Surface grain size of alluvial fans on Mars from thermal inertia, as an indicator of depositional style

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Tables and Figures

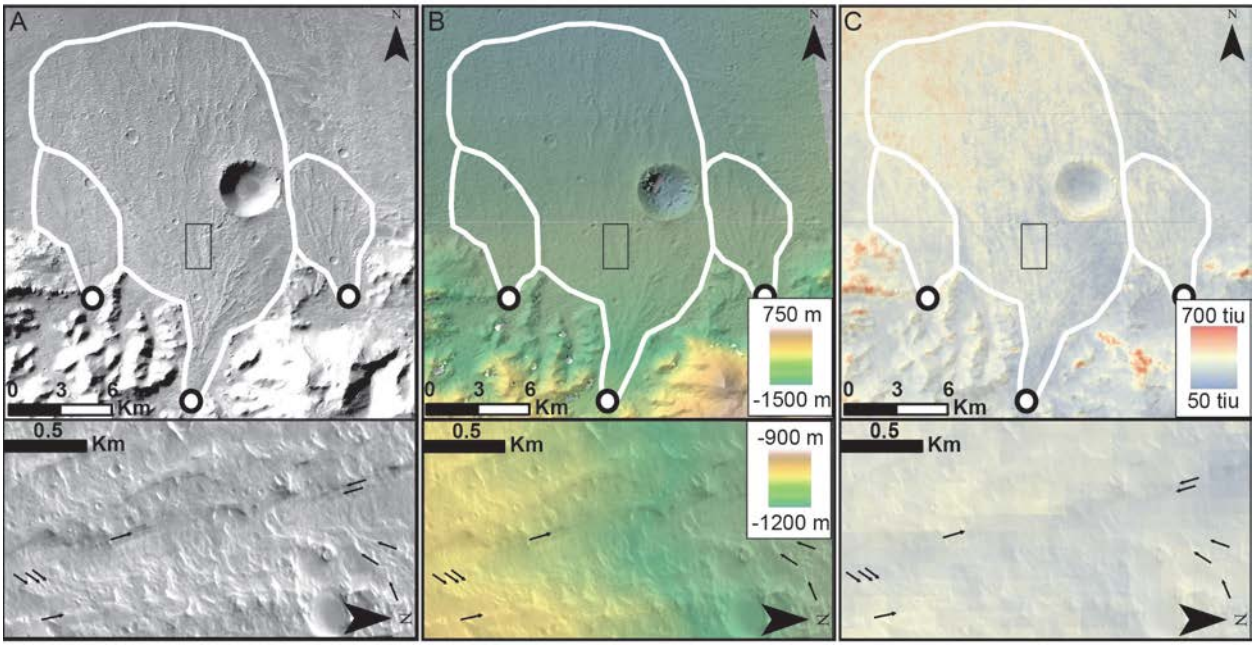


Figure 1. An example alluvial fan surface in visible, thermal, and elevation data
A typical alluvial fan surface on Mars as seen in A) CTX visible image data (~5 m/px), B) an elevation-graded DTM (~20 m/px) generated from CTX data, and C) thermal inertia data (~100 m/px). Fan surfaces are often altered post-deposition by scattered impact features, yardangs, and other evidence of aeolian erosion. On these fan surfaces, layered features (black arrows) which may be original depositional stratigraphy are exposed along the edges of remnant channel features. Large impact features such as the one seen on the middle fan are excluded from the thermal inertia statistics of fan surfaces in this study.
FanIDs, left to right: 745, 770, 742; Lat/Long: -26.96, -28.0 (See Supplemental Information for full database of features)
Data credits: CTX mosaic: Dickson et al., (2023), NASA/JPL/MSSS/The Murray Lab; CTX DTM: Laura et al., (2023), USGS/NASA; TI mosaic: Fergason et al., (2006).

