[AV]Geomorphology of the Mars Northeast Holden Delta

By
Lesli J. Wood[1]

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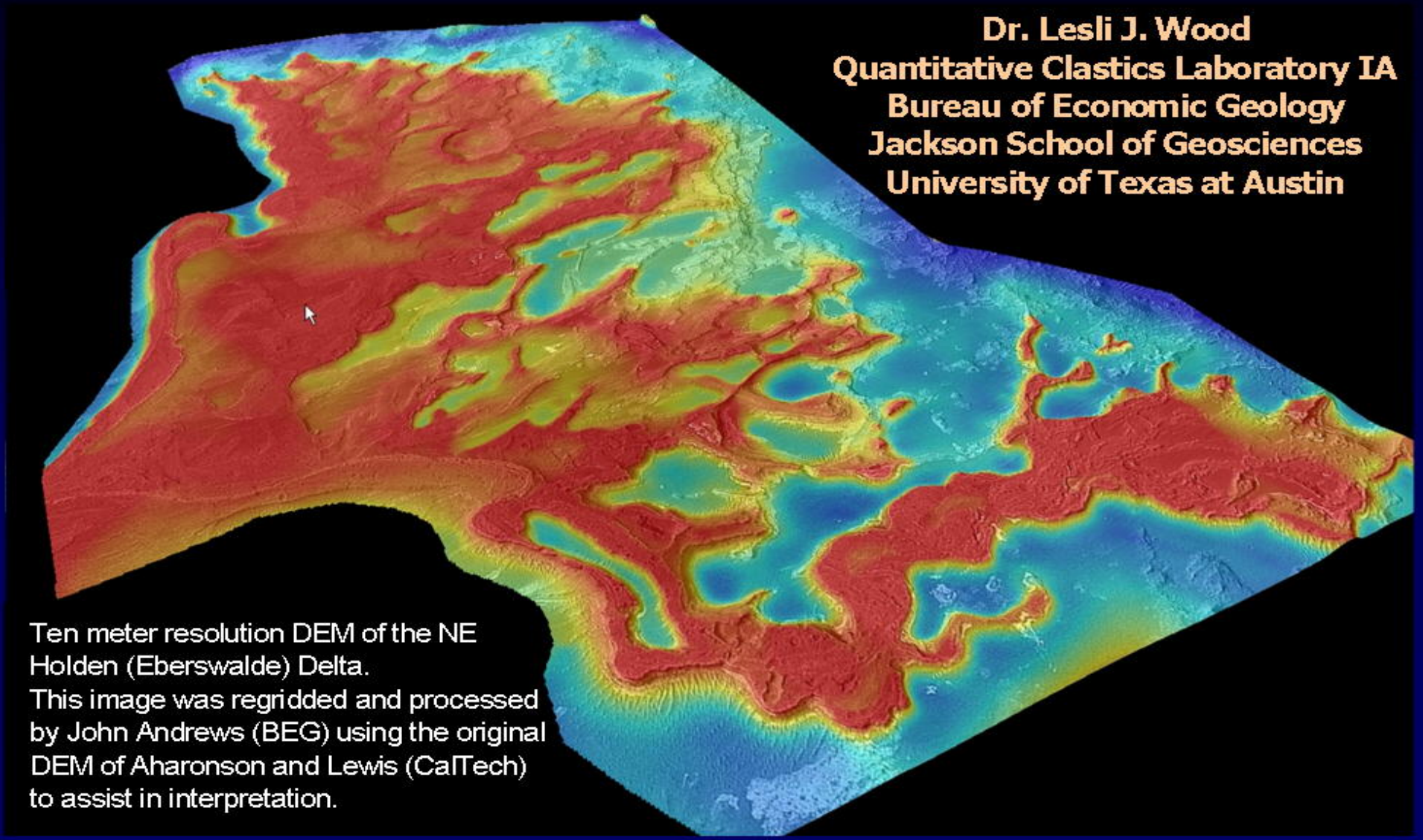
[1]The University of Texas at Austin, Austin, TX (lesli.wood@beg.utexas.edu)

Abstract

Mars' NE Holden Delta contains six separate depositional lobes that appear to have prograded ~17 km from their apex. Crosscutting distributary relationships and compensated lobe deposition are visible in images from the Mars Global Surveyor Orbiter Camera. Sinuosity, radius of channel curvature, meander-bend width, and channel-width parameters are examined for several lobe systems. Channel sinuosities of 1.2–1.8 define low- to moderate-sinuosity channel systems typical of subaerial systems transporting bed- or mixed-grain-size loads. Some convergence between age and sinuosity occurs; however, some younger systems show specific reaches of increased sinuosity associated with abutment against resistant, older-lobe beds. This effect of older deposits on channel morphology suggests that these older lobes were fairly well indurated before deposition of the youngest progradational lobes. 86% of distributaries in Mars deltas are 100–240m wide. This number compares with 62% and 44% in Atchafalaya and Wax Lake Deltas of Louisiana, respectively, although the Mars delta is ~14 times larger than these deltas. Such small distributaries may indicate lower average, shorter duration flows or coarser sediment volumes in Mars distributaries than those typical of Gulf Coast systems. However, the volume of material in the Mars deposit suggests long periods of active sediment deposition. Likewise, sinuosity indices, meander-bend migration, and ridge-and-swale point-bar topography development all suggest periods of stable discharge on the delta surface. Future comparative research in the architectural morphometrics of alluvial fans versus deltas will help differentiate these features and bear significantly on scientific communities' understanding of fluid behavior and distribution on other planets.

Geomorphology of the Mars Northeast Holden Delta

Dr. Lesli J. Wood
Quantitative Clastics Laboratory IA
Bureau of Economic Geology
Jackson School of Geosciences
University of Texas at Austin

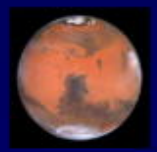


Ten meter resolution DEM of the NE Holden (Eberswalde) Delta.
This image was regridded and processed by John Andrews (BEG) using the original DEM of Aharonson and Lewis (CalTech) to assist in interpretation.

Eberswalde Delta, Holden Crater Region, Mars

Differences

- Mars is 1/3 the size of earth
- Mars has lower gravity than earth.
- Mars is colder than earth with avg. temp ~ -50 deg celsius.
- Mars has been a "dead" planet for a VERY long time.
- Mars atmosphere is maybe 1/15th the density of earth, with very limited amounts of oxygen.

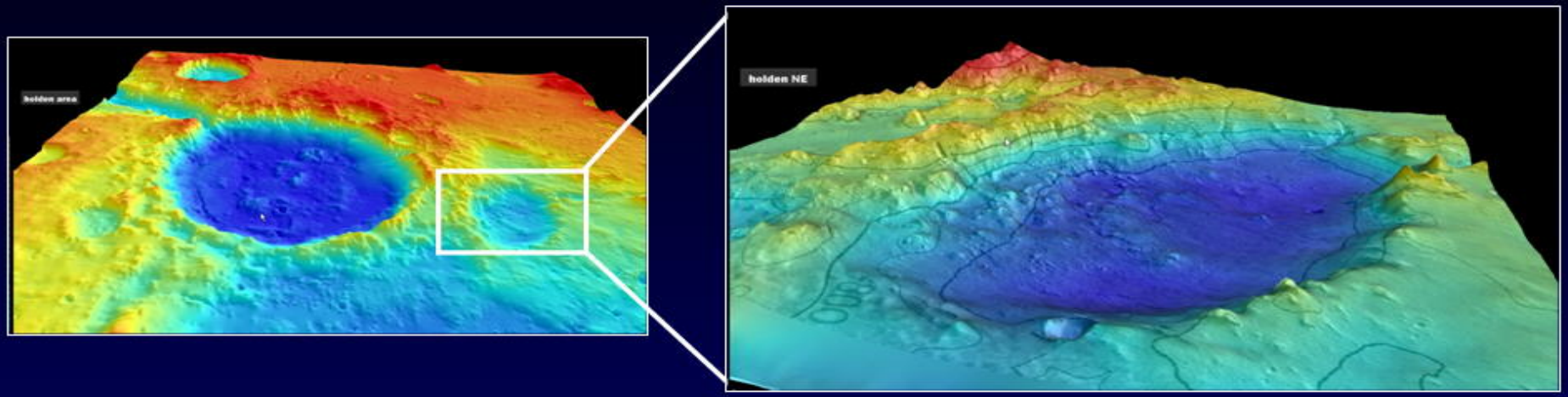


Similarities

- Both have two poles
- Both have frozen water presently. Today, martian water is contained in 35 to 100% of dirt extending down 2/3 of way to equator.
- Both have a geologic history of sedimentary rocks, erosion and transport of sediments by flowing water, standing lakes, etc.
- Both have a history of tectonics and surface fault expressions.
- Both have volcanoes – in Mars case, really really big ones.

