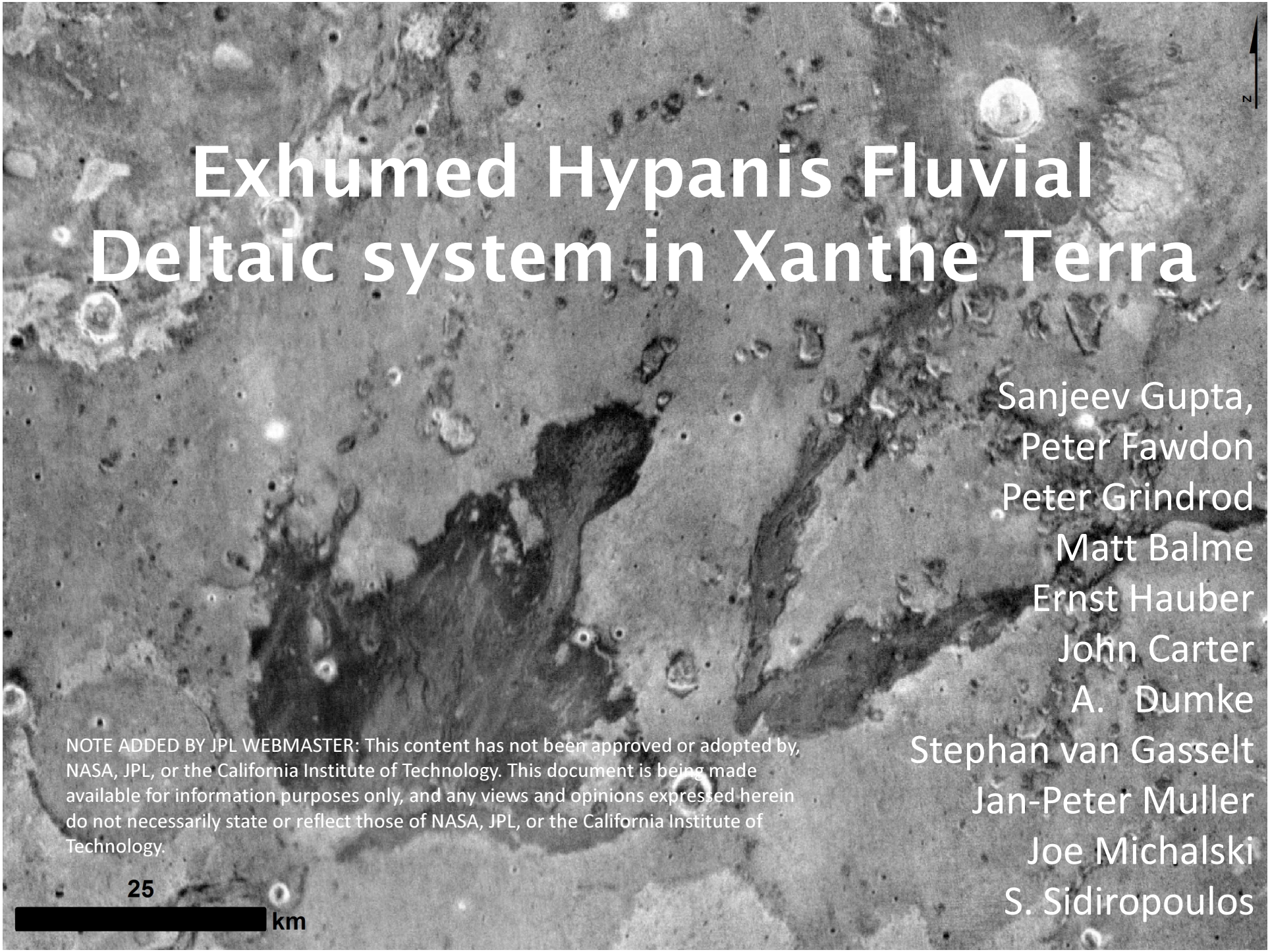


Exhumed Hypanis Fluvial Deltaic system in Xanthe Terra

Sanjeev Gupta,
Peter Fawdon
Peter Grindrod
Matt Balme
Ernst Hauber
John Carter
A. Dumke
Stephan van Gasselt
Jan-Peter Muller
Joe Michalski
S. Sidiropoulos

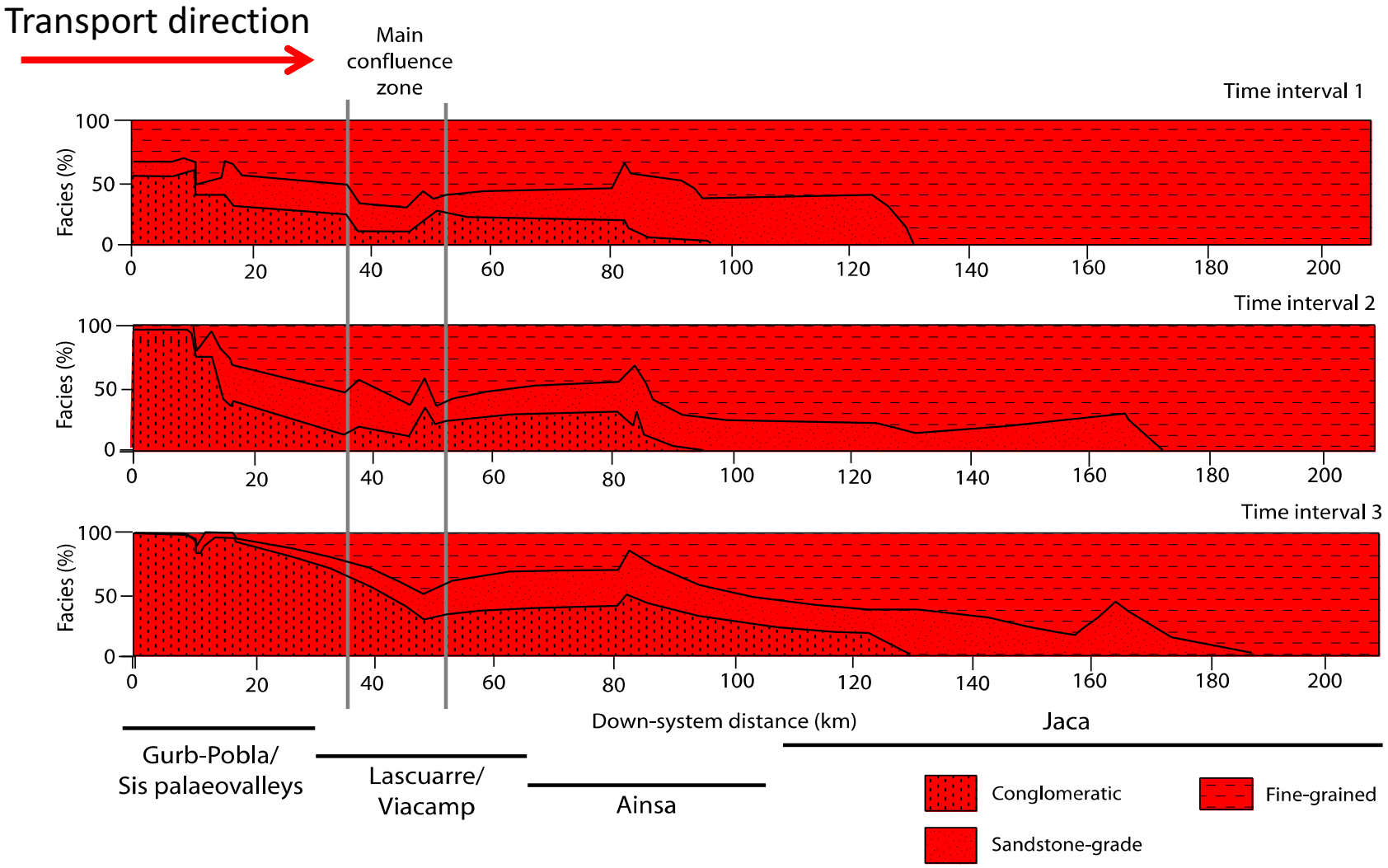
What makes fluvio-deltaic systems special?

- Form part of sediment routing systems – have predictable properties – grain size trends, textural trends, facies transitions,
- Integrate erosional products from large areas of bedrock – bedrock erosion and redistribution over large areas
- Efficient grain size fractionating systems – large fluvial systems produce large quantities of fine-grained sediment
- Concentrating systems

Volumetric budget and grain-size fractionation of a geological sediment routing system: Eocene Escanilla Formation, south-central Pyrenees

Nikolas A. Michael, Alexander C. Whittaker, Andrew Carter and Philip A. Allen

Geological Society of America Bulletin published online 3 February 2014;
doi: 10.1130/B30954.1



What makes deltaic-lacustrine systems good for biosignature formation and preservation?

- Rapid deposition due to abrupt change in sediment transport efficiency => rapid burial => enhanced preservation of organics
- Enhanced settling of fines (silts & clays) from suspension – include clay minerals
- Input of mineral ‘resources’ – nutrients
- Low energy environments – reduced destruction by high energy fluid flows

Delta toe deposits interfingering with basinal mudstones

Preservation?

- Rapid deposition and burial – organics enter sediment column rapidly – limits near surface alteration
- Burial close to entry point of sediment routing system – reduction of multiple cycles of erosion and deposition
- Progradation of coarser facies over finer creates geologic ‘protection’

Why an ancient delta?

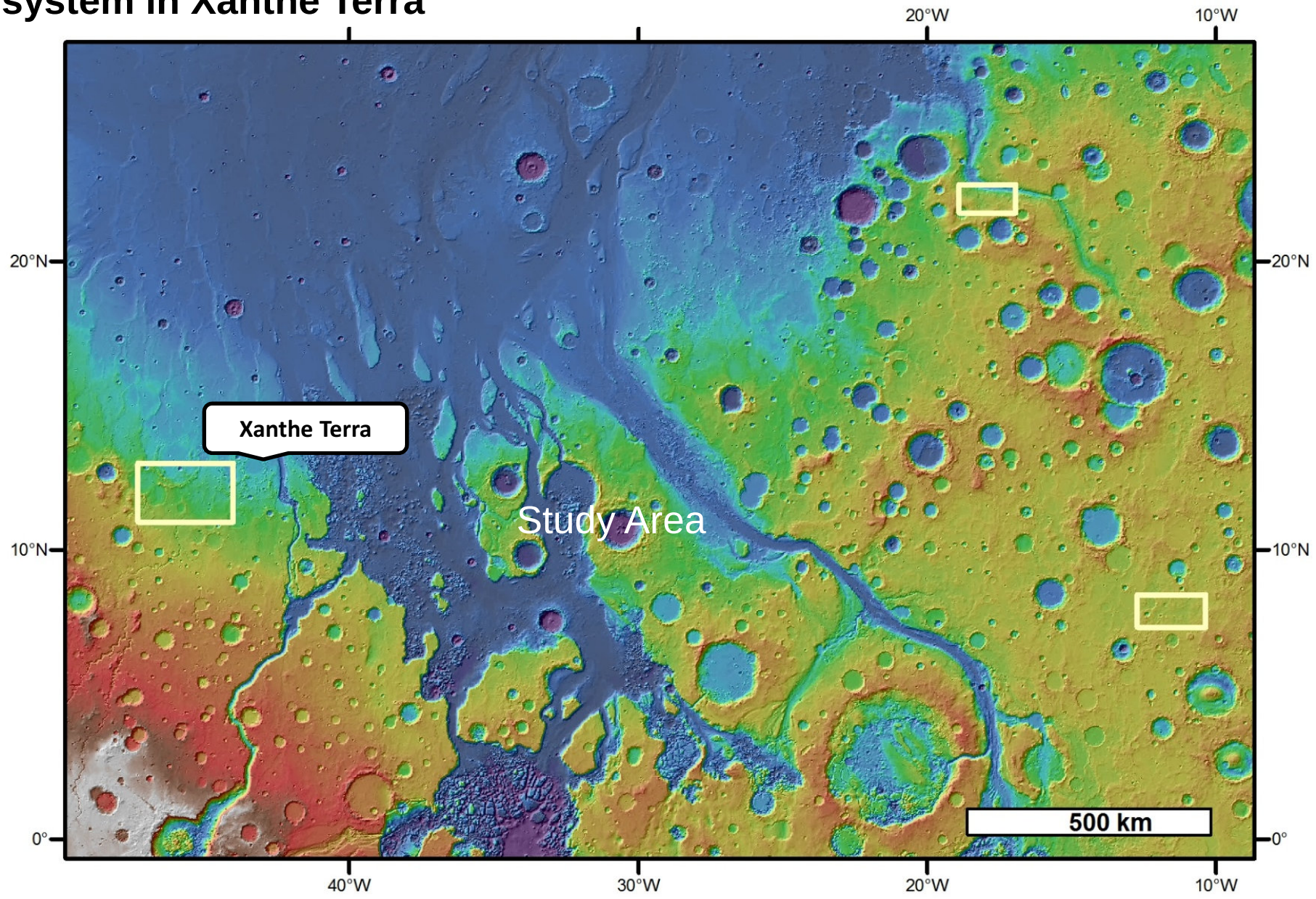
Martian context → early Mars environment	*Support biotic OM formation*	*Support for abiotic OM formation*	*Support OM concentration*	*Support preservation*
Eolian sediments (sand)	low	low	low	low
Altered eolinites (dust)	very low	low	low	low
Fluvial channel	low	low	low	low
Fluvial floodplain	low-mod	low	mod	mod
Alluvial fan	low	low	low	low
Deltaic	high	low	high	high
Lacustrine (perennial)	high	low	high	high
Lacustrine (evaporitic)(Cl)	low	low	high	high-very high
Lacustrine (evaporitic)(SO_4)	mod	low	high	high-very high
Regional groundwater pore system	low	low	low	low
Glacial deposits	low	low	low	low
Permafrost	low	low	low	mod
Soil (surface fines chemically altered by atmosphere)	low	low	low	low
Regolith/Fractured bedrock (not soil)	low	low	low	low

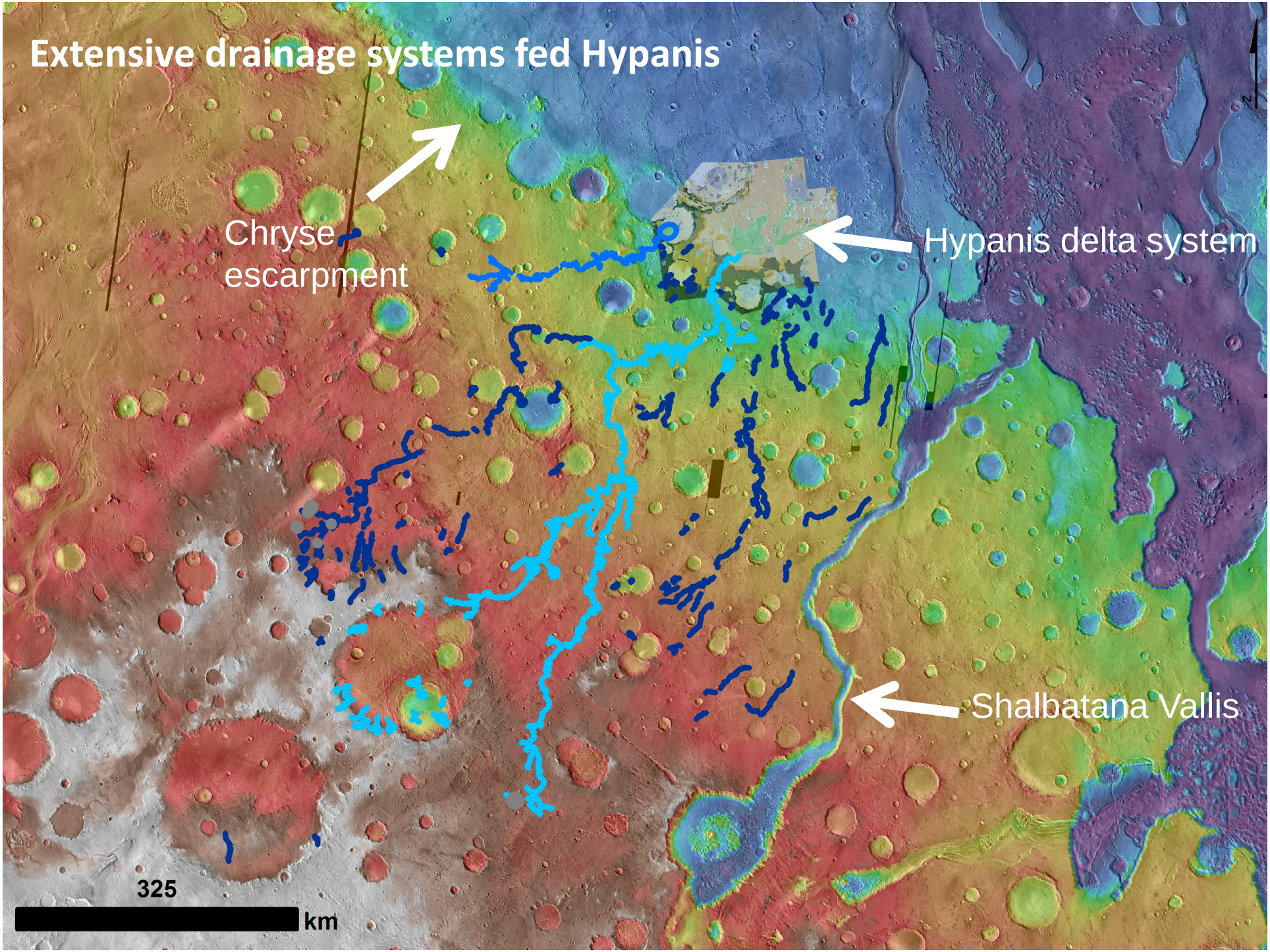
Ancient deltas and lakes are excellent exploration targets for NASA 2020