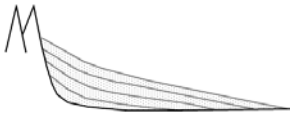
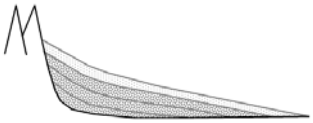
modern fan surface / depositional grain size		pristine fan surface (no erosion)	eroded parallel to depositional layers	eroded cross-cutting depositional layers
	**coarse-grained**	coarse	coarse	coarse
	**fine-grained**	fine	fine	fine
	**coarse-grained with late fine-grained layer**	fine	coarse	increasing grain size downslope
	**interbedded coarse- and fine-grained deposits**	either (most recent deposit is preserved)	either (heterogeneous across full fan population)	patches of fine- and coarse-grains

Table 1. Observable surface grain size based on depositional style and erosion state
The alluvial fan surfaces observed on Mars today were formed more than 2.5 Gya. The erosional state of these alluvial fans affects how the original depositional grain size patterns are expressed at the surface. For two end-member grain size categories (fine-grained and coarse-grained), this table shows what dominant grain size would be observable on the modern surface for a range of depositional models. It should be noted that these are meant to be simplified end-member cases and additional complexity is possible between all of these scenarios. Global heterogeneity or homogeneity between fans in either depositional style or erosional state would be expected to be expressed in the range of grain sizes observed on modern alluvial fan surfaces.

TI range (tiu)	grain size	# of alluvial fans (by meanTI)
50 - 169.2	dust	5
169.2 - 206.8	dust to sand	20
206.8 - 396.0	sand	362
396.0 - 484.0	sand to pebble	37
484.0 - 603.0	pebble	9
603.0 - 737.0	pebble to cobble	4
737.0 - 810.0	cobble	0
810.0 - 990.0	cobble to boulder	0

Table 2. Alluvial fan grain size categories

Alluvial fans categorized by TI range and grain size classification, based on the mean TI value of each alluvial fan surface. The intermediate grain size ranges ("sand to pebble", for example) are defined by the uncertainty of the thermal inertia values, imposed on the TI cutoff value between grain size ranges. For example, based on a 10% uncertainty (Fergason et al., 2006), the "sand to pebble" TI range encompasses +/- 10% of the cutoff TI value between sand and pebble grain sizes (Edgett and Christensen, 1991).

