

Background

- Deltas and fluvial fans are both fan-shaped landforms with complex channel networks
- Exhibit channel networks where channel lengths and widths decrease basinward [1]
- Fan-shaped landforms form from different sedimentological processes and generate distinctive channel network morphologies [2] (Table 1)

Table 1	Deltas	Fluvial Fans	Alluvial Fans
Process	Channel bifurcation	Apex avulsion Crevasse-splay	Debris flow Sheets floods
Shoreline	Required	Not required	Not required
Area (km²)	10 ¹ - 10 ³	10 ³ - 10 ⁵	< 10
Gradient (°)	< .5	0.001 - 0.03	2.5 - 25
Watershed	Large	Large	Small
Profile	Concave up	Concave up	Convex up
Mean angle (°)	~72-75, ~79 in the arctic [1,2]	~54	n/a
References	[e.g., 1,2]	[e.g., 1,3]	[e.g., 4]

- >170 fan-shaped landforms have been identified on Mars (Fig. 1) [5]
- Likely formed during 2 distinct periods of fluvial activity [6] ranging from 100 - 1 million years [7] and differing rates of erosion and sediment supply [8]
- Fluvial fan formation on Earth is linked to fluctuations in discharge resulting from highly seasonal precipitation changes [9]

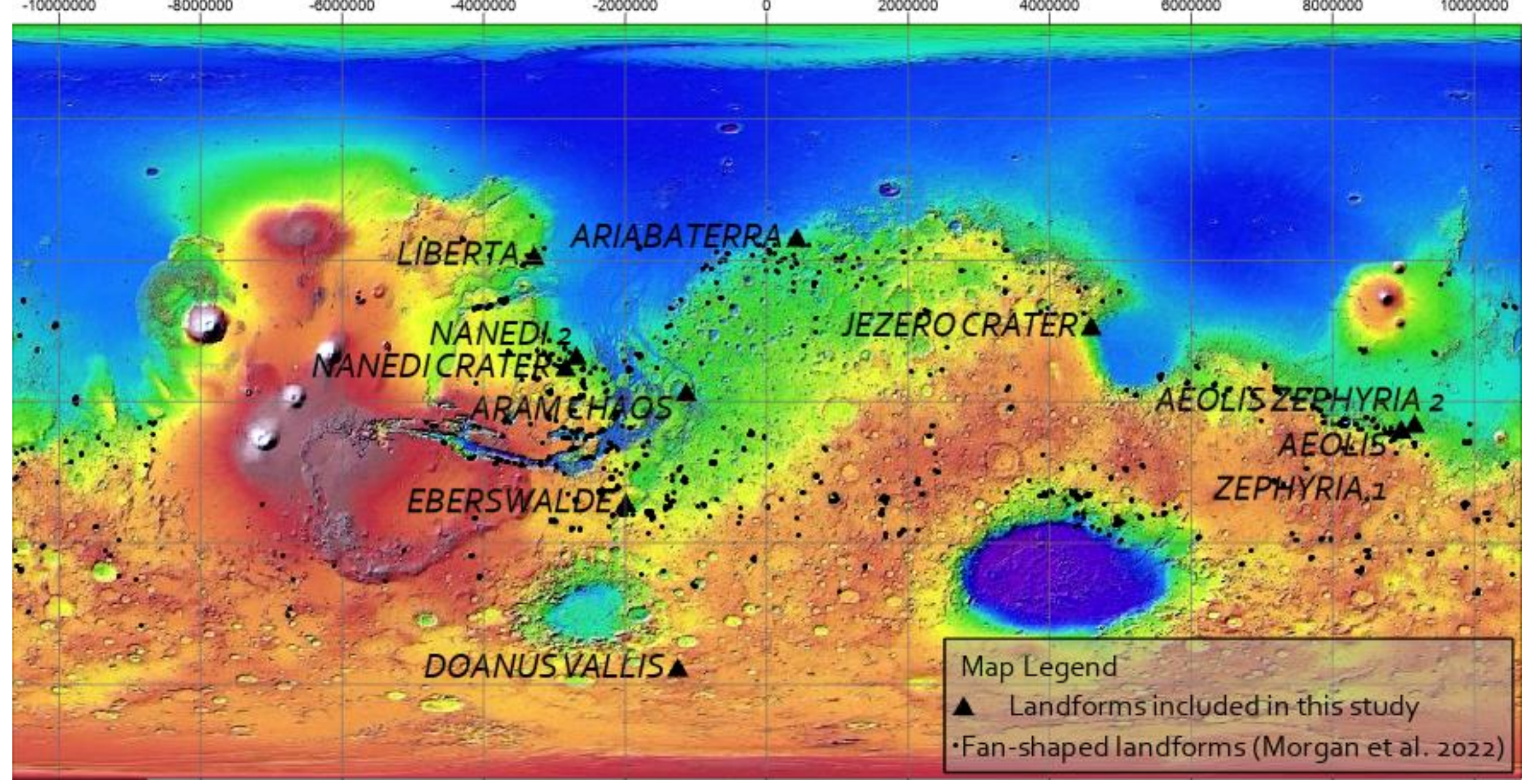


Figure 1: Mars fan-shaped landforms

- Little work has been done to differentiate deltas and fluvial fans on Mars
- Deltas and fluvial fans could host different opportunities for life and space resources
- This is the first study to discriminate Martian deltas from fluvial fans using quantitative metrics derived from Earth analogs
- **What are the mean network angles for fan-shaped landforms on Mars?**
- **How do these compare to Earth deltas and fluvial fans?**
- **What is the nature (i.e. fluvial or deltaic) of individual fan-shaped landforms on Mars?**

Methodologies

- 10 Martian landforms that met multiple criteria for a delta or fluvial fan were selected
 - Varying degrees of erosion/alteration by impacts
- Created photomosaics of MRO-HiRIse and CTX camera images
- Used ArcGIS Pro to individually map channel networks (Fig. 2)
 - Used multiple images to infer and mitigate shadow effects
- Traced channel networks as polyline features, automatically collecting channel lengths
- Widths averaged from 3 measurements: immediately before (w_b), after (w_a), and halfway between (w_h), between two bifurcations or cross-over points (Fig. 2)
- All apparent bifurcations, avulsions, and cross-overs measured
- Angles (θ_n) measured where angle limbs are equal in length to the final parent channel width (w_f) tracking alongside the channel banks and bars