- **Low energy fine-grained sediments**
- **Higher sedimentation rates – due to abrupt gradient in sediment transport rates**
- **Concentrates organics + potential for detrital organics**

Summons et al., 2011

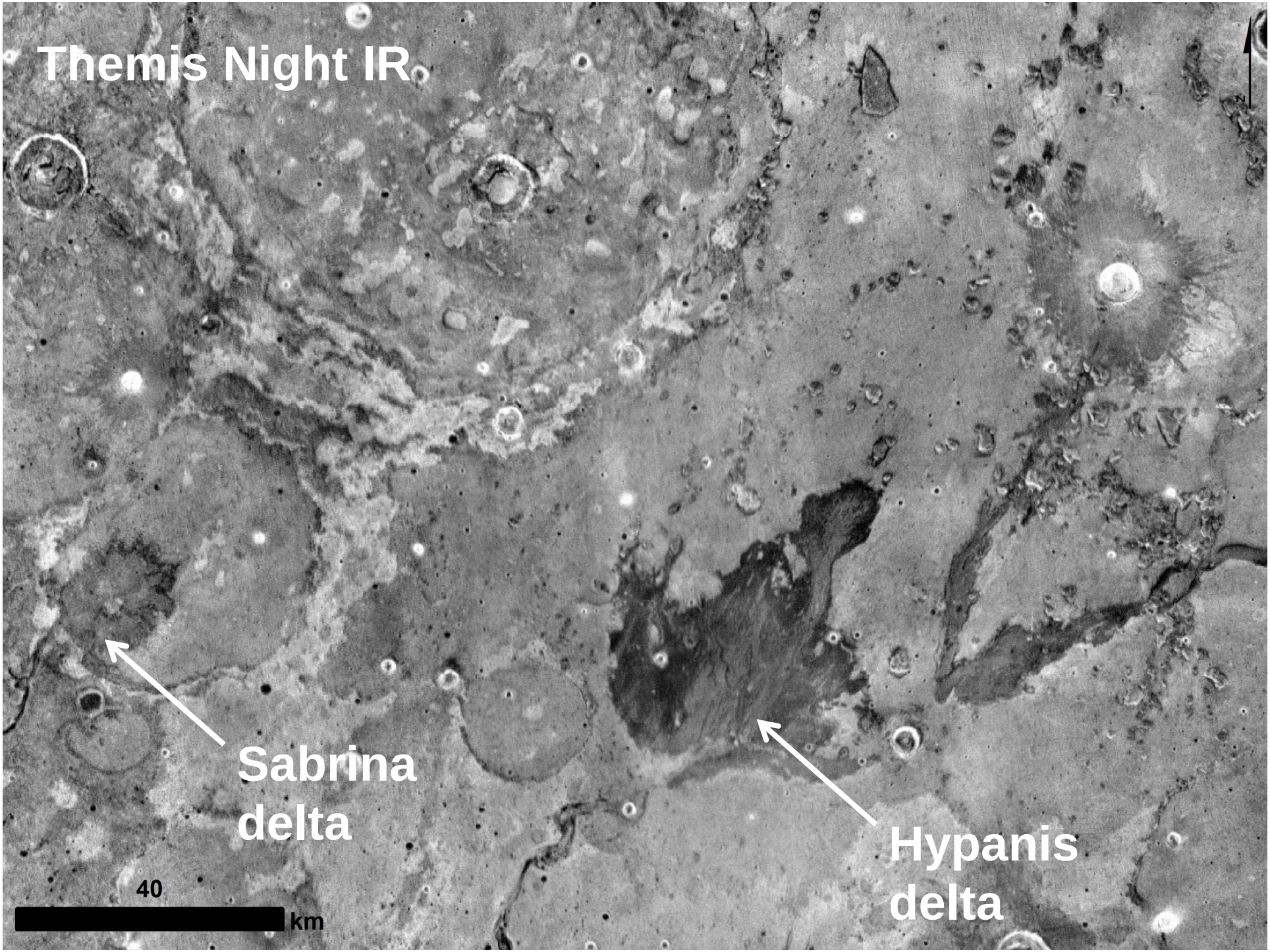
Overview location of the Hypanis system in Xanthe Terra

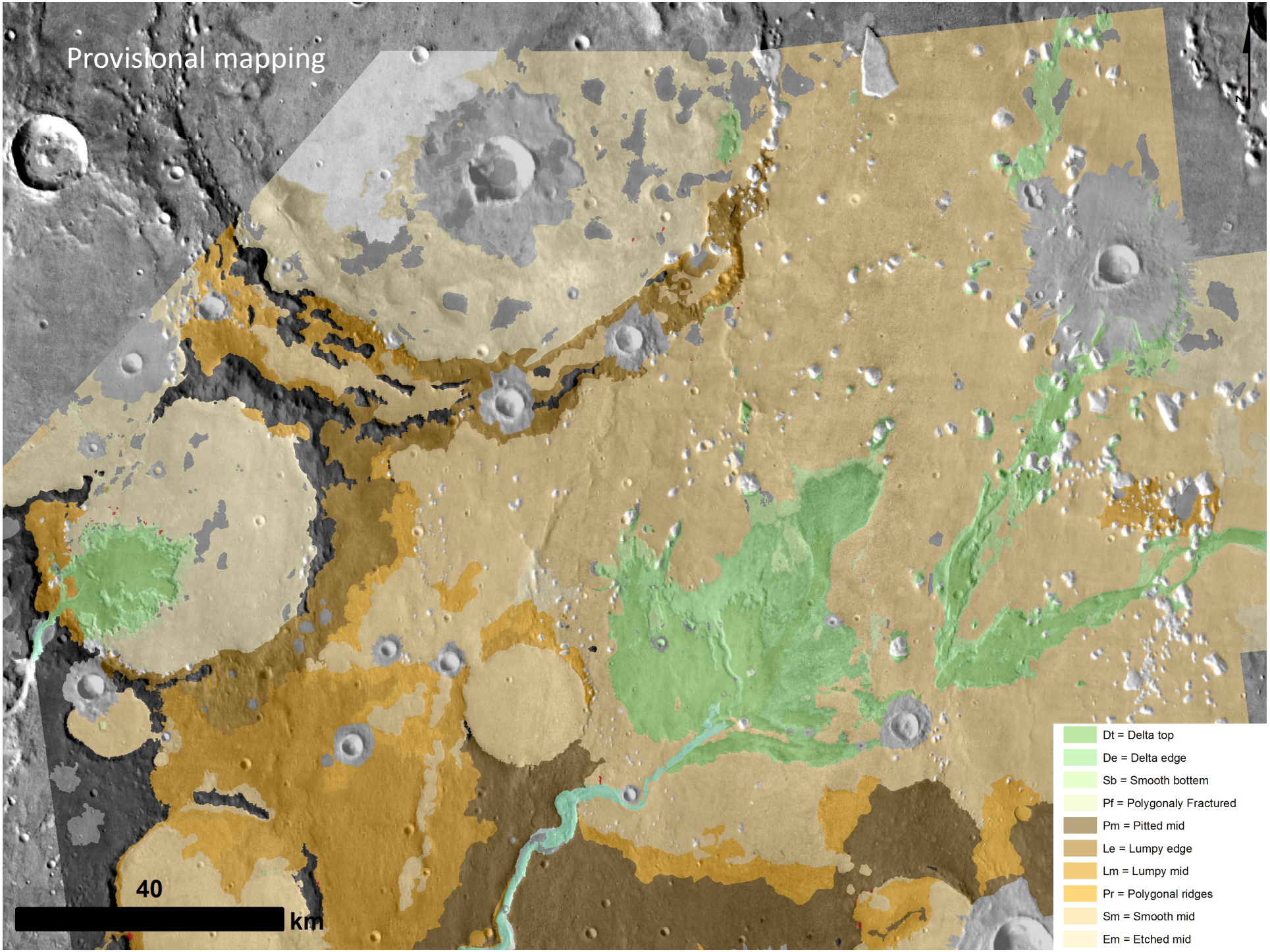



Extensive drainage systems fed Hypanis
Chryse escarpment
Hypanis delta system
Shalbatana Vallis
325
km

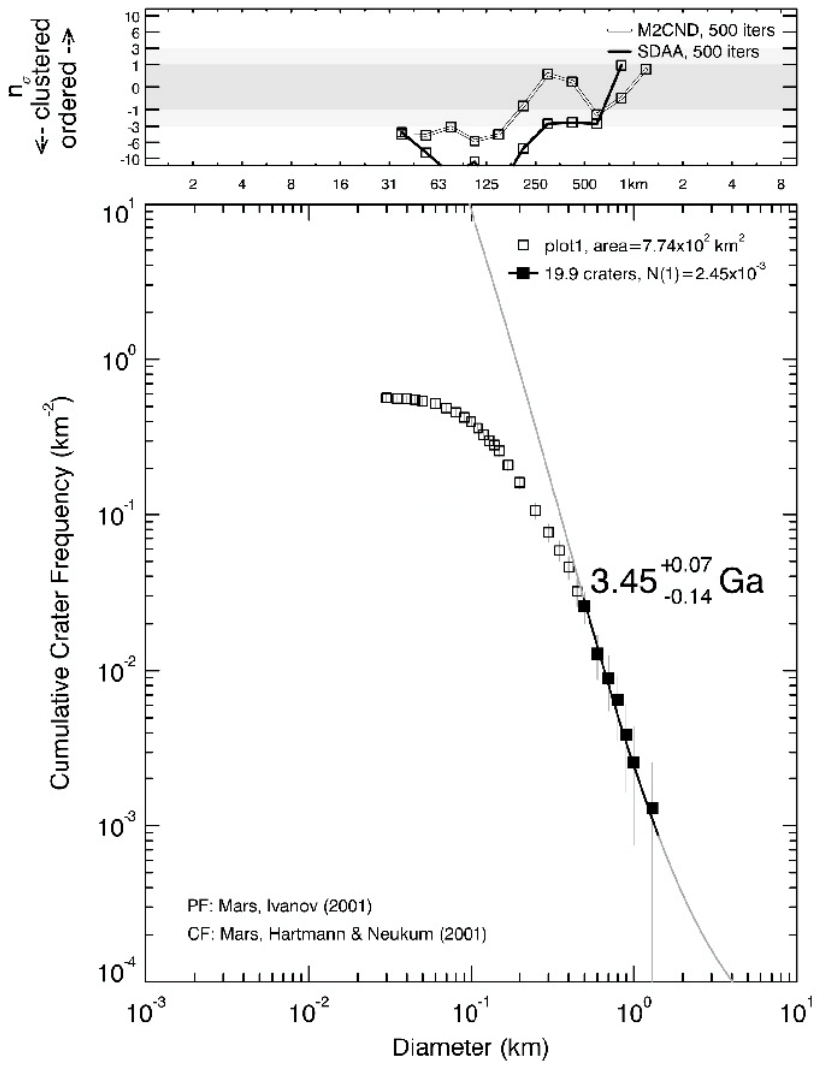
Source of Hypanis

- **Hypanis fan system is fed by a very extensive bedrock valley – Hypanis Vallis – several hundred kilometres long (?), ~75 m deep**
  - **Perhaps connects to Nanedi Vallis**
- **Large volume of rock has been removed by fluvial erosion**
- **Valley network is very different to drainages sourced from crater rims cf. Gale crater fan and other crater-rim fed fans**
- **Hypanis is a much bigger system**
- **Hypanis and Sabrina deltas are located at margin of Chryse escarpment – abrupt transition from erosional to depositional realm**
- **Timescale of fluvial erosion**
  - **Difficult to estimate precisely**
  - **Valley form is different to outflow channels**
  - **Narrow width, sinuous valley form**
  - **Suggests long-lived erosion – not instantaneous or short-lived erosion**

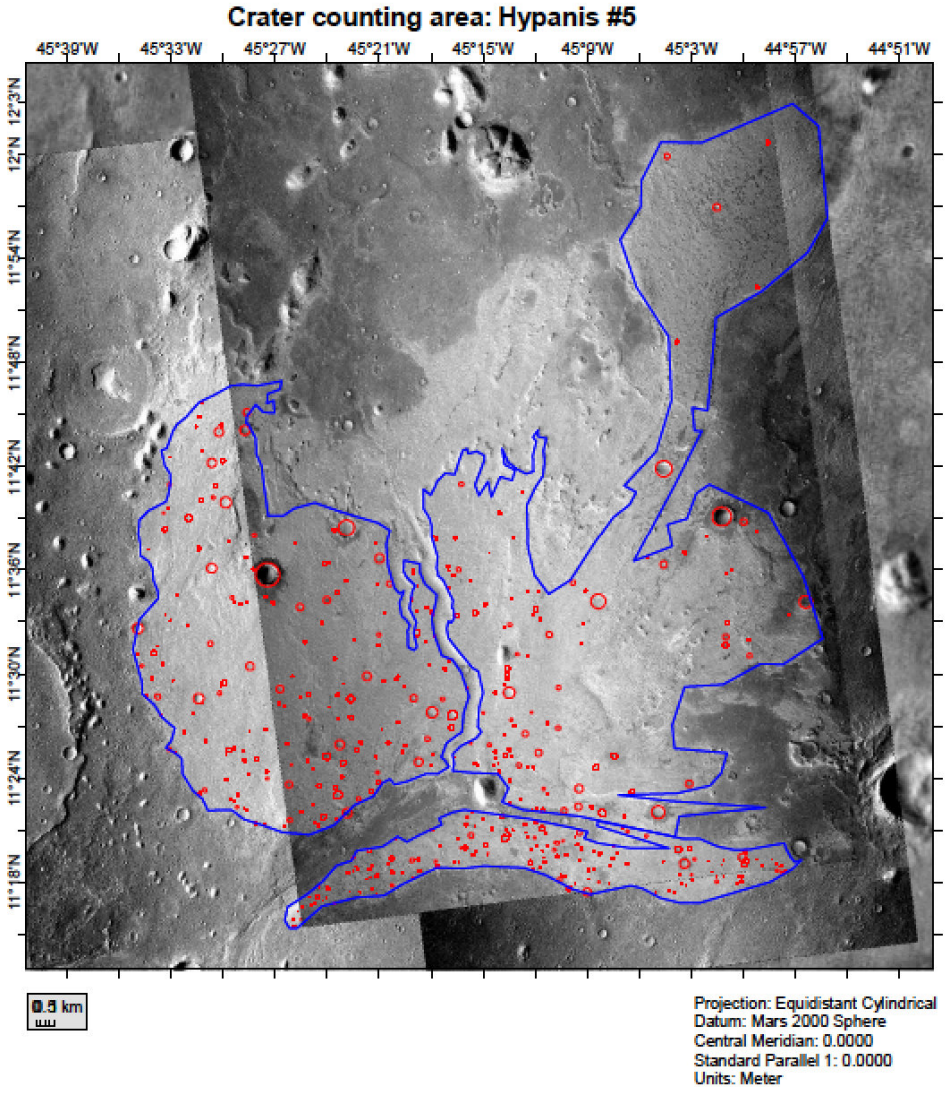

Themis Night IR
N
Sabrina
delta
Hypanis
delta
40
km


Provisional mapping
N
40
km
Dt = Delta top
De = Delta edge
Sb = Smooth bottem
Pf = Polygonaly Fractured
Pm = Pitted mid
Le = Lumpy edge
Lm = Lumpy mid
Pr = Polygonal ridges
Sm = Smooth mid
Em = Etched mid

