A MORPHOLOGIC APPROACH TO DISTINGUISHING ALLUVIAL FANS FROM OTHER DEPOSITIONAL FEATURES ON MARS.

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Introduction: Alluvial fans on Mars are hypothesized to have formed in the late Hesperian to early Amazonian [1] and may represent the final era of liquid water activity on the surface [2,3]. Early localized surveys of large alluvial fans and fan-shaped features [4,5] have been gradually expanded into global surveys containing hundreds of features [6,7] However, alluvial fans, deltas, and some fluvial systems can be difficult to distinguish from one another from remote sensing data without detailed sedimentary analysis, and therefore commonly have been lumped together in surveys of Mars sedimentary features. Alluvial fans form in a specific depositional environment characterized by sporadic, high-energy run-off events, which is distinct from the depositional environments of deltas, fan-deltas, gilbert deltas, or distributive fluvial systems [8–10]. Deltaic and fluvial features are also more likely to be associated with valley network formation, which has been dated to the Noachian [11]. By distinguishing alluvial fans from other fan-shaped features in the global catalog, we can isolate distinct depositional environments on a local scale refine our understanding of the spatial and temporal distribution of aqueous depositional environments during the early history of Mars.

Objectives: In this study we conducted an updated global survey of fan-shaped features on Mars in order to assess the full extent of alluvial fan depositional environments. For each feature in the global catalog we then characterized the morphology by planform shape, radius, average radial slope, and radial profile. We classified each feature as either an alluvial fan, possible alluvial fan, or non-alluvial radial feature based on how accurately it fit the morphologic definition of an alluvial fan (Table 1).

Feature Classification	Shape	Radius	Radial slope	Radial profile
Non-fan	not radial	-	-	-
Small feature	radial	< 2 km	-	-
Non-alluvial radial deposit (NARF)	radial	> 2 km	< 1.0°	-
Possible alluvial fan	radial	> 2 km	> 1.0°	segmented
Alluvial fan	radial	> 2 km	> 1.0°	smooth or terraced

Table 1. Feature classifications and morphologic parameters that are consistent with alluvial fan morphology (green), indicative of possible alluvial fans (yellow), and not consistent with alluvial fan morphology (red).

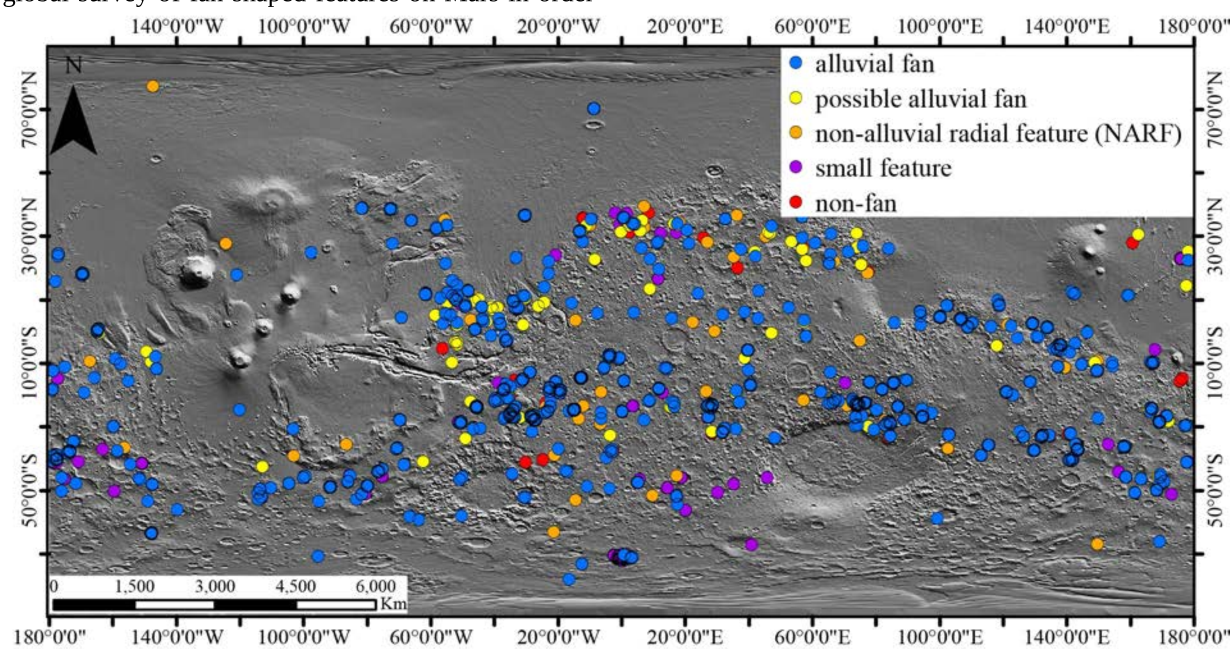

Figure 1. Global distribution of alluvial fans and other depositional features, color coded by the assigned classification according to morphologic parameters.