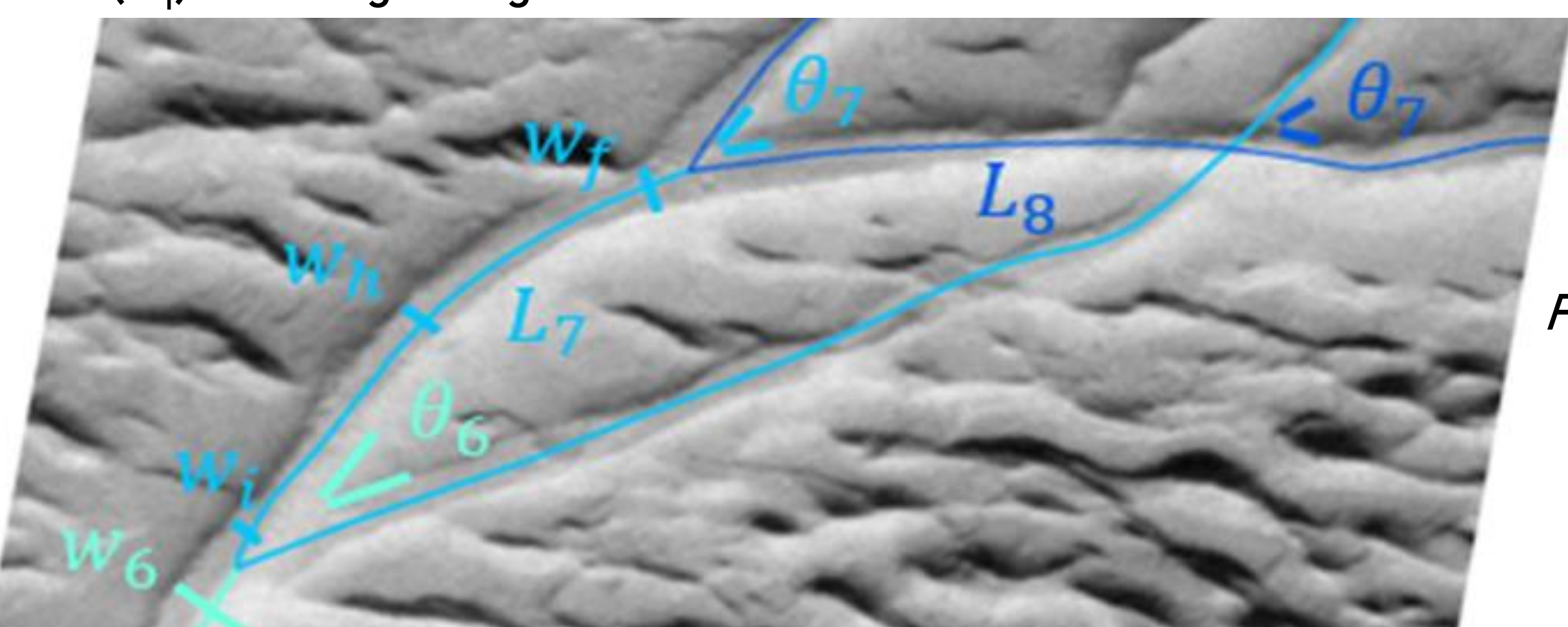
