Local-scale Stratigraphy of Inverted Fluvial Features in Aeolis Dorsa, Western Medusae Fossae Formation, Mars.

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Poster Summary

- We **use stratigraphy to study fluvial history in Aeolis Dorsa (AD),** 800 km E of Gale Crater.
- We use fluvial, eolian, and volcanic geomorphic units, as well as superposition and embayment relationships to **derive relative stratigraphies.**
- Stratigraphies were tied to mapping by [5,11] to **constrain numerical ages for fluvial activity.**
- Findings suggest **fluvial activity in AD was spatially diverse, widespread, and occurred during multiple time-intervals in the Hesperian-Amazonian transition and early Amazonian.**

1. Background

- The **Medusae Fossae Formation (MFF, Fig. 1)** is interpreted as friable layers of volcanic ash [1-4, and refs. therein]. Recent crater size-frequency distributions and superposition relationships suggest an age no younger than Late Hesperian [5,6].
- **Aeolis Dorsa (AD, Fig. 2),** between Aeolis and Zephyria Plana, hosts a dense and diverse group of sinuous ridges, which are interpreted as **inverted fluvial features**. Inverted fluvial features in AD are observed in the lower MFF and thought to form by precipitation, run-off, induration, burial, and exhumation by aeolian erosion [7-10, and refs. therein].
- ➢ We present multiple local-scale analyses of stratal markers in AD to derive a history of fluvial activity. Mapping of northern plains volcanic material [11] and the MFF [5] constrain the timing of fluvial activity. This work is part of a regional investigation testing 3 hypotheses of fluvial history in AD [10].

2. Hypotheses for fluvial activity in AD

1. **Fluvial activity occurred during a confined time-interval, and by implication occurred due to unique climate and/or environmental conditions (e.g., obliquity, volcanism).** Evidence supporting Hypothesis 1 would be inverted fluvial features contained within a single MFF stratum.
2. **Fluvial activity occurred episodically during separable time-intervals, and by implication occurred due to repeated conditions,** which would be evidenced by inverted fluvial features found in multiple non-adjacent strata.
3. **Fluvial activity occurred continuously through multiple time-intervals, and by implication occurred due to prolonged conditions,** which would be evidenced by inverted fluvial features found in multiple adjacent strata.

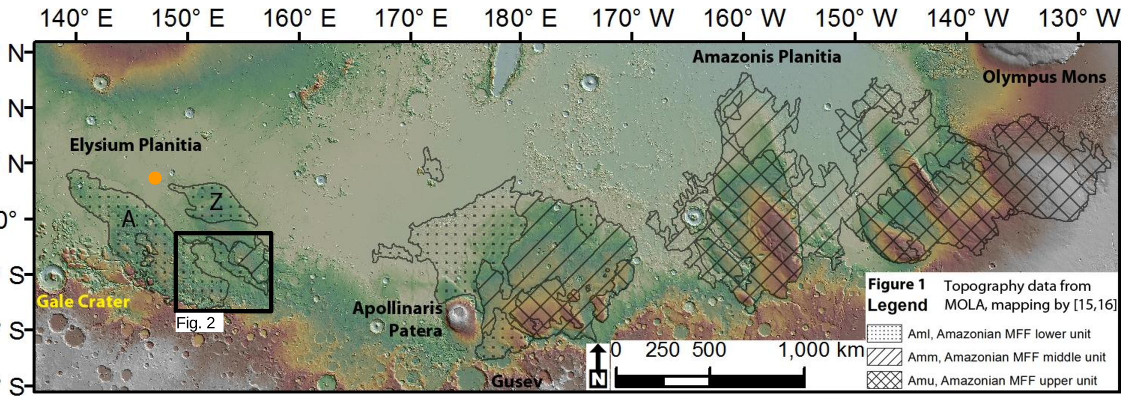


Fig. 1: Equatorial distribution of MFF stratigraphic members. Inverted fluvial features in Aeolis Dorsa are predominately located between the westernmost lobes, Aeolis (A) and Zephyria Plana (Z). Orange circle indicates the location of Fig. 5B.