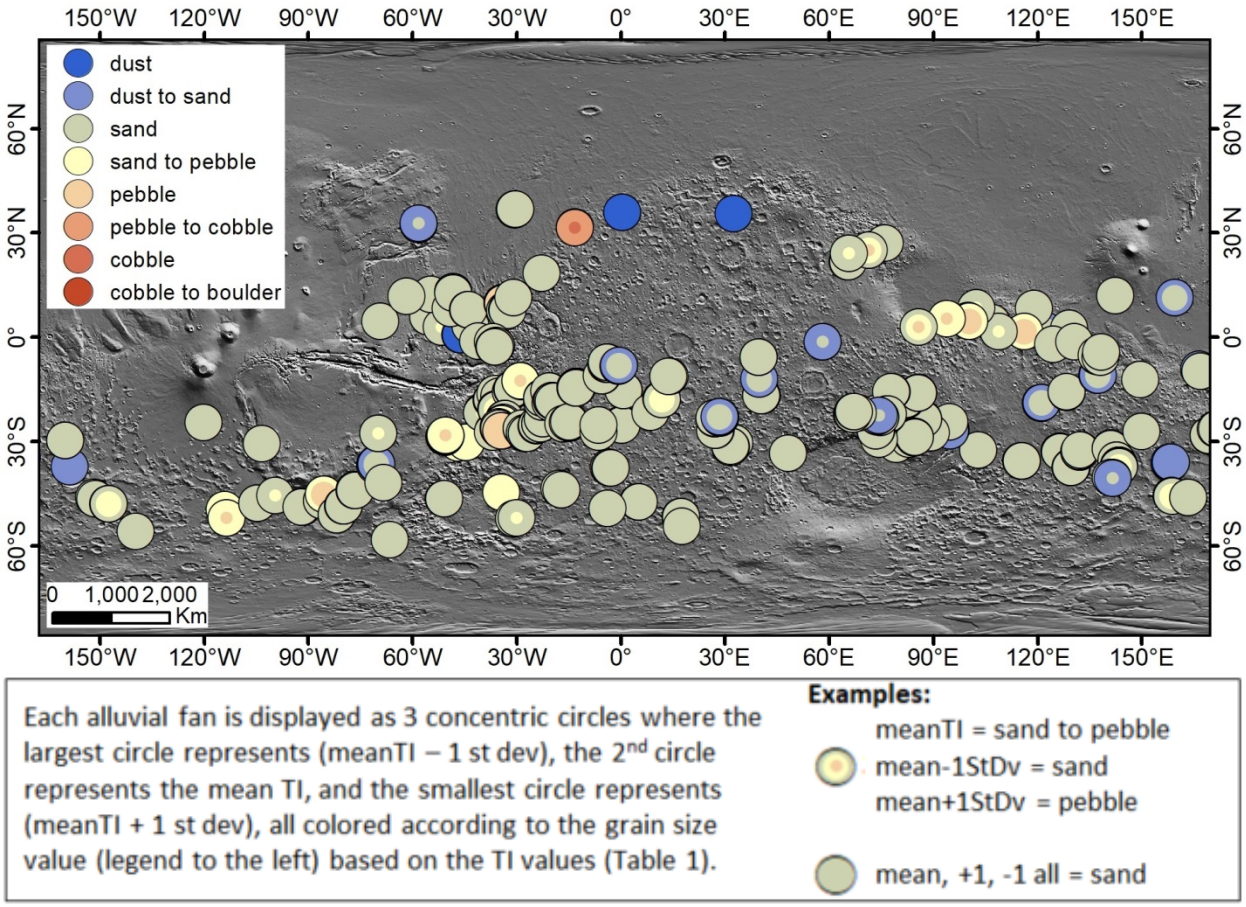


Figure 2. Grain size of Mars alluvial fans
Map of the global population of alluvial fans on Mars which were analyzed in this study, displayed by mean TI value across each alluvial fan surface, with outer and inner circles which represent the grain size of the TI values 1 standard deviation below and above the mean TI. The grain size categories in the legend correspond to the TI ranges in Table 3.1. Fans in areas of high dust coverage were eliminated from the initial analysis.

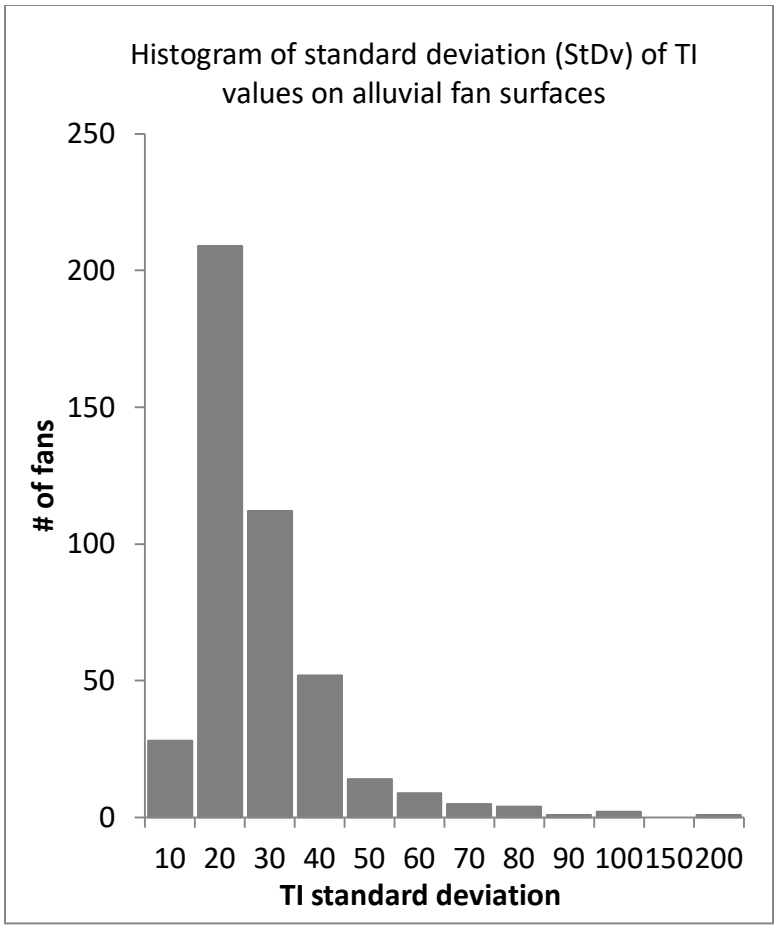


Figure 3. Standard deviation values of TI on fan surfaces
The range of TI values across an individual fan surface is relatively small for most of the fans in the global population. The range of TI values representing a single grain size category is often ~100-200 tiu (Table 1). The low standard deviation values shown here, relative to the TI range of grain size categories, indicates that the population of alluvial fans generally have a narrow range of TI values present across the fan surface.

