Evolution and stratigraphic architecture of the Eberswalde basin

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(with contributions from Melissa, Bill, Sanjeev and Nick)

4th landing site workshop
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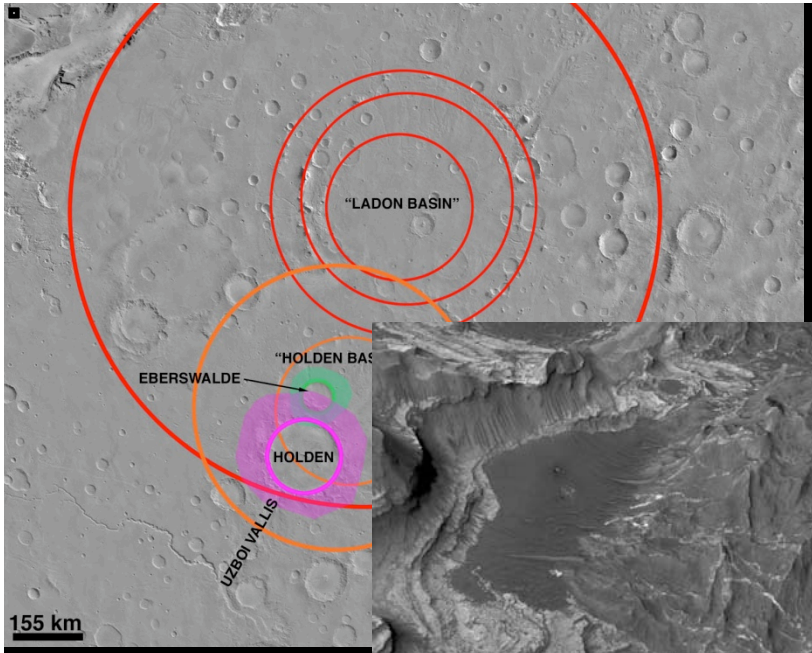
Outline

- Evolution of the Eberswalde basin
  - Provenance of deltaic sediment
  - Complex record of fluvial activity
  - Evidence for a lacustrine phase(s)
- Stratigraphic architecture
  - What we can see from orbit
  - Finding the right facies on the ground

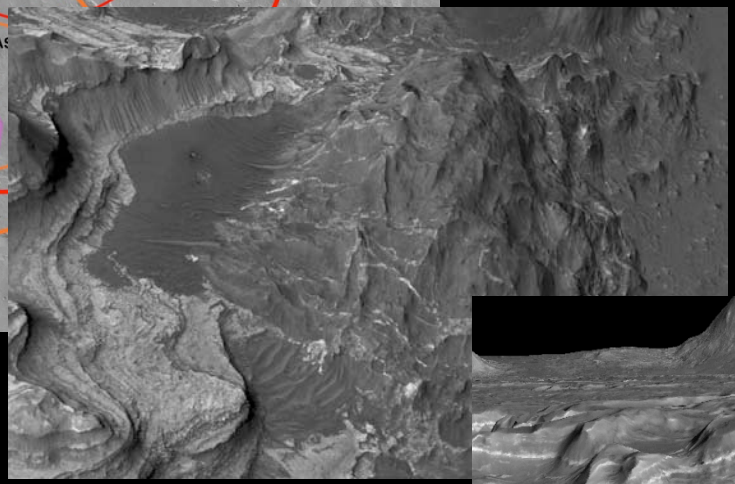
Outstanding Scientific Questions for Eberswalde

- Duration of aqueous activity
- Stability/Intermittency of fluvial episodes
- Regional/Global boundary conditions
  - Where is the water coming from?

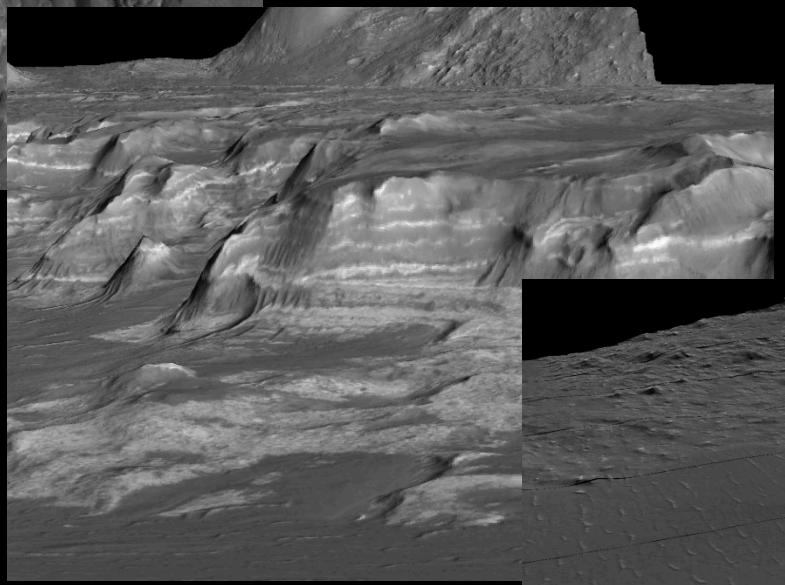
First-order Geologic history



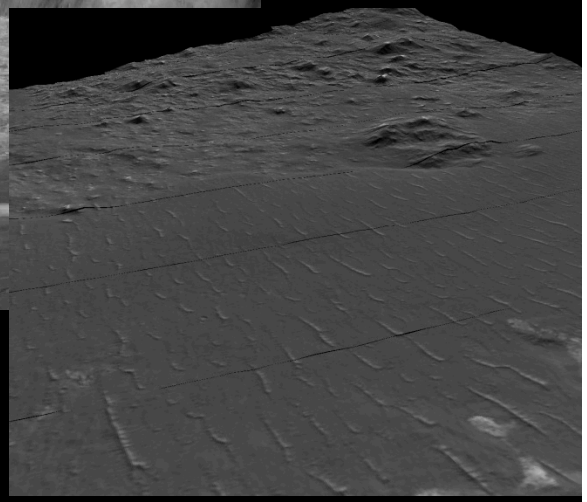
Eberswalde Formation



Holden Ejecta (hydrothermal?)



