ALLUVIAL FAN MORPHOLOGY NORTH OF HELLAS INDICATES MULTIPLE STAGES OF DEPOSITION. R. B. Anderson1, R.M.E. Williams2, A.L. Gullikson1, 1United States Geological Survey Astrogeology Science Center, Flagstaff, AZ (rbanderson@usgs.gov), 2Planetary Science Institute

Introduction: The cratered highlands north of Hellas are one of several locations on Mars where numerous large alluvial fans have been observed [1]. These fans have been interpreted as evidence of a late-stage period of fluvial activity on Mars [2], and recent work indicates that they may have formed over hundreds of Myr indicating persistent or recurrent habitability [3].

We have mapped sinuous ridges in the cratered highlands to the north and west of Hellas (-15°N to -45°N, 30°E to 75°E), using 6 m/pixel Context Camera (CTX) images [4]. We find that sinuous ridges in this region are primarily concentrated within intracraterr alluvial fans and are interpreted as inverted distributary channels. Several of the most prominent examples are shown in Figure 1. We present initial observations and interpretations of the geomorphology of these fans and the morphometry of the inverted features.

Results: Fan Morphology: The craters highlighted in this study show three distinct morphological types of alluvial fans (Figure 2). Some fans exhibit negative relief channels or “chutes” while others are heavily eroded, resulting in extensive inversion of relief. The sinuous ridges exhibit slight sinuosity and distributary branching, consistent with channelized mud-rich flows [5], while the channels tend to be wider and more linear than the sinuous ridges. A third category of fans is “degraded”, with a rough surface with few clear channels or sinuous ridges.

Figure 3 shows overviews of Saheki crater and Crater L, with sinuous ridges traced in yellow, and fan boundaries marked in green. The variations in fan morphology within the same crater may represent different periods of fan formation, with the oldest fans subject to extensive erosion and inversion of relief, younger fans exhibiting a degraded but not fully inverted surface, and the youngest fans retaining negative relief chutes or channels. If this is not the case and the fans are the same age, then the degree of induration would need to vary significantly to result in such different morphologies. This seems unlikely, particularly for fans that are sourced from adjacent catchments in the walls of the same crater (e.g. the two large fans in Saheki, Figure 3).

Figure 1: Craters of interest to the north of Hellas. Yellow markings are mapped sinuous ridges. Crater “L” is named based on [1], Crater “7” is the seventh unnamed crater in the broader mapping region containing sinuous ridges associated with alluvial fans or similar features.

Figure 2: CTX images of fans in Crater L illustrating three distinct morphologies. Fan apices are marked with “a” and arrows indicate flow direction. (A) Negative relief “chute” morphology. (B) Inverted channel morphology. (C) Degraded morphology.
In several cases, fans with channels transition to inverted relief at their distal ends. One explanation for this is that grain size sorting downfan during deposition led finer-grained and therefore more easily eroded distal deposits. Alternatively, this may fit with the interpretation above that the fan surfaces with channels represent a later stage of deposition that has partially buried the more proximal region of inverted relief. One possible example of this is shown in Figure 4.

Late stage deposition could also help to explain the apparent truncation of the small channel-bearing fans along the southern rim of Crater 7 by the larger, partially inverted fan sourced from the western wall. This is also consistent with the interpretation of the large alluvial fan in Harris crater as having formed in multiple discrete phases [6].

One challenge faced by the late-stage deposition hypothesis is that it does not appear to have occurred on all fans. For example, the southern fan in Crater L is almost entirely inverted, while the northern fan in the same crater is entirely channeled (Figure 3). This may indicate that highly localized precipitation was responsible for at least the final stage of fan deposition.

**Discharge Calculations:** We have also begun work on measuring the widths of the mapped sinuous ridges, to be used in estimating fluvial discharge. Width measurements are conducted using the highest resolution data available (HiRISE, 0.25-0.50 cm/pix), and when possible multiple measurements per ridge spaced every ~200 m are collected. Along with the average and standard deviation of the measured widths, each ridge is assigned a confidence ranking between 1 (very confident: well-defined flat-topped cap for the full length of the feature) and 4 (unmeasurable).

We find that the northern fan in Saheki crater has a median ridge width of 63 m, while the southern fan has a median ridge width of 34 m. Using width-discharge relationships from [7], these values yield a median discharge of ~170 m$^3$/s for the northern large fan, and ~55 m$^3$/s for the southern, more inverted fan. This latter value is in agreement with the 30-60 m$^3$/s found by [5] for the southern fan. Although the uncertainties in empirical discharge calculations of this sort are large, and the number of measurable ridges in the northern fan is relatively small, the difference between the two results is consistent with the fans forming under different discharge conditions, and potentially at different times.

**Future Work:** Work is ongoing to understand the stratigraphic relationships between the fans in the craters discussed here, and to relate these to other ridge-bearing fans and fan-like features in the mapping area. We will also continue estimating discharge where possible to determine whether systematic changes in discharge can be related to the observed differences in fan morphology. These observations will lead to a better understanding of the history of fluvial activity on Mars.

**References:**