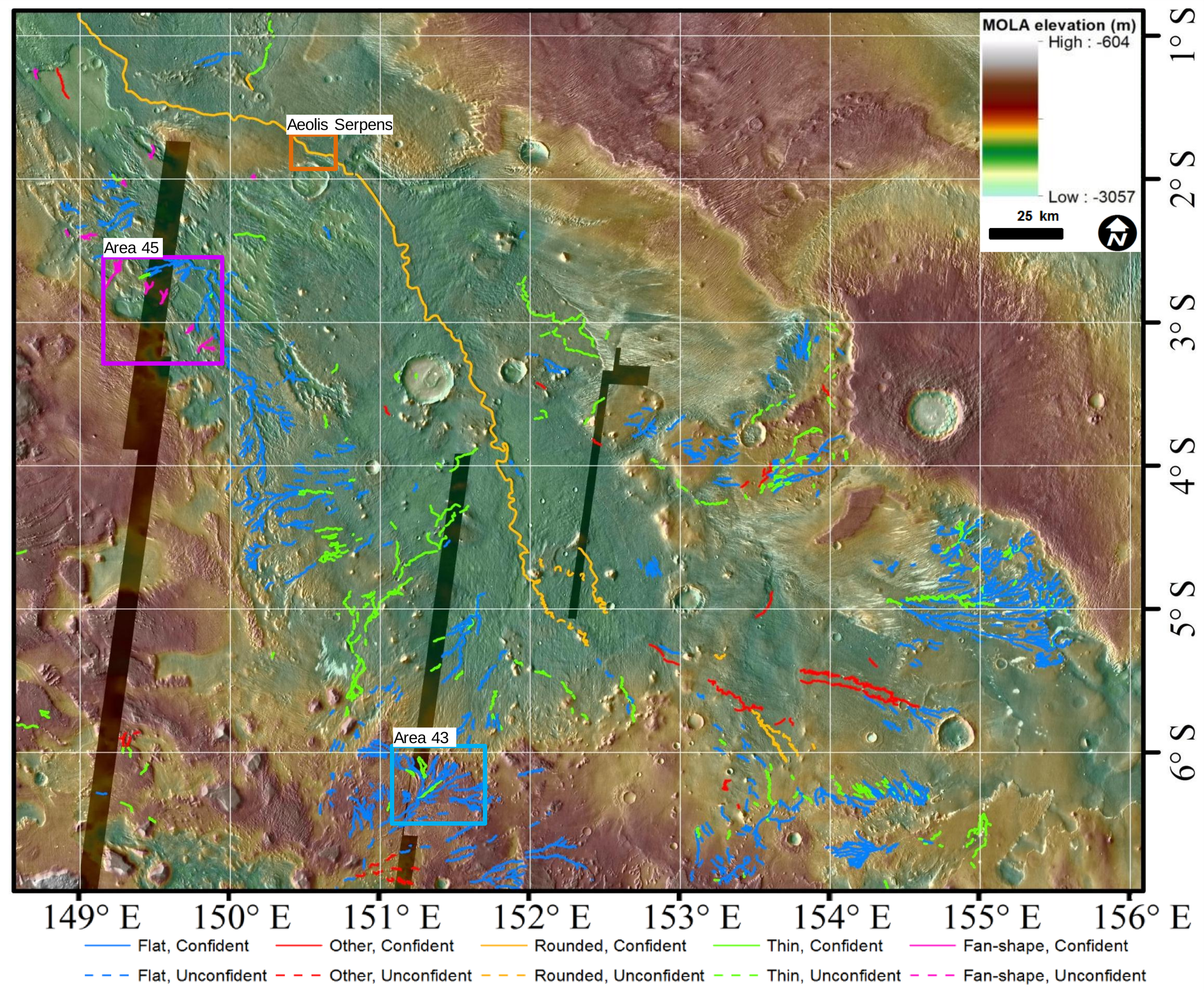


Fig. 2: Distribution of inverted fluvial features in Aeolis Dorsa [10] and local-scale study areas (colored boxes). Colored delineations denote inverted fluvial feature morphologies [10].

3. Data, Methods, and Study Areas

Data: Context Camera (CTX, 6 m/px) and High Resolution Imaging Science Experiment (HiRISE, 0.3 m/px) images, topographic data from Mars Orbiter Laser Altimeter (MOLA, 160 m spot) and CTX digital elevation models, and geologic maps from [5,11].

Methods:

1. **Identify local geomorphologic units**. Delineations of sinuous ridges [10] identify strata containing or adjacent to inverted fluvial features. Orientations, sizes, and aspect ratios of elongate hills identify strata containing or adjacent to yardangs and indicate paleo-wind direction [12]. Rootless cones [13] identify where Cererus lavas embay MFF strata.
2. From topographic data, 3-point solutions for strike/dip, and principles of superposition and embayment, we **derive relative stratigraphic relationships** between geomorphic units.
3. Stratigraphic relationships are used to **interpret stratigraphic columns**. Inverted fluvial features are interpreted as periods of MFF deposition, fluvial activity, and subsequent fluvial inversion [1]. Yardangs are interpreted as periods of MFF deposition and aeolian abrasion [8,12]. Rootless cones are interpreted as Cerberus lava flow events [11,13].