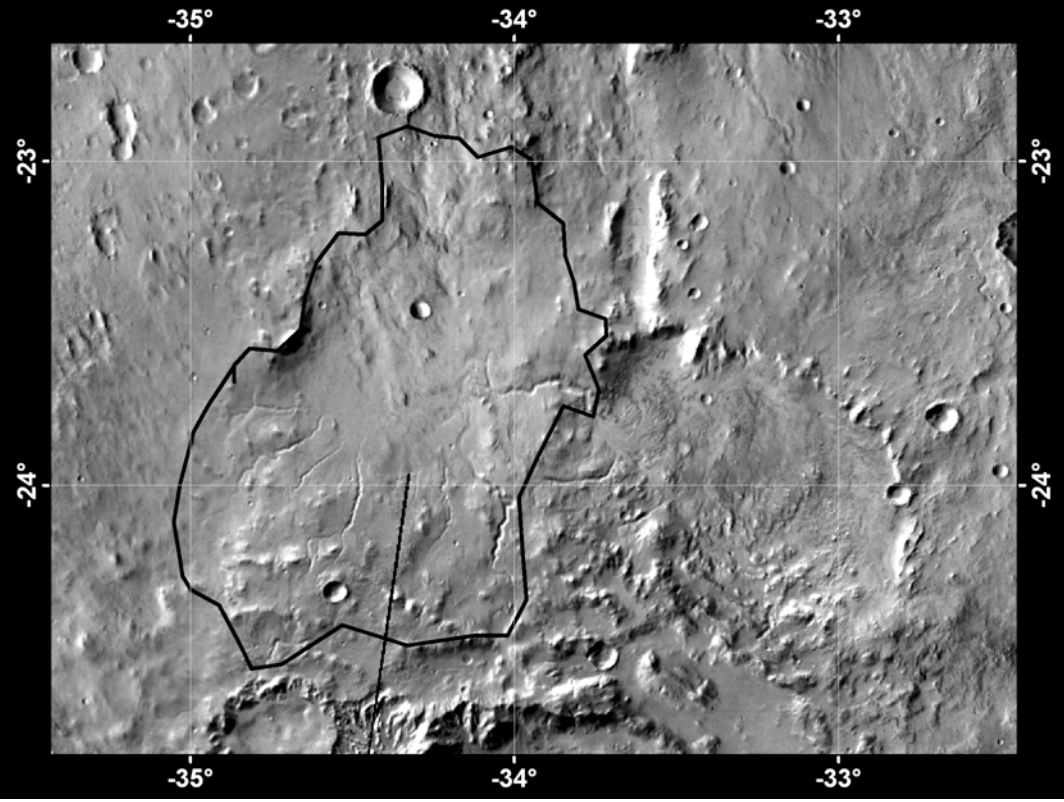
Fluvial Activity



Aeolian Erosion

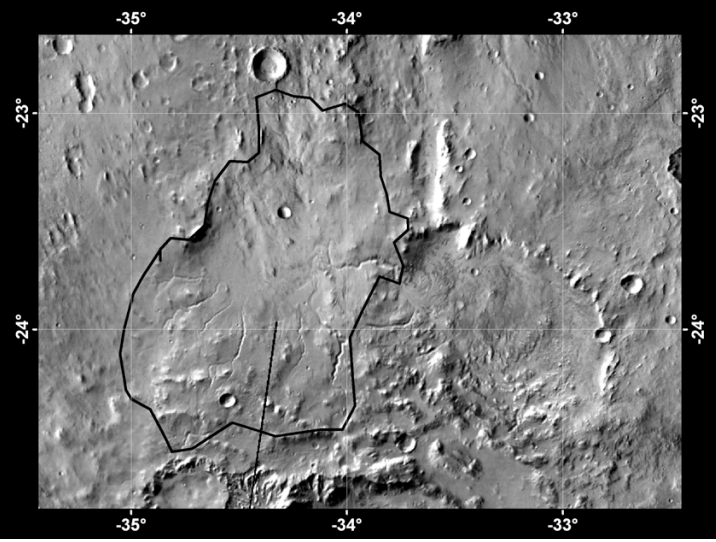
Greater Eberswalde basin

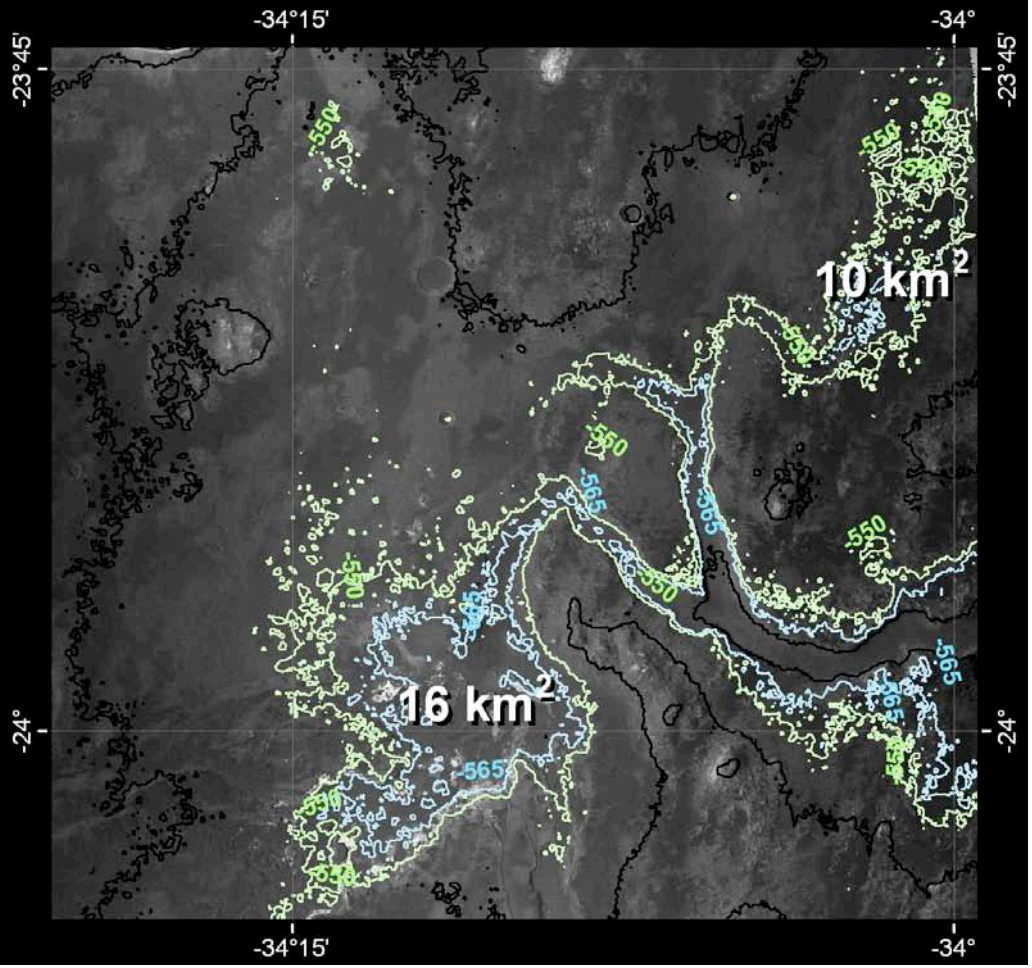
- Main delta drains an area of ~5000 km^2
  - Roughly the size of Delaware, (or 1.5 – 2 Rhode Islands)
  - ~2 km elevation range throughout contributing basin



Local Depressions upstream

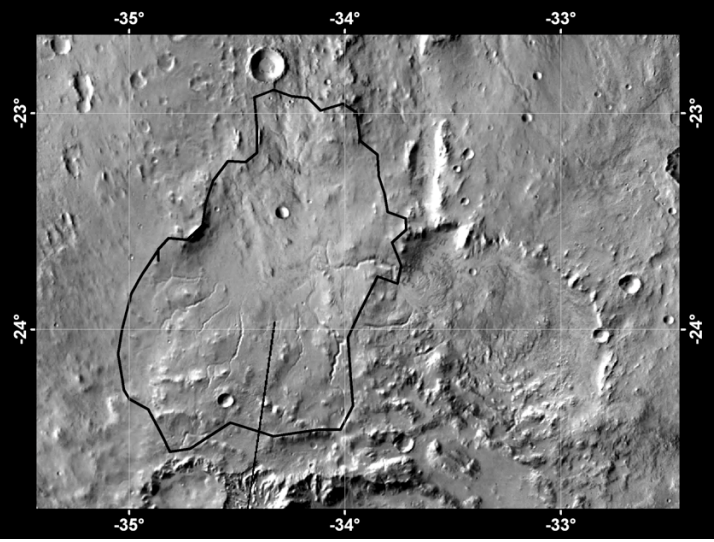
- Basin evolution is marked by progressive interconnection of drainage systems
- Some sites remain where ponded water likely accumulated

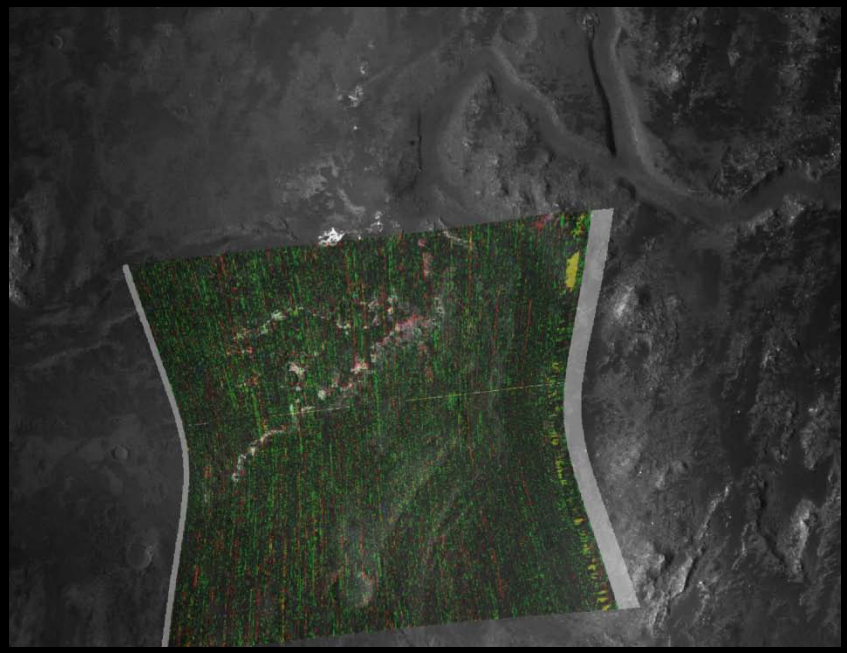




Local Depressions upstream

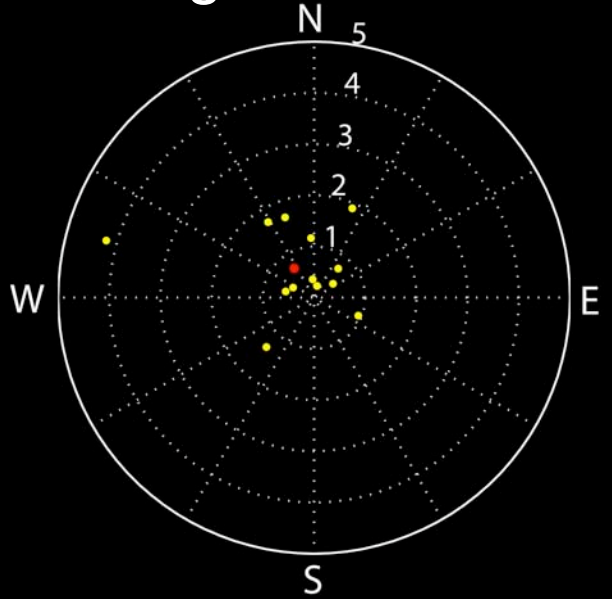
- Evidence for clays in former basin (h/t Ralph Milliken)
- Bright unit is not perfectly horizontal – gentle dips to the north of ~0.6 degrees