Re-think your concepts of processes.

MARS: Eberswalde Delta, Holden Region



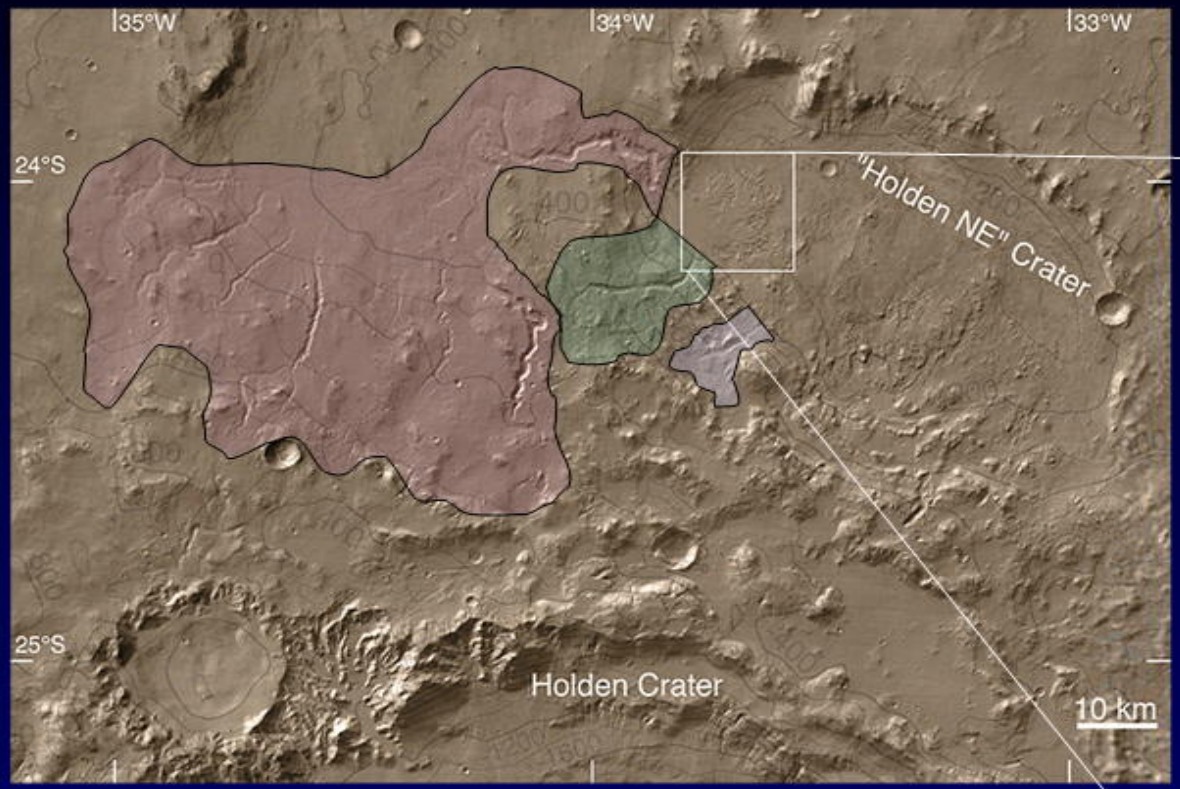
Can rivers erode and transport sediments?
Absolutely! But the density of the material is critical.

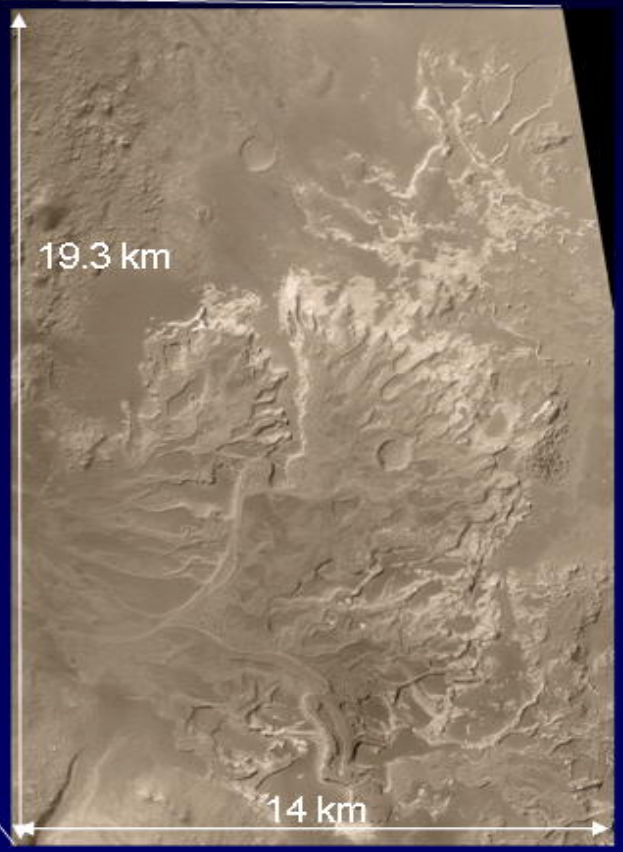
What do "gravity" processes and deposits look like on Mars?

Can waves form on standing bodies of water and erode the shoreline?
No! *(Kraal et al., in review)*

How high do winds have to blow to actually transport sands in such a low atmospheric density and pressure setting?
Very High! Clocked at 40-80 m/sec.