Timing of fluvio-deltaic activity

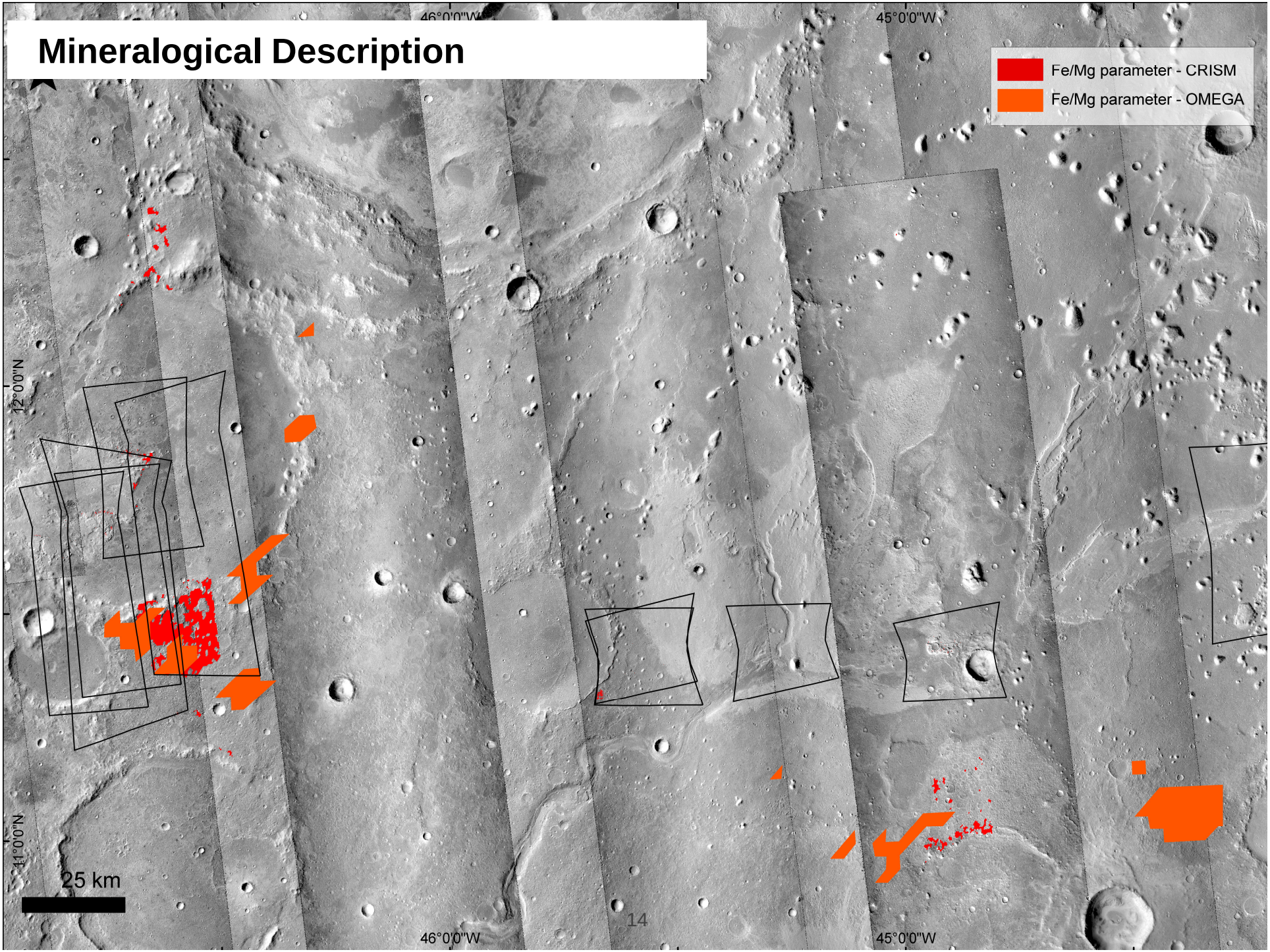


Early Hesperian



Hauber et al 2013

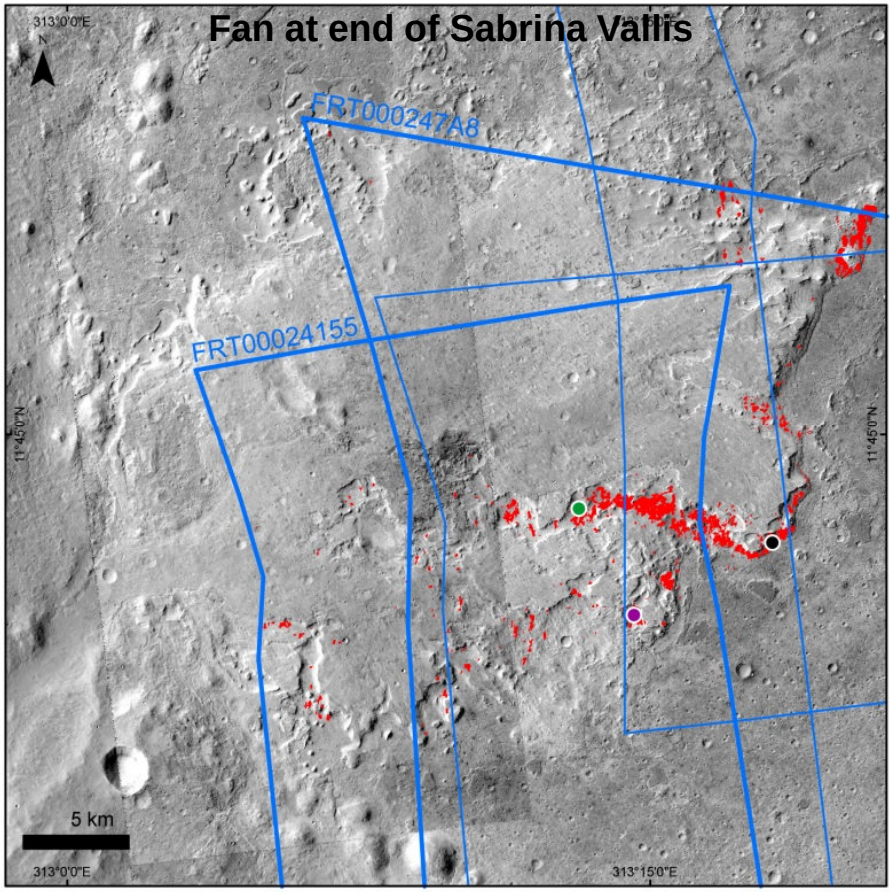
Mineralogical Description

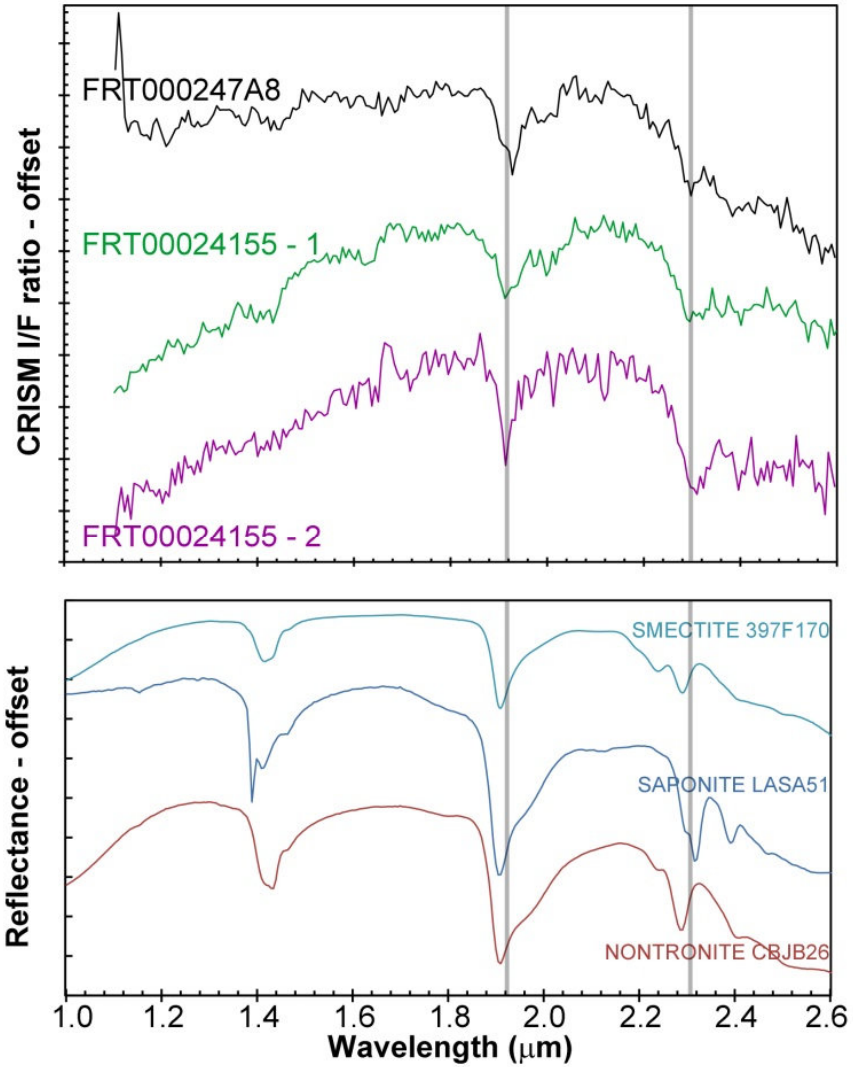


Mineralogical Description

CRISM Mineralogy -

- Analogous fan mineralogy, ~75 km west of Hypanis.
- Fe/Mg phyllosilicates (nontronite?) at low stratigraphic level in fan deposits.

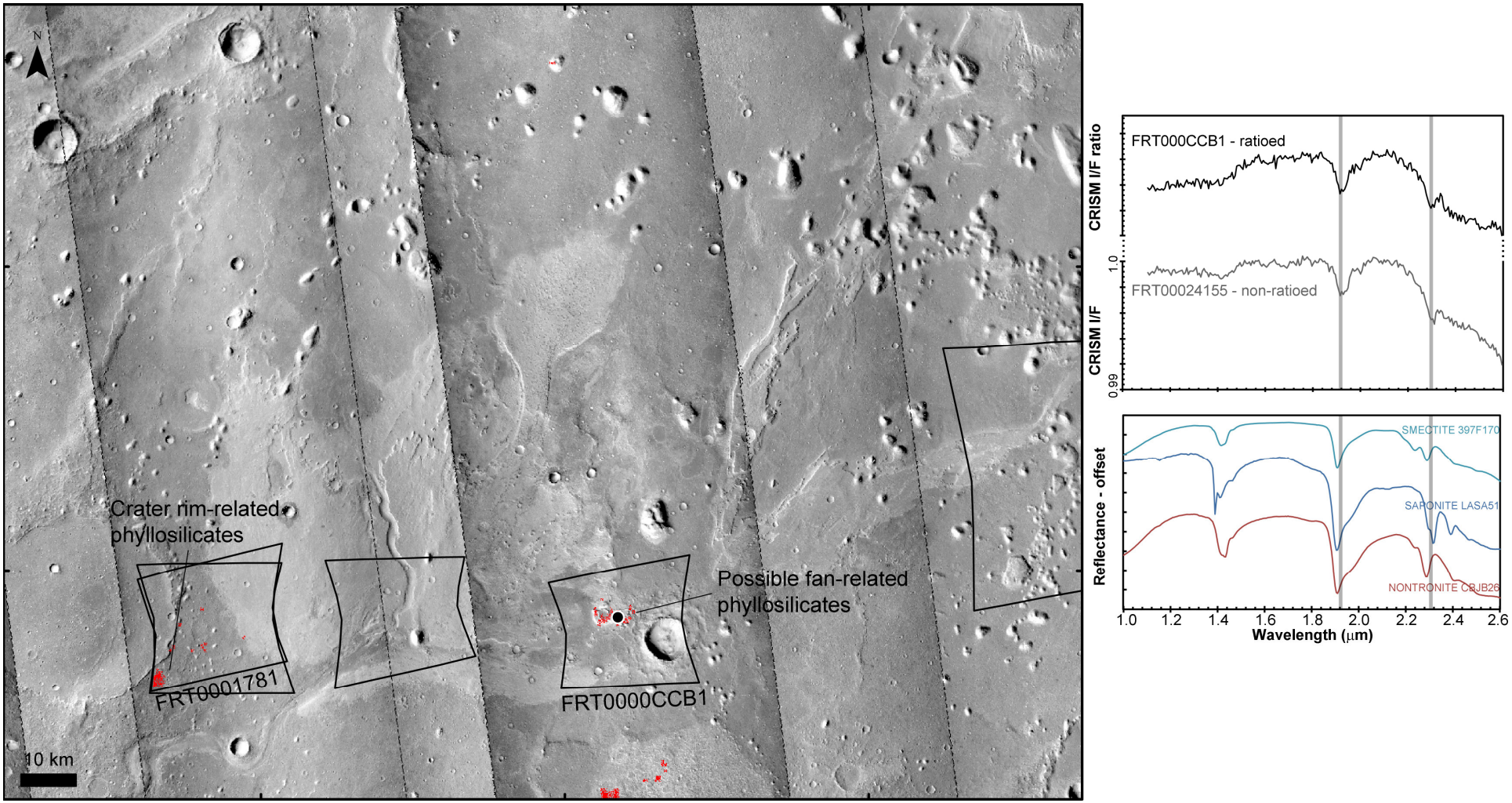




Mineralogical Description

CRISM Mineralogy – within ellipse (just!)

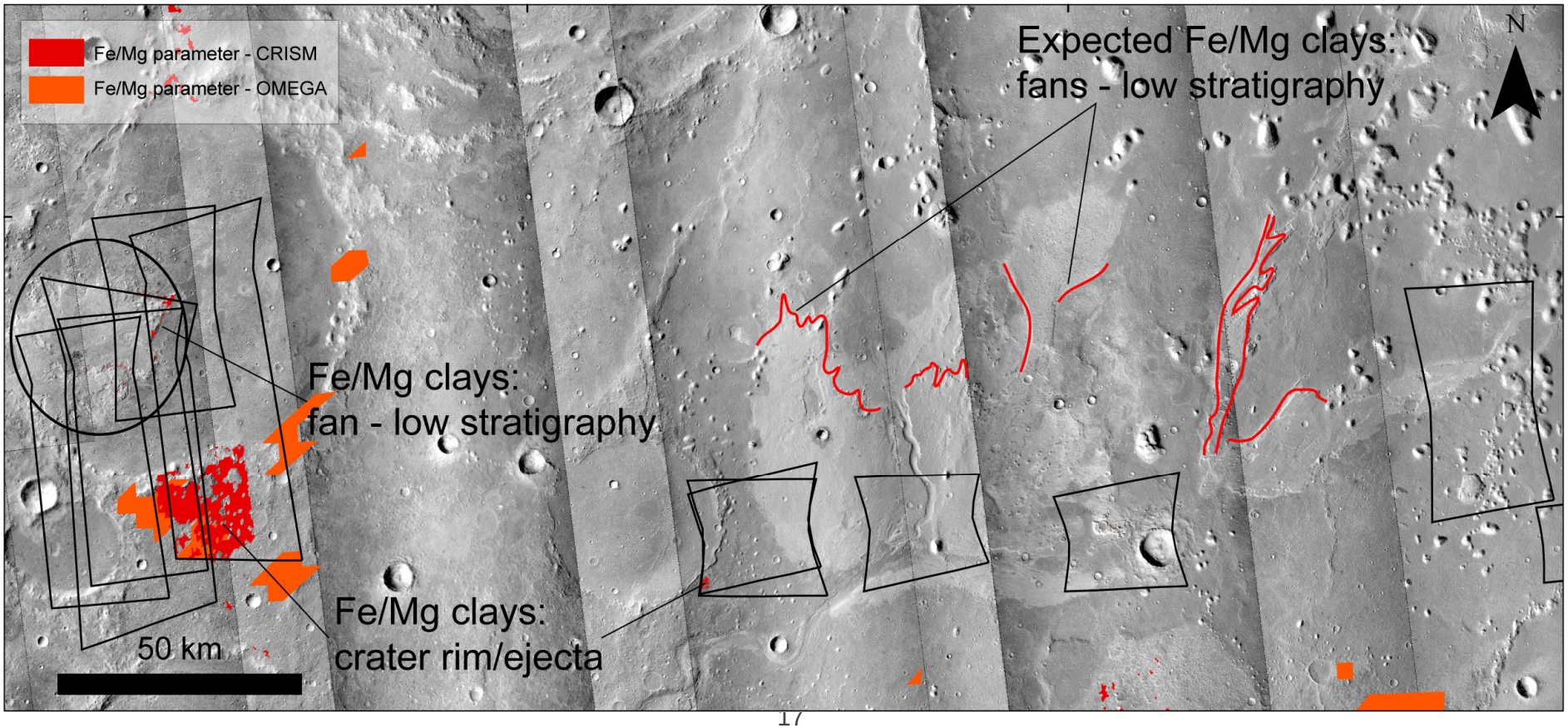
- Limited by available data – only two CRISM images intersect edge of Hypanis regions.
- Limited (ambiguous) mineralogy near Hypanis, although possible phyllosilicates.