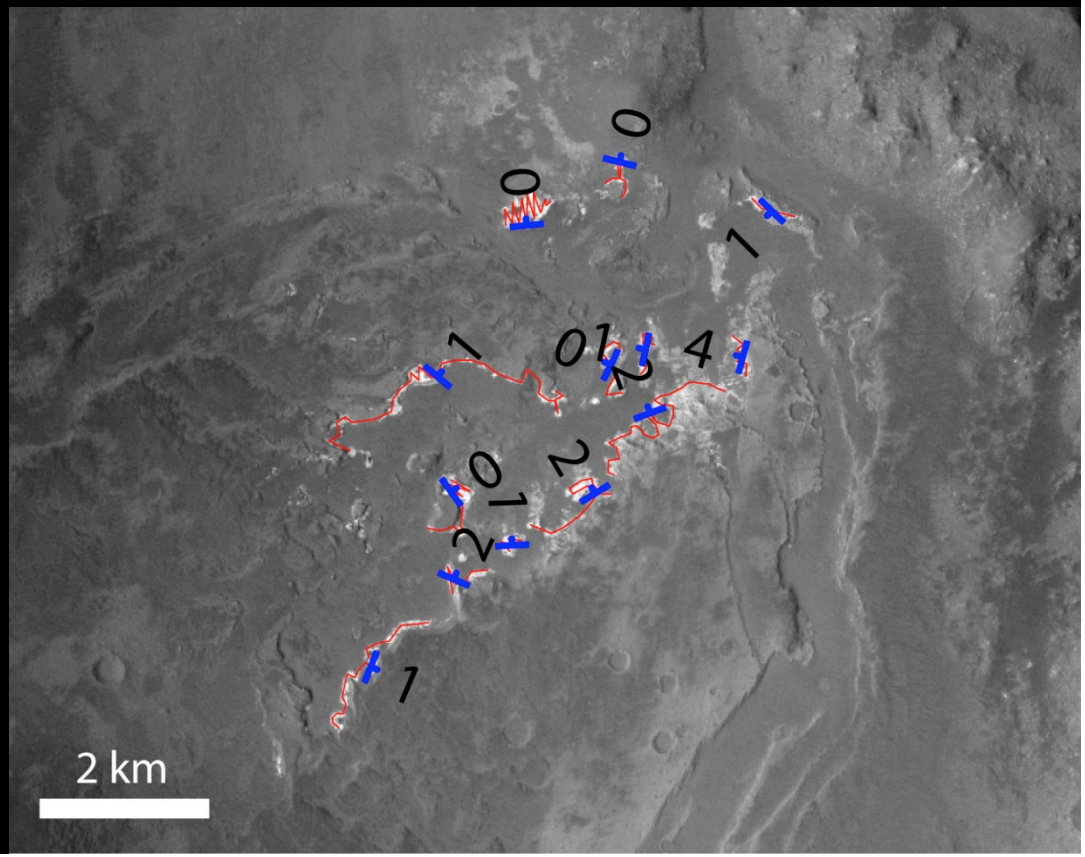




Local Depressions upstream

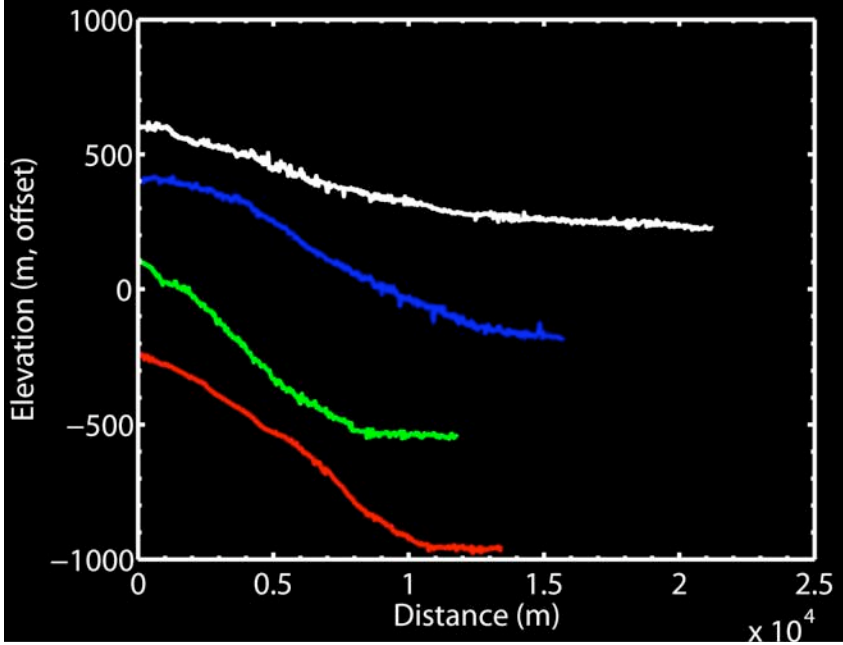
- Evidence for clays in former basin (h/t Ralph Milliken)
- Bright unit is close to flat-lying – mean dip to the north of ~0.6 degrees

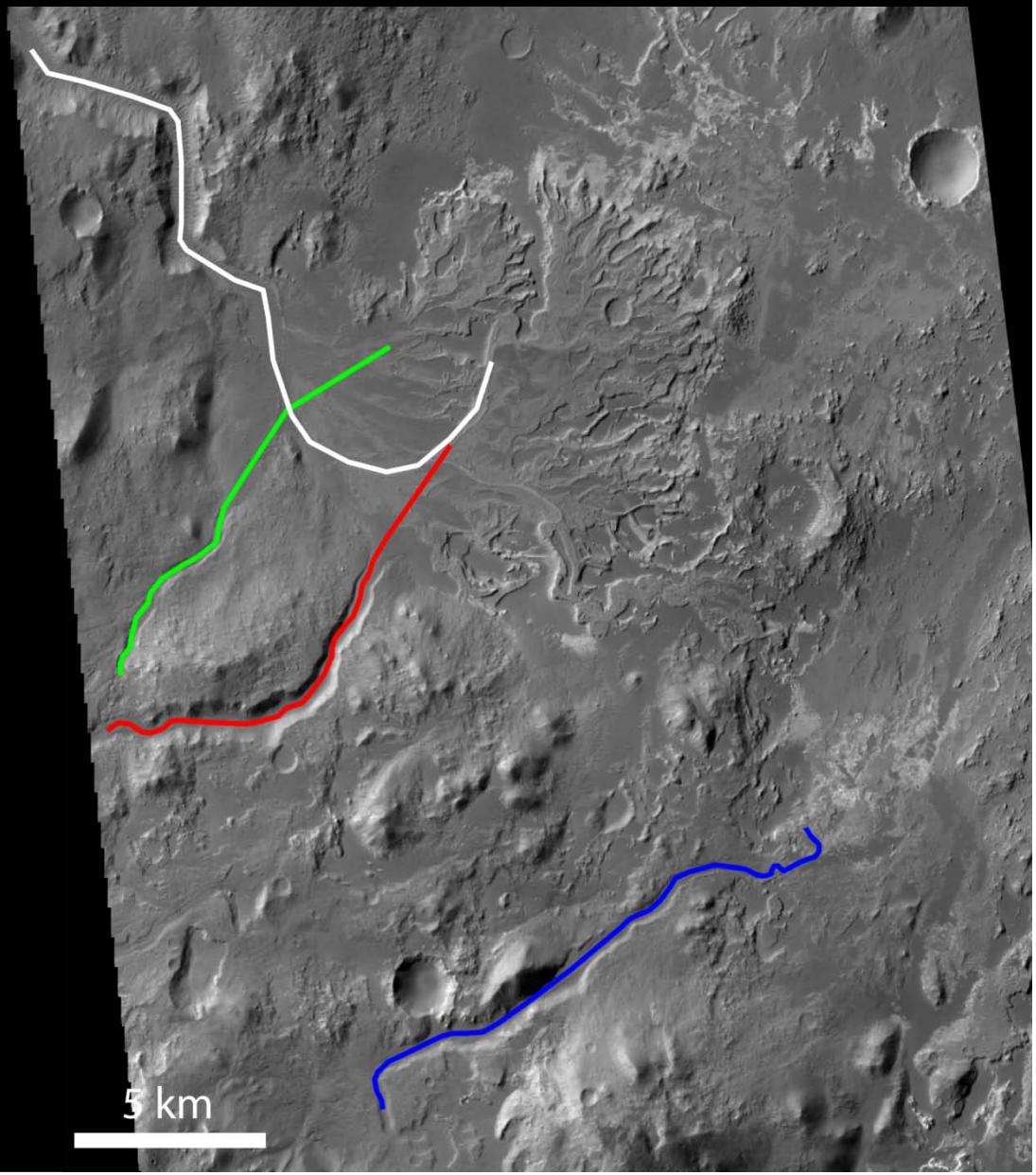




Stages of fluvial activity

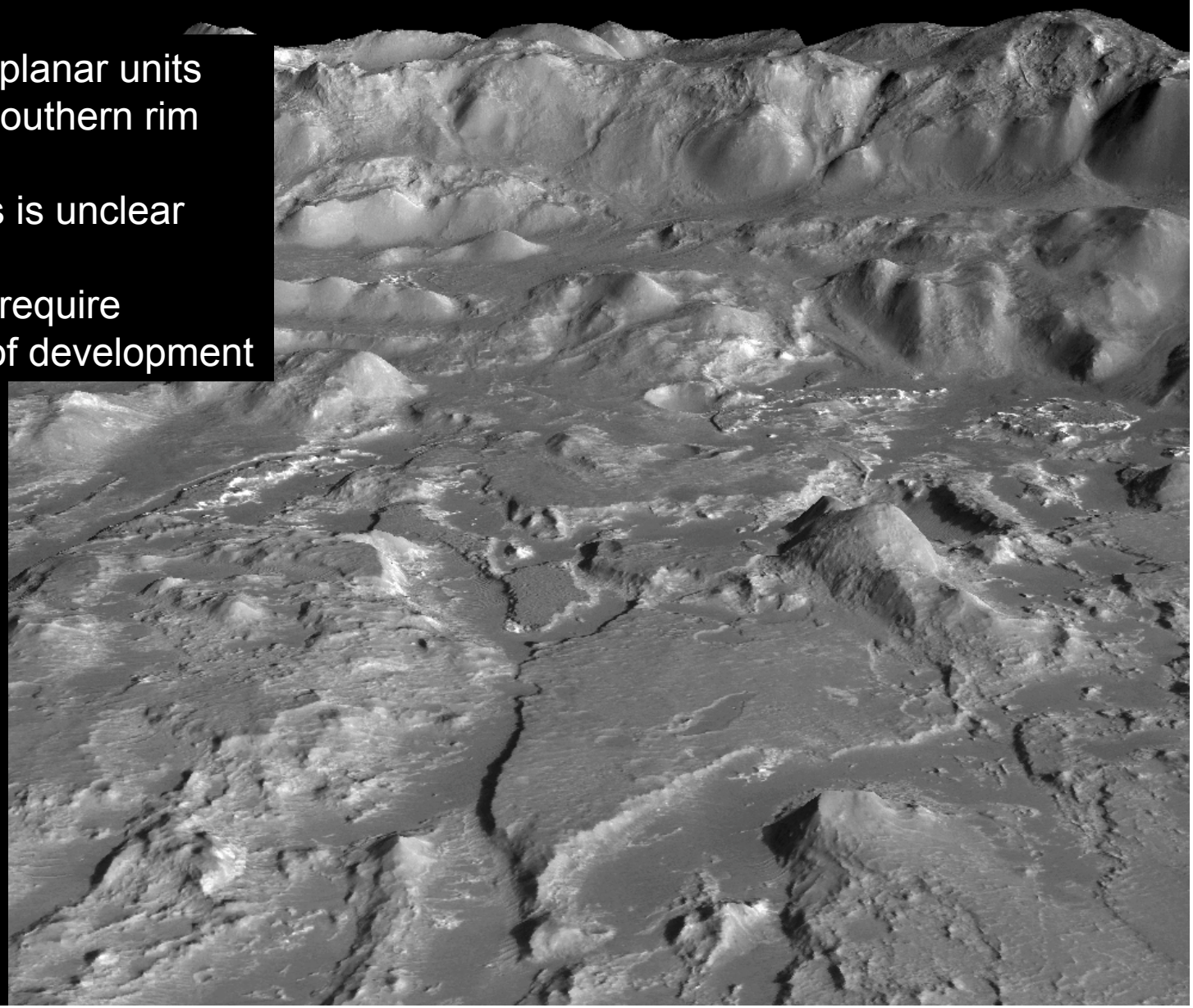
- Blue, white show smooth concave up profiles
- Red, green show a sharp break in slope, possibly indicating inactivity at the time of delta formation