Eberswalde Delta, Holden Crater Region, Mars

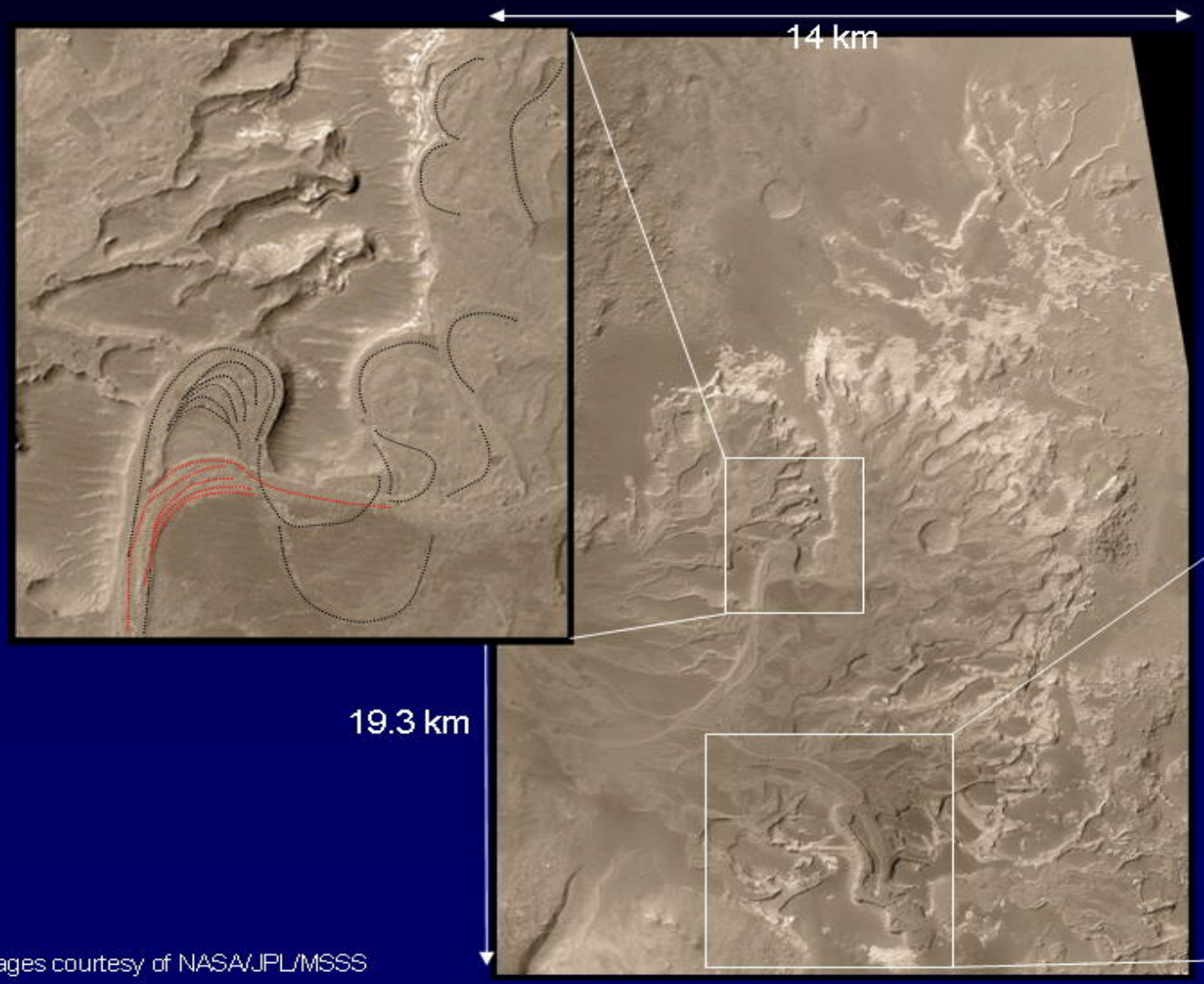




- Crater – highly degraded elliptical impact structure about 67 by 42 km wide.
- Filled mostly with ejecta of the Noachian Holden Crater to the south.
- Drainage, 4800 km^2. Smaller, possibly older drainage basin to the south. (Moore et al., 2003) (Nueces – 40,000 km^2, Trinity – 50,000 km^2)

Images courtesy of NASA/JPL/MSSS

Eberswalde Delta, Holden Crater Region, Mars



Fluvial-dominated delta

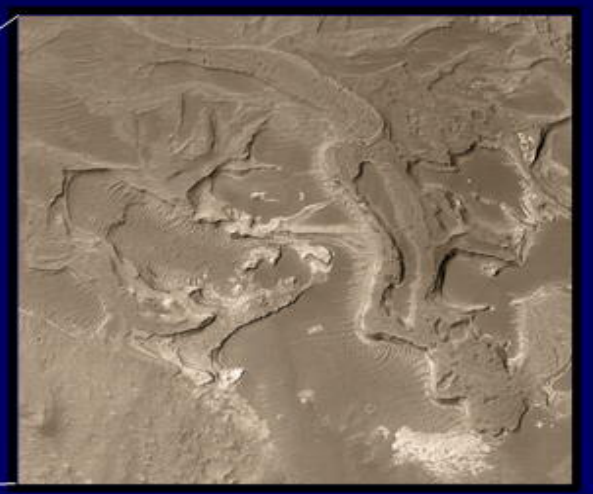
Area: 88 km^2, 115 km^2, 250 km^2

Volume: <6 km^3, 13.2 km^3, 20 to 30 km^3

(Malin and Edgett, 2003; Moore et al., 2003; Battacharya et al.,2005)

Direct Evidence for Persistent Fluvial Activity

1. **Meander loop cut-offs**
2. **Distributive behavior**
3. **Lateral accretion of meanders**



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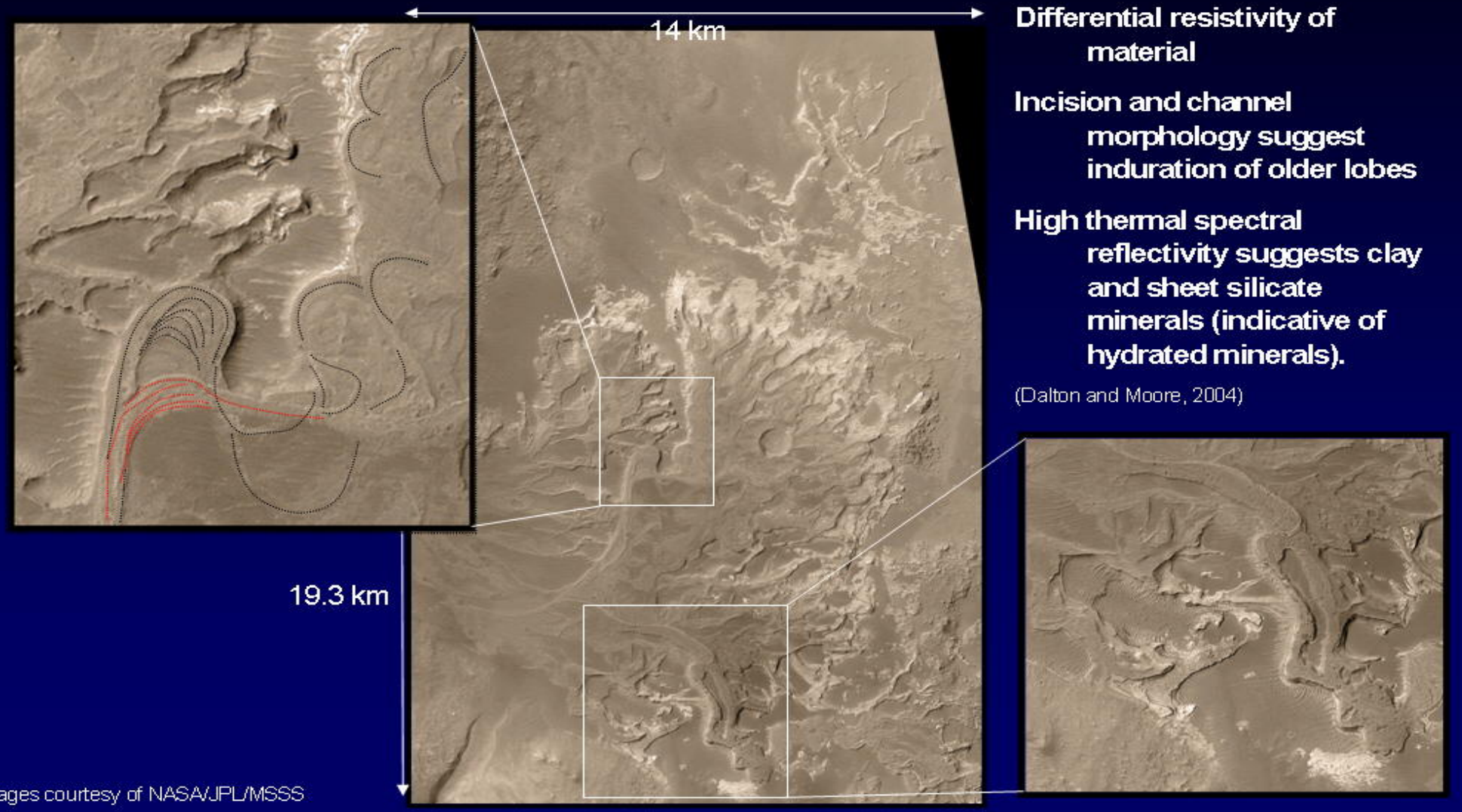
Eberswalde Delta, Holden Crater Region, Mars