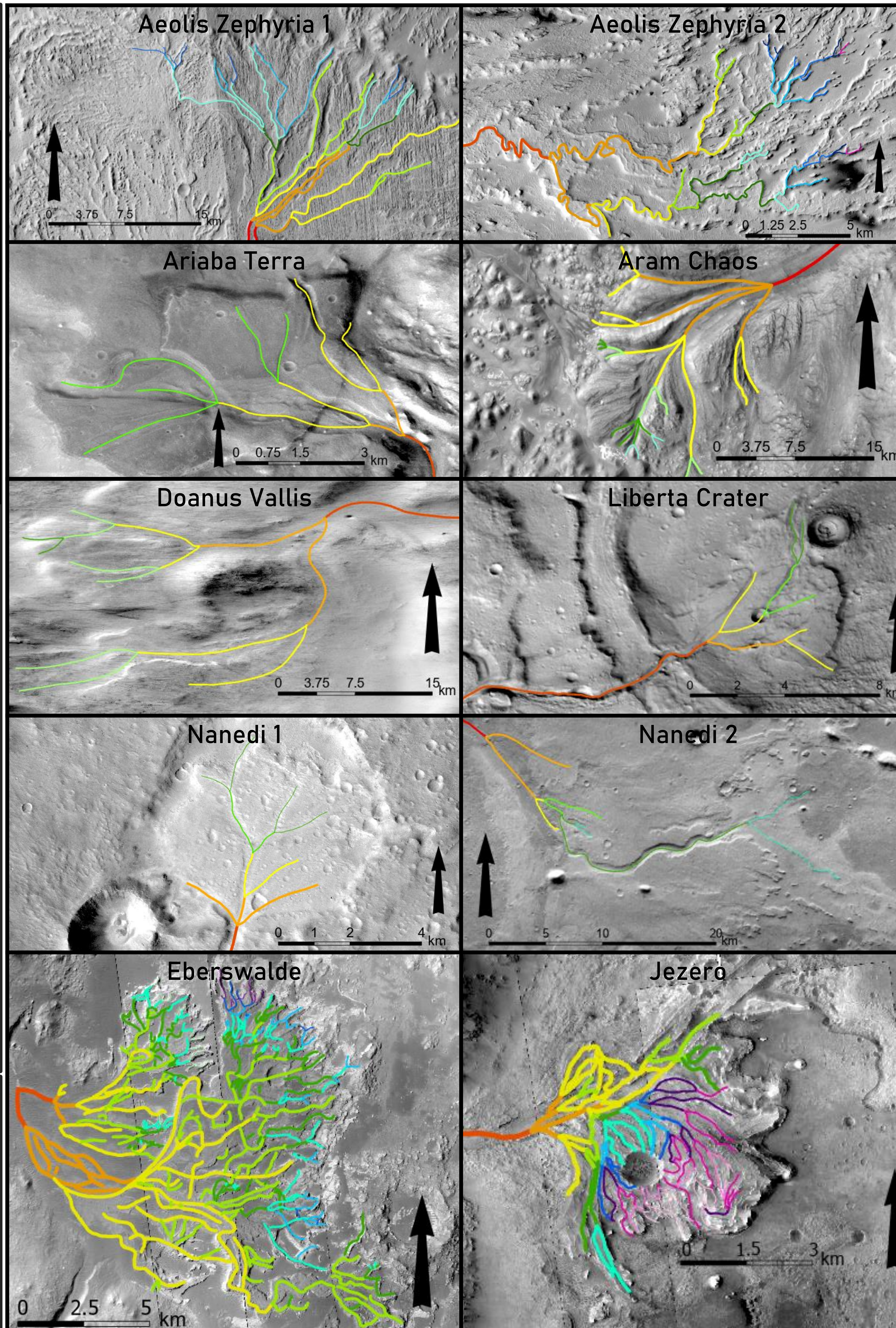