Stages of fluvial activity

- A number of broad, planar units are found along the southern rim
- Origin of these units is unclear
- If fluvial, elevations require several generations of development



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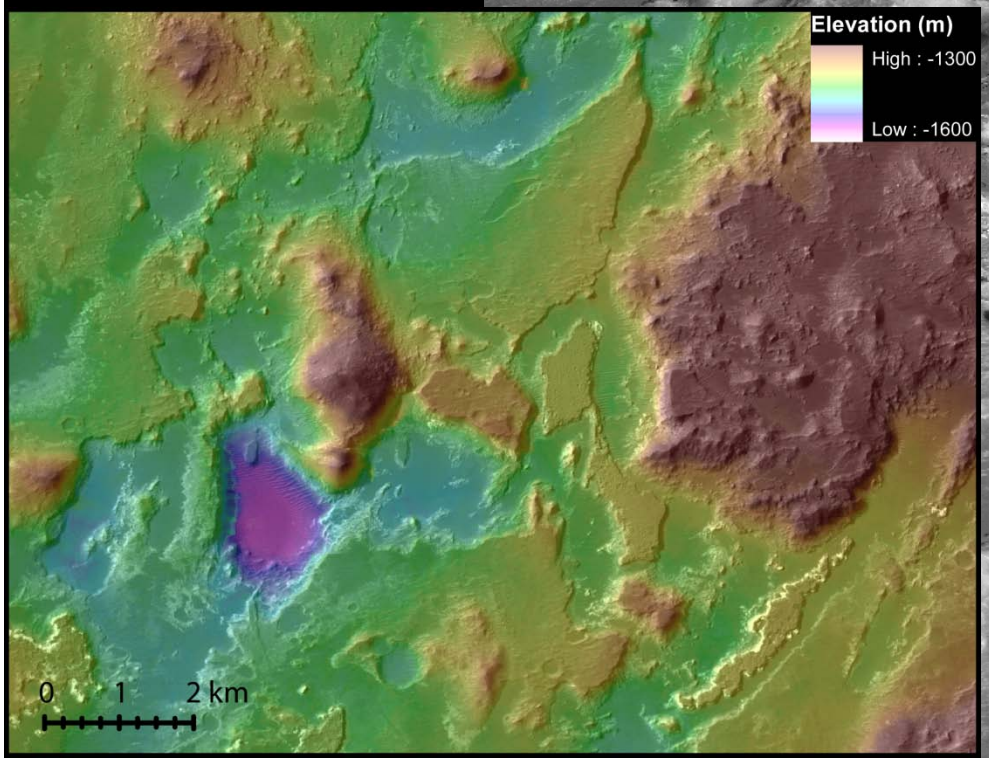
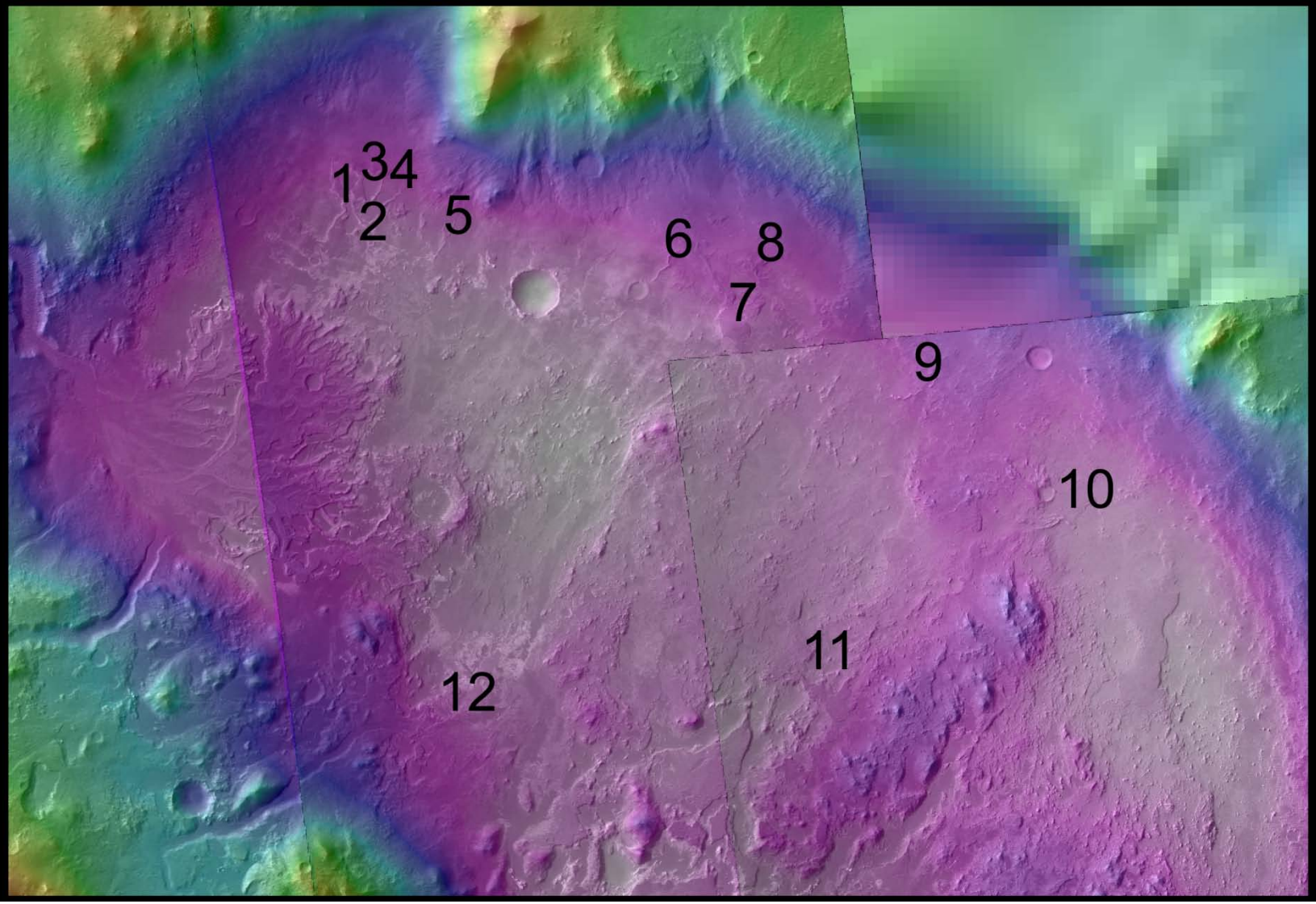
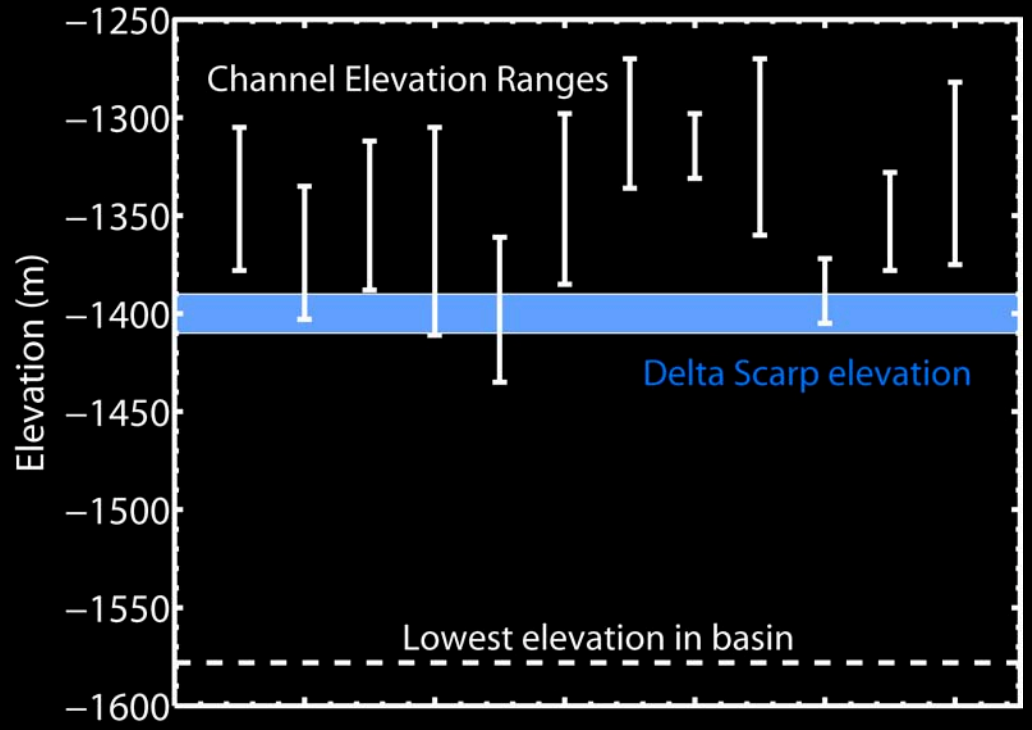