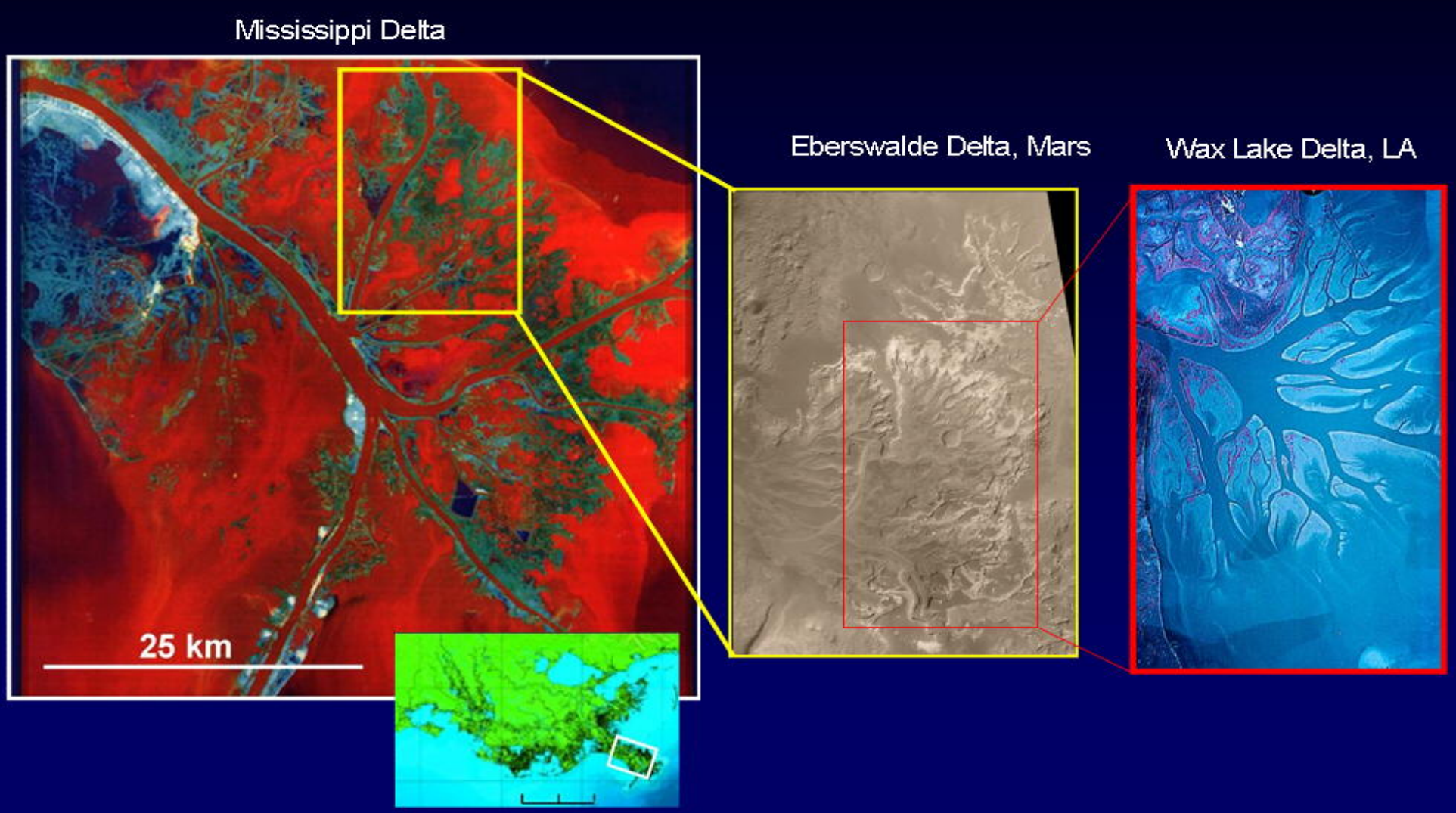
Composition:

- **Differential resistivity of material**
- **Incision and channel morphology suggest induration of older lobes**
- **High thermal spectral reflectivity suggests clay and sheet silicate minerals (indicative of hydrated minerals).**

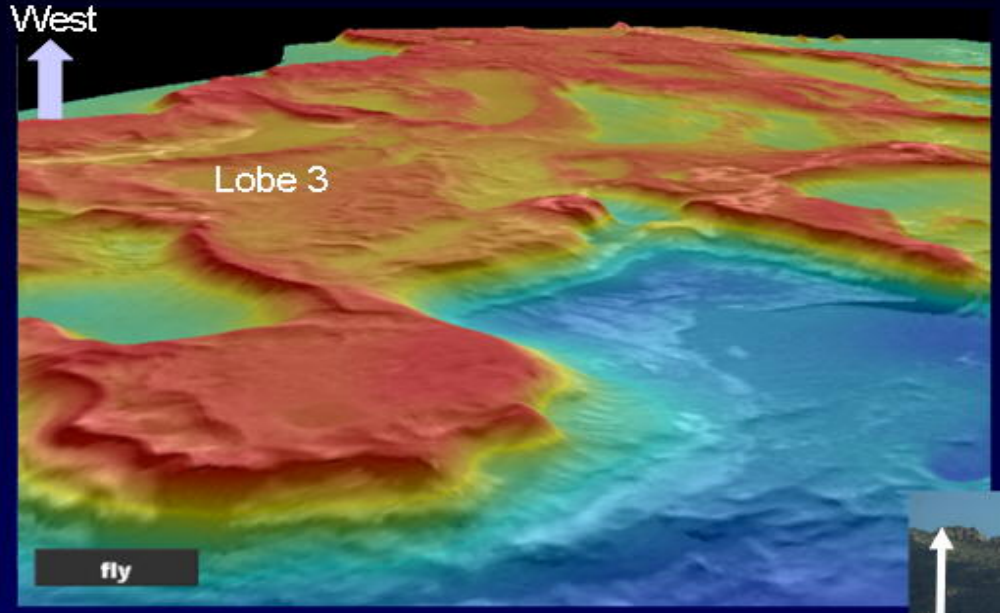
(Dalton and Moore, 2004)

Images courtesy of NASA/JPL/MSSS

Exactly how big is the Eberswalde Delta?



Exactly how big is the Eberswalde Delta?