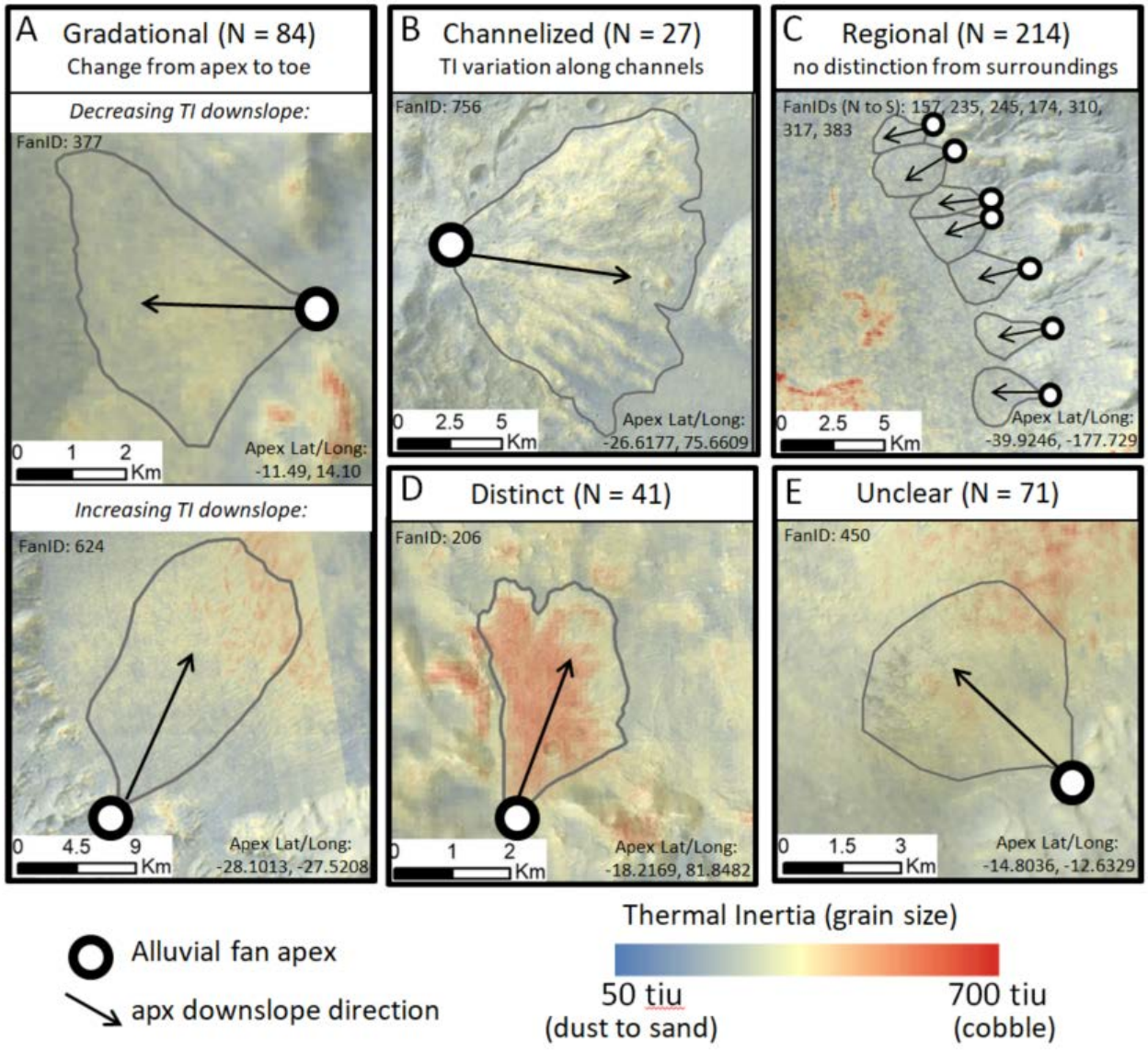


Figure 4. TI spatial patterns on Mars alluvial fans
Examples of spatial patterns of TI distribution on Mars alluvial fans. A) Gradational TI patterns can be either increasing or decreasing downslope. B) Channelized patterns show variations in TI values which correlate to morphologic channel features on the fan surface, where the channels correlate to lower TI values. C) Regional TI patterns are indistinguishable from the TI of the surrounding surface and have no variations within the alluvial fan surface. D) TI patterns described as Distinct are noticeably higher or lower than the TI of the surrounding surface but have no variations within the alluvial fan surface. E) Alluvial