Other Fluvial Channels



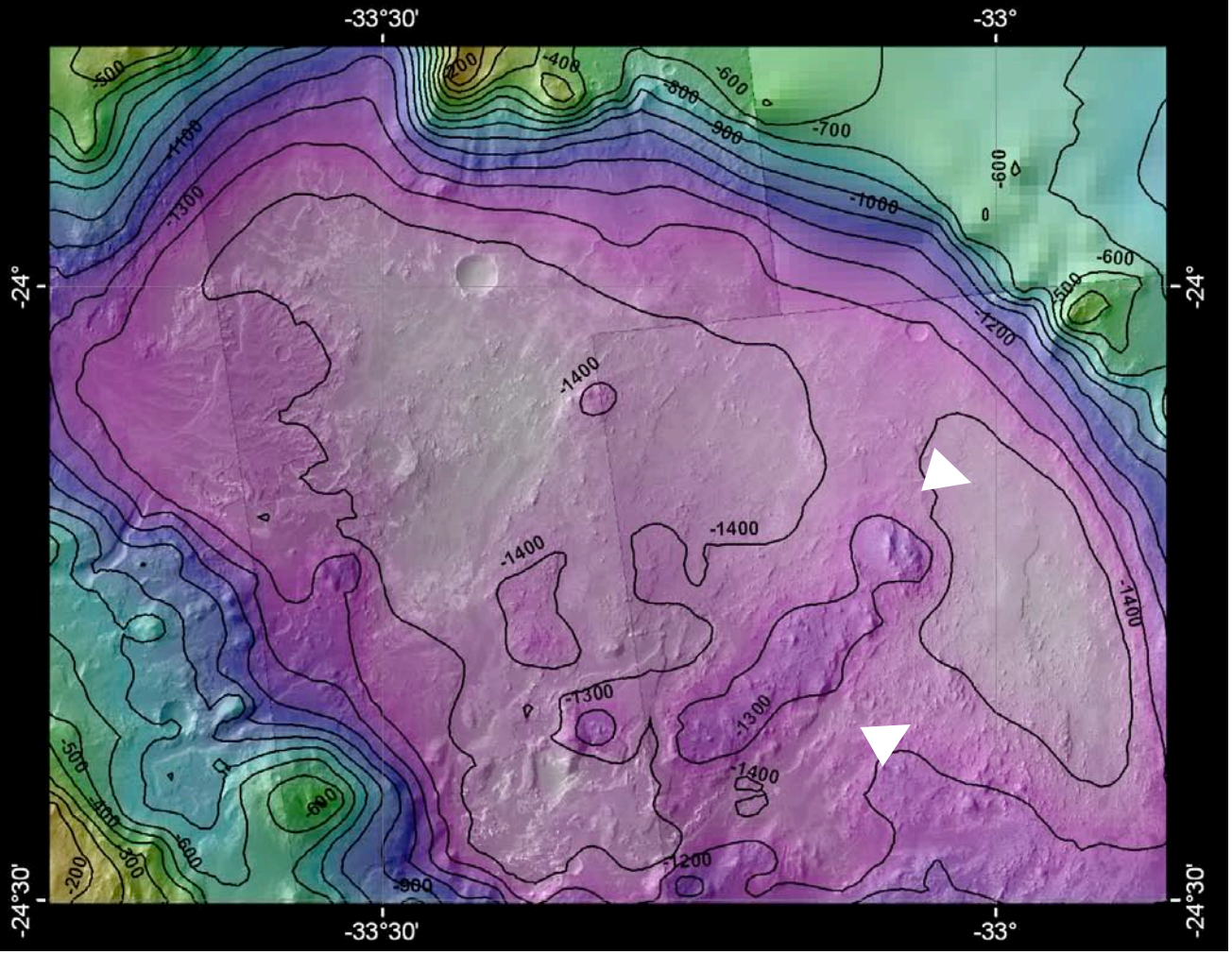
Other Fluvial Channels

- While Channels are found in many places across the crater, they are rarely found below the -1400m margin of the delta
- Consistent with a persistent, or recurring lake level around maximum delta elevation

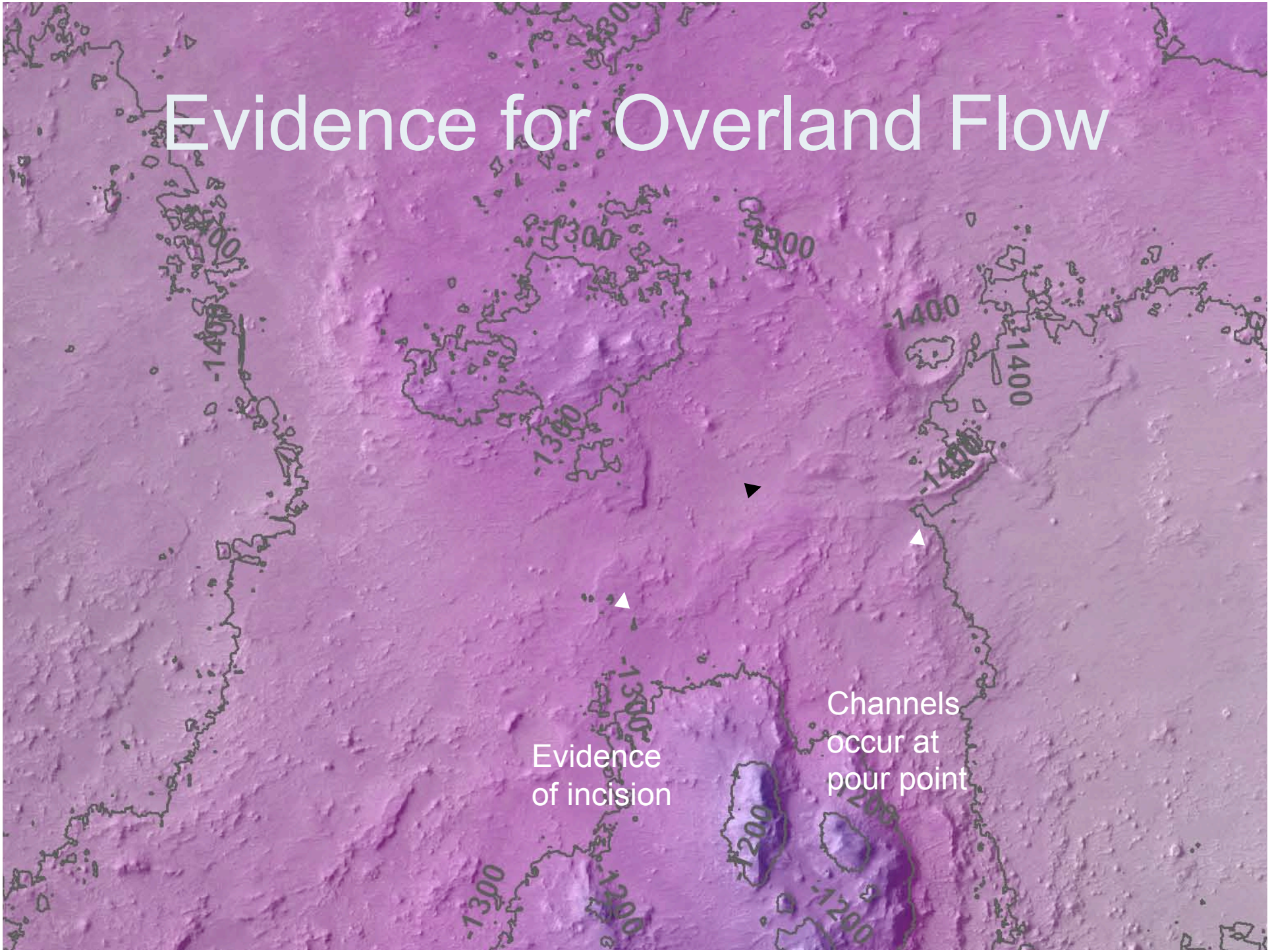


Basin divide

- Two basins are divided by two low saddles
- Lowest saddle elevations are remarkably similar to delta margin