Figure 2: Measurement methodology



Discussion

- Most Martian landforms resemble Earth-fluvial fans
- The Eberswalde landform resembles an Earth-delta
- Drainage network angles suggest more overland than groundwater flow generating narrower angles (~40°) [10]
 - Bifurcation angles on Mars could differ from Earth
- We must carefully assess the nature of landforms on Mars using multiple quantitative morphometric criteria
- Correctly identifying fan-shaped landforms on Mars can assist with paleoshoreline studies
- If these landforms are fluvial fans, this could indicate significantly different environmental conditions
- Fluvial fans' morphology significantly differs in different climate types (arid v. wet)
- We do not include the possibility of submarine fans
- Saturn's moon Titan also has fan-shaped landforms [11]

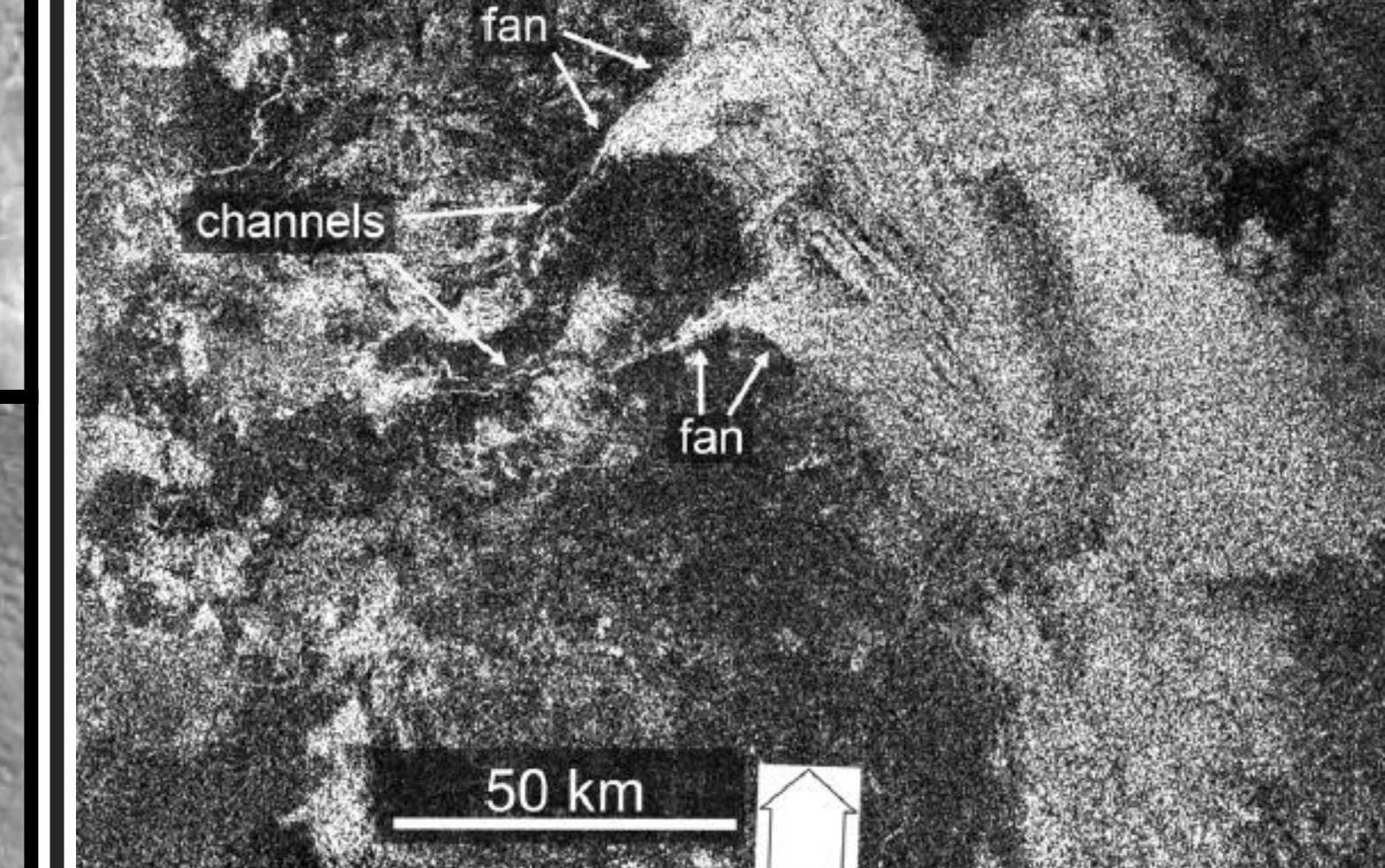


Figure 3: Titan's fan-shaped landforms [11]

- Integrating other remote sensing data (thermal-IR) to determine approximate grain size
- Stratal geometry analysis of outcrops can be used to differentiate deltas and fluvial fans on Mars
 - Jezero could contain both fluvial and deltaic deposits
 - Some outcrops at Jezero crater resemble a delta [12]
- Eocene Green River Fm. in the Uinta basin contains both fluvial and deltaic deposits