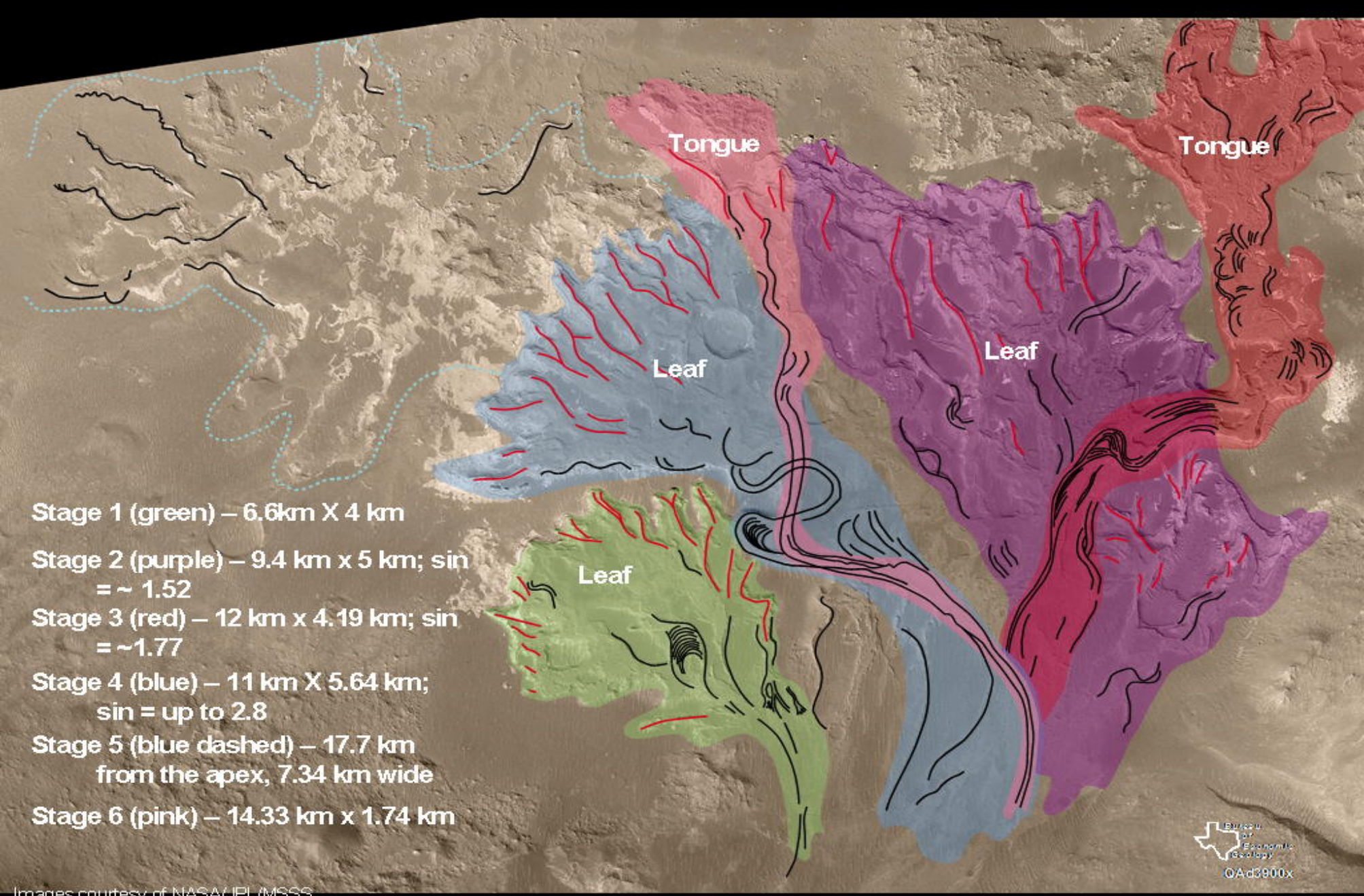


Cliffs ~ 60 m high
off the delta front.

L. Wood (2004)

Animation not available

Images courtesy of NASA/JPL/MSSS


Tongue
Tongue
Leaf
Leaf
Leaf
Stage 1 (green) – 6.6km X 4 km
Stage 2 (purple) – 9.4 km x 5 km; sin = ~ 1.52
Stage 3 (red) – 12 km x 4.19 km; sin = ~1.77
Stage 4 (blue) – 11 km X 5.64 km; sin = up to 2.8
Stage 5 (blue dashed) – 17.7 km from the apex, 7.34 km wide
Stage 6 (pink) – 14.33 km x 1.74 km
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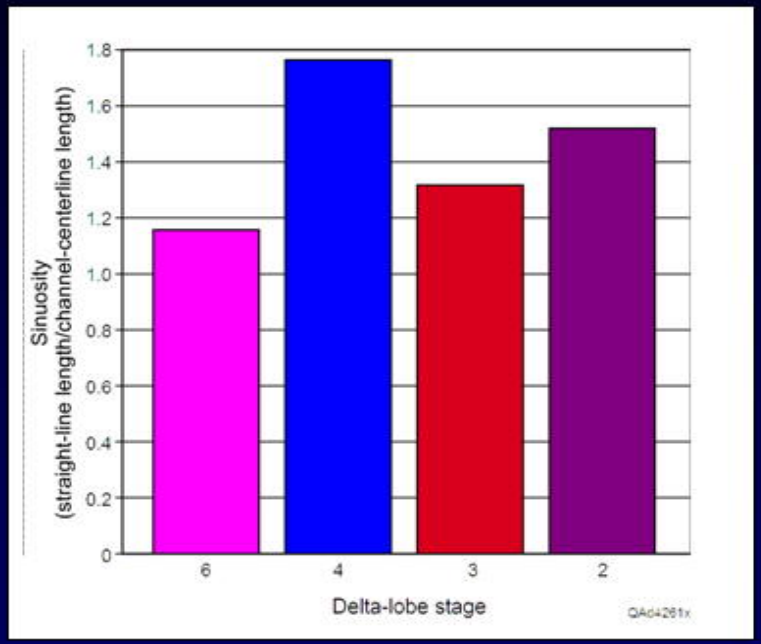
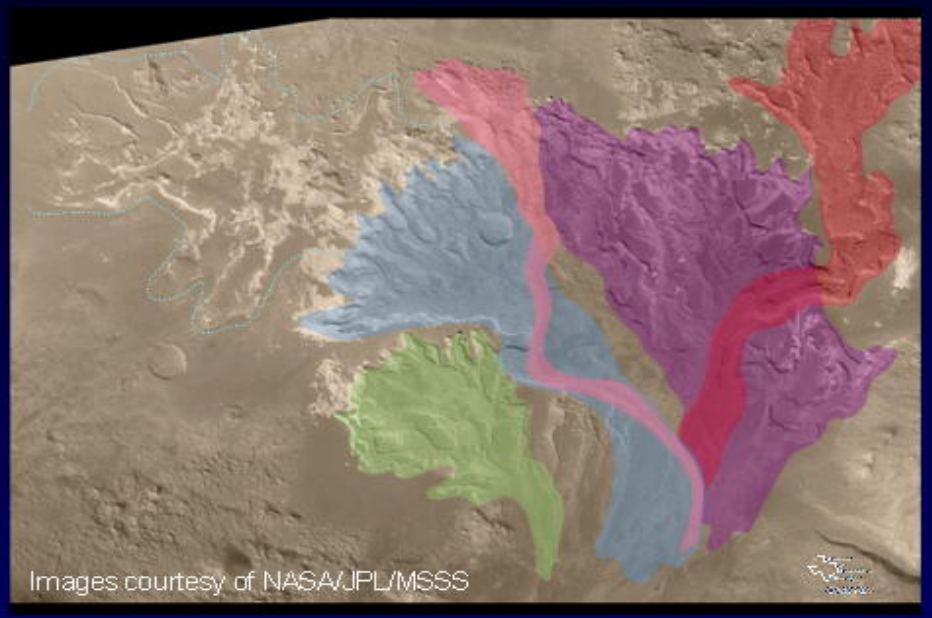
QAd3900x
Images courtesy of NASA/JPL/MSSS