fans which have no clear TI spatial pattern are described as Unclear. FanID identifiers refer to the table provided as Supplementary Material.

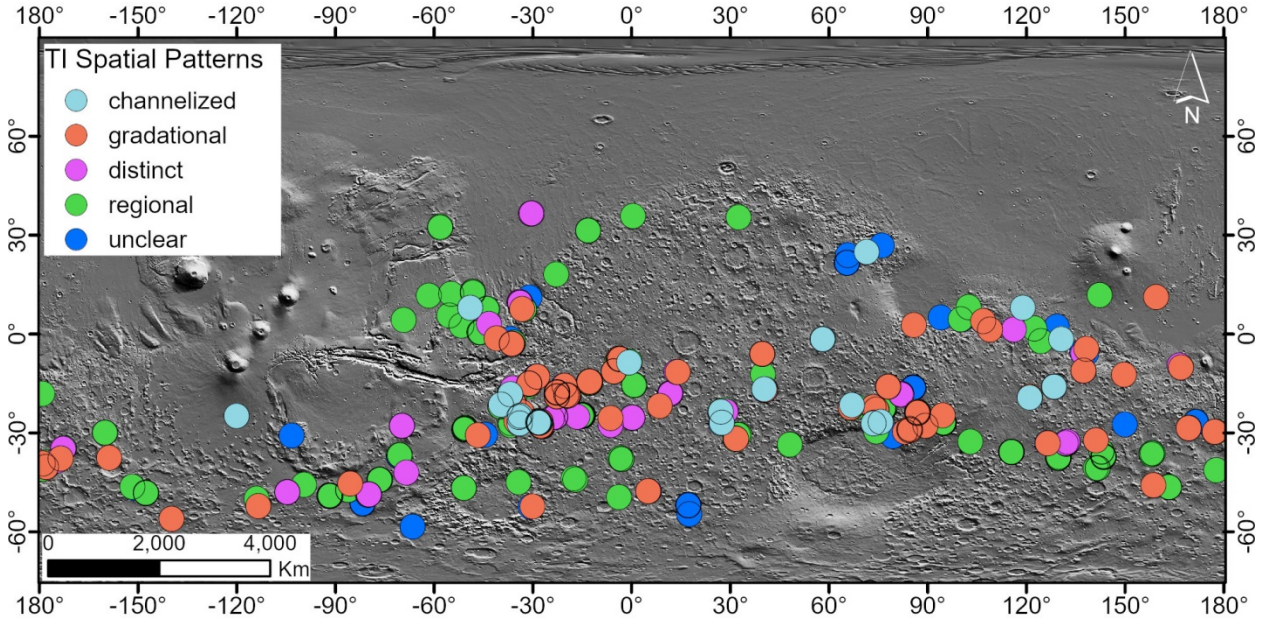


Figure 5. Global distribution of TI spatial patterns
Global distribution of thermal inertia spatial patterns of alluvial fan surfaces. Alluvial fans where the TI values correlate to channelized patterns on the fan surface appear to be restricted to the more central latitudes and do not appear in the high southern latitudes. All other spatial patterns appear throughout the global population of alluvial fans with no clear regional trends. Figure 3 includes more detail about the visual descriptions of each TI spatial pattern.