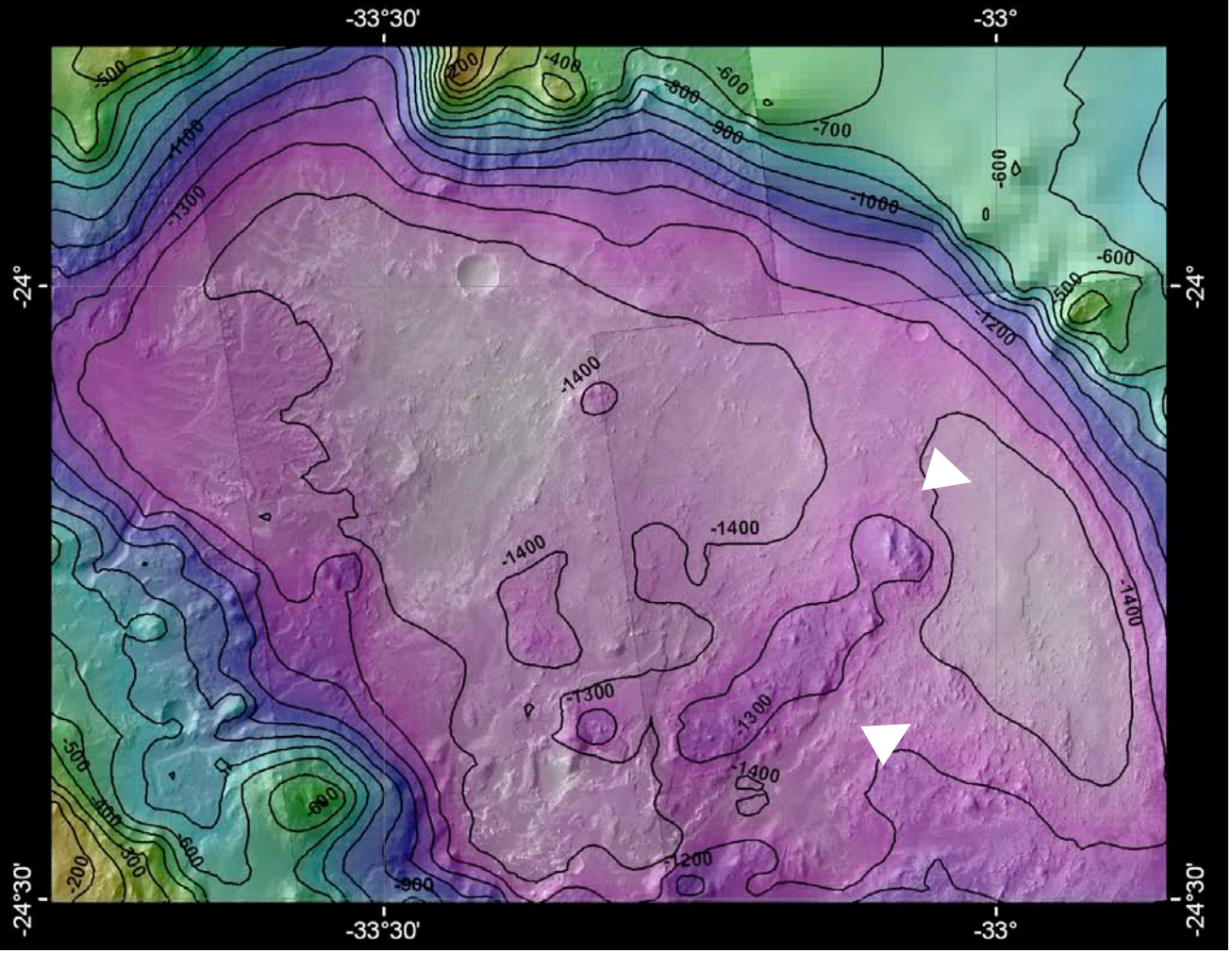


Evidence for Overland Flow



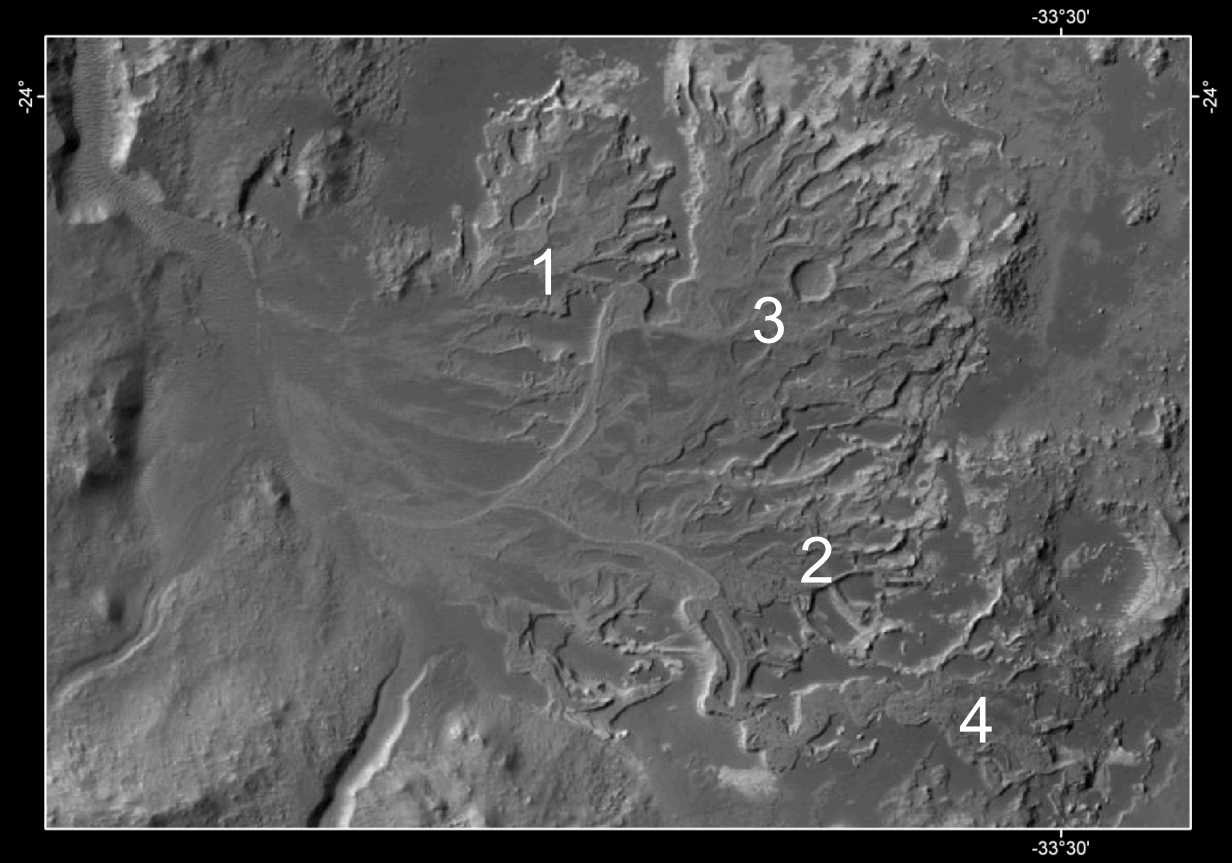
Basin divide

- Eastern basin would add roughly 30% to the volume of the lake, also increasing surface area for evaporation and infiltration
- Spillway may have dictated a naturally recurring highstand for the delta
- Rough calculation shows groundwater flux could be comparable to fluvial input – opportunity to interrogate upper 100's meters of Martian crust



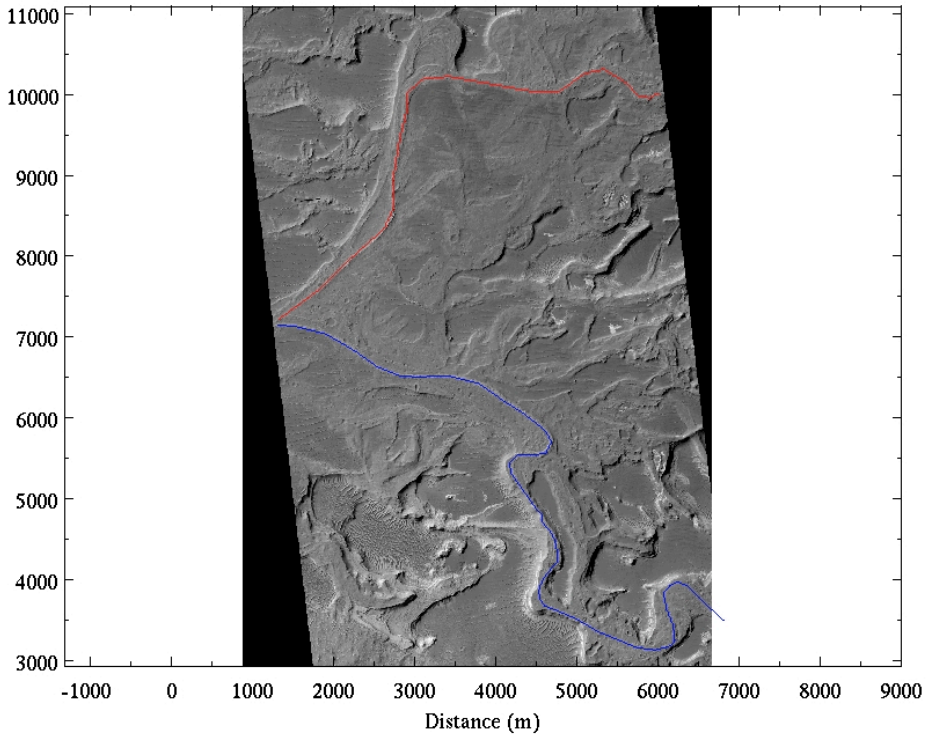
Delta Construction

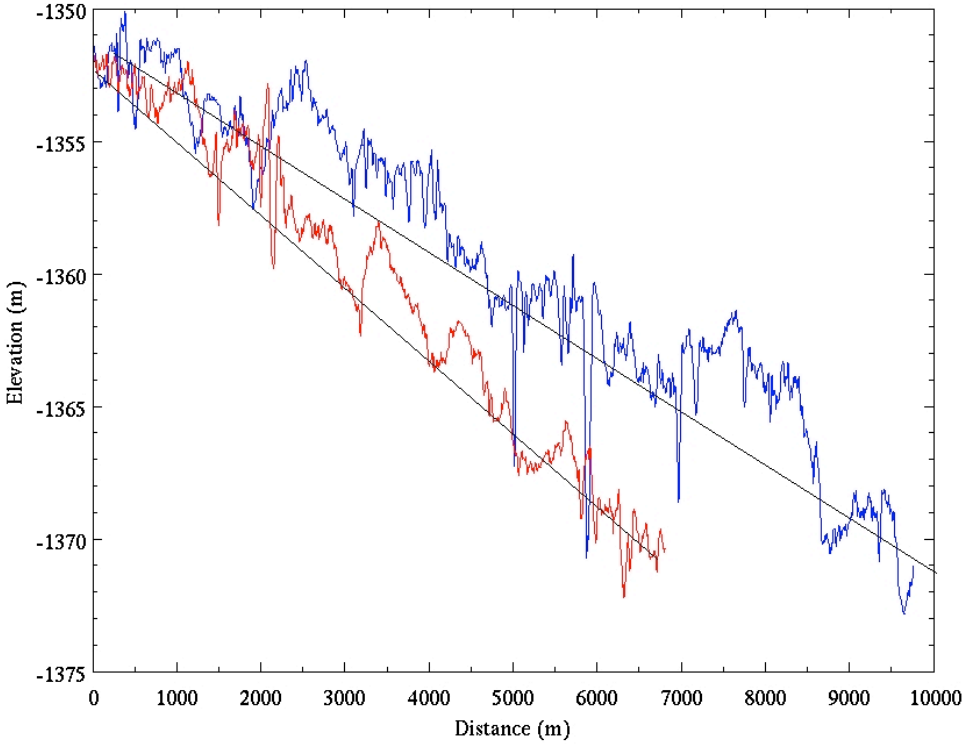
- Several phases of delta building
  - Precise details would be resolvable by MSL