Study Areas (colored boxes in Fig. 2), location identifiers from [7, their table 1]:

- We study **Area 43** to understand fluvial stratigraphy near the highland/lowland boundary (HLB). Area 43 is a well-preserved, well-imaged (stereo coverage) fan-shaped network of inverted fluvial features [e.g., 7]. Some fluvial features exhibit post-depositional topographic undulations possibly due to compaction or tectonic deformation [14].
- We study **Area 45** to understand the fluvial stratigraphy of several fan-shaped inverted fluvial landforms clustered along Aeolis Planum, ~250 km north of the HLB.
- We study **Aeolis Serpens**, a ~600-km-long inverted fluvial feature in central AD, because it contacts several mapped geologic units [5,11]. These mapped geologic units provide some numerical constraints on the timing of fluvial activity related to Aeolis Serpens.

4. Stratigraphic observations

Area 43

Units are ordered in increasing elevation. Area 43 contains 3 units:

- **Unit A** is a NE-SW elongate surface texture contained in topographic lows (yellow outlines, Fig. 3A & 3B).
- **Unit B** stands ~80 meters above Unit A (Profile A-A') and contains broadly distributed N-S oriented yardangs.
- **Unit C** is inverted fluvial features, ~20 m above Unit B. Some yardangs of Unit B on-lap/cut inverted fluvial features (arrows, Fig. 3B & 3C).

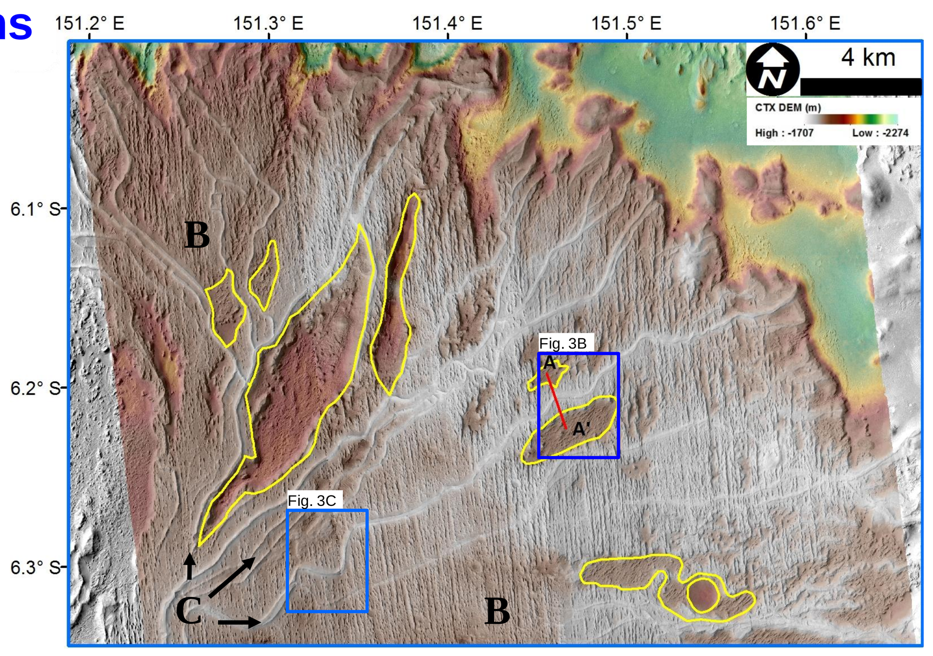


Fig. 3A: Area 43 with 3 units. NE-SW elongate textures (Unit A) are outlined in yellow; N-S oriented yardangs (Unit B) broadly cover Area 43; and, inverted fluvial features (Unit C) radiate from the lower left corner.