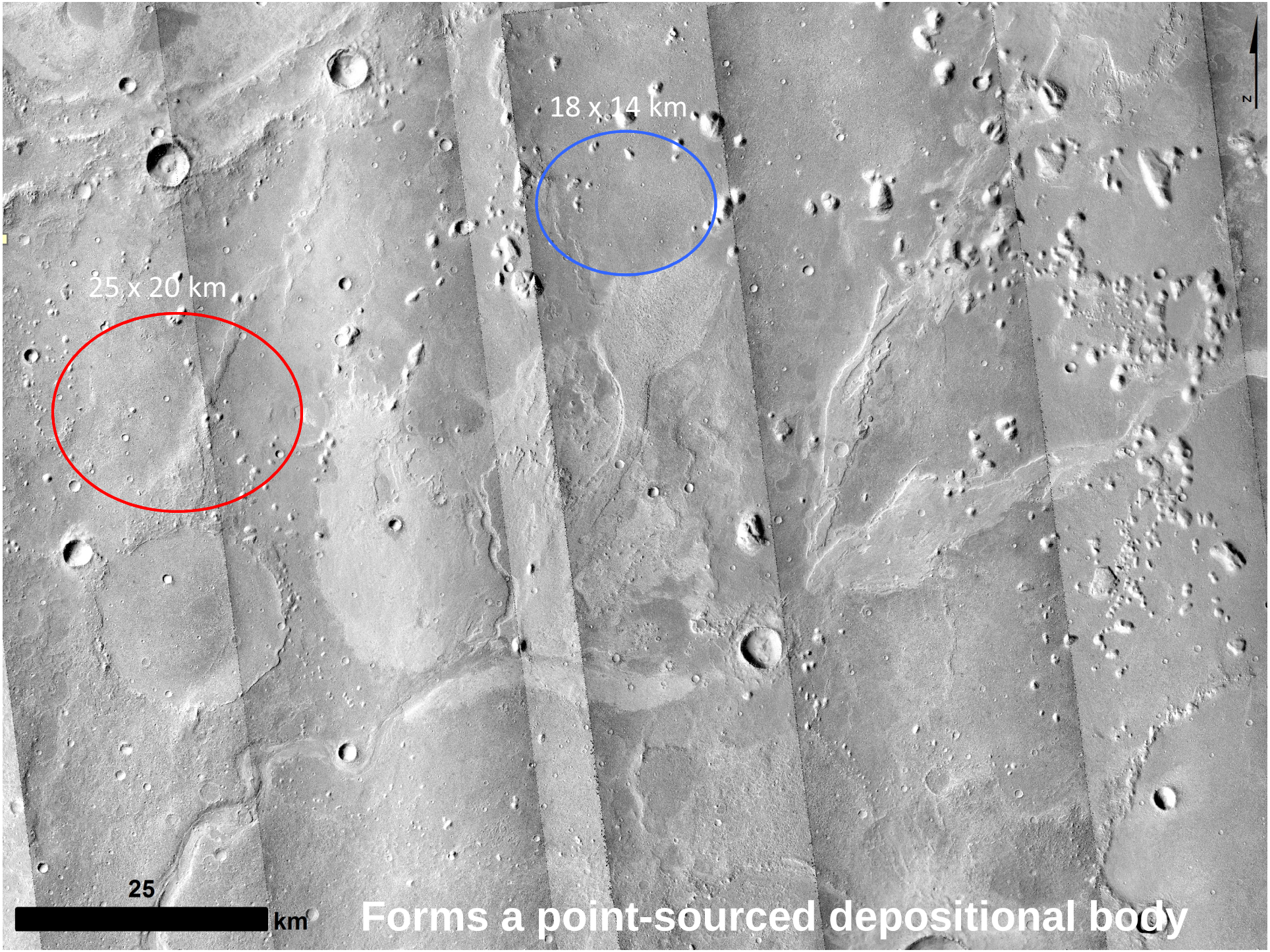
Mineralogical Description

CRISM Mineralogy – predicted

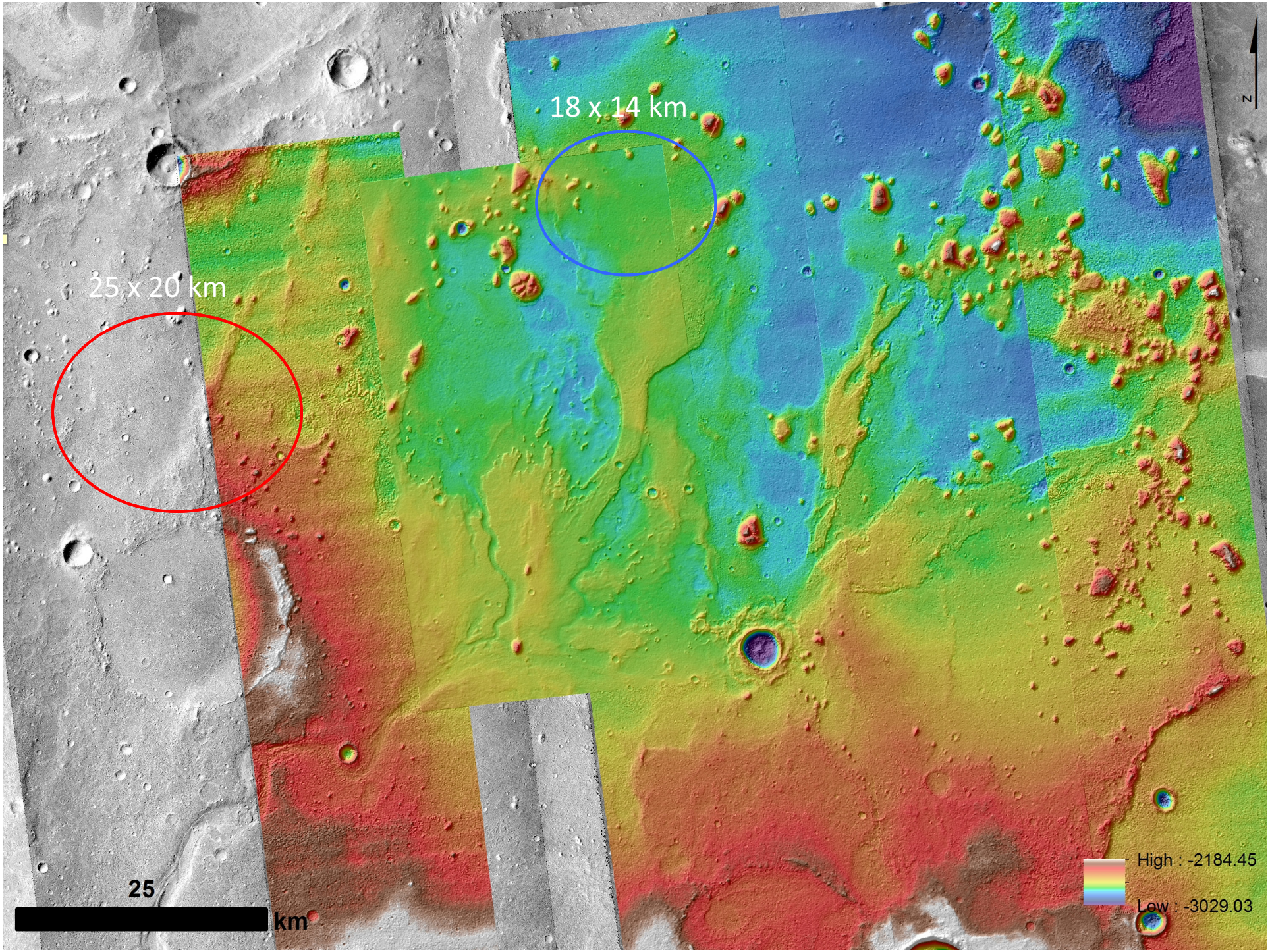
- More CRISM images have been requested, covering distal (low stratigraphy) fan region.
- New CRISM data could show evidence of aqueous alteration, as:
  1. Allochthonous deposits – channel eroding and depositing Noachian material.
  2. Autochthonous deposits – in situ alteration possible in low-energy environment.
  3. Deep alteration products – brought up and distributed by impacts.