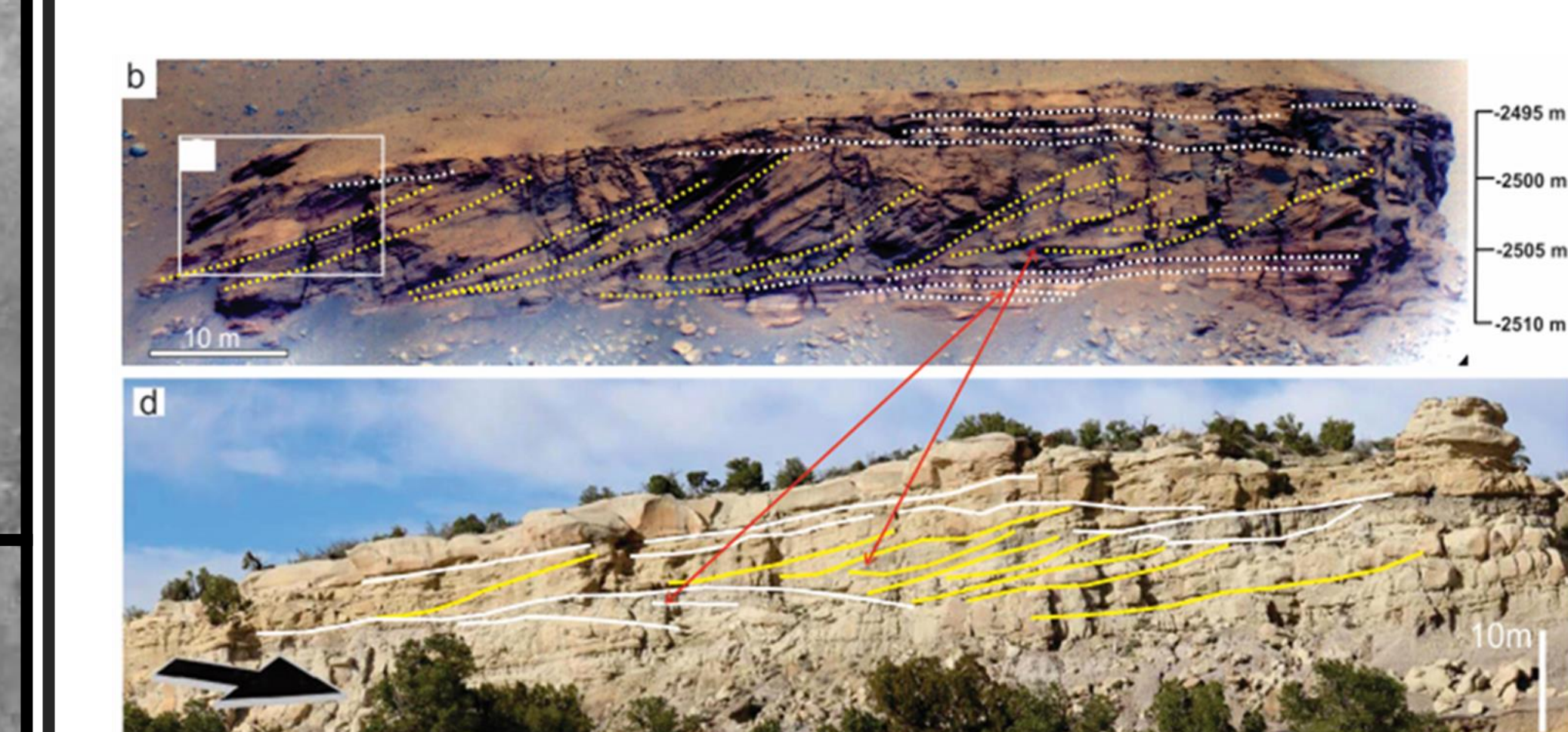
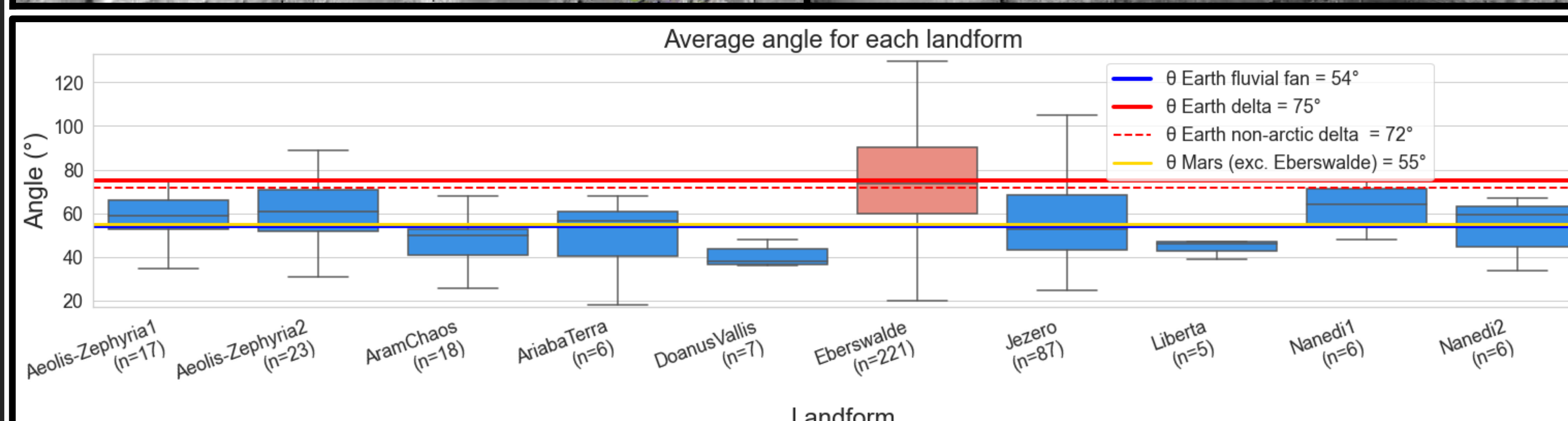


Figure 4: Jezero outcrop re-interpreted [12] and similar scale fluvial fan deposit in the Green River Fm. [13]

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