. M. E and Malin M. C. (2008), *Icarus*, 198. [2] Williams R. M. E and Malin M. C. (2004), *Lunar and Planetary Science*, XXXV. [3] Craddock R. A and Howard A. D. (1997), *JGR-Planets*, 102. [4] Kenkmann T. (2002), *Geology*, 30. [5] Kenkmann T and von Dalwigk I. (2000), *Meteoritics and Planetary Science*, 35. [6] Tornabene L. et al. (2007) *7th Int. Conf. Mars*. [7] McEwen A. S. et al. (2007), *Science*, 317.