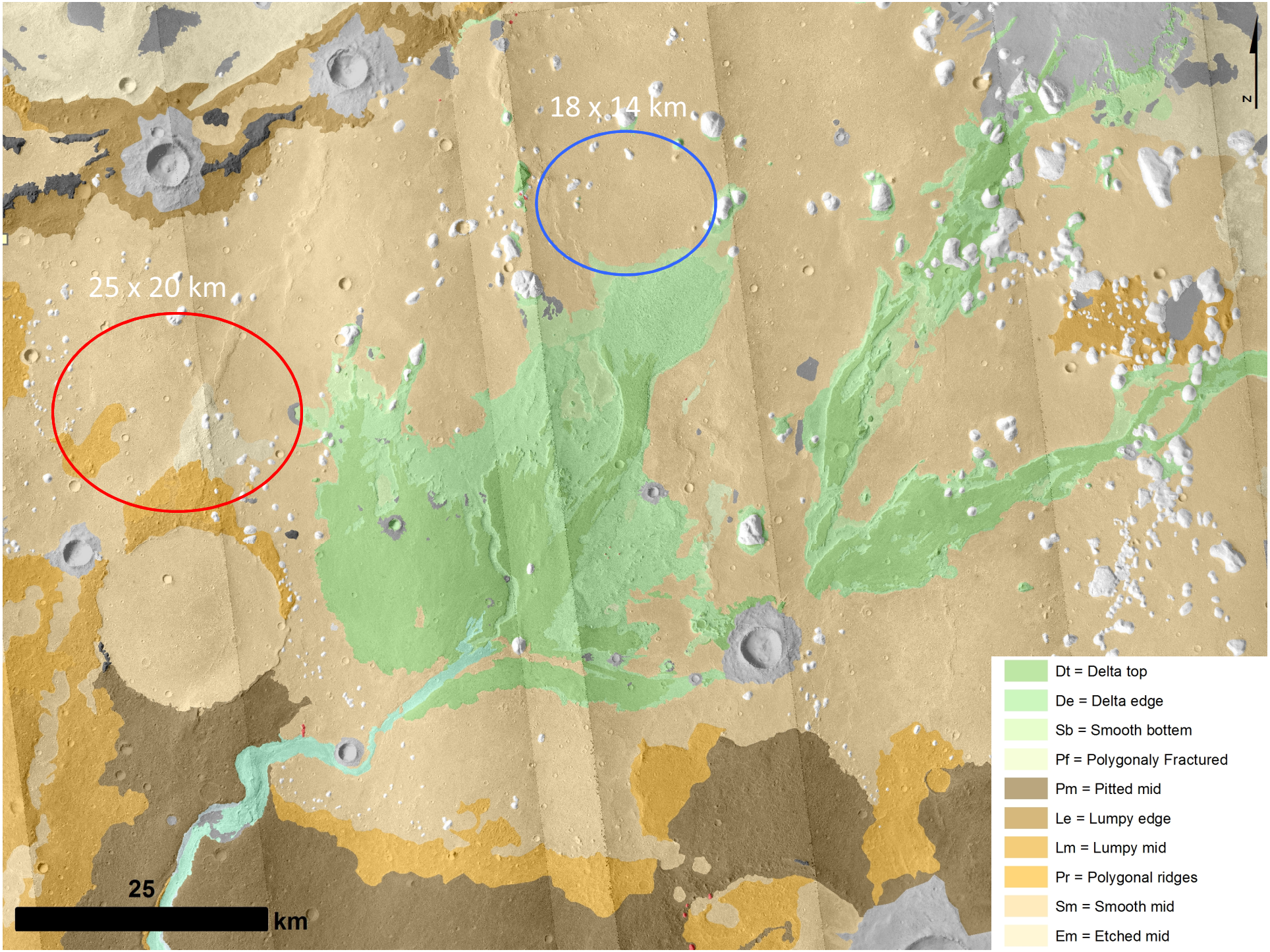


Hypanis sedimentary system

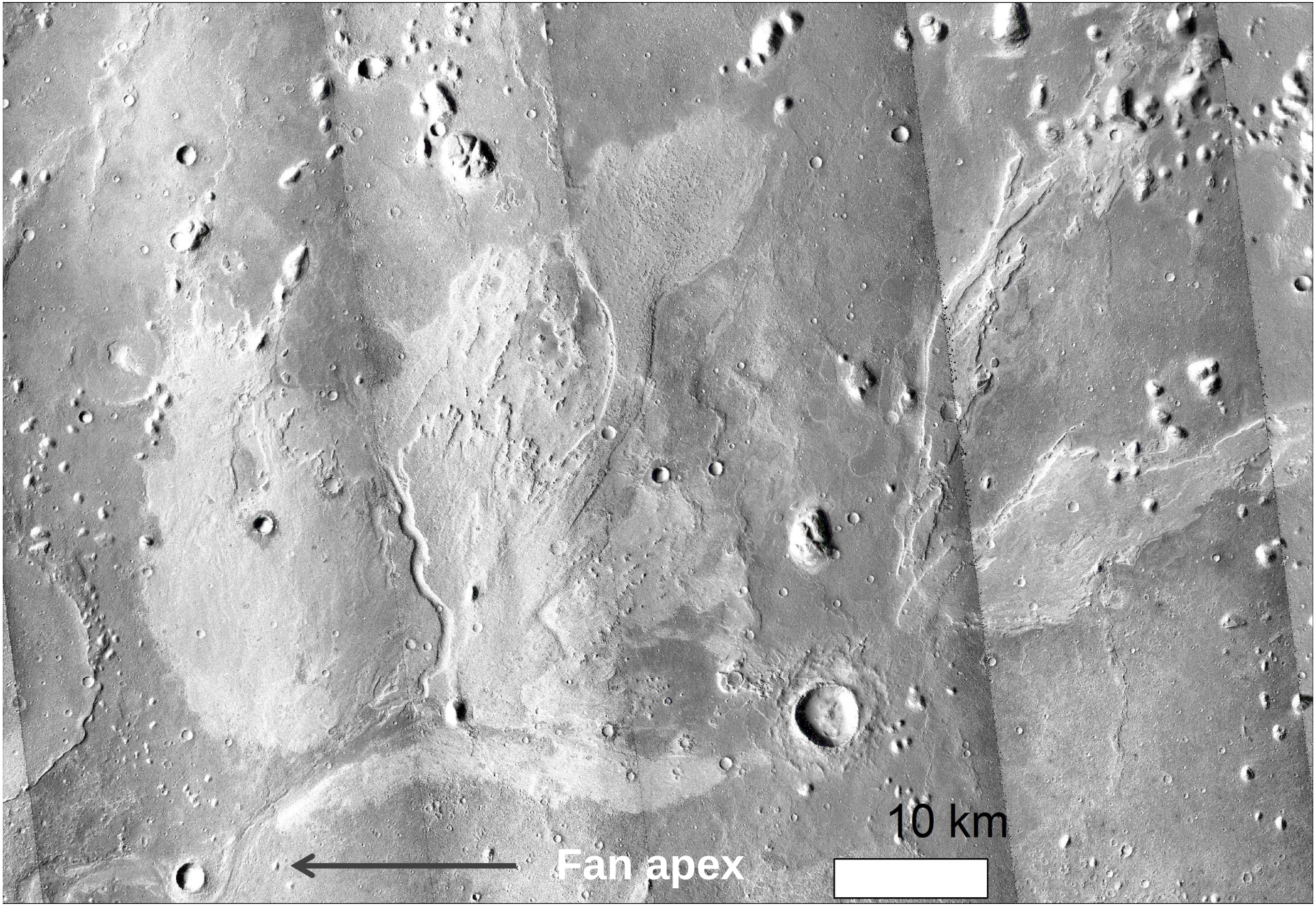


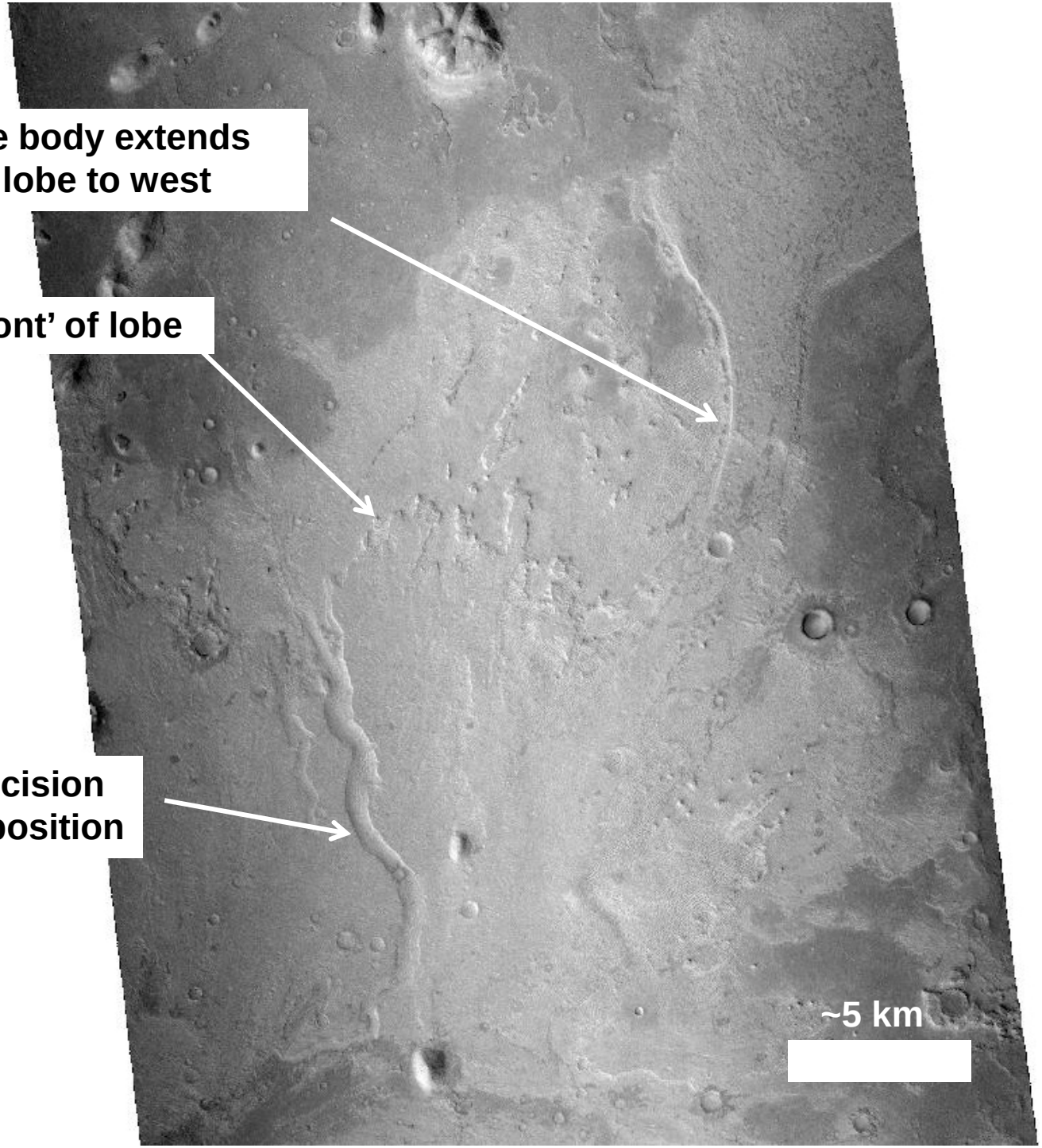
Forms a point-sourced depositional body

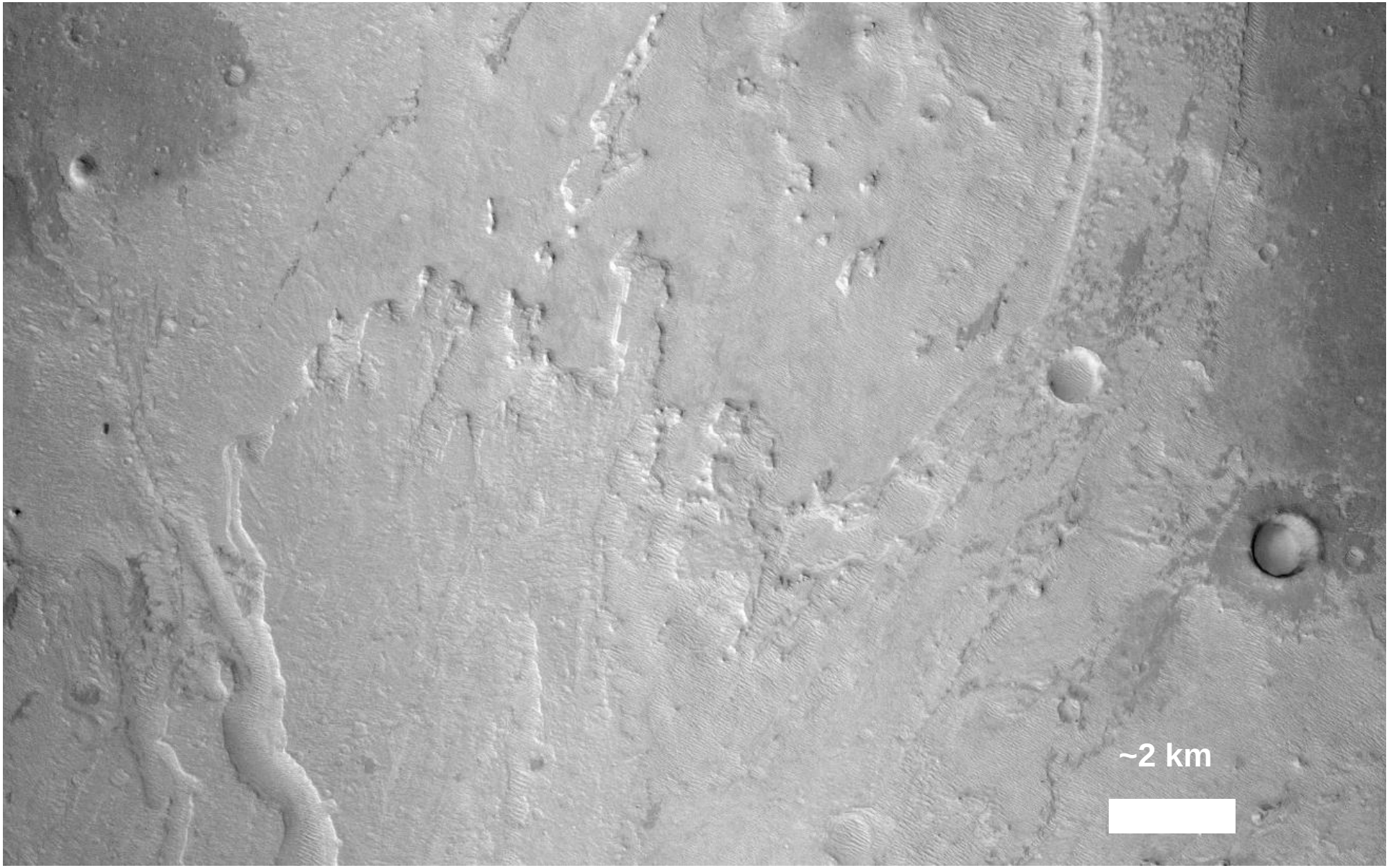

18 x 14 km
25 x 20 km
N
25
km
High : -2184.45
Low : -3029.03


18 x 14 km
25 x 20 km
N
25
km
Dt = Delta top
De = Delta edge
Sb = Smooth bottem
Pf = Polygonaly Fractured
Pm = Pitted mid
Le = Lumpy edge
Lm = Lumpy mid
Pr = Polygonal ridges
Sm = Smooth mid
Em = Etched mid

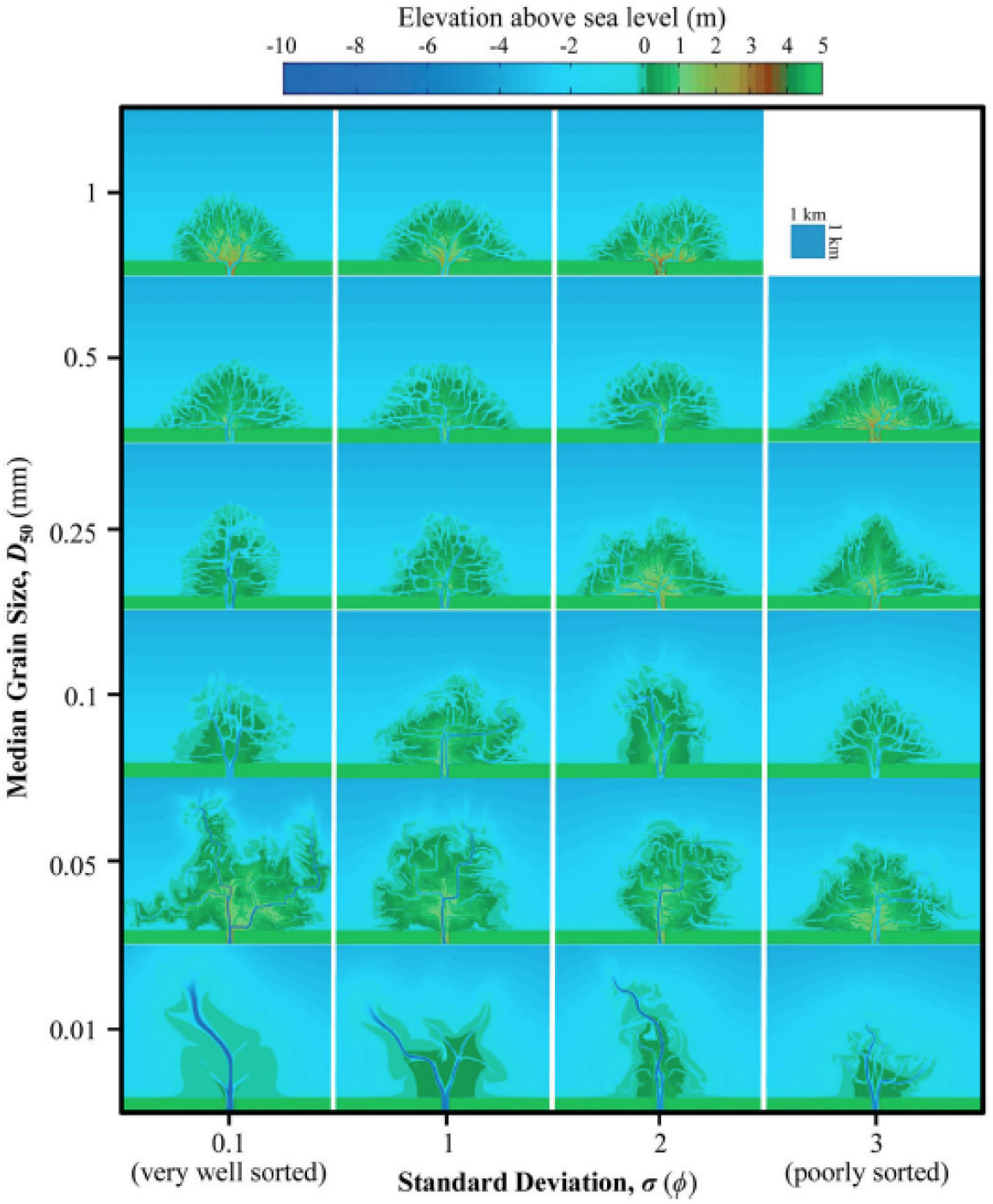
Hypanis – multiple depositional lobes




Channel-lobe body extends basinward of lobe to west
Erosional ‘front’ of lobe
Late stage incision after lobe deposition
~5 km


~2 km

Variation of delta shape as a function of sediment grain size from numerical simulations



Caldwell & Edmonds 2014

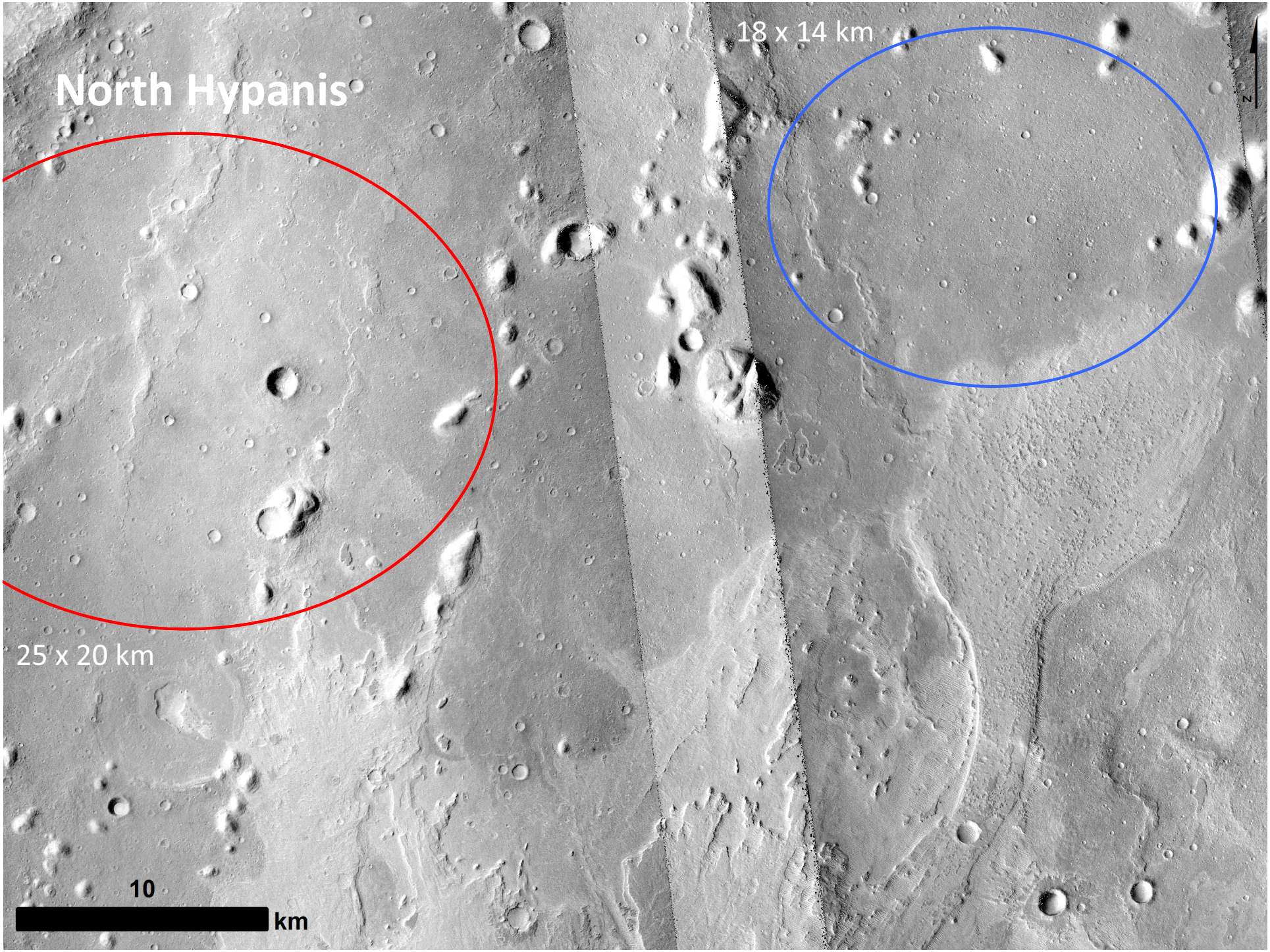
Large-scale geometry of the Hypanis system

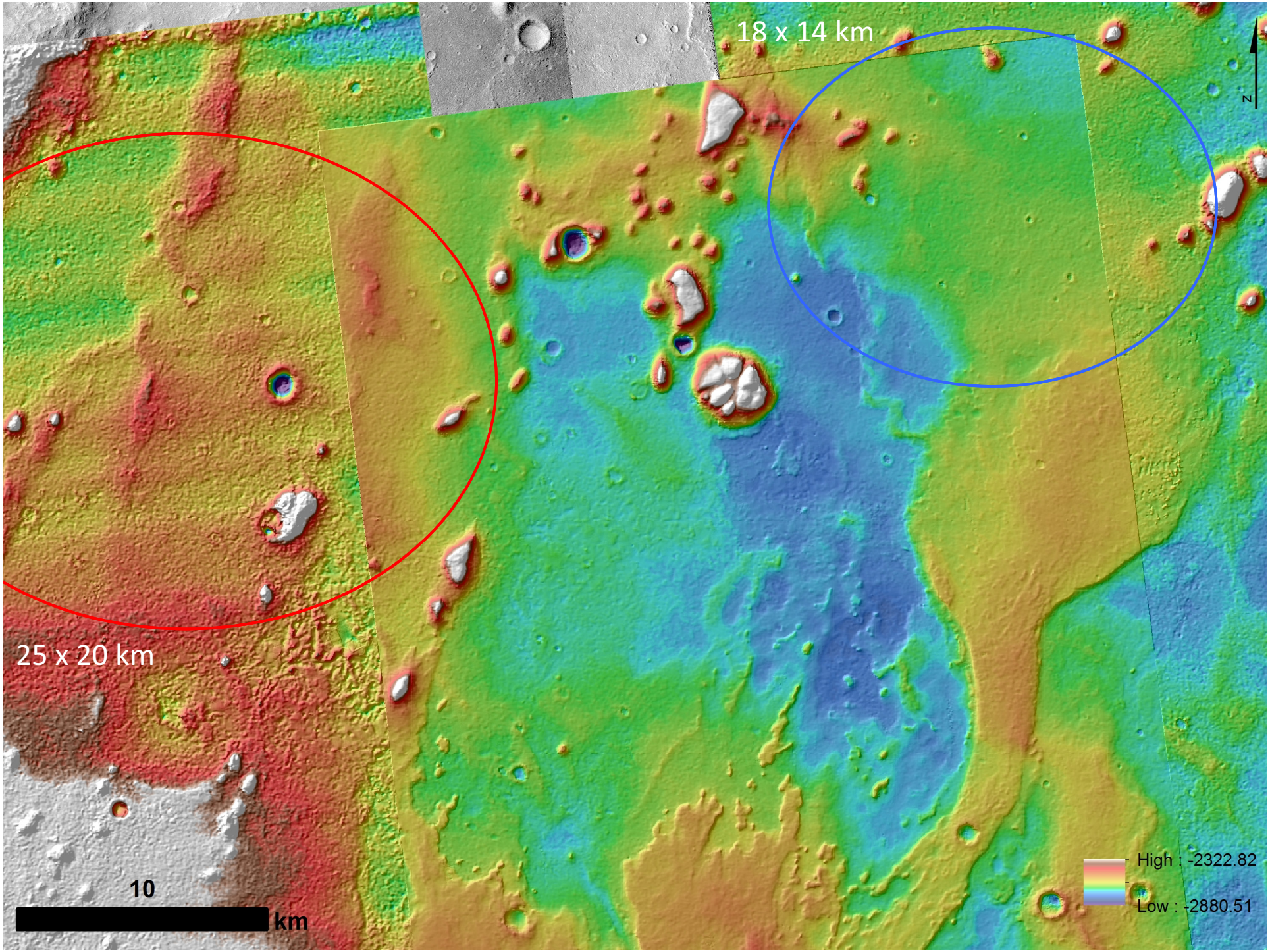
- **Hypanis system comprises multiple depositional lobes**
- **Individual lobes appear to cross-cut each other**
- **=> we observe temporal variation in deposition – lobes are shifting sideways through time – this is classical behaviour – called compensation cycles**
- **Channel-lobe features appear to shift basinward**
  - **System progrades basinwards…**
- **In eastern part of ellipse, we observe long, inverted channel system extending beyond termination of central lobe**
  - **Does this indicate further basinward progradation of fluvial systems?**
  - **Maybe an overall progradational system.. Would prograde over finer-grained basinal lower energy deposits**