Channel Gradients

- Channels show varying gradients between lobes
  - Controlled by sediment characteristics, base level
- Final lobe shows ~30% reduced gradient compared to previous channel course
  - Evolution, basinward migration



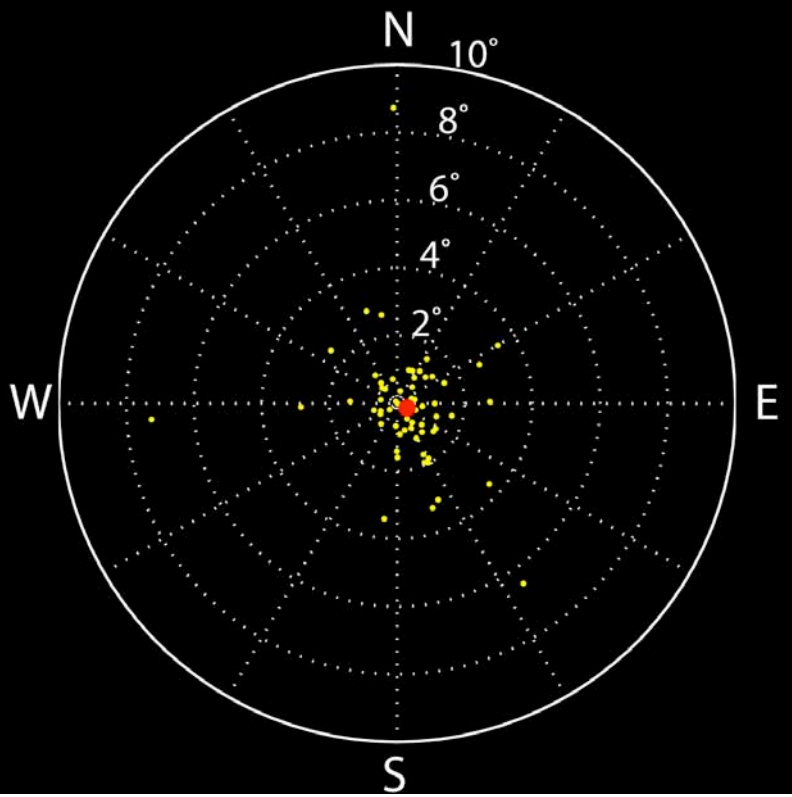


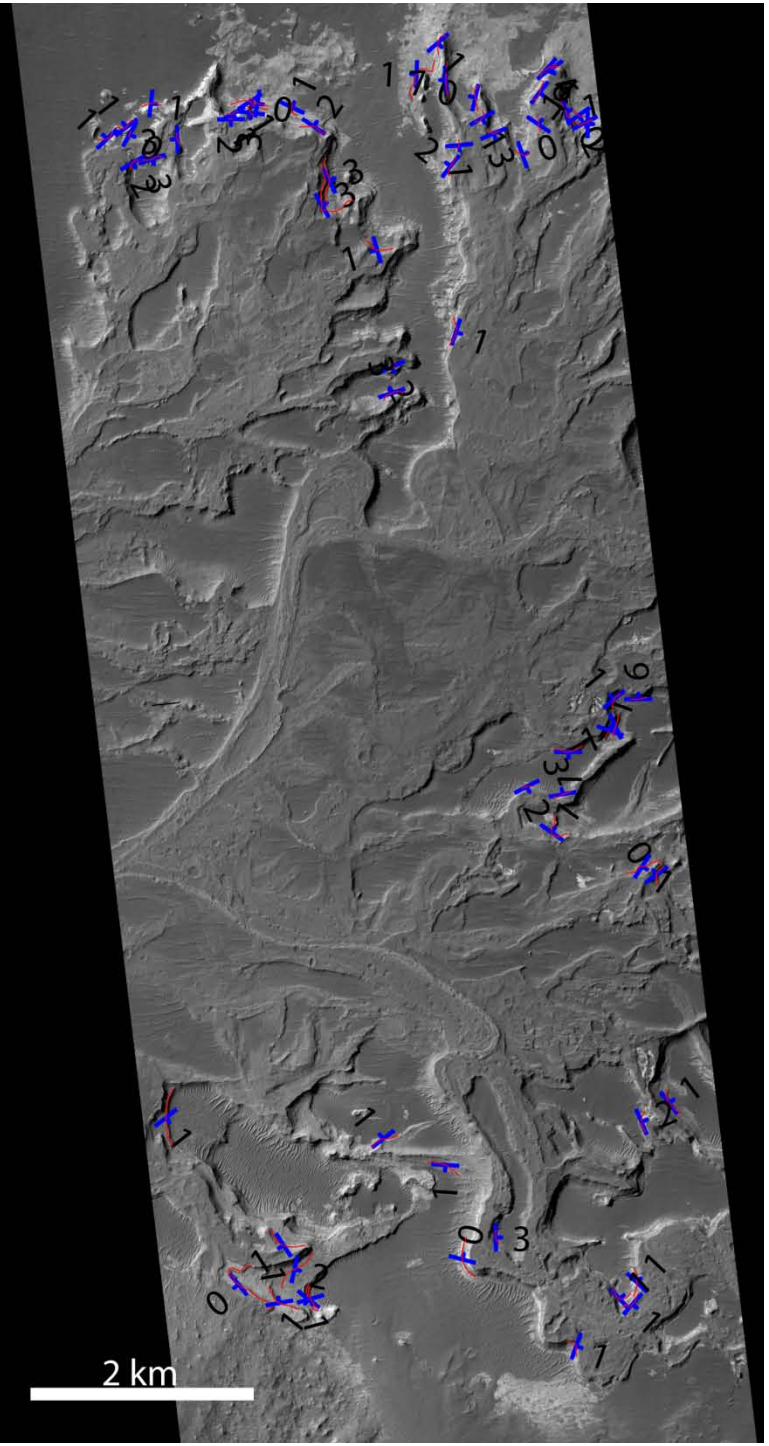
Stratigraphic Architecture

- Understanding of deltaic evolution gives us a built-in road map
- We would know where to drive to find distal, channel bed, foreset, etc. facies
- A landed mission would give us critical information that would be impossible to attain from orbit
  - Grain size, sedimentary structures, fine-scale bedding, etc.

HiRISE Dips

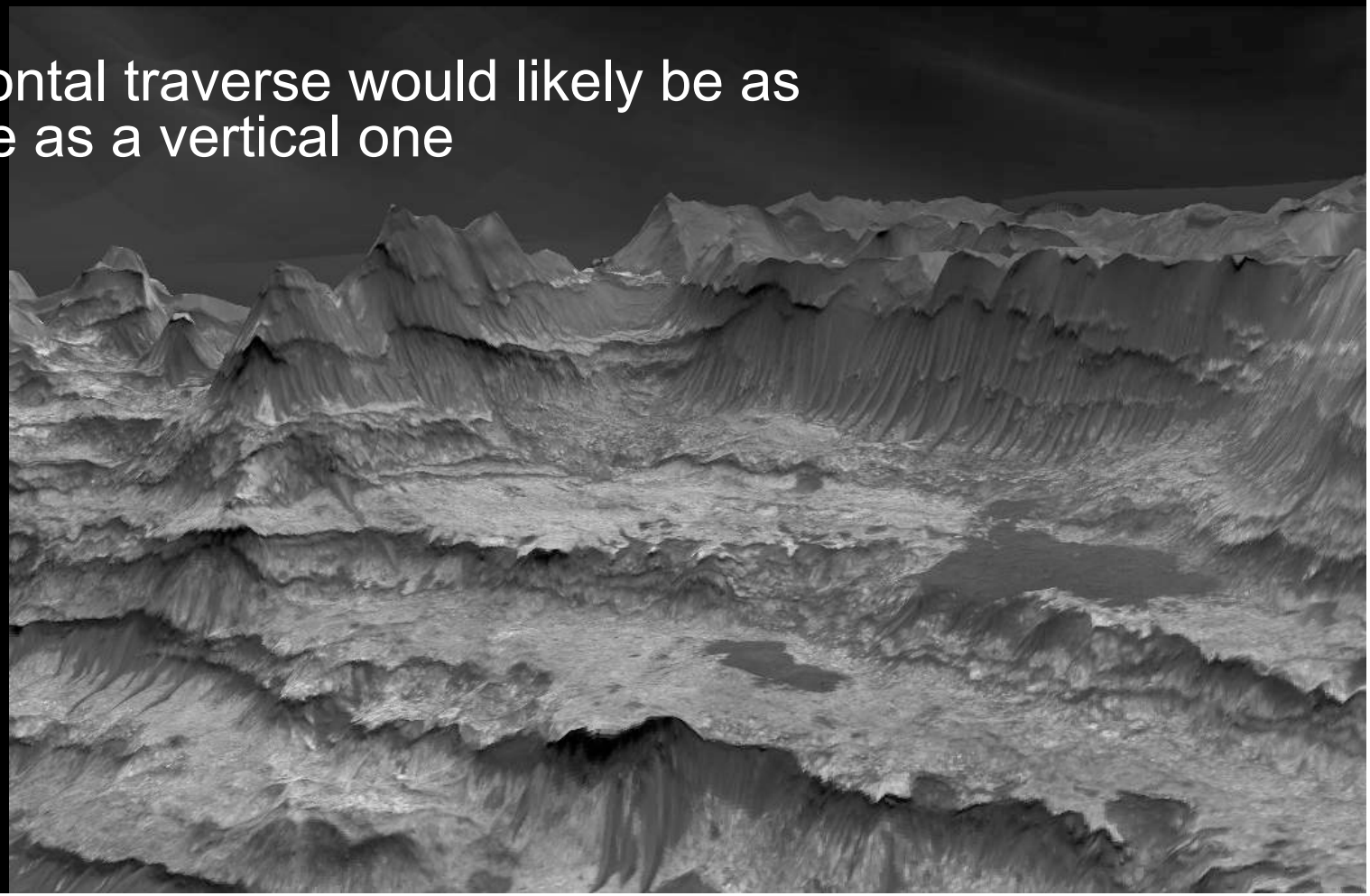
- Bedding is nearly horizontal everywhere, with a slight mean dip to the east (~0.3 degrees)