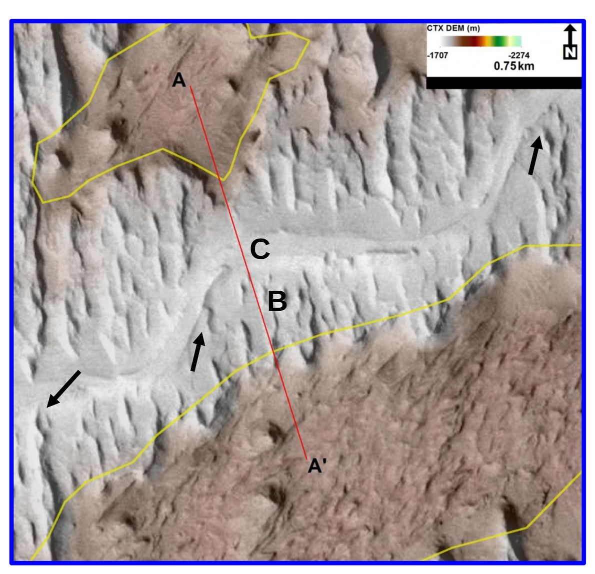
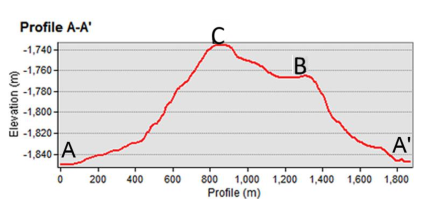
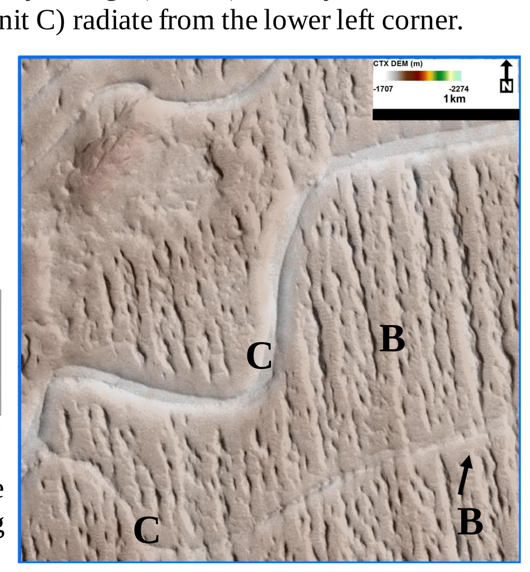


Fig. 3B: 3 units in Area 43. Arrows show where yardangs onlap an inverted fluvial feature.

Fig. 3C (right): Arrow shows an inverted fluvial feature (Unit C) cross-cut by a N-S yardang (Unit B).



Profile A-A': Topographic profile from CTX DEM showing elevations of geomorphic units.

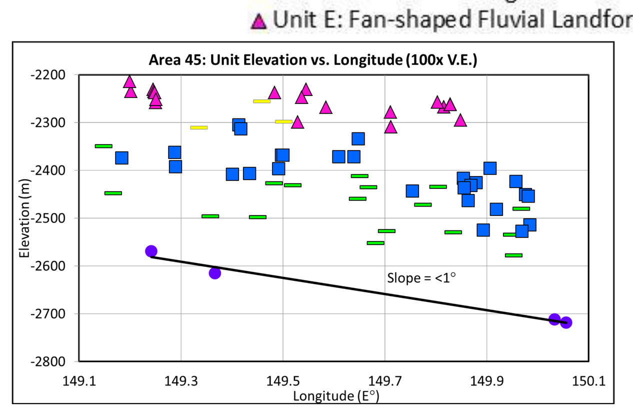


Area 45

Area 45 contains 5 units (A-E):

- **Unit A** is a smooth-to-rippled surface and the lowest local unit. 3-point solutions for strike/dip give a near horizontal surface (topographic plot).
- **Unit B** is defined by irregular yardangs and rough MFF topography
- **Unit C** is inverted fluvial features above and adjacent to Unit B
- **Unit D** contains NW-SE orientated yardangs above Unit D.
- **Unit E** is the highest unit and defined by several fan-shaped inverted fluvial landforms.

Legend:
- Unit A: Smooth-to-rippled surfaces
- Unit B: Irregular Yardangs
- Unit C: Inverted Fluvial Features
- Unit D: NW-SE Yardangs
- Unit E: Fan-shaped Fluvial Landforms



Topographic plot: MOLA elevations for Units A-E show average topographic relationships.