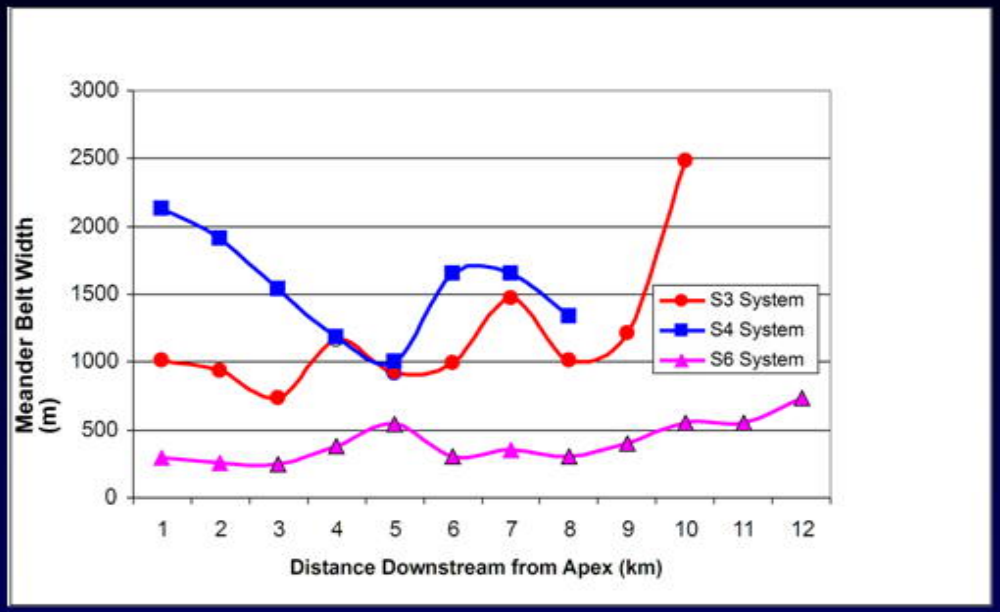
Eberswalde Delta, Holden Region, Mars

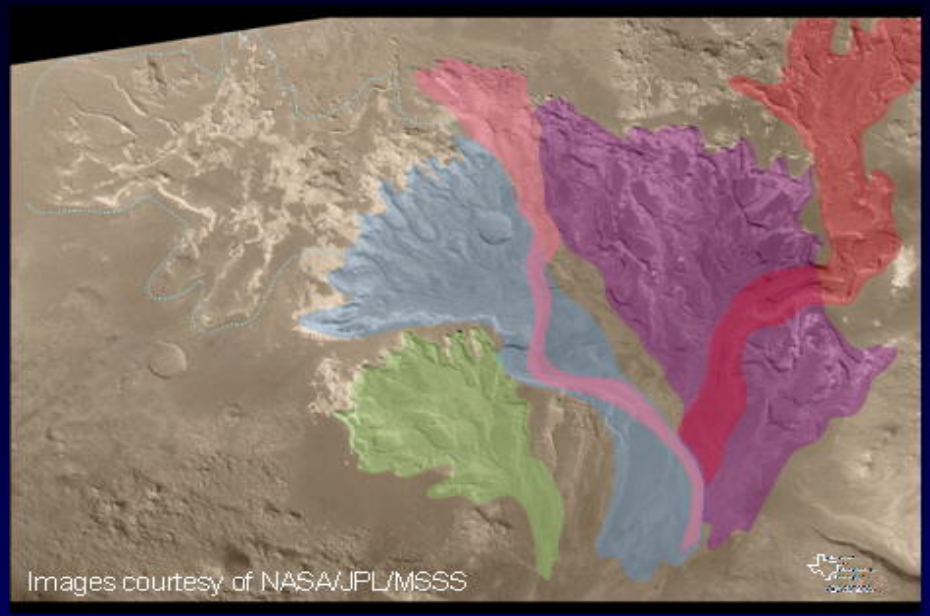


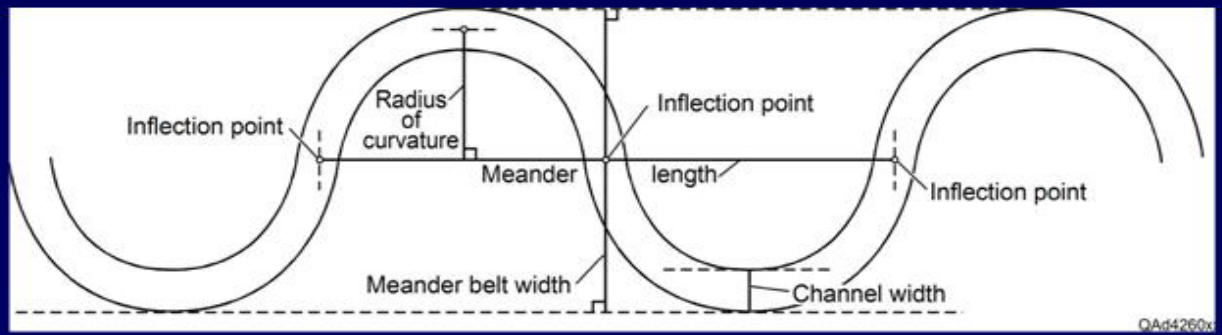


- Channel sinuosities in the systems range from 1.17 to 1.77; up to 2.8 in some reaches
- Sinuosities decrease from oldest to youngest – sort of. System 4 has the highest sinuosity of all the lobes, buoyed by a few distinct reaches.
- Indurated or lithified strata of the older delta lobes influences the morphology of the younger channels. Sediments of the green lobe (earliest) were indurated by the time the blue lobe was deposited.