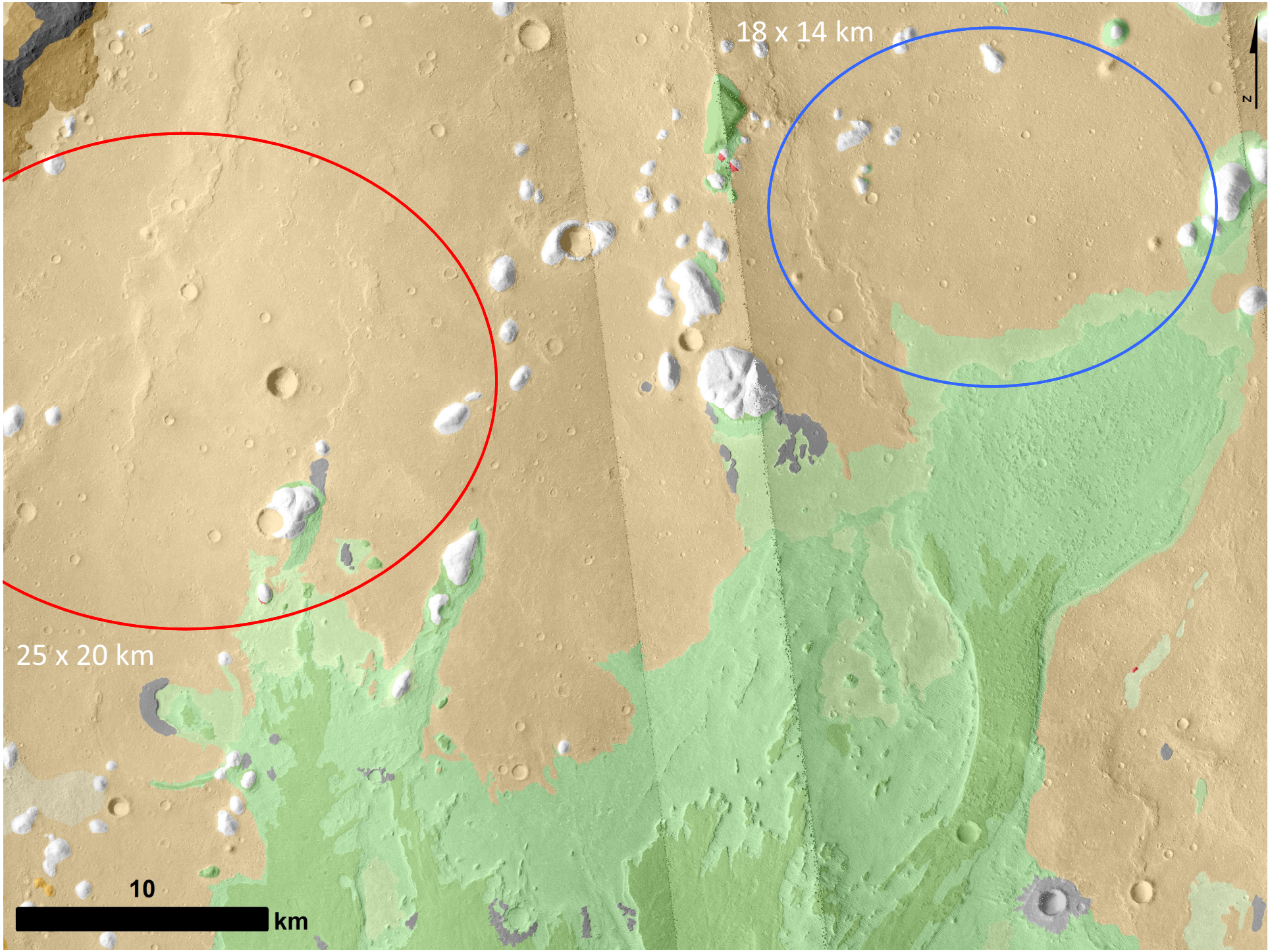
What is the bath-tub that ponded water?

Was the Chryse basin the bathtub?

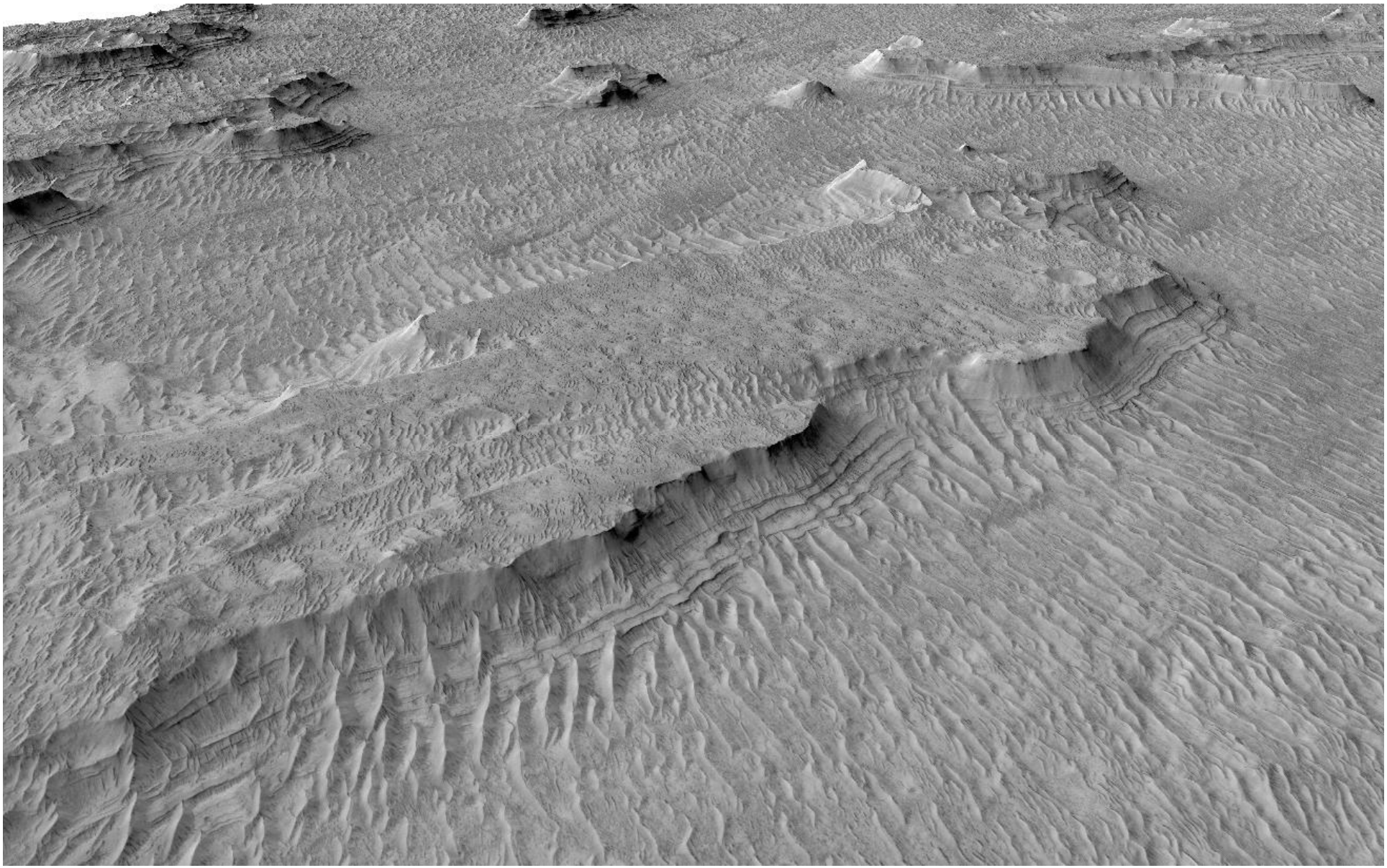
Hypanis - Sedimentology and Stratigraphy