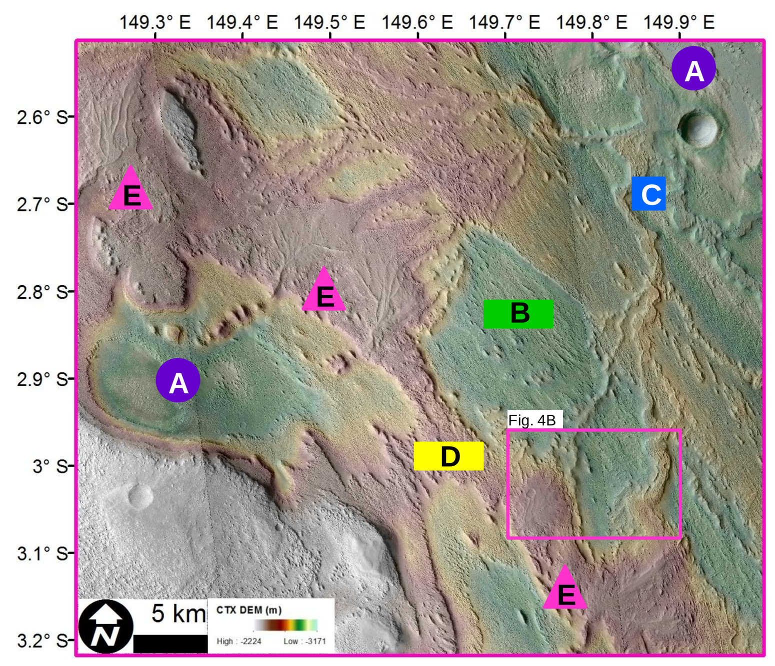


Fig. 4A: Area 45 and examples of Units A-E.

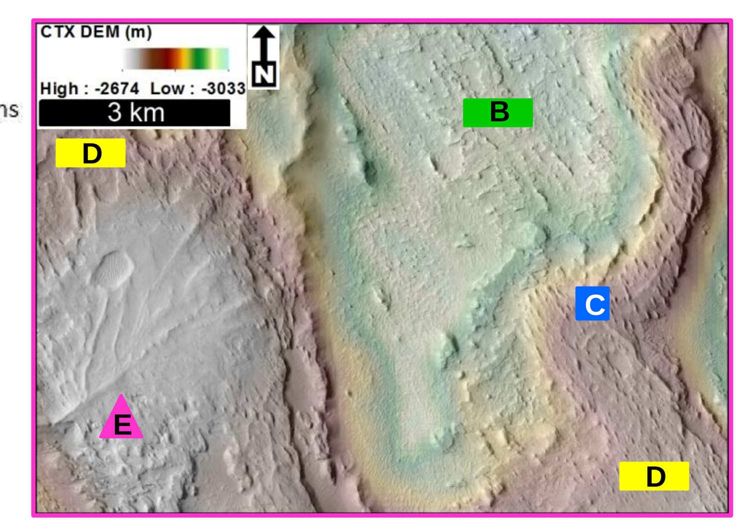


Fig. 4B: Examples of 4 geomorphic units (B-E).

Aeolis Serpens

Aeolis Serpens contacts 3 units:

- **Older MFF Unit:** Aeolis Serpens has positive relief in the Amazonian-Hesperian lower member [5].
- **Younger MFF Unit:** Aeolis Serpens has no relief, but retains fluvial morphologies (Fig. 5A) in the early Amazonian lower member [5].
- **Cerberus Lavas Unit:** North of AD (Fig. 1 & Fig 5B), moats around yardangs and rootless cones proximal to Aeolis Serpens indicate middle to late Amazonian Cerberus lavas [11] embay Aeolis Serpens.