HiRISE Dips

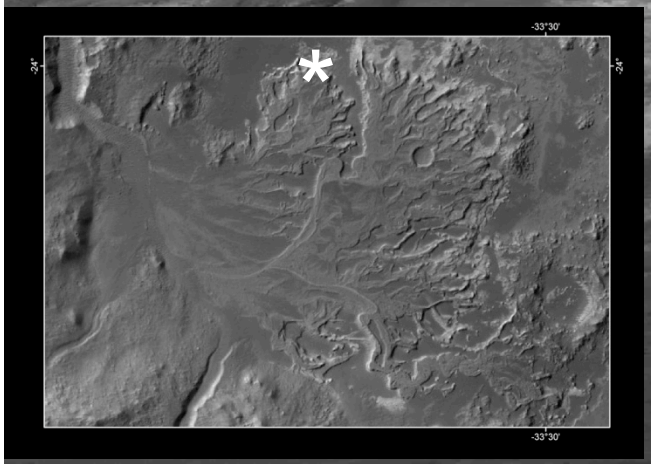
- In detail, stratigraphy is much more complex
- Truncated bedding, depositional lenses, etc.
- A horizontal traverse would likely be as valuable as a vertical one

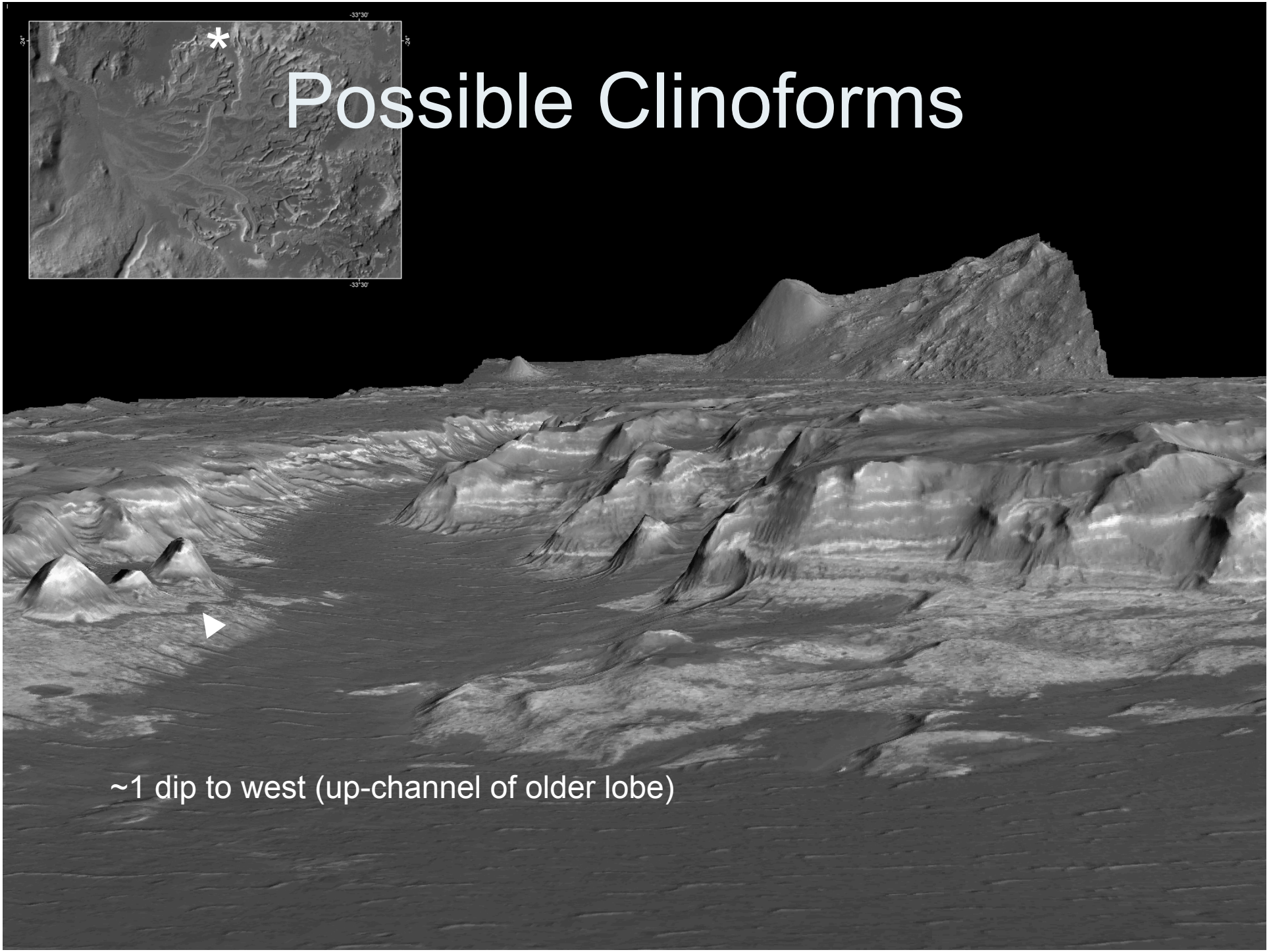


Possible Clinoforms

1-2° apparent dips to East

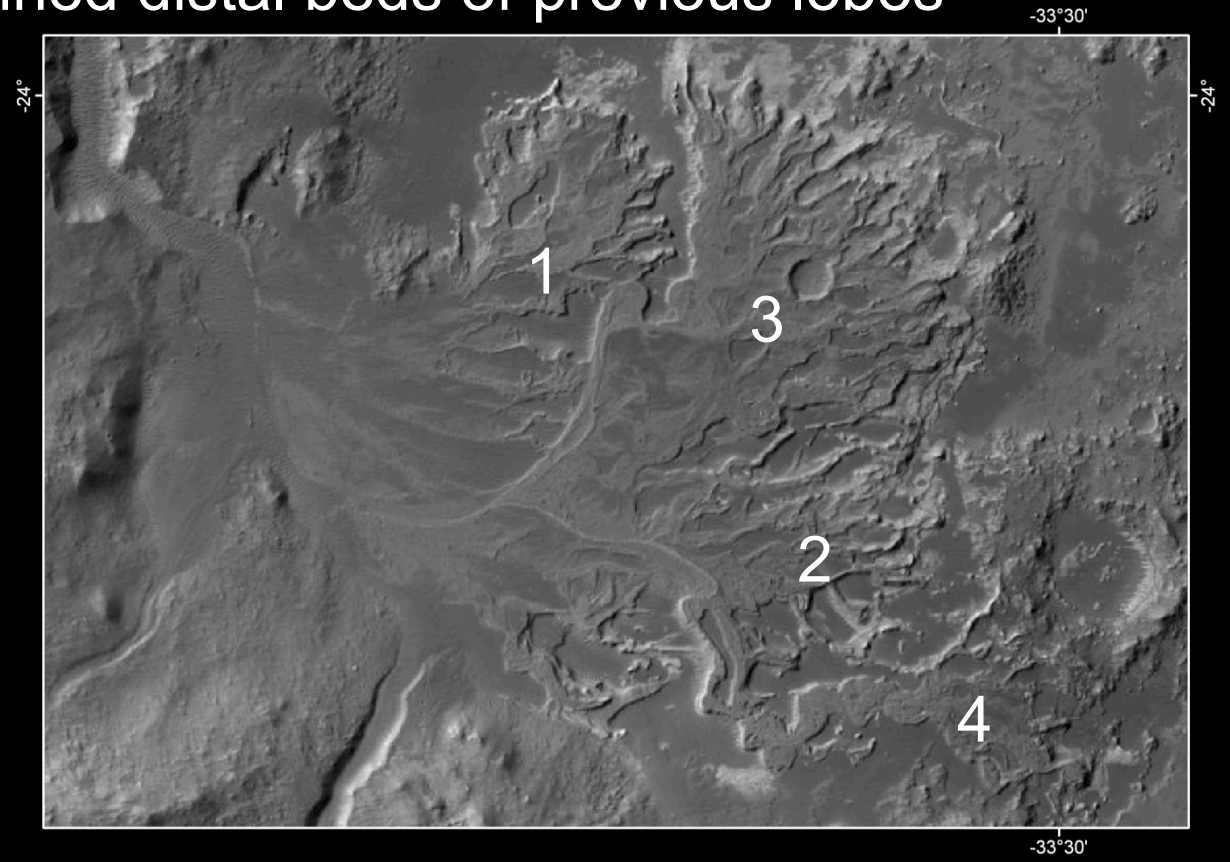
"Horizontal"




-33°30'
-34°
-33°30'
Possible Clinoforms
~1 dip to west (up-channel of older lobe)

Stratigraphic Road Map Example: Finding distal facies

- Even if distal lacustrine facies are not well preserved on crater floor, channels should overlie and preserve the fine-grained distal beds of previous lobes



Key observations for a rover

- Look for evidence of a lacustrine phase
  - -1400 m “shoreline” surrounds ellipse
- Look evidence of hiatuses in fluvial activity
  - Weathering horizons? Aeolian intervals?
- Determine controls on water availability
  - Discrete episodes? Continuous? Cyclic?
- Determine fluxes in/out
  - Grain sizes, channel depths, gradients
  - Closed system allows for well-constrained modeling
- Find the fine-grained facies
  - Deltaic architecture provides guidance

Summary

- Eberswalde crater records the development of a delta system(s) into a lake.
  - Fluvial morphology records multiple events, complex history
- Exposed stratigraphy and channels reveal time and process history that can be used to constrain Martian climate, hydrology, weathering and geochemistry.
- The deposits have clear context, with high probability of concentration and excellent likelihood of preservation: all this favors an ideal location to find biosignatures
- Diverse units in crater can explore older history and processes: e.g. older deposits ejected into Eberswalde, various light-toned outcrops and Fe-Mg phyllosilicate units.
- Well understood fluvio-deltaic architecture predicts where specific facies should occur

Traversability

- Key exposures have consistently low slopes averaging only a few degrees