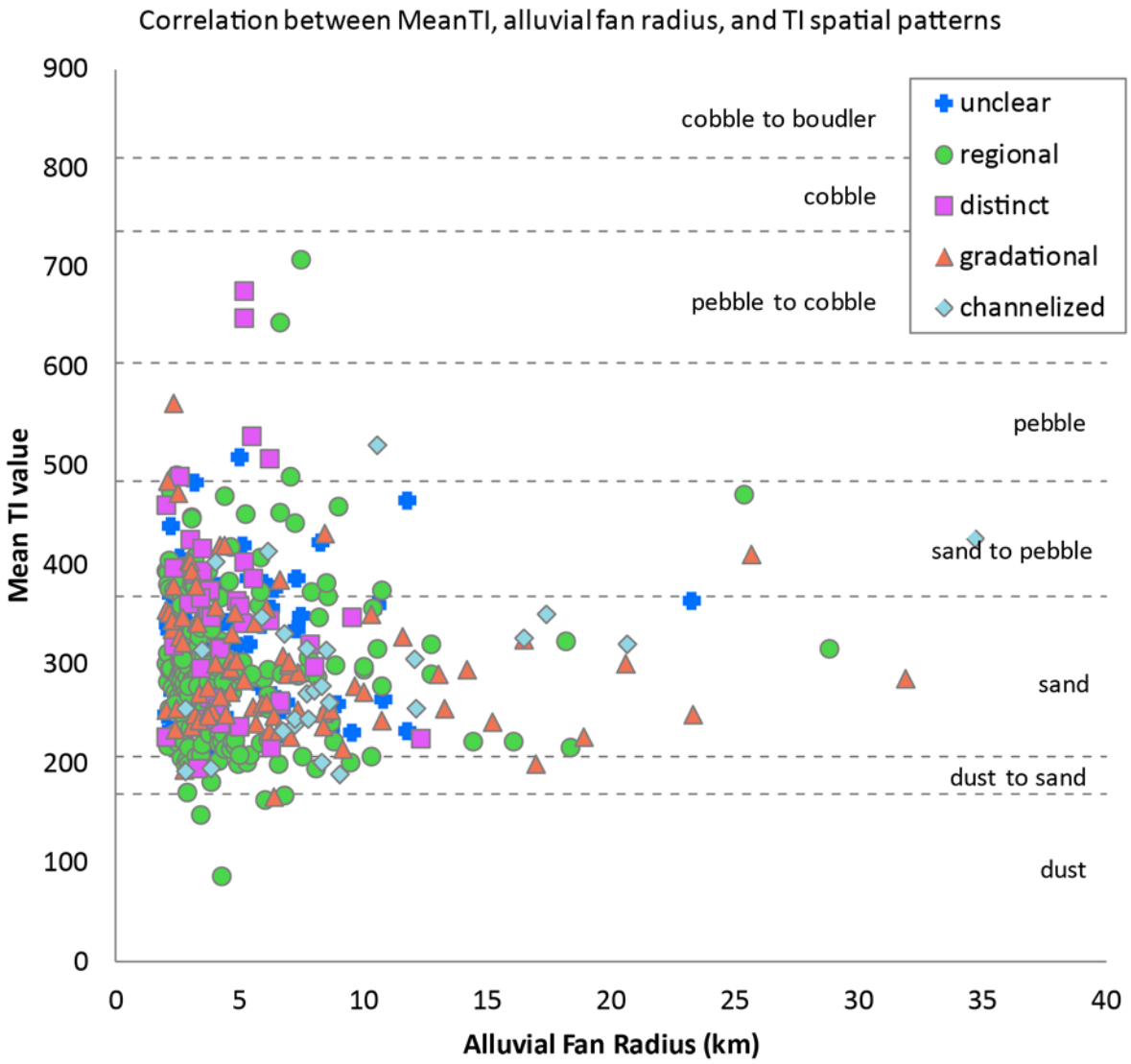


Figure 6. Correlation between MeanTI and TI spatial patterns
MeanTI of alluvial fan surfaces plotted against fan radius for each feature. Alluvial fan data points are colored according to the TI spatial pattern category (Figure 3). TI grain size categories are indicated by the dotted lines and labels along the right side. The global population of alluvial fans shows no clear correlation of meanTI with fan radius or with spatial TI patterns.