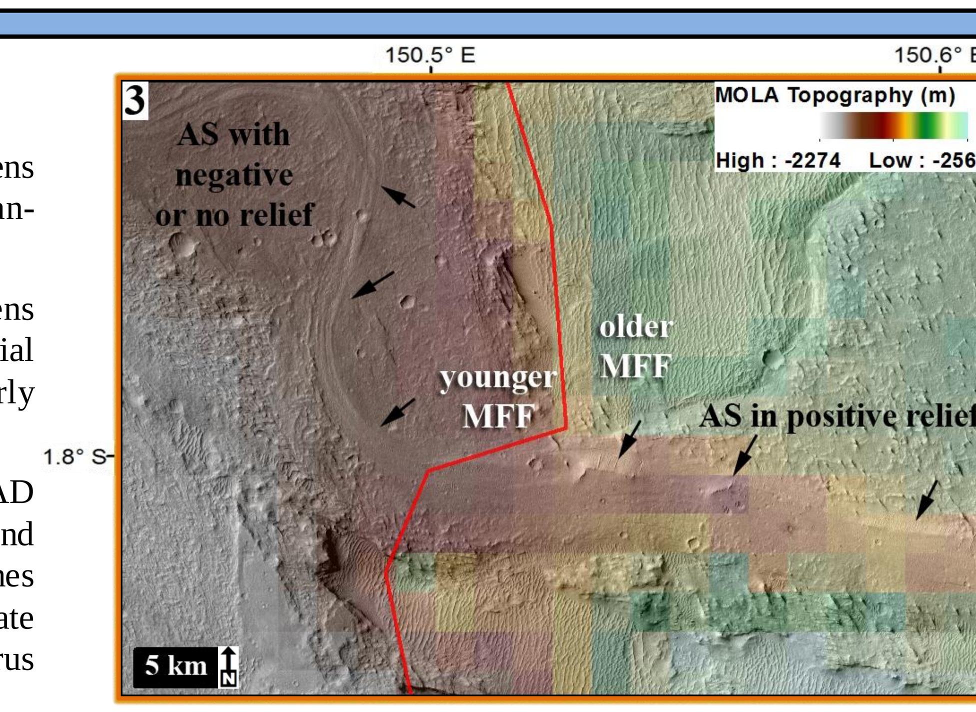


Fig. 5A: Aeolis Serpens contacts two mapped MFF units [5].

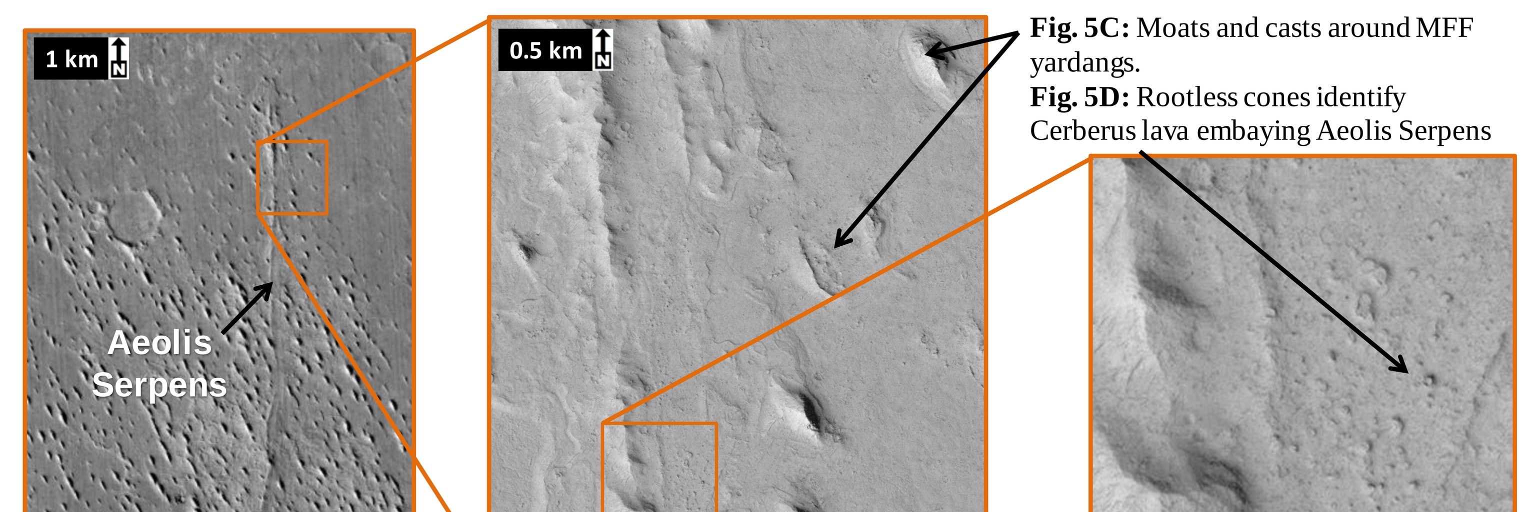


Fig. 5B: Aeolis Serpens contact with Cerberus lava. For location, see Fig. 1

Fig. 5C: Moats and casts around MFF yardangs.
Fig. 5D: Rootless cones identify Cerberus lava embaying Aeolis Serpens

5. Stratigraphic interpretations

Area 43

At least **3 strata of MFF material are interpreted in Area 43.** Topographic lows (Unit A, yellow Fig. 1) are interpreted as "erosional windows", revealing a subjacent MFF stratum, which was eroded by abrading NE-SW paleo-winds. Following this erosion, which we recognize as a disconformity, a second stratum of MFF, at least 80-100 m thick, was laid down. Fluvial features indicate fluvial activity and subsequent inversion processes in this second stratum. After aeolian erosion, which produced a second disconformity, a third stratum of MFF material was laid down and abraded by N-S paleo-winds.