North Hypanis
18 x 14 km
25 x 20 km
10
km
N

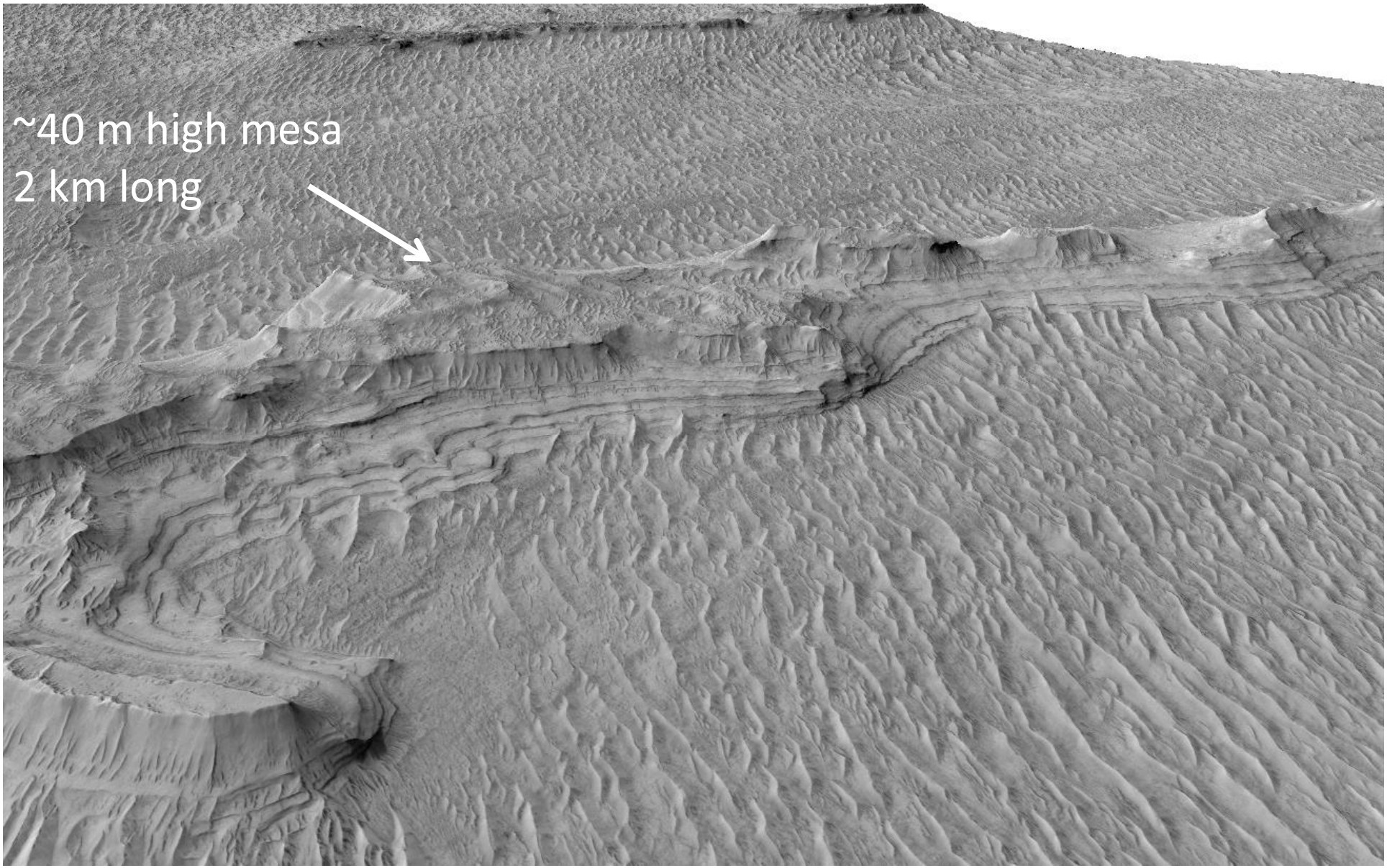

18 x 14 km
25 x 20 km
N
10
km
High : -2322.82
Low : -2880.51


18 x 14 km
25 x 20 km
N
10
km

CTX image and dtm

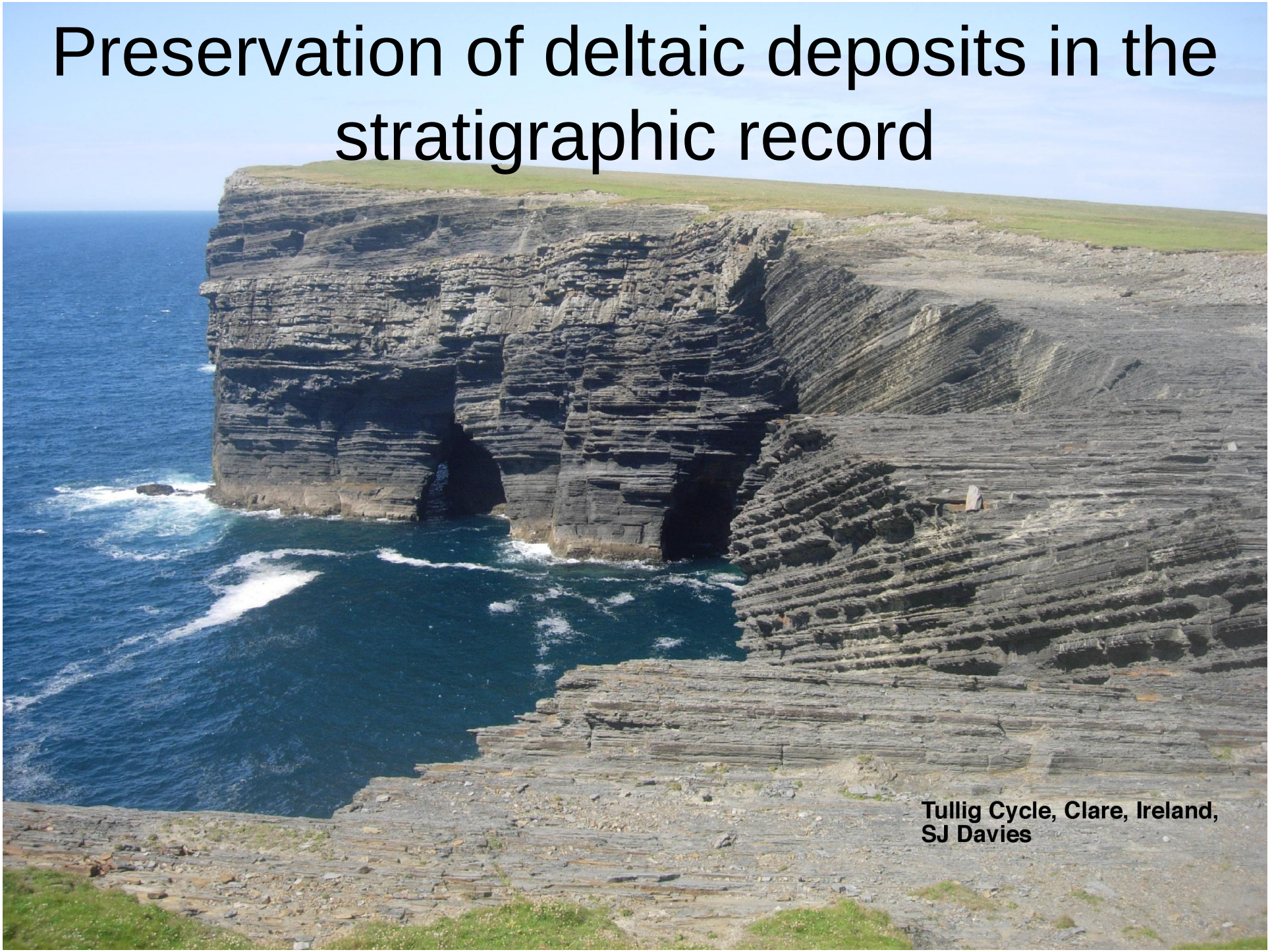


Hirise image and dtm

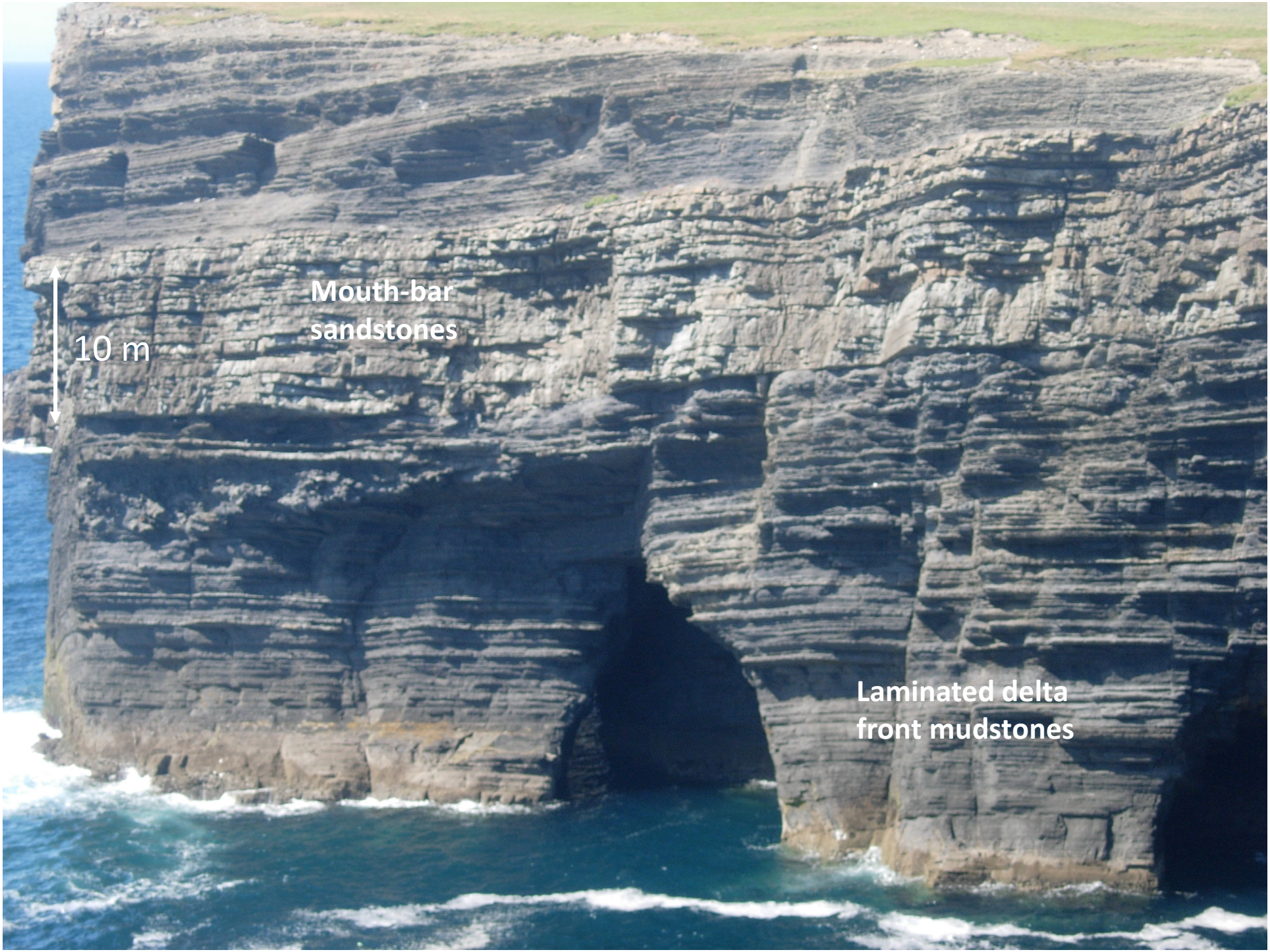


Hirise image and dtm

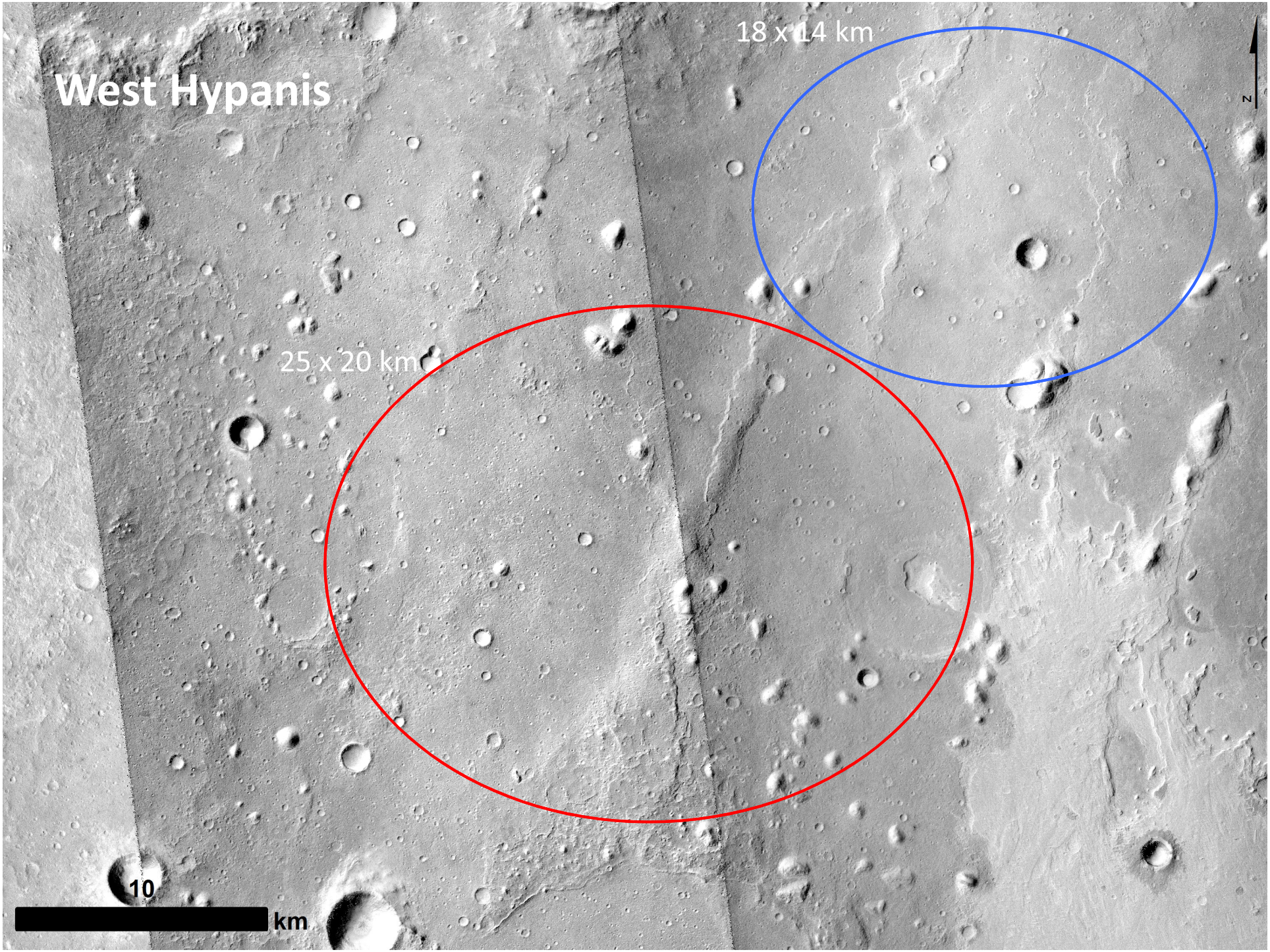
Preservation of deltaic deposits in the stratigraphic record