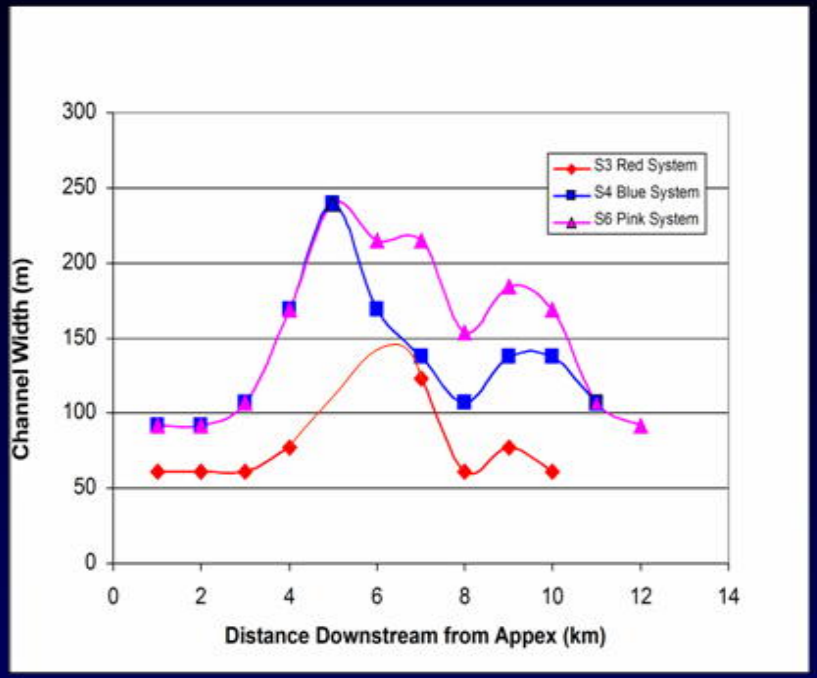
Eberswalde Delta, Holden Region, Mars

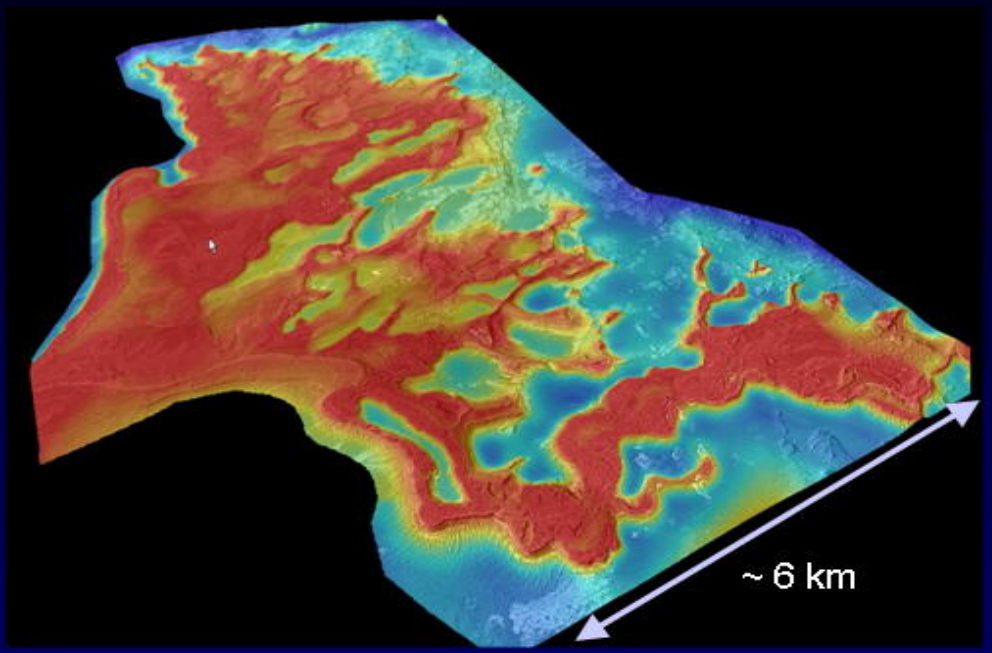






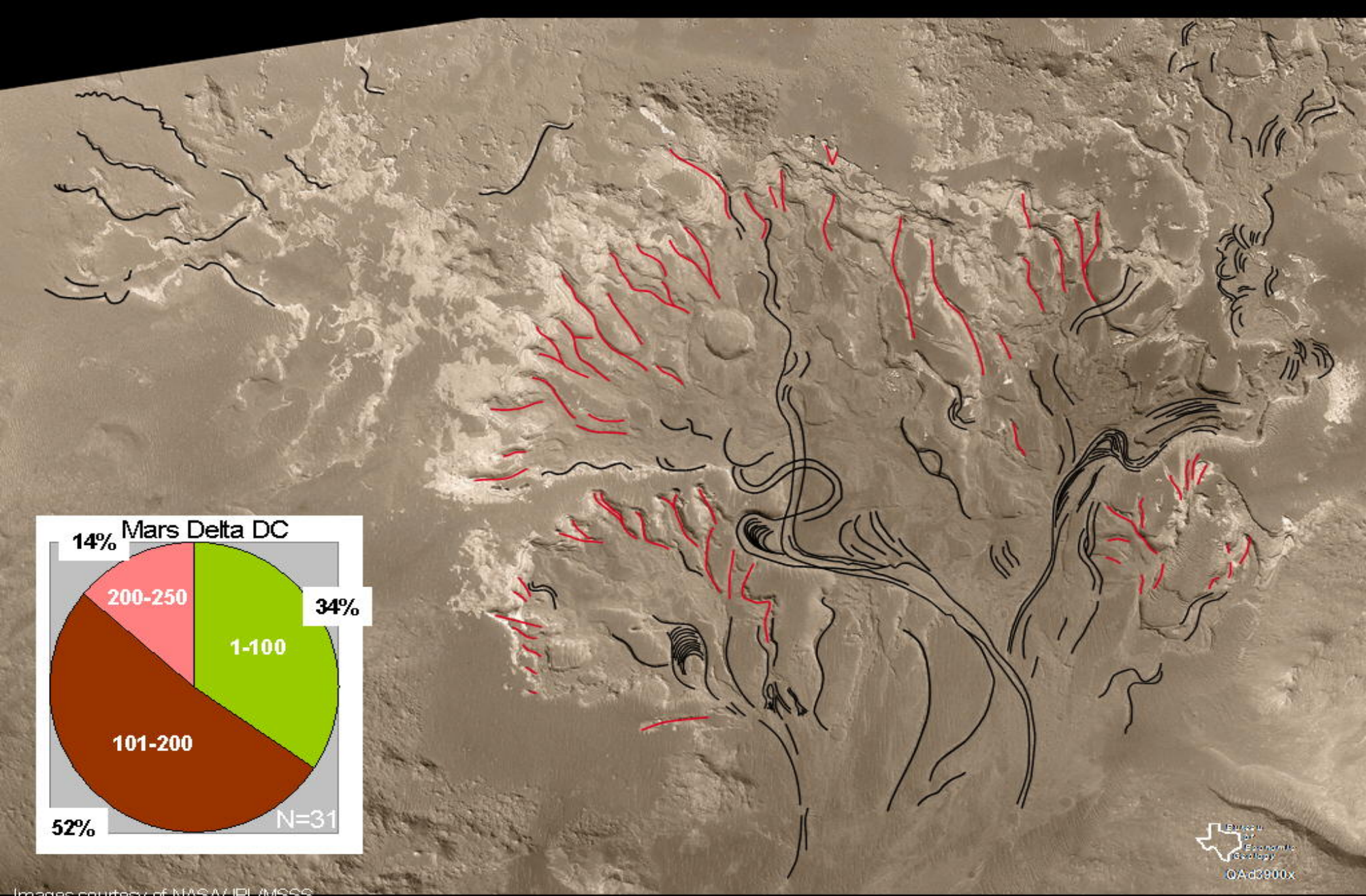
Eberswalde Delta, Holden Region, Mars





Channel width increases downstream, then decrease.

Consistent among all ages of systems.



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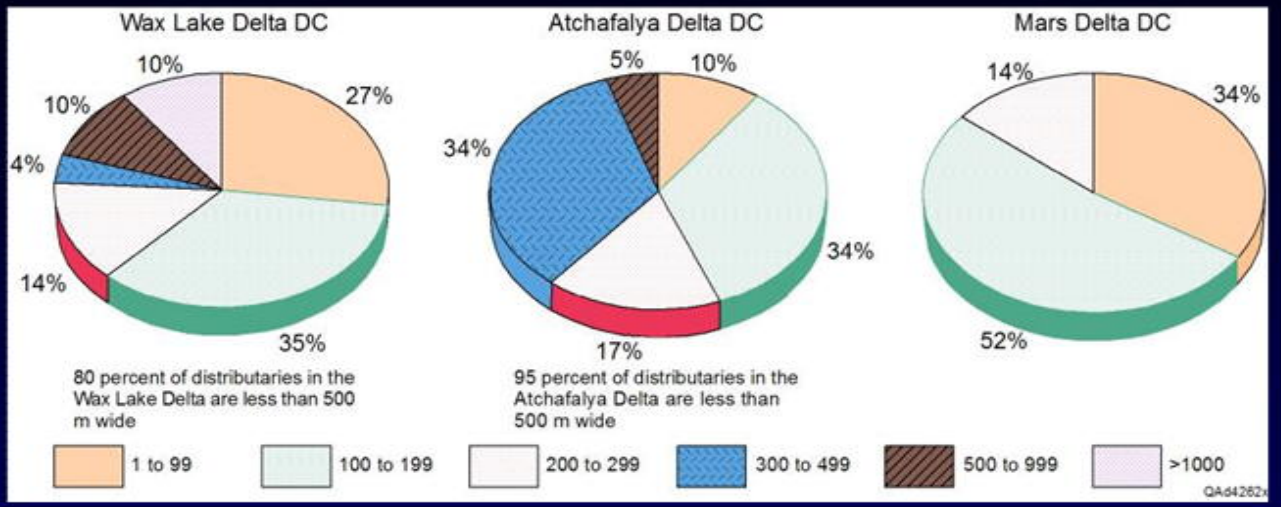
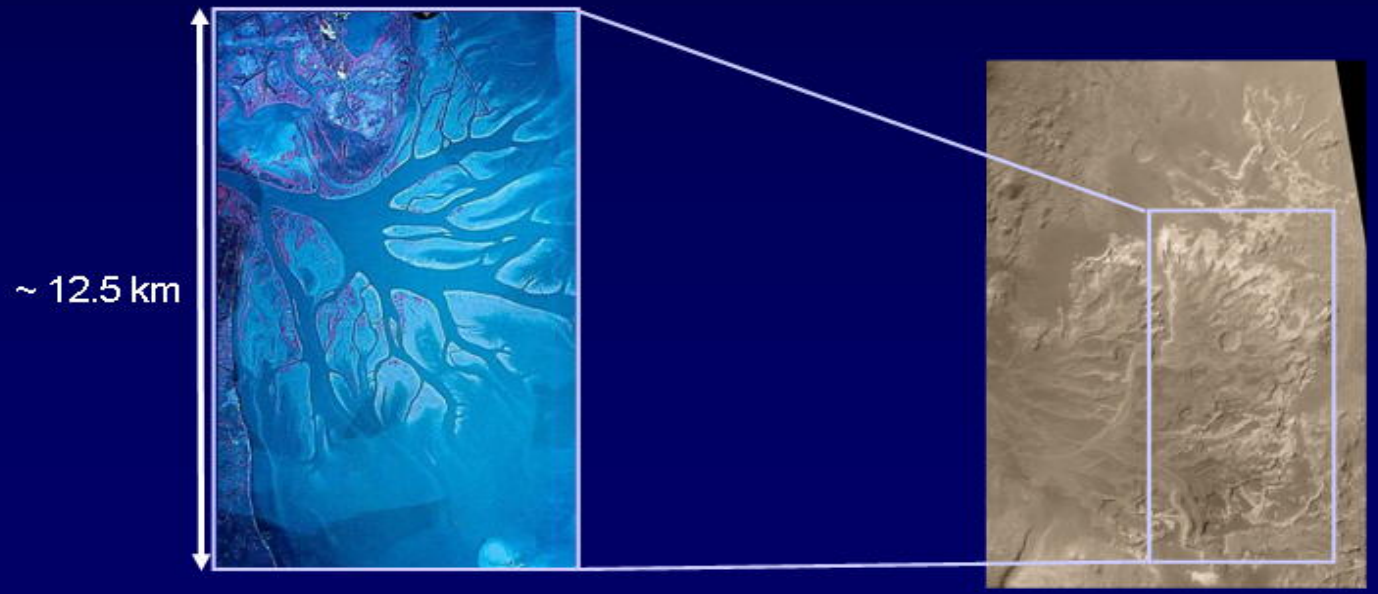
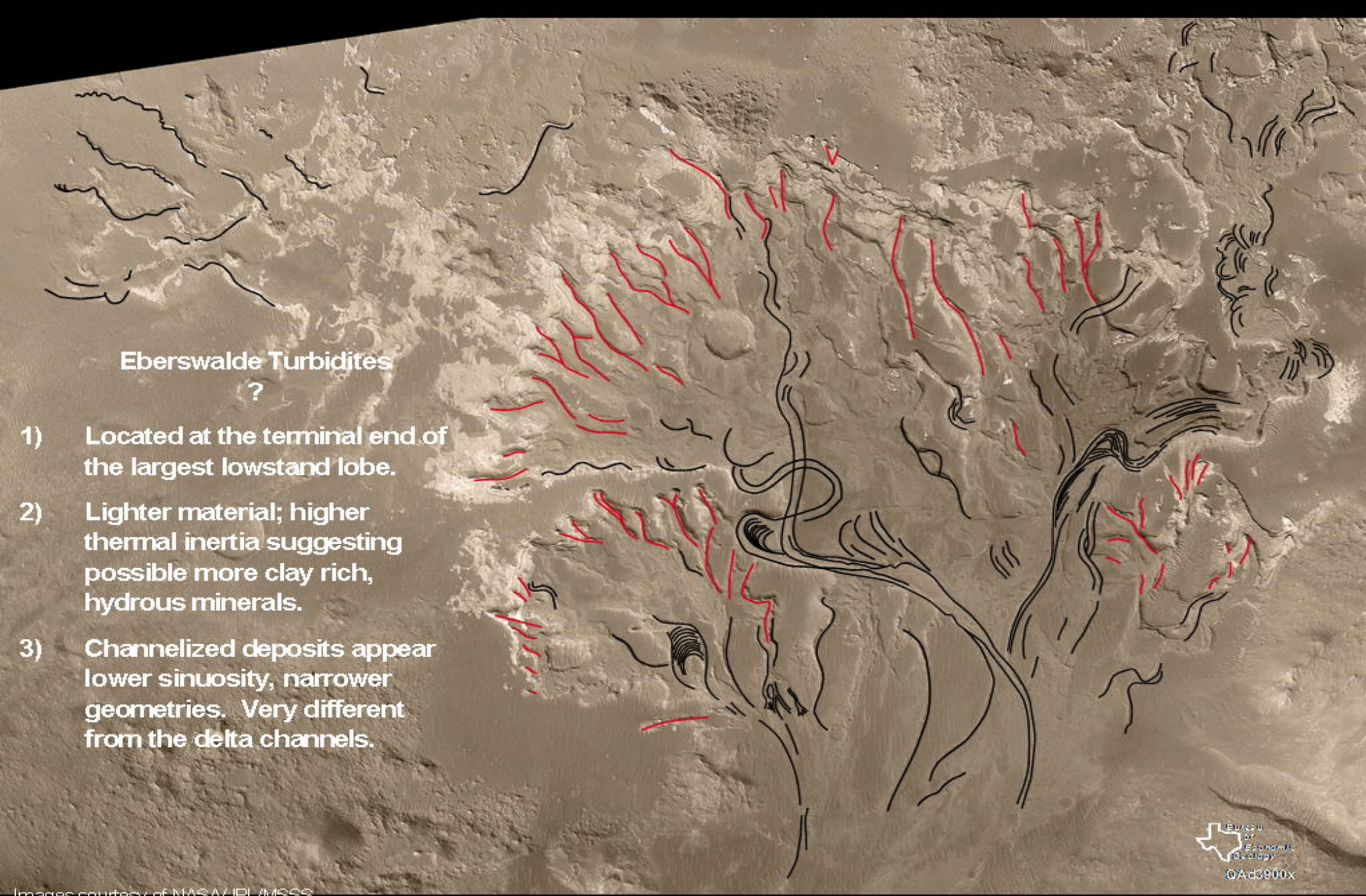
Eberswalde Delta, Holden Region, Mars