Based on this work and mapping by [5], we infer **fluvial activity in Area 43 during a confined time-interval in the Hesperian-Amazonian transition.**

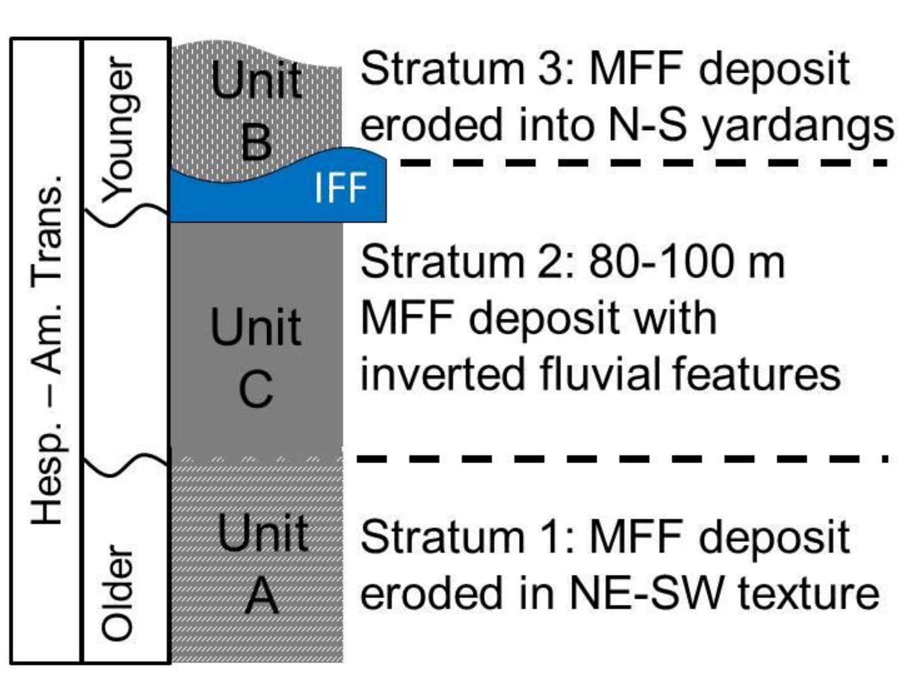


Fig. 6: Interpreted stratigraphy for Area 43

Area 45

At least **3 strata are interpreted in Area 45**. The topographically low smooth-to-rippled unit (Unit A) is interpreted as eolian sedimentary fill and/or eolian abrasion with exposure of underlying smooth topography (e.g., volcanic plains). Erosion of Unit A indicates a disconformity. A depositional episode of MFF material is required for the formation of the irregular yardangs (Unit B) and the inverted fluvial features (Unit C). Erosion of these units indicates a second disconformity. Another stratum of MFF is required to explain NW-SE yardangs (Unit D) on inverted fluvial features (Unit C). Formation of NW-SE yardangs may have been coeval with exhumed fans (Unit E), or as a separate stratum.

Based on this work and mapping by [5], we infer **fluvial activity in Area 45 during separable time-intervals in the Amazonian-Hesperian transition and the early Amazonian period.**