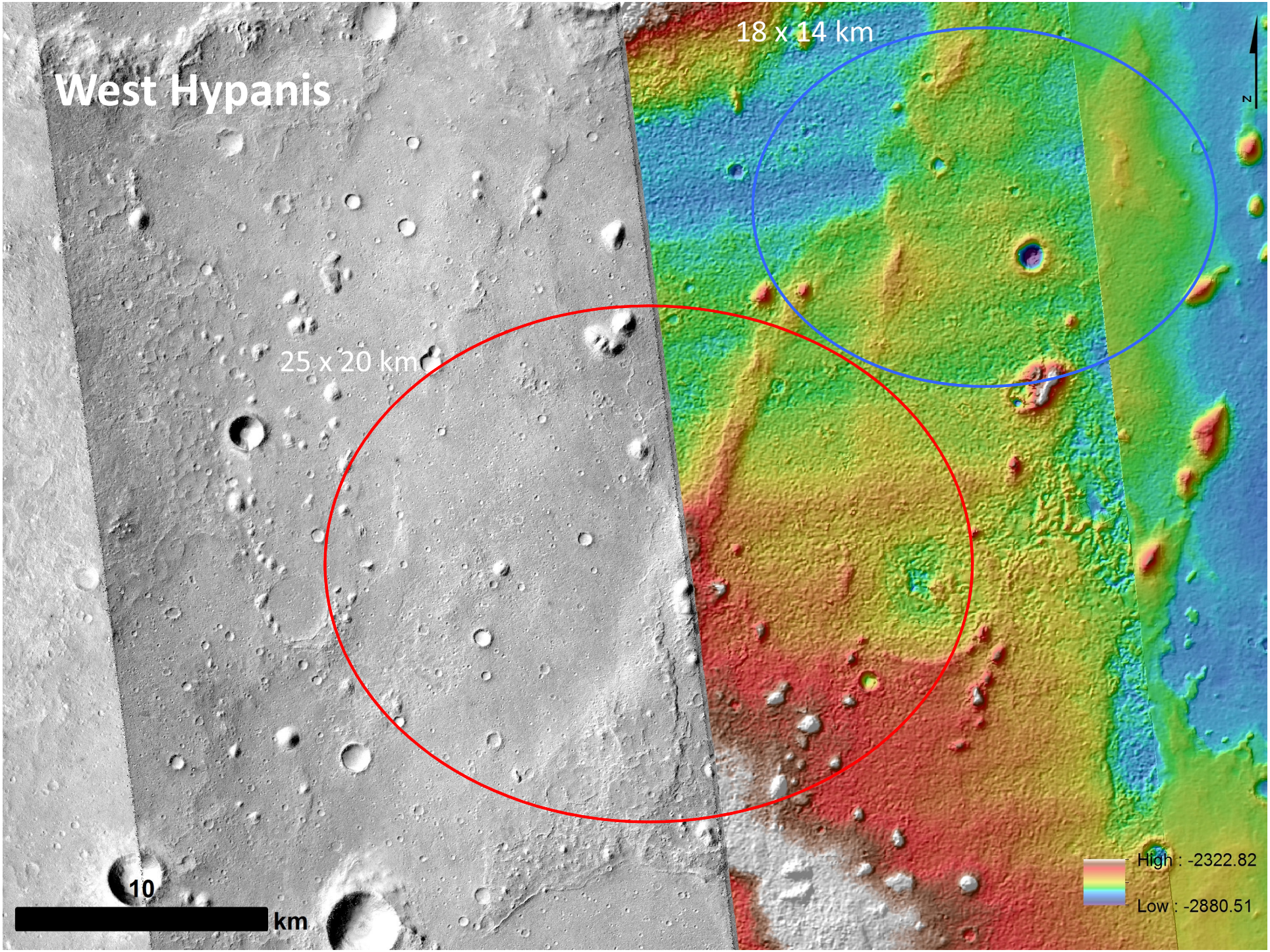


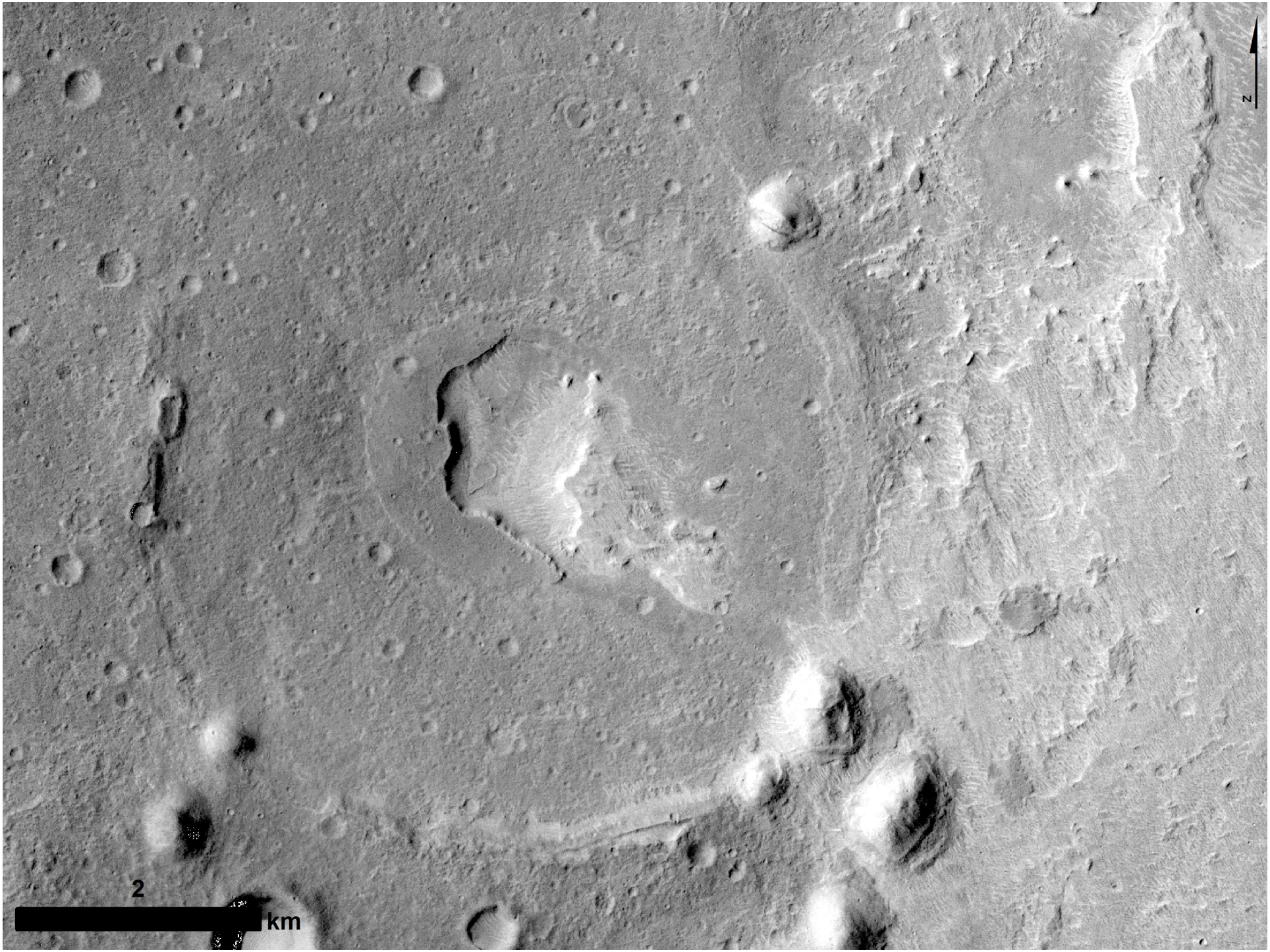
Tullig Cycle, Clare, Ireland,
SJ Davies

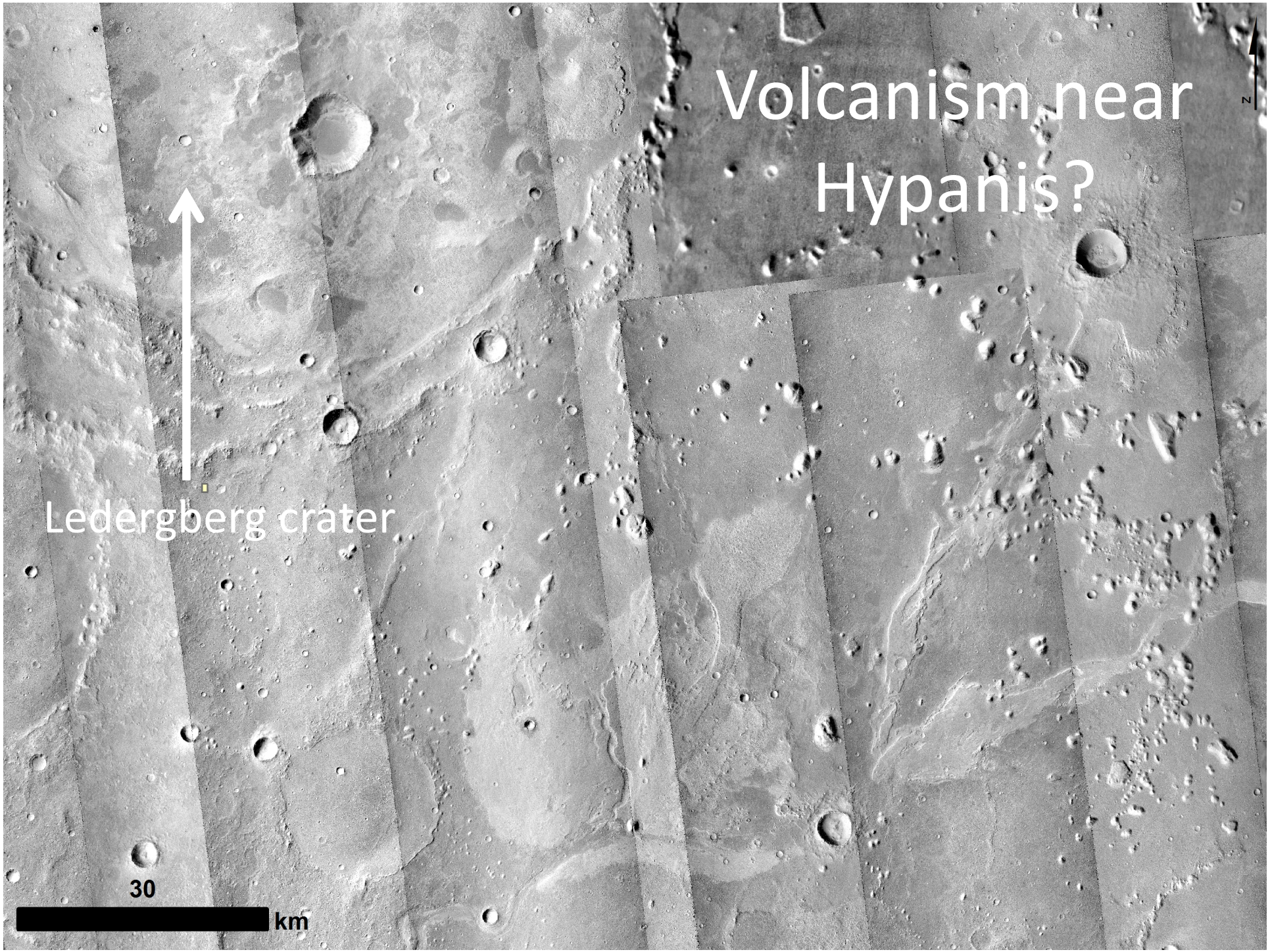

10 m
Mouth-bar
sandstones
Laminated delta
front mudstones

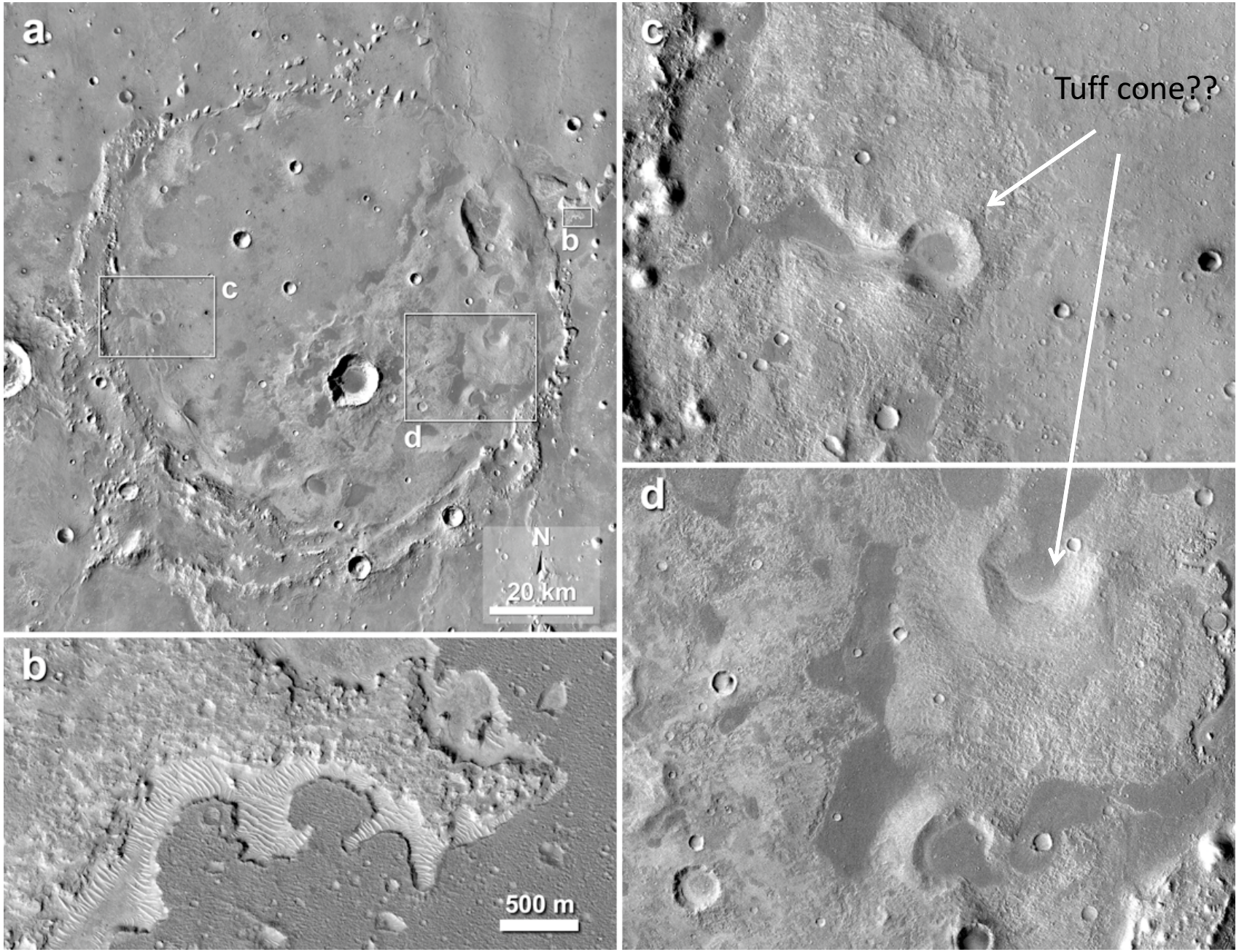
CTX image and dtm


West Hypanis
18 x 14 km
25 x 20 km
N
10
km


West Hypanis
18 x 14 km
25 x 20 km
N
10
km
High : -2322.82
Low : -2880.51


N
2
km


Volcanism near Hypanis?
N
Ledergberg crater
30
km



Broz and Hauber JGR 2012

Meeting 2020 Criteria

Objective A: Characterize geology of astrobiologically relevant area	Analyze clear fluvio-deltaic system of Early Hesperian age. Likely potential to characterize lacustrine environment
Objective B: Determine habitability and biosignature preservation potential	Lacustrine system associated with Hypanis delta like to have formed habitable environment. Deltas have high rate of deposition and fine-grained material in distal areas with high preservation potential of OM
Objective C: Caching of scientifically selected and compelling samples	Will be able to access wide variety of sedimentary rocks of aqueous origin Access possible volcanic rocks as float

Hypanis – key points 1

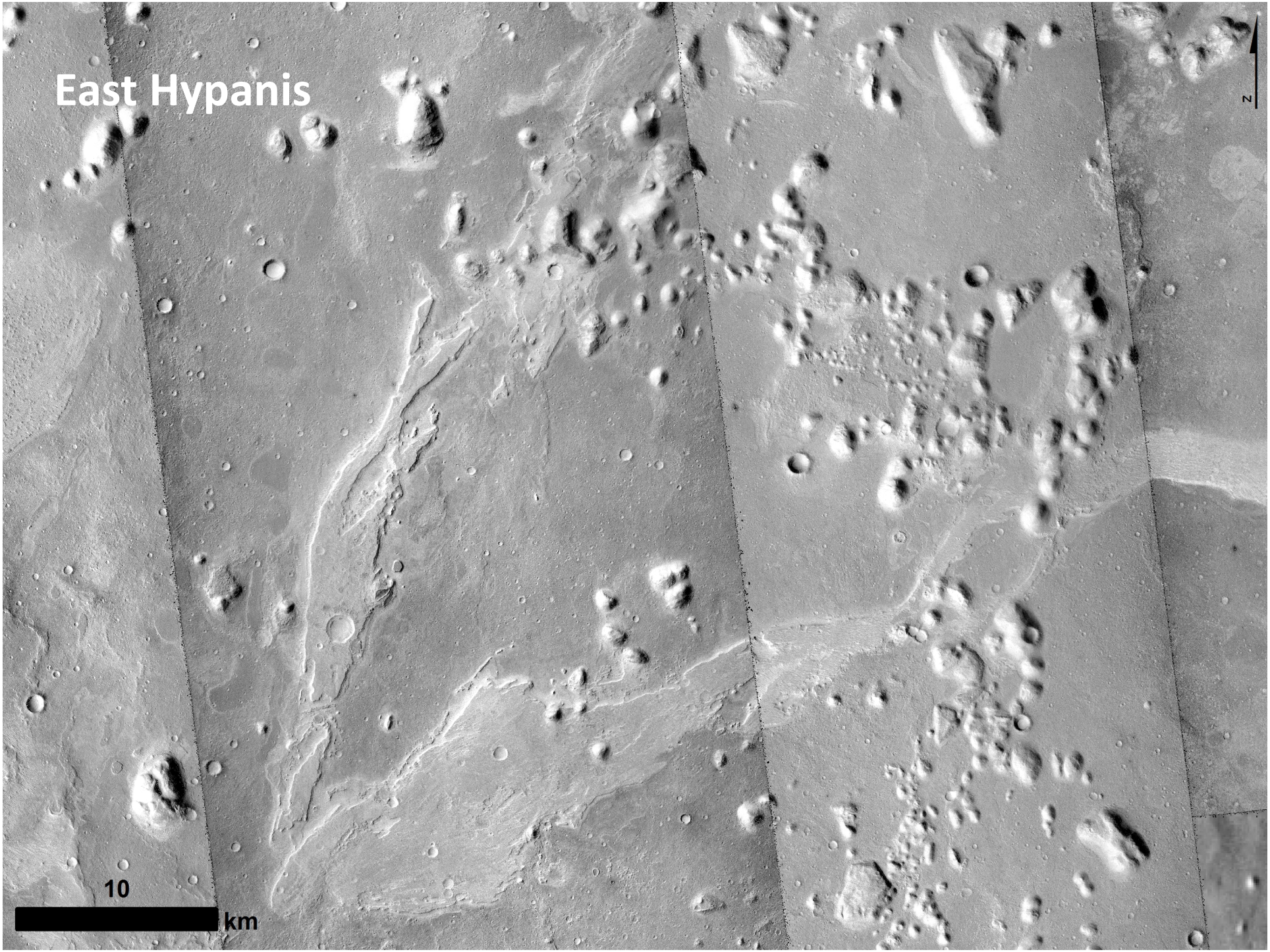
- **Late Hesperian aged, sedimentary rocks throughout the area**
  - **Therefore, lots of science targets**
- **Clear fluvio-deltaic context – excellent aqueous geological setting**
- **Sourced from extensive fluvial system – likely long duration of activity**
- **Likely downstream association with low energy fine-grained pro-delta and lacustrine deposits**
  - **High rates of sedimentation**
  - **Good biomarker preservation potential**

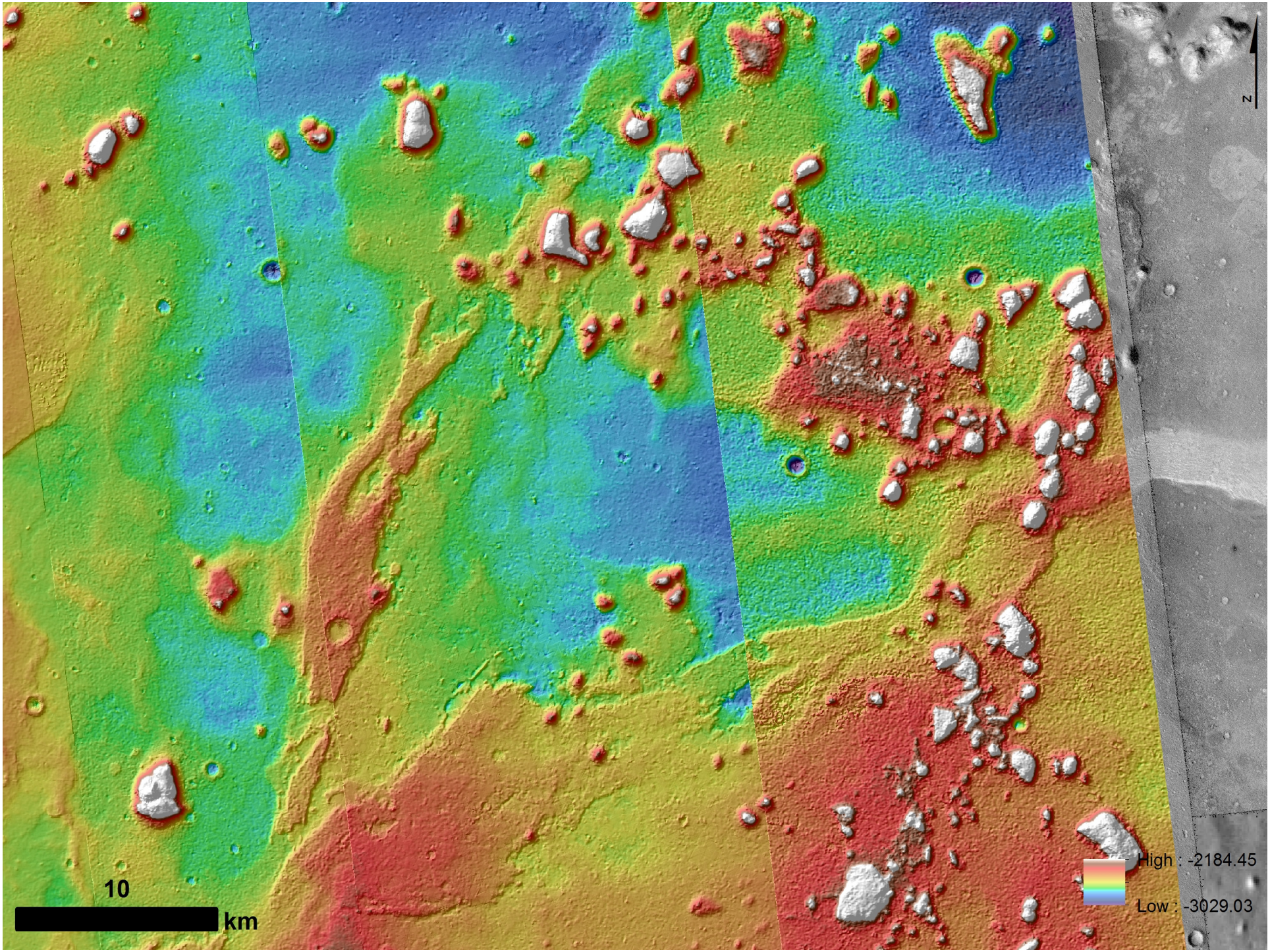
Hypanis – key points 2

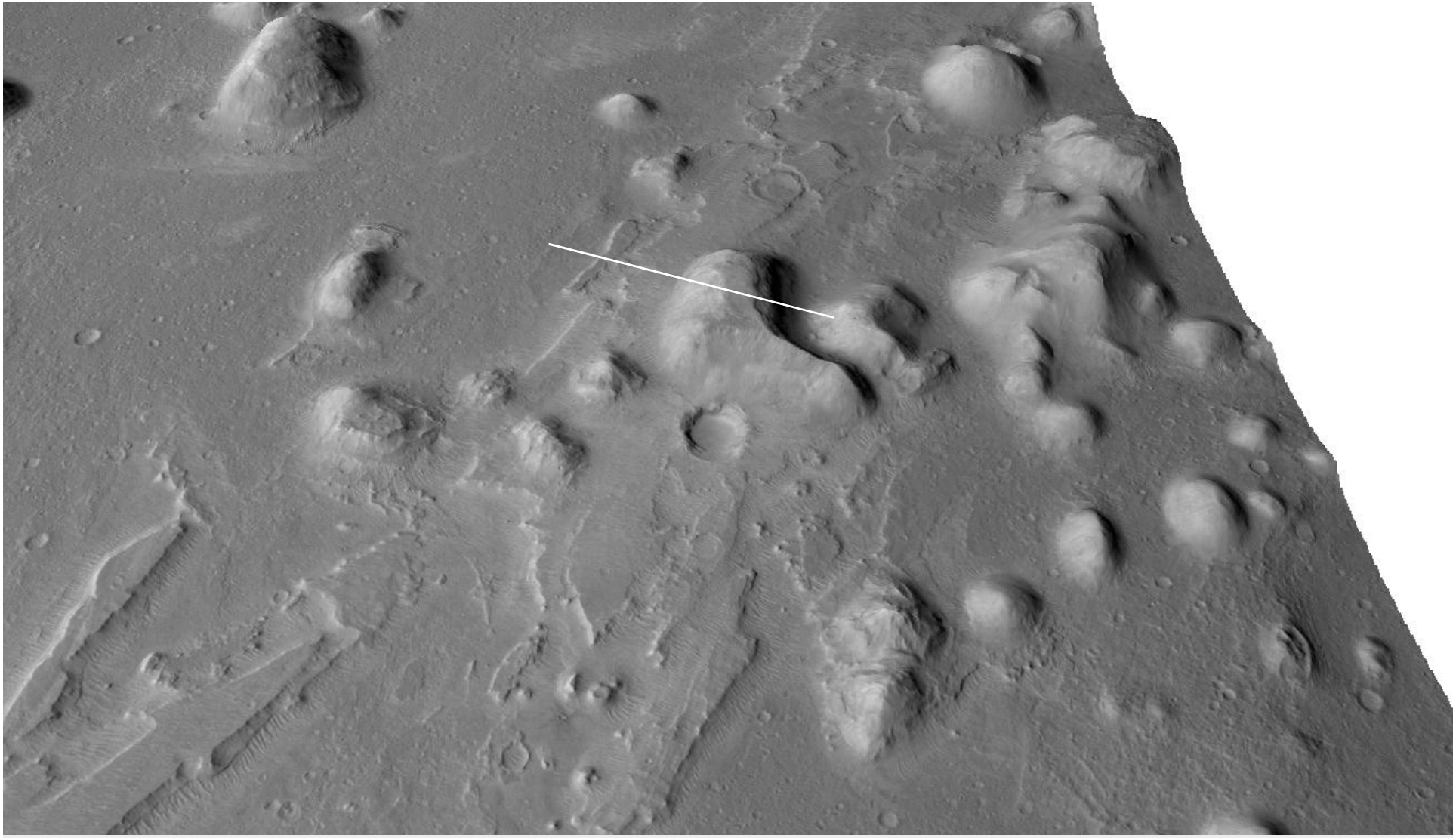
- **Extensive layered sedimentary rocks associated with geomorphic features**
- **One of several deltaic systems in the region – this could be a representative example of widespread, ancient deltaic systems at Chryse basin margin**
- **No downstream topographic boundary – what created the basin – a large Chryse lake/sea???**

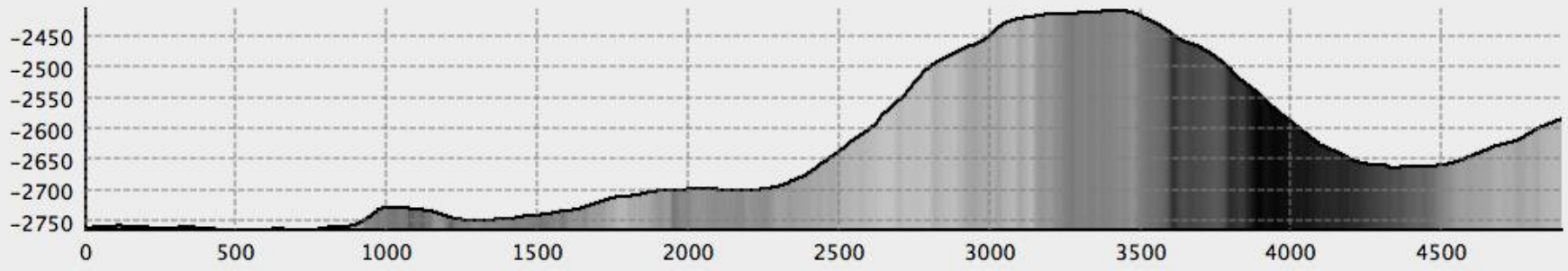
Potential to investigate and cache a large variety of sedimentary rocks from an ancient aqueous environment. Possible volcanic rocks as float?

Land on distal sedimentary layers


East Hypanis
N
10
km


N
10
km
High : -2184.45
Low : -3029.03




-2450
-2500
-2550
-2600
-2650
-2700
-2750
0
500
1000
1500
2000
2500
3000
3500
4000
4500