Morphology of alluvial fans: Alluvial fans on Earth are distinguished from deltas, braided fluvial systems, and other radial depositional features based on measurable morphologic characteristics [8]. Alluvial fans have a radial shape emanating from single apex point along a topographic break. The radial topographic profiles of alluvial fans are straight or slightly concave-up. Alluvial fans have average radial slopes > 1.0°, in contrast to fluvial and deltaic systems which have slopes < 1.0° and often < 0.5° [8]. For the purposes of this study, we eliminated features with radii <2 km as they are often morphologically indistinguishable from talus cones, which form from slope collapse rather than aqueous sediment transport [12]. Some locations from previous surveys of potential alluvial fans were also eliminated and marked as "non-fans" due to a lack of visible radial features that could be characterized.

Results and Discussion: The final catalog of alluvial fans (Figure 1) contains 775 features with morphology that is consistent with the established morphologic definition of alluvial fans [8] (Figure 2). We included another 223 features as possible alluvial fans because they have segmented radial profiles that often look like a remnant alluvial fan that has been cut by an erosional surface (Figure 2). In some cases, the features classified as potential alluvial fans may be other similar depositional features such as fan-deltas or lacustrine shoreline deposits that have coincidentally been eroded into a fan shape.

A total of 63 of the features we characterized have the radial shape of a fan-shaped feature but have an average radial slope <1.0°, which is not consistent with alluvial fan morphology. These features we classified as "non-alluvial radial features" (Figure 2). These are most likely other depositional features formed by aqueous sediment transport, such as deltas or braidplains. More investigation is needed to determine specific depositional environments of the non-alluvial features. The potential depositional environments represent a selection of locations most likely to have direct evidence of long-term standing water early in the history of Mars. Therefore, it is important to distinguish these features from alluvial fans in order to more precisely analyze the history of changing water activity on the surface of Mars.

Of the confirmed alluvial fans, 175 are new features identified for the first time in this survey. Newly-identified alluvial fans are approximately evenly distributed across the central highlands and southern high latitudes and are found as far south as 78°S latitude (Figure 1). The discovery of alluvial fans in the high southern latitudes suggests that the climatic conditions necessary for alluvial fan formation were not constrained to equatorial and mid-latitudes during the time of fan formation. About a dozen new alluvial fans were also identified outside of craters, along the edges of large channels or chaos terrain blocks, which expands our understanding of potential locations for localized aqueous depositional environments beyond the commonly studied crater lakes and large basins.

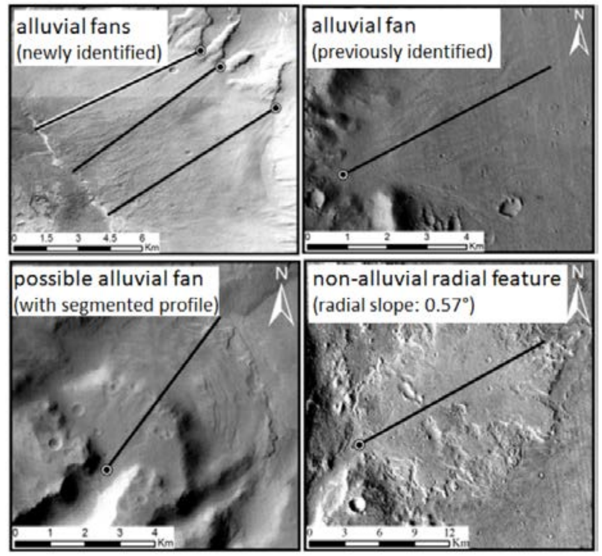

Figure 2. Examples of features classified as alluvial fans, possible alluvial fans, and non-alluvial radial features based on morphologic parameters.

Conclusions: By applying morphologic characterization developed from terrestrial depositional systems to sedimentary features on Mars which have formed by similar processes, we are able to distinguish alluvial fans and their associated depositional environments from other aqueous depositional features. This allows us to better constrain regional and global depositional environments specific to alluvial fans and better understand the era of alluvial fan formation on Mars during the transition from regular surface water activity to the current dry and cold climate.

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