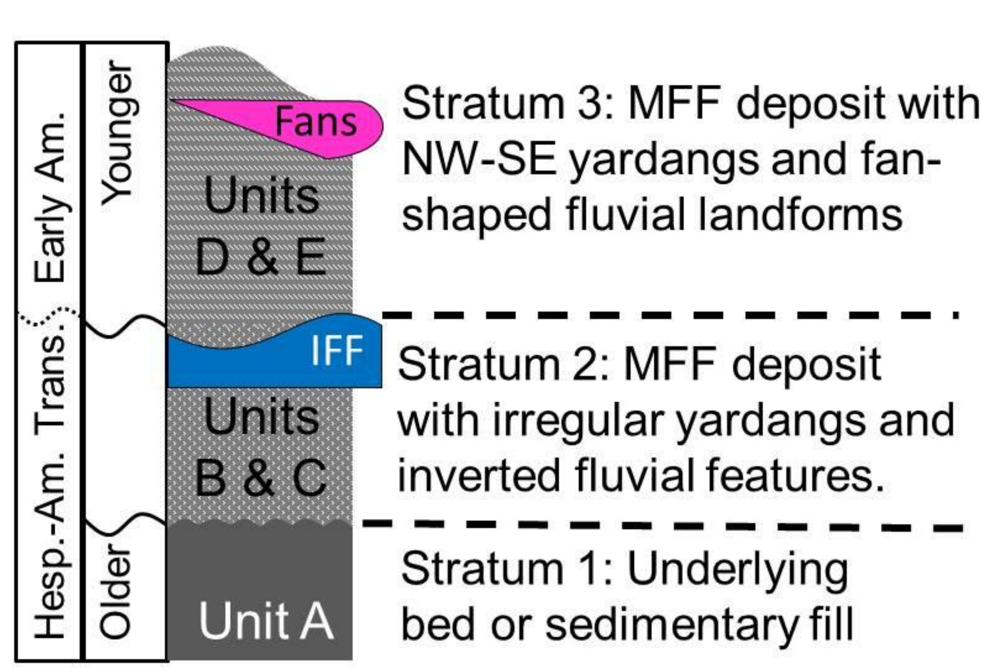


Fig. 7: Interpreted stratigraphy for Area 45

Aeolis Serpens

Three strata are interpreted with respect to Aeolis Serpens. We interpret fluvial activity of Aeolis Serpens within the younger Amazonian MFF stratum because Aeolis Serpens is visible in the superjacent (younger) stratum. Aeolis Serpens is embayed by middle to late Amazonian Cerberus lavas and indicates Aeolis Serpens formed prior to the middle to late Amazonian [11].

Based on this work and mapping by [5], we infer **fluvial activity associated with Aeolis Serpens during a confined time-interval during the early Amazonian period.**

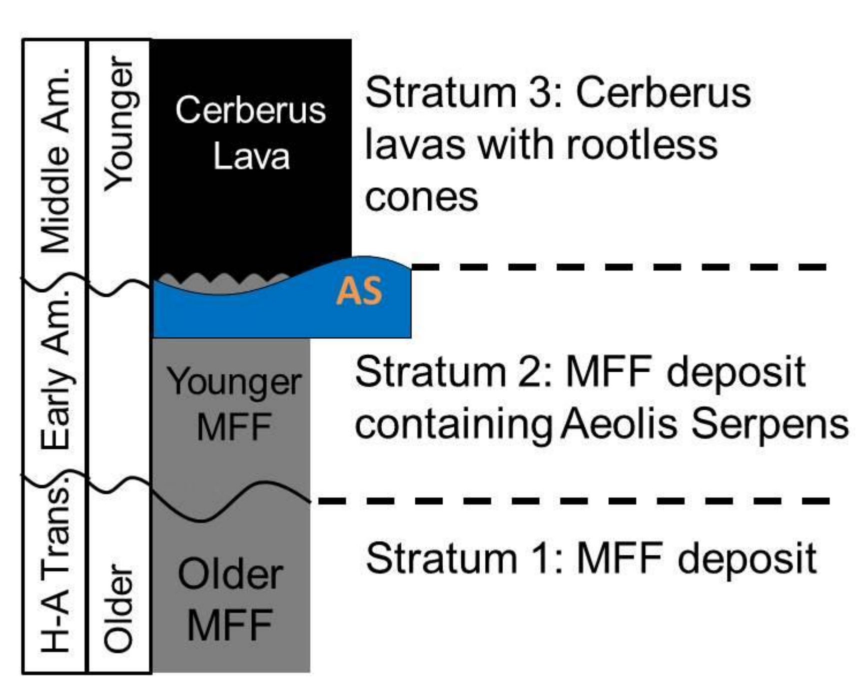


Fig. 8: Interpreted stratigraphy for Aeolis Serpens

6. Discussion & Conclusions

We interpret the study areas to have different stratigraphies of inverted fluvial features.

1. **Area 43 shows evidence of fluvial activity in one MFF stratum, which is consistent with hypothesis 1.**
2. **Area 45 presents a stratigraphy with two adjacent strata containing inverted fluvial features, which is consistent with hypothesis 3** (change from abstract).
3. **Aeolis Serpens formed within one stratum of early Amazonian MFF, consistent with hypothesis 1.**

From this work we suggest that **the history of fluvial activity in Aeolis Dorsa is spatially diverse and occurred over an extended time period, beginning as early as the Hesperian-Amazonian transition, with activity also occurring in the early Amazonian.**

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