Eberswalde Turbidites
?
1) Located at the terminal end of the largest lowstand lobe.
2) Lighter material; higher thermal inertia suggesting possible more clay rich, hydrous minerals.
3) Channelized deposits appear lower sinuosity, narrower geometries. Very different from the delta channels.
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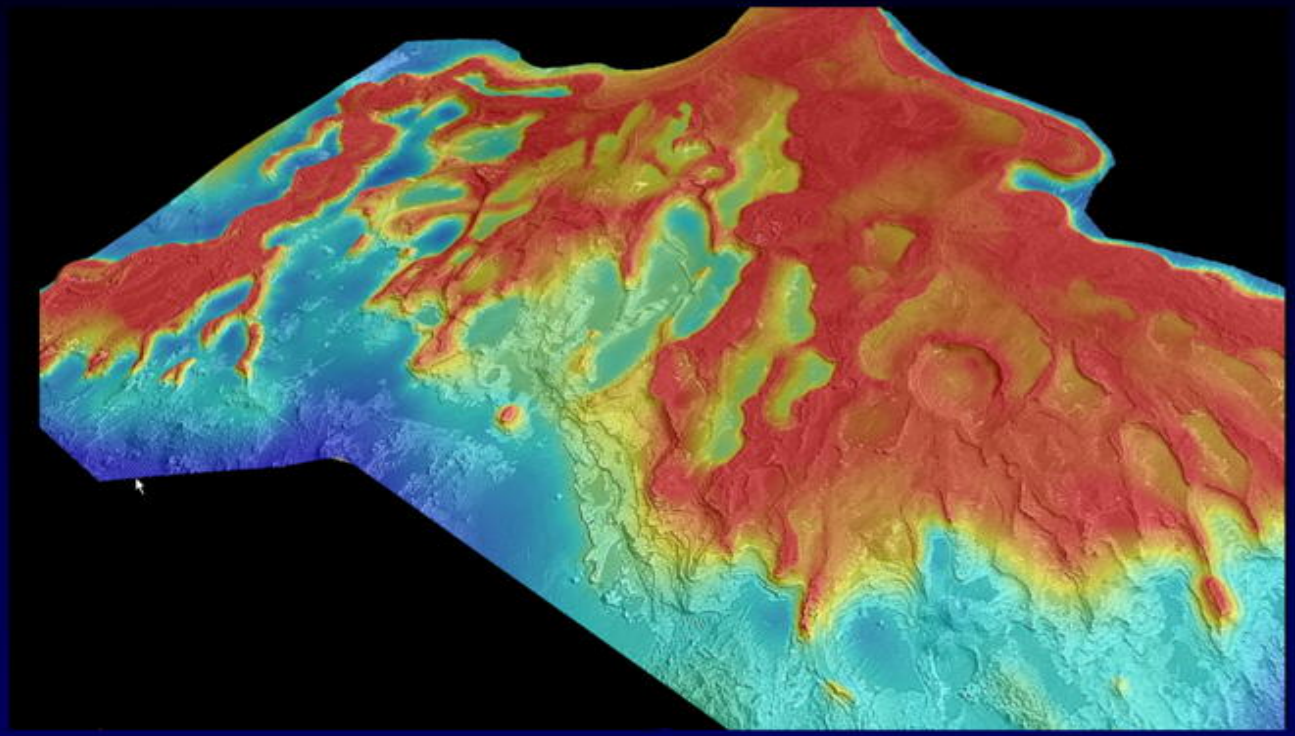
Images courtesy of NASA/JPL/MSSS

Eberswalde Delta, Holden Region, Mars



This delta lacks the component of large distributary channels seen in many Gulf Coast deltas.

Distributaries are very persistent in their size.

Flows were persistent enough to generate accretionary and migratory architecture, but not constant.

Chute cut-offs and sudden rejuvenation and basinward movement of new lobes suggest sudden shift in flow.

Leaf-shaped lobes suggest more aggradational processes. Tongue-shaped lobes suggest more progradational processes.

Possible indication of high and low lake levels? Or simply sudden flow influx,